I. *REGNUM INORGANICUM.*—THE INORGANIC KINGDOM.

ORDER I.—OXYGEN AND ITS AQUEOUS SOLUTION.

Oxyge'nium.—Ox'ygen.

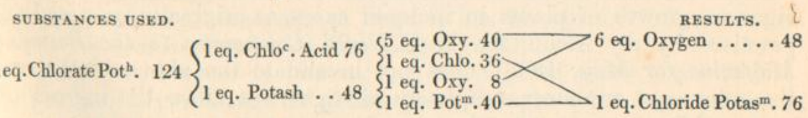
HISTORY, SYNONYMES, and ETYMOLOGY.—Oxygen gas was discovered on the 1st of August, 1774, by Dr. Priestley, who denominated it *dephlogisticated air*. In the following year, Scheele also discovered it, without knowing what Priestley had done, and he called it *empyr'eal air*. Condorcet termed it *vital air*. Lavoisier called it *oxygen*, from (ὀξὺς, *acid;* and γεννάω, *to engender* or *produce.*)

NATURAL HISTORY.—(*a.*) *In the inorganized kingdom.*—Oxygen is, of all substances, that which is found in the largest quantity in nature, for it constitutes at least $\frac{3}{4}$ of the known terraqueous globe. Thus, water, which covers about three-fourths of the surface of the earth, contains $\frac{8}{9}$ of its weight of oxygen; and the solid crust of our globe probably consists of at least $\frac{1}{3}$ part, by weight, of this principle; for silica, carbonate of lime, and alumina, the three most abundant constituents of the earth's strata, contain nearly half their weight of oxygen. Mr. De la Beche (*Researches in Theoretical Geology*, p. 8) calculates that silica alone constitutes "forty-five per cent. of the mineral crust of our globe." Of the atmosphere, oxygen constitutes 20 or 21 per cent. by volume, or about 23 per cent. by weight, to which must be added $\frac{8}{9}$, by weight, of the atmospheric aqueous vapour.

(*b.*) *In the organized kingdom.*—Oxygen is an essential constituent of all living bodies. Vegetables, in the sun's rays, absorb carbonic acid decompose it, retain the carbon, and emit the oxygen Hence they have been supposed to be the purifiers of the atmosphere.

PREPARATION.—There are several methods of procuring this gas, but I shall notice three only:—

1. *By heating chlorate of potash in a glass retort.*—This method yields pure oxygen gas. One equivalent, or 124 parts of chlorate of potash, yield six equivalents or 48 parts of oxygen, and one equivalent or 76 parts of chloride of potassium.

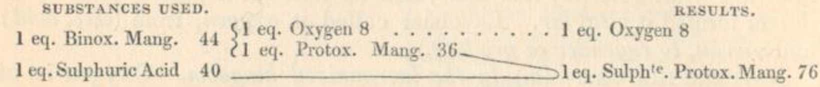


2. *By heating binoxide of manganese in an iron bottle.*—This is the cheapest method, and, for ordinary purposes, it yields oxygen gas sufficiently pure. To free the gas from carbonic acid, wash it with lime-water or with a solution of caustic potash. One pound of the commercial binoxide usually yields from 30 to 40 pints of gas: but, from fine samples, 40 to 50 pints may be procured. Two equivalents or 88 parts of pure binoxide yield one equivalent or 8 parts of oxygen, and two equivalents or 80 parts of the sesquioxide of manganese.

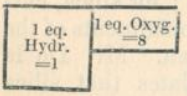
SUBSTANCE USED. RESULTS.

2 eq. Binoxide Manganese = 88 $\left\{ \begin{array}{l} \text{1 eq. Oxygen 8} \\ \text{2 eq. Sesquioxide Manganese 80} \end{array} \right.$

3. *By heating binoxide of manganese with about its own weight of strong sulphuric acid in a glass retort.*—The quantity of acid to be employed should be sufficient to form with the binoxide a mixture having the consistence of cream. This method is followed only when an iron bottle cannot be procured, or when a small quantity of gas is wanted at a very short notice. One equivalent, or 44 parts, of the binoxide, yield one equivalent or 8 parts of oxygen, and one equivalent or 36 parts of the protoxide of manganese: the latter substance forms, with an equivalent or 40 parts of anhydrous sulphuric acid, one equivalent or 76 parts of sulphate of the protoxide of manganese.



PROPERTIES.—It is elastic, colourless, odourless, tasteless, incombustible, but a supporter of combustion. According to Dr. Thomson, 100 cubic inches of this gas weigh, at the temperature of 60° Fah., and when the barometer stands at 30 inches, 34·60 grains: hence its specific gravity is 1·111̇. According to Berzelius and Dulong, the spec. grav. is 1·1026. Its atomic weight is 8: its atomic volume 0·5, hydrogen being in both cases unity.



CHARACTERISTICS.—If a taper or match be plunged into this gas after the flame has been blown out, but while the wick or charcoal is yet glowing, the flame is instantly reproduced. The only gas likely to be confounded with oxygen in this respect is the protoxide of nitrogen, from which oxygen is distinguished by exploding it with hydrogen. A mixture of one volume oxygen and two volumes hydrogen, yields, by explosion, water only, whereas a mixture of one volume of the protoxide of nitrogen with one volume hydrogen, yields water and one volume of nitrogen.

PHYSIOLOGICAL EFFECTS.—(*a.*) *On vegetables.*—Oxygen gas is essential to the germination of seeds, and to the existence and growth of plants. In the shade vegetables absorb it from the atmosphere, and evolve an equal volume of carbonic acid; while in the solar rays the reverse changes take place; carbonic acid being absorbed and oxygen expired. The vigorous growth of plants in inclosed cases, as originally proposed and practised by my friend Mr. N. B. Ward (*Companion to the Botanical Magazine for May*, 1836), does not invalidate the above statements; since the cases are never completely air-tight, but allow the ingress and egress of air consequent on changes of temperature.

The effects of pure oxygen gas on germination and vegetation have been examined by Theod. de Saussure (*Recherches Chimiques sur la Végétation*, 1804). He found that the period of germination is the same in oxygen gas as in atmospheric air, but that seeds evolve more carbonic acid in the former than in the latter (pp. 11 and 12). Plants do not thrive so well in an atmosphere of oxygen gas in the shade as in one of common air; they give out more carbonic acid, which is always injurious to vegetation in the shade. When exposed in oxygen gas to the direct rays of the sun, they augment in weight about as much as in atmospheric air (p. 93, *op. cit*).

(*b*). *On animals generally.*—It is usually asserted that all animals require the influence of oxygen, or rather of air, to enable them to exist: but this assertion cannot be proved in the case of some of the lower animals. Thus intestinal worms seem to dispense with respiration (Müller's *Physiology*, p. 295). Some animals which respire have no organs specially devoted to this function; in these the cutaneous surface effects respiration; as in the *Polypifera*. In the *Infusoria* the respiratory organs are delicate cilia. Many animals have branchiæ or gills for respiration, as some *Mollusca*, some *Annelida*, and fishes. Leeches respire by subcutaneous sacs which open externally. The respiratory organs of insects are ramifying tracheæ. Lastly, the higher classes of animals respire by means of lungs. Whenever respiration is effected a portion of oxygen disappears, while a quantity of carbonic acid, nearly equal in volume to the oxygen consumed, is produced.

The continued respiration of oxygen gas is injurious, and even fatal to animal life: this has been observed by all experimenters. Animals live longer in a given volume of oxygen than in the same quantity of atmospheric air, but the continued employment of it causes death. Mr. Broughton confined rabbits, guinea-pigs, and sparrows, in glass jars containing oxygen, and inverted over water. At first they suffered no inconvenience, but in about an hour their breathing became hurried, and the circulation accelerated. This state of excitement was followed by one of debility; the respirations became feeble, and were more slowly performed; loss of sensibility and of the power of voluntary motion supervened, till the only remaining visible action was a slight one of the diaphragm, occurring at distant intervals. On opening the body, the blood (both venous and arterial) was found to be of a bright scarlet hue; it was thin, and rapidly coagulated. The gas in which animals had thus been confined till they died, retained its power of rekindling a blown-out taper, and of sustaining, for a time, the life of another animal introduced into it; and Mr. Broughton hence deduced the inference that it does not contain so great an excess of carbonic acid as the gas left when animals have perished by confinement in atmospheric air, and he considered the train of symptoms induced by the respiration of pure oxygen gas as analogous to those which follow the absorption of certain poisons into the system (*Medical Gazette*, vol. iii. p. 775). Injected into the pleura, oxygen gas is very quickly absorbed, without producing inflammation. Cautiously injected into the veins of dogs, it has no sensible effect on the system (*Nysten, Recherches de Physiologie*, p. 60).

(*c.*) *Effects on man.*—If pure oxygen be inspired a few times it does not produce any remarkable phenomena; though some have ascribed various effects to it, such as agreeable lightness in the chest, exhilaration, increased frequency of pulse, a sensation of warmth in the chest, gentle perspiration, and an inflammatory state of system. But several of these results arise probably from mental influence, others from the mode of inhaling the gas, and perhaps some might depend on the employment of impure oxygen.

USES.—Oxygen gas was formerly employed in medicine in certain diseases supposed to depend on a deficiency of oxygen in the system; and the beneficial results obtained by the use of acids (especially the nitric acid) of the oxides of mercury, chlorate of potash, vegetable food, &c. were referred to the oxygen which these substances contained, and which they were supposed to communicate to the system. These notions are now exploded.

In asphyxia arising from a deficiency of atmospheric air, or from breathing noxious vapours, the inhalation of oxygen gas has been said to be, and probably is, useful. On the same principle, it may be employed during an attack of spasmodic asthma, when there is danger of suffocation, but it is at best only a palliative, and has no power of preventing the occurrence of other attacks. Chaussier has recommended its use in children apparently still-born. To combat the asphyxia of malignant cholera, inhalations of oxygen were tried in Russia, Poland, Prussia, and France, but without success (Merat and De Lens, *Dict. Mat. Méd.* tom. 5^{me}. p. 143).

A'qua Oxyge'nii.—Ox'ygen Water.

At the mean pressure and temperature of the atmosphere, 100 vols. of water dissolve, according to Dalton and Henry (*Elem. Experim. Chem.*) 3·7 vols. of oxygen gas, according to Saussure (*ibid.*) 6·5 vols. By pressure in a proper machine, water may be charged with a much larger quantity (Jourdan, in the *Pharmacopée Universelle*, says with half its volume) of gas. This solution has been termed *oxygenated water*, but is a very different substance to the peroxide of hydrogen, which also has been known by this appellation. It has been used to the extent of one or two bottlefuls daily, as a slight excitant. It is said to increase the appetite and promote the secretions; and to be serviceable in spasm of the stomach, amenorrhœa, hysteria, atonic dropsy, &c.

ORDER II.—CHLORINE AND ITS AQUEOUS SOLUTION.

Chlorin'ium.—Chlo'rine.

HISTORY, SYNONYMES, AND ETYMOLOGY.—This gas was discovered by Scheele in 1774, who termed it *dephlogisticated muriatic acid.* Berthollet, in 1785, named it *oxygenated muriatic acid.* Sir H. Davy called it *chlorine* (from χλωρὸς, *green*), on account of its colour.

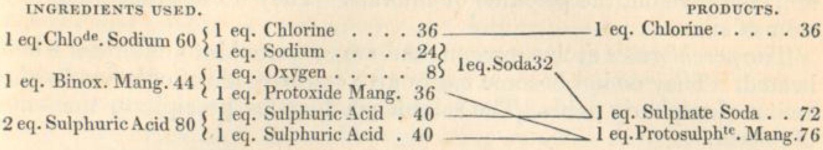
NATURAL HISTORY.—It is found in both kingdoms of nature. (*a.*) *In the inorganized kingdom* it exists principally in combination with sodium, either dissolved in the water of the ocean or forming deposits of rock salt. Chlorine also occurs native, in combination with magnesium, calcium, lead, silver, &c. Free hydrochloric acid is met with in the neighbourhood of volcanoes, and is probably produced by the decomposition of some chloride. (*b.*) *In the organized kingdom*, it is found in combination, in both animals and vegetables. Sprengel (*Decand. Physiol. Vég.* tom. i. p. 220), says maritime plants exhale chlorine, principally during the night. Hydrochloric acid, in the free state, exists, according to Dr. Prout, in the stomach of animals during the process of digestion.

PREPARATION.—There are several methods of procuring chlorine gas:—

1. *By adding sulphuric acid to a mixture of common salt and binoxide of manganese.*—This is the cheapest and most usual method of preparing it. Mix intimately three parts of dried common salt with one part of the binoxide of manganese, and introduce the mixture into a retort. Then add as much sulphuric acid, previously mixed with its own weight of water, as will form a mixture of the consistence of cream. On the

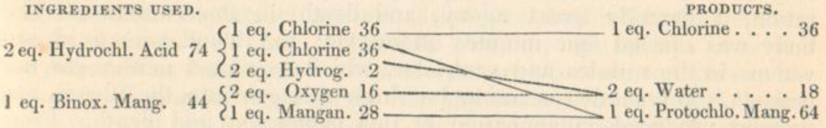
application of a gentle heat, the gas is copiously evolved, and may be collected over either warm or cold water.

In this process two equivalents, or 80 parts of sulphuric acid, react on one equivalent or 44 parts of the binoxide, and on one equivalent or 60 parts of chloride of sodium, and yield one equivalent or 36 parts of chlorine, one equivalent or 76 parts of the sulphate of the protoxide of manganese, and one equivalent or 72 parts of the sulphate of soda.



2. *By heating a mixture of equal weights of common hydrochloric acid and binoxide of manganese in a glass retort over a lamp.*

In this process two equivalents or 74 parts of hydrochloric acid react on one equivalent or 44 parts of the binoxide, and yield one equivalent or 36 parts of chlorine, one equivalent or 9 parts of water, and one equivalent or 64 parts of protochloride of manganese.



3. *By the action of hydrochloric acid on chloride of lime.*—This method may be resorted to when binoxide of manganese cannot be procured. The products of the reaction of the ingredients are, chlorine, water, and chloride of calcium.

Properties.—Chlorine, at ordinary temperatures and pressures, is a gaseous substance, having a yellowish green colour, a pungent, suffocating odour, and an astringent taste. 100 cubic inches weigh between 76 and 77 grains. Its sp. gr. is, according to Dr. Thomson, 2·5. Its equivalent by weight is 36, by volume 1;—hydrogen being unity. It is not combustible, but is a supporter of combustion. Phosphorus and powdered antimony take fire spontaneously when introduced into it,—a taper burns in it with the evolution of a red light and much smoke. When water is present it destroys vegetable colours, organic odours, and infectious matters.

By a pressure of 4 atmospheres at the temperature of 60° F., chlorine is a yellow liquid, having a sp. gr. of 1·33 (water being 1·).

Characteristics.—The colour, odour, and bleaching property of chlorine readily distinguish it from other gases. It forms a white curdy precipitate (chloride of silver) with the nitrate of silver: this precipitate blackens by exposure to light, from the escape of a little chlorine and the formation of a sub-chloride of silver (Wetzlar, in Landgrebe's *Versuch über das Licht.* p. 53, 1834); is insoluble in nitric acid, readily dissolves in liquid ammonia, and when heated in a glass tube fuses, and on cooling concretes into a gray, semi-transparent mass (*horn silver* or *luna cornea*). An aqueous solution of chlorine dissolves leaf gold. The *chlorides* react on the solution of nitrate of silver as free chlorine. They evolve hydrochloric acid when heated with liquid sulphuric acid. If a watery solution of a chloride, coloured blue by sulphate of indigo, be submitted to the action of a galvanic battery, the chlorine is evolved at the positive pole (*anode*) and destroys the colour of the sulphate of indigo in the neighbourhood of that pole.

The *chlorates* when heated evolve oxygen, and are converted into chlorides. When mixed with strong sulphuric acid they become orange red, and give out the peroxide of chlorine. They do not precipitate the salts of silver.

The *perchlorates* evolve oxygen, and are converted into chlorides when heated. They do not become red or give out peroxide of chlorine by the action of sulphuric acid. The soluble perchlorates precipitate the salts of potash.

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—The germination of seeds has been said to be promoted by watering them with a weak solution of chlorine, but the statement is probably erroneous. (*Decand. Phys. Végét.* t. ii. p. 632.)

b. On animals generally.—Nysten (*Recherches*, p. 140,) injected a small quantity of chlorine gas into the jugular vein of a dog, and the only effect was howling. A larger quantity occasioned difficult respiration, apparently great agony, and death in three minutes. The body was opened four minutes afterwards: the blood was fluid and venous in the auricles and ventricles, which contained neither gas nor coagula. On another occasion he threw this gas into the pleura, and thereby produced inflammation of this membrane and death. From these experiments, Nysten (*op. cit.* p. 143) concludes that it is a local irritant, but has no specific effect on any part of the system.

c. On man.—Chlorine gas acts as a *local* irritant. Mr. Wallace (*Researches respecting the Medical Powers of Chlorine, particularly in Diseases of the Liver*, 1822), tells us, that diluted with air, or aqueous vapour, of 116° F., and applied to the skin, it produces peculiar sensations, similar to those caused by the bite or sting of insects: this effect is accompanied with copious perspiration, and a determination of blood to the skin, sometimes attended with an eruption of minute papulæ, or even vesicles. Applied to the skin in a pure form, its action is similar, but more energetic.

If an attempt be made to inspire undiluted chlorine gas, it produces spasm of the glottis. If the gas be mixed with air, it enters into the bronchial ramifications, causes a sensation of tightness and suffocation, and violent cough. Twice I have suffered most severely from the accidental inhalation of it; and each time it gave me the sensation of constriction of the air-tubes, such as might be produced by a spasmodic condition of the muscular fibres of the bronchial tubes. The attack usually goes off in increased secretion from the mucous membrane. When diluted with a large quantity of air, chlorine may be inhaled without exciting cough: it occasions a sensation of warmth in the respiratory passages, and promotes expectoration.

The irritating effects of chlorine are less powerful on those accustomed to inhale it; as I have repeatedly seen in patients who were using the gas, and which is also shewn by the following statement made by Dr. Christison, (*Treatise on Poisons*, p. 736):—"I have been told (says he) by a chemical manufacturer at Belfast, that his workmen can work with impunity in an atmosphere of chlorine, where he himself could not remain above a few minutes."

The constitutional or *remote* effect caused by inhalations of chlorine, is increased frequency of the pulse and of respiration. But this effect may be in part owing to the increased muscular efforts of the patient. Mr. Wallace states that the application of chlorine to the skin also occasions soreness of the mouth, fauces, and œsophagus, increased vascularity, and even minute ulcerations of these parts, and an alteration in the quantity and quality of the salivary and biliary secretions. He thinks that it has a tranquillizing, and at the same time exciting power, with respect to the nervous system. Dr. Christison tells us that at the Belfast manufactory above alluded to, the chief consequences of exposure to an atmosphere of chlorine are acidity and other stomach complaints, which the men generally correct by taking chalk. Absorption of fat is said to be an effect observed in the manufactories at Glasgow, Manchester, and Belfast. (Cogswell's *Essay on Iodine*, p. 82.)

When applied to the skin or bronchial membrane, does chlorine gas become absorbed? If Mr. Wallace's observation be correct, we must infer that it does, and that it is thrown out of the system by the kidneys; for he says the urine acquires bleaching properties.

USES.—(*a*.) *As a fumigating agent, disinfectant, and antiseptic,* chlorine, I believe, stands unrivalled. Hallé, in 1785, appears to have been the first person who employed it as a disinfectant; but we are greatly indebted to Guyton-Morveau for the zeal and energy he manifested in his attempts to introduce it into use. For destroying miasmata, noxious effluvia, and putrid odours, it is the most powerful agent known; and is, therefore, well adapted for disinfecting prisons, ships, hospitals, dissecting-rooms, and all other places, the air of which requires purification. The best method of fumigating a large building is that adopted by Dr. Faraday, at the General Penitentiary at Milbank. One part of common salt was intimately mixed with one part of the black or binoxide of manganese; then placed in a shallow earthen pan, and two parts of oil of vitriol, previously diluted with two parts by measure of water, poured over it, and the whole stirred with a stick. Chlorine continued to be liberated from this mixture for four days. The quantities of the ingredients consumed were 700 lbs. of common salt, 700 lbs. of binoxide of manganese, and 1400 lbs. of sulphuric acid. The disinfecting power of chlorine is supposed to depend on its affinity for hydrogen, by which it effects the decomposition of water or aqueous vapour, with the hydrogen of which it unites, while the nascent oxygen oxidizes the organic matter: or it may act merely by abstracting hydrogen from the putrid miasmata.

(*b*.) *As an antidote in poisoning by hydrocyanic acid, sulphuretted hydrogen, or hydrosulphate of ammonia,* chlorine gas is a very valuable agent. I believe, however, that the chloride of lime will be found a more convenient, safe, and opportune substance; of course its activity depends on the chlorine which it contains or gives out. The beneficial influence of chlorine in the treatment of animals asphyxiated by sulphuretted hydrogen, doubtless arises in part at least from its chemical properties; for when mixed with sulphuretted hydrogen, it forms chloride of sulphur and hydrochloric acid. The best method of applying the remedy is to diffuse a little chlorine in the air, and then to effect artificial respiration.

(*c*.) *Inhaled in chronic pulmonary diseases* it is sometimes a useful remedy. I have carefully watched its effects in phthisis and other chronic diseases of the lungs; and the result of my observation is, that chlorine is rarely serviceable. Frequently, after the first and second inhalations, the patients fancy their breathing much relieved, while the expectoration is promoted, but the amendment is seldom permanent. I need hardly say it has no pretensions to the cure of phthisis, but it may be useful as a palliative (sometimes diminishing the sweating); and I can readily believe that occasionally in chronic bronchitis it may be of essential service, though, I confess, I have never found it so.

I have before described the mode of administering the gas (p. 51). Either the aqueous solution of chlorine, or a small portion of the chloride of lime, may be placed into the inhaling bottle: if the latter be not sufficiently strong, a few drops of muriatic acid are to be added, to develop free chlorine.

(*d.*) *In diseases of the liver*, not attended with active inflammation, Mr. Wallace has successfully employed baths of gaseous chlorine, either in the pure state or diluted with air or aqueous vapour. The benefit of chlorine in these cases has been confirmed by others. The temperature of the bath, and the time the patient ought to remain in it, will vary in different instances; but Mr. Wallace thinks, that, in the greater number, 115° Fah. will be found to answer best, and the proper time about half an hour. The benefit obtained is in part referrible to the heat employed, in part to the irritant effect of the chlorine on the skin, and (according to Mr. Wallace) in part to the specific influence of chlorine on the liver. Ziese, an apothecary at Altona, has also employed chlorine baths in these cases with advantage.

ANTIDOTES.—The inhalation of ammoniacal gas, of the vapour of warm water, of spirit of wine, or of ether, has been recommended, to relieve the effects of chlorine. I tried them all when suffering myself, but without the least apparent benefit. In a case related by Kastner, and which is reported in Wibmer's work (*Die Wirkung der Arzneim. u. Gifte.* 2er. Bd. 109), sulphuretted hydrogen gave great relief. If this agent be employed, it must be done cautiously, as it is itself a powerful poison.

A'qua Chlorin'ii.—Chlo'rine Water.—Ph. Dub.

HISTORY.—This compound has been known by the various names of *liquid oxymuriatic acid*, *aqua oxymuriatica*, and *liquor chlori*. In the Dublin Pharmacopœia it is termed *aqua chlorinii*, or *chlorine water*.

PREPARATION.—In the Dublin Pharmacopœia this compound is prepared as follows:—add 87 parts of sulphuric acid to 124 of water, and when the mixture has become cold, pour it on a mixture of 100 parts of dried common salt, intimately mixed with 30 parts of binoxide of manganese, and placed in a retort. Transmit the gas which is evolved on the application of a moderate heat, through 200 parts of water, placed in a Woolfe's bottle: but in the absence of this a wide-mouthed bottle closed by a cork with two perforations, through which pass two glass tubes, both dipping into the water, but one of which communicates with the retort. A Florence flask, to which a curved tube is adapted by means of a cork, is a more convenient vessel for generating the gas in, than a retort.

PROPERTIES.—At the temperature of 60° F. and common pressure of the atmosphere, water takes up about twice its bulk of the gas (*Gay-Lussac*).

The solution has a greenish yellow colour, the strong and peculiar odour of the gas, and an astringent taste. Its sp. gr. is 1·003. It bleaches vegetable colours—as tincture of litmus, turmeric, &c. By exposure to light, the water is decomposed, the oxygen is evolved, while the hydrogen unites with the chlorine to form muriatic acid. Hence the solution should be kept in bottles excluded from the light.

Characteristics.—Its odour, its action on a solution of nitrate of silver (as before described for chlorine gas), its power of dissolving leaf gold, and its bleaching properties, readily distinguish this solution. It destroys the blue colour of iodide of starch and of sulphate of indigo. A piece of silver plunged into it is immediately blackened.

Physiological effects.—In a concentrated form, the aqueous solution of chlorine acts as a corrosive poison. Somewhat diluted it ceases to be a caustic, but is a powerful local irritant. Administered in proper doses, and sufficiently diluted, it acts as a tonic and stimulant. The continued use of it is said to have caused salivation. Applied to dead organic matter it operates as an antiseptic and disinfectant.

Uses.—Chlorine water has been employed in medicine both as an external and internal remedy.

(*a.*) *Externally.*—It has been used in the concentrated form as a caustic, applied to wounds caused by rabid animals; diluted, it has been employed as a wash in skin diseases, namely, in the itch and porrigo; as a gargle in putrid sore-throat; as a local bath in liver diseases; and as an application to cancerous and other ulcers attended with a fœtid discharge. In the latter cases I have repeatedly employed it with advantage, though I give the preference to a solution of the chloride of soda.

(*b.*) *Internally.*—It has been administered in those diseases denominated putrid; for example, in the worst forms of typhus, in scarlet fever, and in malignant sore throat. It has also been employed in venereal maladies, and in diseases of the liver.

Dose.—The dose of this solution varies with the degree of concentration. I have frequently allowed patients to drink, *ad libitum*, water, to which some of this solution has been added. If made according to the directions of the Dublin Pharmacopœia, the dose is from one to two drachms properly diluted.

Antidotes.—According to Devergie, the antidote for poisoning by a solution of chlorine is albumen. The white of egg, mixed with water or milk (the caseum of which is as effective as the albumen of the egg) is to be given in large quantities. The compound which albumen forms with chlorine has little or no action on the animal economy, and may be readily expelled from the stomach. In the absence of eggs or milk, flour might be exhibited: or if this cannot be procured, magnesia or chalk. The gastro-enteritic symptoms are, of course, to be combated in the usual way.

Order III.—Iodine.

Iodin'ium.—I'odine.

General History.—Iodine was discovered in 1811 by M. Courtois, a saltpetre manufacturer at Paris. It was first described by Clement in 1813, but was afterwards more fully investigated by Davy and Gay-Lussac. It was named *Iodine*, from *ἰώδης*, *violet-coloured*, on account of the colour of its vapour.

NATURAL HISTORY.—It exists in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—Vauquelin met with iodide of silver in a mineral brought from Mexico, and Mentzel found iodine in an ore of zinc which contained cadmium. It has also been met with in an ore of lead—(*Journ. de Pharmacie*, tom. xxiii. for 1837, p. 29.) In sea-water it has also been discovered, where it probably exists as an iodide of sodium or of magnesium. Many mineral waters likewise contain it. It was detected by Mr. Copeland in the carbonated chalybeate of Bonnington. About one grain of iodine was found by Dr. Daubeny in ten gallons of the water of Robbin's Well at Leamington, in Warwickshire. In the old well at Cheltenham the quantity was not more than one grain in sixty gallons. In a brine-spring at Nantwich, in Cheshire, there was about a grain of iodine in twelve gallons. In the sulphurous water of Castel Nuovo d'Asti, iodine was discovered by Cantu. In some of the mineral waters of Germany, Bavaria, and South America, it has also been detected—(*Gairdner on Mineral and Thermal Springs*, p. 27.) Fuchs found it in the rock-salt of the Tyrol—(*Gmelin, Handbuch der Chemie.*)

(*b.*) *In the organized kingdom.*—Of animals containing iodine I may mention the genera *Spongia*, *Gorgonia*, *Doris*, and *Venus:* likewise *Sepia*, the envelopes of the eggs of which contain it. An insect has been found near Ascoli, in Italy, which Savi has described under the name of *Julus fœtidissimus*, containing iodine. The animal emits, when disturbed, a yellow fluid strongly smelling of iodine, and which immediately strikes the characteristic violet colour with starch—(*British and Foreign Medical Review* for January, 1838, p. 163.) Recently iodine has been detected in the oil of the cod's liver—(*Journ. Pharm.* tom. xxiii. p. 501.) A very considerable number of vegetables, particularly those belonging to the family *Algæ*, yield it. The following are some instances: *Fucus vesiculosus*, F. *serratus*, and F. *nodosus*; (fig. 36, *a*, *b*, *c*.) *Laminaria saccharina*, and *L. digitata*; (fig. 36 *d*) *Halidrys siliquosa*; *Chorda Filum*; *Gelidium cartilagineum*; *Halyseris polypodioides*; *Phyllophora rubens*; *Rhodomenia palmata*; *Ulva Linza*; *Porphyra umbilicalis*; *Padina Pavonia*; *Gigartina Helminthocorton*, and some of the marine *Confervæ*.

FIG. 36.

a. Fucus vesiculosus. *c.* F. serratus.
b. F. nodosus. *d.* Laminaria digitata.

It has been found in several species of phænogamous plants, as *Zos-*

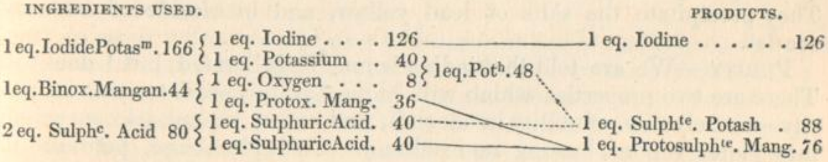
tera marina, and, more recently, in two growing in Mexico; namely, a species of *Agave* and a species of *Salsola*—(*Journ. Pharm.* tom. xxiii. p. 31.)

PREPARATION.—Iodine is obtained from the *Fucoideæ* (one of the divisions of the family *Algæ*). The plants of this tribe, by combustion, yield an ash or cinder, commonly denominated *kelp*, which contains iodine. Davy states that French kelp is more productive than British; and Eklond, from experiments made at the Cape of Good Hope, concludes that the *Laminaria buccinalis* yields more than any European *Algæ*.

Kelp is a very heterogeneous substance. Its soluble parts are the chlorides of sodium and potassium, carbonate of soda, sulphates of soda and potash, and the sulphuret and iodide of potassium or of sodium. To these must be added a small quantity of alkaline bromide. The quantity of iodide, however, is very small in comparison with some of the other salts, and, therefore, the first object in the manufacture of iodine is to separate as much of these as possible. By repeated crystallizations we readily attain this, since the iodide being very soluble is left in the mother liquor, along with the sulphuret and a portion of the other salts.

This liquor is introduced into a stoneware still, sulphuric acid and the binoxide of manganese are added, and heat applied. Iodine distils over, and after being washed with water, is dried between folds of bibulous paper.

In this process two equivalents, or 80 parts of sulphuric acid, react on one equivalent, or 44 parts of binoxide of manganese, and on one equivalent, or 166 parts of iodide of potassium, and yield one equivalent, or 126 parts of iodine, one equivalent, or 88 parts of sulphate of potash, and one equivalent, or 76 parts of the sulphate of the protoxide of manganese.



Bussy (*Journ. Pharm.* t. 23, p. 17) has proposed another mode of procuring iodine.

PROPERTIES.—Iodine is a crystallizable solid, its primary form being a rhombic octahedron. It is usually met with in micaceous, soft, friable scales, having a greyish black colour, a metallic lustre, an acrid hot taste, and a disagreeable odour somewhat similar to that of chlorine. It fuses at about 225° F., and at 347° is volatilized, though the vapour rises along with that of water at 212°. Iodine vapour has a beautiful violet colour, and a great specific gravity; namely, 8·716, according to Dumas. Iodine requires 7000 times its weight of water to dissolve, but alcohol and ether are much better solvents for it. Its atomic weight is about 126.

CHARACTERISTICS.—In the free state iodine is distinguished from most other bodies by its forming an intense blue colour with starch. So delicate is this test, that Stromeyer says, water which does not contain more than one four-hundred-and-fifty thousandth of its weight of iodine, acquires a perceptibly blue tinge on the addition of starch. This blue colour is destroyed by heat, and, therefore, in testing for iodine the liquids employed should be cold: an excess of alkali also destroys it by forming two salts, an iodate and an iodide, but by supersaturating with acid the colour is restored.

The blue compound of iodine and starch is usually designated the iodide of starch, but Raspail, (*Nouveau Système Chimie Organique*) objects to the term, as grains of starch consist of two parts—an external envelope, within which is a soluble gummy substance. Now the iodine, says Raspail, attaches itself to the envelope only, giving it a blue colour, just as it gives a yellow colour to other organic textures.

Iodine forms a blue compound with narceine (see *Opium*). The mineral acids (sulphuric, nitric, and hydrochloric) have the same effect on narceine.

When iodine is in combination with oxygen, starch will not recognize it. For example, if a little starch be added to a solution of iodic acid, no change of colour is observed; but if some deoxidating substance be now employed (such as sulphurous acid or morphia) the blue colour is immediately produced. The iodates give out oxygen when heated, and are converted into iodides. They deflagrate when thrown on red hot coals. The soluble iodates produce with a solution of the nitrate of silver, a white precipitate of iodate of silver soluble in ammonia If the iodine be combined with a base (as with potassium, or sodium), chlorine or sulphuric or nitric acid must be employed to remove the latter; and the iodine being then set free, will react on the starch. This is the mode of proceeding to detect iodine in the urine of a patient; for the mere addition of starch will not suffice. Nitric or sulphuric acid or chlorine must be employed to remove the base with which the iodine is combined.

The soluble iodides produce, with a solution of nitrate of silver, a yellowish precipitate (iodide of silver) very slightly soluble only in ammonia. They precipitate the salts of lead yellow, and bichloride of mercury scarlet.

PURITY.—We are told that iodine is much adulterated, but I doubt it. There are two properties which will, in most instances, determine its purity—namely, its solubility in alcohol, and, when heated, its conversion into violet vapour, leaving no residuum. Coal, plumbago, peroxide of manganese, sand, and charcoal (all of which, it is said, have been found in iodine), would be in this way readily distinguished. But Dr. O'Shaughnessy (*Translation of Lugol's Essays*, p. 210) states that he met with one specimen so artfully adulterated, that the foreign ingredients were at the same time soluble in alcohol and volatilizible by heat. A little imposition may be, and indeed is, practised by some dealers in iodine, by selling it in a moist state. An ounce, if very moist, may contain one drachm, or perhaps even a drachm and a half, of water. The easiest way of detecting this is by compression between folds of blotting paper.

PHYSIOLOGICAL EFFECTS.—(*a*.) *On vegetables.* Cantu states that seeds placed in pure sand and moistened with a solution of iodine, germinate more readily than seeds sown in the usual way. Vogel, however, asserts that iodine, so far from promoting, actually checks or stops germination. (*Decandolle*, *Physiolog. Végét.* tom. 3^{me}. p. 1337).

(*b*). *On animals generally.*—Hitherto no examination has been made of the effects of iodine on the different classes of animals, for, with the exception of man, the only animals on which experiments have hitherto been made with it, are horses, dogs, and rabbits. On these it operates as an irritant and caustic poison, though not of a very energetic kind.

Magendie threw a drachm of the tincture of iodine into the veins of a dog without causing any obvious effects (*Formulaire*). Dr. Cogswell has repeated this experiment: the animal was slightly affected only (*Experimental Essay on Iodine*, p. 31, 1837). The last-mentioned writer found that two drachms of the tincture caused death. But something must be ascribed to the alcohol employed. Orfila (*Toxicologie générale*) applied 72 grains of solid iodine to a wound on the back of a dog: local inflammation, but no other inconvenience, resulted. One or two drachms administered by the stomach caused vomiting, and when this was prevented by tying the œsophagus, ulceration of the alimentary canal and death took place. Mr. Dick (*Cogswell's Essay*, p. 24) gave iodine, in very large doses, to a horse for three weeks, but the only symptom which could be referred to its influence was an unusual disregard for water. The average daily allowance was two drachms, administered in quantities ascending from a drachm up to two ounces. Dr. Cogswell (*op. cit.* p. 60) gave 73 grains of iodine to a dog in nine days. Five days after the cessation of the iodine the dog was killed: the urine contained a highly appreciable quantity of iodine—and a trace, and but a trace, of iodine was found in the blood, brain, and stomach.

(*c.*) *On man.*—The *local* action of iodine is that of an irritant. Applied to the skin it stains the cuticle orange-yellow, causes itching, redness, and desquamation. If the vapour of it, mixed with air, be inhaled, it excites cough and heat in the air-passages, and promotes bronchial secretion. Swallowed in large doses it irritates the stomach, as will be presently mentioned.

The effects produced by the internal administration of iodine may be considered under the two heads of those arising from the use of small,—and those produced by large doses.

a. In small, medicinal doses, we sometimes obtain the palliation, or even the removal of disease, without any perceptible alteration in the functions of the body. Thus, in a case of chronic mammary tumor which fell under my observation, iodine was taken daily for twelve months, without giving rise to any perceptible functional change, except that the patient was unusually thin during this period. Sometimes it increases the appetite, an effect noticed both by Coindet (*Biblioth. Univers.* tom. 14, Sciences et Arts), and by Lugol (*Essays*, translated by Dr. O'Shaughnessy), from which circumstance it has been denominated a *tonic*. But the long-continued use of it, in large doses, has, occasionally, brought on a slow or chronic kind of gastro-enteritis; an effect which I believe to be rare, and only met with when the remedy has been incautiously administered.

In irritable subjects, and those disposed to dyspepsia, it occasions nausea, sickness, heat of stomach, and loss of appetite, especially after its use has been continued for some days: the bowels are oftentimes slightly relaxed, or at least they are not usually constipated. More than one-third of the patients treated by Lugol experienced a purgative effect; and when the dejections were numerous, colics were pretty frequent (*op. cit.* p. 20). Gendrin (*Dict. de Mat. Méd.* t. 3^{me}, p. 628), and Manson (*Medical Researches on Iodine*), however, observed a constipating effect from the use of iodine.

The action of iodine on the *organs of secretion* is, for the most part, that of a stimulant; that is, the quantity of fluid secreted is usually increased, though this effect is not constantly observed. Jörg (*Material zu* *einer Arzneimittell*, Leipsic, 1824) and his friends, found, in their experiments on themselves, that small doses of iodine increased the secretion of nasal mucus, of saliva, and of urine, and they inferred that the similar effect was produced on the gastric, pancreatic, and biliary secretions. " Iodine," says Lugol, (*Essays*, p. 19) " is a powerful *diuretic*. All the patients using it have informed me that they pass urine copiously." Coindet, however, expressly says that it does not increase the quantity of urine. In some cases in which I carefully watched its effects, I did not find any diuretic effect. Iodine frequently acts as an *emmenagogue*. Coindet, Sablairoles (*Jour. général de Méd.* tom. 97), Brera (quoted by Bayle in his *Bibliothèque de Thérapeutique*, tom. 1, p. 129), Magendie (*Formulaire*), and many others, agree on this point; but Dr. Manson (*Medical Researches on the Effects of Iodine*, London, 1825) does not believe that it possesses any emmenagogue powers, further than as a stimulant and tonic to the whole body. In one patient it occasioned so much sickness and disorder of stomach that the menstrual discharge was suppressed altogether. On several occasions iodine has caused *salivation* and soreness of mouth. In the cases noticed by Lugol the patients were males. In the *Medical Gazette*, vol. xvii. for 1836, two instances are mentioned, one by Mr. Winslow (p. 401), the other by Dr. Ely (p. 480). Other cases are referred to in Dr. Cogswell's work. This effect, however, I believe to be rare. De Carro (quoted by Bayle, *op. cit.* p. 50) denies that iodine causes salivation, but says it augments *expectoration*. Lastly, *diaphoresis* is sometimes promoted by iodine.

Two most remarkable effects which have been produced by iodine are, *absorption of the mammæ* and *wasting of the testicles*. Of the first of these (absorption of the mammæ) three cases are reported in *Hufeland's Journal* (quoted by Bayle, *op. cit.* p. 162), one of which may be here mentioned. A healthy girl, twenty years of age, took the tincture of iodine during a period of six months, for a bronchocele, of which she became cured; but the breasts were observed to diminish in size, and notwithstanding she ceased to take the remedy, the wasting continued, so that at the end of two years not a vestige of the mammæ remained. Sometimes the breasts waste, though the bronchocele is undiminished: Reichenau (*Christison*, p. 180) relates the case of a female, aged twenty-six, whose breasts began to sink after she had employed iodine for four months, and within four weeks they almost wholly disappeared; yet her goître remained unaffected. With regard to the other effect (wasting of the testicle) I suspect it to be very rare. I have seen iodine administered in some hundreds of cases, and never met with one in which atrophy either of the breast or testicle occurred. Magendie also says he never saw these effects, though they are said to be frequent in Switzerland.

A disordered condition of the cerebro-spinal system has in several instances been caused by iodine. Thus slight headache and giddiness are not unfrequently brought on. Lugol tells us that, by the use of ioduretted baths, headache, drowsiness, intoxication, and even stupor, are produced. Analogous symptoms were observed in some of Dr. Manson's cases; and in one there were convulsive movements.

A specific effect on the skin is sometimes produced by iodine, besides the diaphoresis before alluded to. Thus Dr. C. Vogel (*Rust, Magazin*, Bd. 14, p. 156) gives an account of a lady, twenty-eight years of age, of a yellow complexion, who from the internal employment of the tincture of iodine, became suddenly brown, besides suffering with other morbid symptoms. After some days the skin had the appearance of having been smoked! Mr. Stedman (*Medical Gaz.* vol. xv. p. 447) says that in some scrofulous patients it improves the condition of the hair and scalp.

The rapid emaciation said to have been occasionally produced by iodine, as well as the beneficial influence of this substance in scrofulous diseases, and the disappearance of visceral and glandular enlargements under its use, have given rise to an opinion that iodine *stimulates the lymphatic vessels and glands.* Manson, however, thinks that it exerts no peculiar or specific influence over the absorbent system, which only participates in the general effects produced on the whole body. And Lugol asserts, that instead of producing emaciation, it encourages growth and increase of size.

There can be no doubt that the continued use of iodine must have some effect over the general nutrition of the body, and by modifying the actions previously performed by the various organs and systems, it may at one time cause the *embonpoint* described by Lugol, and at another may have the reverse effect: in one case it may promote the activity of the absorbents, and occasion the removal of tumours of considerable size, in another check ulceration (a process which Mr. Key, in the 19th vol. of the *Medico-Chirurgical Transactions*, denies to be one of absorption, but considers to be one of degeneration or disorganization) and cause the healing of ulcers.

Some have ascribed to iodine an *aphrodisiac* operation. Kolley (*Journ. Complém.* tom. 17, p. 307), a physician at Breslau, who took it for a bronchocele, says it had the reverse effect on him.

In some instances, the continued use of iodine has given rise to a disordered state of system, which has been designated *iodism.* The symptoms (termed by Dr. Coindet, *iodic*) are violent vomiting and purging, with fever, great thirst, palpitation, rapid and extreme emaciation, cramps, and small and frequent pulse, occasionally with dry cough, and terminating in death. This condition, however, must be a very rare occurrence, for it is now hardly ever met with, notwithstanding the frequency and the freedom with which iodine is employed. But it has been noticed by Coindet (*op. cit.*), Gairdner (*Essay on the Use of Iodine*), Zink (*Journ. Complém.* xviii. p. 126), Jahn (quoted by Christison, p. 181), and others. The daily experience of almost every practitioner proves that the dangers resulting from the use of iodine have been, to say the least of them, much exaggerated, and we can hardly help suspecting that many symptoms which have been ascribed to the injurious operation of this remedy ought to have been referred to other causes; occasionally, perhaps, they depended on gastro-enteritis. In some cases, the remarkable activity of iodine may have arisen from some idiosyncracy on the part of the patient. Dr. Coindet attributes the iodic symptoms to the *saturation* of the system with iodine—an explanation, to a certain extent, borne out by the results of an experiment made by Dr. Cogswell, and which I have before mentioned: I allude now to the detection of iodine in the tissues of an animal five days after he had ceased taking this substance.

β. In very large doses iodine has acted as an irritant poison. In a fatal instance recorded by Zink (*Journ. Compl.* tom. xviii.) the symptoms were restlessness, burning heat, palpitations, very frequent pulse, violent priapism, copious diarrhœa, excessive thirst, trembling, emaciation, and occasional syncope. The patient died after six weeks' illness. On another occasion this physician had the opportunity of examining the body after death. In some parts the bowels were highly inflamed, in others they exhibited an approach to sphacelation. The liver was very large, and of a pale rose colour.

Such cases, however, are very rare. In many which might be referred to, enormous quantities of iodine have been taken with very slight effects only, or perhaps with no marks of gastric irritation. Thus Dr. Kennedy, of Glasgow (quoted in Dr. Cogswell's *Essay*), exhibited within eighty days, 953 grains of iodine in the form of tincture: the daily dose was at first two grains, but ultimately amounted to 18 grains. The health of the girl appeared to be unaffected by it. It should here be mentioned that the presence of bread, potatoes, sago, arrow-root, tapioca, or other amylaceous matters, in the stomach, will much diminish the local action of iodine, by forming an iodide of starch, which, as will hereafter be mentioned, is a very mild preparation.

MODUS OPERANDI. — That iodine becomes absorbed, when employed either externally or internally, we have indisputable evidence, by its detection not only in the blood but in the secretions. Cantu (*Journ. de Chimie Méd.* tom. ii. p. 291) has discovered it in the urine, sweat, saliva, milk, and blood. In all cases it is found in the state of iodide, or hydriodate; from which circumstance he concludes that its influence on the body is chemical, and consists in the abstraction of hydrogen. Bennerscheidt (*Journ. de Chim. Méd.* tom. iv. p. 383) examined the serum of the blood of a patient who had employed for some time iodine ointment; but he could not detect any trace of iodine. In the crassamentum, however, he obtained evidence of its existence, by the blue tint communicated to starch.

USES.—(*a.*) In *bronchocele.* Of all remedies yet proposed for bronchocele, this has been by far the most successful. Indeed, judging only from the numerous cases cured by it, and which have been published, we should almost infer it was a sovereign remedy. However, it is to be recollected that of those who have written on the use of iodine in this complaint, some only have published a numerical list of their successful and unsuccessful cases. Bayle (*Bibliothèque de Thérapeutique,* tom. 1er, p. 394) has given a summary of those published by Coster, Irmenger, Baup, and Manson, from which it appears that of 364 cases treated by iodine, 274 were cured. Dr. Copland (*Dict. of Pract. Med.*) observes that of several cases of the disease which have come before him since the introduction of this remedy into practice, " there has not been one which has not either been cured or remarkably relieved by it." I much regret, however, that my own experience does not accord with this statement. I have several times seen iodine, given in conjunction with iodide of potassium, fail in curing bronchocele; and I know others whose experience has been similar. Dr. Bardsley (*Hospital Facts and Observations,* p. 121) cured only nine, and relieved six, out of thirty cases, with iodide of potassium. To what circumstance, then, ought we to attribute this variable result? Dr. Copland thinks that where it fails it has been given " in too large and irritating doses, or in an improper form; and without due attention having been paid to certain morbid and constitutional relations of the disease during the treatment."

But, in two or three of the instances before mentioned, I believe the failure did not arise from any of the circumstances alluded to by Dr. Copland, and I am disposed to refer it to some peculiar condition of the tumor, or of the constitution. When we consider that the terms *bronchocele*, *goître*, and *Derbyshire neck*, are applied to very different conditions of the thyroid gland, and that the causes which produce them are involved in great obscurity, and may, therefore, be, and indeed probably are, as diversified as the conditions they give rise to, we can easily imagine that while iodine is serviceable in some, it may be useless or even injurious in others. Sometimes the bronchocele consists in hypertrophy of the substance of the thyroid gland,—that is, this organ is enlarged, but has a healthy structure. In others, the tumefaction of the gland took place suddenly, and may even disappear as suddenly, from which it has been inferred that the enlargement depends on an accumulation of blood in the vessels, and an effusion of serum into its tissue. Coindet mentions a goître which was developed excessively during the first pregnancy of a young female: twelve hours after her accouchement it had entirely disappeared. The same author also relates the circumstance of a regiment composed of young recruits, who were almost every man attacked with considerable enlargement of the thyroid gland, shortly after their arrival at Geneva, where they all drank water out of the same pump. On their quarters being changed the gland soon regained its natural size in every instance. A third class of bronchoceles consists in an enlargement of the thyroid gland from the developement of certain fluid or solid substances in its interior, and which may be contained in cells, or be infiltrated through its substance. These accidental productions may be serous, honey-like, gelatinous, fibrous, cartilaginous, or osseous. Lastly, at times the enlarged gland has acquired a scirrhous condition. Now it is impossible that all these different conditions can be cured with equal facility by iodine; those having solid deposits are, of course, most difficult to get rid of.

Kolley, the physician before alluded to, who was himself cured of a large goître of ten years' standing, says, that for iodine to be useful, the bronchocele should not be of too long standing, nor painful to the touch; the swelling confined to the thyroid gland, and not of a schirrous or carcinomatous nature, nor containing any stony or other analogous concretions; and that the general health be not disordered by any febrile or inflammatory symptoms, or any gastric, hepatic, or intestinal irritation. If the swelling be tender to the touch, and have other marks of inflammation, let the usual local antiphlogistic measures precede the employment of iodine. When this agent is employed we may administer it both externally and internally. The most effectual method of employing iodine externally is that called *endermic*, already described; namely, to apply an ioduretted ointment (usually containing iodide of potassium) to the cutis vera, the epidermis being previously removed by a blister. But the *epidermic*, or *iatroleptic* method, is more usually followed—that is, the ioduretted ointment is rubbed into the affected part, without the epidermis being previously removed. On the agency of galvanism in promoting the passage of iodine into the system, I have already made some observations (see pp. 55-6).

With respect to the internal use of this substance, some think that the success depends on the use of small doses largely diluted,—while others consider that as large a quantity of the remedy should be administered as the stomach and general system can bear.

(*b.*) *Scrofula* is another disease for which iodine has been extensively used. Dr. Coindet was, I believe, the first to direct public attention to this remedy in the disease in question. Subsequently, Baup, Gimelle, Kolley, Sablairoles, Benaben, Callaway, and others, published cases illustrative of its beneficial effects.—(See Bayle's *Bibliothèque de Thérap.* tom. i.) Dr. Manson (*op. cit.*) deserves the credit of having first tried it on an extensive scale. He treated upwards of eighty cases of scrofula and scrofulous ophthalmia by the internal exhibition of iodine, sometimes combined with its external employment; and in a large proportion of cases, where the use of the medicine was persevered in, the disease was either cured or ameliorated, the general health being also improved. Three memoirs on the effects of iodine in scrofula have been subsequently published by Lugol, physician to the Hospital St. Louis, serving to confirm the opinions already entertained of its efficacy. From the first memoir it appears, that in seventeen months—namely, from August, 1827, to December, 1828—109 scrofulous patients were treated by iodine only; and that of these 36 were completely cured, and 30 relieved; in 4 cases the treatment was ineffectual, and 39 cases were under treatment at the time of the report made by Serres, Magendie, and Dumeril, to the Academie Royale des Sciences. In his illustrative cases we find glandular swellings, scrofulous ophthalmia, abscesses, ulcers, and diseases of the bones, were beneficially treated by it. Lugol employs iodine internally and externally: for internal administration, he prefers iodine dissolved in water by means of iodide of potassium, given either in the form of *drops*, or largely diluted, under the form of what he calls *ioduretted mineral water*, presently to be described. His external treatment is of two kinds; one for the purpose of obtaining local effects only, the other for procuring constitutional or general effects. His local external treatment consists in employing ointments or solutions of iodine: the *ointments* are made either with iodine and iodide of potassium, or with the protiodide of mercury; the *solutions* are of iodine and iodide of potassium in water; and according to their strength are denominated caustic, rubefacient, or stimulant: the rubefacient solution is employed in making cataplasms and local baths. His external general treatment consists in the employment of *ioduretted baths*. Of these different preparations more will be said hereafter.

The successful results obtained by Lugol in the treatment of this disease cannot, I think, in many instances, be referred to iodine solely. Many of the patients were kept several months (some as much as a year) under treatment in the hospital, where every attention was paid to the improvement of their general health by warm clothing, good diet, the use of vapour and sulphureous baths, &c.; means which of themselves are sufficient to ameliorate, if not cure, many of the scrofulous conditions before alluded to. Whether it be to the absence of these supplementary means of diet and regimen, or to some other cause, I know not, but most practitioners will, I think, admit that they cannot obtain by the use of iodine the same successful results which Lugol is said to have met with, though in a large number of cases this agent has been found a most useful remedy.

(*c.*) Iodine has been eminently successful when employed *in chronic* *diseases of various organs, especially those accompanied with induration and enlargement.* By some inexplicable influence, it sometimes not only puts a stop to the further progress of disease, but apparently restores the part to its normal state; hence it is placed by some pharmacologists (as Vogt and Sundelin) among the *resolventia.* It is usually given with the view of exciting the action of the absorbents, but its influence is not limited to this set of vessels: it exercises a controlling and modifying influence over the blood-vessels of the affected part, and is in the true sense of the word an *alterative.*

In chronic inflammation, induration, and enlargement of the liver, after antiphlogistic measures have been adopted, the two most important and probable means of relief are iodine and mercury, which may be used either separately or conjointly. If the disease admit of a cure these are the agents most likely to effect it. Iodine, indeed, has been supposed to possess some specific power of influencing the liver, not only from its efficacy in alleviating or curing certain diseases of this organ, but also from the effects of an over dose. In one case pain and induration of the liver were brought on;—and in another, which terminated fatally, this organ was found to be enlarged, and of a pale rose colour.—(Christison, *Treatise on Poisons*, pp. 180-1.)

Several cases of enlarged spleens relieved or cured by iodine have been published.

In chronic diseases of the uterus, accompanied with induration and enlargement, iodine has been most successfully employed. In 1828 a remarkable instance was published by Dr. Thetford (*Trans. of the King and Queen's College of Phys.* Ireland, vol. v). The uterus was of osseous hardness, and of so considerable a size as nearly to fill the whole of the pelvis: yet in six weeks the disease had given way to the use of iodine, and the catamenia were restored. In the *Guy's Hospital Reports*, No. I. 1836, is an account by Dr. Ashwell of seven cases of "hard tumours" of the uterus successfully treated by the use of iodine, in conjunction with occasional depletion and regulated and mild diet. Besides the internal use of iodine, this substance was employed in the form of ointment (composed of iodine gr. xv. iodide potassium ℈ij. spermaceti oint. ℥iss). of which a portion (about the size of a nutmeg) was introduced into the vagina and rubbed into the affected cervix for ten or twelve minutes every night. It may be applied by the finger, or by a camel-hair pencil, or sponge mounted on a slender piece of cane. The average time in which resolution of the induration is accomplished varies, according to Dr. Ashwell, from eight to sixteen weeks. "In hard tumors of the walls or cavity of the uterus, resolution, or disappearance, is scarcely to be expected;" but "hard tumors of the cervix, and indurated puckerings of the edges of the os (conditions which most frequently terminate in ulceration) may be melted down and cured by the iodine."—(pp. 152-3.)

In ovarian tumors iodine has been found serviceable. In the chronic mammary tumor, described by Sir A. Cooper, I have seen it give great relief—alleviating pain and keeping the disease in check. In indurated enlargements of the parotid, prostate, and lymphatic glands, several successful cases of its use have been published.

(*d.*) As an *emmenagogue* iodine has been recommended by Coindet, Brera, Sablairoles, Magendie, and others. The last-mentioned writer tells us that on one occasion he gave it to a young lady, whose propriety of conduct he had no reason to doubt, and that she miscarried after using it for three weeks. I have known it given for a bronchocele during pregnancy without having the least obvious influence over the uterus.

(*e.*) In *gonorrhœa* and *leucorrhœa* it has been employed with success after the inflammatory symptoms have subsided.

(*f.*) *Inhalation* of *iodine vapour* has been used in phthisis and chronic bronchitis. In the first of these diseases it has been recommended by Berton, Sir James Murray, and Sir Charles Scudamore. I have repeatedly tried it in this as well as in other chronic pulmonary complaints, but never with the least benefit. The apparatus for inhaling it has been already described (see p. 51.) The liquid employed is a solution of ioduretted iodide of potassium, to which Sir C. Scudamore adds the tincture of conium.—(*Med. Gaz.* vol. viii. p. 157.)

(*g.*) *Chronic diseases of the nervous system,* such as paralysis and chorea, have been successfully treated by iodine, by Dr. Manson.

(*h.*) In some forms of *the venereal disease,* iodine has been found a most serviceable remedy. Thus Rochond (quoted by Bayle, *op. cit.*) employed it, after the usual antiphlogistic measures, to remove buboes. De Salle cured chronic venereal affections of the testicles with it. Mr. Mayo (*Med. Gaz.* vol xi. p. 249), has pointed out its efficacy in certain disorders which are the consequences of syphilis, such as emaciation of the frame, with ulcers of the skin; ulcerated throat; and inflammation of the bones or periosteum,—occurring in patients to whom mercury has been given.

(*i.*) *In checking or controlling the ulcerative process,* iodine is, according to Mr. Key (*Medico-Chirurg. Trans.* vol. 19), one of the most powerful remedies we possess. "The most active phagedenic ulcers, that threaten the destruction of parts, are often found to yield in a surprising manner to the influence of this medicine, and to put on a healthy granulating appearance."

(*k.*) Besides the diseases already mentioned there are many others in which iodine has been used with considerable advantage: for example—*chronic skin diseases,* as lepra, psoriasis, &c. (Cogswell, *Essay,* p. 81); —*dropsies* (*ibid*); *in old non-united fractures,* to promote the deposition of ossific matter (*Med. Gaz.* vol. vi. p. 512, 1830); *in chronic rheumatism;* but in this disease iodide of potassium is more frequently employed. *As an antidote in poisoning* by *strychnia, brucia,* and *veratria,* iodine has been recommended by M. Donne (*Journ. de Chim. Méd.* tom. v. p. 494), because the compound formed by the union of these alkalies with iodine is less active than the alkalies themselves; *as an injection for the cure of hydrocele,* Velpeau (*Med. Gaz.* vol. xx. p. 90), has employed a mixture of the tincture of iodine with water, in the proportion of from one to two drachms of the tincture to an ounce of water: of this mixture from one to four ounces are to be injected and immediately withdrawn; lastly, to *check mercurial salivation* iodine has been successfully used.—(*Med. Gaz.* vol. xiii. p. 32, and vol. xx. p. 144.)

ADMINISTRATION.—Iodine is rarely used alone, but generally in combination with the iodide of potassium: formulæ for the conjoint exhibition of these I shall give when describing the iodide: at present I shall confine myself to those preparations into which iodine alone enters.

Before noticing these, however, it may not be amiss to mention that with the view of preventing gastric irritation, we should avoid giving iodine on an empty stomach. If administered immediately after a meal the topical action of this substance is considerably diminished. This is especially the case if potatoes, bread-pudding, sago, tapioca, or other amylaceous substances, have been taken, since an iodide of starch (which possesses very slight local influence) is immediately formed in the stomach.

(*a.*) *In substance*, iodine has been given in the form of pills, in doses of half a grain, gradually increased. But this mode of exhibition is now rarely resorted to.

(*b.*) *Tincture of iodine.*—This is a simple solution of iodine in rectified spirit, and may be made of various strengths. In the Dublin Pharmacopœia the proportions are two scruples of iodine to one ounce (by weight) of spirit. It is, however, an objectionable preparation: for, in the first place, by keeping, part of the iodine is deposited in a crystalline form, so that the strength is apt to vary; secondly, it undergoes decomposition, especially when exposed to solar light; the iodine abstracts hydrogen from the spirit, and forms hydriodic acid, which, acting on some spirit, forms a little hydriodic ether. These are not the only objections: when added to water, the iodine is deposited in a solid state, and may thus irritate the stomach. It is used both externally and internally: externally it may be mixed with the soap liniment, and internally it is exhibited in doses of from five or six drops to half a drachm. Each drachm contains five grains of iodine. The best mode of exhibiting it, to cover its flavour, is in sherry wine. Where this is inadmissible, sugared water may be employed.

(*c.*) *Combined with starch*, iodine has been given in enormous quantities by Dr. Buchanan (*Med Gaz.* vol. xviii. p. 515.) His formula for making the iodide of starch is the following:—"Rub 24 grs. of iodine with a little water, and gradually add one ounce of finely-powdered starch: dry by a gentle heat, and preserve the powder in a well-stoppered vessel." In persons not labouring under any dyspeptic ailment or constitutional delicacy of habit, Dr. Buchanan commences with half an ounce for a dose, and increases this to an ounce three times a day,—equivalent to 72 grains daily. It frequently caused costiveness, attended with griping pains of the bowels and pale-coloured evacuation. In some cases, but rarely, it produced purging. Though starch diminishes or nearly destroys the irritant properties of iodine the prudent practitioner will commence with small doses, (ʒss.), of the iodide, and carefully watch the effect of gradually and cautiously increased doses. I have found the colour of this preparation objected to by patients.

(*d.*) *Combined with hydrogen*, forming *hydriodic acid*, Dr. Buchanan (*op. cit.*) has given iodine in very large quantities. His formula for making this acid is the following:—"Dissolve 264 grs. of tartaric acid in 1½ ounces of distilled water, and to this add a solution of 330 grs. of iodide of potassium also dissolved in 1½ ounces of distilled water. When the bitartrate of potash has subsided, strain, and, to the strained liquor, add sufficient water to make fifty drachms (℥vj. ʒij.) of solution." Of this solution Dr. Buchanan has given as much as an ounce three times a day, or two drachms of iodine daily: and he regards half an ounce as the ordinary dose. But I would advise it to be given at first in very much smaller quantity (ʒss.), and to be gradually increased.

(*e.*) *Ointment of iodine.*—This is composed, according to the Dublin Pharmacopœia, of a scruple of iodine to an ounce of lard. If this be too irritating, the quantity of lard must be increased. The colour of this compound is brown, but, by keeping, it becomes paler; and hence should always be made when wanted. It is employed as a local application to scrofulous tumors, bronchocele, &c.

ANTIDOTES.—In the event of poisoning by iodine, or its tincture, the first object is to evacuate the poison from the stomach. For this purpose, assist the vomitings by the copious use of tepid demulcent liquids—especially by those containing amylaceous matter; as starch, wheaten flour, sago, or arrow-root, which should be boiled in water, and exhibited freely. The efficacy of these agents depends on the iodide of starch, which they form, possessing very little local action. In their absence, other demulcents, such as milk, eggs beat up with water, or even tepid water merely, may be given to promote vomiting. Magnesia is also recommended. Opiates have been found useful. Of course the gastro-enteritis must be combated by the usual means.

ORDER IV. BROMINE.

Bromin'ium.—Bro'mine.

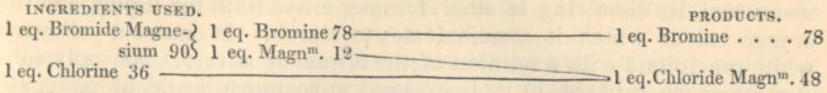
HISTORY AND ETYMOLOGY.—This substance was discovered by M. Balard, of Montpelier, in 1826. He at first termed it *muride* (from *muria, brine*), in allusion to the substance from whence he procured it; but, at the suggestion of Gay-Lussac, he altered this name to that of *brome*, or *bromine*, (from βρῶμος, *a stench* or *fetor*,) on account of its unpleasant odour.

NATURAL HISTORY.—It is found in both kingdoms of nature, but never in the free state.

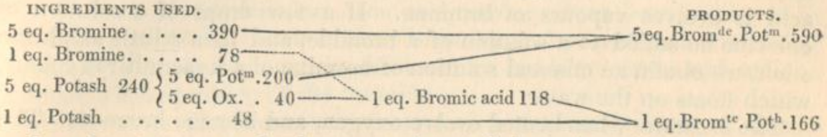
(*a.*) *In the inorganized kingdom.*—Hollander detected it in an ore of zinc, and Cochler recognised it in Silesian cadmium (Gmelin, *Handbuch der Chemie.*) It exists in sea water and many mineral waters, in combination with either magnesium or sodium, or sometimes with both. Thus it has been found in the waters of the Mediterranean, the Baltic, the North Sea, the Frith of Forth, the Dead Sea, many of the brine springs of Europe and America (as those of Middlewich, Nantwich, Ashby-de-la-Zouch, and Shirleywich, in England), and in many other mineral springs of Europe and America (as the Pittville spring at Cheltenham, the water of Llandridod and of Bonnington.) It has been justly observed by Dr. Daubeny (*Phil. Trans.* 1830), that the detection of bromine in brine-springs is a fact interesting in a geological point of view, as tending to identify the product of the ancient seas, in their most minute particulars, with those of the present ocean.

(*b.*) *In the organized kingdom.*—Bromine has been found in the sea-plants of the Mediterranean, and in the mother-waters of Kelp. It has likewise been detected in marine animals, and in the sea-sponge (*Spongia officinalis*), in the stony concretion found in this animal, and in the ashes of the *Janthina violacea*, one of the gasteropodous mollusca.

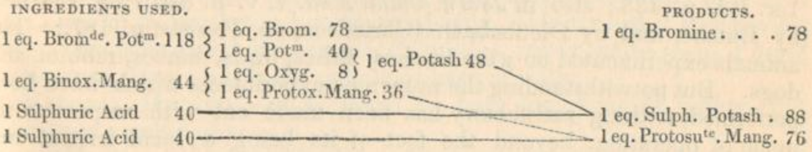
PREPARATION.—Bromine is usually procured from *bittern* (the mother liquor of sea-water, from which the chloride of sodium has been separated by crystallization). A current of chlorine gas is passed through this liquid in order to decompose the bromide of magnesium, and thereby to form chloride of magnesium and set free the bromine, as shown by this diagram:—



The liquid through which the bromine is diffused is then to be strongly agitated with ether, by which an etherial solution of this substance is obtained, which floats on the water. To the decanted etherial solution add caustic potash: six equivalents, or 468 parts of bromine, react on six equivalents or 288 parts of potash, and produce five equivalents or 600 parts of bromide of potassium, and one equivalent or 168 parts of bromate of potash, as shown by the following diagram:—



In order to convert the bromate of potash into bromide of potassium the mass is exposed to a dull red heat, by which six equivalents or 48 parts of oxygen are evolved. The bromide of potassium is then distilled with sulphuric acid and binoxide of manganese, and the disengaged bromine condensed in water. One equivalent or 118 parts of the bromide react on one equivalent or 44 parts of the binoxide of manganese, and on two equivalents or 80 parts of sulphuric acid; and by this reaction one equivalent or 78 parts of bromine, one equivalent or 88 parts of sulphate of potash, and one equivalent or 76 parts of the sulphate of the protoxide of manganese, are produced.



Properties.—At ordinary temperatures bromine is a dark-coloured very volatile liquid, which, seen by reflected light, appears blackish red; but viewed in thin layers, by transmitted light, is hyacinth red. Its odour is strong and unpleasant, its taste acrid. Its sp. gr. is about 3; water being 1. When exposed to a cold of —4° F. it is a yellowish brown, brittle crystalline solid. At ordinary temperatures liquid bromine evolves ruddy vapours, so that a few drops put into a small vessel immediately fills it with the vapour of bromine. At 116½ F. bromine boils. The vapour is not combustible: a lighted taper plunged into it is immediately extinguished, but before the flame goes out it becomes red at the upper and green at the lower part. Antimony or arsenicum take fire when dropped into liquid bromine: when potassium or phosphorus is dropped in, a violent explosion takes place. Bromine is a nonconductor of electricity: it is a bleaching agent: it dissolves very slightly only in water, more so in alcohol, and much more so in sulphuric ether. It communicates a fine orange colour to starch.

Characteristics.—Liquid bromine is recognised by its colour, odour, volatility, and the colour of its vapour. To these characters must be added its powerful action on antimony, arsenicum, and potassium, before mentioned, its dissolving in ether, forming a hyacinth red liquid, and the orange colour which it communicates to starch. It causes a yellowish white precipitate with a solution of the nitrate of silver. The only substances which resemble in their external appearance liquid bromine, are the terchloride of chromium and the chloride of iodine.

The soluble *bromides* cause white precipitates with the nitrate of silver, acetate of lead, and protonitrate of mercury. The precipitates are bromides of the repective metals. Bromide of silver is yellowish white, clotty, insoluble in boiling nitric acid, and in a weak solution of ammonia (by which it is distinguished from chloride of silver), but dissolves in a concentrated solution of this alkali. Heated with sulphuric acid it evolves vapours of bromine. If a few drops of a solution of chlorine be added to a solution of a bromide, and then a little sulphuric ether, we obtain an ethereal solution of bromine of a hyacinth red colour, which floats on the water.

The *bromates* when heated evolve oxygen, and become bromides. The bromates cause white precipitates with the nitrate of silver, the protosalts of mercury, and with strong solutions of the acetate of lead. Bromate of silver is not soluble in nitric acid, but dissolves readily in solution of ammonia. If a few drops of hydrochloric acid be added to a bromate, and then some ether, a yellow or red ethereal solution of brome is obtained.

Physiological effects.—(*a.*) *On vegetables.*—I am unacquainted with any experiments made with bromine on plants.

(*b.*) *On animals generally.*—The action of bromine on animals has been examined by Franz, (quoted by Wibmer, *Die Wirkung d. Arzneim.* 1er. Bd. p. 433; also in *Journ. Chim. Méd.* t. v. p. 540;) by Barthez, by Butske, and by Dieffenbach (Christison, *on Poisons.* p. 187.) The animals experimented on were leeches, fishes, birds, horses, rabbits, and dogs. But notwithstanding the numerous experiments which have been performed, nothing satisfactory has been made out with respect to its mode of operation, beyond the fact of its being a local irritant and caustic, and, therefore, when swallowed, giving rise to gastro-enteritis. Injected into the jugular vein it coagulates the blood, and causes immediate death, preceded by tetanic convulsions. No positive inferences can be drawn as to the specific influence of bromine on any organs of the body. Some of the symptoms (such as dilated pupil, insensibility, and convulsions) would seem to indicate a specific affection on the brain. Franz frequently observed inflammation of the liver.

(*c.*) *On man.*—Bromine stains the cuticle yellowish brown, and by continued application acts as an irritant. Its vapour is very irritating when inhaled, or applied to the mucous lining of the nose or to the conjunctiva. Franz, by breathing the vapour, had violent cough, and a feeling of suffocation followed by headache. Butske swallowed a drop and a half of bromine in half an ounce of water, and experienced heat in the mouth, œsophagus, and stomach, followed by colicky pains.

Two drops occasioned nausea, hiccup, and increased secretion of mucus.

The constitutional effects resulting from the continued use of bromine have not been determined. They are probably analogous to those of iodine.

Hitherto no cases of poisoning with it in the human subject have been seen.

USES.—It seems to possess the same therapeutic influence as iodine, and has been administered in bronchocele, in scrofula, in tumors, in amenorrhœa, and against hypertrophy of the ventricles. It is usually regarded as possessing more activity than iodine.

ADMINISTRATION.—It may be administered dissolved in water. An aqueous solution, composed of one part by weight of bromine and forty parts of water, may be given in doses of five or six drops properly diluted and flavoured with syrup. This solution has also been used as an external agent in lotions.

The bromides of potassium, iron, and mercury, have been employed in medicine, and will be described hereafter. An ointment containing bromide of potassium and liquid bromine has been used, and will be noticed when speaking of the bromide.

ANTIDOTES.—The treatment of cases of poisoning by bromine should be the same as for poisoning by iodine. Barthez has recommended magnesia as an antidote.

ORDER 5.—HYDROGEN, AND ITS COMPOUNDS WITH OXYGEN AND CHLORINE.

Hydroge'nium.—Hy'drogen.

HISTORY AND SYNONYMES.—Cavendish may be considered as the real discoverer of hydrogen, though it must have been occasionally procured, and some of its properties known, previously. He termed it *inflammable air*. Lavoisier called it hydrogen (from ὕδωρ, *water*, and γεννάω, I *beget* or *produce*), because it is the radicle or base of water.

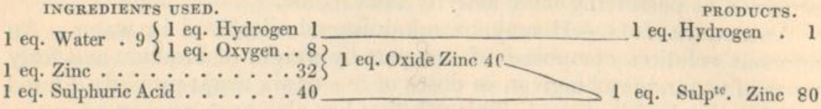
NATURAL HISTORY.—It is found in both kingdoms of nature, but always in combination.

(*a*.) *In the inorganized kingdom.*—Next to oxygen, it may be regarded as the most important constituent of the terraqueous globe. It constitutes 11·1 per cent. by weight of water, presently to be noticed. It is an essential constituent of some minerals (as coal and sal ammoniac) in which it does not exist as an element of water. Lastly, it is evolved from volcanoes or from fissures in the earth, in combination with carbon, sulphur, chlorine or nitrogen, under the forms of light carburetted hydrogen, sulphuretted hydrogen, hydrochloric acid, and ammonia.

(*b*.) *In the organized kingdom*—Hydrogen is an essential constituent of all organized beings (animals and vegetables), either combined with oxygen, to form water, or otherwise. Certain fungi exhale both night and day hydrogen gas (Decandolle, *Phys. Vég*. tom. i. p. 459.)

PREPARATION.—Hydrogen is always procured by the decomposition of water, but this may be effected in three ways—by the action of electricity, of heat and iron, or of sulphuric acid and a metal (zinc or iron). The latter method only will require notice here.

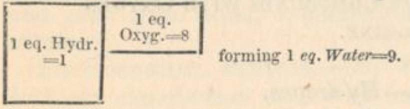
Add some granulated zinc to a mixture of 1 part sulphuric acid and 5 or 6 parts of water by measure. One equivalent or 32 parts of zinc decompose one equivalent or 9 parts of water, and unite with one equivalent or 8 parts of the oxygen, forming one equivalent or 40 parts of the oxide of zinc, while an equivalent or 1 part of hydrogen is evolved from the water. This equivalent of oxide of zinc combines with an equivalent or 40 parts of sulphuric acid, and forms one equivalent or 80 parts of the sulphate of zinc.



It is remarkable that zinc alone does not decompose water, but sulphuric acid enables it to do so.

Properties.—Hydrogen is a colourless, tasteless, and, when pure, odourless gas. Its sp. gr. is 0·0694,—so that it is 14·4 times lighter than atmospheric air. Its refractive power is very high. It is combustible, burning in atmospheric air or oxygen gas with a pale flame, and forming water. It is not a supporter of combustion. It is a constituent of some powerful acids, as the hydrochloric, and of a strong base, ammonia. Its atomic weight or equivalent is 1. Its atomic volume is also 1.

Characteristics.—It is recognised by its combustibility, the pale colour of its flame, its not supporting combustion, and by its yielding when exploded with half its volume of oxygen, water only.



Physiological Effects. (*a.*) *On vegetables.*—Plants which are deprived of green or foliaceous parts, or which possess them in small quantity only, cannot vegetate in hydrogen gas: thus seeds will not germinate in this gas: but vegetables which are abundantly provided with these parts vegetate for an indefinite time in hydrogen (Saussure, *Recherches Chém. sur la Végét.* pp. 195 and 209). Applied to the roots of plants in the form of gas, it is injurious (*ibid.* p. 105,) but an aqueous solution of it seems to be inert (Decandolle, *Physiol. Végét.* t. iii. p. 1360). It has been said that when plants are made to vegetate in the dark their etiolation is much diminished, if hydrogen gas be mixed with the air around them; and in proof of this Humboldt has mentioned several green plants found in the Freyberg mines (Thomson's *Syst. of Chemistry*, 6th ed. p. 347-8.)

(*b.*) *On animals generally.*—Injected into the jugular vein of a dog hydrogen produces immediate death, probably from its mechanical effects in obstructing the circulation and respiration (Nysten, *Recherches*, p. 10.)

(*c.*) *On man.*—It may be breathed several times without any injurious effects. Scheele made twenty inspirations without inconvenience. Pilatre de Rozier frequently repeated the same experiment, and to shew that his lungs contained very little atmospheric air he applied his mouth to a tube, blew out the air, and fired it, so that he appeared to breathe flame. If much atmospheric air had been present detonation must have taken place in his lungs (Beddoes, *New Method of treating Pulmonary Consumption*, p. 44). If we speak while the chest is filled with hydrogen, a remarkable alteration is perceived in the tone of the voice, which becomes softer, shriller, and even squeaking. That this effect is, in part at least, if not wholly, physical, is shewn by the fact that wind instruments (as the flute, pitchpipe, and organ) have their tones altered when played with this gas. The conclusion which has been drawn by several experimenters as to the effects of breathing hydrogen is, that this gas possesses no positively injurious properties, but acts merely by excluding oxygen.

USES.—(*a*). In *pulmonary consumption* Dr. Beddoes recommended inhalations of a mixture of atmospheric air and hydrogen gas, on the ground that in this disease the system was hyperoxygenised. The inhalation was continued for about fifteen minutes, and repeated several times in the day (*New Method of treating Pulmonary Consumption*). Ingenhousz fancied that it had a soothing effect when applied to wounds and ulcers.

(*b*.) In *rheumatism and paralysis* it has been used by Reuss as a resolvent.

(*c*.) A *flame of hydrogen* has been employed in Italy as a cautery, to stop caries of the teeth (*Dict. Mat. Méd.* par Merat et De Lens).

(*d*.) *Hydrogen water* (an aqueous solution, prepared by artificial pressure) has been employed in diabetes (*ibid*).

A'qua.—Water.

HISTORY.—The ancients regarded water as an elementary substance, and as a constituent of most other bodies. This opinion, apparently supported by numerous facts, was held until the middle of the last century, when the Hon. Mr. Cavendish proved that this liquid was a compound of oxygen and hydrogen. It is, however, only doing justice to Mr. Watt to say, that he had previously inferred this to be the composition of water, but was deterred from publishing his opinion in consequence of some of Dr. Priestley's experiments being apparently opposed to it.

NATURAL HISTORY.—(*a*.) *In the inorganized kingdom.* Water exists in the atmosphere; forms seas, lakes, and rivers; it is mechanically disseminated among rocks; and, lastly, it constitutes an essential part of some minerals.—*In the atmosphere* it is found in two states: as a vapour (which makes about one-seventieth by volume, or one one-hundredth by weight, of the atmosphere) it is supposed to be the cause of the blue colour to the sky; and, in a vesicular form, it constitutes the clouds. Terrestrial water forms about three-fourths of the surface of the terraqueous globe. The average depth of the ocean is calculated at between two or three miles. Now, as the height of dry land above the surface of the sea is less than two miles, it is evident, that if the present dry land were distributed over the bottom of the ocean, the surface of the globe would present a mass of waters a mile in depth. On the supposition that the mean depth of the sea is not greater than the fourth part of a mile, the solid contents of the ocean would be 32,058,939$\frac{3}{4}$ cubic miles (Thomson's *System of Chemistry*, 6th ed. vol. iii. p. 195). The quantity of water disseminated through rocks must be, in the aggregate, very considerable, although it is impossible to form any correct estimate of it.

Water enters into the composition of many minerals, either as *water of crystallization*, or combined as a *hydrate*.

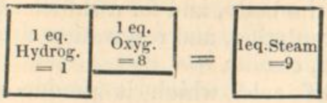
(*b*.) *In the organized kingdom*, water is an essential constituent of vegetables and animals.

PREPARATION.—Absolutely pure water may be procured by combining its elements. For all practical purposes it is obtained sufficiently pure by the distillation of common water. But water which has been repeatedly distilled gives traces of acid and alkali when examined by the agency of galvanic electricity. Distilled water remains unchanged on the addition of any of the following substances:—solutions of the caustic alkalies, lime water, oxalic acid, the barytic salts, nitrate of silver, and solution of soap. If any turbidness, milkiness, or precipitate, be occasioned by any of the above, we may infer the existence of some impurity in the water. But the most delicate test of the purity of water is galvanism, as before mentioned. The purest natural water is snow and rain water; then follow river, spring, and well waters.

PROPERTIES.—Pure water has the following properties:—at ordinary temperatures it is a transparent liquid, usually described as being both odourless and colourless; but it is well known that the camel can scent water at a considerable distance, so that to this animal it is odorous; and as regards its colour, we know that all large masses of water have a bluish-green colour, though this is usually ascribed to the presence of foreign matters. When submitted to a compressing force equal to 30,000 lbs. on the square inch, 14 volumes of this liquid are condensed into 13 volumes; so that it is elastic. A cubic inch of water, at 60° F., weighs 255·5 grains; so that this fluid is about 815 times heavier than atmospheric air: but being the standard to which the gravities of solids and liquids are referred, its specific weight is usually said to be 1·. At a temperature of 32°, it crystallizes, and in so doing expands. The fundamental form of crystallized water (ice) is the rhombohedron. Water evaporates at all temperatures, but at 212° boils, and is converted into steam, whose bulk is about 1700 times that of water, and whose sp. gr. is 0·624 (that of hydrogen being 1). Water unites with both acids and bases, but without destroying their acid or basic properties. Thus the crystallized vegetable acids, tartaric, citric, and oxalic, are atomic combinations of water with acids. Potassa fusa and slacked lime may be instanced as compounds of water and basic substances: these are called *hydrates*. It is a chemical constituent of some crystallized salts; for example, alum, sulphate of soda, and sulphate of magnesia. Here it exists as *water of crystallizatian*. It rapidly absorbs some gases—as fluoride of boron, ammonia, &c. It is neither combustible nor a supporter of combustion.

CHARACTERISTICS.—In the liquid state it is recognized by being volatile, tasteless, odourless, neither acid nor alkaline, and not combustible nor a supporter of combustion: it is miscible with alcohol, but not with the fixed oils; if potassium be thrown on it in the open air, the metal takes fire. Lastly, water may be decomposed into oxygen and hydrogen by the galvanic agency. The most delicate test of aqueous vapour in any gas, is fluoride of boron (commonly called fluoboric acid gas), which produces white fumes with it.

COMPOSITION —The composition of water is determined both by analysis and synthesis. If this liquid be submitted to the influence of a galvanic battery, it is decomposed into two gases—namely, one volume of oxygen, and two volumes of hydrogen. These gases, in the proportions just mentioned, may be made to recombine, and form water, by heat, electricity, or spongy platinum.



	Eq. or At.	Eq. Wt.	Per Cent.	Berz.&Dulong.		Vol.	Sp. Gr.
Hydrogen	1	1	$11{\cdot}1\dot{1}$	11·1	Hydrogen gas	1	$0{\cdot}069\dot{4}$
Oxygen	1	8	$88{\cdot}8\dot{8}$	88·9	Oxygen gas	0·5	$0{\cdot}555\dot{5}$
Water	1	9	$100{\cdot}0\dot{0}$	100·0	Aqueous vapour	1	$0{\cdot}624\dot{9}$

PHYSIOLOGICAL EFFECTS.—Water is a vital stimulus; that is, it is one of the external conditions essential for the manifestation of life. It constitutes four-fifths of the weight of the tissues, and is the source of their physical properties, extensibility and flexibility. Considered in a *dietetical* point of view, it serves at least three important purposes in the animal economy: namely, it repairs the loss of the aqueous part of the blood, caused by the action of the secreting and exhaling organs; secondly, it is a solvent of various alimentary substances, and, therefore, assists the stomach in the act of digestion, though, if taken in very large quantities, it may have an opposite effect, by diluting the gastric juice; thirdly, it is probably a nutritive agent, that is, it assists in the formation of the solid parts of the body.

In a *medicinal* point of view, the physiological effects of water are much modified by its temperature.

(*a*.) *Effects of tepid water.*—Water moderately warm, and which neither cools nor heats the body, acts locally as an emollient, softening and relaxing the various tissues to which it is applied. When swallowed it allays thirst, becomes absorbed, mixes with, and thereby attenuates, the blood, and promotes exhalation and secretion, especially of the watery fluids. Administered in large quantities it excites vomiting. The continued excessive use of water has an enfeebling effect on the system, both by the relaxing influence on the alimentary canal and by the excessive secretion which it gives rise to.

Injected into the veins in moderate quantities, tepid water has no injurious effects; it quickens the pulse and respiration, and increases secretion and exhalation. Large quantities cause difficulty of breathing and an apoplectic condition. Thrown with force into the carotid artery it kills by its mechanical effect on the brain. I have already (p. 23) made some observations on the action of water on the sanguineous globules out of the body.

(*b*.) *Effects of ice, snow, and ice-cold water.*—The temperature of these agents is not higher than 32° F. When brought in contact with a living part, they produce two series of effects—the first of which may be denominated *direct*, *primary*, or *immediate;* while the second may be termed *indirect*, *secondary*, or *mediate*, since they are developed by the vital actions, after the cold agent has ceased to act.

a. Of the primary effects.—When ice is applied to the body, it abstracts heat, causes pain, reduces the volume of the part, and diminishes vital action; and, if applied for a sufficient period, occasions mortification—an effect which is hastened by the previously weakened condition of the part. If applied to a large surface of the body, and for a sufficient length of time, the processes of secretion, circulation, and respiration, are checked, and stupefaction, followed by death, ensues.

When taken *internally*, the sensation of cold which it produces is not so obvious as that occasioned by its external application; and the effect is more temporary, from the greater heat of the internal parts, by which the ice is sooner melted, and the resulting liquid quickly raised to the temperature of the body. If, however, it be taken in large quantity, the effects are of the same general kind as those already described; namely, a sensation of cold in the epigastrium, sometimes attended with shivering; diminished frequency of pulse; temporary contraction of the alimentary canal; diminution of irritability, and of secretion. Employed in small quantities, these effects are not at all perceived, or are only momentary; and the second stage, or that of reaction, almost immediately follows. Baglivi (quoted by Wibmer) found that the injection of four ounces of cold water into the jugular vein of a dog caused shivering of the whole body.

β. *Secondary effects.*—When the application of cold is temporary, more especially if the subject be young and robust, reaction follows the removal of the cold agent. The vascular action of the part is increased, the pulse becomes full and more frequent, and the animal heat is restored to its proper degree, or is even increased beyond its natural standard. These effects, more or less modified, are observed both from the internal and external employment of ice. Thus, after the internal use of it, a feeling of warmth at the epigastrium soon succeeds that of cold, and this extends shortly over the whole body; the secretions of the alimentary canal, of the kidneys, and of the skin, are increased; and the circulation is accelerated. Sometimes these secondary effects are attended with those of a morbid character: thus, inflammation of the stomach has been brought on by the employment of ice.

γ. *Effects of hot, but not scalding, water.*—Hot, but not scalding, water increases the temperature and volume of living parts, relaxes the tissues, and augments vital activity. Applied to the skin it causes rubefaction.

δ. *Effects of boiling water and steam.*—Both of these are local irritants, and, if sufficiently long applied, caustics, giving rise to extensive and deep eschars. Steam contains more specific heat than boiling water, but its conducting power is less than the latter.

Uses.—These may be subdivided into internal and external.—I. *Internal.* (*a.*) *Of ice and ice-cold water.*—Sometimes we administer ice internally, for the purpose of obtaining its primary effects: thus, in hæmorrhage from the stomach we use it for the purpose of causing contraction of the vessels of the gastric surface, and thereby of checking or stopping sanguineous exhalation. So also in violent pulmonary, or bronchial, or nasal hæmorrhage, ice-cold water, taken into the stomach, has been found beneficial. In most cases, however, we use it on account of its secondary effects. Thus, in relaxed and atonic conditions of the stomach—in dyspepsia and cardialgia, it is employed to check vomiting, and to allay spasmodic pain. In those forms of fever denominated putrid, the internal use of small quantities of ice is sometimes highly serviceable.

(*b.*) *Of cold water.* α. *Taken into the stomach.*—Cold water was employed as a drink in fevers in the time of Hippocrates, who, as well as Celsus, Galen, and other ancient writers, strongly recommended its use. Celsus, in speaking of ardent fever, says, "Cum vero in summo incremento morbus est, utique non ante quartum diem, magna sit antecedente, frigida aqua copiose præstanda est, ut bibat etiam ultra satietatem."

Cold water constitutes the *febrifugum magnum* of Dr. Hancock. We are indebted to Dr. Currie for examining the circumstances under which its exhibition is proper. According to him, it is inadmissible during the cold or sweating stage of fever, but may be employed with safety and advantage when the skin is dry and burning. In other words, the regulations for its administration are precisely the same as for the cold affusion presently to be noticed. When exhibited under proper circumstances it acts as a real refrigerant, reducing preternatural heat, lowering the pulse, and disposing to sweating. I ought not, however, to omit noticing, that serious and even fatal consequences have resulted from the employment of large quantities of cold water by persons who have been rendered very warm by exercise and fatigue.

Besides fever, there are many other affections in which cold water is a useful remedy. For example, to facilitate recovery from an attack of epilepsy or hysteria, and also in fainting, a draught of cold water is oftentimes beneficial. There are also various morbid states of the alimentary canal in which cold water may be administered with advantage; as, to diminish irritable conditions of the stomach, and to allay vomiting and gastrodynia. Large quantities of cold water have sometimes caused the expulsion of intestinal worms (both *Tænia* and *Ascaris vermicularis*, or small thread-worms, commonly termed *ascarides*, and which are found in the large intestines of children, particularly in the rectum). Salt-water acts more efficaciously, as I shall hereafter have occasion to notice.

β. *Injected into the rectum.*—Cold water is thrown into the rectum sometimes to check hæmorrhage; to cause the expulsion of worms (the small thread-worm); to allay pain; in poisoning by opium; in inflammation of the bowels; and in various other cases.

γ. *Injected into the vagina.*—Dr. A. T. Thomson speaks very favourably of the effects of cold water when applied in uterine hæmorrhages by means of the stomach pump, and he says he has seen it used in several cases most successfully.

(*c.*) *Tepid and warm water.* α. *Taken into the stomach.—Tepid* and *warm* drinks are employed for various purposes; as, for promoting vomiting, to dilute the contents of the stomach and to render them less acrid, as in cases of irritant poisoning; but in poisons acting by absorption, diluents are objectionable, since they facilitate this process, and, therefore, ought not to be given unless vomiting be present, or the stomach-pump be at hand. Warm aqueous drinks are administered with the view of exciting diaphoresis, in gout, rheumatism, catarrh, &c., and to assist their operation the patient should be kept warm in bed, in order to promote the cutaneous circulation. Warm liquids are oftentimes used as emollients; as to allay irritable and troublesome cough, particularly when this appears to depend on irritation at the top of the larynx.

β. *Injected into the rectum*, warm water is sometimes employed to promote the hæmorrhoidal flux, and thereby to relieve affections of distant organs; as an emollient, to diminish irritation either in the large intestine itself, or in some neighbouring organ, namely, the bladder, prostate gland, or uterus; to promote the catamenial discharge, &c. Clysters of tepid water are frequently employed to excite alvine evacuations. I have before (p. 53) expressed my opinion as to the impropriety of frequently introducing several pints of fluid into the rectum, since the gut, by dilatation, becomes less susceptible to the natural stimulus of the fæces.

γ. *Injected into the vagina*, warm water may be used to diminish irritation or pain in the womb,—to promote the lochial discharge, &c.

δ. *Injected into the bladder*, warm water is sometimes employed either to diminish irritation in this viscus, or to distend it previously to the operation of lithotrity.

ε. *Injected into the urethra*, it has been used to allay irritation, or to check discharges from the mucous membrane.

ζ. *Injected into the veins*, warm water was proposed by Magendie as a remedy for hydrophobia, but it has neither theory nor experience to recommend it. However, in a disease which has hitherto resisted all known means of cure, practitioners are glad to try any remedy that may be proposed, however improbable, or unlikely of success. I have already (p. 55) mentioned a case in which I tried warm water injections, but without much benefit. Vernière (Christison's *Treatise on Poisons*, p. 35) has proposed to distend the venous system with warm water, to check or stop absorption in poisoning, by those agents whose operation depends on their absorption; for example, opium. I am not acquainted with any case in which it has been tried on the human subject. Warm water is sometimes a medium for the introduction of other more powerful agents into the circulating system; as, for example, tartar emetic.

d. Vapour.—The *inhalation of aqueous vapour* acts as a serviceable emollient in irritation or inflammation of the tonsils, or of the membrane lining the larynx, trachea, or bronchial tubes. It may be employed by means of Mudge's inhaler, or by merely breathing over warm water. Various narcotic and emollient substances are frequently added to the water, without increasing its therapeutical power. In some pulmonary complaints, Dr. Paris states he has been long in the habit of recommending persons confined in artificially warmed apartments to evaporate a certain portion of water, whenever the external air has become excessively dry by the prevalence of the north-east winds which so frequently infest this island during the months of spring; and the most marked advantage has attended the practice.

II. *External.—a. Ice and ice-cold water.*—Ice is sometimes applied externally to check hæmorrhage, more especially when the bleeding vessel cannot be easily got at and tied. Thus, after operations about the rectum (more especially for piles and fistula) hæmorrhage sometimes occurs to a most alarming extent; and in such cases our principal reliance must be on cold. In two instances that have fallen under my own observation, I believe the lives of the patients were preserved by the introduction of ice within the rectum. In many other cases of hæmorrhage, the external application of cold (either in the form of ice or ice-cold water) is exceedingly useful. Thus, applied to the chest in dangerous pulmonary hæmorrhage, to the abdomen in violent floodings, it is oftentimes most beneficial. In some of these cases, especially in uterine hæmorrhage, more benefit is obtained by pouring cold water from a height, than by the mere use of ice.

Pounded ice, tied up in a bladder, has been applied to hernial tumors, to diminish their size and facilitate their reduction; but notwithstanding that the practice has the sanction and recommendation of Sir Astley Cooper, it is, I believe, rarely followed, not having been found successful; and if too long continued, it may cause gangrene. In this, as well as in other cases where ice or snow cannot be procured, a freezing mixture may be substituted. For this purpose, five ounces of muriate of ammonia, five ounces of nitre, and a pint of water, are to be placed in a bladder, and applied to the part. Ice has also been applied in prolapsus of the rectum or vagina, when inflammation has come on which threatens mortification.

In inflammation of the brain, ice, pounded and placed in a bladder, may be applied to the head with a very beneficial effect. In fever also, where there is great cerebral excitement, with a hot dry skin, I have seen it advantageously employed. In apoplexy, likewise, it might be useful. In the retention of urine to which old persons are liable, ice-cold water applied to the hypogastrium is sometimes very effective, causing the evacuation of this secretion.

In the above-mentioned local uses of ice, we either apply it directly to the part, or inclose it in a bladder: the latter is to be preferred, since the patient is not wetted with the melted water, while the effect is less violent.

In the last place, I must notice the employment of ice or snow in the form of *friction*. Whenever it is used in this way, the ultimate object is the production of the secondary effects, or those which constitute the stage of reaction. Thus this practice has been resorted to in diminished sensibility of the skin, in the rheumatism or gout of old and enfeebled persons, in order to produce excitement of the skin; but its most common use is as an application to parts injured by cold. The affection thus induced is called *pernio*, or the *chilblain;* and the parts affected are said to be *frost-bitten*. The feet, hands, tip of the nose, and pinna of the ear, are the organs most frequently attacked. Now, with the view of preventing the mortification and other ill consequences arising from the application of cold, great care must be used to avoid sudden changes of temperature. The frost-bitten part, or the chilblain, should be rubbed with snow or pounded ice, or bathed in ice-cold water, very gradually raising the temperature of the applications until the part acquires its natural heat.

(*b*.) *Cold, cool, tepid, and hot water.*—Water of various degrees of temperature is employed for baths, affusion, washing or sponging, the *douche*, and for various local purposes.

a. Baths.—History.—The practice of bathing is of great antiquity, and, in fact, precedes the date of our earliest records. It was employed, sometimes for the purpose of cleanliness, sometimes for the preservation of health, and frequently as a means of sensual gratification. Ablutions were practised by the ancient Hebrews, as you will find mentioned in the Old Testament. Baths were used by the Egyptians, as well as by the

Hindoos, the Syrians, the Medes, the Persians, and other inhabitants of the East. The most ancient of the Greek writers also frequently mention them: thus Homer speaks of them in the Iliad and Odyssey. In the writings attributed to Hippocrates, you will find baths alluded to, and their effects noticed. Celsus describes the different parts of baths, and the mode of employing them; but the best description will be found in the works of Galen.

The following is a sketch of the baths of the Romans, copied from a painting found at the *thermæ* of Titus. (De Montfaucon, *l'Antiquité expliquée et répresentée en figures*, tom. 3^me, part 2^de, p. 204).

Fig. 37.

Ancient Baths.

On the right is the *eleotherium* (ἀλειπτήριον) where the oils and perfumes are kept in vases: next to this is the *frigidarium* (ἀϖοδυτήριον) or dressing-room: the third is the *tepidarium:* the fourth is the sudatory (*concamerata sudatio*) in which are seen the *laconicum* (so called from being first used in Laconia) a brazen furnace to heat the room, and persons sitting on the steps: the fifth is the *balneum*, with its huge basin (*labrum*) supplied by pipes communicating with three large bronze vases, called *milliaria*, from their capaciousness; the lower one contained hot, the upper one cold, and the middle one tepid water. The bathers returned back to the frigidarium, which sometimes contained a cold bath. The subterranean portion of the building, where the fires were placed for heating the baths, was called *hypocaustum.*

For further information on the ancient baths, consult "*An Account* of the *Ancient Baths*, by Thomas Glasse, M. D. 1752;" or Dr. Parr's "*Medical Dictionary.*" All the remarks made on baths by the Greeks, Latins, and Arabs, have been brought together in one volume, folio, under the following title:—"*De Balneis omnia quæ extant apud Græcos, Latinos, et Arabos*, 1553."

Effects and uses of baths.—The effects of baths depend, for the most part, on the temperature of the fluid employed, on its conducting power, and, in part also, on its pressure. We may, therefore, conveniently, arrange them thus:—

(*a.*) LIQUID BATHS.

(1.) *The cold bath.*	(4.) *The tepid bath.*
(2.) *The cool bath.*	(5.) *The warm bath.*
(3.) *The temperate bath.*	(6.) *The hot bath.*

(*b.*) VAPOUR BATHS.

Writers are not agreed on the precise temperature of the above baths, but the order in which I have arranged them, according to their respective degrees of heat, is that which is generally admitted.

(1.) *The Cold Bath.*—The temperature of this ranges from 33° F. to about 60° F.: when it is below 50°, it is sometimes termed a *very cold bath.* The *effects* of immersion in the cold bath are analogous to those already described as being produced by the application of ice or snow to the body, and, therefore, may be conveniently subdivided into primary and secondary.

(*a.*) *Primary effects.*—(*The shock.*)—The sudden abstraction of heat from the surface, and the pressure of the water, produce a powerful shock on the system: a sensation of cold, (speedily followed by a sensation of warmth) contraction of the cutaneous vessels, paleness of the skin, diminution of perspiration, and reduction of the volume of the body, are the immediate effects. Shivering, and, as the water rises to the chest, a kind of convulsive sobbing, are also experienced. Continued immersion renders the pulse small, and, ultimately, imperceptible—the respiration difficult and irregular; a feeling of inactivity succeeds—the joints become rigid and inflexible—pain in the head, drowsiness, and cramps, are experienced—the temperature of the body falls rapidly, and faintness, followed by death, comes on. Many of these symptoms are readily comprehended: the contracted state of the superficial vessels produced by the cold, together with the pressure of the water, causes the blood to accumulate in the internal vessels. The heart makes great efforts to get rid of this increased quantity of blood, and hence palpitations occur; but as the arteries remain contracted, the pulse continues small. The internal veins, therefore, being gorged with blood, the brain necessarily suffers:—hence the headache, the drowsiness, the cramps, and, in some cases, apoplexy. The difficult respiration depends on the accumulation of blood in the lungs. The contracted state of the superficial vessels accounts for the diminished perspiration; while the increased secretion of urine is referrible to the blood being driven towards the internal organs.

(*b.*) *Secondary effects.*—(*Re-action or glow.*)—In general, the immersion being only temporary, re-action quickly takes place; a sensation of warmth soon returns; the cutaneous circulation is speedily re-established; a glow is felt; perspiration comes on; the pulse becomes full and frequent; and the body feels invigorated. In weakly and debilitated subjects, however, this stage of re-action may not occur, or at least may be imperfectly effected; and usually, in such cases, the cold bath will be found to act injuriously.

The *uses* of the cold bath may be in part comprehended from the effects just detailed. It is employed with the view of obtaining one of the three following effects: the nervous impression or shock,—the refrigeration,—the re-action or glow. (*Cyclopædia of Practical Medicine*, art. *Bathing*, by Dr. J. Forbes.) It is evident that it ought not to be applied unless there be a sufficient degree of tone and vigour in the system to cause a perfect state of re-action; and, therefore, in weak subjects, its use is to be prohibited. So also, in visceral inflammation, more especially peripneumonia, it is a dangerous remedy; since the determination of blood to the internal organs is increased by the cold, and it seems even within the range of probability that death might be the result. Apoplectic subjects, who are unaccustomed to cold bathing, had also, for a similar reason, better avoid trying it. In some affections of the nervous system it has been found highly useful; for example, in tetanus and insanity. So also, in any cases where we wish to increase the tone and vigour of the body, and where the before-mentioned objections do not exist, the cold bath may be used advantageously. It is a common opinion that immersion in cold water is dangerous when the body is heated by exercise, or other exertion; and hence it is customary with bathers to wait until they become cool. Dr. Currie has strongly combated both the opinion and the practice: the first, he says, is erroneous, the second injurious.

(2.) *The Cool Bath* (whose temperature is from 60° to about 75°) is analogous in its operation to the cold bath, but less powerful. It is commonly employed for the purposes of pleasure and cleanliness; but it may be resorted to, therapeutically, in the same diseases as the cold bath, where we are in doubt as to the power of the patient's constitution to establish full re-action. It is frequently used as a preparatory measure to the cold bath.

(3.) The *Temperate Bath* ranges from 75° F. to 85° F. Its effects and uses are similar to the cool bath.

(4.) The *Tepid Bath* gives rise to a sensation of either heat or cold, according to the heat of the body at the time of immersion. The temperature of this bath ranges between 85° and 92°. It cleanses the skin, promotes perspiration, and is used as preparatory to either of the before-mentioned baths. It is said to allay thirst. Where there is a tendency to apoplexy, it has been recommended to immerse the body in the tepid bath, and at the same time to pour cold water over the head.

(5.) The *Warm Bath* varies in its *effects* on different individuals. Its temperature is about that of the body, or a little below it: we may say from 92° to 98°. In general it causes a sensation of warmth, which is more obvious when the body has been previously cooled. It renders the pulse fuller and more frequent, accelerates the respiration, and augments the perspiration. It gives rise to languor, loss of muscular power, faintness, and disposition to sleep. The *uses* of it are various. Sometimes it is employed to cause relaxation of the muscular system; as in dislocation of the larger joints: and also in hernia, to assist the operation of the taxis. In the passage of calculi, either urinary or biliary, it is applied with the greatest advantage: it relaxes the ducts, and thereby facilitates the passage of the foreign body. As a powerful antiphlogistic, it is employed in inflammation of the stomach, bowels, kidneys, bladder, &c. With the view of increasing the cutaneous circulation, it is used in the exanthemata, when the eruption has receded,—and to promote perspiration, in chronic rheumatism, and various chronic skin diseases.

(6.) The *Hot Bath* (the temperature of which is somewhat above that of the body, as from 98° to 112°) gives rise to a sensation of heat, renders the pulse fuller and stronger, accelerates the respiration, occasions intense redness of the skin, and copious perspiration,—causes the vessels of the head to throb violently—brings on a sensation of fulness about the head, with a feeling of suffocation and anxiety,—and, if the immersion be continued, may even induce apoplexy. Being a powerful excitant, it must be used very cautiously. Paralysis, rheumatism, and some chronic diseases, are the principal cases in which it is employed.

(*b.*) The *Vapour Bath.*—The vapour bath differs somewhat in its effects from the warm or hot bath: hot air and vesicular water being much worse conductors of heat than water in its usual liquid form, the temperature of the bath is neither so quickly, nor so powerfully felt, so that the body can support a higher heat, and for a longer period; moreover, the pressure is less. Dr. Forbes (*Cyclop. Pract. Med.*, art. *Bathing*) gives the following comparative view of the heating powers of water and of vapour, distinguishing the latter according as it is or is not breathed:—

	Water.	*Vapour*	
		Not breathed.	Breathed.
Tepid bath .	85° — 92°	96° — 106°	90° — 100°
Warm bath .	92° — 98°	106° — 120°	100° — 110°
Hot bath . .	98° — 106°	120° — 160°	110° — 130°

The vapour bath acts as a stimulant to the skin; it excites the cutaneous circulation, softens and relaxes the tissue, produces copious perspiration, accelerates the pulse, quickens the respiration, and induces a feeling of languor, and a tendency to sleep. There are two modes of employing it; either by immersing the whole body in the vapour, which is consequently inhaled; or inclosing the body in a chest or box, so that the head is not exposed to the vapour, which, therefore, is not inspired. The aqueous vapour is conveyed into the chamber or box by a pipe communicating with a steam boiler. Sometimes it is made to pass through various vegetable substances, with the odour of which it becomes impregnated, and from which it has been supposed to gain an increase or modification of therapeutical power. These are the ***medicated vapour baths***. Sometimes the common vapour bath is accompanied by a process of friction, kneading and extension of the muscles, tendons, and ligaments, constituting the ***massing*** of the Egyptians, or the ***shampooing*** of the Indians. Here is the account of the process, as given by Dr. Gibney (*Treatise on the Vapour Bath,* p. 84):—"After exposure to the bath, while the body is yet warm from the effects of the vapour, the shampooman proceeds, according to the circumstances of the case, from gentle friction gradually increased to pressure, along the fleshy and tendinous parts of the limb; he kneads and grasps the muscle repeatedly, presses with the points of his fingers along its course, and then follows friction, in a greater or less degree, alternating one with the other, while the hand is smeared with a medicated oil, in the specific influence of which the operator has considerable confidence. This process is continued for a shorter or longer space of time, and, according to circumstances, is either succeeded or preceded by an extension of the capsular ligament of each joint, from the larger to the smaller, causing each to crack, so as to be distinctly heard, which also succeeds from the process being extended to each connecting ligament of the vertebræ of the back and loins. The sensation at the moment is far from agreeable, but is succeded by effects

Fig. 38.

Egyptian Bath.

not dissimilar to what arise from brisk electrical sparks, taken from the joints in quick succession."

The application of vapour to particular parts of the body is sometimes accompanied with the simultaneous removal of atmospheric pressure, constituting the *air-pump vapour bath*, which has been employed in cases of gout, rheumatism, and paralysis. I must refer, for a further account of it, to Dr. R. Blegborough's "*Facts and Observations respecting the Air-pump Vapour Bath.*"

The vapour bath is applicable to a great variety of cases, a few only of which can be noticed here. Whenever it is desired to excite the vascular system, more especially the cutaneous portion of it, this remedy may be resorted to with advantage. The cold stage of an intermittent, and malignant cholera, are cases which readily suggest its employment. In rheumatism and gout, in old paralytic cases unaccompanied with signs of vascular excitement about the head, in various atonic affections of the uterine system—such as some forms of chlorosis and amenorrhœa, in dropsy of old debilitated subjects, in various skin diseases, in scrofula, in chronic liver complaints of long standing, &c. this remedy may be employed, and frequently with advantage.

I ought not to leave this subject without alluding to the extensive use made of vapour baths in some parts of the world, particularly Russia, where, we are told, it is customary for the bathers to issue from the bathing-houses while quite hot, and to roll themselves naked in the snow, and then return to the bath, not only without any hurtful, but apparently with beneficial, effects.

β. *Affusion.*—Another mode of employing water externally is by *affusion;* that is, the pouring of water over some portion of the body. It is the καтάχυσις of Hippocrates.

History.—This practice is of very ancient date: as a hygienic agent and luxury it was practised by the Greeks and Orientalists at a very early period, and allusions to it will be found in the Odyssey of Homer. Hot, tepid, and cold affusions, are mentioned by Celsus, in the fourth chapter of the first book, and are recommended in some affections of the head. This last writer also states, that Cleophantus (a physician who lived about 300 years before Christ) employed the affusion of hot water in intermittents. For an account of the effects and uses of cold affusion, I must refer to the *Medical Reports* of Dr. Currie, and to a paper by Dr. Copland, in the *Medical Gazette*, vol. x.

Mode of applying affusion.—In many cases the object is to use affusion to the *head* merely. If the patient be able to sit up, let him incline his head over a large vessel, say a pan or tub, and then pour the water from a height of two or three feet from an ewer or large pitcher. If, however, he be too ill to be removed, he must incline his head over the side of the bed. In children it will be sufficient to squeeze a large sponge at some height above the head, as recommended by Dr. Copland. In some cases it is necessary to guard against the cold water coming in contact with the chest.

When the object is to apply the affusion to the *whole body*, the patient must be placed in a large tub or pan—for example, a bathing-tub or washing-pan—and then an attendant, standing on a chair, may readily effect it. The time that the affusion should be continued will vary according to circumstances, from a quarter to two or three minutes; but in some cases it has been employed for twenty minutes. After the affusion the body should be carefully wiped dry, the patient wrapped up warm, and placed in bed.

Effects.—The effects of affusion depend partly on the temperature of the water, and partly also on the sudden and violent shock given to the system by the mechanical impulse of the water; hence the reason why the effects vary, according to the height from which the liquid is poured.

1. *Of the affusion of cold water*—that is, of water whose temperature is between 32° F. and 60° F. To a certain extent the effect of this agent is analogous to that of the cold bath, but modified by two circumstances, namely, the short period during which the cold is applied, and the mechanical influence of the stream: hence, its primary effects are very transient, and re-action follows very speedily. By a long continuance of affusion, however, the heat of the body is very considerably reduced, and the same diminution of vital action occurs as when the cold bath is employed. The sensation of cold, the constriction of the skin, and the contraction of the superficial vessels, first experienced in the part to which the water is applied, is very speedily communicated to the rest of the system by sympathy, in consequence of the shock; the effects of which are perceived in the nervous, vascular, secreting, and cutaneous systems. The temperature of the whole body falls, the pulse becomes reduced in volume and frequency, the respiration is irregular, and convulsive shiverings take place, faintness, and, in fact, all the effects already described of the cold bath are produced. During this condition the excretions are suspended. "When," says Dr. Copland, "the stream of water is considerable, and falls from some height upon the head, the effect on the nervous system is often very remarkable, and approaches more nearly than any other phenomenon with which I am acquainted to electro-motive or galvanic agency."

After the affusion, re-action is soon set up, the heat of the body is re-established, the pulse becomes full and regular, though sometimes reduced in frequency, the thirst is diminished, and frequently perspiration and tendency to sleep are observed.

Cold affusion is used principally in those cases where it is considered desirable to make a powerful and sudden impression on the system: for as a mere cooling agent it is inferior to some other modes of applying water. Thus it is employed, for the most part, in fevers, and affections of the nervous system. It is objectionable in visceral inflammation, on account of the determination of blood which it produces to the internal parts. Cold affusion has been employed with great benefit in *fevers*, both continued and intermittent. It may be used with safety, according to Dr. Currie and others, "when there is no sense of chilliness present, when the heat of the surface is steadily above what is natural, and when there is no general or profuse perspiration." It is inadmissible during either the cold or the sweating stage of fever, as also in the hot stage, when the heat is not greater than ordinary. In some instances it seems to act by the shock it communicates to the system; for the effect is almost immediate, the disease being at once cut short. The patient has fallen asleep immediately afterwards, profuse perspiration has succeeded, and from that time recovery begun to take place. This plan of extinguishing a fever, however, frequently fails; and in that event the patient may be in a worse condition; hence the practice is not often adopted. I think the cases best adapted for the use of cold affusion are those in which there is great cerebral disorder,—either violent delirium or a soporose condition. My friend, Dr. Clutterbuck, (*Inquiry into the Seat and Nature of Fever*, 2d ed. p. 451), says he has seen pulmonic inflammation and rheumatism brought on by cold affusion in typhus; but he adds, "I have not, in general, observed that the situation of the patient was rendered materially worse by the combination."

In the *exanthemata*, cold affusion has been applied during the fever which precedes the eruption, as also after this has been established; it has been used in scarlet fever, and also in small-pox; likewise in measles; but its employment in the latter disease is objectionable, on account of the tendency to pulmonary inflammation, in which cold affusion is prejudicial.

Croup is another disease in which cold affusion has been used with advantage, principally with the view of removing the spasm of the glottis, which endangers the life of the patient.

In *inflammatory affections of the brain*, especially of children, after proper evacuations have been made, it is useful. In many cases of *narcotic poisoning*, cold affusion is of the greatest service; as in poisoning with hydrocyanic acid, and in asphyxia caused by the inhalation of carbonic acid; so also in poisoning with opium, belladonna, and other narcotic substances, in intoxication, in asphyxia from the inhalation of sulphuretted hydrogen gas or of the vapours of burning charcoal, this practice is most advantageous. In *hysteria* and *epilepsy* it is oftentimes serviceable: it diminishes the duration of the paroxysms, and relieves the comatose symptoms. In *puerperal convulsions* Dr. Copland relies on cold affusion and blood-letting. In *mania* it is oftentimes serviceable; as also in *tetanus*.

2. *Cool affusion* has been employed instead of the cold; and in weak irritable subjects it is always preferable. Dr. Currie regards it as a milder form of the cold affusion, as a preparatory means to which it is sometimes used. It has been applied in febrile diseases and paralysis.

3. *Tepid affusion.*—The affusion of tepid water is frequently resorted to as a substitute for that of cold water, where great dread is entertained of the latter agent, or where there is doubt as to the production of a perfect reaction after the application of cold water, or where there is some pulmonary disease. It may be regarded as a safer, though less powerful means. Thus it is very useful in febrile complaints, especially of children. It is very beneficial in scarlet fever, as I have seen on several occasions. Dr. Currie thinks that it reduces the temperature more than cold affusion; first, because the evaporation is greater; secondly, because it does not excite that reaction by which heat is evolved. It diminishes the frequency of the pulse and of respiration, and causes a tendency to sleep. The same writer tells us that he has not found its effects so permanent as those of the cold affusion; and that he never saw it followed by the total cessation of regular fever. In other words, it produces a much less powerful shock to the system, and therefore is less influential over disease. In hectic fever, however, the paroxysm is sometimes completely extinguished by the affusion of tepid water at the commencement of the hot stage.

4. *Warm affusion* excites very pleasant sensations, but which are soon

followed by chilliness, and oftentimes by pulmonary affections. It has been used in mania with advantage: it reduces the frequency of the pulse and of respiration, and occasions a tendency to repose; but the effects are much more temporary than those produced by the warm bath.

γ. *Washing or sponging.*—Cold, cool, or tepid washing or sponging, may be used in febrile diseases, with great advantage, in many cases where affusion is not admissible, or where timidity on the part of the patient or practitioner prevents the employment of the latter. Dr. Currie remarks, that in all cases of fever where the burning heat of the palms of the hands and soles of the feet is present, this method of cooling them should be resorted to. A little vinegar is frequently mixed with the water, to make the effect more refreshing. Washing or sponging must be effected under precisely the same regulations as those already laid down for affusion.

δ. *Shower bath.*—The shower bath is similar in its effects to affusion, but milder in its operation, and is mostly employed in chronic diseases, or as a hygienic agent. In various affections of the nervous system, more especially insanity, it is very useful. In many cases it is a valuable agent when we are afraid to venture on the common cold bath or cold affusion, since it is less likely to cause cramps or other symptoms indicative of a disordered state of the nervous system.

ε. *The Douche.*—The French word *douche*, or the Italian *doccia*, signifies a continued current of fluid applied to, or made to fall on, some part of the body. Dr. Parr states that it is synonymous with our word "*pumping*," and with the Latin word *stillicidium*. At Bath, for example, the waters are applied, say to a paralyzed part, by means of a pump, and the degree or quantity of the application is determined by the number of times the handle is raised or depressed. The water, however, does not issue in gushes, but in a continuous stream. This is evidently what the French would call a *douche*, but our word "pumping" is not applicable to a "*douche de vapeur*." According to the direction in which the water is applied we have the *douche descendante*, *douche latérale*, and *douche ascendante*.

History.—It is uncertain at how early a period this remedy was in use. The following passage from Cælius Aurelianus has been supposed by some to refer to this mode of employing water. "Item *aquarum ruinis* partes in passione constitutæ sunt subjiciendæ, quas Græci κατακλυσμοὺς appellant, plurimum etinim earum *percussiones* corporum faciunt mutationem." By others, however, this passage is supposed to refer to affusion.

General operation.—The effects of the douche depend on several circumstances; such as the nature of the fluid employed, whether vapour or liquid, and if liquid, whether simple or some saline water: the temperature also must have an influence, as is very evident,—the size and direction of the jet, the force with which it is applied, and its duration. At Bath, Dr. Falconer tells us, "from 50 to 200 strokes of the pump is the number generally directed to be taken at one time, which, however, may be increased or diminished according to the age, sex, strength, or other circumstances of the patient." On the continent it is rarely employed for a longer period than 15 or 20 minutes.

The *vapour douche* is nothing more than a jet of aqueous vapour directed on some part of the body, its action depending principally on the temperature of the fluid, since its mechanical effects are comparatively slight. In the *common vapour douche* the temperature of the aqueous vapour does not exceed that employed in the vapour baths already described; and in such cases it may be regarded as a kind of local vapour bath. Thus in some affections of the ear, as otitis, otorrhœa, and otalgia, a stream of aqueous vapour may be applied to the meatus auditorius externus with great benefit; and the most ready means of effecting this is by a funnel inverted over a vessel of hot water, the ear being placed over the orifice of the funnel.

Sometimes *steam* has been used—that is, aqueous vapour heated to 212° F.; and, of course, it acts as a caustic if sufficiently long applied, causing sometimes an extensive and deep eschar. In this respect its action is similar to that of boiling water, from which, indeed, it principally differs in the circumstance of having a much larger quantity of specific heat, and in the great facility with which we can localize its effects. It may be readily applied to any part of the body by means of a small boiler (copper or tin), furnished with a pipe and stop-cock, and heated by a spirit lamp. It has been used as a powerful counter-irritant in diseases of the hip-joint, neuralgic pains, chronic rheumatism, &c.; but the objections to its use are the great pain and the danger of its employment; for it is a more painful application than many other modes of causing counter-irritation, while its effects are inconstant.

The action of the *liquid douche* depends in a great measure on the temperature of the liquid, but in part also on the mechanical action of the water. This effect of percussion is common to both the cold and hot douche, and by continuance excites pain and inflammation of the part. This local excitement is observed almost immediately when hot water is employed, but takes place more slowly when we use cold water; indeed, the long action of a stream of cold water may act as a sedative, and cause all the effects which I have already described as the primary effects of cold applications.

The effect of the douche is, however, not altogether local, since the neighbouring parts, and even the whole animal economy, soon become affected. A column of water twelve feet high, made to fall perpendicularly on the top of the head, excites such a painful sensation, that, we are told, the most furious maniacs who have once tried it may sometimes be awed merely by the threat of its application; and hence one of its uses in madness, as a means of controlling the unfortunate patient.

The *cold douche* is applicable to those cases of local disease requiring a powerful stimulus. For example, chronic affections of the joints, of long standing, whether rheumatic, gouty, or otherwise, paralytic affections of the limbs, old glandular swellings, and those forms of insanity in which there are no marks of determination of blood to the head. The *warm* douche may be employed in similar cases.

For a variety of local purposes, a syringe is employed to throw a jet of water on particular parts, as into sinuous ulcers, or into the vagina, into the ear, into the rectum, &c., constituting thus a kind of douche.

ζ. *Local uses.—Hot, warm,* and *cold* water, applied to particular parts of the body, may be regarded as local baths. *Cold water* is applied to produce evaporation, and thereby to generate cold, with the view of relieving local irritation and inflammation. In ophthalmia, phrenitis, and even in gout (though in the latter complaint the practice has been objected to), cold water lotions are employed with great advantage. One method of treating burns is by the application of cold water, and, if I am to judge by my own sensations, it is by far the most agreeable. By some, however, *warm water* is employed as an emollient application in burns and scalds. This is the practice of my friend Mr. Luke, one of the surgeons to the London Hospital. (*Med. Gaz.* vol. xviii. p. 7).

Warm fomentations and poultices (made of bread or linseed meal) may be regarded, in reference to their effects, as a local bath.

Boiling water is employed externally as a powerful irritant and a speedy vesicant; its action being in this respect analogous to steam, already noticed, and objectionable on the same ground, namely, the great pain, and the uncertainty of its effects; in addition to which may be mentioned, the difficulty of localizing its action. When applied in diseases of internal organs, it may be regarded as a powerful counter-irritant.

III. ***Pharmaceutical Uses.***—Water is frequently employed in pharmacy for extracting the active principles of various medicinal agents. The solutions thus procured are termed, by the French reformers of pharmaceutical nomenclature, *hydroliques* or *hydrolica* (*Pharm. Nomenclat.* of MM. Chereau and Henry, in the *Supplement* to the *Edinb. New Dispens.* p. 152). Those prepared by solution or mixture are called *hydrolés;* and others, procured by distillation, are denominated *hydrolats.*

1. *Hydrolés.*—Cottereau (*Traité Elém. de Pharmacologie*, 1835), divides these into three classes; α. *Mineral hydrolés* (*hydrolés chimico-basiques*), of which Goulard-water and lime-water are examples; β. *vegetable hydrolés* (*hydrolés phytobasiques*), as almond emulsion, mucilage, vegetable infusions, and decoctions, &c.; γ. *animal hydrolés* (*hydrolés zoobasiques*), as broths.

2. *Hydrolats.*—These are the *aquæ distillatæ* of the British Pharmacopœias: as *aqua menthæ piperitæ*, called, in the French codex, *hydrolatum menthæ piperitæ.*

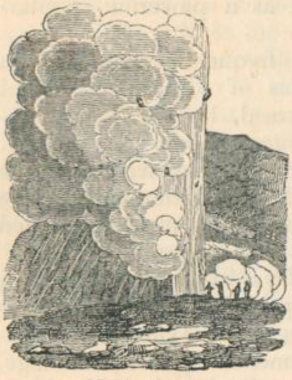
A'quæ Minera'les.—Mineral Waters.

History.—Mineral waters were known to mankind in the most remote periods of antiquity, and were employed, medicinally, both as external and internal agents. Homer (*Iliad*, xxii. 147) speaks of tepid and cold springs. The Asclepiadeæ, or followers of Æsculapius, erected their temples in the neighbourhood of mineral and thermal waters (Sprengel, *Hist. de Médec.* par Jourdan, t. 1er. p. 144). Hippocrates (*De aeribus, aquis, locis*) speaks of mineral waters, though he does not prescribe them when speaking of particular diseases. Pliny (*Hist. Nat.* lib. xxxi.) notices their medical properties.

Natural History.—The principal source of mineral waters is the atmosphere, from which water is obtained in the form of rain, snow, hail, and dew, and which after percolating a certain portion of the earth, and dissolving various substances in its passage, reappears on the surface at the bottom of declivities (*spring water*), or is procured by sinking pits or wells (*well water*). But springs are sometimes observed under circumstances which are inconsistent with the supposition of their atmospheric origin. "The boiling springs which emerge on the verge of perpetual snows, at an altitude of 13,000 feet above the level of the sea, as in the Himalayahs, cannot be derived from the atmosphere, not to mention the peculiar relations of the Icelandic Geysers" (Gairdner's *Essay on Mineral and Thermal Springs*, p. 289). Other sources, therefore, have been sought for, and the writer just quoted enumerates three; viz. the focus of volcanic activity, the great mass of the ocean, or other masses of salt-water, and subterranean reservoirs.

Considered with reference to their temperature, mineral waters are divided into *cold* and *hot*. The hot or thermal waters are those which possess a temperature more or less elevated above the mean of the latitude or elevation at which they are found, and the changes of which, if any, observe no regular periods coincident with the revolutions of the seasons. Three causes have been assigned as the source of the heat of mineral waters; viz. volcanic action, now in existence; volcanic action, now extinguished, but the effects of which still remain; and, a central cause of heat, which increases as we descend from the surface to the interior of the earth (Gairdner, *op. cit.*).

Fig. 39.



New Geyser.

The *Geysers*, or boiling springs, of Iceland, are evidently connected with volcanic action. They are intermittent fountains, which throw up boiling water and spray to a great height into the air. For further information concerning them, I must refer to Sir G. S. Mackenzie's "*Travels in Iceland during the Summer of* 1810," and to Barrow's "*Visit to Iceland, by way of Tronyem, &c., in the Summer of* 1834."

The origin of the saline and other constituents is another interesting topic of inquiry connected with the natural history of mineral springs. As water in its passage through the different strata of the earth must come in contact with various substances which are soluble in it, we refer certain constituents of mineral waters to solution and lixiviation merely: as chloride of sodium, carbonates of lime and magnesia, iodides and bromides of sodium and magnesium, iron, silica, &c. Chemical action must, in some cases, be the source of other constituents. Thus sulphuretted hydrogen is probably produced by the action of water on some metallic sulphuret (especially nonpyrites): sulphurous and sulphuric acid, from the oxidation and combustion of sulphur, free or combined. The carbonic acid found in the acidulous or carbonated waters is referrible to the decomposition of carbonate of lime, either by heat or by the action of sulphuric acid. Hydrochloric acid is doubtless produced by the decomposition of some chloride or muriate (probably chloride of sodium or sal ammoniac). Carbonate of soda must also be considered as the product of some chemical process; thus, that found in the natron lakes of Egypt is supposed to be formed by the action of chloride of sodium on carbonate of lime (Bertholett, *Essai de Statique Chimique*, 1er. part. p. 406). "The different orifices of the Karlsbad Sprudel discharge annually about 13,000 tons of carbonate of soda, and 20,000 of the sulphate in the crystallized state" (Gairdner, *op. cit.* p. 325): but a "very simple calculation is sufficient to shew, that the Donnersberg alone, the loftiest of the Bohemian Mittelgebirge, a cone of clinkstone

2,500 feet in elevation, contains soda enough to supply the Karlsbad waters alone for more than 30,000 years." (*Ibid.* p. 338).

DIVISION AND PROPERTIES.—Mineral waters may be classified according to their temperature, their chemical composition, or their medicinal properties. But hitherto no satisfactory classification has been effected by any of these methods, nor perhaps can it be formed. The most convenient arrangement is that founded on chemical composition, and which consists in grouping mineral waters in four classes.

CLASS 1. *CHALYBEATE, FERRUGINOUS, OR MARTIAL WATERS.* (*Aquæ minerales ferruginosæ; aquæ martiales*).—Oxide of iron is a constituent of most mineral waters, and when the quantity is considerable, the term *chalybeate* is applied to them. Chalybeate waters have an inky, styptic taste, and the property of becoming purplish black on the addition of tannic or gallic acids, or of substances which contain these, as the infusion of galls or of tea. If the iron be in the state of sesquioxide, the ferrocyanide of potassium causes a blue, and sulphocyanide of potassium a red colour.

Most chalybeate waters contain the carbonate of the protoxide of iron; and are termed *carbonated-chalybeates.* Such waters, when exposed to the air, evolve carbonic acid, attract oxygen, and deposit the sesquioxide of iron. By boiling also, the whole of the iron may be precipitated as sesquioxide. When the protocarbonate of iron is associated with a considerable quantity of free carbonic acid, the waters are termed *acidulous-carbonated-chalybeates*, or simply *acidulous-chalybeates;* as the celebrated waters of Spa in Belgium. When a carbonated-chalybeate contains alkaline and earthy salts, but not much free carbonic acid, it is termed a *saline-carbonated-chalybeate;* as the waters of Tunbridge Wells, Oddy's saline chalybeate at Harrowgate, and the Islington Spa near London.

In some cases the oxide of iron is in combination with sulphuric acid: these waters might be termed, in contradistinction to the above, *sulphated-chalybeates.* Exposure to the air, or boiling, does not precipitate all the iron, and in this they are distinguished from the carbonated-chalybeates. The sulphated-chalybeates usually contain sulphate of alumina, and, in that case, are termed *aluminous-chalybeates:* of these, the Sand Rock Spring, Isle of Wight, the strong Moffatt Chalybeate, and Vicar's Bridge Chalybeate, are examples: the last-mentioned is probably the strongest chalybeate in existence.

The effects of chalybeate waters are analogous to those of other ferruginous compounds which I shall have occasion to notice in a subsequent part of this work, and to which, therefore, I must refer for further information. I may, however, mention here that these waters are tonic, stimulant, and astringent, and produce blackening of the stools. The acidulous-carbonated-chalybeates sit more easily on the stomach than other ferruginous agents, in consequence of the excess of carbonic acid present. The aluminous-chalybeates are very apt to occasion cardialgia, especially if taken in the undiluted state.

The use of this class of waters is indicated in cases of debility, especially when accompanied with that state of system denominated anæmia. It is contra-indicated in plethoric, inflammatory, febrile, and hæmorrhagic conditions.

CLASS 2. *SULPHUREOUS OR HEPATIC WATERS.* (*Aquæ minerales* *sulphureæ* seu *hepaticæ*).—These waters are impregnated with hydrosulphuric acid (sulphuretted hydrogen); in consequence of which they have the odour of rotten eggs, and cause black precipitates (metallic sulphurets) with solutions of the salts of lead, silver, copper, bismuth, &c. Those sulphureous waters which retain, after ebullition, their power of causing these precipitates, contain a sulphuret (hydrosulphuret) in solution, usually of calcium or sodium. All the British sulphureous waters are cold, but some of the continental ones are thermal. The most celebrated sulphureous waters of England are those of Harrowgate; those of Scotland are Moffatt and Rothsay; of the continent, Enghien, Baréges, Aix, and Aix-la-Chapelle.

The general operation of these waters is stimulant. They are supposed to possess a specific power over the cutaneous and uterine systems. They are employed both as external and internal agents; in chronic skin diseases (as lepra, psoriasis, scabies, pityriasis, herpes, &c.)—in derangements of the uterine functions (amenorrhœa and chlorosis)—in old syphilitic cases—in chronic rheumatism and gout, and in other diseases in which sulphur or its compounds have been found serviceable, and which will be noticed hereafter. On account of their stimulant effects, they are contra-indicated in all plethoric and inflammatory conditions of system.

CLASS 3. ACIDULOUS OR CARBONATED WATERS. (*Aquæ minerales acidulæ*).—These waters owe their remarkable qualities to carbonic acid gas, which gives them an acidulous taste, a briskness, a sparkling property, and the power of reddening litmus slightly, but fugaciously, and of precipitating lime and baryta waters. When they have been exposed to the air for a short time, this gas escapes from them, and the waters lose their characteristic properties.

Most mineral and common waters contain a greater or less quantity of free carbonic acid. Ordinary spring and well waters do not usually contain more than three or four cubic inches of carbonic acid gas in 100 cubic inches of water. Dr. Henry found, in one experiment, 3·38 inches (Thomson's *System Chem.*, vol. iii. p. 193, 6th edit.). But the waters called acidulous or carbonated contain a much larger quantity. Those which have from 30 or 60 cubic inches of gas are considered rich; but the richest have from 100 to 200 or more cubic inches (Gairdner, *op. cit.* p. 30). Alibert (*Nouveaux Elémens de Thérapeutique*, tom. 3^{me}. p. 517, 5^{me}. ed.) states, that the waters of Saint Nectaire contain 400 cubic inches in 100 of the water. This is the richest of all the acidulous springs.

Some of the waters of this class contain carbonate or bicarbonate of soda: these are termed *acidulo-alkaline.* Frequently they contain carbonate of the protoxide of iron also.

The only acidulous or carbonated spring in Great Britain is that of Ilkeston, near Nottingham, and which has been described by Mr. A. F. A. Greeves (*Account of the Medicinal Water of Ilkeston*, 1833), and by Dr. T. Thomson (*Cyclopædia of Practical Medicine*, art. *Waters, Mineral*).

Those acidulous waters which owe their medicinal activity principally to the carbonic acid which they contain, act chiefly on the digestive and nervous systems, but their effects are transient. They stimulate the stomach and relieve nausea. Sometimes they occasion a sensation of fulness in the head, or even produce slight temporary intoxication. They are used in some disordered conditions of the digestive organs, especially when connected with hepatic derangement, in dropsical complaints, in uterine affections, and in various other cases, which will be more fully noticed when treating of carbonic acid. When the acidulous waters contain the protocarbonate of iron, their effects and uses are analogous to those of the ferruginous springs already noticed. The acidulo-alkaline waters are useful in the lithic acid diathesis, in gout and rheumatism, &c. The acidulous or carbonated waters are objectionable, on account of their stimulant effects, in febrile, inflammatory, and plethoric subjects.

Class 4. *Saline mineral waters* (*Aquæ minerales salinæ*).—These waters owe their medicinal activity to their saline ingredients; for although they usually contain carbonic acid, and sometimes oxide of iron or hydrosulphuric acid, yet these substances are found in such small quantities as to contribute very slightly only to the medicinal operations of the water.

Saline mineral waters may be conveniently divided into five orders, founded on the nature of the predominating ingredient.

Order 1. *Purging saline waters.*—The leading active ingredient of the waters of this order is either the sulphate of soda or the sulphate of magnesia; but the chlorides of calcium and magnesium, which are usually present, contribute to their medicinal efficacy. Those springs, in which the sulphate of magnesia predominates, are called *bitter*—as those of Epsom, Scarborough, and Seidlitz. The springs of Cheltenham, Leamington, and Spital, contain sulphate of soda. In full doses the waters of this order are mild cathartics. In small and repeated doses they act as refrigerants and alteratives. They are useful in diseased liver, dropsical complaints, habitual constipation, hæmorrhoids, determination of blood to the head, &c.

Order 2. *Saline* or *brine waters.*—The characteristic ingredient of these waters is chloride of sodium. Iodine or bromine has been recognized in some of them, and doubtless contributes somewhat to the medicinal effects. The most important brine springs of England are those of Middlewich and Nantwich, in Cheshire; Shirleywich, in Staffordshire, and Droitwich, in Worcestershire. The springs of Ashby-de-la-Zouch, in Leicestershire, contain, besides chloride of sodium, a considerable quantity of chloride of calcium. Taken in large quantities, saline or brine waters are emetic and purgative. In small but continued doses they act as alteratives, and are supposed to stimulate the absorbent system. They have been principally celebrated in glandular enlargements, especially those which are of a scrofulous nature.

Order 3. *Calcareous waters.*—Those saline mineral springs whose predominating constituent is either sulphate or carbonate of lime, or both, are denominated calcareous waters. The Bath, Bristol, and Buxton thermal waters are of this kind. When taken internally, their usual effects are stimulant (both to the circulation and the urinary and cutaneous secretions), alterative, and constipating; and are referrible, in part, to the temperature of the water, in part to the saline constituents. Employed as baths they are probably not much superior to common water heated to the proper temperature; but they have been much celebrated in the cure of rheumatism, chronic skin diseases, &c. Bath water is generally employed both as a bath and as an internal medicine in various chronic diseases admitting of, or requiring, the use of a gentle but continued stimulus; as chlorosis, hepatic affections, gout, rheumatism, lepra, &c. Buxton water, taken internally, has been found serviceable in disordered conditions of the digestive organs, consequent on high indulgence and intemperance; in calculous complaints, and in gout: employed externally, it has been principally celebrated in rheumatism. The water of Bristol Hotwell is taken in dyspeptic complaints and pulmonary consumption.

Order 4. *Alkaline waters.*—The mineral waters denominated alkaline contain carbonate or bicarbonate of soda as their characteristic ingredient. They pass insensibly into, and are, therefore, closely related to, the waters of the preceding classes. Thus springs which contain carbonate of soda, with a considerable excess of carbonic acid (as those of Carlsbad and Seltzer), are denominated acidulo-alkaline, and are classed with the acidulous or carbonated waters. Those in which carbonate of soda is associated with protocarbonate of iron and excess of carbonic acid (as Spa water), are termed chalybeate waters. The only waters in this country which contain carbonate of soda are those of Malvern, in Worcestershire; and Ilkeston, in Derbyshire, near Nottingham; but the quantity in both cases is very small. The first, which is a very pure water, contains only 0·61 parts of the carbonate in 10,000 of the water, and the second 3·355 grains in an imperial gallon. For external use the alkaline waters are principally valuable on account of their detergent qualities. When taken internally they act on the urinary organs. They may be employed in calculous complaints connected with lithic acid diathesis, in gout, in dyspepsia, &c.

Order 5. *Siliceous waters.* — Most mineral waters contain traces of silica, but some contain it in such abundance that they have been denominated siliceous. Thus in the boiling springs of Geyser and Reikum, in Iceland, it amounts to nearly one-half of all the solid constituents. In these waters the silica is associated with soda (silicate of soda) sulphate of soda, and chloride of sodium (See Dr. Black's analysis, in the *Trans. Royal Soc. Edin.* vol. iii.: also Faraday's, in Barrow's *Visit to Iceland*). I am unacquainted with their action on the body. It is probably similar to that of the alkaline waters.

Ac'idum Hydrochlo'ricum.—Hydrochlo'ric Acid.

HISTORY AND SYNONYMES.—Liquid hydrochloric acid was probably known to Geber, the Arabian chemist, in the eighth century. The present mode of obtaining it was contrived by Glauber. It has been known by the various names of *spirit of salt*, *marine acid*, and *muriatic acid*. Some modern chemists term it *chlorohydric* acid. Scheele, in 1774, may be regarded as the first person who entertained a correct notion of the composition of hydrochloric acid. To Sir H. Davy we are principally indebted for the establishment of Scheele's opinion.

NATURAL HISTORY.—It is found in both kingdoms of nature.

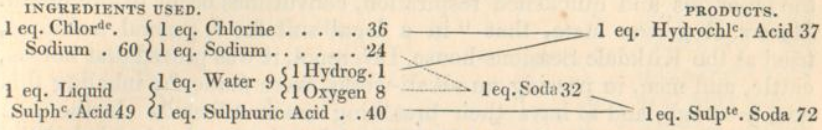
(*a.*) *In the inorganized kingdom.*—Hydrochloric acid is one of the gaseous products of volcanoes. Combined with ammonia, we find it in volcanic regions.

(*b.*) *In the organized kingdom.*—Free hydrochloric acid is an essential constituent of the gastric juice in the human subject. Hydrochlorate of ammonia (sal ammoniac) was found, by Berzelius, in the urine. Chevreul states he detected free hydrochloric acid in the juice of *Isatis tinctoria.*

1. *Gaseous Hydrochloric Acid.*

Preparation.—Hydrochloric acid, in the gaseous state, is procured by the action of strong liquid sulphuric acid on dried chloride of sodium. The ingredients should be introduced into a tubulated retort, and the gas collected over mercury. Or they may be placed in a clean and dry oil flask, and the gas conveyed, by means of a glass tube curved twice at right angles, into a proper receptacle, from which the gas expels the air by its greater gravity.

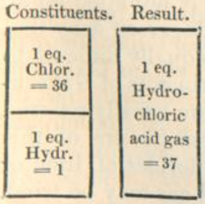
In this process, one equivalent, or 60 parts of chloride of sodium, react on one equivalent, or 49 parts of the protohydrate of sulphuric acid (strong oil of vitriol), and produce one equivalent, or 37 parts of hydrochloric acid (gas), and one equivalent, or 72 parts of the sulphate of soda.



Properties.—It is a colourless invisible gas, fuming in the air, in consequence of its affinity for aqueous vapour. It is rapidly absorbed by water. Its specific gravity is, according to Dr. Thomson, 1·2847. It has a pungent odour and acid taste. Under strong pressure (40 atmospheres) it becomes liquid. It is neither combustible nor a supporter of combustion. When added to a base (that is, a metallic oxide), water and a chloride are the results.

Characteristics.—Hydrochloric acid gas is known by its fuming in the air, by its odour, by its reddening moistened litmus paper, and by its forming white fumes with the vapour of ammonia, and by the action of nitrate of silver on an aqueous solution of the gas, as will be mentioned when describing the liquid acid.

Composition.—The composition of this gas is determined both by analysis and synthesis. Thus, one volume of chlorine gas may be made to combine with one volume of hydrogen gas, by the aid of light, heat, or electricity, and the resulting compound is two volumes of hydrochloric acid gas. Potassium or zinc heated in this acid gas, absorbs the chlorine and leaves a volume of hydrogen.



	Eq.	Eq.Wt.	Per Cent.		Vol.	Sp. gr.
Chlorine	1	36	97·297	Chlorine gas	1	2·5
Hydrogen	1	1	2·702	Hydrogen gas	1	0·0694
Hydrochl^{c}. Acid	1	37	10·000	Hydrochl^{c}. Acid gas	2	1·2847

Physiological effects.—(*a.*) *On vegetables.*— Mixed with 20,000 times its volume of atmospheric air, this gas is said by Drs. Christison and Turner (Christison's *Treatise on Poisons*) to have proved fatal to plants, shrivelling and killing all the leaves in twenty-four hours. But, according to Messrs. Rogerson (*Medical Gazette*, vol. x. p. 312) it is not injurious to vegetables when mixed with 1500 times its volume of air. Dr. Christison ascribes these different results to Messrs. Rogerson having employed glass jars of too small size. We have good evidence of the poisonous operation of this gas on vegetables in the neighbourhood of those chemical manufactories in which carbonate of soda is procured from common salt. The fumes of the acid which issue from these works have proved so destructive to the surrounding vegetation, that in some instances the proprietors have subjected themselves to actions at law, and have been compelled either to pay damages, or to purchase the land in their immediate neighbourhood.

(*b.*) *On animals* this gas acts injuriously, even when mixed with 1500 times its volume of atmospheric air. Mice or birds introduced into the pure gas struggle, gasp, and die, within two or three minutes. Diluted with atmospheric air, the effects are of course milder, and in a ratio to the quantity of air present. In horses it excites cough and difficulty of breathing. When animals are confined in the dilute gas, in addition to the laborious and quickened respiration, convulsions occur before death. Messrs. Rogerson state, that "in a legal suit for a general nuisance, tried at the Kirkdale Sessions-house, Liverpool, it was proved that horses, cattle, and men, in passing an alkali-works, were made, by inhaling this gas, to cough, and to have their breathing much affected. In the case of Whitehouse *v.* Stevenson, for a special nuisance, lately tried at the Staffordshire assizes, it was proved that the muriatic acid gas from a soap manufactory destroyed vegetation, and that passengers were seized with a violent sneezing, coughing, and occasional vomiting. One witness stated, that when he was driving a plough, and saw the fog, he was obliged to let the horses loose, when they would gallop away till they got clear of it." It acts as an irritant on all the mucous membranes.

(*c.*) *On man* this gas acts as an irritant poison, causing difficult respiration, cough, and sense of suffocation. In Mr. Rogerson's case, it caused also swelling and inflammation of the throat. Both in man and animals it has appeared to produce sleep.

The action of hydrochloric acid gas on the lungs is injurious in at least two ways: by excluding atmospheric air, it prevents the decarbonization of the blood; and, secondly, by its irritant, and perhaps also by its chemical properties, it alters the physical condition of the bronchial membrane. The first effect of attempting to inspire the pure gas seems to be a spasmodic closure of the glottis. Applied to the conjunctiva, it causes irritation and opacity.

USE.—It has been employed as a *disinfectant*, but is admitted on all hands to be much inferior to chlorine. The Messrs. Rogerson deny that it possesses any disinfecting property. It is perhaps equally difficult to prove or disprove its powers in this respect. The experiments of Guyton-Morveau, in purifying the cathedral of Dijon, in 1773, are usually referred to in proof of its disinfecting property. If it possess powers of this kind, they are certainly inferior to chlorine, or the chlorides of lime or soda; but, in the absence of these, hydrochloric acid gas may be tried. In neutralizing the vapour of ammonia it is certainly powerful.

APPLICATION.—In order to fumigate a room, building, or vessel, with this gas, pour some strong sulphuric acid over dried common salt, placed in a glass capsule or iron or earthen pot, heated by a charcoal fire.

ANTIDOTE.—Inhalations of the vapour of ammonia may be serviceable in neutralizing hydrochloric acid gas. Symptoms of bronchial inflammation are of course to be treated in the usual way.

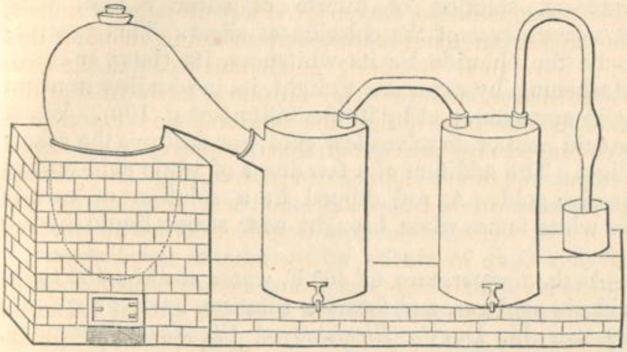
2. *Liquid Hydrochloric Acid.*

SYNONYMES.—This is an aqueous solution of hydrochloric acid, and is usually called, for brevity, *hydrochloric* or *muriatic acid.* It is the *acidum hydrochloricum* of the London Pharmacopœia.

PREPARATION.—(*a.*) *According to the Pharmacopœias.* In the London Pharmacopœia this acid is prepared by adding twenty ounces of sulphuric acid mixed with twelve fluid ounces of distilled water, to two pounds of dried chloride of sodium, placed in a glass retort. Twelve fluid ounces of distilled water are to be put into the receiver Distil by a sand bath. In the Dublin Pharmacopœia a somewhat larger quantity of water is employed. The Edinburgh Pharmacopœia orders equal weights of sulphuric acid, water, and chloride of sodium (previously heated to redness).

(*b.*) *In commerce.*—Manufacturers of hydrochloric acid generally employ an iron or stoneware pot set in brickwork over a fire-place, with a stoneware head luted to it, and connected with a row of double-necked bottles, made of the same material, and furnished with stop-cocks of earthenware. The last bottle is supplied with a safety tube, dipping into a vessel of water (fig. 40).

Fig. 40.



Apparatus for making Hydrochloric Acid.

Since the manufacture of carbonate of soda from the sulphate of soda, and the consequent necessity of obtaining the latter salt in large quantities, another mode of making hydrochloric acid has been adopted. It consists in using a semi-cylindrical vessel for the retort: the upper or flat surface of which is made of stone, while the curved portion exposed to the fire is formed of iron. The chloride of sodium is introduced at one end, which is then closed by an iron plate, perforated to allow the introduction of the leg of a curved leaden funnel, through which strong sulphuric acid is poured. The funnel is then removed, and the aperture closed. Heat being applied, the hydrochloric acid gas is developed, and is conveyed by a pipe into a double-necked stoneware bottle, half filled with water, and connected with a row of similar bottles, likewise containing water. The gas dissolves in the water, which, when saturated, constitutes the *common yellow hydrochloric acid of commerce,* which is coloured by iron. By a second distillation, at a low heat, a liquid nearly colourless is obtained, which is sold as *pure* hydrochloric acid.

The *theory* of the above process is precisely that already explained in the manufacture of hydrochloric acid gas. The salt is dried, to expel any water which may be mechanically lodged between the plates of the crystal, and to obtain uniform weights. The Edinburgh

College order the chloride to be heated to redness, to decompose any nitrate which which may be present; and, in order to insure the complete decomposition of the salt, employ a large excess of sulphuric acid, so that the residual salt is the bisulphate of soda.

Properties.—Pure liquid hydrochloric acid is colourless, evolves acid fumes in the air, and possesses the usual characteristics of a strong acid. It has the odour and taste of the gaseous acid. Its specific gravity varies with its strength. That of the London Pharmacopœia is 1·16. It is decomposed by some of the metals (as zinc and iron), hydrogen gas being evolved, while a chloride is formed in solution. It is decomposed by those oxyacids which contain five atoms of oxygen—namely, nitric, chloric, iodic, and bromic acids: the oxygen of these acids unites with the hydrogen of the hydrochloric acid to form water. It combines with ammonia, as well as with the vegetable alkalies, to form a class of salts called hydrochlorates or muriates. When it acts on a metallic oxide, water and a chloride are generated.

Characteristics.—A solution of nitrate of silver causes, with hydrochloric acid, a precipitate of the chloride of silver. This precipitate is known to be the chloride by its whiteness, its clotty or curdy appearance, its blackening by exposure to light, its insolubility in nitric acid, its solubility in ammonia, and by its fusibility (see p. 105). When pure, hydrochloric acid neither dissolves leaf gold, nor destroys the colour of sulphate of indigo. The addition of a few drops of nitric acid readily enables it to dissolve gold. A rod dipped in a solution of caustic ammonia produces white fumes when brought near strong liquid hydrochloric acid.

Composition.—At the temperature of 40° F. water absorbs 480 times its bulk of hydrochloric acid gas, and forms a solution, having a specific gravity of 1·2109 (Sir H. Davy's *Elements of Chemical Philosophy*, p. 252). Prepared according to the London Pharmacopœia, liquid hydrochloric acid has a sp. gr. of 1·16, and contains about a third of its weight of hydrochloric acid gas.

Sp. gr. of liquid acid.	Hydrochloric acid gas in 100 of liquid.	Authority.
1·16	32·32	Mr. E. Davy.
1·162	33·945	Dr. Thomson.
1·1620	32·621	Dr. Ure.
1·1641	33·029	
1·1661	33·437	
1·1681	33·845	

100 grains of liquid hydrochloric acid sp. gr. 1·16 should saturate 132 grains of crystallized carbonate of soda. A better substance for ascertaining the strength of the acid is pure Carrara marble (carbonate of lime): every 50 grains dissolved indicates 37 grains of real hydrochloric acid.

The *Acidum hydrochloricum dilutum* of the London Pharmacopœia is composed of four fluid ounces of the strong liquid hydrochloric acid, and twelve fluid ounces of water. One fluidrachm of it saturates very nearly 32 grains of crystallized carbonate of soda (Phillips, *Translation of the Pharmacopœia*).

Impurities.—The ordinary impurities of the common liquid hydrochloric acid of the shops are perchloride of iron, sometimes a little free chlorine, and occasionally a little sulphuric acid. Dr. T. Thomson suspects that bromine may be present, partly because this substance has been found in common salt, and partly because a small quantity of this substance gives a yellow colour to pure hydrochloric acid.

The presence of *iron* is shewn by saturating the acid with carbonate of soda, and then applying tincture of nutgalls, which produces a black tint. Another mode is to supersaturate the liquid with ammonia or its sesquicarbonate, by which the red or sesquioxide of iron will be precipitated.

If the liquid acid contain either *free chlorine* (or *bromine*) it will possess the power of dissolving leaf-gold, or even of decolourizing a small quantity of sulphate of indigo. A solution of protochloride of tin produces a purplish colour with a solution of gold.

Sulphuric acid (free or combined) may be detected by adding to the suspected acid a solution of chloride of barium: if sulphuric acid be present, a heavy white precipitate of sulphate of baryta is procured, which is insoluble in both acids and alkalies. In applying this test the suspected acid should be previously diluted with five or six times its volume of water; otherwise a fallacy may arise from the crystallization of the chloride of barium.

PHYSIOLOGICAL EFFECTS.—(*a*.) *On dead animal matter.*—Very dilute hydrochloric acid, mixed with dried mucous membrane, has the property of dissolving various animal substances (as coagulated albumen, fibrin of the blood, boiled meat, &c.), and of effecting a kind of artificial digestion of them, somewhat analogous to the natural digestive process—(Müller, *Elements of Physiology*, p. 544).

(*b*.) *On living animals.*—The effects of liquid hydrochloric acid on living animals (horses and dogs) have been investigated by Sproegel, Courton, Viborg (Wibmer, *die Wirkung der Arzneimittel und Gifte*), and by Orfila (*Toxicologie Générale*). Thrown into the veins it coagulates the blood, and causes speedy death. Small quantities, however, may be injected without giving rise to fatal results. Thus Viborg found that a horse recovered in three hours from the effects of a drachm of the acid diluted with two ounces of water, thrown into a vein. Administered by the stomach to dogs, the undiluted acid acts as a powerful caustic poison. Exhalations of the acid vapours take place through the mouth and nostrils, and death is generally preceded by violent convulsions.

(*c*.) *On man.*—Properly diluted, and administered *in small but repeated doses*, hydrochloric acid produces the usual effects of a mineral acid before described (pp. 80, 81, and 84): hence it is tonic, refrigerant, and diuretic. It usually causes a sensation of warmth in the stomach, relaxes the bowels, and increases the frequency of the pulse. *Larger doses* are said to have excited giddiness and a slight degree of intoxication or stupor. In a *concentrated form* it operates as a powerfully caustic poison. The only recorded case of poisoning by it (in the human subject) with which I am acquainted, is that mentioned by Orfila (*Toxicolog. Générale*). The particular nature of the chemical changes effected by it in the organic tissues with which it comes in contact, is not so well understood as in the case of sulphuric or nitric acid. Its chemical action is less energetic than either of the acids just mentioned.

USES—(*a*.) *Internal* or *remote*.—Hydrochloric acid has been employed in those diseases formerly supposed to be connected with a putrescent condition of the fluids; as the so-called putrid and petechial fevers, malignant scarlatina, and ulcerated sore throat. It is usually administered, in these cases, in conjunction with the vegetable tonics; as cinchona or quassia. We frequently employ it to counteract phosphatic deposits in the urine. After a copious evacuation, it is, according to Dr. Paris, the most efficacious remedy for preventing the generation of worms; for which purpose the infusion of quassia, stronger than that of the Pharmacopœia, is the best vehicle. It has been employed with benefit in some forms of dyspepsia. Two facts give a remarkable interest to the employment of this acid in dyspeptic complaints; namely, that it is a constituent of the healthy gastric juice; and, secondly, when mixed with mucus, it has a solvent or digestive power in the case of various articles of food, as before mentioned. Lastly, hydrochloric acid has been used in scrofulous and venereal affections, in hepatic disorders, &c.

(*b.*) *External.*—In the concentrated form it is employed as a caustic to destroy warts, and as an application in sloughing phagedæna, though for the latter purpose it is inferior to nitric acid. Properly diluted it forms a serviceable gargle in ulceration of the mouth and throat. The objection to its use as a gargle is its powerful action on the teeth: to obviate this as much as possible, the mouth is to be carefully rinsed each time after using the gargle. It is sometimes applied to ulcers of the throat by means of a sponge. Water acidulated with this acid has been applied to frostbitten parts, to chilblains, &c. An injection composed of from 8 to 12 drops of the acid to three or four ounces of water, has been employed as an injection in gonorrhœa.

ADMINISTRATION.—It is given, properly diluted, in doses of from five to fifteen or twenty minims. The *diluted* acid of the Pharmacopœia may be administered in doses of from half a fluidrachm to one fluidrachm. The most agreeable mode of exhibiting it is in the infusion of roses, using the hydrochloric instead of sulphuric acid.

ANTIDOTES.—In a case of poisoning by this acid, the antidotes are chalk, whiting, magnesia or its carbonate, and soap; and in the absence of these, oil, the bicarbonated alkalies, milk, white of egg, or demulcents of any kind. Of course the gastro-enteritis is to be combated in the usual way.

ORDER 6.—NITROGEN, AND ITS COMPOUNDS WITH OXYGEN AND HYDROGEN.

Nitrogé'nium.—Ni'trogen.

HISTORY AND SYNONYMES.—This gas was first recognised by Dr. Rutherford, in 1772. He termed it *mephitic air*. Priestley called it *phlogisticated air*. Lavoisier, *a'zote* (*azo'tum*). Cavendish, finding it to be a constituent of nitric acid, gave it the name it now usually bears (nitrogen).

NATURAL HISTORY.—It is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—It has not hitherto been found in non-fossiliferous rocks. It is a constituent of coal, of nitrates, of ammoniacal salts, and of some mineral waters. It forms 79 or 80 per cent. of the atmosphere.

(*b.*) *In the organized kingdom.*—It is a constituent of various vegetable principles, as the organic alkalies, gluten, and indigo blue; and is particularly abundant in the families *Cruciferæ* and *Fungi*. It enters into the composition of most animal substances, as albumen, fibrin, gelatine, mucus, urea, uric acid, &c. It is found in the swimming bladders of fishes.

Preparation.—The readiest method of procuring nitrogen is to burn a piece of phosphorus in a confined portion of atmospheric air. The phosphorus combines with the oxygen of the air and forms metaphosphoric acid. The residual gas after being thoroughly washed is nearly pure nitrogen.

Properties.—It is a colourless, odourless, tasteless gas; neither combustible nor a supporter of combustion. It neither reddens litmus, nor whitens lime water. Its sp. gr. is 0·9722. It is very slightly absorbed by water. Its equivalent by weight is 14, by volume 1.

1 eq.
Nitrog.
= 14

Characteristics.—Nitrogen is usually distinguished by its negative properties just described. The only positive test for it is combining it with oxygen to form nitric acid. This may be effected in two ways; either by electrifying a mixture of nitrogen and oxygen, or by burning a stream of hydrogen in a mixture of oxygen and nitrogen. The nitric acid thus produced reddens litmus, and when absorbed by potash may be recognised by the tests hereafter to be mentioned. (See *Nitric Acid.*)

Physiological effects.—The effects of nitrogen gas on vegetables and animals are analogous to those of hydrogen before mentioned (p. 126). Thus, when inspired, it acts as an asphyxiating agent, by excluding oxygen; when injected into the blood it acts mechanically only. It is an essential constituent of the air employed in respiration.

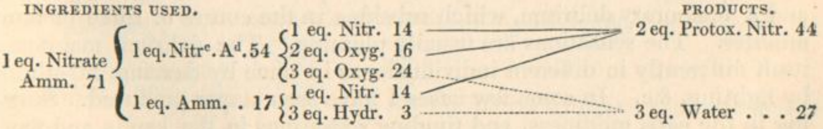
Uses.—It has been mixed with atmospheric air, and inspired in certain pulmonary affections, with the view of diminishing the stimulant influence of the oxygen, and thereby of acting as a sedative. (*Dict. Mat. Med.*)

Nitrogé'nii Protox'ydum.—Protox'ide of Ni'trogen.

History and Synonymes.—This gas was discovered by Dr. Priestley in 1776. He termed it *dephlogisticated nitrous air*. Sir H. Davy, in his "*Researches*" on it, calls it *nitrous oxide*. Its common name is *laughing gas*.

Natural History.—This compound is always an artificial production.

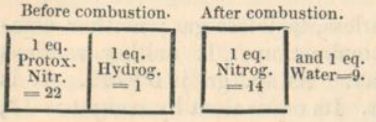
Preparation.—It is obtained by heating nitrate of ammonia in a glass retort. Every equivalent or 71 parts of the salt are resolved into three equivalents or 27 parts of water, and two equivalents or 44 parts of protoxide.



Properties.—At ordinary temperatures and pressure it is a colourless gas, with a faint not disagreeable odour, and a sweetish taste. It is not combustible, but is a powerful supporter of combustion, almost rivalling in this respect oxygen gas. Protoxide of nitrogen does not affect vegetable colours. It undergoes no change of colour or of volume when mixed with either oxygen or the binoxide of nitrogen.

Its equivalent, by weight, is 22, by volume 1. Its sp. gr. according to Dr. T. Thomson, is 1·5277. When subjected to a pressure of 50 atmospheres, at 45° F., it is condensed into a limpid colourless liquid.

Characteristics.—The only gas with which it is possible to confound it, is oxygen, with which it agrees in being colourless, not combustible, but a powerful supporter of combustion, re-inflaming a glowing match. It may be readily distinguished by mixing it with an equal volume of hydrogen, and exploding it by the electric spark, by which we obtain one volume of nitrogen and an equivalent or 9 parts of water.



Composition.—It consists of one equivalent or 14 parts of nitrogen, and one equivalent or 8 parts of oxygen; or, by measure, a volume of nitrogen and half a volume of oxygen condensed into the space of a volume.

	Eq.	Eq.Wt.	Per Cent.	Davy.		Vol.	Sp. gr.
Nitrogen	1	14	63·6	63·3	Nitrogen gas	1	$0{\cdot}972\dot{2}$
Oxygen	1	8	36·4	63·7	Oxygen gas	0·5	$0{\cdot}555\dot{5}$
Protoxide Nitrogen	1	22	100·0	10·0	Protox. Nitrogen gas	1	$1{\cdot}527\dot{7}$

Physiological effects. (*a*.) *On vegetables.*—Germinating seeds (peas) when watered with a solution of this gas seemed unaffected by it. Plants introduced into vessels filled with the gas mostly faded in about three days, and died shortly after. (Davy's *Researches.*) But Drs. Turner and Christison did not find that it was injurious to vegetation. (Christison, *On Poisons*, p. 756).

(*b.*) *On animals.*—The effects of this gas on insects, annelides, mollusca, amphibials, birds, and mammals, were examined by Sir H. Davy. On all it acted as a positive poison. It produced "peculiar changes in their blood and in their organs, first connected with increased living action; but terminating in death." (Davy, p. 449). Slowly injected into the veins of animals, considerable quantities were found by Nysten to produce slight staggering only; larger quantities produced the same disorder of the nervous system noticed when the gas is respired. (*Recherches*, p. 77 and 78).

(*c.*) *On man.*—When inhaled its effects on the nervous system are most remarkable: I have administered this gas to about one hundred persons, and have observed that after the respiration of it from a bladder for a few seconds, it usually causes frequent and deep inspirations, blueness of the lips and countenance, an indisposition to part with the inhaling tube, and a temporary delirium, which subsides in the course of three or four minutes. The sensations are usually pleasing. The delirium manifests itself differently in different individuals, as in some by dancing, in others by fighting, &c. In some few cases I have seen stupor produced. Singing in the ears, giddiness, and tingling sensations in the hands and feet, are sometimes experienced.

Uses.—It has been employed in some few cases only of disease. Beddoes used it in paralysis with benefit; but found it injurious to the hysterical and exquisitely sensible. (Davy's *Researches*, p. 542). In a remarkable case of spasmodic asthma, related by Mr. Curtis (*Lancet*, vol. ii. for 1828 and 1829), it acted beneficially. In a second case it also gave relief.

Ac'idum Ni'tricum.—Ni'tric Ac'id.

History and Synonymes.—This acid was known in the seventh century to Geber, who termed it *solutive water*, (*Of the Invention of Verity*, ch. xxi. and xxiii.) The nature of its constituents was shown by Cavendish in 1785, and their proportions were subsequently determined by Davy, Gay-Lussac, and Thomson. It has been known by various names, as *Glauber's spirit of nitre*, and *aquafortis*.

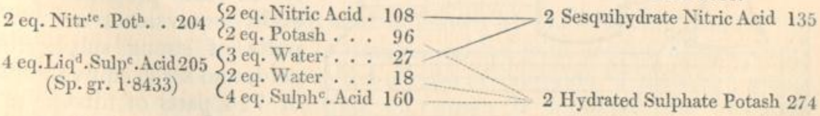
Natural History.—It is found in both kingdoms of nature.

(*a*.) *In the inorganized kingdom.*—Combined with potash, soda, lime, or magnesia, it is found on the surface of the earth in various parts of the world. The nitrates have been found in some few mineral waters. Thus there is a district of Hungary, between the Carpathians and the Drave, where all the springs, for the space of about 300 miles, contain a small quantity of the nitrate of potash (Gairdner, *on Mineral Springs*, p. 20).

(*b*.) *In the organized kingdom.*—Nitrate of lime has been found in *Borago officinalis*, *Urtica dioica*, *Helianthus annuus*, and *Parietaria officinalis*. Nitrate of potash has been detected in the roots of *Cissampelos Pareira*, and *Geum urbanum*; in the juice of *Chelidonium majus*; in *Apium graveolens;* and sometimes in the root of *Beta vulgaris* when advanced in age. The same salt is also found in the flowers of *Verbascum*, in the rhizome of *Zingiber officinale*, in the fruit of *Areca Catechu*, in the tubercle of *Cyperus esculentus*, in *Agaricus acris*, and *A. edulis* (Decandolle, *Physiol. Végét.* t. 1er. pp. 383, 387, and 403).

Preparation. (*a*.) *In the Pharmacopœia.*—In the London Pharmacopœia we are directed to mix in a glass retort two pounds of dried nitrate of potash with an equal weight of strong liquid sulphuric acid, and to distil the nitric acid in a sand bath. Mr. Phillips (*Translation of the Pharmacopœia*) says that this process yields nitric acid of sp. gr. 1·5033 to 1·504.

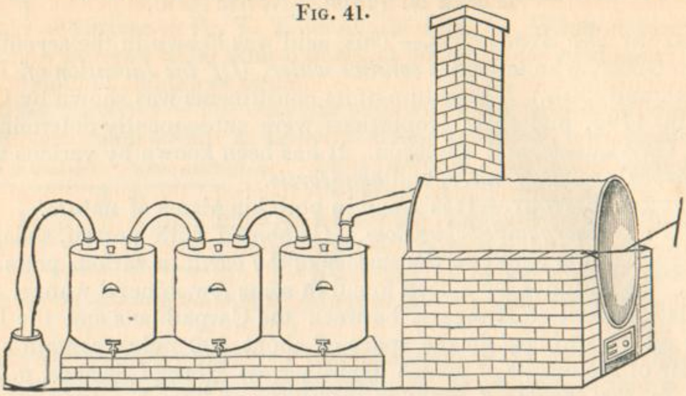
The explanation of the changes which take place is somewhat modified by the strength of the sulphuric acid employed. According to Mr. Phillips, the acid usually met with has a sp. gr. of 1·8433: I have found it generally somewhat below this. The acid alluded to by Mr. Phillips is composed, according to the same authority, very nearly of four equivalents or 160 parts of dry sulphuric acid, and five equivalents or 45 parts of water. These quantities re-act on two equivalents or 204 parts of nitrate of potash, and produce two equivalents or 135 parts of strong liquid nitric acid (sesquihydrate), and one equivalent or 274 parts of the hydrated bisulphate of potash.



Instead of the glass retort directed in the Pharmacopœia, manufacturers generally employ an iron or stone-ware pot, with a stone-ware head, which is connected with a row of double-necked stone-ware bottles. (See fig. 41, p. 158).

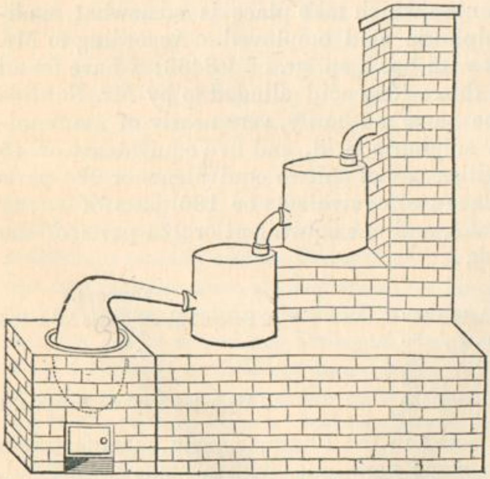
(*b*.) *For commercial purposes.*—The ordinary nitrous and nitric acids of commerce are prepared in an iron cylinder set in brickwork over a fire-place (fig. 41). 168lbs. of nitrate of potash are introduced at one end of the cylinder, which is afterwards closed by a circular disk of iron perforated to allow of the introduction of a leaden funnel, through which are poured 93lbs. of strong sulphuric acid (sp. gr. 1·845). The funnel is then removed, the aperture closed, and heat applied. The vapours are conveyed into a row of five or six bottles of stone-ware filled to about one-sixth of their capacity with water. The acid obtained by this process is brown and fuming, and has a sp. gr. of 1·45. It is called in commerce *nitrous acid*, or *fuming nitric acid*. To render it colourless it is heated in a glass retort, placed in a sand bath: the vapour which escapes is passed through two stone-ware bottles to save any acid that may be expelled, and is subsequently conveyed into a chimney (fig. 42). The colourless acid remaining in the retort has a sp. gr. of about 1·44, and constitutes the *nitric acid* of commerce. The residue in the iron cylinder is a mixture of sulphate with a little bisulphate of potash, and is sold as *sal enixum*. It is employed as a flux, and by the alum-makers*.

Fig. 41.



Nitric Acid Apparatus.

Fig. 42.



Apparatus for the purification of coloured nitric acid.

The quantity of the ingredients employed in the above process is nearly in the proportion of eight equivalents or 392 parts of strong sulphuric acid, and seven equivalents or 714 parts of nitrate of potash. Some manufacturers employ two parts by weight of nitrate of potash

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* For the above information I am indebted to Messrs. White, nitric acid manufacturers, Castle Street, Saffron Hill, London, who have kindly permitted me to make the above sketches of their apparatus.

and one of strong sulphuric acid, or about an equivalent of each of the ingredients. As the water of the sulphuric acid is not sufficient in quantity to form liquid nitric acid with all the acid set free from the nitrate, a part of the nitric acid is decomposed into nitrous acid and oxygen. It is the presence of nitrous acid which communicates the red colour to the commercial or fuming nitric acid.

The generation of nitrous acid is greatest at the commencement and towards the close of the operation: for at the commencement the excess of uncombined sulphuric acid attracts water from the small quantity of nitric acid then set free, in consequence of which the latter is resolved into nitrous acid and oxygen: about the middle of the process, when the quantity of free nitric acid has increased while that of sulphuric acid has diminished, the former passes over with water, unchanged: but towards the end of the process, owing to the volatilization of the nitric acid, the sulphuric acid becomes again predominant, and the red vapours of nitrous acid then make their appearance.

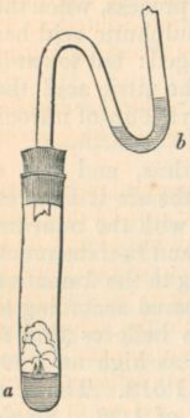
PROPERTIES. — Strong liquid nitric acid is colourless, and has a peculiar odour, and an acrid, intensely sour taste. In the air it evolves white fumes, formed by the union of the acid vapour with the aqueous vapour of the atmosphere; these fumes redden litmus, and become much whiter when mixed with the vapour of ammonia, owing to the formation of the nitrate of ammonia. The sp. gr. of the acid prepared according to the Pharmacopœia is 1·5033 to 1·504, and Mr. Phillips believes this to be the strongest procurable; but Proust obtained it as high as 1·62, Kirwan 1·554, Davy 1·55, Gay-Lussac 1·510, Thenard 1·513. The acid sold in the shops as *double aquafortis* has a sp. gr. of 1·36. *Single aquafortis* is of sp. gr. 1·22. It has a powerful affinity for water, and, when mixed with it, heat is evolved.

Nitric acid is easily deprived of part of its oxygen. Thus exposure to solar light causes the evolution of oxygen and the production of nitrous acid, which gives the liquid a yellow, orange, or reddish brown colour. The acid thus coloured may be rendered colourless by the application of a gentle heat, to drive off the nitrous acid. Several of the non-metallic combustibles rapidly decompose nitric acid, as charcoal, phosphorus, sugar, alcohol, volatile oils, resins, &c. The acid is unacted on by leaf gold, platinum, &c. Some of the metals also act powerfully on it, as copper (in the form of turnings) and tin (in the state of foil). A little water added to the acid facilitates, in some cases, the action of metals on it. For an account of the anomalous relations of this acid and iron, I must refer the reader to Becquerel's *Traité de l'Electricité*, tom. v. p. 8. The hydracids (as hydrochloric acid) decompose and are decomposed by nitric acid.

CHARACTERISTICS.—Nitric acid is known by the following characters: it stains the cuticle yellow or orange: mixed with copper filings, effervescence takes place, owing to the escape of binoxide of nitrogen, and a greenish blue solution of nitrate of copper is obtained: the binoxide forms ruddy vapours in the air, by uniting with oxygen to form nitrous acid gas; and passed into a solution of the protosulphate of iron, forms a dark olive-brown coloured liquid, which has a strong affinity for oxygen, and has in consequence been employed for analysing atmospheric air: but the results obtained by it are uncertain. Morphia, brucia, or commercial strychnia, communicates a red colour to nitric acid, which is heightened by supersaturating with ammonia: powdered nux vomica renders this acid yellow or orange-coloured. If hydrochloric acid be added to nitric acid, the mixture acquires the power of dissolving leaf gold: the presence of gold in solution may be recognized by the protochloride of iron, which strikes a purple or dark colour. Lastly, saturated with pure carbonate (or bicarbonate) of potash, a nitrate of potash is procured.

The *nitrates* are known by the following characters:—they evolve oxygen when heated, and deflagrate when thrown on a red-hot cinder or charcoal; when heated with sulphuric acid they disengage nitric acid, which may be recognized by its action on morphia, brucia, or commercial strychnia; lastly, when mixed with sulphuric acid and copper turnings, they generate binoxide of nitrogen, which is readily recognized by its blackening a solution of protoxide of iron. This last-mentioned property enables us to recognize very minute portions of the nitrates. The mixture of the nitrate, copper filings, and sulphuric acid is to be put into the test-tube (fig. 43 *a.*): adapt, by means of a cork, a small curved glass tube, containing at the bend (*b*) a drop or two of the solution of the protosulphate of iron; apply heat to the mixture in the test-tube, and in a few minutes the ferruginous solution becomes brown or blackish.

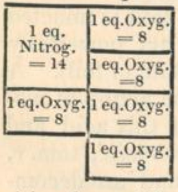
Fig. 43.



Composition.—*Anhydrous* or *dry nitric acid*, such as we find it in some nitrates, has the following composition by weight:

	Eq.	Eq. Wt.	Per Cent.	Lavoisier.	Cavendish.	Berzelius.	Davy.
Nitrogen	1	14	25·9	20	25	26	29·5
Oxygen	5	40	74·1	80	75	74	70·5
Nitric Acid	6	54	100	100	100	100	100·

Its composition by volume is, one volume of nitrogen gas and two and a half volumes of oxygen gas. The degree of condensation, however, is not known, as uncombined anhydrous nitric acid has not yet been procured.



Liquid nitric acid is composed of nitric acid and water. According to Mr. Phillips, when the specific gravity of the liquid is 1·5033 to 1·504, the composition is as follows:

	Eq.	Eq. Wt.	Per Cent.
Dry or Anhydrous Nitric Acid	1	54	80
Water	1½	13·5	20
Sesquihydrate of NitricAcid	1	67·5	100

100 grains of this acid will saturate about 217 grains of carbonate of soda.

The *dilute nitric acid* of the London Pharmacopœia is prepared by mixing a fluid ounce of the strong liquid nitric acid with nine fluid ounces of distilled water. Its sp. gr. is 1·080. 100 grains saturate about 31 grains of crystallized carbonate of soda. The following is its composition:—

Dry or Anhydrous Nitric Acid	11·44	Strong Liquid Nitric Acid (sesquihydrate)	14·3
Water	88·56	Water	85·7
Dilute Nitric Acid	100·00		100·0

IMPURITIES.—The presence of nitrous acid is known by the colour. To detect chlorine or the chlorides, dilute with distilled water, and apply nitrate of silver; a white chloride of silver is precipitated. To recognise sulphuric acid, add a solution of chloride of barium to the diluted acid; a heavy insoluble white sulphate is thrown down. Any fixed impurities may be obtained by evaporating the acid by heat.

PHYSIOLOGICAL EFFECTS.—(*a.*) *On vegetables.*—Nitric acid decomposes the different vegetable tissues to which it may be applied, and gives them a yellow colour.

(*b.*) *On animals.*—Orfila found that 26 grains of commercial nitric acid injected into the jugular vein, coagulated the blood, and caused death in two minutes (*Toxicolog. Générale*). Viborg threw a drachm of the acid, diluted with three drachms of water, into the jugular vein of two horses; in two hours they were well: the blood, when drawn, was slightly coagulated (Wibmer, *die Wirkung*, &c.) Introduced into the stomach of dogs it disorganizes this viscus, and causes death in a few hours.

(*c.*) *On man.*—On the *dead body*, M. Tartra has made various experiments to determine the appearances produced by the action of nitric acid. Of course this caustic decomposes the organic textures; but the phenomena presented vary according to different circumstances,—as the quantity employed, the presence of other substances, &c.

On the *living body*, its action of course varies, with the degree of concentration or dilution of the acid. In the concentrated form the acid acts as a powerfully corrosive poison, which property it derives in part from its affinity for water, but more especially from the facility with which it gives out oxygen; so that the appearances caused by its action on some of the tissues are different from those produced by sulphuric acid. Thus the permanent yellow stain which it communicates to the cuticle is peculiar to it. Iodine, indeed, stains the skin yellow or brown, but a little caustic potash readily removes the stain when recent; whereas the yellowish stain produced by nitric acid becomes orange on the addition of an alkali or soap. Bromine also stains the skin yellow, but when recently produced, the colour may also be removed by potash. The yellow or citron stain communicated to the lining membrane of the tongue, pharynx, &c. by nitric acid is well shewn in Dr. Roupell's *Illustrations of the Effects of Poisons*. A preparation, presenting similar appearances, is preserved in the anatomical museum of the London Hospital. The yellow substance produced by the action of nitric acid on fibrine, was termed by MM. Fourcroy and Vauquelin the *yellow acid:* the same substance is probably produced by the application of nitric acid to other animal principles. This yellow substance is bitter, and is said by Berzelius to consist of yellow, altered fibrin, combined with nitric acid and with malic acid, formed by the action of some nitric acid on the fibrin. Nitric, like sulphuric acid, also chars the animal tissues, and thus, after the ingestion of it, the stomach is sometimes found blackened, as if sulphuric acid had been swallowed. The symptoms are analogous to those produced by sulphuric acid (see *Sulphuric Acid*). The yellow, citron, or orange spots, sometimes observed on the lips, chin, or head, will, when present, at once indicate the kind of acid swallowed. Sometimes the binoxide of nitrogen is evolved by the mouth.

Properly diluted, nitric acid produces effects similar to those of the other dilute acids (see pp. 81 and 84: also *Hydrochloric* and *Sulphuric Acids*). It is said, however, to act less evidently as a tonic, and to be more apt to disagree with the stomach, so that it cannot be employed for so long a period. In some cases it has excited ptyalism, and from this circumstance, as well as from the occasional benefit derived from its use in the venereal disease, it has by some writers been compared, in its operation, to mercury; a comparison founded rather on theoretical than practical considerations.

USES.—(*a.*) *Internal.*—As nitric acid produces certain effects, in common with other mineral acids, it may be used as a substitute for the latter in various diseases. Thus, it is administered in conjunction with the bitter infusions, in those conditions admitting of, or requiring, the use of tonics. Properly diluted, it is employed as a refrigerant in febrile disorders. In lithiasis, attended with phosphatic deposits in the urine, it may be used instead of the sulphuric or hydrochloric acid. In some obstinate cutaneous diseases, as impetigo, it is given to the extent of half a drachm daily in barley water (Rayer, *Treatise on the Diseases of the Skin*, p. 502). It may be employed also to relieve heartburn.

In 1793 this acid was used by Mr. Scott, a surgeon at Bombay, as a substitute for mercurial preparations, which Girtanner erroneously fancied owed their efficacy to the quantity of oxygen which they contained. Mr. Scott first tried it in chronic hepatitis, and with considerable success. He then extended its use to venereal diseases, and obtained the happiest results from it.

Subsequently, it has been most extensively employed in the last-mentioned diseases; but the success attending its use has been very variable. That it has been, and is frequently serviceable, no one can doubt who reads the immense body of evidence offered in its favour by Scott, Kellie, Albers, Prioleau, Rollo, Cruickshank, Beddoes, Ferriar, and others. But on the other hand it is equally certain that on very many occasions it has been useless. The same remark, indeed, may be made of mercury, or of any other remedy: but as an antivenereal medicine it does not admit of comparison with this metal. However, we frequently meet with syphilitic cases in which the employment of mercury is either useless or hurtful. Thus it can rarely be employed with advantage in scrofulous subjects; or in persons whose idiosyncrasies render them peculiarly susceptible to the influence of this metal; and in sloughing sores it is inadmissible. Now these are the cases in which nitric acid may be employed with benefit; and I believe the best mode of administering it is in conjunction with the compound decoction of sarsaparilla.

For further information respecting its employment, I must refer to the works of Holst (*De Acidi Nitrici usu Medico Dissertatio*, Christianæ 1818) and Mr. Samuel Cooper (*Dict. of Practical Surgery*).

(*b.*) *External.*—In the *concentrated* state, nitric acid has been employed as a powerful caustic to destroy warts, and as an application to parts bitten by rabid animals or venomous serpents, to phagedenic ulcers, &c. In order to confine the acid to the spot intended to be acted on, the neighbouring parts may be previously smeared with some resinous ointment. In sloughing phagedæna the application of strong nitric acid, as recommended by Mr. Welbank (*Medico-Chirurg. Trans.* vol. xi.) is attended with the most successful results, as I have on several occasions witnessed. The best mode of applying it is by a piece of lint tied round a small stick or skewer. When the slough is very thick, it is sometimes necessary to remove part of it with a pair of scissors, in order to enable the acid to come in contact with the living surface.

Largely *diluted* (as 50 or 60 drops of the strong acid to a pint or quart of water) it is recommended by Sir Astley Cooper as a wash for sloughing and other ill-conditioned sores.

In the form of *ointment* (*Unguentum acidi nitrici*, Ph. Dub.) it is used in various skin diseases, especially porrigo and scabies, and as an application to syphilitic sores.

Nitric acid vapour has been employed to destroy contagion, but it is probably inferior to chlorine. It was first introduced for this purpose by Dr. Carmichael Smyth (to whom Parliament granted a reward of £5000): hence these fumigations have been termed *Fumigationes nitricæ Smythianæ.* The vapour is readily developed by pouring one part of oil of vitriol over two parts of nitrate of potash in a saucer placed on heated sand.

ADMINISTRATION.—*Strong nitric acid* may be administered, in some mild diluent, in doses of from five to ten minims, three or four times daily. The *dilute nitric acid* may be given to the extent of thirty or forty minims.

The *Unguentum acidi nitrici*, Ph. Dub., also called *pommade d'Alyon*, or *oxygenized fat*, is prepared by adding 5½ fluidrachms of nitric acid to a mixture of one pound of olive oil, and four ounces of prepared hog's-lard. Binoxide of nitrogen is evolved, showing that the nitric acid is decomposed. Part of the fatty matter is oxidized, and a portion is converted into *elaïdine* (see *Unguentum hydrargyri nitratis*). This ointment has a firm consistence and a yellow colour. It is more efficacious when recently prepared.

ANTIDOTES.—Poisoning by nitric acid requires precisely the same treatment as that by sulphuric acid. (See *Sulphuric Acid*).

Ac'idum Ni'tro-hydrochlor'icum.—Ni'tro-hydrochlor'ic Ac'id.

HISTORY AND SYNONYMES.—This liquid was known to Geber (*Invention of Verity*, ch. xxiii.). It was formerly called *aqua regia*, or *nitro-muriatic acid.* Its nature was first explained by Davy.

PREPARATION.—It is readily prepared, according to the Dublin Pharmacopœia, by mixing 2 parts, by measure, of hydrochloric acid with 1 part, by measure, of nitric acid. In the arts, however, hydrochlorate of ammonia, or common salt, is often substituted for hydrochloric acid; or nitrate of potash for the nitric acid. By the re-action of one equivalent or 54 parts of nitric acid on one equivalent or 37 parts of hydrochloric acid, we obtain one equivalent or 46 parts of nitrous acid, one equivalent or 36 parts of chlorine, and an equivalent or 9 parts of water.

INGREDIENTS USED.		RESULTS.
1 eq. Hydrochl^{ic}. Acid 37	1 eq. Chlorine . 36	1 eq. Chlorine . . 36
	1 eq. Hydrogen 1	1 eq. Water . . . 9
1 eq. Nitric Acid . . 54	1 eq. Oxygen . 8	
	1 eq. Nitr^{s}. Acid 46	1 eq. Nitrous Acid 46

PROPERTIES.—It has a yellow colour. Its most remarkable property is that of dissolving gold and platinum, metals that are insoluble in either nitric or hydrochloric acid separately. It should be kept in a cool dark place; for heat rapidly expels the chlorine, while light enables it to decompose the water and to form hydrochloric acid.

CHARACTERISTICS.—It is recognised by its colour, by its power of dissolving gold, by its precipitating a solution of nitrate of silver; the precipitate being insoluble in nitric acid, but soluble in ammonia; by the production of two salts, a chloride and a nitrate, when an alkali is added to it; and by the evolution of binoxide of nitrogen on the addition of copper turnings (see *Nitric Acid*).

PHYSIOLOGICAL EFFECTS.—It is a powerfully corrosive poison, acting in a similar manner to nitric acid.

USES.—It has been employed *internally* in the same cases as nitric acid, more especially syphilis, diseases of the liver, and some of the exanthemata. *Externally* it has been used as a bath, either local or general, in syphilis and hepatic affections. In India the whole body (the head excepted) is immersed, but in this country pediluvia only are usually employed, or the body is merely sponged with it. The *nitro-muriatic bath* is prepared in wooden tubs, by adding this acid to water, until the latter becomes as acid to the taste as vinegar (from 4½ to 6 fluidounces of the acid to about 3 gallons of water in a deep narrow tub). The patient should remain in the bath from 10 to 30 or 40 minutes. It excites tingling and prickling of the skin, and is said to affect the gums and salivary glands, causing plentiful ptyalism; indeed, we are told that without the latter effect, every trial is to be regarded as inconclusive. In the passage of biliary calculi this bath is said to be remarkably effective.

ADMINISTRATION.—When taken internally the dose is three or four drops properly diluted and carefully increased.

ANTIDOTE.—Poisoning by this acid is to be treated in the same way as that by sulphuric acid.

Ammo'nia.—Ammo'nia or *Ammoni'acal Gas.*

HISTORY AND SYNONYMES.—Dr. Black, in 1756, first pointed out the distinction between ammonia and its carbonate; and Dr. Prestley (*On Air*, vol. ii. p. 369, 1790) first procured ammonia in a gaseous form. He called it *alkaline air*. It is sometimes termed *volatile alkali*, and occasionally *azoturetted hydrogen*.

NATURAL HISTORY.—Ammonia, free or combined, exists in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—Hydrochlorate and sulphate of ammonia are met with native usually in the neighbourhood of volcanoes. Aluminous sulphate of ammonia (or ammonia-alum) occurs in Bohemia. Dr. Marcet detected the hydrochlorate in sea water. This salt has also been recognized in mineral waters (Gairdner, *On Mineral Springs*, p. 15). Ammonia exists in many of the native oxides of iron, and in some chalybeate waters (*Dict. des Drogues*, t. i. p. 293).

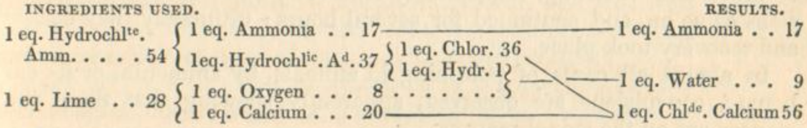
(*b.*) *In the organized kingdom.*—Ammonia is found in vegetables, in small quantities only. In the free state, it is said to exist in several plants, as *Chenopodium vulvaria*, *Sorbus aucuparia* (*Dict. des Drog.*,

p. 293), in the juice of the leaves of *Isatis tinctoria*, in the bark of *Zanthoxylum Clava Herculis*, and in *Fucus vesiculosus*. Combined with carbonic acid, it is found in *Justicia purpurea;* with nitric acid, in the extract of hyoscyamus, distilled water of the lettuce, &c. In combination with different substances, it is found in the root of *Helleborus niger*, and of *Nymphæa;* in the leaves of *Aconitum Napellus;* in the barks of *Cusparia febrifuga* and *Simaruba;* and in the fruit of *Areca Catechu* (Decandolle, *Physiol. Végét.* p. 339). Lastly, it is developed during the decomposition (spontaneous or artificial) of most vegetable substances which contain nitrogen, as gluten.

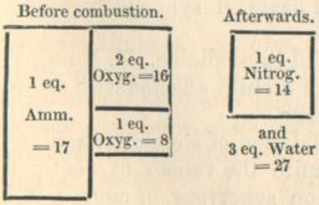
Ammonia is one of the bases found in the urine of man, where it exists in combination with phosphoric, hydrochloric, and uric acids. United to the last-mentioned acid, it exists in the excrement of the boa constrictor, and of some birds. The hydrochlorate is found in the dung of the camel. Ammonia is one of the products of the putrefaction of animal matters.

Preparation.—Ammoniacal gas is obtained by heating a mixture of hydrochlorate of ammonia and quicklime in a glass retort, and collecting over mercury. In the absence of a mercurial apparatus, the gas may be generated in a Florence flask, to the mouth of which a straight glass tube is connected by means of a cork. The bottles which are to be filled with gas are to be inverted over the tube.

In this process, one equivalent or 54 parts of hydrochlorate of ammonia are decomposed by one equivalent or 28 parts of lime; and the results of the decomposition are one equivalent or 17 parts of ammonia; one equivalent or 56 parts of chloride of calcium, and one equivalent or 9 parts of water.



Properties.—It is a colourless invisible gas, having a strong and well-known odour. It reddens turmeric paper, and changes the colour of violet juice to green; but by exposure to the air, or by the application of heat, both the turmeric paper and violet juice are restored to their original colour. The sp. gr. of this gas is 0·59. By a pressure of 6·5 atmospheres, at the temperature of 50°, it is condensed into a colourless, transparent liquid. Ammoniacal gas is not a supporter of combustion, but is slightly combustible in the atmosphere, and when mixed with air or oxygen it forms an explosive mixture. Every two volumes of ammoniacal gas require one and a half volumes of oxygen for their complete combustion. The results of the explosion are, a volume of nitrogen and some water.

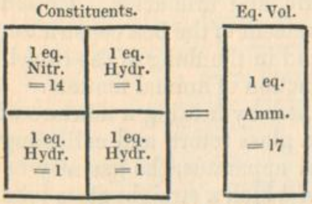


Characteristics.—It is readily recognised by its peculiar odour, its action on turmeric paper, and by its forming white fumes with hydrochloric acid or chlorine. Dissolved in water, it communicates a deep blue colour to the salts of copper, and throws down a yellow precipitate (*platino-bichloride of ammonia*) with the chloride of platinum.

Conia agrees with ammonia in evolving a vapour which reddens turmeric paper, and forms white fumes (hydrochlorate of conia) with hydrochloric acid gas.

Composition.—Ammonia is composed of hydrogen and nitrogen, in the following proportions:—

	Eq.	Eq. Wt.	Per Cent.	A. Berthollet.		Vol.	Sp. Gr.
Nitrogen	1	14	82·35	81·13	Nitrogen gas	1	0·9722$\dot{2}$
Hydrogen	3	3	17·65	18·87	Hydrogen gas	3	0·2083$\dot{3}$
Ammonia	1	17	100·00	100·00	Ammoniacal gas	2	0·5902$\dot{7}$



The annexed diagram illustrates the volumes of the constituents of the gas, and their degree of condensation when in combination to form ammoniacal gas.

Physiological Effects.—(*a.*) *On vegetables.*—Ammoniacal gas is destructive to plants, and changes their green colour to brown (Decandolle, *Physiol. Vég.*, p. 1344).

(*b.*) *On animals.*—If an animal be immersed in this gas, spasm of the glottis is immediately brought on, and death results from asphyxia. Nysten (*Recherches*, p. 140) injected some of this gas into the veins of a dog: the animal cried out, respiration became difficult, and death soon took place. Neither gas nor visible lesion was observed in the heart, the two ventricles of which contained liquid blood. In another experiment he threw ammoniacal gas into the pleura of a dog: cries, evacuation of urine, and vomiting, immediately followed; soon afterwards convulsions came on, and continued for several hours; ultimately they ceased, and recovery took place.

In almost all cases of poisoning in animals, by ammonia, or its carbonate, convulsions are observed, apparently shewing that these substances act on the spinal marrow.

(*c.*) *On man.*—Ammonia is a powerful local irritant. This is proved by its pungent odour, and its acrid and hot taste; by its irritating the eyes; and, when applied for a sufficient length of time to the skin, by its causing vesication. If an attempt be made to inhale it in the pure form, spasm of the glottis comes on: when diluted with atmospheric air, it irritates the bronchial tubes and larynx, and, unless the quantity be very small, brings on inflammation of the lining membrane. Its powerful action on the nervous system is best seen in cases of syncope (see *Aqua Ammoniæ.*)

Uses.—Ammoniacal gas is rarely employed in medicine. M. Bourguet de Béziers used it with success in the case of a child affected with croup, to provoke the expulsion of the false membrane.

Antidote.—In case of the accidental inhalation of strong ammoniacal vapour, the patient should immediately inspire the vapour of acetic or hydrochloric acid. If bronchial inflammation supervene, of course it is to be treated in the usual way.

A'qua Ammo'niæ.—Water of Ammo'nia.

History and Synonymes.—The *Liquor ammoniæ* of the London Pharmacopœia is, more properly as I conceive, denominated *aqua ammoniæ* in the United States and Edinburgh Pharmacopœias. In the Dublin Pharmacopœia it is called *aqua ammoniæ causticæ*. It has also been termed *spiritus salis ammoniaci causticus, cum calce viva paratus*.

Preparation.—(*a*.) In the London Pharmacopœia it is prepared from ten ounces of hydrochlorate of ammonia, eight ounces of lime, and two pints of water. The lime, slacked with water, is to be first put into a retort, and then the hydrochlorate of ammonia broken into small pieces: the remainder of the water is then to be added, and fifteen fluid ounces of the solution of ammonia distilled.

The theory of the process is the same as that for making ammoniacal gas just described. The equivalent proportions of hydrochlorate of ammonia and lime are 54 of the first and 28 of the latter. Now it is obvious that more lime is employed in the process of the London Pharmacopœia than is theoretically necessary, if the ingredients were pure. Yet in some other pharmacopœias the quantity is considerably greater. Thus in that of Dublin the proportions are three parts of hydrochlorate, two parts of lime, and ten parts of water. In the Edinburgh and United States Pharmacopœias the quantities are, a pound of hydrochlorate, a pound and a half of lime, a pint (or pound) of distilled water, and nine ounces of distilled water. The distilled water is placed in the receiver to absorb the gas. The advantage contended for by using this great excess of lime is the facility with which the ammonia is disengaged: but this is more than compensated in the Edinburgh and United States processes by the inconvenient bulk of the ingredients. Some excess is of course necessary to allow for impurities.

(*b*.) *In commerce*, the impure sulphate of ammonia is frequently substituted for the hydrochlorate. The apparatus employed is an iron cylinder connected with the ordinary worm refrigerator, and this with a row of double-necked stone-ware bottles containing water, analogous to those described under the head of nitric acid (see *Nitric Acid*).

Properties.—Solution of ammonia is a colourless liquid, having a very pungent odour, and a caustic alkaline taste. Its action on turmeric paper and violet juice is like that of ammoniacal gas before described. It is lighter than water, but its sp. gr. varies with its strength. In the shops a very strong solution (called *Liquor ammoniæ fortior*) is kept, having a sp. gr. 0·880: it is employed for smelling-bottles. Prepared according to the London Pharmacopœia, the sp. gr. of the water of ammonia is 0·960; according to the Dublin, 0·905; according to the United States, 0·944; and according to the Edinburgh, 0·939. The quantity of ammoniacal gas which water can dissolve varies with the pressure of the atmosphere and the temperature of the water.

Davy (*Elements of Chem. Phil.* p. 268) ascertained that at the temperature of 50°, under a pressure equal to 29·8 inches, water absorbs about 670 times its volume of gas, and becomes of sp. gr. 0·875. He drew up the following table, shewing the quantity of ammonia in solutions of different specific gravities:—

100 parts of Sp. Gr.	Of Ammonia.	100 parts of Sp. Gr.	Of Ammonia.
0·8750	contain 32·50	0·9435	contain 14·53
0·8875	29·25	0·9476	13·46
0·9000	26·00	0·9513	12·40
0·9054	25·37	0·9545	11·56
0·9166	22·07	0·9573	10·82
0·9255	19·54	0·9597	10·17
0·9326	17·52	0·9619	9·60
0·9385	15·88	0·9692	9·50

It appears from the observations of Davy and Dalton that the specific gravity of mixtures of liquid ammonia and water is exactly the mean of that of the two ingredients.

COMPOSITION.—From the above observations the composition of officinal solutions of ammonia is nearly as follows:—

	Lond. Ph. (sp. gr. 0·960)	Dub. Ph. (sp. gr. 0·950)	U. S. Ph. (sp. gr. 0·944)	Ed. Ph. (sp. gr. 0·939)	Liq. am. fort. (sp.gr.0·880)
Ammoniacal gas	10	12·5	14·5	15·8	30·5
Water	90	87·5	85·5	84·2	69·5
Liquor Ammoniæ	100	100·0	100·0	100·0	100·0

CHARACTERISTICS.—(See *Ammoniacal Gas*).

IMPURITIES.—Liquor ammoniæ frequently contains traces of the carbonate of ammonia which may be detected by lime-water, or by a solution of the chloride of calcium, either of which occasions a white precipitate of the carbonate of lime. When a portion of the liquid has been neutralized by pure nitric acid, it ought not to cause a precipitate by the addition of the nitrate of silver, of oxalic acid, or of sesquicarbonate of ammonia: for the first would indicate the presence of hydrochloric acid, or chlorine; the second, of lime; the third of lime, or other earthy matter.

INCOMPATIBLES.—It is hardly necessary to say that all acids are incompatible with ammonia. With the exception of the salts of potash, soda, lithia, lime, baryta, and strontia, ammonia decomposes most of the metallic salts.

PHYSIOLOGICAL EFFECTS.—(*a.*) *On vegetables.*—The effects of ammonia on plants have been before noticed.

(*b.*) *On animals.*—Orfila injected sixty grains of liquor ammoniæ into the jugular vein of a strong dog: tetanic stiffness immediately came on, the urine passed involuntarily, and the animal became agitated by convulsions: death took place in ten minutes. The body was immediately opened, when the contractile power of the muscles was found extinct. In another experiment, thirty-six grains of concentrated solution of ammonia were introduced into the stomach, and the œsophagus tied: in five minutes the animal appeared insensible, but in a few moments after was able to walk when placed on his feet; the inspirations were deep, and his posterior extremities trembled. In twenty hours he was insensible, and in twenty-three hours died. On dissection the mucous membrane of the stomach was found red in some places. These experiments show the effects of large doses of this solution on the nervous system. The first experiment agrees in its results (that is, in causing tetanic convulsions) with that made by Nysten, and which has been before mentioned, of throwing ammoniacal gas into the cavity of the pleura. From the convulsions it may be inferred that in these instances the (grey matter of the) spinal marrow was specifically affected.

(*c.*) *On man.* α. *Local effects.*—In the concentrated form the local action of liquor ammoniæ is exceedingly energetic. Applied to the skin it causes pain, redness, vesication, and destruction of the part; thus acting first as a rubefacient, then as a vesicant, and lastly as a caustic or corrosive. Its emanations are also irritant: when they come in contact with the conjunctival membrane, a flow of tears is the result; when inhaled, their powerful action on the air-passages is well known. Persons in syncope are observed to be almost immediately raised from a death-like state, merely by inhaling the vapour of this solution. In cases of insensibility it must be employed with great caution; for, if used injudiciously, serious or even fatal consequences may result. Nysten (*Christison's Treatise*) tells us that a physician, for some years subject to epilepsy, was found by his servant in a fit. In order to rouse his master, the latter applied a handkerchief moistened with this solution to his nose, so assiduously, that he brought on bronchitis, of which the physician died on the third day. In the *Edinburgh Medical and Surgical Journal*, there is the report of the case of a lad whose death was produced, or at least hastened, by an attendant applying, "with such unwearied but destructive benevolence," ammonia to the nose, that suffocation had almost resulted. Dyspnœa, with severe pain in the throat, immediately succeeded, and death took place forty-eight hours afterwards. A French physician also suffered ulceration of the mouth, and violent pulmonary catarrh, in consequence of the excessive use of ammonia, given as an antidote for hydrocyanic acid.

When the solution of ammonia is swallowed in large doses, it acts as a powerfully corrosive poison; but modern well-marked cases in the human subject are wanting. However, it is very evident that violent inflammation of all that part of the alimentary canal with which the poison may be in contact, would be the result, and that if much be taken, decomposition of the part might be expected. When swallowed in a very dilute form, and in small quantity, the local phenomena are not very marked, and the effect of the substance is then seen in the affection of the general system.

The chemical action of ammonia on the tissues is analogous to that of potash, hereafter to be described.

β. *Remote effects.*—The remote effects may be investigated under two heads, according as they are produced by small or large doses. *In small or therapeutic doses*, such as we are accustomed to employ in the treatment of diseases, ammonia acts as a stimulant, excitant, or calefacient. It produces a sensation of warmth in the mouth, throat, and epigastrium, frequently attended with eructations. The pulse is soon rendered quicker and fuller; the heat of the skin is sometimes increased, and there is a tendency to sweating, which, if promoted by the use of warm diluents and clothing, frequently terminates in copious perspiration. But the skin is not the only secreting organ stimulated to increased exertion; we observe the kidneys produce more urine, and frequently the quantity of bronchial mucus is increased. The nervous system is also affected. Wibmer (*die Wirkung*, &c. p. 123) has made several experiments on himself, and from them it appears that ammonia affects the head, sometimes causing oppression, or a sense of fulness, but no pain. The increased capability of muscular exertion, the excitement of the mental functions, and the greater facility with which all the functions are executed, are further indications of the action of ammonia on the nervous system. *The effects of large or poisonous doses* on the human subject have not been described: but that the nervous system is affected, seems probable from a case mentioned by Plenck, which terminated fatally in four minutes; though the symptoms are not related.

The *modus operandi* of ammonia deserves to be noticed. Does this substance become absorbed? I am not acquainted with any facts which enable us to decide this question. Even admitting that absorption does take place, it is more likely that the remote effects are of a sympathetic kind, than the result of the absorption. In calculous complaints, ammonia and its carbonate may be used with considerable advantage in those cases where potash and soda are serviceable; from which I think it probable that, like the fixed alkalies, ammonia taken into the stomach is evolved by the kidneys.

USES.—We resort to a solution of ammonia, properly diluted, on a variety of occasions, some only of which can be here noticed.

1. *To neutralize acid.*—In dyspeptic complaints, accompanied with preternatural acidity of stomach and flatulence, but without inflammation, a properly diluted solution of ammonia may be employed with a two-fold object—that of neutralizing the free acid, and of stimulating the stomach. It must be remembered that the healthy secretions of the stomach are of an acid nature, and that the continued use of ammonia, or any other alkali, must ultimately be attended with injurious results, more especially to the digestive functions. While, therefore, the occasional employment of alkalies may be serviceable, their constant or long-continued use must ultimately be deleterious.

Ammonia may, under some circumstances, be employed to neutralize acids introduced into the stomach from without, as in poisoning by the mineral acids, though chalk and magnesia would be more appropriate, being less irritant. It is a valuable antidote in poisoning by hydrocyanic acid. Its beneficial operation has been ascribed to the union of the alkali with the acid, thereby forming the hydrocyanate of ammonia; but since it has been found that this salt is highly poisonous, it is evident that this explanation is not satisfactory. Some have ascribed the activity of the hydrocyanate to its decomposition by the free acids of the stomach, and the consequent evolution of free hydrocyanic acid, but the explanation is unsatisfactory. I believe the efficiency of ammonia as an antidote to poisoning by hydrocyanic acid, arises from its exerting an influence of an opposite nature to that of the poison. In poisoning by the oil of bitter almonds, or other agents supposed to contain this acid, ammonia is equally serviceable. The remedy should be given by the stomach, if the patient can swallow, and the vapour should be cautiously inhaled.

2. *To produce local irritation, rubefaction, vesication, or destruction of the part.*—As a *local agent*, ammonia has been employed in a variety of diseases, sometimes as a rubefacient or irritant, sometimes as a vesicant, and occasionally as a caustic. Thus it is employed as a rubefacient in rheumatic and neuralgic pains, and as a counter-irritant to relieve internal inflammations. As a local irritant, a weak solution has been injected into the vagina and uterus, to excite the catamenial discharge; but there are some objections to its use. Thus, it is a most unpleasant kind of remedy, especially to young females; moreover, the stoppage of this discharge is in many cases dependent on constitutional or remote causes, and, therefore, a topical remedy is not likely to be beneficial. Lavagna employed ten or fifteen drops of the solution diluted with milk. The following is Nisato's formula:—

℞ Ammon. liquid. gtt. xl.; Decoct. Hordei, unc. viii.; Mucilag. arab. unc. dimid. Misce, et fiant quatuor intra diem injectiones.

Sometimes ammonia is employed as a vesicatory; and it has two advantages over cantharides—a more speedy operation, and non-affection of the urinary organs. It may be employed in the form of ointment or solution. As a caustic, the strong solution of ammonia may be sometimes employed with advantage in the bites of rabid animals.

3. *The vapour of the solution of ammonia may be inhaled* when we wish to make a powerful impression on the nervous system, as in syncope, or to prevent an attack of epilepsy. To guard against or relieve fainting, ammoniacal inhalations are very powerful and useful; their instantaneous operation is frequently astonishing. Pinel says he once saw an attack of epilepsy prevented by this means. The patient (a watchmaker) had intimations of the approaching paroxysm from certain feelings, but he found by inhaling the vapour of ammonia it was frequently prevented. In the case of a confirmed epilepsy, which I was in the habit of watching for some years, I think I have also seen analogous beneficial effects. I speak doubtfully, because it is so difficult to determine, in most cases, the actual approach of the fit. It is deserving of especial notice that ammonia is useful in three conditions of system, which, though produced by very different causes, present analogous symptoms; viz., idiopathic epilepsy—the insensibility and convulsions (? epilepsy) produced by loss of blood—and the insensibility and convulsions (? epilepsy) which poisonous doses of hydrocyanic acid give rise to.

In asphyxia, ammoniacal inhalations have been strongly recommended by Sage, who says that he produced the apparent death of rabbits by immersion in water, and recovered them subsequently by the use of ammonia. A case is told us of a man who had been submerged in the Seine for twenty minutes, and who, when taken out of the water, appeared lifeless, yet by the use of ammonia recovered; and a M. Routier, a surgeon of Amiens, is said to have restored a patient in the same way. That it may sometimes be of service I can readily believe, but it must be employed with great caution.

4. *Ammonia is given internally as a stimulant and sudorific* in a variety of cases with manifest advantage. In recapitulating these, I must be very brief.

(*a*.) In continued fevers which have existed for some time, and where all violent action has subsided, and the brain does not appear much disordered, ammonia is occasionally of great service. Its diaphoretic action should be promoted by diluents and warm clothing. It has an advantage over opium—that if it does no good, it is less likely to do harm.

(*b*.) In intermittent fevers, ammonia is sometimes of advantage given during the cold stage to hasten its subsidence.

(*c*.) In the exanthemata, when the eruption has receded from the skin, and the extremities are cold, ammonia is sometimes of great benefit on account of its stimulant and diaphoretic properties. But in many of these cases the recession arises from, or is connected with, an inflammatory condition of the bronchial membrane, for which the usual treatment is to be adopted.

(*d*.) In some inflammatory diseases (especially pneumonia and rheumatism) where the violence of the vascular action has been reduced by proper evacuations, and where the habit of the patient is unfavourable to the loss of blood, ammonia has been serviceable.

5. *In certain affections of the nervous system*, ammonia is frequently employed with the greatest benefit. Thus it has been used to relieve the cerebral disorder of intoxication. In poisoning by those cerebro-spinants commonly termed sedatives, such as foxglove, tobacco, and

hydrocyanic acid, ammonia is a most valuable agent. This remedy has been supposed to possess a specific influence in relieving those disorders of the nervous system accompanied with spasmodic or convulsive symptoms; and hence it is classed among the remedies denominated *antispasmodic:* but whenever it gives relief it is by its stimulant operation. Velsen, of Cleves, has used it with advantage in delirium tremens. It was a remedy frequently tried in the malignant or Indian cholera, and occasionally procured relief, but this effect was not sufficiently common to lead practitioners to place much reliance on it.

6. *Against the bites of poisonous animals*, as serpents and insects, ammonia is frequently employed with the best effects. There does not appear, however, any ground for the assertion of Sage, that it is a specific: in fact, Fontana declares it to be sometimes hurtful in viper bites.

ADMINISTRATION.—It is given in doses of from five to twenty or thirty drops properly diluted.

ANTIDOTES.—The dilute acids, as vinegar, lemon or orange juice, &c.

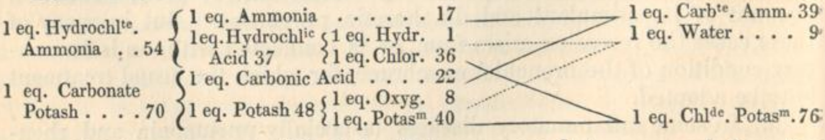
Car'bonas Ammo'niæ.—Car'bonate of Ammo'nia.

HISTORY AND SYNONYMES.—Raymond Lully, in the thirteenth century, was acquainted with carbonate of ammonia as obtained from urine; and it is probable that the Arabians had known it long before. Basil Valentine procured it by decomposing muriate of ammonia by potashes (carbonate of potash).

Carbonate of ammonia has been known by the various appellations of *sal alkali volatile siccum* seu *urinosum; sal volatile salis ammoniaci; subcarbonas ammoniæ; sal volatile cornu cervi*, &c.

NATURAL HISTORY.—(See *Ammonia.*) Carbonate of ammonia is formed during the putrefaction or destructive distillation of those organic substances which contain nitrogen.

PREPARATION, PROPERTIES, EFFECTS, AND USES.—In the pharmacopœia this salt is extracted from hydrochlorate of ammonia by carbonate of potash. The proportions employed in making the *spiritus ammoniæ*, *spiritus ammoniæ aromaticus*, and *spiritus ammoniæ fœtidus*, are ten ounces of the hydrochlorate and sixteen ounces of the carbonate. One equivalent or 54 parts of the hydrochlorate of ammonia react on one equivalent or 70 parts of carbonate of potash, and produce one equivalent or 39 parts of the carbonate of ammonia, one equivalent or 76 parts of chloride of potassium, and one equivalent or 9 parts of water.



1. *Spiritus Ammoniæ* (Ph. L.)—This compound is prepared from ten ounces of hydrochlorate of ammonia, sixteen ounces of carbonate of potash, three pints of rectified spirit, and three pints of water. This mixture is to be placed in a retort, and three pints distilled. The above-described decomposition takes place, and the carbonate of ammonia, which is produced, distils over with the spirit in which the greater part of it dissolves, the remainder being deposited in an imperfectly crystalline state. In

the Dublin Pharmacopœia, a similar compound is prepared by mixing three ounces and a half of coarsely-powdered sesquicarbonate of ammonia with three pints of heated rectified spirit; by the disengagement of some carbonic acid, carbonate of ammonia is produced, which dissolves in the spirit, every fluid ounce of which is capable of taking up thirty grains of the carbonate.

The *spiritus ammoniæ* of either of the above pharmacopœias is a transparent, colourless liquid, having a pungent smell and acrid taste. It reddens turmeric paper, and dissolves camphor and the volatile oils. Its medicinal effects and uses are analogous to caustic ammonia and the sesquicarbonate. It is less pungent than the solution of caustic ammonia, but more so than the liquor ammoniæ sesquicarbonatis. It is employed in hysteria, flatulent colic, and nervous debility, in doses of from half a drachm to a drachm, properly diluted with water. Saturated with camphor it forms a highly stimulating liniment.

2. *Spiritus ammoniæ aromaticus* (Ph. L.).—This compound, usually termed *spirit of sal volatile*, is very analogous to the last, from which it differs in the somewhat different proportions of the ingredients, and the addition of some aromatics. It is prepared from five ounces of hydrochlorate of ammonia, eight ounces of carbonate of potash, two drachms of bruised cinnamon, two drachms of bruised cloves, four ounces of lemon-peel, four pints of rectified spirit, and four pints of water. Mix, and let six pints distil. In this process, double decomposition takes place, as already noticed, and the carbonate of ammonia distils over with the spirit and part of the water, flavoured by the aromatics. This preparation is weaker than the preceding, but is more agreeable both to the taste and smell. Its effects, uses, and doses, are analogous to those of the last-mentioned compound. It is an ingredient in the *ammoniated tincture of guaiacum* and the *compound tincture of valerian*.

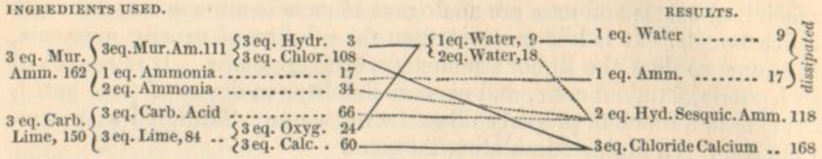
3. *Spiritus ammoniæ fœtidus* (Ph. L.).—This is prepared in the same way as the spiritus ammoniæ, except that five ounces of asafœtida are put into the retort with the other ingredients. It is prepared in the Dublin Pharmacopœia by digesting one ounce and a quarter of asafœtida in two pints of spirit of ammonia, and distilling one pint and a half. This fœtid spirit of ammonia has been very correctly declared to be useless. It is merely a solution of the volatile oil of asafœtida in spirit of ammonia, for which a mixture of the tincture of asafœtida and spirit of ammonia may be conveniently substituted. It is colourless, pungent, and fœtid, and by age becomes brownish. It is employed in hysteria in doses of half a drachm to a drachm in water.

Ammo'niæ Sesquicar'bonas.—Sesquicar'bonate of Ammo'nia.

History and Synonymes.—Though this salt must have been long known, yet, until a few years since, it was confounded with the carbonate of ammonia. It is even now frequently called *carbonate* or *subcarbonate of ammonia* in the shops. It is sometimes termed *volatile* or *smelling salts;* and occasionally *bakers' salt*, on account of its use by bakers in the manufacture of some of the finer kinds of bread.

Natural History.—(See *Ammonia* and *Ammoniæ Carbonas.*)

Preparation.—In the London Pharmacopœia we are ordered to mix a pound of powdered hydrochlorate of ammonia with a pound and a half of powdered chalk, and sublime with a gradually increased heat. In this process three equivalents or 162 parts of hydrochlorate of ammonia react on three equivalents or 150 parts of carbonate of lime, and produce two equivalents or 118 parts of the hydrated sesquicarbonate of ammonia, three equivalents or 168 parts of chloride of calcium, one equivalent or 17 parts of ammonia, and one equivalent or 9 parts of water. The chloride of calcium is left in the subliming pot, the hydrated sesquicarbonate is sublimed, while the ammonia and water are dissipated.



Sesquicarbonate of ammonia is generally procured on the large scale by subliming the ingredients in an iron pot, to which an earthen or leaden head is adapted as a receiver. As a substitute for hydrochlorate of ammonia, manufacturers frequently employ impure sulphate of ammonia; but the resulting sesquicarbonate is sometimes contaminated with a little tar or oil, and deposits a dark carbonaceous matter when dissolved in acids.

PROPERTIES.—Sesquicarbonate of ammonia is met with in the form of fibrous, white, translucent cakes, about two inches thick. When exposed to the air it evolves carbonate of ammonia, and is converted into bicarbonate of ammonia; so that its vapour has a pungent odour, and strongly reddens turmeric paper. The resulting hydrated bicarbonate is opaque, pulverent, and much less pungent, from which it has been termed *mild carbonate of ammonia*. The sesquicarbonate is soluble in four times its weight of cold water; but boiling water or alcohol decomposes it, dissolving the carbonate of ammonia, and evolving carbonic acid.

The *liquor ammoniæ sesquicarbonatis* (Ph. L.) is prepared by dissolving four ounces of this salt in a pint of water.

CHARACTERISTICS.—This is recognized as an ammoniacal salt by its odour, its fugacious action on turmeric paper, and by the action of its solution on the salts of copper and on the chloride of platinum (see *Ammonia*). From a solution of caustic ammonia it may be distinguished by the white precipitate which it produces with the calcareous salts. From the monocarbonate this salt is distinguished by the effervescence caused when it is put into boiling water or alcohol. From the bicarbonate it may be known by its greater pungency and solubility.

COMPOSITION.—This salt consists, according to Mr. Phillips (*Quarterly Journal of Science*, vol. vii. p. 294) and Dr. Thomson, of carbonic acid, ammonia, and water, in the following proportions:—

	Eq.	Eq. Wt.	Per centage.	R. Phillips.
Carbonic Acid	3	66	55·93	54·2
Ammonia	2	34	28·81	29·3
Water	2	18	15·26	16·5
Hydrated Sesquicarbonate of Ammonia	2	118	100·00	100·0

IMPURITIES.—This salt is met with in the shops of various degrees of purity. If pure, it should dissolve acids without depositing any blackish matter; it should leave no residuum when heated on platinum or glass;

it should be translucent, and not opaque and pulverent; and, lastly, its solution, saturated with pure nitric acid, should give no precipitate with chloride of barium or nitrate of silver, for the first would indicate sulphuric acid or a sulphate, the second hydrochloric acid or a chloride.

Physiological Effects (*a.*) *On vegetables.*—[See *Ammonia.*]

(*b.*) *On animals.*—The principal experimenters with this salt are Seybert, Orfila, and Gaspard, on dogs, and Wibmer on man. Seybert (quoted by Wibmer, *die Wirkung*, &c.) injected in one experiment fifteen grains, in a second twenty-five grains, and in a third experiment forty-five grains of this salt, dissolved in a little water, into the crural vein of a dog: the animal appeared to suffer great pain; the frequency of the heart's action was increased, the respiration became difficult, and violent convulsions came on; but in all these cases perfect recovery took place. The blood drawn after the injection had the natural colour, odour, and consistence. Orfila (*Toxicol. Génér.*) found that two drachms and a half of the salt, given to a dog, caused gastric inflammation, with tetanic convulsions; the body ultimately becoming curved, with the head forcibly bent backwards. Gaspard (quoted by Wibmer) killed a young pig, of three weeks old, by injecting twenty-four drops of (a solution of) carbonate of ammonia in an ounce of water into the veins. Death occurred in nine hours.

(*c.*) *On man.*—The principal experimenter here is Wibmer (*op. cit.*), who made his trials on himself. He found that a grain and a half of this salt produced no remarkable effect; three grains increased the frequency of the pulse from 68 to 72 beats per minute, with throbbing headache. In other experiments, in which he took from six to twelve grains (in some repeating the dose at short intervals), the effects were usually, but not constantly, increased frequency of pulse, with disorder of brain, manifested by the pain, heaviness, throbbing, &c. In one instance, he says, disposition to cough, and increased secretion of bronchial mucus, were remarkable.

From these and other experiments we infer, that the *local* action of this salt is that of an irritant and corrosive; but it is much less powerful than the caustic solution of ammonia, in consequence of the presence of carbonic acid, which in some degree neutralizes the alkaline properties of the ammonia. Swallowed in *moderate doses* (of about 30 grains) it occasions vomiting: in *large doses* it excites pain, inflammation, and all the consequences of an irritant poison; while the immoderate inhalation of its vapour is capable of giving rise to bronchial inflammation. The remote action of this salt is similar to that of caustic ammonia. Thus, in small doses it has the same exciting action on the heart, brain, &c. and the same diaphoretic effect. We denominate it, therefore, stimulant, sudorific, antispasmodic, antacid, and rubefacient.

Uses.—Sesquicarbonate of ammonia is used in the same cases and under the same circumstances as the solution of ammonia, to which, therefore, I must refer the reader. In some cases it is also employed in the production of effervescing draughts. The following are the relative proportions of acid and base to be used:—

20 grains of sesquicarbonate of ammonia will saturate about	6	fluidrachms of lemon juice.
	24	grains of crystallized citric acid.
	25½	grains of crystallized tartaric acid.

The *citrate* and *tartrate* of ammonia, obtained as above, are useful in allaying nausea and vomiting; they are also feebly diaphoretic, and in some cases diuretic.

Sesquicarbonate of ammonia has been employed as an emetic in paralysis. An ointment made of the finely pulverized salt and lard is a very useful rubefacient in rheumatic pains, sprains, &c. Mixed with some aromatic oil (as oil of lavender or bergamot) it is employed as a smelling salt against syncope, hysteria, &c.

ADMINISTRATION.—As a stimulant and diaphoretic this salt is used in doses of from five to ten grains, exhibited either in the form of pill or of solution. As an emetic the dose is 30 grains, properly diluted, and repeated if necessary.

ANTIDOTES.—(See *Ammonia.*)

AMMONIACAL SOAPS.—When caustic ammonia is mixed with fatty bodies (such as olive oil, lard, or mutton suet), it forms a kind of soap, composed of the fatty acids, generated by the oil and of ammonia combined with them. Two of these compounds require to be noticed:—

1. *Liniment of ammonia.*—This is prepared, according to the London Pharmacopœia, by mixing a fluid ounce of solution of ammonia with two fluid ounces of olive oil. This compound, sometimes termed *volatile liniment*, is an *oleo-margarate of ammonia;* that is, a compound of oleic and margaric acids with ammonia. It is employed as an external stimulant and rubefacient, to relieve rheumatic and neuralgic pains, sore throat, and various other complaints in which cutaneous stimulants are likely to be useful. It is the

2. *Ointment of ammonia.*—In France an ointment is employed, called *liparolé d'ammoniaque*, or *pommade ammoniacale de Grondret*, and which is composed of eight parts of solution of ammonia, seven parts lard, and one part mutton suet. This compound, rubbed on the skin, and covered by a compress, speedily produces vesication: without the compress it causes rubefaction, merely owing to the volatilization of the ammonia. It is a very useful counter-irritant and vesicant.

Liniment of sesquicarbonate of ammoniæ.—This is prepared by mixing a fluid ounce of the solution of the sesquicarbonate of ammonia with three fluid ounces of olive oil. It forms an imperfect kind of soap, owing to the presence of carbonic acid. Its uses are analogous to those of the liniment of ammonia before mentioned.

Ammo'niæ Bicar'bonas.—Bicar'bonate of Ammo'nia.

HISTORY AND SYNONYMES.—This salt was formed by Berthollet, and hence it is sometimes termed *Berthollet's neutral carbonate of ammonia.*

PREPARATION.—In the Dublin Pharmacopœia it is ordered to be prepared by passing a stream of carbonic acid through a solution of four parts of sesquicarbonate in fifteen parts of water, until the sesquicarbonate be saturated. It is then allowed to remain at rest, and crystals are deposited, which are to be dried without heat, and preserved in a close vessel.

PROPERTIES.—This salt crystallizes in irregular six-sided prisms. It has little or no smell, and less taste than the sesquicarbonate. It is less soluble than the last-mentioned salt, and its solution does not precipitate the magnesian salts, by which circumstance it may be distinguished from the carbonate of ammonia.

Composition.—The composition of this salt is the following:—

	Eq.	Eq. wt.	Per cent.	Schrader.	Berthollet.	Phillips.		Vol.
Ammonia	1	17	21·5	19	20	21·16	Ammoniacal gas	2
Carbonic Acid	2	44	55·7	56	55	55·50	Carbonic Acid gas	2
Water	2	18	22·8	25	25	23·34	Aqueous Vapour	2
Crystallized Bicarbonte. Ammonia	1	79	100·0	100	100	100·00		

Physiological Effects and Uses.—The operation and uses of this salt are analogous to those of the preceding compounds of ammonia. It is termed diaphoretic, antispasmodic, and antacid. Being less caustic, it is more palatable than the other carbonates (Barker and Montgomery's *Observations on the Dublin Pharmacopœia*).

Administration.—The dose of it is from six to twenty-four grains, dissolved in *cold* water.

Ammo'niæ Hydrochlo'ras.—Hydrochlo'rate of Ammo'nia.

History and Synonymes.—The early history of this salt is involved in considerable obscurity; for though the term *sal ammoniacus* (ἅλς ἀμμωνίακος), is met with in several old writers, it is believed, by the erudite Beckmann (*Hist. of Inventions*, vol. iv. p. 370), as well as by others, to refer to rock-salt. The first distinct notice of hydrochlorate of ammonia is to be met with in Geber, who was acquainted with the mode of purifying it by sublimation. But, as my friend Dr. Royle observes, in his *Essay on the Antiquity of Hindoo Medicine* (p. 41), this salt "must have been familiar to the Hindoos ever since they have burnt bricks, as they now do, with the manure of animals; as some may usually be found crystallized at the unburnt extremity of the kiln."

The substance, whatever its nature may be, which the ancients termed sal ammoniac, derived its name from *Ammonia*, the name of a district of Libya where the oracle of Jupiter Ammon was situated. This district took its name from ἄμμος, *sand*, on account of the nature of its soil. Herodotus (lib. iv., cap. 181 et 2) mentions the salt found in this district.

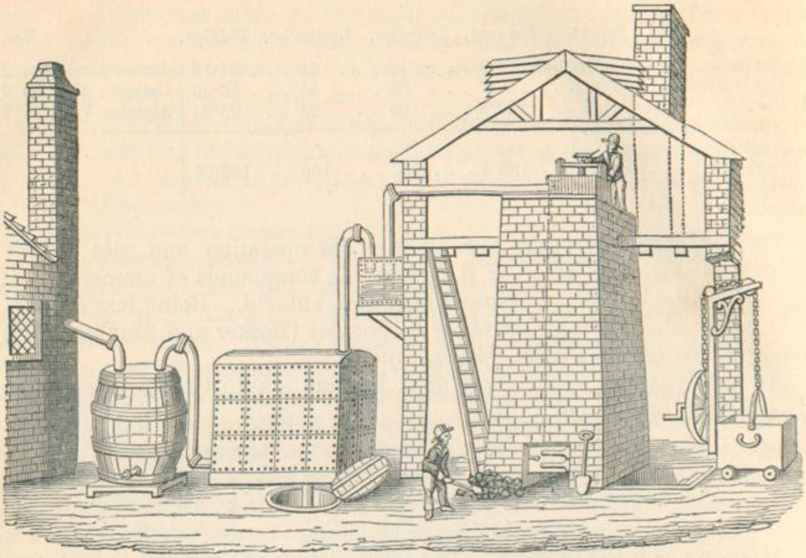
Few substances have had so many synonymes as the hydrochlorate of ammonia; but of those I shall only mention such as are now in use, namely, *muriate of ammonia*, *sal ammoniac*, and *chloride of ammonium*. For others I must refer to Dr. T. Thomson's *Hist. of Chem.* vol. i. p. 125, and *Parr's Med. Dict.*, art. *Ammoniacus*.

Natural History.—(See *Ammonia*).

Preparation. (*a.*) *By the destructive distillation of bones.*—Bones are first boiled to remove the fatty matter, which is used in soap making. The larger and finer pieces are then picked out for the manufacture of buttons, handles of tooth-brushes, of knives, &c.; while the smaller and refuse portions are sold as manure. The remaining pieces are distilled.

The still or retort is made of cast iron or of Welch bricks. In a large manufactory (fig. 44) in this metropolis, the retort (which is made of Welch bricks) is placed perpendicularly in the furnace. Its shape is a right rectangular prism, the height being twenty feet, the length about three feet, the breadth two feet: it is closed at both top and bottom by a moveable iron plate, and the fire is made around it. The bones are introduced at the upper end of the retort. The volatile products are conveyed (by an iron pipe, which opens into the upper part of the retort) first into water, and then into an iron receiver (in some places an old steam boiler is employed as a receiver) where the brown ammoniacal liquor (*bone spirit*) and the empyreumatic oil (*animal oil*) are deposited. The non-condensable portion is a fœtid inflammable gas: this, after passing through water contained in a second receiver (a cask or vat), is conveyed into a chimney, or is burned. The solid residue in the retort is removed, while red hot, through the lower and underground end of the retort into wrought-iron canisters, which are instantly closed by iron covers, luted to make them air tight, and then raised to the surface by a crane. When cold, it is powdered and sold as *ivory black*. A coarse powder is employed by sugar refiners for decolorizing saccharine liquids.

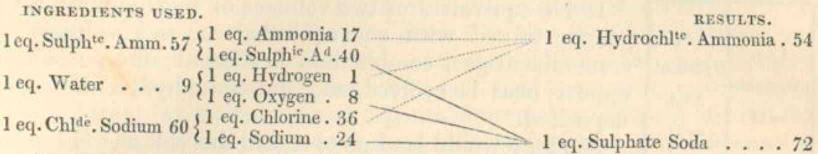
FIG. 44.



Manufacture of bone spirit (*Carbonate of Ammonia*) *and animal charcoal.*

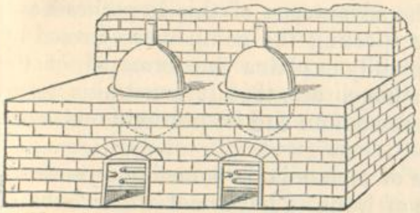
The products of this operation are easily accounted for. When bones are heated, their cartilaginous or gelatinous portion undergoes decomposition, and its elements (carbon, hydrogen, nitrogen, and oxygen) enter into new combinations. Some of the oxygen and hydrogen unite to form water. Carbon and oxygen, combining in different proportions, furnish carbonic oxide and acid. Carbon with hydrogen forms carbohydrogen; while nitrogen uniting with hydrogen produces ammonia, which, with some carbonic acid, forms carbonate of ammonia. The empyreumatic oil consists of carbon, hydrogen, and oxygen, with probably some nitrogen.

The carbonate of ammonia contained in the bone spirit is converted into sulphate, either by the addition of sulphuric acid, or by digestion on ground plaster of Paris (sulphate of lime). In the first case carbonic acid is evolved, in the latter we get carbonate of lime formed, from which the solution of sulphate of ammonia is separated by filtering. By evaporation, the solution yields brown crystals of sulphate of ammonia. This is sublimed with common salt, by which we obtain sulphate of soda and hydrochlorate of ammonia. Every equivalent or 57 parts of sulphate of ammonia re-act on one equivalent or 60 parts of chloride of sodium, and with one equivalent or 9 parts of water produce one equivalent or 54 parts of hydrochlorate of ammonia, and one equivalent or 72 parts of sulphate of soda.



(*b.*) *From coals.*—In the distillation of coal as practised at the gas-works, the volatile matters are conveyed to a condensing vessel or refrigeratory, in which are deposited tar and an ammoniacal liquor which contains several salts of ammonia—as the sulphate, carbonate, hydrocyanate, and hydrosulphate. On the addition of sulphuric acid the carbonate, hydrocyanate, and hydrosulphate are decomposed, and by evaporation brown crystals of sulphate of ammonia are obtained. This salt is mixed with chloride of sodium, and heated in an iron pot lined with clay, to which a leaden head having an open cylindrical tube is adapted (fig. 45). The hydrochlorate of ammonia is sublimed into the head of the apparatus. In the clay removed from the pots after the operation, small but perfect and beautiful crystals of the bisulphuret of iron are sometimes found. They are formed during the process. In some cases the gas liquor is saturated with hydrochloric acid, and the brown crystals of hydrochlorate obtained by evaporation are purified by sublimation. The above is a sketch of the process which I saw in operation a few years since at the Westminster Gas Works. At the present time the gas liquor is sold to sal ammoniac manufacturers, who reside in the outskirts of the metropolis.

Fig. 45.



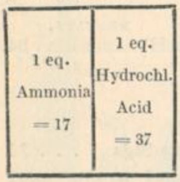
Sublimation of Hydrochlorate of Ammonia.

Properties.—Hydrochlorate of ammonia usually occurs in commerce in the form of large hemispherical cakes, which are translucent, and by exposure to the atmosphere become slightly moist. By solution or sublimation it may be obtained in regular octahedral, or cubic, or plumose crystals. Its sp. gr. is 1·450. Its taste is saline and acrid; it has no odour. When heated, it sublimes without undergoing fusion or decomposition. It is soluble in about 3 parts of cold and 1 of boiling water: cold being produced during the solution. It dissolves in alcohol.

Characteristics.—It may be recognized by the following characters: it is white and volatile; and if heated on the point of a knife by the flame of a candle, it readily sublimes. Mixed with caustic potash, or quicklime, it evolves ammoniacal gas, which is known by its odour, its action on turmeric paper, and its fuming with the vapour of hydrochloric acid. Dissolved in water the hydrochlorate of ammonia produces with a solution of nitrate of silver a white precipitate of chloride of silver, recognized by the properties before described (see p. 105): and with chloride of platinum a yellow precipitate (*the platino-chloride of ammonia*) which when collected, dried, and ignited, yields spongy platinum.

Composition.—The following is the composition of this salt:—

	Eq.	Eq.wt.	Per cent.	Kirwan.	Bucholz.	Berzel.		Vol.	Sp. gr.
Ammonia	1	17	31·48	25	31	31·95	Ammoniacal gas	2	0·59027
Hydrochl^{ic}. Acid	1	37	68·51	75	69	68·05	Hydrochl^{ic}. Acid gas	2	1·28472
Hydrochl^{te}. Amm.	1	54	100·00	100	100	100·00			



If one equivalent or two volumes of hydrochloric acid gas be mixed with one equivalent or two volumes of ammoniacal gas, combination is effected; the gases disappear, heat is evolved, and the white hydrochlorate is deposited.

Analogy would lead us to regard this salt as a chloride of some metallic base. If such a base exist, it must consist of one equivalent nitrogen and four equivalents hydrogen. Berzelius assumes the existence of this hypothetical metallic base, and calls it *ammonium*, while sal ammoniac is termed by him chloride of ammonium. The protoxide of this suppositious metal will be equal to an equivalent of ammonia and one of water. The advantages of this hypothesis are, that it obviates certain difficulties respecting the compounds formed by ammonia with the hydracids, and readily explains the formation of the ammoniacal amalgams: its disadvantages are, that it constrains us to admit the existence of two bodies (ammonium and its protoxide) hitherto not known to exist.

Impurities.—The hydrochlorate of ammonia is sometimes rendered impure by the presence of chloride of iron. I have met with cakes of this salt which when broken presented thin, yellow, concentric laminæ of what I believe to be a double salt of chloride of iron and hydrochlorate of ammonia. That the chloride of iron performs, in this yellow compound, the function of an acid, is shown by its not striking a blue colour on the addition of the ferrocyanuret of potassium.

Physiological Effects. (*a.*) *On Vegetables.*—According to Sir H. Davy (*Agricult. Chemistry*), water holding in solution 1-300 of its weight of hydrochlorate of ammonia promotes vegetation. Solutions which contained 1-30 of their weight of this salt he found to be injurious.

(*b.*) *On Animals.*—Courten (*Phil. Trans.* for 1712), Sprögel, Viborg, and Gaspard (quoted by Wibmer, *die Wirkung*, &c.), injected solutions of sal ammoniac into the veins of animals (dogs and horses): large doses generally caused convulsions, sometimes paralysis, and death. From the observations of Orfila, Smith, Arnold (Wibmer, *op. cit.*), and Moiroud (*Pharmacol. Vétérinaire*), this salt appears to be a local irritant, and when introduced into the stomach in large quantities causes vomiting, purging, and gastro-enteritis. It exercises a specific influence over distant organs, for the three first of the above-mentioned experimenters observed that inflammation of the stomach ensued, to whatever part of the body the salt might have been applied, and the convulsions and paralysis before referred to, attest its action on the nervous system. Arnold says it diminishes the plasticity of the blood.

(*c.*) *On Man.*—Wibmer tried this salt on himself. He took from ten to twenty grains for a dose, which he repeated at the end of an hour. The effects were a sensation of warmth and oppression in the stomach, headache, and increased desire of passing the urine.

In this country it is so rarely employed internally that we have very slight experience either of its physiological or of its therapeutical effects. In Germany, where it is more frequently administered, it is in high repute as a powerful alterative or resolvent. "Like most salts," says Sundelin (*Handbuch der speciellen Heilmittellehre*, 1^er^. Bd. p. 150, 3^te^. Aufl.), "sal ammoniac operates on the alimentary canal as an excito-irritant." After its absorption it appears to reduce moderately the action of the heart and large arteries, and, in this respect, belongs to debilitating or temperant agents. But it acts as excitant and irritant to the venous and arterial capillary systems, to the lymphatic vessels and glands, to the skin, to the kidneys, and especially to the mucous membranes; not only increasing secretion but also improving nutrition and assimilation, and counteracting organic abnormal conditions, (as tumors, thickenings, and relaxations), so frequently met with in those structures. It promotes not only the mucous secretions but also cutaneous exhalation, and even menstruation. Its diuretic effects are less obvious. It extends its stimulating influence to the serous and fibrous tissues, whose nutrition it improves.

"From these statements it follows that sal ammoniac operates like the more-profoundly-acting alterative agents, and even approaches, in many respects, mercury, but is especially distinguished from the latter in this, that it by no means acts to such a degree as a defluxing, nay even melting, agent on solidified organic substance and its crasis, and by its not so powerfully stimulating the lymphatic system. Its long-continued use may, indeed, injure the digestive powers, but never gives rise to general cachexia. I have administered large doses of it against thickening of the mucous membrane, for months, without remarking any injurious effects beyond those just mentioned. In large doses it purges like other salts, but in small ones rather constipates." Kraus (*Heilmittellehre*, p. 309) says, that a slight miliary eruption and very painful aphthæ have been produced by large doses of it.

USES.—In this country it is rarely employed internally. In Germany, where it is frequently used, it is administered in the following cases:—

1. *In mild inflammatory fevers*, especially these complicated with affections of the mucous or fibrous membranes, as in the diseases called bilious, gastric, catarrhal, or rheumatic fevers, it is employed for promoting secretion and hastening critical discharges.

2. *In inflammation of the mucous or serous membranes*, as catarrh, dysentery, urethritis, peritonitis, pleuritis, &c. when the first violence of the disease has been subdued, but when the secretions and exhalations are not yet established. In these cases it is used as a substitute for mercury.

3. *In chronic diseases* of various kinds, as chronic inflammation of the lungs, liver, and spleen—enlargement of the mesenteric glands—induration of the prostate, uterus, and ovaries—catarrhus vesicæ—chronic ulceration of the uterus—mucous discharges from the urethra and vagina, it is administered as an alterative, as a stimulant to the absorbent system, and as a promoter of healthy secretion.

4. *In amenorrhœa* it is strongly recommended by Sundelin (*op. cit.*), as

an emmenagogue, in those cases in which the disease depends on, or is connected with inactivity of the uterus.

Externally it is sometimes employed, on account of the cold produced during its solution, in headache, mania, apoplexy, &c. When used for this purpose it must be applied as soon as the salt is dissolved. Mr. Walker (*Phil. Trans.* 1801, p. 120) found that two parts of this salt, with five parts of nitrate of potash and sixteen parts of water, lowered the thermometer from 50° F. to 10° F. A mixture of this kind placed in a bladder has been recommended by Sir A. Cooper as an application to hernial tumors. It may be applied to the head instead of ice.

Sal ammoniac has been employed externally as a stimulant, or resolvent or discutient. Dr. Paris (*Pharmacologia*) strongly recommends the following stimulant and rubefacient plaster in pulmonary complaints and in rheumatic affections of the muscles of the chest: soap ℥i. lead plaster ʒij., liquified together, to which, when nearly cold, is added of hydrochlorate of ammonia finely powdered, ℥ss. The efficacy of this plaster depends on the evolution of ammoniacal gas in consequence of the action of the alkali of the soap on the hydrochloric acid of the hydrochlorate: hence it should be renewed every twenty-four hours. A strong solution of sal ammoniac (as one or two ounces of the salt to twelve ounces of water) is employed in the cure of contusions and ecchymosis, unaccompanied by any wound of the skin; in chronic tumors, as of the breast; in local dropsies, as hydrocele and dropsy of the thyroid gland; in chilblains; in sphacelus after the requisite scarifications, &c. Weaker solutions (as from one to four drachms of the salt to a pint of water) are employed as washes in scabies and ulcers, as gargles in cynanche, and as injections in gonorrhœa and leucorrhœa. This salt in powder is sometimes used as a tooth-powder.

Administration.—For internal use the dose of it is from five to thirty grains every two or three hours, either in a pulverent form, combined with sugar or gum, or in solution with some saccharine or mucilaginous solution, to which an aromatic should be added.

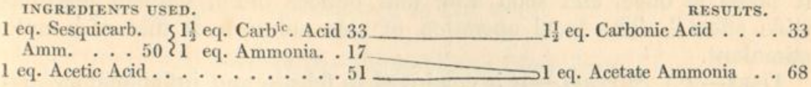
Antidote.—In the event of poisoning by this salt, warm water and mucilaginous and demulcent liquids should be given to promote vomiting. No chemical antidote or counterpoison is known. Gastro-enteritis is of course to be combated by the usual means.

Li'quor Ammo'niæ Aceta'tis.—Solution of Ace'tate of Ammo'nia.

History and Synonymes.—This solution appears to have been first described in 1732, by Boerhaave, who introduced it into the Materia Medica. It was subsequently employed by Minderer or Mindererus; and hence obtained one of its names, *spiritus* seu *liquor Mindereri.*

Natural History.—Acetate of ammonia is, I believe, always an artificial compound.

Preparation.—In the London Pharmacopœia this compound is ordered to be prepared by dissolving, in four pints of distilled vinegar, four ounces and a half (or as much as may be sufficient to saturate the acetic acid) of sesquicarbonate of ammonia. Every equivalent, or 51 parts of acetic acid, unite with one equivalent, or 17 parts of ammonia; while one and a half equivalents, or 33 parts of carbonic acid, are evolved.



In the above diagram no notice has been taken of the water in the hydrated sesquicarbonate of ammonia, nor of that in the vinegar.

PROPERTIES.—When pure, this liquid is colourless. Any tint, therefore, which the solution of the shops may have, is referrible to impurities in either the vinegar or the sesquicarbonate. Filtering it through powdered animal charcoal will usually remove any yellow or brown colour which it may have. If quite neutral, it will affect neither turmeric nor litmus paper. It is better, however, to have a slight excess of acid present than of sesquicarbonate; for if the latter predominate, the solution is much more irritant; and if employed as a collyrium, might produce inconvenient results.

CHARACTERISTICS.—It is totally dissipated by heat. When concentrated it evolves vapours of acetic acid on the addition of strong sulphuric acid, and gives out ammonia if potash or lime be mixed with it.

COMPOSITION.—By evaporating a saturated solution of acetate of ammonia under the exhausted receiver of the air-pump, and over sulphuric acid, crystals of the acetate are obtained. They are transparent oblique rhomboidal prisms, and consist, according to Dr. Thomson, of

	Eq.	Eq. wt.	Per cent.
Acetic Acid	1	51	38·931
Ammonia	1	17	12·977
Water	7	63	48·091
Crystallized Acetate Ammonia	1	131	99·999

The quantity of dry or anhydrous acetate of ammonia contained in the solution kept in the shops, varies with the strength of the distilled vinegar. Now, according to Mr. Phillips, 100 grains of distilled vinegar should saturate 13 grains of crystallized carbonate of soda. This would indicate the presence of 4·6 per cent. of acetic acid; and, consequently, 100 grains of liquor ammoniæ acetatis, prepared from such vinegar, would consist of

Acetate of Ammonia	6·040
Water	93·959
Liquor Ammoniæ Acetatis (Ph. L.)	99·999

IMPURITIES.—This solution ought neither to be discoloured by the addition of hydrosulphuric acid, nor to throw down any precipitate by nitrate of silver or chloride of barium. These substances, therefore, may be employed to detect, respectively, metallic matter, hydrochloric acid or a chloride, and sulphuric acid. Pure acetate of ammonia occasions no precipitate with diacetate or acetate of lead; but the liquor ammoniæ acetatis of the shops usually does, owing to the presence of some free carbonic acid or sesquicarbonate of ammonia.

PHYSIOLOGICAL EFFECTS.—In small doses this solution is regarded as temperant and refrigerant: in large doses, diaphoretic and diuretic. These effects, however, are not very obvious. Wibmer (*die Wirkung*, &c.) took it in moderate doses, yet did not observe any diaphoretic, diuretic, or purgative effects from it; but he experienced headache and disturbed digestion. Dr. Cullen (*Mat. Med.*) says, " I have known four ounces of it taken at once, and soon after four ounces more, without any sensible effect." The local operation of this solution is that of a mild stimulant.

USES—(*a.*) *Internal.*—It is employed in febrile and inflammatory diseases, and forms a constituent of the ordinary saline draught. It is given in conjunction with nitrate of potash, or tartar emetic, and sometimes with camphor and opium. When administered as a diaphoretic, its operation is to be promoted by the use of tepid diluents and external warmth. Its diuretic effect is assisted by keeping the skin cool, and conjoining the spirit of nitric ether.

(*b.*) *External.*—Diluted with water it is sometimes applied as a discutient wash to inflamed and bruised parts. Mixed with six or seven times its volume of rose-water, to which a drachm or two of tincture of opium may sometimes be added, it is employed as a collyrium in chronic ophthalmia.

ADMINISTRATION.—It is given in doses of half a fluid ounce to two or three ounces every five or six hours.

ORDER 7.—CARBON, AND ITS COMPOUNDS WITH OXYGEN, HYDROGEN, AND NITROGEN.

Carbo'nium.—Car'bon.

HISTORY.—The term *carbon* (from *carbo, ōnis*, coal) was first employed by Morveau, Lavoisier, and Berthollet, to designate the pure matter of charcoal. To the second of these chemists, we are indebted for demonstrating, that by combustion in oxygen gas the diamond and charcoal yield the same product; namely, carbonic acid gas.

NATURAL HISTORY.—Carbon is found in both kingdoms of nature:

(*a.*) *In the inorganized kingdom.*—When pure and crystallized it constitutes the diamond, which Sir D. Brewster (*Edinb. Phil. Journ.* vol. iii. p. 98, and *Philosoph. Mag.* vol. i. p. 147, 1827) suspects to be of vegetable origin; but a specimen described by Mr. Heuland (*Geol. Trans.*, 2nd series, i. 419), was found in a primary rock. Plumbago and anthracite consist principally of carbon. The bituminous substances (as coal, petroleum, naphtha, &c.) also contain it. These are admitted by geologists to be of vegetable origin. Carburetted hydrogen is evolved from coal strata, marshy places, stagnant waters, &c. Carbonic acid is found either in the free state, as in the atmosphere, in mineral waters evolved from the earth in old volcanic countries, &c., or combined with metallic oxides, in the form of the carbonate of lime, iron, &c. It is remarkable that carbon is rare among the older rocks (De la Beche, *Researches in Theoretical Geology*, p. 32).

(*b.*) *In the organized kingdom.*—Carbon is an essential constituent of all organized beings, vegetable or animal.

PROPERTIES.—Carbon is a solid, odourless, tasteless substance, neither fusible (?) nor volatile; combustible in oxygen gas, yielding carbonic acid gas. Its equivalent by weight is 6. Some years since Dobereiner asserted that he had discovered a metallic basis in it, but his statement has not been confirmed.

The other properties of carbon are so varied, that chemists are obliged to admit distinct varieties of this substance: the principal are the *diamond*, *plumbago*, and *charcoal* (animal and vegetable). Of these the two latter only require consideration in this work.

1. *Plumba'go.—Graph'ite* or *Black Lead.*

History.—This substance was probably known to the ancients; but it was first accurately distinguished from other bodies with which it had been previously confounded, especially with molybdena (*bisulphide of molybdenum*), by Scheele (*Essays*, p. 246), in 1779. The terms *plumbago*, *plumbum nigrum*, and *molybdena*, met with in Pliny (*Hist. Nat.*), do not apply to graphite.

Natural History.—It is found in various parts of the world; chiefly in primitive rocks and the coal formations. The finest occurs at Borrowdale, in Cumberland. It is brought to London, and sold by auction, at a public-house in Essex-street, Strand, on the first Monday in every month. The best quality usually sells for two guineas or more per pound, and is employed for making pencils. The ordinary kinds used in this country are imported from Ceylon and Hamburgh.

Properties.—It occurs either crystallized in regular six-sided prisms, or in kidney-shaped masses, or disseminated in rocks. Its colour is iron or steel-grey, with a metallic lustre. It has a greasy feel, and writes easily on paper. Its specific gravity is 2·08 to 2.45.

Characteristics.—It is known to be a variety of carbon by its yielding carbonic acid when burned in oxygen gas. Its physical properties distinguish it from most other varieties of this element. Some kinds of coal-gas charcoal closely resemble it. Of non-carbonaceous substances, molybdena (bisulphide of molybdenum) is the only substance that can be confounded with it in external appearance.

Composition.—It consists essentially of carbon, but is mixed with variable properties of iron and other substances. The following are analyses of three varieties by Vanuxen (Silliman's *Journal*, vol. x. p. 105):

	Borrowdale. (pure.)	Borrowdale. (impure.)	Bustletown. (pure.)
Carbon	88·37	61·27	95·4
Water	1·23	5·33	0·6
Silica	5·10	10·10	2·6
Alumina	1·00	3·20	0·0
Oxides of Iron, Manganese, &c.	3·60	20·00	1·4
	99·30	99·90	100·0

I suspect, however, that the finest varieties of the Borrowdale graphite contain a less quantity of foreign matter than is here stated. On the supposition that the carbon was chemically combined with iron, graphite was formerly called *carburet* or *percarburet of iron*. From some observations of Schrader's, however, it would appear that the iron is in combination with titanic acid.

Physiological Effects.—Various properties have been assigned to it; but farther evidence is wanting to establish its action on the body. Richter (*ausführliche Arzneimittellehre*, 3^{er}. Bd. p. 486) says it alters in some way the lymphatic secretion and the condition of the skin, and after some days' use, causes increased secretion of urine, with difficulty in passing it.

USES.—It has been employed both externally and internally in chronic diseases of the skin (as herpes). When used externally, it is mixed with lard in the proportion of one or two drachms to an ounce of the latter. Internally the dose is ten or twelve grains to a drachm.

2. *Car'bo Lig'ni.—Wood Char'coal.*

HISTORY.—Wood charcoal must have been familiar to man from the most remote period of antiquity, and was probably known to the first inhabitants of the globe. For an account of the ancient method of procuring it, I must refer the reader to the works of Theophrastus (cap. x.) and Pliny (*Hist. Nat.* lib. xvi., cap. vii).

NATURAL HISTORY.—Wood charcoal is always an artificial product. Some samples of Bovey coal have very much the appearance of wood charcoal, but are readily distinguished by their containing hydrogen, in consequence of which they burn with a yellow flame. Moreover, they are not good conductors of galvanic electricity (Kidd's *Outlines of Mineralogy*, vol. ii. p. 47.)

PREPARATION.—Ordinary wood charcoal is prepared, on the large scale, for the purposes of fuel, by burning billet-wood piled in a conical heap, covered by turf and sand, to prevent the access of atmospheric air, a few holes being left near the bottom and one at the top, to occasion a draught. The heap is then set fire to, and when the flame has pervaded the whole mass, the holes are closed. When cooled, the billets are found converted into charcoal. For an account of the mode of arranging the wood in heaps, consult Dumas, *Traité de Chimie, appliqué aux Arts*, t. i., p. 561.

The wood charcoal used in the manufacture of gunpowder is obtained by heating wood in cast iron cylinders, the gaseous products being allowed to escape. The woods used for this purpose are Dogwood (*Cornus sanguinea*), the common alder (*Alnus glutinosa*), and the willow (*Salix*).

PROPERTIES.—Wood charcoal is black, odourless, and insipid. It has the texture of the wood from which it has been obtained. It is brittle, and may be easily pulverized, especially when hot. Though a very bad conductor of heat, it is an excellent conductor of electricity. It is insoluble, infusible, and incapable of volatilization. Its specific gravity varies, according to the substance from which it has been obtained. A remarkable property possessed by it is that of abstracting certain substances (such as hydrosulphuric acid, organic colouring principles, various odorous matters, &c.) from liquids in which they are dissolved, or through which they are diffused. Another curious quality is that of condensing, within its pores, a certain quantity of any gas with which it may be placed in contact. One volume of box-wood charcoal absorbs 1·75 volumes only of hydrogen gas, but 90 volumes of ammoniacal gas. Some of the properties now mentioned (as that of decolorizing) are possessed in a more eminent degree by animal charcoal.

CHARACTERISTICS.—By burning in oxygen gas, charcoal yields carbonic acid gas; a property by which it is shown to consist of carbon. Its texture and appearance will distinguish it from other forms of carbon.

PHYSIOLOGICAL EFFECTS.—Wood charcoal I believe to be an inert substance both with respect to animals and vegetables. Burdin (quoted in the *Dict. de Mat. Méd.* of MM. Merat and de Lens) gave a pound of it daily without producing any other effect than that of blackening the stools. A variety of properties and virtues have, however, been ascribed to it, as I believe, without foundation: thus it has been termed anodyne, emmenagogue, tonic, purgative, &c. In Hahnemann's *Traité de Matière Médicale* (traduit par A. J. L. Jourdan), no less than thirty-five pages are occupied with the enumeration of the symptoms produced by less than one-millionth of a grain of this substance!!

Uses.—In this country, charcoal is used as a therapeutic agent, principally as a disinfectant and antiseptic, to absorb the fœtid odour evolved by gangrenous and phagedenic ulcers. For this purpose it may be used in the form of powder or of poultice. Its disinfecting and antiseptic powers, however, are much inferior to those of chlorine, or of the chlorides of lime and soda. As a *tooth-powder* it is a valuable agent, freeing the teeth from the foreign matters which cover them, and at the same time counteracting the unpleasant smell of the breath arising from decayed teeth or disordered stomach. Brachet (*Considerations sur l'Usage du Carbon en Médecine*, Paris, 1803) states, that it checks caries of the teeth. Areca nut charcoal is a favourite variety for tooth-powders. Internally, charcoal has been exhibited in various affections of the alimentary canal, such as dyspepsia, cardialgia, diarrhœa, and dysentery. The beneficial effects said to have been produced in these cases can only be referred to the action of charcoal on the secretions of the bowels; an explanation apparently supported by Dr. Chapman's statement, that in dysentery, where the stools are highly acrid and offensive, charcoal entirely divests them of their bad smell and acrimony. In consequence of the advantage said to have been obtained by Dr. Calcagno, of Sicily, by the use of charcoal in intermittents, it was tried by Dr. Calvert, physician to the British forces at Palermo, and with success. (*Edinb. Med. and Surg. Jour.* vol. x., p. 15). In this country, how ever, it is, I believe, never resorted to in ague by medical practitioners. Dr. Daniel, of Savannah, has recommended it in obstinate constipation, and in the nausea and confinement of bowels which frequently attend pregnancy. It has also been used in various other diseases, but experience has not confirmed its efficacy.

Administration.—The dose of charcoal, as ordered by different writers, varies from ten grains to a table-spoonful or more.

In the Dublin Pharmacopœia there is a formula for a *wood charcoal cataplasm* (*cataplasma carbonis ligni*). It may be prepared by mixing finely powdered charcoal with a common linseed poultice; it is applied to foul ulcers to destroy their offensive odour.

3. *Car'bo Anima'lis.—An'imal Char'coal.*

History and Synonymes.—This substance must have been known from the most ancient times. The kind usually met with in the shops is prepared from bones, and is termed *bone black*, or, more commonly, *ivory black*, (*ebur ustum nigrum*).

Natural History.—It is always an artificial product.

Preparation.—The mode of preparing animal charcoal from bones has been already described. (See *Ammoniæ Hydrochloras*).

PROPERTIES.—In its general properties animal charcoal agrees with charcoal procured from wood. The decolorizing powers of the former are, however, much superior to those of the latter.

COMPOSITION AND PURIFICATION.—Animal charcoal, prepared by calcining the bones of the ox, sheep, and horse, consists of the following ingredients, (Dumas, *Traité de Chimie*, t. i., p. 450):

Phosphate of Lime Carbonate of Lime	88·0
Charcoal	10·0
Carburet or Silicet of Iron	2·0
Sulphuret of Calcium or Iron	traces
Common Bone Black	100·0

For the ordinary purposes of the arts, as sugar refining, this impure animal charcoal answers very well, because the earthy salts in no way affect the process. But in various pharmaceutical operations the presence of phosphate and carbonate of lime would preclude the use of animal charcoal, on account of the free acid in the liquids to be decolorized. Hence the necessity of the purification of animal charcoal.

In the London Pharmacopœia purified animal charcoal (*carbo animalis purificatus*) is ordered to be prepared by digesting for two days, with a gentle heat, a pound of animal charcoal in a mixture of twelve fluid ounces of hydrochloric acid and the like measure of water, frequently shaking them. After pouring off the supernatant liquor the charcoal is to be washed with water until no acid is perceptible, and then dried.

In the above process the hydrochloric acid dissolves the phosphate of lime and decomposes the carbonate of lime and sulphuret of calcium, evolving carbonic and hydrosulphuric acid gases, and forming chloride of calcium, which remains in solution.

Purified animal charcoal causes no effervescence when mixed with hydrochloric acid, nor is any precipitate produced by the addition of ammonia or its sesquicarbonate to the acid. For effervescence would indicate the presence of carbonate of lime, while a precipitate with sesquicarbonate of ammonia would shew either phosphate or carbonate of lime: if phosphate, caustic ammonia would also occasion a precipitate.

Animal charcoal, when deprived of its saline matters, usually contains traces of nitrogen. Döbereiner, indeed, supposed it to be a kind of subnitruret of carbon composed of one equivalent or 14 parts of nitrogen, and six equivalents or 36 parts of carbon. Bussy, however, has shown that though animal charcoal retains its nitrogen with considerable obstinacy, yet that the latter may be separated by heat.

PHYSIOLOGICAL EFFECTS.—The remarks already made in reference to the physiological effects of wood charcoal, apply equally well to animal charcoal.

USES.—The principal use of animal charcoal is as a decolorizing agent in various pharmaceutical processes, as in the preparation of sulphate of quinia, hydrochlorate of morphia, veratria, &c. The theory of its efficacy is imperfectly understood. The superior value of animal to vegetable charcoal is usually referred to the minute separation of the carbonaceous particles effected by the presence of other matters, as of phosphate of lime when bones are employed. Carbonate of potash is better for this purpose than phosphate of lime. The property possessed by minute particles of charcoal, of abstracting colouring matter from liquids, depends, probably, on some chemical affinities existing between carbon and colouring matter. It is stated, in some works, that charcoal which has been once used cannot have its decolorizing property restored by a fresh ignition, unless it be mixed with some inorganic substance. This, however, is an error. The animal charcoal which has been used in sugar refining, is returned to the maker to be fresh ignited, and is then employed again, and this process of re-igniting, is, I am informed, repeated many times, without any loss of decolorizing power.

Ac'idum Carbon'icum.—Carbon'ic Ac'id.

History and Synonymes.—Although the ancients were acquainted with the poisonous properties of carbonic acid gas, Dr. Black, in 1757, was the first who explained the nature of this substance. The *spiritus lethalis* of the ancients is evidently this acid, as is also the *spiritus sylvestris* or *gas* of Paracelsus and Van Helmont. *Fixed air, acid vapour*, and *aërial acid*, are other synonymes for it.

Natural History.—It is a constituent of both kingdoms of nature.

(*a*). *In the inorganized kingdom.*—Carbonic acid is a constituent of the atmosphere. In some parts of the world it is evolved from the earth in large quantities, particularly in old volcanic countries. Thus in the vicinity of the Lake of Laach, Bischof estimates the exhalation as equal to 600,000lbs. daily, or 219,000,000lbs., (equal to about 1,855,000,000 cubic feet) annually! (De la Beche, *Theoret. Geology.*) Some of the acid evolved in the Brohlthal, on the Rhine, is employed by him in the manufacture of chemical preparations on the large scale. Most persons are familiar, by report, with the *Grotto del Cane,* near Naples. It is a cavity in a rock, through the fissures of which carbonic acid is evolved. It has received its name from the practice of putting dogs into it, who fall down suffocated. The *Valley of Poison,* in Java, which has been described by Loudon, is another spot where this acid escapes from the earth. It is a cavity of an oval form, about three quarters of a mile in circumference, and from thirty to thirty-five feet deep; filled to the height of about eighteen feet with carbonic acid gas. The bottom of it is covered with the skeletons of men and various other animals, who have fallen victims to its destructive operation. If a traveller should be so unfortunate as to enter it, he cannot be sensible of his danger until too late to return. Mr. Loudon thrust a dog in ; he fell in fourteen seconds. A fowl thrown in appeared to be dead before it reached the ground!!

Carbonic acid gas is frequently met with in mines and wells ; and is termed by miners *choke damp* (from the German *dampf*, vapour).

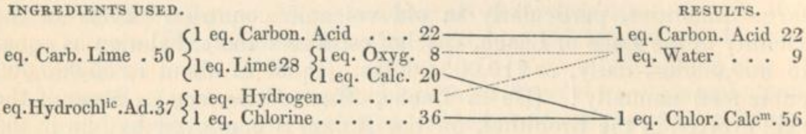
Few mineral waters are without this acid, and in some it exists in such quantity as to give them a sparkling or effervescent quality (see p. 146).

Lastly, carbonic acid is found (native) in combination with various bases ; as with soda, baryta, strontian, lime, magnesia, and the oxides of manganese, zinc, lead, iron, and copper. According to Mr. De la Beche (*op. cit.*) the average amount of carbonic acid locked up in every cubic yard of limestone, is about 16,000 cubic feet.

It is produced in the burning of limestone (carbonate of lime) at lime kilns, and by the combustion of charcoal, coal, wood, coal gas, the fire-damp of coal mines, and other combustibles containing carbon.

(*b.*) *In the organized kingdom.*—Carbonic acid gas is exhaled by plants in dark or shady places, and hence is met with in green-houses, especially during the night. Animals develope it in the process of respiration, and, therefore, in crowded rooms, with imperfect ventilation, accidents have sometimes happened from the accumulated carbonic acid. It is produced by the decomposition of organic matters, as during fermentation of saccharine fluids, and in the destructive distillation of animal substances: hence the danger of descending into brewers' vats. Free or combined carbonic acid is found in the blood, urine, bones, &c.

PREPARATION.—Carbonic acid gas may be procured in various ways, but for ordinary purposes is usually obtained by the action of some acid (usually hydrochloric) on carbonate of lime (as white marble). It is most readily prepared in a tubulated glass retort, and may be collected over water. The ordinary hydrochloric acid of the shops should be diluted with four or five times its volume of water. By the reaction of one equivalent, or 37 parts of hydrochloric acid, on one equivalent, or 50 parts of carbonate of lime, we obtain one equivalent, or 56 parts of chloride of calcium, one equivalent, or 9 parts of water, and one equivalent, or 22 parts of carbonic acid.



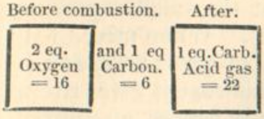
PROPERTIES.—At ordinary temperatures and pressures carbonic acid is gaseous. In this form it is invisible, irrespirable, has a faint odour, and a sharp taste. Its specific gravity is 1·5277. It is neither combustible nor a supporter of combustion, except in the case of potassium, which, when heated in this gas, takes fire, the products of the combustion being carbon and carbonate of potash. It extinguishes most burning bodies when introduced into it in the ignited condition. It reddens litmus feebly.

Under a pressure of 36 atmospheres at 32°, carbonic acid is a limpid, colourless liquid, which is insoluble in water and in the fat oils, but is soluble in all proportions in alcohol, ether, oil of turpentine, and carburet of sulphur. Its refractive power is much less than that of water. Its expansibility by heat is greater than that of gases; for when heated from 32° F. to 86° F., its bulk increases from 20 to 29 volumes, while the pressure of its vapour augments from 36 to 73 atmospheres.

By an intense degree of cold, liquid carbonic acid may be solidified. Thus, when the pressure is removed from this liquid by opening a stop-cock in the condensing vessel, the cold produced by the expansion is so great, that a quantity of solid carbonic acid is formed. In this state it is so intensely cold, that mercury, liquid chlorine, liquid cyanogen, &c. may be readily frozen by it. Being a very bad conductor of heat, it may be handled with impunity.

CHARACTERISTICS.—Carbonic acid gas is recognised by its feebly reddening litmus, by being incombustible and a non-supporter of combustion (except in the case above mentioned), and by its forming, with a solution of lime or of baryta, a white precipitate, soluble in acetic acid.

The carbonates effervesce on the addition of acetic or hydrochloric acid. The evolved gas is known to be carbonic acid by the characters before stated. The soluble carbonates form white precipitates in solutions of lime or baryta



Composition.—By burning charcoal in one volume or 16 parts, by weight, of oxygen gas, we procure one volume or 22 parts, by weight, of carbonic acid gas.

	Eq.	Eq. wt.	Per ct.	Saussure.		Vol.	Sp. gr. or		Vol.	Sp. gr.
Carbon	1	6	27·27	27·04 to 27·38	Carb. vapour	0·5 or 1	0·416$\dot{6}$	Carb. Oxide gas	1	0·972$\dot{2}$
Oxygen	2	16	72·73	72·96 to 72·62	Oxygen gas	1	1·111$\dot{1}$	Oxygen gas	0·5	0·555$\dot{5}$
Carbonic Acid	1	22	100·00	100·00 . 100·00	Carb. Acid gas	1	1.527$\dot{7}$	Carb. Acid gas.	1	1·527$\dot{7}$

Carbonic Acid Water (*Aqua Acidi Carbonici*).—At the ordinary temperature and pressure of the atmosphere, one volume of water absorbs one volume of carbonic acid gas, and acquires a sp. gr. of 1·0018. By doubling the pressure the quantity of gas absorbed is doubled, and so on for other degrees of pressure; for Dr. Henry has shewn that the quantity of gas forced into water is directly as the pressure. In the United States Pharmacopœia five volumes of gas are ordered to be condensed in one of water. This solution is called *Artificial Seltzer Water*. The *bottled soda water*, and *soda water from the fountain* or *pump*, are, in general, merely aqueous solutions of carbonic acid. Carbonic acid water is a sparkling liquid, reddening litmus, having a pungent, acidulous taste, and causing a white precipitate with lime water, which precipitate is re-dissolved by an excess of carbonic acid water.

Physiological Effects. (*a.*) *On Vegetables.*— Carbonic acid gas is injurious to seeds, and diminishes or stops their germination according to the quantity of acid present. An aqueous solution of carbonic acid applied to the roots of plants promotes vegetation. An atmosphere containing not more than $\frac{1}{8}$ of its volume of carbonic acid promotes the vegetation of plants exposed to the solar rays, but is injurious to those which grow in the shade (Saussure, *Recherches*, p. 25, et seq.)

(*b.*) *On dead animal matter.*—Carbonic acid gas retards the putrefaction of animal substances.

(*c.*) *On animals.*—The *respiration* of carbonic acid gas is deleterious and fatal to all classes of animals. That it operates in these cases as a positive poison, and not merely by excluding oxygen, as some have supposed, seems to be proved by two facts:—firstly, that an atmosphere composed of 79 parts of carbonic acid and 21 of oxygen acts as a poison, although there is as much oxygen present as there is in atmospheric air; and, secondly, that one bronchial tube of the land-tortoise may be tied, without any serious injury to the animal; but if, instead of tying it, the animal be made to inhale carbonic acid gas by it, death takes place in a few hours (Christison, *Treatise on Poisons*, p. 745, 3rd edit.) The impression produced on the pulmonary extremities of the par vagum, by the carbonic acid in the lungs, is supposed by some physiologists to be the ordinary stimulus to inspiration. According to the experiments of Nysten (*Recherches*, p. 88), this gas may be *injected into the venous system* in large quantity, without stopping the circulation, and without acting primitively on the brain; but when more is injected than the blood can dissolve, it produces death by distending the heart, as when air is injected into the veins (see p. 23). *Applied to the skin of animals*, free access of common air to the lungs being preserved, it produces, if the experiment be continued long enough, death.

(*d.*) *On man.*—If an attempt be made to *inhale* pure carbonic acid gas, the glottis spasmodically closes, so as to prevent the smallest portions from entering the lungs (Davy, *Researches*, p. 472). When mixed with more than twice its volume of air, this gas ceases to provoke spasm of the glottis, and may be taken into the lungs. In this case it gives rise to symptoms resembling those of apoplexy. It usually causes a sensation of tightness at the chest, uneasiness, giddiness, loss of muscular power, insensibility, and stertorous breathing, sometimes accompanied by convulsions or delirium. These symptoms are succeeded by asphyxia and death.

Applied to the conjunctiva it acts as an irritant, and excites pain, redness, and a flow of tears. *Applied to the skin* (care being taken that it is not inhaled) it produces a sensation of warmth and pricking or tingling, sometimes accompanied by pain, increased frequency of the pulse, sweating, and excitement of the nervous system. M. Collard de Martigny (quoted by Dr. Christison) experienced weight in the head, obscurity of sight, pain in the temples, ringing in the ears, giddiness, and an undefinable feeling of terror. *Taken into the stomach*, dissolved in water, or in the form of effervescing draughts, it allays thirst, and diminishes preternatural heat, thus acting like the other dilute acids. If it be evolved in the stomach, it distends this viscus, excites eructations, and checks both nausea and vomiting. It appears to promote the secretions of the alimentary tube, to assist the digestive process, to allay irritation, and to act as a refreshing and exhilirating substance. It is said to be diuretic and diaphoretic. Wöhler and Stehberger expressly state, that the use of carbonic acid did not increase the quantity of this substance in the urine (Duncan, *Supplement to the Edinb. Disp.* p. 223). When drunk too quickly, and in large quantity, water impregnated with this gas has been known to excite giddiness and intoxication (Fodéré, *Med. Légale*); and it is probable that champagne is indebted to this substance for part of its intoxicating powers. *Applied to ulcers and suppurating surfaces*, carbonic acid gas acts as a stimulant, improves the quality of the discharge in ill-conditioned and indolent ulcers, retards the putrefaction of the secreted matters, diminishes the unpleasant odour of foul and gangrenous sores, and promotes the separation of the dead and mortified parts.

USES—(*a.*) *When inhaled.*—In some diseases of the lungs, particularly phthisis, it has been proposed to mix carbonic acid gas with the atmospheric air breathed by the patient, with the view of lessening the stimulant influence of the oxygen, to diminish the quantity, and improve the quality of the matter expectorated, and at the same time to relieve the hectic symptoms. It is not at all unlikely that temporary relief might be gained by its employment; but difficulty is experienced in the mode of applying it. Of course, to be beneficial, it ought to be constantly inspired. Temporarily it is readily inhaled, by generating it in a large bottle or jar, and breathing it by means of a tube; but for its continued use, the only method that can be employed is to evolve the acid in the patient's chamber. In some parts of the continent a popular remedy for consumption is a residence in rooms or houses inhabited by cows; and the asserted beneficial effects are supposed to be in part attributable to the carbonic acid gas contained in the chamber; but, says Vogt (*Lehrbuch der Pharmakodynamik*, Bd. ii. S. 32), "we must not overlook the humid, mild, balsamic vapour, with which the air of cow-houses is commonly impregnated."

(*b*.) *Taken into the stomach*, carbonic acid is a most valuable remedy for checking vomiting, and diminishing irritable conditions of this viscus. The best mode of exhibiting it is, I believe, in the form of an effervescing draught, composed of citric acid and bicarbonate of potash. In fever, it is an excellent refrigerant; especially serviceable in those cases which are accompanied with gastric irritation. In that form of lithiasis attended with a white or phosphatic deposit in the urine, water impregnated with carbonic acid may be taken with advantage; but in this case the common effervescing draught, (made of a vegetable acid, and a carbonated alkali) cannot be substituted for carbonic acid water, since it communicates an alkaline property to the urine.

(*c*.) *Clysters of carbonic acid gas* have been employed in certain affections of the rectum and colon,—for example, ulceration of the rectum, especially when of the kind commonly denominated cancerous.

(*d*.) *A stream of carbonic acid gas* has been applied to the *uterus* with great benefit, in a painful condition of this viscus, as I have already mentioned (at p. 54).

(*e*.) *Applied to the skin*, care being taken that the gas is not inhaled, it is employed either in its gaseous form, or dissolved in water. It is, of course, adapted to those cases where it is desirable to excite the vascular system, especially of the skin, and to cause perspiration; while, on the other hand, it is objectionable in inflammatory cases. In chlorosis, amenorrhœa, dyspepsia, hysteria, scrofula, &c., it has also been found useful.

(*f*.) It has been *applied to cancerous and other ulcers*, to allay pain, to improve the quality of the secretions, and to check sloughing. It is readily administered by means of a tube connected with a bottle generating the gas. In this case it should be procured by the action of dilute sulphuric acid on marble, for if hydrochloric acid be employed, the gas requires washing, to remove any of this acid which may pass over with it. Or it may be used in the form of solution, in which case the bottle-soda-water may be employed. Or, lastly, we may apply the yeast poultice.

ADMINISTRATION.—Internally, carbonic acid may be administered under the form of carbonic acid water (the ordinary *bottle-soda-water*) which may be given in quantities regulated by the moderate desires of the patient.

Where no objection exists to the use of the vegetable salts of potash, carbonic acid may be administered under the form of the *ordinary effervescing draught*, composed of a vegetable acid and an alkaline carbonate. In febrile disorders, when the stomach is in a very irritable condition, I prefer a draught made with citric acid and the bicarbonate of potash.

Another mode of employing carbonic acid is under the form of the *acidulous* or *carbonated mineral waters*.

These are distinguished, according to the nature of their preponderating constituent, into the *acidulo-alkaline* (as those of Pougues, Vichy, Mont d'Or, Spa, Selters, Bilin, Altwasser, &c.), the *acidulo-chalybeate* (as those of Flinsberg, Giesshübel, Fachingen, and Pyrmont), and the *acidulo-saline* (as those of Wildungen, Kissingen, Schwalheim, &c.)

[For further information concerning the acidulous waters, consult Lee's *Account of the Watering-Places of the Continent*; and the article on mineral waters, by Dr. Thomson, in the *Cyclopædia of Medicine*.]

ANTIDOTES.—In accidents arising from the inhalation of carbonic acid or carbonic oxide, proceed as follows:—remove the patient immediately into the open air, and place him on his back with his head somewhat elevated. Produce artificial respiration by pressing down the ribs, and forcing up the diaphragm, and then suddenly removing the pressure. Dash cold water over the body, and abstract a small quantity of blood either by venesection or cupping. Stimulants of various kinds may be employed either internally by the stomach, or in the form of frictions, or inhalations (as of ammonia, weak chlorine, &c.)

Al'cohol.—Al'cohol.

HISTORY.—Fermented liquors were known in the most remote ages of antiquity. The sacred historian tells us (*Genesis*, ch. ix.) that after the flood (which is supposed to have occurred 2,348 years before Christ), "Noah planted a vineyard: and he drank of the wine, and was drunken." Homer, the most ancient of all the profane writers, and who lived more than 900 years before the Christian era, also frequently mentions wine, and notices its effects on the body, mind, &c. (*Odyssey*, ix. and xxi.) Herodotus (*Euterpe*, lxxvii.), who wrote 445 years before Christ, tells us, that the Egyptians drank a liquor fermented from barley.

It is uncertain at what period vinous liquors were first submitted to distillation. Morewood (*Essay on Inebriating Liquors*, p. 107) considers the Chinese to have been acquainted with this process long before the rest of Asia, Africa, and Europe. It is usually stated that Albucasis, who is supposed to have lived in the 12th century, taught the mode of procuring spirit from wine (Gmelin, *Handbuch d. Chemie*, Bd. 2, p. 274). Raymond Lully in the 13th century was acquainted with spirit, as well as with the mode of depriving it of water by means of carbonate of potash.

PREPARATION.—The preparation of alcohol may be divided into three stages: the production of a fermented vinous liquid; the preparation from this of an ardent spirit by distillation; and, lastly, rectification or purification.

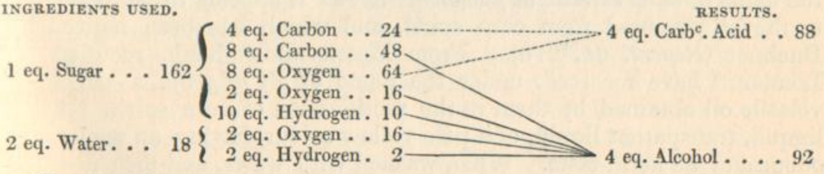
STAGE 1. *PRODUCTION OF A VINOUS LIQUOR.*—When vegetable substances are placed in contact with air and moisture, they undergo that kind of decomposition which is denominated *fermentation*. The products of this process vary at different periods or stages; and on this depends the distinction into kinds or varieties of fermentation. Thus starchy liquids, under some circumstances, become saccharine; the process being termed the *saccharine* fermentation. Sugar dissolved in water, and mixed with glutinous matter, is converted into carbonic acid and alcohol; and to this process the name of *vinous* fermentation is applied. Vinous liquids are capable of generating acetic acid, and the process is denominated *acetous* fermentation. Lastly, most vegetable substances are slowly converted into gases and a substance called vegetable mould (*humus*), constituting the process called the *putrefactive* fermentation.

To produce a vinous liquid it is necessary that there be present sugar (or some substance capable of forming sugar, as starch), a certain quantity of water, and a ferment (usually yeast). Moreover a certain temperature (the best is between 70° and 80° F.) is necessary. The precise functions which each of these essentials performs are not known. As Berzelius has remarked, the changes may depend on the developement of forces of no common nature. The products of this process are carbonic acid, alcohol, and yeast. To account for the two first of these we take the data furnished us by Thenard.

SUBSTANCES FERMENTED AT 59°.		PRODUCTS OF FERMENTATION.	
Sugar	300	Alcohol of 0·822	171·5
Yeast	60	Carbonic Acid	94·6
		Nauseous residue	12·0
		Residual yeast	40·0
			318·1
		Loss	41·9
	360		360·0

Now the nauseous residue and residual yeast nearly make up the quantity of yeast employed; and supposing the loss to be proportionally divided between the alcohol and the acid, it follows that, by the vinous fermentation, sugar is resolved into carbonic acid and alcohol.

The explanation of the changes which occur in the conversion of saccharine solutions into alcoholic liquors, depends, of course, on the view taken of the composition of sugar. If we adopt, with Mr. Brande (*Manual of Chemistry*), 162 as the equivalent for sugar, the following are the changes:—One equivalent or 162 parts of sugar, with two equivalents or 18 parts of water, are converted into four equivalents or 88 parts of carbonic acid, and four equivalents or 92 parts of alcohol.



The liquid obtained by the vinous fermentation has received different names, according to the substance from which it is obtained. When procured from the expressed juices of fruits, as grapes, currants, gooseberries, &c., it is denominated *wine* (*vinum*); from a decoction of malt and hops, *ale* or *beer* (*cerevisia*); and from honey and water, *mead* (*hydromeli*). Fermented infusions of barley (raw grain and malt) prepared by the distillers of this country for the production of ardent spirit, are technically denominated *washes*.

The liquid obtained by the vinous fermentation consists of *water*, *alcohol*, *colouring* and *extractive matters*, *volatile oil*, *various acids* and *salts*.

***Stage* 2. *Production of Ardent Spirit*.**—By the distillation of a vinous liquid we obtain *ardent spirit* (*spiritus ardens*). When wine is employed, the spirit is called *brandy* (*spiritus vini gallici*); when the vinous liquid is obtained by the fermentation of molasses or treacle, the spirit is termed *rum* (*spiritus sacchari*); when the liquid is a fermented infusion of grain (*wash*), the spirit is denominated *corn spirit* (*spiritus frumenti*); and when the vinous liquid is either a fermented infusion of rice or toddy (*palm wine*), the spirit is named *arrack* (if from the former, it is termed *spiritus oryzæ*). The well-known liquors called *gin*, *hollands* or *geneva*, and *whiskey*, are corn spirits flavoured.

Ardent spirit, from whatever source obtained, consists of *water*, *alcohol*, *volatile oil*, and, frequently, *colouring matter*. The following are, according to Mr. Brande (*Phil. Trans.* for 1811 & 1813), the average quantities of alcohol (sp. gr. 0·825 at 60° F.) in some kinds of ardent spirit:—

100 parts (by measure) of	Alcohol (by measure).	100 parts (by measure) of	Alcohol (by measure).
Brandy contain	53·39	Whiskey (Scotch) contain	54·32
Rum	53·68	Whiskey (Irish)	53·90
Gin	51·60		

When wash is distilled, the fluid that comes over is called *singlings*, or *low wines*. It is concentrated or *doubled* by a second distillation, by which *raw corn spirit* is obtained. Towards the end of the distillation the distilled product acquires an unpleasant odour and taste from the presence of volatile oil, and is called *faints*. Raw corn spirit is sold by the distiller to the rectifier at 11 or 25 per cent. *over proof*, in the language of Sykes' hydrometer.

STAGE 3. *RECTIFICATION.*—The object of the rectifier is to deprive ardent spirit of its volatile oil and water. This is effected by repeated distillations, and by the use of pearlash (carbonate of potash), which, by its powerful affinity for water, checks the rise of this fluid in distillation.

All kinds of ardent spirits contain a volatile oil, which is termed by the Germans *Fuselöl*. That obtained from potatoe spirit has been described by Pelletan (*Jour. de Chimie Médicale*, tom. 1^{er}. p. 76), under the name of *huile volatile de pomme-de-terre:* it appears to be analogous to the oil procured from corn spirit, and which has been noticed by Buchner (*Repert.* 24, 270). From Messrs. Bowerbank, rectifiers, of London, I have received, under the name of *oil of grain*, a sample of volatile oil obtained by them in the rectification of corn spirit. It is a limpid, transparent liquid, of a pale yellow colour, having an unpleasant odour and an acrid taste. When washed with water, and then distilled from chloride of calcium, it is quite colourless. Its sp. gr. is 0·833 at 56° F. It burns in the atmosphere with a flame like that of light carburetted hydrogen gas. It dissolves iodine, and is soluble in alcohol and ether, but is insoluble in water, in liquor ammoniæ, and in liquor potassæ. It dissolves in strong nitric acid, but acquires a slightly yellowish red tinge, and when the mixture is heated, violent re-action takes place; nitrous fumes mixed with nitric ether are so rapidly evolved, that if the experiment be performed in a tubulated retort the stopper is sometimes forced out with considerable violence. Sulphuric acid added to this oil forms with it a deep, blood-red coloured, thick liquid, and evolves heat and an odour analogous to that of mint. Potassium rapidly decomposes it with the evolution of hydrogen. I am informed by Messrs. Bowerbank that they obtain from 500 gallons of corn spirit about 1 gallon of oil of grain, which they employ as a substitute for lamp oil.

In the London Pharmacopœia alcohol is directed to be procured by dissolving one pound of chloride of calcium (fused) in a gallon of rectified spirit (sp. gr. 0.838): from this seven pints and five fluid ounces of alcohol (sp. gr. 0·815) are to be distilled. In this process the chloride of calcium, (which is very soluble in spirit) having a powerful affinity for water, prevents the rise of this fluid during distillation, and thus the spirit is deprived of nearly the whole of its water.

Properties.—Alcohol is a limpid, colourless, inflammable liquid, having a peculiar and penetrating odour, and a burning taste. Its sp. gr. at 59° F., is 0·7947; at 62½° F., 0·791; at 173° F., it is only 0·73869 (Dumas, *Traité de Chimie*, t. 5, 462).

No means of solidifying it are at present known. It boils at 173° F.: every volume of the boiling liquid gives 488·3 vols. of vapour calculated at 212° F. The sp. gr. of alcohol vapour by experiment is 1·6133, by calculation; according to Dr. Thomson, 1·5972.

It is very combustible. In atmospheric air it burns with a pale blue flame, giving out a very intense heat, and generating carbonic acid and water, but depositing no soot. The colour of the flame may be variously tinted—as yellow by chloride of sodium, violet by chloride of potassium, green by boracic acid or a cupreous salt, carmine red by chloride of lithium, crimson by chloride of strontium, and greenish yellow by chloride of barium. One volume of alcohol vapour requires, for its complete combustion, three volumes of oxygen gas, and yields two volumes of carbonic acid gas and three volumes of aqueous vapour. If alcohol vapour mixed with atmospheric air or oxygen gas be passed through a tube heated to dull redness, the products are carbonic, acetic, and *aldehydric*[*] acids, water, and a peculiar substance having a disagreeable, pungent odour (*Liebig*). By the combustion of alcohol vapour by spongy platinum the products are *aldehyd*[†], acetal, acetic acid, and acetic ether (*Liebig*).

Alcohol has a strong affinity for water: hence it abstracts this fluid from the atmosphere, and precipitates from their watery solution those salts (*e. g.* sulphate of potash) which are not soluble in spirit: while, on the other hand, water precipitates from their alcoholic solution those substances (*e. g.* resin and oil) not soluble in water. By the mixture of alcohol and water, heat is evolved, while air-bubbles are so copiously developed, that for a few moments the liquid appears turbid. When cold, the resulting compound is found to possess a greater density than the mean of its constituents: but as the condensation varies with the proportions of alcohol and water employed, the sp. gr. of the resulting compound can be ascertained by experiment only. The maximum condensation is obtained by mixing 54 vols. of alcohol with 49·77 vols. of water: the resulting compound measures 100 vols., so that the condensa-

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[*] *Aldehydric acid* (Aldehydsäure) is a term applied by Liebig and Poggendorf (*Handwörterbuch der Chemie*) to the Lampic acid of Daniell. It is derived from *Alcohol de hydrogenatus*. Its probable formula is $C^4 H^3 O^2 + \dot{H}$.

[†] *Aldehyd* (Aldehyd), another term introduced by the same chemists to indicate a fluid composed of $C^4 H^4 O^2$.

tion is 3·77. If we regard this as a definite compound of alcohol and water, its composition may thus be stated:—

	Eq.	Eq. Wt.	Per Cent.	Rudberg.	
				Vols.	Weight.
Alcohol	1	23	46	54·00	42·91
Water	3	27	54	49·77	49·77
Terhydrate of Alcohol	1	50	100	100·00	92·68

Alcohol combines with certain salts (as the chlorides and nitrates) to form definite compounds, which have been termed *alcohates*, in which the alcohol appears to act as a substitute for the water of crystallization.

Alcohol is a solvent of many organic substances, as volatile oil, fixed oil, resin, extractive, most varieties of sugar, many nitrogenous organic acids, the vegetable alkalies, urea, caseum, gliadine, leucine, picromel, and osmazome. It prevents the putrefaction of animal substances, and is, in consequence, extensively employed in the preservation of anatomical preparations. Its efficacy is imperfectly understood. It acts, in part at least, by excluding air (oxygen) and water,—the two powerful promoters of putrefaction; for when animal substances are immersed in spirit, this fluid mixes with and replaces the water with which the tissue was impregnated; and thus prevents putrefaction by removing one of the essential conditions to its production, namely, the presence of water. Its attraction for water, and its power of coagulating albuminous substances, are properties which probably assist powerfully in rendering it an antiseptic. Alcohol and rectified spirit of wine give greater firmness to, and whiten the animal tissues. The latter property is objectionable in the preservation of some morbid specimens, as gelatiniform cancer (*cancer gélatiniforme* or *aréolaire* of Cruveilhier,—the *matière colloïd* of Laennec). A mixture of one part rectified spirit and three parts water will, however, preserve specimens of the last-mentioned disease in a transparent condition.

CHARACTERISTICS.—Alcohol and ardent spirits are recognized by their inflammability, odour, taste, and miscibility with water. In order to detect alcohol in liquids supposed to contain it, let the suspected liquor be submitted to distillation with a gentle heat (as from a vapour or water bath), and to the distilled liquid add dry carbonate of potash, to abstract the water. The alcohol floats on the surface of the alkaline solution, and may be recognized by the characters above mentioned.

COMPOSITION.—The elementary constituents of alcohol are carbon, hydrogen, and oxygen.

	Eq.	Eq.Wt.	Per Cent.	Dumas & Boullay.	Saussure.
Carbon	2	12	52·18	52·37	51·98
Hydrogen	3	3	13·04	13·31	13·70
Oxygen	1	8	34·78	34·61	34·32
Alcohol	1	23	100·00	100·29	100·00

	Vol.	Sp. Gr.
Carbon vapour	1 or 2	$0{\cdot}833\dot{3}$
Hydrogen gas	3	$0{\cdot}208\dot{3}$
Oxygen gas	0·5	$0{\cdot}555\dot{5}$
Alcohol vapour	1	$1{\cdot}597\dot{2}$

Chemists are not agreed as to the manner in which these constituents are grouped. By some these elements are regarded as forming one equivalent of olefiant gas, and one equivalent of water: others consider alcohol to be a compound of one equivalent of a $\frac{4}{4}$ carbo-hydrogen (called by some *etherine*, by others *tetarto-carbo-hydrogen* or *quadri-hydrocarburet*), and two equivalents of water; while a third class of philosophers view this liquid as a hydrated oxide of a $\frac{4}{5}$ carbo-hydrogen (*ethereum* of Kane, *ethule* of Berzelius), or as the hydrate of ether; for ether is by them regarded as the oxide of ethereum. The latter opinions involve the necessity of assuming the equivalent for alcohol to be 46; that is, double the amount stated above. The following table illustrates the views just stated:—

	Eq.	Eq. Wt.	Per Cent.		Eq.	Eq. Wt.	Per Cent.		Eq.	Eq. Wt.	Per Cent.		Eq.	Eq. Wt.	Per Cent.
Olefiant gas	1	14	60·7	Etherine	1	28	60·7	Ethereum	1	29	63·04	Ether	1	37	80·43
Water	1	9	39·3	Water	2	18	39·3	Oxygen	1	8	17·39				
								Water	1	9	19·56	Water	1	9	19·56
Alcohol	1	23	100·0	Alcohol	1	46	100·0	Alcohol	1	46	99·99	Alcohol	1	46	99·99

ALCOHOLOMETRY.—The value of ardent spirit is, of course, proportionate to the quantity of alcohol contained therein; and, therefore, a ready mode of estimating this is most desirable. The alcoholometrical method usually adopted consists in determining the sp. gr. of the liquid by an instrument called the hydrometer. That employed in this country, in the collection of the duties on spirits, is called *Sykes's hydrometer*. Spirit having the sp. gr. 0·920, at 60° F. is called *proof spirit*; that which is heavier is said to be *under proof*, while that which is lighter is called *over proof*. The origin of these terms is as follows:—Formerly a very rude mode of ascertaining the strength of spirit was practised, called the *proof:* the spirit was poured upon gunpowder, in a dish, and inflamed. If at the end of the combustion the gunpowder took fire, the spirit was said to be *above* or *over proof;* but if the spirit contained much water, the powder was rendered so moist that it did not take fire: in this case the spirit was declared to be *below* or *under proof*. As spirit of different strengths will or will not inflame gunpowder, according to the quantity of spirit employed, it became necessary to fix the legal value of proof spirit: this has been done, and proof spirit (*spiritus tenuior*, Ph. L.) is defined, by act of parliament, to be such that at the temperature of 51° F. thirteen volumes of it weigh exactly as much as twelve volumes of water. According to this definition the sp. gr. at 60° F. is 0·920, and spirit of this strength consists of

	By Weight.	Sp. Gr.
Alcohol	49	0·791
Water	51	1·000
Proof spirit	100	0·920

Proof spirit may be prepared by adding three pints of distilled water, at 60°, to five pints of rectified spirit, sp. gr. 0·838. Compounded spirits (*e. g.* gin) are not allowed (6 Geo. 4, cap. 80, sect. 124) to be kept or sent out stronger than 17 per cent. under proof; but gin, as usually sold by the rectifier, is 22 per cent. under proof. Distillers are not permitted (6 Geo. 4, cap. 80, sect. 81) to send out spirits at any other strength than 25 or 11 per cent. above, or 10 per cent. below proof. The legislature (6 Geo. 4, cap. 80, sects. 101 & 114) has also defined spirits of wine to be of the strength of 43 per cent. over proof at the least. The liquid sold as rectified spirit has usually a sp. gr. of from 54 to 60 or 64 per cent. over proof. Hatters employ that at 54 or 56; varnish-makers that at 58 per cent. over proof. Rum and brandy, as usually sold, are 10 per cent. under proof. The act already quoted (sect. 130) declares, that no foreign or colonial spirits (not being compounded colonial spirits) shall be kept or sent out of less strength than 17 per cent. under proof. The following table, showing the specific gravities of spirits of various strengths, indicated by Sykes's hydrometer at 60° F., has been drawn up from "*The Ne Plus Ultra* (vol. ii.) *of Assaying, Weighing, Measuring, and Valuing of Spirituous Liquors*. By W. Gutteridge. London, 1828."

	Sykes's Hydrometer.	Sp. Gr.
Over proof.	70 per centum	0·8095
	64	0·8221
	62	0·8259
	60	0·8298
	58	0·8336
	56	0·8376
	55·9	0·8379
	55·7	0·8383
	54·1	0·8413
	50·1	0·8482
	43·1	0·8597
	25	0·8869
	11·1	0·9060
	Proof	0·9200
Under proof.	5 per centum	0·9259
	10	0·9318
	11	0.9329
	17·1	0·9396
	22·3	0·9448
	23·1	0·9456
	25·1	0·9476
	50·3	0·9673
	80·4	0·9854
	100 (water)	1·0000

Another mode of judging of the strength of spirits (as brandy) is the phial test, technically called the *bead*, the *preuve d'Hollande* of the French. It consists in shaking the spirit in a phial, and observing the size, number, and bursting of the bubbles (or beads as they are termed): the larger and more numerous the beads, as well as the more quickly they break, the stronger the spirit.

Hitherto chemical analysis has been of little avail in determining the strength of spirit, at least for commercial purposes. For, on the one hand, we are yet in want of an accurate method of determining the relative quantities of alcohol and water in mixtures of these fluids; while, on the other, the combustion of spirit by the black oxide of copper, and the estimation of the quantity of alcohol by the carbonic acid produced, is impracticable for ordinary purposes.

PURITY.—Alcohol, or rectified spirit of wine, should be colourless and transparent. Its freedom from other substances than alcohol or water is to be determined by the purity of its odour, by the absence of any acid or alkaline reaction, by its easy and complete volatility. The presence of volatile oil (*oil of grain*, or *Fuselöl* of the Germans) may be ascertained by strong sulphuric acid, which communicates a red colour to this substance (Geiger, *Handb. d. Pharm.*) Vogel says, that a solution of silver is a delicate test of volatile oil: when mixed with spirit, and exposed to solar light, it becomes red if any oil be present, but undergoes no change of colour if the spirit be pure.

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—Alcohol acts on plants as a rapid and fatal poison. Its effects are analogous to those of hydrocyanic acid.

(*b.*) *On animals.*—Leeches immersed in spirit die in two or three minutes. Their bodies are shrivelled or contracted, and before death they make but few movements; the head and tail of the animal are drawn together. Fontana found, that when half the body of a leech was plunged in spirit, this part lost all motion, whilst the other half continued in action. The same experimentalist observed, that spirit killed frogs when administered by the stomach (in doses of 40 drops), injected beneath the skin, or when applied to the brain or spinal marrow. Plunging the heart of this animal in spirit caused its motion to cease in twenty seconds. Applied to the right crural nerve of a frog, it destroyed the power of moving, in the right foot, on the application of stimulus (Fontana, *Treatise on the Venom of the Viper*, translated by J. Skinner, vol. ii. p. 371, *et. seq.*) Monro (*Essays and Observ. Physic. and Literary*, vol. iii. p. 340) observed, that alcohol applied to the hind legs of a frog rendered the pulsations of the heart less frequent, and diminished sensibility and mobility. Fontana (*op. cit.* p. 365, *et. seq.*) states that turtles were killed by spirit administered by the stomach or by the anus, or injected beneath the skin: before death the animal became motionless: applied to the heart of these animals it destroyed the contractility of this viscus. Some very interesting experiments were made with spirit on birds by Flourens (*Recherches sur les fonctions et les propriétés du système nerveux dans les animaux vertébrés*, 1824). This distinguished physiologist administered six drops of alcohol to a sparrow, whose skull he had laid bare. In a few minutes the animal began to be unsteady both in walking and flying. After some time a dark-red spot appeared on the skull, in the region of the cerebellum, and became larger and deeper-coloured in proportion as the alcohol more powerfully affected the animal. In some other experiments, Flourens observed that alcohol produced the same effects on the movements of birds as the removal of the cerebellum occasioned, but that when alcohol was administered the animal lost the use of his senses and intellectual faculties; whereas when the cerebellum was removed, no alcohol being given, he preserved them. From these and other observations, Flourens is of opinion that alcohol, in a certain dose, acts specifically on the cerebellum, and that in larger doses it affects other parts also. Furthermore, he thinks the physical action of alcohol on the cerebellum to be absolutely the same as a mechanical lesion.

The effect of alcohol on fishes is analogous to that on other animals. If a little spirit be added to water in which are contained some minnows (*Cyprinus phoxinus*, Linn.), the little animals make a few (spasmodic?) leaps, and become incapable of retaining their proper position in the water, but float on their sides or back. If removed into pure water they soon recover.

The mammals on which the effects of alcohol have been tried are dogs, cats, horses, rabbits, and guinea-pigs. The principal experimentalists are Courten (*Phil. Trans.* for 1712); Fontana (*op. cit.*); Viborg (*Abhandl. für Thierärzte*, Theil II. quoted by Wibmer, *Die Wirkung*, &c.); Brodie (*Phil. Trans.* for 1811); and Orfila (*Toxicologie Générale*). The results of their experiments may be thus briefly expressed:—Four drachms of alcohol injected into the jugular vein of a dog coagulated the blood and caused instant death (Orfila). Introduced into the stomach of cats, dogs, or rabbits, it produces an apoplectic condition (Brodie and Orfila): this state is preceded, according to Orfila, by a strong excitement of the brain. The same experimentalist found that alcohol acts with less energy when injected into the cellular texture, than when introduced into the stomach; from which he infers that its first effects are the result of the action which it exerts on the extremities of the nerves; though he admits that ultimately it becomes absorbed. On examining the bodies of animals killed by introducing alcohol into the stomach, this viscus has been found in a state of inflammation.

(*c.*) *On man.*—The effects of alcoholic liquors on man vary with the strength of the liquid, the substances with which the alcohol is combined, the quantity taken, and the constitution of the patient.

α. *The local effects of alcohol and rectified spirits* are those of a powerfully irritant and caustic poison. To whatever part of the body these agents are applied they cause contraction and condensation of the tissue, and give rise to pain, heat, redness, and other symptoms of inflammation. These effects depend partially or wholly on the chemical influence of alcohol over the constituents of the tissues: for the affinity of this liquid for water causes it to abstract the latter from soft living parts with which alcohol is placed in contact; and when these are of an albuminous or fibrinous nature, it coagulates the liquid albumen or fibrin, and increases the density and firmness of the solid albumen or fibrin. The irritation and inflammation set up in parts to which alcohol is applied, depends (in part) on the resistance which the living tissue makes to the chemical influence of the poison: in other words, it is the reaction of the vital powers, brought about by the chemical action of alcohol. But, besides the local influence of this liquid dependent on its affinity, we can hardly refuse to admit a dynamical action (*vide* pp. 7, 11), in virtue of which it sets up local irritation and inflammation, independent of its chemical agency. The coagulation of the blood contained in the vessels of the part to which this liquid is applied (an effect which Orfila observed when he killed an animal by injecting alcohol into the cellular tissue of the thigh of a dog), depends of course on the chemical influence of the poison.

β. *The remote effects of ardent spirits* on man may be conveniently considered in the order of their intensity; and for this purpose we may divide them into three degrees or stages.

1. *First or mildest degree* (*Excitement*).—This is characterized by excitement of the vascular and nervous systems: the pulse is increased in frequency, the face flushed, the eyes animated and perhaps red, the intellectual functions are powerfully excited, the individual is more disposed to joy and pleasure; cares disappear; the ideas flow more easily and are more brilliant. At this period the most violent protestations of love and friendship are frequently made, there is a strong disposition to talk, and various indiscretions are oftentimes committed. This degree of effect I presume to be the condition to which all persons aspire in drinking: the unfortunate drinks to drown his cares; the coward to give him courage; the *bon-vivant* for the sake of enjoying the society of his friends; the drunkard from mere sensuality. None, perhaps, would wish to go beyond this, yet many, when they have got thus far, exceed their intended limit.

2. *Second degree* (*Intoxication* or *Drunkenness*).—The essential characters of this stage are a disordered condition of the intellectual functions and of volition, manifested by delirium, varying in its characters in different individuals, and by an incapability of governing the action of the voluntary muscles. This state is accompanied with excitement of the vascular system, and frequently with nausea and vomiting: it is followed by an almost irresistible desire for sleep, which usually continues for several hours, and is attended with copious perspiration. When the patient awakes he complains of headache, loathing of food, great thirst, and lassitude: the tongue is furred and the mouth clammy.

3. *Third degree* (*Coma* or *True Apoplexy*).—This condition is usually observed when excessive quantities of spirit have been swallowed in a short time. According to Dr. Ogston (quoted by Dr. Christison) the patient is sometimes capable of being roused; the pulse is generally slow, the pupils are occasionally contracted, but more commonly dilated, and the breathing is for the most part slow: but exceptions exist to all these statements. Convulsions are rare: when they occur the patients are usually young. In some cases actual apoplexy (with or without sanguineous extravasation) is brought on. The immediate cause of death appears to be either paralysis of the muscles of respiration, or closure of the glottis.—(*Vide* pp. 68 and 69).

CONSEQUENCES OF HABITUAL DRUNKENNESS.—The continued use of spirituous liquors gives rise to various morbid conditions of system, a few only of the most remarkable of which can be here referred to. One of these is the disease known by the various names of *delirium tremens*, *d. potatorum*, *oinomania*, &c., and which is characterized by delirium, tremor of the extremities, watchfulness, and great frequency of pulse. Its pathology is not understood. It is sometimes, but not constantly, connected with, or dependent on, an inflammatory condition of the brain or its membranes. Opium has been found an important agent in effecting the subsidence of this affection.

Insanity is another disease produced by the immoderate and habitual use of spirituous liquors. The records of our pauper lunatic asylums shew that, in a large proportion of cases, the exciting cause of madness is the use of ardent spirits.

Disease of the liver is frequently met with in drunkards. It is generally of the kind termed by Baillie *common tubercle of the liver*, by Dr. Elliotson (*Med. Gaz.* vol. xii. p. 484) the *gin liver;* by others, *granulated*, *lobulated*, *mamellated*, or *scirrhous liver*. Laennec calls it *cirrhosis* (from *κιῤῥὸς*, *yellowish*), in reference to its usual tawny yellow colour. A beautiful representation of it is given by Cruveilhier (*Anatom. Patholog.* liv. 12^{e}. pl. 1.) Dr. Carswell (*Patholog. Anat.* art. *Atrophy*) has described it as consisting in atrophy of the lobular structure of the liver produced by the presence of a contractile fibrous tissue. It is not, therefore, a disease depending on the formation of a new tissue. The ascites, which so frequently accompanies it, arises from the compression to which the portal vessels are subjected by the fibrous tissue; and the jaundice, another frequent effect of it, doubtless depends on compression of the gall ducts. Some excellent remarks on this disease have been made by my able colleague, Dr. Hope (*Principles and Illustrations of Morbid Anatomy*.)

Persons addicted to the use of ardent spirits are usually dyspeptic. Chronic inflammation of the stomach, or even a scirrhous state of the pylorus, has been said to be occasionally produced by hard drinking.

The kidneys of dram-drinkers are sometimes affected with a disease first described by Dr. Bright, and which is generally attended by albuminous urine. They assume a granular state, which Dr. Hope regards as corresponding to the granular liver just described.

MODUS OPERANDI.—That alcohol becomes absorbed is proved by the fact that it has been found in the blood. Tiedemann and Gmelin (*Uber die Wege auf welchen Substanzen aus d. Magen ins Blut gelangen*) recognized the odour of it in the blood of the splenic vein, though they were unable to detect it in the chyle. A similar observation is reported by Magendie (*Element. Compend. of Physiology*, by Dr. Milligan, p. 248, 1823). Moreover the recognition of the odour of alcoholic liquors in the breath of individuals who have swallowed them, as well as their detection by their smell in the fluid contained in the ventricles of the brain, in the pericardium, &c., prove indisputably that alcohol becomes absorbed. Dr. Cooke (*Treatise on Nervous Diseases*, i. 222) states, on the authority of Sir A. Carlisle, that in one case the fluid of the ventricles of the brain had the smell, taste, and *inflammability* of gin. The correctness of the last observation has been questioned by Dr. Christison, on the ground that gin of sufficient strength to take fire could not enter the bloodvessels without coagulating the blood.

MORBID APPEARANCES.—On examining the bodies of individuals who have been poisoned by ardent spirits, redness and inflammation of the stomach are sometimes, but not invariably found. In old drunkards the mucous membrane of the stomach is often injected and thickened. Congestion of the cerebral vessels, with or without extravasation of blood or effusion of serum, is not unfrequently observed. Traces of the poison may or may not be found in the stomach, according to the rapidity with which death has been produced. The odour of the spirit may perhaps be recognised in various parts of the bodies, especially in the brain and the serous cavities.

USES.—1. *MEDICINAL.* (*a.*) *Internal.*—Raw spirit is rarely administered internally: for when ardent spirit is indicated, brandy, rum, gin, or whiskey, is usually employed. Each of these liquors presents some peculiarity of operation which makes it preferable in certain cases. "Brandy," observes Dr. Paris (*Pharmacologia*), "is said to be simply cordial and stomachic; rum, heating and sudorific; gin and whiskey, diuretic; and arrack, heating and narcotic." *As a stomachic stimulant*, brandy is employed to relieve spasmodic pains, to check vomiting, especially sea-sickness, and to give temporary relief in some cases of indigestion attended with pain after taking food. *As a stimulant and restorative* in the last stage of fever, brandy is sometimes given with considerable benefit. For this purpose the *mistura spiritûs vini gallici* of the London Pharmacopœia, better known as *egg flip*, is said to be a favourite preparation with Sir H. Halford. *To relieve mild cases of diarrhœa*, attended with griping pain, but unaccompanied by any inflammatory symptoms, a small quantity of brandy and water, taken warm with nutmeg, is often an efficacious remedy. *As a powerful stimulant*, to support the vital powers, and to prevent fainting during a tedious operation, brandy is most serviceable. It is also used to relieve syncope, and to restore patients from a state of suspended animation. *In delirium tremens* it is not always advisable to leave off the employment of spirituous liquors at once, since the sudden withdrawal of the long-accustomed stimulus may be attended with fatal consequences. *In poisoning by foxglove*, brandy and ammonia are the remedies most to be relied on.

(*b.*) *External.*—Spirit of wine is used externally for several purposes, of which the following are the principal:—*As a styptic*, to restrain hæmorrhage from weak and relaxed parts. It is efficacious in two ways: it coagulates the blood by its chemical influence on the liquid albumen and fibrin, and it causes the contraction of the mouths of the bleeding vessels by its stimulant and astringent qualities. Sponge or soft linen soaked in brandy, or in spirit and water, has been applied to the mouth of the uterus in uterine hæmorrhage (Richter, *Arzneimittellehre*, 3er Bd. S. 256). *Spirit is used to harden the cuticle over tender and delicate parts.* Thus brandy is sometimes applied to the nipples several weeks before delivery, in order to prevent production of sore nipple from suckling, in individuals predisposed to it. The efficacy of spirit, in hardening the cuticle, depends, in part, on its chemical influence. Spirit gargles have been found serviceable in checking the tendency to inflammation and swelling of the tonsils. *As a stimulant application*, warm rectified spirit has been applied to burned or scalded parts, on the principles laid down for the treatment of these cases by Dr. Kentish. Properly diluted, spirit has been employed as a wash *in various skin diseases*, and *in ulcers of bed-ridden persons*, and as a *collyrium* in chronic ophthalmia. *Frictions with rectified spirits* have been used in the abdominal region, to promote labour pains; on the chest, to excite the action of the heart, in fainting or suspended animation; in the hypogastric region, to stimulate the bladder, when retention of urine depends on inertia, or a paralytic condition of this viscus; in various parts of the body, to relieve the pain arising from bruises, or to stimulate paralyzed parts.

The inhalation of the vapour of rectified spirit has been recommended to relieve the irritation produced by the inspiration of chlorine; but I have tried the practice on myself without benefit. The readiest mode of effecting it is to drop some spirit on a lump of sugar, and hold this in the mouth during inspiration.

Diluted spirit has been used *as an injection for the radical cure of hydrocele.* A mixture of wine and water, however, is commonly employed in this country.

Spirit has been used to form cold lotions. — As the efficacy of it depends on its evaporation, it should be applied by means of a single layer of linen, and not by a compress. Evaporating lotions are applied to the head in cephalalgia, in phrenitis, in fever, in poisoning by opium, &c.; to fractures of the extremities; to parts affected with erysipelatous inflammation, &c.

2. *PHARMACEUTICAL.*—The alcohol of the Pharmacopœia (sp. gr. 0·815) is not employed in the preparation of any officinal substances, but it is a valuable agent in chemical analysis, and is used in determining the purity of certain medicinal substances; as iodine, iodide of potassium, the vegetable alkalies, castor oil, &c. Rectified and proof spirits are most extensively employed in officinal pharmacy: as in the formation of tinctures (the *alcoolés* of the French pharmacologists), spirits (*alcoolats* or *alcoolata* of the Codex), ethers, etherial oil, and resinous extracts, and in the manufacture of the vegetable alkalies. Spirit is added to various preparations to assist in preserving them.

ANTIDOTES. — The first object in the treatment of poisoning by spirituous liquors is to evacuate the contents of the stomach, which is best effected by the stomach-pump; emetics being frequently unsuccessful. Stimulants are then to be employed: the most effectual are the injection of cold water into the ears, cold affusion to the head and neck, warmth to the extremities, when these are cold, and the internal use either of ammonia, or of the solution of the acetate of ammonia, both of which agents have been found useful in relieving stupor. The cerebral congestion often requires the cautious employment of local blood-letting, and the application of cold to the head. If the patient appear to be dying from paralysis of the respiratory muscles, artificial respiration should be effected: if from closure of the larynx, tracheotomy may be performed (see pp. 68 and 69).

Æ′ther Sulphu′ricus.—Sul′phuric E′ther.

History and Synonymes.—This liquid is said to have been known to Raymond Lully, who lived in the 13th century, and to Basil Valentine, in the 15th century. In 1540, Valerius Cordus described the method of making it. He termed it *oleum vitrioli dulce*. The Germans call it *vitriolic naphtha* (*naphtha vitrioli*).

Natural History.—It is always an artificial product.

Preparation.—The following are the directions in the London Pharmacopœia for preparing it:—"Take of rectified spirit three pounds, sulphuric acid two pounds, carbonate of potash, previously ignited, an ounce: pour two pounds of the spirit into a glass retort, add the acid to it, and mix. Afterwards place it on sand, and raise the heat so that the liquor may quickly boil, and the ether pass into a receiving vessel cooled with ice or water. Let the liquor distil until some heavier portion begins to pass over. To the liquor which remains in the retort after the heat has subsided, pour the remainder of the spirit, that ether may distil in the same manner. Mix the distilled liquors, then pour off the supernatant portion, and add to it the carbonate of potash, shaking them frequently during an hour. Lastly, let the ether distil from a large retort, and be kept in a stoppered vessel."

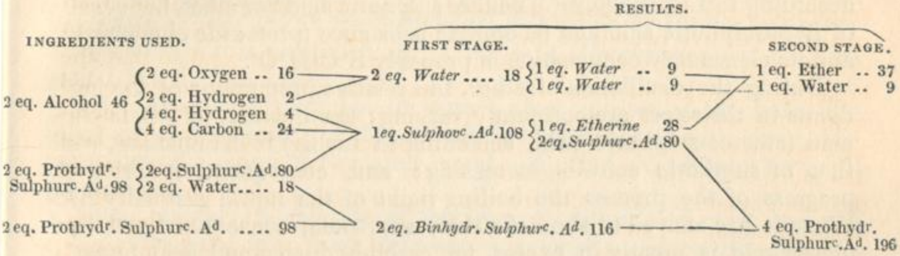
When required to be produced in small quantities, ether may be made in a tubulated glass retort, connected by an adopter with a cooled glass receiver; but on the large scale a leaden still heated by steam is used instead of the retort. With this is connected a condensing worm, kept cool in the usual way, and delivering the distilled liquor into a receiver with a glass lid.

Theory of Etherification.—In order to convert two equivalents or 46 parts of alcohol into one equivalent or 37 parts of ether, we must abstract one equivalent or nine parts of water.

	Carbon.	Hydrogen.	Oxygen.
2 equivalents Alcohol are composed of	4 eq.	6 eq.	2 eq.
Abstract 1 equivalent Water composed of	0 eq.	1 eq.	1 eq.
1 equivalent Ether	4 eq.	5 eq.	1 eq.

But though the phenomena are thus far very simple, there are some accessory changes which make the theory of etherification exceedingly complicated, and about the precise nature of which chemists are not quite agreed.

It appears that when strong liquid sulphuric acid and rectified spirit are mixed, the acid loses part of its saturating power, and a new compound is formed (*sulpho-vinic acid* of Hennell; *ethereo-sulphuric acid* of Liebig). The heat employed causes this to undergo decomposition, by which ether and sulphuric acid are obtained. Mr. Hennell explains the process in the following way:—Four equivalents or 196 parts of the protohydrated sulphuric acid re-act on two equivalents or 46 parts of alcohol, and produce two equivalents or 18 parts of water, one equivalent, or 108 parts of sulpho-vinic acid, and two equivalents or 116 parts of the binhydrated sulphuric acid. These are the products of the first stage of the process. By the heat employed the sulpho-vinic acid is decomposed into one equivalent or 28 parts of a $\frac{4}{4}$ carbo-hydrogen (*etherine*), and two equivalents or 80 parts of anhydrous sulphuric acid. The carbo-hydrogen *(etherine)* uniting with one equivalent or 9 parts of water forms one equivalent or 37 parts of ether, which distil over; while the anhydrous sulphuric acid, with the binhydrated sulphuric acid, reproduces protohydrated sulphuric acid, which remains in the retort with one of the two equivalents of water formed in the first stage of the process; so that ether, water, and protohydrated sulphuric acid, are the products of the second stage of the process. The following diagram illustrates the changes according to Mr. Hennell's views (*Phil. Trans.* 1826 and 1828):—

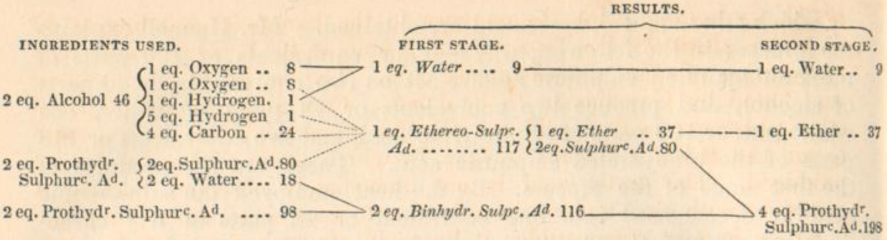


According to this theory, sulpho-vinic acid may be regarded as a *bisulphate of etherine.*

2 eq. Sulphuric Acid	80	2 eq. Sulphuric Acid		80
4 eq. Carbon	24	1 eq. Etherine	4 eq. Carbon	24
4 eq. Hydrogen	4		4 eq. Hydrogen	4
1 eq. Sulpho-vinic Acid	108	1 eq. Bisulphate Etherine		108

The theory of etherification, according to Liebig *(Handwörterbuch der Chemie*, 1 Bd. S. 110—116, 1837), may be thus concisely stated:—Four equivalents or 196 parts of the protohydrated sulphuric acid re-act on two equivalents or 46 parts of alcohol, and produce one equivalent or 9 parts of water, one equivalent or 117 parts of ethereo-sulphuric acid, and two equivalents or 116 parts of binhydrated sulphuric acid. These are the products of the first stage of the process. At a temperature of about 255° F. the ethereo-sulphuric acid is decomposed into an equivalent or 37 parts of ether, which distil over, and two equivalents or 80 parts of anhydrous sulphuric acid, which, with the binhydrated sulphuric acid, reproduce four equivalents or 196 parts of the protosulphuric acid: the latter remain in the retort with the equivalent of water produced in the first stage of the process.

The following diagram will perhaps serve to render this view more intelligible:—



The ethereo-sulphuric acid of Liebig may be viewed as the *hydrate of sulpho-vinic acid* (Hennell),—as a *bisulphate of ether*,—as the *hydrated bisulphate of etherine*,—or, lastly, as the *bisulphate of the oxide of ethereum* (*ethule*).

1 eq. Sulpho-vinic A^{d}. (Hennell)	108	1 eq. Sulphuric Acid	80	1 eq. Sulphuric A^{d}.	80	2 eq. Sulphuric A^{d}.	80
1 eq. Water	9	1 eq. Ether	37	1 eq. Etherine	28	1 eq. Ether^{m}. (Ethule)	29
				1 eq. Water	9	1 eq. Oxygen	8
1 eq. Hydr^{d}. Sulpho-vinic A^{d}.	117	1 eq. Bisulph^{e}. Ether	117	1eq. Hydr^{d}. Bisulph^{e}. Etherine	117	1 eq. Bisulphate Ox^{e}. Ethereum........	117

The ethereo-sulphuric acid of Liebig must not be confounded with a compound of a similar name described by Magnus, and which contains, according to Liebig (*op. cit.*), neither sulphuric acid nor ether, but consists of hyposulphuric acid and an organic substance (protoxide of etherine?); and its elementary composition is probably $S^2C^4H^4O^6$.

During the distillation of ether, the relative proportions of the ingredients in the retort are constantly varying: the quantity of sulpho-vinic acid (ethereo-sulphuric acid, according to Liebig) is diminishing, while that of sulphuric acid is increasing; and, consequently, during the progress of the process the boiling point of the liquid gradually rises. When it has arrived at about 340° F., and when, consequently, the sulphuric acid is greatly in excess, the carbo-hydrogen and acid begin to react on each other; the products of this reaction are water, sulphurous acid, and carbon: the latter blackens the liquid in the retort, while the sulphurous acid is distilled over with some water. Hence, therefore, as soon as " a heavier portion" (*i.e.* an aqueous solution of sulphurous acid) is perceived under the ether in the receiver, the process is stopped; and when the liquid in the retort has become sufficiently cool, more rectified spirit is added, and distillation again performed.

The rectification of ether is intended to free it from alcohol, water, sulphurous acid, and oil of wine. It is ordered to be effected by the addition of carbonate of potash and re-distillation. In order to separate alcohol from ether, the readiest method is to shake the ether with twice its bulk of water; then pour it off, and remove the water which the washed ether has dissolved, by adding some fresh burned lime, and distilling the ether a second time.

PROPERTIES.—At ordinary temperatures ether is a colourless, very limpid liquid, having a penetrating, peculiar, though somewhat fragrant odour; a hot, pungent taste, and a high refractive power. It is a bad conductor of electricity. Absolutely pure ether has not been solidified by any degree of cold hitherto produced. The sp. gr. of pure ether at 68° F. is, according to Dumas and Boullay, 0·713 (Brande's *Manual of Chemistry*). The ether of the shops contains a little alcohol, and its sp. gr. varies from 0·733 to 0·765: in the Pharmacopœia the sp. gr. at 62° F. is fixed at 0·750. Ether is extremely volatile: when of sp. gr.

0·720, its boiling point (the mercury in the barometer standing at 30 inches), is about 98° F. In a vacuum it boils at 40° F. below zero. The evaporation of ether causes intense cold. The sp. gr. of ether vapour was found by Gay-Lussac to be 2·586. Pure and recently prepared ether possesses neither acid nor alkaline properties; but, by exposure to air and light, it absorbs oxygen, by which acetic acid and water are produced. The acetic acid is not immediately observed, because it combines with some undecomposed ether to form acetic ether (Dumas).

Ether is very combustible: it burns in atmospheric air with a yellowish white flame, and forms carbonic acid and water. Its vapour, mixed with oxygen or atmospheric air, forms a violently explosive mixture. The house of an apothecary at Bern was blown up, in consequence of a lighted candle being taken into a cellar in which a bottle of ether had been broken. One volume of ether vapour consumes, in burning, six volumes of oxygen gas: the products are four volumes of carbonic acid, and five volumes of aqueous vapour. By the slow combustion of ether vapour, by means of a coil of platinum wire, a substance is formed which Mr. Daniell called *lampic acid*, but which he afterwards supposed to be acetic acid, combined with a peculiar compound of carbon and hydrogen. I have before mentioned, that it is called by Liebig, *aldehydric acid*, who says it is composed of $C^4H^3O^2+\dot{H}$ (*Handwörterbuch der Chemie*, 1 Bd. S. 188, 1837).

Ether is sparingly soluble in water: nine volumes of the latter dissolve one of the former. Ether, which has been washed with water, contains a small portion of the latter liquid. Alcohol dissolves ether in all proportions.

Ether abstracts bichloride of mercury, terchloride of gold, and the sesquichloride of iron, from their watery solutions. It readily dissolves bromine and iodine, but the solutions by keeping undergo decomposition. It sparingly dissolves sulphur and phosphorus: the ethereal solution of phosphorus is luminous in the dark, when poured on hot water. It dissolves the volatile oils, most of the fatty and resinous substances, some of the vegetable alkalies, urea, and osmazome.

CHARACTERISTICS.—Sulphuric ether may be recognized by its combustibility, its yellowish white flame, its volatility, its peculiar odour and taste, its complete solubility in alcohol, and its sparing solubility in water, in consequence of which, when mixed with water and agitated in phial, the mixture speedily separates, on standing, into two layers.

COMPOSITION.—The following is the elementary composition of ether:

	Eq.	Eq.Wt.	Per Cent.	Dumas & Bouillay.
Carbon	4	24	64·87	65·05
Hydrogen	5	5	13·51	13·85
Oxygen	1	8	21·62	21·24
Ether	1	37	100·00	100·14

Chemists are not agreed as to the manner in which these elements are associated. Ether has been considered, at different times, as a *dihydrate of olefiant gas*,—a *hydrate of etherine*,—or as the *protoxide of ethereum* (*ethule*).

2 eq. Olefiant gas	28	1 eq. Etherine	28	1 eq. Ethereum (Ethule)	29
1 eq. Water	9	1 eq. Water	9	1 eq. Oxygen	8
1 eq. Dihydrate of Olefiant gas	37	1 eq. Hydrate of Etherine	37	1 eq. Protox^{e}. of Ether^{m}.	37

In this diagram olefiant gas is regarded as a $\frac{2}{2}$ carbo-hydrogen, etherine as a $\frac{4}{4}$ carbo-hydrogen, and ethereum as $\frac{4}{5}$ carbo-hydrogen.

Purity.—Absolutely pure ether is not necessary for medicinal purposes. Hence in the London Pharmacopœia we are told that ether which has a sp. gr. of 0·750 may be employed: but it would have been better to have limited the sp. gr. to 0·740. Of course the presence of alcohol or water increases the sp. gr. of this liquid: hence the lightest ether is to be preferred, as being the freest from these. Ether which contains no alcohol does not coagulate the serum of the blood. Pure ether does not redden litmus, but the ether of the shops usually does so slightly. Ten fluidounces of water should not dissolve more than one fluidounce of ether, and the solution should be quite transparent.

Physiological Effects. (*a.*) *On Vegetables.*—Ether, like alcohol, acts as a powerful and rapid poison to plants.

(*b.*) *On Animals.* The effects of it on dogs have been determined by Orfila (*Toxicolog. Générale*), who found that half an ounce introduced into the stomach, and the œsophagus tied, caused attempts to vomit, diminished muscular power, insensibility, and death in three hours. Three drachms and a half injected into the cellular tissue of the thigh caused death on the fourth day. Jäger (quoted by Wibmer, in *Die Wirkung*, &c.) found that half an ounce of ether acted as a fatal poison to a crane: at the end of 48 hours its odour could be readily detected in the body. He made similar experiments with pigeons and ducks. One of the last mentioned animals took altogether an ounce of ether, yet was not dead at the end of 24 hours.

(*c.*) *On man.* The operation of ether is analogous to that of alcohol, but is much more rapid and transient. *Swallowed in moderate doses* it makes a powerful impression on the mouth, throat, and stomach, allays spasm, and relieves flatulence: but, according to some observers, it augments neither the heat of the body nor the frequency of the pulse (Schwilgué, *Traité de Mat. Méd.* 1818): also, Trousseau and Pidoux, *Traité de Thérap.* 1836). Its first effects on the cerebral functions are those of an excitant, but the subsequent ones are those of a depressing agent. *In somewhat larger doses* it produces intoxication like that caused by alcohol. *In excessive doses* it occasions nausea, a copious flow of saliva, giddiness, and stupefaction.

The long and habitual use of ether diminishes the effect of this substance over the system, and therefore the dose must be proportionately increased. Dr. Christison mentions the case of an old gentleman who consumed sixteen ounces every eight or ten days, and had been in the habit of doing so for many years. Yet with the exception of an asthma for which he took the ether, he enjoyed tolerable health. The chemist Bucquet, who died of scirrhus of the colon, with inflammation of the stomach and of the intestines generally, took, before his death, a pint of ether daily to alleviate his excruciating pains (Merat and De Lens, *Dict. Mat. Méd.*).

When the vapour of ether, sufficiently diluted with atmospheric air, is *inhaled*, it causes irritation about the epiglottis, a sensation of fulness in the head, and a succession of effects analogous to those caused by the protoxide of nitrogen (*vide* p. 156), and persons peculiarly susceptible of the action of the one are also powerfully affected by the other (*Journ. of Science*, vol. iv. p. 158). If the air be too strongly impregnated with ether, stupefaction ensues. In one case this state continued with occasional periods of intermission for more than 30 hours: for many days the pulse was so much lowered that considerable fears were entertained for the safety of the patient (*op. cit.*) In another case, an apoplectic condition, which continued for some hours, was produced.

MODUS OPERANDI.—When ether is swallowed it is rapidly absorbed, and subsequently thrown out of the system by the pulmonary surface. Magendie (*Elem. Compend. Physiol.* by Milligan) says, that ether introduced into the cavity of the peritoneum is discoverable in the expired air by its odour. Thrown into the cavity of the pleura, it produces speedy death, and its odour is very obvious when we approach the mouth of the animal.—(*Lectures on the Tissues*, Lancet, Nov. 22, 1834).

USES.—1. *MEDICINAL.* (*a.*) *Internal.*—Ether is principally valuable as a speedy and powerful agent in spasmodic and painful affections, not dependent on local vascular excitement, and which are accompanied by a pale, cold skin, and a small, feeble pulse. If administered during a paroxysm of spasmodic asthma, it generally gives relief, but has no tendency to prevent the recurrence of the attacks. In cramp of the stomach, singultus, and flatulent colic, its happy effects are well established. It is sometimes highly advantageous in a paroxysm of angina pectoris. During the passage of urinary or biliary calculi it may be used as a substitute for, or in combination with, opium, to overcome the spasm of the ducts or tubes through which the calculus is passing.

In the latter stages of continued fever, ether is sometimes admissible. It is employed to relieve the subsultus tendinum and hiccup. Desbois de Rochefort (*Mat. Méd.*) administered it in intermittent fevers. He gave it about half an hour before the expected paroxysm; it acted as a mild diaphoretic, and prevented the recurrence of the attack.

Headache of the kind popularly called nervous, that is, unconnected with vascular excitement, is sometimes speedily relieved by ether. I have found it beneficial principally in females of delicate habits. In such it occasionally gives immediate relief, even when the throbbing of the temporal vessels and suffusion of the eyes (symptoms which usually contraindicate the employment of ether), would seem to shew the existence of excitement of the cerebral vessels.

In flatulence of stomach it may be taken in combination with some aromatic water. Against sea-sickness it should be swallowed in a glass of white wine. Durande (*Observ. sur l'Efficacité du Mélange d'Ether sulphuriq. et d'Huile volatile de Tereb. dans Coliques hépatiq. produites par des Pierres Biliaires*, 1790), recommends a mixture of three parts ether and two oil of turpentine as a solvent for biliary calculi Bourdier (*Mém. de la Société de Méd.*) employed ether to expel tape-worm. He administered it by the stomach and rectum in an infusion of male fern, giving a dose of castor-oil an hour after. In faintness and lowness of spirits it is a popular remedy. In poisoning by hemlock and mushrooms it has been employed (J. Frank, *Toxicologie*, s. 70,108). In asphyxia it has been used with benefit.

The vapour of ether is inhaled in spasmodic asthma, chronic catarrh, and dyspnœa, hooping cough, and to relieve the effects caused by the accidental inhalation of chlorine gas. It may be used by dropping some ether in hot water, and inspiring the vapour mixed with steam, or it may be dropped on sugar which is to be held in the mouth. The inhalation of the vapour of the etherial tincture of hemlock is occasionally useful in relieving spasmodic affections of the respiratory organs, and hasbeen recommended in phthisical cases.

(*b.*) *External.*—The principal external use of ether is to produce cold by its speedy evaporation. Thus in strangulated hernia it may be dropped on the tumour and allowed to evaporate freely: by this means a considerable degree of cold is produced, and, in consequence, the bulk of the part diminished, whereby the reduction of the hernia is facilitated. Dropped on the forehead, or applied by means of a piece of thin muslin, ether diminishes vascular excitement, by the cold produced from its evaporation, and is exceedingly efficacious in headache and inflammatory conditions of the brain. In burns and scalds it may also be employed as a refrigerant. If its evaporation be stopped or checked, as by covering it with a compress, it acts as a local irritant, causing rubefaction, and, by long-continued application, vesication. It is used with friction as a local stimulant.

2. *PHARMACEUTICAL.*—Ether is employed in the preparation of the compound spirit of sulphuric ether. It is also used to extract the active principles of certain drugs, as of lobelia, aloes, musk, &c. The solutions (none of which are contained in the London Pharmacopœia) are called etherial tinctures (*tincturæ æthereæ*), or by the French pharmacologists *éthérolés.* Ether is of assistance in determining the purity of some medicinal substances, as of aconitina and veratria, which are very soluble in it. It is also employed in toxicological researches, to remove bichloride of mercury from organic mixtures.

ADMINISTRATION.—It may be given in doses of from half a fluidrachm to two drachms:—a tea-spoonful is the ordinary quantity. This dose may be repeated at short intervals. It is usually exhibited in some aromatic water, and frequently in combination with other antispasmodics and stimulants, as ammonia, valerian, &c. It may be perfectly incorporated with water, or any aqueous mixture, by rubbing it with spermaceti employed in the proportion of two grains for each fluidrachm of ether (*United States Dispensatory.*)

ANTIDOTES.—In cases of poisoning by ether the same treatment is to be adopted as before recommended in cases of poisoning by alcohol.

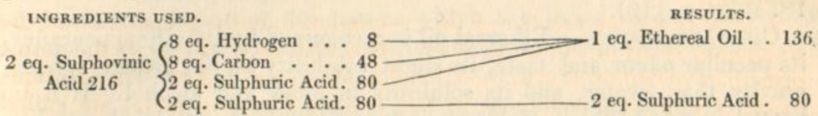
O'leum Æthe'reum (Ph. L.)—*Ethe'real Oil.*

HISTORY AND SYNONYMES.—This liquid is commonly termed *heavy oil of wine*, or simply *oil of wine*. Dumas (*Traité de Chimie*, t. 5$^{me.}$ p. 543), says it was known to Paracelsus, who designated it *sweet oil of vitriol.* Modern writers have given it various appellations founded on its supposed composition. Thus according to Mr. Hennell it is a *sulphate of hydrocarbon,*—Dumas calls it *sulphatic ether,*—others a *double sulphate of ether* and *hydrocarbon,*—while Liebig terms it *ethereo-sulphate* of *ether-oil*, the term ether-oil being applied by this writer to a fluid $\frac{4}{4}$ carbohydrogen.

PREPARATION.—The following directions for procuring it are given in the London Pharmacopœia. "Take of rectified spirit two pounds, sulphuric acid four pounds, solution of potash, distilled water, of each a fluidounce, or as much as may be sufficient. Mix the acid cautiously with the spirit. Let the liquor distil until a black froth arises; then immediately remove the retort from the fire. Separate the lighter supernatant liquor from the heavier one, and expose the former to the air for a day. Add to it the solution of potash first mixed with water, and shake them together. Lastly, when sufficiently washed, separate the ethereal oil which subsides." I am informed by Mr. Hennell that 33 lbs. (*avoird.*) of rectified spirit, and 64 lbs. (*avoird.*) of oil of vitriol, yielded, in one operation, 17 ounces (*avoird.*) of ethereal oil.

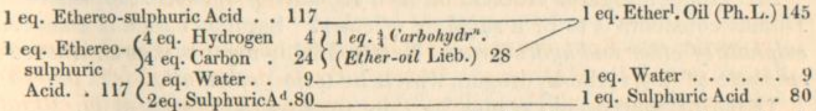
THEORY OF THE PROCESS.—In the first part of the process the changes are the same as those which occur in the process for making sulphuric ether. When the sulphuric acid and rectified spirit are mixed, sulpho-vinic acid (ethereo-sulphuric acid, according to Liebig) is formed, and by distillation water and ether are obtained.

The formation of ethereal oil depends, according to Mr. Hennell, on the decomposition of two equivalents or 216 parts of sulpho-vinic acid into one equivalent or 136 parts of ethereal oil, and two equivalents or 80 parts of sulphuric acid.



This view of the subject is principally founded on the fact that sulpho-vinic acid, or a sulpho-vinate, when heated, yields, among other products, ethereal oil.

But Liebig states that the compound formed by the mixture of sulphuric acid and rectified spirit is ethereo-sulphuric acid, and that the heavy oil of wine (the ethereal oil, Ph. L.) is an ethereo-sulphate of a $\frac{4}{4}$ carbo-hydrogen, which he calls ether-oil (Aetherol). Consistently with this view we may account for the formation of the heavy oil of wine by supposing that by the heat employed, one equivalent or 117 parts of ethereo-sulphuric acid are resolved into one equivalent or 28 parts of a fluid $\frac{4}{4}$ carbo-hydrogen (ether-oil of Liebig), two equivalents or 80 parts of sulphuric acid, and one equivalent or 9 parts of water. By the union of the $\frac{4}{4}$ carbo-hydrogen (ether-oil of Liebig) with one equivalent or 117 parts of ethereo-sulphuric acid, there are formed an equivalent or 145 parts of the ethereal oil of the Pharmacopœia (the *ethereo-sulphate* of Liebig's *ether-oil*).



During the process olefiant gas is evolved. By the mutual action of sulphuric acid and the $\frac{4}{4}$ carbo-hydrogen, water, sulphurous acid, and carbon, are produced. The deposition of the last-mentioned substance is the cause of the black froth alluded to in the Pharmacopœia. The lighter supernatant liquor also referred to is the ethereal oil mixed with ether. The latter evaporates by exposing the mixture to the air for a day. To remove any traces of sulphurous acid, the oil is to be washed with a solution of caustic potash. Liebig says alkalies decompose it (*op. cit.* p. 122).

PROPERTIES.—Ethereal oil is usually a yellowish oily liquid, having a peculiar aromatic odour, and a bitter aromatic taste. Its sp. gr. according to Mr. Hennell, is 1·05; but according to Serullas, it is 1·13. It is insoluble in water, but dissolves readily in alcohol and ether. It neither reddens litmus nor precipitates a solution of chloride of barium, so that the sulphuric acid contained in it seems to be completely neutralized.

According to Mr. Hennell ethereal oil dissolves a variable quantity of a $\frac{4}{4}$ carbo-hydrogen, part of which separates in a crystalline form when the oil is kept for some time, or when exposed to cold. This crystalline compound, the existence of which was first pointed out by Mr. Hennell, is called *wine-oil-camphor* (*Weinöl-Campher*) by Gmelin (*Handb. d. Chemie*, 2^{er}. Bd. s. 405),—*etherine* by Liebig (*Handwört d Chemie*, 1^{er}. Bd. s. 116).

When ethereal oil is slightly heated with water it yields ethereo-sulphuric acid (sulpho-vinic acid of Hennell) and a light oily fluid (*light* or *sweet oil of wine*) which floats on water. This substance is a mixture of two isomeric compounds,—the one a solid (*wine-oil-camphor* or *etherine*) the other a liquid (*ether-oil* of Liebig). Each of these compounds is a $\frac{4}{4}$ carbo-hydrogen (Liebig and Poggendorf, *Handwört. d. Chemie*, 1^{er}. Bdes. s. 119).

CHARACTERISTICS.—Ethereal oil is recognized by its oily appearance, its peculiar odour and taste, its slight solubility in, but greater specific gravity than, water, and its solubility in ether and alcohol. If it be heated in a test tube it yields an inflammable vapour which burns like olefiant gas, and a carbonaceous residue which contains sulphuric acid, as is proved by lixiviating with water and testing by chloride of barium. Ethereal oil added to a solution of chloride barium, occasions no cloudiness, but if we evaporate the mixture to dryness, the residue is found to contain sulphate of baryta.

COMPOSITION.—Three chemists have analysed ethereal oil, namely, Hennell, Serullas, and Liebig. The results of two only of these agree, namely, those of Liebig and Serullas.

	LIEBIG AND SERULLAS.					HENNELL.		
	Eq.	Eq.Wt.	Theory.	Liebig.	Serullas.	Eq.	Eq.Wt.	Per Cent.
Sulphuric Acid	2	80	55·17	55·614	55·02	1	40	38·0
Carbon	8	48	33·10	33·180	33·05	9	54	53·7
Hydrogen	8	8	5·52	5·418	5·49	9	9	8·3
Water	1	9	6·21	5·788	6·11	0	0	0·0
Ether^{l}.Oil(Ph.L.)	1	145	100·00	100·000	99·67	1	103	100·0

Mr. Hennell regards ethereal oil as a *sulphate of hydrocarbon*, whereas Dumas considers it to be a *sulphate of ether*. Serullas called it a *double sulphate of ether and hydrocarbon*. Lastly, Liebig regards it as an *ethereo-sulphate of* (a $\frac{4}{4}$ carbo-hydrogen, which he terms) *ether-oil*.

These different opinions may be thus represented:—

LIEBIG.	SERULLAS.	DUMAS.	HENNELL.
1eq.Ethereo-sulp^{c}. Ad. 117 1 eq. Ether-oil 28	2 eq. Sulphuric Acid 80 1 eq. Ether........ 37 4 eq. Hydrocarbon .. 28	1 eq. Sulphuric Acid.. 40 1 eq. Ether 37	1 eq. Sulph^{c}. Acid . 40 9 eq. Hydrocarbon . 63
1 eq.Ethereo-sulphate Ether-oil 145	1eq.Doub.Sulph^{e}.Eth^{r}. and Hydrocarbon . 145	1 eq. Sulphate Ether..117	1 eq. Sulphate Hydrocarbon...... 103

PHYSIOLOGICAL EFFECTS.—These have not been determined. I gave fifteen drops to a small rabbit: death took place within an hour. The symptoms were indisposition to move, apparent tendency to sleep, followed by incapability of supporting the erect position, occasional convulsive movements, grating of the teeth, and insensibility. The body was opened immediately after death: the heart was still beating, and its right cavities were gorged with purple blood. Ethereal oil, therefore, acts on the nervous system in a somewhat analogous way to ether.

USES.—Ethereal oil is used in the manufacture of the *spiritus ætheris sulphurici compositus* of the Pharmacopœia. This preparation is an imitation of the *liquor anodynus mineralis* of Hoffman. It is made by mixing eight fluidounces of sulphuric ether, sixteen fluidounces of rectified spirit, and three fluidrachms of ethereal oil. In addition to the stimulating and antispasmodic qualities derived from the ether and alcohol, it is supposed by some to possess anodyne properties highly useful in nervous irritation, and want of sleep arising from that cause.

"Dr. Hare," in his *Chemical Compendium*, "reports the opinion of Drs. Physick and Dewees in favour of the efficacy of the officinal oil of wine, dissolved in alcohol, in certain disturbed states of the system, as a tranquillizing and anodyne remedy." (*United States Dispensatory*). The compound spirit of sulphuric ether is sometimes employed as an adjunct to laudanum, to prevent the nausea which the latter excites in certain habits. Its dose is from half a fluidrachm to two fluidrachms, in any proper vehicle.

Spir'itus Æ'theris Nit'rici.—Spir'it of Ni'tric E'ther.

HISTORY AND SYNONYMES.—Spirit of nitric ether was known to Raymond Lully in the 13th century. Basil Valentine, in the 15th century, taught an improved method of obtaining it (Geiger, *Handb. d. Pharm.*). It has been known by various names,—such as *sweet spirit of nitre* (*spiritus nitri dulcis*),—*spirit of nitrous ether* (*spiritus ætheris nitrosi*), and *nitre drops*. Nitric ether was first mentioned by Kunkel in 1681.

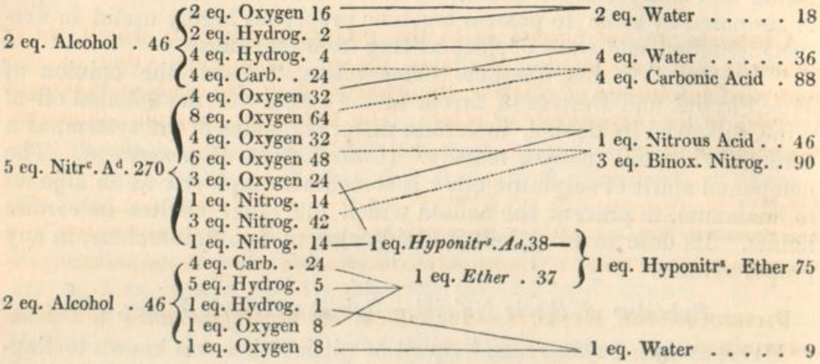
PREPARATION.—The following directions for its preparation are given in the London Pharmacopœia:—"Take of rectified spirit three pounds, nitric acid four ounces: add the acid gradually to the spirit, and mix: then let thirty-two fluid ounces distil." At Apothecaries' Hall it is prepared in an earthenware still (heated by the slow application of steam to its outer surface), with a condensing worm-pipe of the same material.—It should be slowly distilled at a temperature of about 180° F. (Brande's *Manual of Pharmacy*).

THEORY OF THE PROCESS.—The changes in this process are complicated, in consequence of the products being very numerous. The nitric acid is deprived of part of its oxygen, and thereby furnishes binoxide of nitrogen, and nitrous and hyponitrous acids, as well as some nitrogen and protoxide of nitrogen. The oxygen which is abstracted from the nitric acid unites with some hydrogen of the alcohol to form water, and with some carbon to produce carbonic acid.

One equivalent or 38 parts of hyponitrous acid react on two equivalents or 46 parts of alcohol, and produce one equivalent or 75 parts of hyponitrous ether (commonly termed nitric ether), and one equivalent or 9 parts of water. The hyponitrous ether and some spirit distil over, and constitute the spirit of nitric ether of the Pharmacopœia.

Besides the above, which are the more essential changes, others take place by which additional products are obtained. Thus acetic, malic, (oxalhydric?) and oxalic acids, are likewise produced, but in small quantities. The production of acetic acid may be accounted for by supposing either that a portion of the alcohol is deprived of part of its hydrogen, or that some oxygen of the nitric acid unites with portions of hydrogen and carbon of the alcohol. The acetic acid re-acting on some alcohol produces acetic ether, which distils over. The origin of the malic (oxalhydric ?) acid is probably similar to that of the acetic acid. The oxalic acid is produced by the union of a portion of the oxygen of the nitric acid with some carbon of the alcohol.

The following diagram will explain some of the more essential changes attending the production of hyponitrous ether.



Properties.—Spirit of nitric ether, (Ph. L.,) is a colourless limpid liquid, having a fragrant ethereal odour somewhat analogous to that of ripe apples, and a pungent, aromatic, sweetish, acidulous taste. Its sp. gr. should not exceed 0·834. It is very volatile, producing much cold by its evaporation. It is very inflammable, and burns with a whitish flame. By keeping, it becomes powerfully acid, and then strongly reddens litmus, and produces effervescence with the alkaline carbonates. It dissolves in alcohol and water in all proportions.

Characteristics.—It is principally distinguished by its peculiar odour, its inflammability, its lightness, and its miscibility with water. The spirit of nitric ether of the shops usually strikes a deep olive colour with the protosulphate of iron, thereby indicating the presence of binoxide of nitrogen, and produces, with tincture of guaiacum, a blue tint, which passes through various shades of green: this last effect probably depends on the presence of nitrous or nitric acid. These effects are not invariably produced; as when spirit of nitric ether has been long kept, though it may still possess the proper odour.

Purity.—This compound is most extensively adulterated by mixing it with rectified spirit and water. The fraud is recognized by an attentive examination of the flavour of this substance, and by taking the sp. gr. of the liquid. If the sp. gr. exceed 0·834, the presence of water may be suspected. Nitric or nitrous acid may be suspected, if the liquid possess the power of strongly reddening litmus, and of causing effervescence with the alkaline carbonates. Some years since, large quantities of spirit of wine, flavoured with nitric ether in order to evade the payment of the duty on spirit, were brought to England from Ireland, under the name of spirit of nitric ether.

Composition.—The spirit of nitric ether of the Pharmacopœia is a mixture of *hyponitrous ether*, *alcohol*, and *water*: the relative proportions have not been ascertained.

The ultimate composition of hyponitrous ether is the following :—

	Eq.	Eq.Wt.	Theory.	Dumas & Boullay.
Carbon	4	24	32·00	32·69
Hydrogen	5	5	6·67	6·85
Oxygen	4	32	42·67	41·46
Nitrogen	1	14	18·66	19·00
Hyponitrˢ. Ether	1	75	100·00	100·00

	Vols.	Sp. Gr.
Carbon vapour	2 or 4	1·6666̇
Hydrogen gas	5	0·3472̇
Oxygen gas	2	2·2222̇
Nitrogen gas	1	0·9722̇
Vapour of Hyponitrˢ. Ether	2	2·6041

Chemists are not agreed as to the precise manner in which these elements are associated. We may regard hyponitrous ether as the *hydrated hyponitrite of etherine*, the *hyponitrite of the oxide of ethereum* (*ethule*), or the *hyponitrite of ether*. The following diagram illustrates these opinions :—

1 eq. Etherine	28	1 eq. Ethereum	29	} 1 eq. Ether	37
1 eq. Water	9	1 eq. Oxygen	8		
1 eq. Hyponitrous Acid	38	1 eq. Hyponitrous Acid	38	1 eq. Hyponitrous Acid	38
1 eq. Hydrᵈ.Hyponitrite Etherᵉ.	75	1 eq. Hyponitrite Oxide Ethereum	75	1 eq. Hyponitrite Ether	75

Physiological Effects.—Its effects on *vegetables* have not been ascertained.

I am not acquainted with any experiments made to determine its effects on *animals* generally. Veterinarians employ it as a diuretic on various occasions, and as a stimulant in the advanced stages of fever to rouse the exhausted powers of horses (Youatt, *The Horse*, in the Library of Useful Knowledge).

On man its effects have not been satisfactorily ascertained. The inhalation of its vapour is dangerous when too long continued, as is proved by the following case. A druggist's maid-servant was found one morning dead in her bed, and death had evidently arisen from the air of her apartment having been accidentally loaded with the vapour of this liquid from the breaking of a three-gallon jar of it. She was found lying on her side, with her arms folded across the chest, the countenance and posture composed, and the whole appearance like a person in a deep sleep (Christison's *Treatise on Poisons*).

Taken internally in moderate doses it acts as a diuretic. It is believed to possess diaphoretic properties. By some pharmacologists it is described as being refrigerant, a quality which it probably owes to the free acid which it usually contains. I am unacquainted with the effects of large doses, but they are probably analogous to, though less energetic than, those of other ethereal compounds. Kraus (*Heilmittellehre*) says, a boy twelve years of age took a drachm in the morning fasting, and that it caused violent colic which lasted for six hours, and was accompanied with vomiting. Probably these effects arose from the preparation containing a considerable quantity of free acid.

Uses.—It is employed as a diuretic in some disorders of children and in mild dropsical complaints, as in the anasarca which follows scarlatina. It is given in conjunction with squills, acetate or nitrate of potash, or foxglove. As a refrigerant and diaphoretic it is used in febrile complaints in combination with the acetate of ammonia and tartar emetic. As a carminative it is frequently useful in relieving flatulence and allaying nausea. On account of its volatility it may be applied to produce cold by its evaporation.

Administration.—The usual dose of this liquid in febrile cases is about half a drachm. When we wish it to act as a diuretic it should be given in large doses, as two or three tea-spoonfuls.

Antidotes.—In poisoning by the inhalation of the vapour of this compound, the treatment will be the same as that described for poisoning by carbonic acid gas.

Ac′idum Acet′icum.—Ace′tic Ac′id.

History.—Vinegar must have been known from the most remote periods of antiquity. It is mentioned by Moses (*Numbers*, ch. vi. v. 3), 1490 years before Christ. Hippocrates (*De natura muliebri*) employed ὄξυς λευκὸν, or *white vinegar*, medicinally. Both Plutarch and Livy tell us that Hannibal, in his passage over the Alps, softened the rocks by fire and vinegar. Geber (*Investigation of Perfection*, ch. iii.) was acquainted with the purification of vinegar by distillation. Stahl, in 1723, obtained concentrated acetic acid from the acetates by the action of sulphuric acid.

Natural History.—Free or combined with potash, lime, or ammonia, acetic acid is met with in the juices of many plants. Thus, Vauquelin found the acetates of potash and lime in the sap of the elm; and Morin detected acetate of ammonia in the fruit of the Areca Catechu. Free acetic acid has been recognized in the gastric juice by Tiedemann and Gmelin. The acid found in the perspiration, the urine, milk, and blood, and which some have called acetic, is now generally believed to be a distinct substance, and is termed lactic acid. Gmelin (*Handb. d. Chem.*) says acetic acid has been found in some mineral waters. If the observation be correct, the acid is probably to be referred to some decomposing organic matter accidentally present in the water.

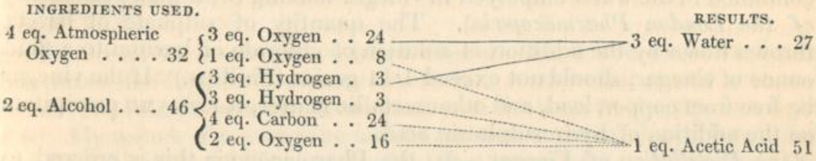
Preparation.—The acetic acid of commerce is obtained from two sources—vinegar and pyroligneous acid: the first is procured by exciting the acetous fermentation in certain liquors, the other by the distillation of wood.

1. *By the Acetous Fermentation.* (*a.*) *Manufacture of Vinegar.*—Vinegar may be procured by the fermentation of various substances; but that met with in English commerce, and which is employed in this country for domestic purposes, is prepared from malt, or a mixture of malt and raw barley, which is mashed with hot water, as in the ordinary operation of brewing. The cooled wort is then transferred to the fermenting tun, where it is mixed with yeast, and undergoes the vinous fermentation. The wash is then introduced into barrels, placed close together in a chamber, and a moderate heat (about 80° F.) is kept up until the acetous fermentation is complete. This process usually occupies several weeks, or even months. The liquor thus procured is not yet fit for sale. It is introduced into large tuns furnished with false bottoms, on which is placed *rape* (the residuary fruit which has served for making domestic wines). These rape-tuns are worked by pairs; one of them is quite filled with the vinegar from the barrels, and the other only three-quarters full, so that the fermentation is excited more easily in the latter than the former, and every day a portion of the vinegar is conveyed from one to the other, till the whole is completely finished, and fit

for sale.—(For further information on this subject, consult Aikins' *Dict. of Chem.*, and Donovan's *Domestic Economy*, in Lardner's *Cabinet Cyclopædia*). Green twigs, or fresh cuttings of the vine, recommended by Boerhaave, are sometimes employed, instead of rape, to flavour vinegar.

Formerly acetification was effected by placing the wash in barrels the bung-holes of which were loosely covered with tiles, and exposing it to the air for several months. But the introduction of stoved chambers has nearly superseded this method.

(*b.*) *Theory of acetification.*—The theory of the acetous fermentation is imperfectly understood. During the process oxygen of the air is absorbed, and carbonic acid is usually evolved, while the alcohol of the wash gradually disappears, and acetic acid is produced. A remarkable distinction between the acetous and vinous fermentation, is, that for the former to be perfectly established, the presence of atmospheric air (or of oxygen) is essential, while for the latter this is not necessary. It is usually supposed, that during the acetous fermentation the alcohol is converted into acetic acid. Two equivalents or 46 parts of alcohol, with four equivalents or 32 parts of atmospheric oxygen, contain the elements of one equivalent or 51 parts of acetic acid, and of three equivalents or 27 parts of water.



Several circumstances favour this hypothesis; such as the simultaneous disappearance of alcohol and production of acetic acid—the strongest wines yielding the best vinegars: in other words, the quantity of acetic acid being proportional to that of alcohol; and, lastly, the formation of acetic acid by the slow combustion of alcohol, as well as by allowing a mixture of alcohol, water, and yeast, to trickle through beech shavings previously soaked in vinegar,—a mode of generating acetic acid practised in Germany. (Mitscherlich, *Lehrbuch der Chemie.*) But, on the other hand, it is to be recollected, that many vegetable substances yield acetic acid during their spontaneous decomposition, without the production of alcohol. In alluding to these cases, Dr. Turner (*Elem. of Chem.*) observes—"all these processes, however, appear essentially different from the proper acetous fermentation above described, being unattended with visible movement in the liquid, with absorption of oxygen, or disengagement of carbonic acid."

The student will observe that the theory of acetification above given does not account for the appearance of carbonic acid during the process. The evolution of this substance is generally considered to be accidental, and not essential to the formation of acetic acid.

(*c.*) *Properties of Vinegar.*—Malt vinegar is of a yellowish or reddish colour, an agreeable acid taste, and a peculiar but pleasant odour. Its sp. gr. varies from 1·0135 to 1·0251. (Thomson, *System of Chemistry*). It is very liable to undergo decomposition when exposed to the air: it becomes turbid, loses its acidity, acquires an unpleasant odour, and deposits a slippery gelatinous substance called the *mother of vinegar*, which, when collected and dried, resembles gum, and is destitute of nitrogen. During these changes we observe mouldiness (*Mucor mucedo*) on its surface. Vinegar nourishes some microscopic animals, commonly though very improperly termed *eels* (*Vibrio Aceti*). These may be destroyed by submitting the vinegar to heat. It is also infested by a small fly (*Musca Cellaris*).

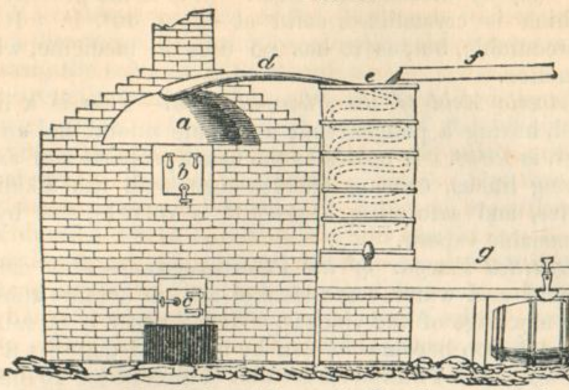
(*d.*) *Constituents of Vinegar.*—Malt vinegar consists of *water*, *acetic acid*, *colouring matter*, a *peculiar organic matter* commonly termed mucilage, a small portion of *alcohol*, and *a peculiar odorous principle.* Vinegar makers are allowed to add one one-thousand part by weight of sulphuric acid. The strongest malt vinegar, called *proof vinegar*, (or No. 24 vinegar) should contain 5 per cent. of real acetic acid; but, according to Mr. Phillips, that of commerce does not usually contain more than 4·6 per cent. One fluidounce, or 446 grains of vinegar of the latter strength, should saturate very nearly 58 grains of crystallized carbonate of soda, or dissolve about 20 grains of pure white marble (carbonate of lime). In the Pharmacopœia we are told, that a fluidounce of vinegar is saturated by 60 grains of crystallized carbonate of soda, two grains being allowed for saturating the sulphuric acid permitted to be added by law, and for decomposing the sulphates contained in the water employed in vinegar-making (Phillips's *Translation of the London Pharmacopœia*). The quantity of sulphate of baryta thrown down by the addition of solution of chloride of barium to a fluid ounce of vinegar, should not exceed 1·14 grains (Phillips.) If the vinegar be free from copper, lead, and other metallic matter, it forms no precipitate on the addition of hydrosulphuric acid.

(*e.*) *Distillation of Vinegar.*—In the Pharmacopœia this is ordered to be effected in a glass apparatus. The seven-eighths first distilled are to be kept for use: they constitute the *acetum distillatum* of the London Pharmacopœia. If a copper still or pewter worm be employed, the distilled product has a metallic impregnation. On the large scale, earthenware or silver condensing tubes are employed.

2. *By the destructive Distillation of Wood.*—This acid is procured by the distillation of wood in cast-iron cylinders. Oak, ash, birch, and beech woods, are employed: fir wood does not answer. The brushwood or spray of trees is sometimes used. The products are charcoal, which remains in the still, and various volatile substances; some condensible, others not.

The condensation of the vapours is effected by passing them through a worm, kept cool by immersion in water. The condensible products are water, acetic acid, and tar: these form crude pyroligneous acid. The incondensible products are carbonic acid and some inflammable gases: viz. carbonic oxide, light carburetted hydrogen, and olefiant gas. These are allowed to escape, or are burned in the furnace.

FIG. 46.



Distillation of Spray for Pyroligneous Acid.

- *a.* The still, a cast-iron boiler.
- *b.* The boiler door for the introduction of the spray.
- *c.* Furnace door.
- *d.* Still head.
- *e.* Worm tub.
- *f.* Waterspout for supplying the refrigeratory.
- *g.* Gutter conveying the acid and tar from the worm to the barrels or other receiving vessels.

The receiver is usually a large cistern. In it the distilled liquor separates into layers: the lower one is tar; next to this, acetic acid and water, holding in solution some tar; and, floating on the top, is a light tar. By means of a pump the middle stratum is removed, and is rectified by slow distillation. The first product that comes over is *pyroxilic spirit;* after this, acetic acid and water, with some essential oil of tar. This rectified acid is of a brownish colour, and has an empyreumatic smell. It is saturated with lime, forming an impure acetate of lime, which is decomposed by a concentrated solution of sulphate of soda: sulphate of lime precipitates, and acetate of soda remains in solution. The latter is purified by crystallization, fusion in an iron pot, and re-crystallization.

From the crystallized acetate of soda, strong acetic acid is obtained by distillation with sulphuric acid. The proportions in the Pharmacopœia are:—two pounds of the crystallized acetate, nine ounces of sulphuric acid, and nine fluidounces of water. On the small scale, the acid is distilled in glass or earthenware vessels. On the large scale, silver condensors are sometimes used. The above proportions are very nearly equal to one equivalent or 137 parts of crystallized acetate of soda, one equivalent or 49 parts of protohydrate of sulphuric acid, and six equivalents or 54 parts of water. The results of the distillation, on this calculation, will be the formation of one equivalent or 72 parts of anhydrous sulphate of soda, and the disengagement of one equivalent or 51 parts of anhydrous acetic acid, which distils over with thirteen equivalents or 117 parts of water.

INGREDIENTS USED.					RESULTS.		
6 eq. Water			54	13 eq. Water	117	Acid Acet. (Ph. L.)
1 eq. Cryst^{d}. Ac^{e}. Soda	117	6 eq. Water .	54			
		1 eq. Acet^{c}. A^{d}.	51	1 eq. Anhyd. Acet^{e}. A^{d}.	51	
		1 eq. Soda . .	32			
1 eq. Protohyr^{d}. Sulph^{c}. Acid . .	49	1 eq. Water .	9			
		1 eq. Sulph^{c}. A^{d}.	40	1 eq. Sulph^{te}. Soda .	72	

Properties.—(*a.*) *Of Glacial Acetic Acid.*—This is the protohydrated acetic acid, which is crystallized solid at about 40°. F. It is the strongest acid procurable, but, as it has no uses in medicine, will not require further notice.

(*a.*) *Of the Acetic Acid of the Pharmacopœia.*—This is a limpid, colourless liquid, having a pungent but agreeable odour, and an acrid taste. Its sp. gr. is 1·048. It possesses the usual properties of an acid, such as reddening litmus, causing effervescence with the alkaline or earthy carbonates, and saturating bases. It is volatile, and by heat evolves an inflammable vapour.

(*c*). *Of the Distilled Vinegar of the Pharmacopœia.*—This contains, besides acetic acid and water, some alcohol and an organic substance derived from the mucilage of the vinegar. Hence when it is saturated with alkalies the solution becomes brown by heat, and deposits a dark-coloured substance. Mr. Phillips states that a mixture of 15 parts by weight of the officinal acetic acid and 85 of water is equal in strength to distilled vinegar.

Characteristics.—Free acetic acid is known by its peculiar odour and by its volatility. Its vapour reddens litmus, and fumes with ammonia. This acid produces no precipitate with lime water, with solutions of the barytic salts, or with a solution of nitrate of silver. It forms with potash a very deliquescent salt.

The neutral acetates are all soluble save those of molybdenum and tungsten. The acetates of silver and protoxide of mercury are slightly soluble. The acetates are known by the acetic odour which they emit on the addition of sulphuric acid, and by the white lamellar and pearly precipitates which many of them produce with either the nitrate of silver or the protonitrate of mercury. All the acetates are decomposed by heat, and give results which vary somewhat according to the nature of the base. Some of the acetates, as those of potash, lead, and copper, evolve when heated an inflammable fluid called *acetone* or *pyro-acetic spirit*, whose composition is C^3. H^3. O^1.

Composition.—Anhydrous or real acetic acid consists of carbon, hydrogen, and oxygen, in the following proportions :—

	Eq.	Eq.Wt.	Per Cent.	Prout.	Berzelius.
Carbon	4	24	47·06	47·05	46·83
Hydrogen	3	3	5·88	5·88	6·35
Oxygen	3	24	47·06	47·07	46·82
Anhydrous Acetic Acid	1	51	100·00	100·00	100·00

The acetic acid of the London Pharmacopœia consists of water and pure acetic acid. As 100 grains of it saturate 87 grains of crystallized carbonate of soda, it must contain 30·8 per cent. of pure acetic acid (Phillips, *op. cit.*). This is very nearly one equivalent of acid to thirteen equivalents of water.

	Eq.	Eq.Wt.	Per Cent.	Phillips.
Anhydrous Acetic Acid	1	51	30·35	30·8
Water	13	117	69·65	69·2
Acetic Acid (Ph. L.)	1	168	100·00	100·0

Purity.—The foreign matters likely to be present in acetic acid are excess of water, sulphuric, hydrochloric, or nitric acid, copper, lead, tin, or other metallic matter. Acrid substances, such as capsicums, grains of paradise, &c. are sometimes added to vinegar to increase its pungency. They are discovered by carefully saturating the vinegar with potash, and then tasting the solution with attention.

The strength of the acetic acid is ascertained by determining its saturating power. One hundred grains of the officinal acid should saturate 87 grains of crystallized carbonate of soda, or dissolve about 30 grains of white marble (carbonate of lime). One hundred grains of distilled vinegar should saturate 13 grains of crystallized carbonate of soda, or dissolve about $4\frac{1}{2}$ grains of white marble.

If sulphuric acid be present, a white precipitate is produced by the addition of acetate of lead or chloride of barium. Hydrochloric acid is detected by the white precipitate (chloride of silver) caused with nitrate of silver. The presence of nitric acid is known by immersing a piece of silver in the suspected acetic acid: if nitric acid be present, nitrate of silver would be formed, which might be recognized by the subsequent addition of hydrochloric acid.

Lead, copper, or tin, would be recognized by the precipitate produced by hydrosulphuric acid or ammonia. If lead be present, the iodide of potassium would throw down a yellow precipitate of iodide of lead.

Physiological Effects.—Before proceeding to notice the operation of acetic acid on vegetables and animals, it may be useful to point out such of its effects on *dead organic matters* as have reference to the influence of this substance on living beings. In the first place, it is a well-known and powerful antiseptic, and is employed, partly on this account, in the ordinary operation of pickling, and in the preservation of animal food, and of anatomical preparations. The impure acetic acid obtained in the distillation of wood, acts more efficaciously in this respect than the pure acid, on account of the creosote which it contains. Secondly, the action of acetic acid on albumen, fibrin, and the sanguineous particles, deserves especial notice. Liquid albumen (as the serum of the blood, and the white of egg) is not coagulated by the ordinary acetic acid of the shops. Coagulated albumen is readily dissolved by it with the evolution of nitrogen, especially with the assistance of heat. Fibrin, as muscle or the crassamentum of the blood, also dissolve in it: the solution, by evaporation, yields a gelatiniform mass. Caseum is coagulated by it. It changes the form of the red particles of frog's blood, and dissolves part of the red colouring matter (Müller's *Physiology*, p. 106). It is an excellent solvent of gelatine. Diluted and mixed with mucus, it acts as a digestive fluid (Müller, *op. cit.*, p. 545).

(*a*). *On vegetables.*—Distilled vinegar is ranked, by Achard, among vegetable poisons (Decandolle, *Phys. Végét.*).

(*b*). *On animals generally.*—According to Orfila (*Journ. Chim. Méd.* t. vii. p. 449) concentrated acetic acid acts as a caustic poison to dogs. It causes blackening of the mucous lining of the stomach, analogous to that produced by sulphuric acid. The same authority tells us that four or five ounces of common vinegar prove fatal to dogs in ten or fifteen hours, if vomiting be prevented by the œsophagus. Injected into the veins, vinegar does not appear to act very energetically. Viborg threw two ounces and a half of wine vinegar into the jugular vein of a horse: the next day the animal was well (Wibmer, *Wirkung d. Arzneim.*)

Analogous results have been obtained by Courten and Hertwich (quoted by Wibmer) and by Pommer (mentioned by Dr. Christison).

The impure acetic acid obtained by the distillation of wood, has been usually regarded as possessing much more activity than pure acetic acid of the same strength, in consequence of the presence of empyreumatic oil. An extensive series of experiments have been made with it on amphibials, birds, and mammals, by Berres, Kerner, and Schubarth. From these it appears that pyroligneous acid is a caustic poison; and that it destroys some of the lower animals, viz. amphibials, merely by contact with the external skin. Large doses affect the cerebro-spinal system, and cause giddiness, insensibility, paralysis, and convulsions. A very constant effect was an affection of the windpipe and lungs. The acid was detected in the blood and secretions by its odour (Wibmer, *Wirkung d. Arzneim*).

(*c.*) *On man.*—In the concentrated state acetic acid is an irritant and corrosive poison. Its chemical influence depends principally on its power of dissolving fibrin, albumen, and gelatine, as before mentioned, by which it acts as a solvent of many of the animal tissues. Applied to the skin it acts as a rubefacient and vesicant. Only one case of poisoning by its internal use is known. The patient (a girl) appeared to be intoxicated, complained of acute pain, and was violently convulsed (*Journ. Chim. Méd.* t. vii).

Swallowed in a very dilute form, and in moderate doses, acetic acid acts in a very analogous manner to the diluted mineral acids (see pp. 80, 81, 84, and 96). Thus it is refrigerant, tonic, diaphoretic, and diuretic. Its local operation is astringent. Used moderately it assists the digestive process, and is therefore taken as a condiment. It is in repute with young ladies for diminishing obesity. It is said that the long-continued use of it, in full doses, will induce chronic diseases of the gastro-intestinal mucous membrane; and Morgagni says, it has even given rise to scirrhus of the pylorus.

Vinegar may be taken in considerable quantity at one time without inconvenience. Dr. Christison knew a case in which eight ounces were swallowed without injury.

The vapour of strong acetic acid is very pungent and irritating. The long-continued inhalation of acetic vapours, as by the workmen employed at vinegar-works, is said by Sundelin (*Handb. d. Heilmittellehre*) to be injurious to the lungs, and to bring on chronic inflammation of these organs.

USES.—1. *MEDICINAL.*—Taken internally, common vinegar or acetic acid, properly diluted, is used for various purposes; the most important of which are, to allay febrile heat by its refrigerant qualities, to diminish inordinate vascular action, to relieve certain affections of the brain supposed to depend on, or be connected with, venous congestion, and to act by its chemical properties of an acid. Thus, in *fevers*, whether simple or eruptive, but especially in those varieties commonly denominated putrid and bilious, vinegar (more or less diluted with water) is a most refreshing drink, allaying thirst, and diminishing excessive heat. In *hæmorrhages*, as from the nose, lungs, stomach, or uterus, it is particularly beneficial by its refrigerant, sedative, and astringent qualities. It diminishes excessive vascular action, and promotes contraction of the bleeding vessels. As a local astringent, it is injected into the nose in epistaxis, and is used as a wash in profuse hæmorrhoidal discharges. The benefit obtained by the application of vinegar and water to the abdomen, vulva, and thighs, in uterine hæmorrhages, arises from the cold produced. In *phthisis pulmonalis*, vinegar diluted with water is sometimes serviceable as a palliative, by its refrigerant qualities: it relieves the hectic symptoms, diminishes or puts a stop to the night sweats, checks bronchial hæmorrhage, and prevents diarrhœa. In *mania* it has been recommended as a means of allaying cerebral excitement. In *poisoning by opium*, and some other narcotics, it is used to counteract the effects of these substances: but as acetic acid forms soluble and powerful compounds with the active principles of some of these poisons, it ought not to be exhibited until the contents of the stomach have been evacuated. In poisoning by the alkalies and their carbonates, and by lime, vinegar is the safest and most efficacious acidulous substance that can be employed. In diseases attended with *phosphatic deposits* in the urine, it may be advantageously used either as a medicine or condiment. *As an adjunct to the acetate of lead*, acetic acid is recommended by Dr. A. T. Thomson, to prevent the formation of carbonate of lead, which he believes to be more apt to produce lead colic than the acetate. In *scurvy*, the acetic, as well as other vegetable acids, has been found serviceable. *Clysters containing vinegar* have been employed for the purpose of provoking alvine evacuations in obstinate constipation and strangulated hernia; of expelling the small round worm (*Ascaris vermicularis*); of checking uterine and intestinal hæmorrhage; and of relieving inflammation or congestive conditions of the brain.

As a stimulant, disinfectant, and antiseptic, lotions containing acetic acid are used in gangrenous and other ill-conditioned ulcers. For these purposes crude pyroligneous acid is more efficacious than ordinary vinegar, on account of the creasote and other substances which it contains. In ulceration of the throat, in scarlatina and cynanche, gargles containing acetic acid or vinegar are sometimes used with good effect. Collyria, containing it, are useful as mild astringent applications in chronic ophthalmia, and for removing lime-dust adhering to any part of the globe or lid of the eye.

Sponging the face, trunk, or extremities, with cold or tepid vinegar and water, is frequently most refreshing and grateful in febrile disorders. It diminishes preternatural heat, promotes the cutaneous functions, and operates as a beneficial stimulant to the nervous system.

Fomentations containing vinegar are used in bruises, sprains, &c.

The concentrated acetic acid sold in the shops under the name of pyroligneous acid, is a valuable remedy for the cure of the different forms of porrigo, popularly called ring-worm or scalled head. Its application, which may be effected by means of a piece of lint wrapped round a wooden stick, causes acute but temporary pain, redness of the skin, and whitening of the abraded spots. One or two applications are usually sufficient to effect a cure. Strong acetic acid is also employed as a caustic to destroy corns and warts. It has been proposed as a speedy means of exciting rubefaction and vesication, and for this purpose blotting-paper or cambric, moistened with this acid, has been applied to the neck in cases of croup.

Under the name of *aromatic vinegar*, concentrated acetic acid, flavoured with other odorous substances, is employed in smelling-bottles and vinaigrettes. The vapour is inhaled to relieve fainting and headache; and is sometimes employed for correcting unpleasant odours, which it does, not by destroying but by covering them.

2. *PHARMACEUTICAL.*—Vinegar or acetic acid is employed for extracting the virtues of various medicinal substances, as squills, colchicum, and cantharides: the solutions are called *medicated vinegars* (*acetica*), or, by the French pharmacologists, *oxéolés*. A small quantity of spirit is usually added to them for the purpose of preventing the decomposition of the vinegar, and, in consequence of this, a small portion of acetic ether is generated. The preparations into the composition of which acetic acid and honey enter, are called *oxymels*, or the *acid mellites*. Acetic acid is employed also in the manufacture of the salts called *acetates*. Lastly, it is a powerful solvent of the gum-resins, and is used, on this account, in the preparation of the emplastrum ammoniaci.

ADMINISTRATION.—Vinegar is given internally in doses of from a tea-spoonful to half an ounce: used as a clyster, the quantity is one or two fluidounces. A refrigerant drink in fevers is made by adding one or two ounces of vinegar to a quart of water.

The *aromatic vinegar* (*acetum aromaticum*) of the shops is a solution of camphor and of the oils of cloves, lavender, and rosemary, in concentrated acetic acid. On the addition of water, part of the camphor is precipitated. It is made in imitation of *Henry's aromatic vinegar*. In the Edinburgh and Dublin Pharmacopœias is an officinal substitute for the latter preparation: it is called *acidum aceticum camphoratum*. It is prepared by dissolving half an ounce of camphor (pulverized by means of a few drops of alcohol) in six fluidounces of acetic acid. These preparations are only used as errhines.

In the Edinburgh Pharmacopœia is a very useless preparation called *acidum aceticum aromaticum*, made by digesting dried rosemary tops, dried sage leaves, dried lavender flowers, and cloves, in distilled vinegar. It is an imitation of the celebrated *Thieves* or *Marseilles vinegar* (*acetum quatuor furum*), once supposed to be a prophylactic against the plague and other contagious diseases.

As the medicinal value of *oxymel* (*oxymel simplex*) depends principally on the vinegar which it contains, it is best noticed here. In the London Pharmacopœia this compound is directed to be prepared by mixing a pint and a half of acetic acid (Ph. L.) with two pounds of honey made hot.

This preparation has been reputed detergent, and, in consequence, has been employed in gargles. It is commonly esteemed expectorant, and as such is used in slight colds. Diffused through barley water, it forms a refrigerant and agreeable drink in febrile and inflammatòry complaints. It is frequently used as a vehicle for other medicines. The dose of it is usually two or three spoonfuls.

ANTIDOTES.—In cases of poisoning by strong acetic acid, the treatment should be that recommended for poisoning by hydrochloric and sulphuric acids.

Creaso'ton.—Cre'asote.

HISTORY.—This substance was discovered a few years since by Reichenbach, who termed it *creasote* (from κρεας, *flesh*; and σώζω, *I preserve*) or the *flesh-preserver*, on account of its antiseptic property. Its name is sometimes written *Creosote* or *Kreosote*. In the London Pharmacopœia it is described as *an oxyhydrocarburet* (*oxy-hydro-carburetum*) prepared from pyroxilic oil.

NATURAL HISTORY.—It is an artificial product; and is obtained by the destructive distillation of organic substances. It is found in pyroligneous acid, in tar, in Dippel's oil, in wood smoke, and empyreumatic waters.

PREPARATION.—The preparation of creasote is a very troublesome and tedious process. The following concise abstract of it is taken from Turner's Chemistry (5th ed. p. 872). Those portions of the oil (called in the Pharmacopœia *pyroxilic oil*) distilled from wood-tar, which are heavier than water, are first freed from adhering acetic acid by carbonate of potash, and, after separation from the acetate, are distilled. A little phosphoric acid is mixed with the product to neutralize ammonia, and another distillation resorted to. It is next mixed with a strong solution of potash, which combines with creasote, allows any eupion which may be present to collect on its surface, and by digestion decomposes other organic matter: the alkaline solution is then neutralized by sulphuric acid, and the oil which separates is collected and distilled. For the complete purification of the *creasote*, this treatment with potash, followed by neutralization and distillation, requires to be frequently repeated. (For further details I must refer to Dumas' *Traité de Chimie*, and to the *Ann. de Chim. et Physiq.* t. 57, 1834).

PROPERTIES.—Pure creasote is colourless and transparent: it has a high refractive power, and an oleaginous consistence. Its odour is that of smoked meat, its taste burning and caustic, its sp. gr. 1.037 at 68° F. It boils at 397° F.; and is fluid at —16·6° F. It is combustible, burning with a sooty flame. It absorbs chlorine, and is resinified by it. Nitric acid is decomposed by it, with the evolution of nitrous fumes. Sulphuric acid in small quantity reddens, and in large quantity blackens it. Potassium decomposes it, with the evolution of gas (hydrogen?) and the formation of potash, which combines with some inspissated creasote. It is soluble in alcohol, ether, sulphuret of carbon, eupion, naphtha, acetic acid, and acetic ether. It dissolves resins, various colouring matters (as of cochineal, saffron, and madder), and some salts (as the acetate of potash). It has very little action on caoutchouc; and does not possess any acid or alkaline re-action on test paper. Mixed with water, it forms two combinations: one is a solution of 1·25 parts of creasote in 100 of water; the other, on the contrary, is a solution of 10 parts of water in 100 of creasote.

It coagulates the albumen of eggs and of the blood. Concentrated albuminous liquids are immediately coagulated by it; dilute ones, gradually. Fibrin is not altered by it. It is powerfully antiseptic with respect to meat and fish. Tar, smoke, and crude pyroligneous acid, owe part, if not the whole, of their antiseptic properties to it. According to Mr. J. R. Cormack (*Treatise on Creosote*, 1836), the only essential part of the mummifying process practised by the ancient Egyptians was the application of such a heat as would first dry up the body, and then decompose the tarry matters which had been previously introduced, and thus generate creasote.

CHARACTERISTICS.—The odour of creasote is its most characteristic property. To this must be added its combustibility, its oleaginous appearance, its complete solubility in acetic acid and caustic potash, and its action on albumen before mentioned.

Purity.—Creasote, when pure, is perfectly colourless; but that met with in commerce has frequently a more or less brownish tinge. Rectified oil of tar, capnomor, and almond oil, are substances which have been or might be associated with it (Cormack, *op. cit.*) These impurities are readily detected by mixing separate portions of the suspected liquid with acetic acid and caustic potash: pure creasote is completely soluble in these fluids; not so the adulterated.

Composition.—Ettling (*Ann. de Chimie*, liii. p. 333), analyzed creasote which was supposed to contain three per cent. of water. Making allowance for this impurity, its composition, as determined by this chemist, is nearly as follows:—

	Eq.	Eq.Wt.	Per Cent.
Carbon	14	84	77·42
Hydrogen	9	9	8·12
Oxygen	2	16	14·46
Creasote	1	109	100·00

At present, however, the equivalent of creasote must be considered as uncertain, since no definite compound of this substance has been analyzed by which the combining proportion could be ascertained.

Physiological Effects. (*a.*) *On vegetables.*—Plants moistened with creasote water fade and die. (Miguet, *Recherches sur la Créasote*, 1834). The injurious effects of smoke on vegetation are probably to be referred principally to the creasote which it contains.

(*b.*) *On animals generally.* — Insects (as flies), spiders, and small fishes, die in two minutes after their immersion in water containing a few drops of creasote suspended in it. According to Mr. Cormack, the effects of creasote on dogs are remarkably similar to those of hydrocyanic acid, and are much less apparent when this substance is injected into the carotid arteries than into the veins. When thrown into the latter it suddenly stops the heart's action and causes hurried respiration, one or two convulsive fits, shrill cries, and death. Injected into the carotid artery it produces coma. Introduced into the stomach it gives rise to dimness and fixation of the eyes, vertigo, and coma: when given in large quantities it also affects the heart. (Cormack, *op. cit.* p. 66, et. seq.) Corneliani (*Jour. Chem Méd.* t. ii. ser. 10) and Miguet have observed inflammation of the gastro-intestinal mucous membrane of dogs poisoned by creasote, but which survived some time.

(*c.*) *On man.*—Creasote operates locally as an irritant and caustic. Applied to the skin it causes heat, redness, and the destruction of the cuticle, which comes away in the form of furfuraceous scales. On the tongue it produces a painful sensation. Dropped into the eye it occasions acute pain. Placed in contact with a suppurating surface it whitens the part as does nitrate of silver. Swallowed in large doses it causes vomiting and purging. The caustic effect of creasote doubtless depends on the same property which renders it capable of preserving meat and of coagulating albumen.

Unless largely diluted, it occasions, when swallowed, heat in the tongue, pharynx, œsophagus, and stomach. Small doses, as one or two minims, produce in most individuals no other unpleasant effect than that just mentioned. Larger doses give rise to nausea, vomiting, vertigo, headache, and heat of head. Dr. Elliotson (*Medico-Chirur. Trans.* vol. xix.) knew a lady who increased the dose of creasote to forty drops before it disagreed: the addition of a single drop beyond this produced extreme giddiness, insensibility, and vomiting, followed by headache for several days. When given in moderate doses it does not affect the bowels; so that, as Dr. Elliotson has observed, "aperients are as requisite as if it was not taken." When, however, the dose has been considerably augmented, diarrhœa or even dysentery has been produced. (Cormack, *op. cit.* p. 93). The influence of creasote on the urinary organs is sometimes very marked. Dr. Macleod (*Med. Gaz.* vol. xvi. p. 599, and vol. xvii. p. 653), was I believe the first who noticed that the urine acquired a blackish colour by the use of it. A similar effect is referred to by Dr. Elliotson. In some cases creasote is recognized, by its odour, in the urine, showing that it has been absorbed. Occasionally it increases the quantity of this secretion, but in diabetes it sometimes has an opposite effect. In some instances it has caused micturition and strangury, so that in its influence over the urinary organs it bears some resemblance to turpentine. Some other effects which have been ascribed to it require further evidence to establish them.

USES.—Various substances, some known to contain creasote, others supposed to do so, have long been used in medicine, in the same diseases in which creasote itself is now employed: and, in consequence, it has been imagined that they owe part of whatever efficacy they really possess to this substance. These remarks apply to tar, soot, crude pyroligneous acid, *aqua Binelli*[*], the empyreumatic water of Runge and Hanke, pyrothonide[†], and animal or Dippel's oil. To this list should be added, according to Mr. Cormack (*op. cit.*), mummy.

As an *internal* remedy, creasote has been principally celebrated, in this country, as a remedy possessing extraordinary powers of arresting vomiting. It has, however, been greatly overrated. It is decidedly injurious in inflammatory conditions and structural disease of the stomach, and frequently fails in allaying the sickness dependent on organic diseases, as of the heart and kidneys. It is most successful in hysterical cases, and sometimes succeeds in pregnancy. Creasote was first employed to relieve vomiting by Dr. Elliotson (*Medico-Chirurg. Tr.* vol. xix.), to whose paper, as well as to that of Mr. Taylor, apothecary of the North London Hospital (*Lancet*, August 15, 1835), I must refer for cases illustrative of extraordinary success with it. It is regarded by Dr. Macleod (*Med. Gaz.* vol. xvi. p. 598, and vol. xvii. p. 653) as of doubtful efficacy; and has completely failed in the hands of Dr. Paris (*Appendix* to the 8th edit. of the *Pharmacologia*, 1838).

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[*] *Aqua Binelli*, or *Aqua arterialis balsamica Doctoris Binelli*, a once celebrated styptic, discovered by a physician (Dr. Binelli) of Turin, in 1797 (Dierbach, *Neuesten Entdeck. in d. Mat. Med.* 2^{te}. Ausg. 1837. See also Dr. J. Davy, *Edinb. Med. and Surg. Journ.* July 1833).

[†] *Pyrothonide* (from πῦρ, *fire*; and ὀθόνη, *linen*), or *liquor pyro-oleosus e linteo paratus*, is a very popular remedy for tooth-ache and skin diseases. It is sometimes prepared by distilling rags, and is then called *rag oil;* but the common mode of procuring it is to burn a cone of paper on a plate or other cold body; it is then termed *paper oil.* It has been analyzed by Herberger (Buchner, *Repertorium*, Bd. 32, S. 347). For further particulars concerning it, consult Merat and De Lens, *Dict. Mat. Méd.*; Dierbach, *op. cit.*; Schwartze, *Pharm. Tabell.* 2^{te}. Aus.; L. Richter, *Ausführl. Arzneim.* Supplem. Bd.

It sometimes relieves gastrodynia or flatulence, but is admissible in those cases only in which local stimulants are usually found beneficial. Where both hydrocyanic and creasote have been separately tried without success, Dr. Elliotson advises their union.

Creasote has been tried in a few cases of diabetes. In some it diminished both the quantity and saccharine quality of the urine (Dr. Elliotson, *Med.-Chir. Trans.* and Professor Berndt, *Lancet*, July 18, 1835). In no case does it appear to have effected a permanent cure.

In neuralgia, hysteria, and pulmonary diseases, it has also been used with occasional advantage: but a more extended experience is required to establish its efficacy in these cases.

As an *external* agent creasote may frequently be employed with great advantage. It has been successfully applied to relieve toothache. After carefully cleaning out the cavity of the tooth, a drop of creasote may be introduced by means of a camel's hair pencil, and the cavity filled with cotton soaked in this liquid. As a local application to chronic skin diseases (particularly the different forms of porrigo and impetigo) it is of considerable value. Where a caustic application is required, it may be applied undiluted; but for other purposes it is used either in the form of ointment, or dissolved in water as a wash. Creasote may be beneficially used as an application to foul and indolent ulcers. It serves the double purpose of stimulating the living surface (and thereby of changing the quality of actions going on in the part), and also of preventing the putrefaction of the secreted matters. It is sometimes applied pure, but more commonly diluted with water. In hæmorrhages it acts as a most efficient styptic, partly in consequence of its power of coagulating albuminous liquids, and thereby of causing the formation of a clot, and partly by causing contraction of the bleeding vessels. Creasote water may be applied either to bleeding wounds and leech-bites, or introduced into the vagina in uterine hæmorrhage, by means of pledgets of lint soaked in it. There are many other purposes for which creasote has been applied as a local agent, but which I think it sufficient merely to name, referring the reader to the various papers and works before quoted for further information. It has been employed to check caries, to restrain excessive suppuration, and to repress fungous granulations in burns and scalds; to act as a counter-irritant in chronic ophthalmia, in which disease it is sometimes dropped into the eye on the same principle that nitrate of silver and other local stimulants are used; and to remove condylomatous and other excrescences. The inhalation of creasote vapour is occasionally useful in relieving excessive bronchial secretion. Dr. Elliotson cured two cases of chronic glanders in the human subject, by injecting an aqueous solution of creasote up the affected nostril.

ADMINISTRATION.—Creasote may be given, at the commencement of its use, in doses of one or two drops diffused through an ounce of water by the aid of mucilage: the dose should be gradually increased. As before mentioned, in one case forty drops were given with impunity: in another instance, ninety drops were administered in less than half a day without any bad symptom (Mr. Taylor, *Lancet*, August 15, 1835).

As a caustic, undiluted creasote is sometimes applied by means of a camel's hair pencil.

The *unguentum creasoti* of the London Pharmacopœia is composed of a fluidrachm of creasote and an ounce of lard. It is used principally in skin diseases, as ringworm. The quantity of creasote in it may be increased or diminished according to circumstances. When used by way of friction, eight or ten drops of creasote to the above quantity of lard may be sufficient.

Lotions, gargles, or injections of creasote, are prepared by dissolving from two to six drops (according to the circumstances of each case) in an ounce of water. A solution of this kind is sometimes mixed with poultices.

The inhalation of creasote vapour may be effected by diffusing a few drops of creasote through water or a mucilaginous liquid, and breathing through this, by means of the ordinary inhaling bottle (see p. 51).

ANTIDOTES.—In a case of poisoning by creasote, the depression of the vital powers is to be counteracted by ammonia and other stimulants. Mr. Cormack suggests the use of chlorine, but the value of this agent has not been determined by actual experiment. Oleaginous and mucilaginous drinks are recommended by Corneliani, for the purpose of preventing the local action of creasote on the mucous lining of the stomach and intestines. Vinegar does not diminish, but, according to Corneliani, increases its activity. Mr. Cormack says albumen augments its poisonous operation. Bleeding is suggested by this writer, in order to relieve the distension of the heart, and thereby to excite the contractions of this viscus. Artificial respiration should on no account be omitted. Any inflammatory symptoms which may subsequently appear are of course to be treated by the usual antiphlogistic measures.

Petro'leum.—Petro'leum.

HISTORY.—Herodotus (*Melpomene*, cxcv.) mentions the petroleum springs of Zacynthus (now called Zante) more than 400 years before Christ. The substance known to mineralogists as petroleum is the *black naphtha* (*μέλαν*) of Dioscorides (lib. i.), the *bitumen liquidum* of Pliny (lib. xxxv.)

NATURAL HISTORY.—There are two varieties of liquid bitumen or mineral oil: one is transparent and nearly colourless, or only slightly yellow, and when burnt leaves no residuum; the other is thick, of a reddish brown colour or blackish, and leaves, after combustion, a black coal. The first is called *naphtha* (a Chaldæan word); the second *petroleum* (from *petra*, *a* rock; and *oleum*, oil) or *rock oil*, because it is frequently found exuding in the form of an oily liquid from rocks. Both kinds are supposed to be produced by the decomposition of organic (vegetable) matter, for they are always found in Neptunian rocks, and they appear sometimes to be one of the products of the decomposition of coal (Berzelius, *Traité de Chim.* t. 6me.) From the investigation of Drs. Christison and Gregory (*Tr. Roy. Soc. Edinb.* vol. xiii. p. 1), it appears probable that some varieties of petroleum, as that of Rangoon, are products of destructive distillation, since they contain paraffine and eupion, substances obtained from organic bodies by heat.

Petroleum is found in this country at Ormskirk in Lancashire, at Colebrook Dale in Derbyshire, and at St. Catherine's Well near Edinburgh. In France it is produced at the village of Gabian in Languedoc, and hence it was termed *Oleum Gabianum*. It is also found in various other parts of Europe, especially in Italy. In the United States of

America it is met with in various places: that from the shore of Seneka Lake in New York is called *Seneka oil.* Several of the West India Islands, especially Barbadoes and Trinidad, yield it. The Barbadoes petroleum (*Petroleum Barbadense,* Ph. Lond. et Dubl.: *Pisselæum Indicum,* Dale) is commonly termed *Barbadoes Tar,* or *B. Naphtha.* That imported by Mr. Clarke professes to be the produce of the springs on Mount Hall estate, in Barbadoes. In various localities of Asia, petroleum is met with in great abundance.

PROPERTIES.—Barbadoes petroleum, at ordinary temperatures, has the consistence of treacle: its colour is reddish brown or blackish; its odour and taste are bituminous. It floats on water: is combustible, yielding a thick black smoke, and leaving a carbonaceous residuum. It is insoluble in water.

COMPOSITION.—The ultimate constituents of Barbadoes petroleum are carbon and hydrogen, with small quantities of oxygen and nitrogen. By distillation, five parts by measure yield rather more than four parts of a yellow oily fluid, somewhat similar in appearance to the liquid carbohydrogen obtained in the manufacture of oil-gas. The residuum in the retort is a substance analogous to asphaltum. It yields by destructive distillation traces of ammonia. Some kinds of petroleum contain paraffine and eupion.

PHYSIOLOGICAL EFFECTS.—Petroleum possesses stimulating properties, which are principally observed in its effects on the organs of secretion (the skin, the kidneys, and the mucous membranes), the activity of which it promotes: hence it has been called sudorific, diuretic, expectorant, &c. It is said to be an excitant to the lymphatic vessels and glands.

USES.—As an internal remedy it is employed in chronic pulmonary affections (as winter coughs, old asthmas, &c.), in obstinate skin diseases (as lepra, psoriasis, and impetigo), and against tape-worm.

As an external agent it is applied to obstinate ulcers, as lupus, and cutaneous diseases, and is employed as a stimulating liniment in chronic rheumatism, paralysis, and chilblains.

ADMINISTRATION.—The dose of Barbadoes petroleum is a small teaspoonful given in any convenient vehicle (as some aromatic water, tea, or spirit). The quantity should be gradually increased. It is said that an ounce has been taken in the day without inconvenience.

Suc'cinum.—Am'ber.

HISTORY.—Amber was known to Thales of Miletus, 600 years before Christ. He was the first who noticed that when rubbed it acquired the power of attracting light bodies. Hence arose the term electricity, from ηλέκτρον, *amber.* Theophrastus (*De lapidibus*) also mentions this property.

NATURAL HISTORY.—Amber is found in different parts of the world. The principal portion of that met with in commerce, comes from the southern coasts of the Baltic, in Prussia, and is cast on the shore between Königsberg and Memel. It is supposed to be disengaged, by the action of the sea, from beds of lignite.

The vegetable origin of amber is shewn by various facts. It is usually associated with substances (bituminous wood, coal, &c.) known to be derived from plants. Externally we observe on it various impressions of the branches and bark of trees; and inclosed in it are insects and parts of plants (as the wood, leaves, flowers, and fruit). According to Sir D. Brewster (*Edinb. Philosoph. Journ.* vol. ii.) its optical properties are those of an indurated vegetable juice. From these circumstances, as well as from its chemical composition, amber is supposed to have been a resinous exudation from some tree. Now as the wood, leaves, blossoms, and fruit of some coniferous plant are found in amber, this plant has been supposed to be the amber tree: and a microscopic examination of the wood leads to the conclusion that the amber tree is a species, though probably an extinct one, of the genus Pinus, closely allied to P. balsamea. (Hope, *On Succinic Insects*, in *Trans. Entom. Soc.* vols. i. and ii.)

Properties.—It occurs in irregular shaped pieces, usually flat and somewhat rounded at the sides. Its colour is yellowish white (*succinum album*), yellow (*s. citrinum*), or reddish (*s. rubrum*). It is usually translucent, sometimes opaque or transparent: it is tasteless and odourless. Its sp. gr. is about 1·07. It is brittle, yields readily to the knife, has a conchoidal vitreous or resinous fracture, and becomes negatively electrical by friction: it contains various insects which, apparently, must have become entangled in it while it was soft and viscid. (For an account of these, consult Mr. Hope's paper before quoted; also Burmeister's *Manual of Entomology*, p. 574).

Heated in the air, amber fuses at about 541° F., then inflames, and burns with a yellow flame, emitting a peculiar odour, and leaving behind a light shiny black coal. It cannot be fused without undergoing some chemical change. It evolves water, volatile oil, and succinic acid: the residual mass is termed *colophonium succini*. By destructive distillation in a retort or alembic, amber yields first an acid liquor (which contains succinic and acetic acids), then some succinic acid deposits in the neck of the retort, and an empyreumatic oil (*oleum succini*) comes over, at first thin and yellowish, afterwards brown and thick: towards the end of the operation, a yellow light sublimate is observed in the neck of the retort; this is called, by Berzelius, *crystallized pyrétine;* by Vogel, *volatile resin of amber;* by Gmelin, *amber-camphor*. An inflammable gas is evolved during the whole time of the operation.

Composition.—The *ultimate* constituents of amber are carbon, hydrogen, and oxygen. The *proximate* principles are a volatile oil, two resins, succinic acid, and a bituminous substance.

Ultimate Constituents.			Proximate Constituents.
	Drassier.	Ure.	(Berzelius.)
Carbon	80·59	70·68	Volatile Oil
Hydrogen	7·31	11·62	Two Resins
Oxygen	6·73	7·77	Succinic Acid
Ashes (silica, lime, and alumina)	3·27		Bitumen
Amber	97·90	90·07	Amber.

The *volatile oil* has a strong but agreeable odour. The *resins* are soluble in both alcohol and ether: if an alcoholic solution of the two resins be prepared by heat, and then allowed to cool, one of the resins deposits. *Succinic acid* is white and crystalline, soluble in water, scarcely so in cold, but more so in boiling, alcohol. It is distinguished from benzoic acid by its insolubility in oil of turpentine. Succinate of ammonia throws down a reddish precipitate with the persalts of iron. The *bituminous matter* constitutes the principal part of amber: it is insoluble in alcohol, ether, the oils both volatile and fixed, and alkaline solutions.

CHARACTERISTICS AND PURITY.—The resins copal and animi are sometimes substituted for amber. They may be distinguished by the difference in their colour and fracture, and by their not emitting the peculiar odour of amber when thrown upon hot iron (*United States Dispensatory*). Copal during its combustion is constantly falling in drops; and by this character may be distinguished from amber (*Kidd's Mineralogy*.)

PHYSIOLOGICAL EFFECTS.—Amber was formerly celebrated as a stimulant and antispasmodic.

USES.—(*a*.) *Medicinal*.—It is not employed as a medicine in this country. It was formerly used in chronic catarrhs, amenorrhœa, hysteria, &c., and was given either in the form of powder, in doses of from ten grains to a drachm, or in that of tincture, a formula for which is contained both in the French Codex and Prussian Pharmacopœia.

(*b*.) *Phamaceutical*.—Amber is used for the preparation of the *oil* and *acid*. The oil obtained by the destructive distillation of amber, when rectified by three distillations, constitutes the *oleum succini* of the Pharmacopœia.

OLEUM SUCCINI.—This oil, prepared as above mentioned, is a local irritant, and when rubbed on the skin acts as a rubefacient. Taken internally it operates, like most other empyreumatic oils, on the nervous system, and is used as a stimulant and antispasmodic. Its dose is from five to fifteen drops. In the former edition of the London Pharmacopœia there was contained a formula for the preparation of the *spiritus ammoniæ succinatus*, made in imitation of the celebrated *eau de luce* (the history of which has been fully detailed by Beckmann, in his *History of Inventions*, vol. iv. p. 595). Its active ingredient is ammonia, but the oils of amber and lavender, and mastich, entered into its composition. It is a powerful stimulant, and was employed as an application to the nostrils in fainting and hysteria; and also internally, in doses of from ten to thirty drops.

ACIDUM SUCCINUM.—This, though contained in the Dublin Pharmacopœia, is, I believe, never used in medicine. It was supposed to be, like the oil, antispasmodic, and was exhibited in doses of from five to twenty grains.

O'leum Anima'le.—An'imal Oil.

This perhaps is the most convenient place for noticing the empyreumatic oil obtained by the decomposition of animal substances by heat. It is obtained in considerable quantities in the manufacture of ivory-black (see p. 178), and is sold under the name of *animal* or *Dippel's oil*. It is identical in its nature with the *oleum cornu cervi*, or *oil of hartshorn*, formerly used in medicine. As usually met with, it is a thick, brown, viscid oil, having a most repulsive odour. By distillation, however, it may be rendered colourless and limpid, but is soon altered by the action of air and light. Its ultimate constituents are carbon, hydrogen, nitrogen, and oxygen. From its alkaline reaction it doubtless contains ammonia. Unverdorben alleges that it contains four oily salifiable bases, to which he has given the names of *odorine*, *animine*, *olanine*, and *ammoline*. Reichenbach has obtained *creasote* from it, and ascribes to this principle the supposed virtues of animal oil. Whatever may be its active principle, animal oil is undoubtedly a very powerful agent. In large doses it acts as an energetic poison, operating in two ways, locally as an irritant, remotely as a narcotic (Christison, *Treatise on Poisons*). Swallowed in moderate doses, it stimulates the vascular and nervous systems, and is esteemed antispasmodic. It has been employed as a local agent in bruises, gangrene, porrigo, &c. Internally, it has been used to prevent an attack of epilepsy or ague, as a stimulant in low fevers, and as antispasmodic in hysteria and other affections of the nervous system accompanied with convulsive movements. Bremser (*Traité sur les Vers Intestin.*) used *Chabert's oil* (prepared by mixing three parts oil of turpentine with one part Dippel's oil, and distilling three parts) as an anthelmintic in tape-worm. The dose of animal oil is a few drops, cautiously increased.

Ac'idum Hydrocyan'icum.—Hydrocyan'ic Ac'id.

History.—The substance called *Prussian* or *Berlin blue* (*Cæruleum Borussicum* seu *Berolinense*) was accidentally discovered by Diesbach at the commencement of the 18th century, and various conjectures were soon offered regarding its nature. In 1746, Dr. Brown Langrish published some experiments made with laurel water in order to investigate its effects on animals (*Physical Experiments upon Brutes*). In 1752, Macquer announced that Prussian blue was a compound of oxide of iron, and some colouring principle which he could not isolate; and in 1772, Guyton Morveau concluded that this principle was of an acid nature. Scheele, in 1782, removed some of the mystery connected with Prussian blue, by obtaining *hydrous prussic acid* from it. In 1787 Berthollet ascertained this acid to be a compound of carbon, nitrogen, and hydrogen. In 1800, and 1802, Bohn and Schrader discovered it in laurel-water. Borda, Brugnatelli, and Rasori, first employed the acid in medicine, from 1801 to 1806. In 1815, Gay-Lussac obtained the acid in its pure *anhydrous* state, and explained its composition. (The chemical history of hydrocyanic acid is fully detailed in Thomson's *System of Inorganic Chemistry*, vol. ii. 7th edition.) The medical history of it is contained in Dr. Granville's *Hist. and Pract. Treatise* on this acid, 2d ed. 1820.

Synonymes and Etymology.—It has been denominated *prussic* (*acidum borussicum*), *zootic* (*acidum zooticum*), or *hydrocyanic acid:* the first name indicates the substance (Prussian blue) from which it was obtained, the second refers to its animal origin, and the third indicates its constituents, hydrogen and cyanogen (so called from κύανος, *blue;* and γεννάω, *to produce;* because it is one of the constituents of Prussian blue).

Natural History.—Hydrocyanic acid is a product peculiar to the organized kingdom. It may be readily procured from many *vegetables*, more especially those belonging to the sub-orders *Amygdaleæ* and *Pomeæ:* as from bitter almonds, apple-pips, the kernels of peaches, apricots, cherries, plums, and damsons; the flowers of the peach, cherry-laurel, and bird-cherry; the bark of the latter, and the root of the mountain ash. It is said to have been also obtained from plants of other families, as from *Rhamnus Frangula* and ergot of rye. In some of the vegetables now referred to, hydrocyanic acid does not exist ready formed, but is a product of the process by which it is obtained. This has been fully proved in the case of the bitter almond, and is inferred in other instances.

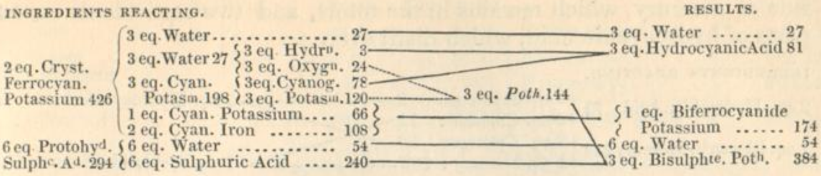
This acid is rarely, if ever, found in animals. One of its constituents (cyanogen) has, however, been detected, in combination with iron, (forming Prussian blue) in the urine, the menstrual fluid, and the sweat: and with sulphur and potassium in the saliva. During the decomposition of animal matters, cyanogen is frequently generated: as when blood and carbonate of potash are calcined in an iron pot. It has also been stated that when cheese is exposed to the action of water and the sun, it disengages ammonia, and if treated, in this state, by alcohol, yields traces of hydrocyanic acid.

PREPARATION.—The processes for procuring this acid are very numerous. I shall only notice the most important of those which yield the dilute acid employed for medicinal purposes.

(*a.*) *By the action of dilute sulphuric acid on ferrocyanide of potassium.*—The proportions directed in the London Pharmacopœia for the preparation of dilute hydrocyanic acid, are two ounces of the ferrocyanide, an ounce and a half of sulphuric acid, and a pint and a half of distilled water. "Mix the acid with four fluidounces of the water, and to these, when cooled and put into a glass retort, add the ferrocyanide of potassium, first dissolved in half a pint of water. Pour eight fluidounces of the water into a cooled receiver; then, having adapted the retort, let six fluidounces of acid, distilled with a gentle heat in a sand-bath, pass into this water. Lastly, add six more fluidounces of distilled water, or as much as may be sufficient, that 12·7 grains of nitrate of silver, dissolved in distilled water, may be accurately saturated by 100 grains of this acid."

If the distillation be performed in a [tubulated] retort, as directed in the Pharmacopœia, an adopter should be employed. When small quantities are to be operated on, we may conveniently employ two Florence flasks (one as the receiver, the other as the distilling vessel), connected by a glass tube curved twice at right angles. The receiver should be kept very cool, ice or snow being used if it can be procured; and the heat employed in distilling should be very moderate. The distilled liquor frequently contains a little sulphuric acid, and by standing deposits a small portion of Prussian blue. A second distillation, cautiously conducted, will often separate the sulphuric acid: but I have seen Prussian blue formed after the hydrocyanic acid has been distilled three times.

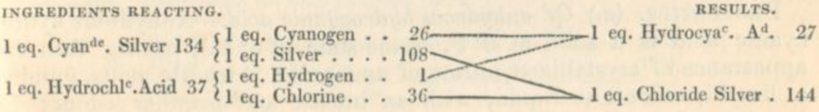
The theory of the process, founded on the experiments of Mr. Everitt (*Lond. and Edinb. Phil. Mag.* Feb. 1835) is as follows:—Six equivalents or 294 parts of protohydrated sulphuric acid react on two equivalents or 426 parts of crystallized ferrocyanide of potassium (composed of four equivalents cyanide of potassium, two of cyanide of iron, and six of water), and produce three equivalents or 384 parts of the bisulphate of potash, three equivalents or 81 parts of hydrocyanic acid, one equivalent or 174 parts of a new salt (which I shall term the *biferrocyanide of potassium*), and nine equivalents or 81 parts of water. The bisulphate and the new salt remain in the retort, while the hydrocyanic acid and the water distil over. In the Pharmacopœia an additional quantity of water is employed to assist the condensation of the acid.



The salt here called biferrocyanide of potassium, is termed, by Mr Everitt, *yellow salt*. I have prepared it with the greatest care, but have always found it to be white. Gay-Lussac also says it is white (*Ann. Chim. et Phys.* t. 46, p. 77). By exposure to the air it becomes blue.

(*b.*) *By the action of hydrochloric acid on cyanide of silver.*—This process, proposed by Mr. Everitt, yields an acid of uniform strength, and may be followed when the acid is required for immediate use. The Pharmacopœal directions for its performance are (or rather ought to be) as follows:—Add 48¼ grains of cyanide of silver to a fluidounce of distilled water, mixed with 39½ grains of hydrochloric acid. "Shake all these in a well-stoppered phial, and, after a short interval, pour off the clear liquor into another vessel. Keep this for use, the access of light being prevented." The proportions directed by Mr. Everitt are 40 grains of cyanide, 7 fluidrachms and 20 minims of water, and 40 minims of dilute hydrochloric acid (sp. gr. 1·129). This gentleman says, that practitioners could obtain an ounce of the acid, prepared by this process, for one shilling, while the manufacturer could obtain 50 per cent. profit by it.

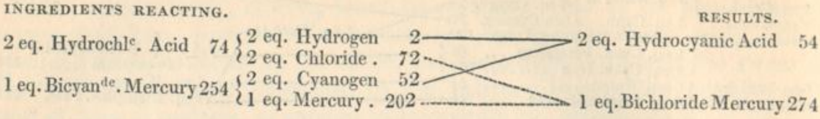
The *theory* of the process is as follows:—By the mutual reaction of one equivalent or 134 parts of cyanide silver and one equivalent or 37 parts of hydrochloric acid, there are obtained one equivalent or 144 parts of chloride of silver, and one equivalent or 27 parts of hydrocyanic acid.



(*c.*) *By the action of hydrochloric acid on bicyanide of mercury.*—At Apothecaries' Hall hydrocyanic acid was formerly prepared from one part of bicyanide of mercury, one part hydrochloric acid (sp. gr. 1·15), and six parts of water. The mixture was distilled until six parts had passed over. The acid thus obtained had a sp. gr. 0·995, and its standard strength was such, that two fluidrachms of it dissolved 14 grains of the red oxide of mercury, thereby indicating a strength of about 2·9 per cent. of real acid.

The most convenient method of procuring *concentrated* or *anhydrous* hydrocyanic acid, is by the action of strong liquid hydrochloric acid on bicyanide of mercury. The vapour should be passed over carbonate of lime, to deprive it of hydrochloric acid; and over chloride of calcium, to remove the water. The receiver should be immersed in a freezing mixture, consisting of ice and chloride of sodium.

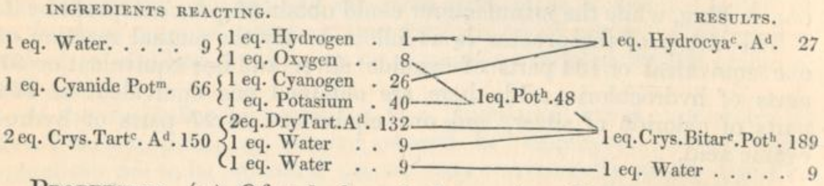
The theory of the process is as follows:—Two equivalents or 74 parts of hydrochloric acid react on one equivalent or 254 parts of the bicyanide of mercury, and form one equivalent or 274 parts of the bichloride of mercury, which remains in the retort, and two equivalents or 54 parts of hydrocyanic acid, which distil over.



(*d.*) *By the action of tartaric acid on cyanide of potassium.*—This process was proposed by Dr. Clarke, and adopted by Mr. Laming. The formula of the latter is the following:—22 grains of the cyanide of potassium are to be dissolved in 6 fluidrachms of distilled water, and to this solution are to be added 50 grains of crystallized tartaric acid, dissolved in 3 fluidrachms of rectified spirit. One fluidrachm of the decanted clear liquor contains one grain of pure hydrocyanic acid.

The objections to this process (which, however, has several advantages) are the trouble and expense of procuring pure cyanide of potassium, and the liability of the salt to undergo spontaneous decomposition.

The theory of the process is the following:—Two equivalents or 150 parts of crystallized tartaric acid, one equivalent or 9 parts of water, and one equivalent or 66 parts of cyanide of potassium, react on each other, and produce one equivalent or 189 parts of the crystallized bitartrate of potash, which precipitates, and one equivalent or 27 parts of hydrocyanic acid, which remains in solution.



PROPERTIES. (*a.*) *Of anhydrous hydrocyanic acid.*—Anhydrous hydrocyanic acid is a solid at 0° F. (some state at 5° F.), having then the appearance of crystallized nitrate of ammonia: it readily melts, forming a limpid, colourless liquid, with an intense and peculiar odour; its taste is at first cool, then hot; at 45° its sp. gr. is 0·7058, and at 64½ is 0·6969. In this state it is exceedingly volatile: a drop placed on paper freezes by its own evaporation. It unites with water and alcohol in every proportion. At 79° or 80° F. it boils, forming hydrocyanic acid vapour, which is combustible; and when mixed with oxygen, explodes. Two volumes of the vapour require two and a half volumes of oxygen gas for their complete combustion. The products are two volumes of carbonic acid gas, one volume of nitrogen, and one volume of aqueous vapour.

Anhydrous hydrocyanic acid undergoes speedy decomposition. Dr. Christison says he has kept it unchanged for a fortnight in ice-cold water.

(*b.*) *Of dilute hydrocyanic acid.*—Dilute or medicinal hydrocyanic acid is a colourless, transparent liquid, having the taste and smell of the strong acid, but in a lesser degree. Heated in a tube it gives off a combustible vapour.

COMPOSITION.—The ultimate constituents of pure hydrocyanic acid are carbon, nitrogen, and hydrogen.

	Eq.	Eq.Wt.	Theory.	Gay-Lussac.
Carbon	2	12	44·4	44·45
Nitrogen	1	14	51·9	51·85
Hydrogen	1	1	3·7	3·70
Hydrocy^{c}. A^{d}.	1	27	100·0	100·00

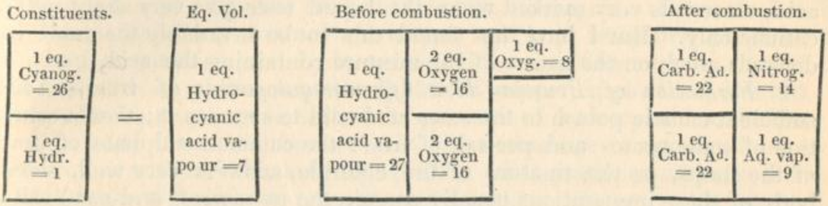
	Vols.	Sp. Gr.
Carbon vapour	1 or 2	$0{\cdot}833\dot{3}$
Nitrogen gas	1	$0{\cdot}972\dot{2}$
Hydrogen gas	1	$0{\cdot}069\dot{4}$
Hydrocyanic vapour	2	$0{\cdot}937\dot{4}$

But it is more usual to regard this acid as a compound of hydrogen and cyanogen, the latter substance being a bicarburet of nitrogen. On this view the composition will be as follows:—

	Eq.	Eq.Wt.	Per Cent.
Cyanogen	1	26	96·3
Hydrogen	1	1	3·7
Hydrocyanic Acid	1	27	100·0

	Vols.	Sp. gr.
Cyanogen gas	1	$1{\cdot}805\dot{5}$
Hydrogen gas	1	$0{\cdot}069\dot{4}$
Hydrocyanic vapour	2	$0{\cdot}937\dot{4}$

The following diagrams illustrate the composition as well as the products of the combustion of the gaseous acid when exploded with oxygen gas:—



Strength of the Dilute Acid.—In the Pharmacopœia, hydrocyanic acid is directed to be prepared of such a strength that 100 grains of it will exactly precipitate 12·7 grains of nitrate of silver dissolved in water:—the precipitate, which is cyanide of silver, should weigh 10 grains. Hence the dilute acid should consist of—

Real Hydrocyanic Acid	2·0
Water	98·0
Dilute Hydrocyanic Acid (Ph. L.)	100·0

Purity.—Dilute hydrocyanic acid should be perfectly colourless; decomposed acid is frequently, but not invariably, coloured. It should be vaporizable by heat: this character shows the absence of fixed impurities. The presence of metallic matter is recognized by hydrosulphuric acid, which has no effect on the pure acid. If the acid strongly redden litmus, it must contain some other acid, most probably the sulphuric or hydrochloric. The presence of any foreign acid is easily determined by the hydrargyro-iodo-cyanide of potassium. This salt is easily formed by adding a concentrated solution of bicyanide of mercury to a solution of iodide of potassium: a precipitate of white or pearly crystalline plates immediately takes place: these are the salt in question. If a small portion of this salt be placed in diluted hydrocyanic acid, no change is observed unless some foreign acid be present: in the latter event the red biniodide of mercury immediately makes its appearance. For this test we are indebted to Dr. Geoghegan (*Dublin Journal*, Nov. 1835). Sulphuric acid may be detected by a solution of chloride of barium: hydrochloric acid by nitrate of silver, which forms therewith white chloride of silver insoluble in boiling nitric acid, whereas the white cyanide of silver is soluble in nitric acid at a boiling temperature. I would observe, that the presence of either of these acids is no further objectionable, than that it creates a difficulty in the determination of the strength of the hydrocyanic acid: while, on the other hand, it confers the advantage of rendering the hydrocyanic acid much less liable to decompose. The acid prepared from ferrocyanide of potassium will keep for years (Dr. Christison has had some unchanged for two years and a half, though it was exposed to day-light), owing, it is supposed, to the presence of some sulphuric acid. Mr. Barry adds a little hydrochloric acid to all his medicinal hydrocyanic acid, in order to preserve it. As air and light hasten, though they are not essential to, the decomposition of the acid, they should be carefully excluded.

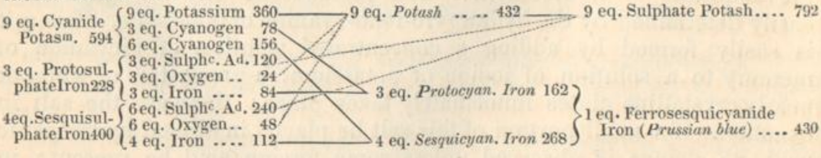
CHARACTERISTICS.—The following are the best tests for hydrocyanic acid.

1. *The odour.*—The peculiar odour of hydrocyanic acid is well known. It must not be confounded with the odour of the volatile oil of bitter almonds. Orfila says, that this is the most delicate characteristic of the acid, since it is very marked when the liquid tests give very slight indications only. But I have not found this to be invariably the case: it depends much on the nature of the mixture containing the acid.

2. *Formation of Prussian blue* (*ferrosesquicyanide of iron*).—Add sufficient caustic potash to the suspected acid to saturate it; then a solution of some proto- and per-salt of iron: the common sulphate of iron of the shops, or the tincture of the chloride, answers very well, since both of these preparations usually contain the two (*prot-* and *per-*) salts of iron. A precipitate is thus obtained, which is liable to considerable variation in its colour, depending on the quantity of potash and the quality of the ferruginous salt employed; it may be yellowish brown, or greenish, or bluish. Then add dilute sulphuric or hydrochloric acid, when Prussian blue (ferrosesquicyanide of iron) will immediately make its appearance, if hydrocyanic acid were present.

The formation of Prussian blue is thus accounted for. When potash is added to hydrocyanic acid, water and cyanide of potassium are generated. By the reaction of this salt on a proto-salt of iron the protocyanide of iron is produced, while with a per-salt of iron it forms sesquicyanide of iron. The two ferruginous cyanides, by their union, constitute the ferrosesquicyanide or Prussian blue.

The following diagram explains the reaction of nine equivalents of cyanide of potassium on three equivalents of the protosulphate, and four equivalents of the sesquisulphate of iron.



3. *Nitrate of silver.*—This is by far the most delicate test of the presence of hydrocyanic acid. It causes a white precipitate of cyanide of silver, which is soluble in *boiling* nitric acid. By this latter character cyanide is distinguished from chloride of silver. If carefully

dried cyanide of silver be heated, it evolves cyanogen gas, known by its combustibility and the colour (violet or bluish red) of its flame.

4. *Sulphate of Copper.*—This test is applied as follows:—Supersaturate with potash; then add sulphate of copper. A greenish blue precipitate is obtained, which, by the cautious addition of a few drops of hydrochloric acid, becomes white, if hydrocyanic acid be present. The objections to the test are, that the results are not sufficiently striking, and that an inexperienced manipulator may fail in getting any evidence of hydrocyanic acid. When excess of potash is added to hydrocyanic acid, we obtain water, cyanide of potassium, and free potash. On the addition of sulphate of copper, hydrated oxide of copper, sulphate of potash in solution, and white cyanide of copper, are formed. The hydrochloric acid is added to redissolve the oxide of copper.

5. *Tincture of guaiacum and sulphate of copper.*—If tincture of guaiacum be added to a very dilute aqueous solution of hydrocyanic acid, a whitish precipitate (resin of guaiacum) is thrown down. If now a few drops of a solution of sulphate of copper be added, a blue colour is produced, which is rendered more intense by the addition of rectified spirit. Pagenstecher, of Berne (*Quarterly Journal of Science*, vol. x. p. 182), first proposed tincture of guaiacum and hydrocyanic acid as a test for copper. I find that tincture of guaiacum and sulphate of copper, applied as directed above, form a very *sensible* test of the presence of hydrocyanic acid: but unfortunately it is not *characteristic*, since other agents also develope a blue colour with it. Thus spirit of nitric ether produces a blue colour with tincture of guaiacum.

DETECTION OF THIS ACID IN CASES OF POISONING.—As hydrocyanic acid is a substance which readily undergoes decomposition, it is not likely to be met with in bodies which have been interred for many days. It has, however, been recognized in one case, seven days after death, notwithstanding that the trunk had not been buried, but had been lying in a drain (Chevallier, *Ann. d'Hygiène Publiq.* ix. 337). In recent cases the acid is readily distinguished by its odour, with which, in some cases, the whole body is impregnated. The tests for this acid, already mentioned, will sometimes detect the poison in the filtered contents of the stomach; but the foreign matters present may in some instances prevent their characteristic action. The best mode of proceeding, in that case, is to introduce them into a tubulated retort, to add some sulphuric acid to neutralize any ammonia which might be generated by the process of putrefaction, and to distil by means of a vapour or water bath; then apply the tests already mentioned.

It has been suggested that hydrocyanic acid may be formed during the process of distillation by the decomposition of the animal matters. But, as Dr. Christison has justly observed, the objection appears only to rest on conjecture, or presumption at farthest. It is to be recollected that unsound cheese has, under certain circumstances, been found to contain this acid, as already mentioned. It is not improbable that it may be found in many animal substances during their spontaneous decomposition. Spurred rye has been found to contain it.

PHYSIOLOGICAL EFFECTS.—(*a.*) *On vegetables.*—Hydrocyanic acid is a poison to plants. The stamina of *Berberis vulgaris* and the leaves of *Mimosa pudica* lose their irritability when the stems bearing them are immersed in the dilute acid (Macaire, *Biblioth. Universelle*, xxxi. 244).

Seeds lose the power of germination by immersion in this acid. In those parts of lactescent plants which are poisoned by it, the milky juice does not flow from the cells or vessels in which it is contained. By chemical means it has been shewn that the acid becomes absorbed (Decandolle, *Physiol. Végét.* p. 1357). Ammonia has, in some cases, appeared to favour the recovery of plants which had been exposed to the vapour of the acid (Macaire, *op. cit.*).

(*b.*) *On animals generally.*—Hydrocyanic acid is an energetic poison to all classes of animals. Experiments have been made with it on the following:—*Mammalia*, *Aves*, *Reptilia*, *Amphibia*, *Pisces*, *Gasteropoda*, *Annelida*, *Crustacea*, *Insecta*, *and Infusoria* (Coullon, quoted by Wibmer, *Wirkung d. Arzneim.* 3 Bd. p. 110). The general effects are very similar on all classes, and consist essentially of loss of sensation and voluntary motion, with convulsive movements. The cold-blooded animals are more slowly affected by it than the hot-blooded ones.

Dr. Christison states that twenty-five grains of the strong acid, applied to the mouth, killed a rabbit within ten seconds. I once caused the instantaneous death of a rabbit by applying its nose to a receiver filled with the vapour of the pure acid: the animal was killed without the least struggle. If a drop of the pure acid be placed on the throat of a dog, or applied to the eye, death takes place in a few seconds. Inhaling the vapour decidedly produces death more quickly than any other mode of applying the acid.

(*c.*) *On man.*—*α. In small or medicinal doses.*—Small doses of hydrocyanic acid sometimes relieve certain morbid conditions (as of the stomach), without producing any remarkable alteration in the condition of the general system. If the dose be cautiously increased, and its operation carefully watched, the following effects are usually observed: bitter but peculiar taste; increased secretion of saliva; irritation in the throat; frequently nausea; disordered and laborious respiration (sometimes quick, at others slow and deep); pain in the head, giddiness, obscured vision, and sleepiness. The vascular system is in some cases not obviously affected, but in others much affected, though not uniformly; being sometimes quickened, at others reduced in frequency. In some instances faintness is experienced. Drs. Macleod and Granville (*London Med. and Physic. Journ.* vol. xlvi. pp. 359 and 363) have noticed salivation and ulceration of the mouth during its medicinal use.

β. In poisonous doses: convulsions and insensibility: if death occur, it takes place slowly.—Immediately after swallowing the acid, a remarkably bitter taste is experienced; this is soon followed by a sensation of faintness and giddiness, with salivation, and succeeded by tetanic convulsions, and insensibility; the respiration is difficult and spasmodic; the odour of hydrocyanic acid may be recognized in the breath; the pupils are usually dilated, though sometimes contracted; the pulse is small or imperceptible. When recovery takes place it is usually very rapid, and the whole period of suffering seldom exceeds half an hour. However, exceptions, to this exist, in which the symptoms have been prolonged for several hours.

The following case, related by Dr. Geoghegan, (*Dublin Med. Journ.* Nov. 1835), is an interesting illustration of these effects:—A gentleman, aged 21, having been for some time subject to an uneasiness in the stomach, not actually amounting to gastrodynia, after having tried many remedies in vain, was induced to have recourse to hydrocyanic acid. He commenced with one minim of the Dublin Pharmacopœia, sp. gr. 0·998: this dose he repeated twelve times the first day, without any perceptible effect. On the following day he took half a drachm, with the same result. The third day his dose was a drachm, which he repeated the fourth day. On the fifth day he took a drachm and a half, still no effect of any kind. On the sixth day he increased his dose to two drachms. In about two minutes after taking this latter quantity, he experienced a sensation of extreme bitterness in the mouth, and having walked a few paces, was affected with great confusion, headache, and loud ringing in his ears. He now with difficulty retraced his steps, and leaning forward on a table, became insensible and fell backwards. In this state he remained altogether between three and four minutes, during which time he was violently convulsed. Two drachms of the spiritus ammoniæ aromaticus were diluted with a little water, and applied as quickly as possible to the mouth, but as the teeth were clenched it could not be swallowed. The solid sesqui-carbonate of ammonia was then applied assiduously to the nostrils; its beneficial effects were soon apparent, and he was shortly able to swallow a little fluid. Sensibility now speedily returned, and vomiting supervened, from which he experienced great relief; and at the expiration of half an hour he was quite well, with the exception of pain and feeling of distension in the head, which continued for the remainder of the day. After he had become insensible, and while leaning on the table, his thighs became rigid, and were drawn up on the abdomen; and as he was about falling, he was caught, and placed on the ground. The upper extremities were then observed to be also rigid, and on drawing them from the side, they forcibly reverted to their former position; the eyes were shut, the teeth clenched, and the muscles of the face violently convulsed. It is deserving of notice that the old complaint was completely removed by this extraordinary dose.

γ. *In poisonous doses: death rapid with or without convulsions.*—In these cases the death is so rapid that, in the human subject, the symptoms have scarcely been observed. They are probably similar to those noticed in animals,—viz. imperceptible pulse, breathing not obvious, or there may be two or three deep, hurried inspirations, insensibility, and death. Convulsions may or may not be present. The presence or absence of convulsions, as connected with the time within which death occurs in these cases, is sometimes of great moment. Some years ago the life of a prisoner almost turned on this point. The following is an outline of the case, which is more fully developed in Dr. Christison's *Treatise on Poisons*, and in the *Medical Gazette*, vol. viii. pp. 577 and 797. An apothecary's maid-servant at Leicester, was found one morning dead in bed. The body lay in a composed posture—the arms crossed over the trunk, and the bed-clothes pulled smoothly up to the chin. At her right side lay a phial, from which about five drachms of the medicinal hydrocyanic acid had been taken, and which was corked and wrapped in paper. It was suspected that she took the acid to occasion miscarriage, and that the apprentice was accessory to its administration; in consequence of which he was put on his trial. Now, the important question for the consideration of the medical witnesses was, could the deceased, after having drunk the poison, have had time to cork the phial, wrap it up, and adjust the bed-clothes before insensibility came on? It was supposed that if the death were of that slow description to allow of these acts of volition, convulsions would have occurred, and the bed-clothes would have been found disordered. On the other hand, those cases in which no convulsions occur usually terminate too quickly to allow of the above acts. The medical witnesses in the above case were not agreed in opinion: the majority thought that it was impossible the deceased could have had the power of corking the bottle. The jury very properly found the prisoner not guilty.

There are two points of inquiry connected with the action of this acid, which are interesting, more particularly in a medico-legal point of view—namely, the time at which the poison begins to operate, and the period in which it proves fatal. No absolute answer can be given to either of these questions, since the strength and quantity of the acid exhibited, and peculiarities (not known or understood) affect the result. Very strong acid, in large doses, begins to operate immediately on touching the throat, and death is almost instantaneous. The dilute acid, on the other hand, sometimes does not produce any obvious effect for several minutes, and death may not occur for nearly half an hour. Of seven epileptic patients killed in one of the Parisian hospitals by hydrocyanic acid, some did not die for forty-five minutes. But I have not found the same quantity of the same acid kill different individuals of the same species in the same period of time.

MORBID APPEARANCES.—The post-mortem appearances in cases of poisoning by this acid are the following:—Glistening and staring expression of the eyes, but which, however, is not a constant phenomenon, since it was not observed in the seven Parisian epileptics: nor is it peculiar to this poison, for the same is observed after death by carbonic acid, and in other cases (Christison) the odour of the acid is oftentimes very obvious in the blood, brain, chest, or stomach: the venous system is usually gorged with blood, while the arteries are empty: the blood is, in many cases, fluid, dark, or bluish black, and viscid or oily: the vessels of the brain and spinal marrow are frequently gorged with blood; and the cerebral ventricles sometimes contain a serous or sanguineous liquor; the lungs are, in some instances, natural—in others, turgid with blood: the internal lining of the stomach is sometimes red.

It has been stated by Magendie, that after death by the strong acid, the muscles are not sensible to the galvanic influence. But this condition is very rarely present; indeed I have never observed it in animals killed by this acid; but Dr. Christison states he has occasionally found it. I have examined a considerable number of animals (principally rabbits) destroyed by hydrocyanic acid, and have always found the muscles to be powerfully affected by the galvanic influence: nor have I once met with a single case in which the heart had ceased to beat when the chest had been laid open immediately after death.

MODUS OPERANDI.—There are several interesting subjects of inquiry connected with the operation of hydrocyanic acid, which, as they are principally theoretical, I shall briefly notice under this head.

(*a.*) *Local action.*—Dr. Christison says that Robiquet's fingers became affected with numbness, which lasted several days, in consequence of their exposure for some time to the vapour of this acid (*Treatise on Poisons*, 3d ed. p. 698). This effect would appear to depend on the local action of the poison on the nerves,—a mode of operation which we are constrained likewise to admit in the case of some other narcotics. (See p. 13: also Müller's *Physiology*, by Baly, vol i. p. 630). Some of the local effects produced by hydrocyanic acid are those of an irritant: such are, the acrid impression made by the vapour on the nose and mouth—the ptyalism—the vomiting and purging—and the redness of the mucous membrane of the stomach.

(*b.*) *Absorption.*—That hydrocyanic acid becomes absorbed, is proved by its having been detected by Krimer (quoted by Dr. Christison, p. 15), in the blood of animals poisoned with it, and by the odour of it exhaled by various parts of the body.

(*c.*) *Are the remote effects of this acid caused by its absorption?*—In many cases the operation of hydrocyanic acid on the system is so rapid, and death so speedily follows the application of the poison, that we cannot satisfactorily account for the effects by the slow process of absorption: and hence many persons have felt themselves constrained to admit the agency of the nerves. I have before (p. 27) alluded to this subject, and have quoted a passage from Müller's *Physiology*, in which the operation by absorption is defended. Further information on this point will be found at p. 627, vol. i. of this celebrated work. The principal arguments which have been adduced in favour of the agency of absorption are the following: *first*, that the acid produces no remote effects when applied either to the nerves or brain: *secondly*, that applied to the tongue or stomach, it operates as an energetic poison, although the nerves of these parts were previously divided: *thirdly*, that if the acid be applied to a part where circulation is arrested, the operation of the poison is prevented: *fourthly*, the activity of the acid is in proportion to the absorbing powers of the part with which it is placed in contact. (See p. 18).

(*d.*) *Organs affected.*—The parts specifically affected by this acid are the brain and true spinal system. The pain in the head, the insensibility, and the coma, are evidence of the cerebral affection; while the tetanic convulsions depend on the disorder of the true spinal system. Marx (*die Lehre von d. Giften*, 1er. Bd. 2e. Abt. S. 154,) mentions the following experiment performed by Wedemeyer (*Versuche über das Nervensystem*, S. 241, Vers. 7), and which shews the independent action of the acid on the spinal marrow: the spinal cord of a dog was divided between the last dorsal and first lumbar vertibræ, so that the hind legs were completely paralyzed and insensible to mechanical irritants: hydrocyanic acid was then introduced into one of the hind legs;—in one minute symptoms of poisoning commenced, the hind as well as the fore legs were violently convulsed,—and in twelve minutes the animal was dead. The affection of the respiratory and circulatory systems produced by hydrocyanic acid is probably only secondary: that is, is the result of the influence of this agent over those parts of the nervous system from which the respiratory organs and heart derive their nervous power. The insensibility caused by hydrocyanic acid occurs too rapidly, in many cases, to be the result of asphyxia caused by paralysis of the muscles of respiration.

(*e.*) *Condition of the brain and spinal marrow.*—The precise pathological condition of the brain and spinal cord of an animal under the influence of hydrocyanic acid, cannot be positively determined, and is, therefore, a matter of conjecture. Whatever it may be, it is probably identical with that which occurs during an epileptic paroxysm, and with that produced by loss of blood: for the essential symptoms (insensibility and convulsions occurring suddenly) are the same in all three states,—and ammonia has been found to relieve them (see p. 171). Dr. Hall (*Lect. on the Nerv. Syst.* p. 139), has shewn that the convulsion from hæmorrhage is spinal. Dr. Holst, Professor of Materia Medica in the University of Christiana, Norway, told me of a case of epilepsy under his care, in which it was observed that the pulse in one arm was always imperceptible during the paroxysm. On a post-mortem examination it was discovered that an anomalous distribution of the arteries existed,—so that this arm was supplied with blood which had circulated through the brain. Hence it would appear that during the epileptic paroxysm the cerebral circulation was impeded. Does this happen in poisoning by hydrocyanic acid?

(*f.*) *Cause of death.*—In most cases the immediate cause of death is obstruction of respiration. In some instances it is stoppage of the heart's action. There are cases, however, in which the death is too immediate to be produced by obstructed respiration, while, on opening the chest, the heart is found still beating: this I have observed in experiments on rabbits with strong hydrocyanic acid.

(*g.*) *Cumulative effects.*—Hydrocyanic acid is not usually regarded as a cumulative poison; but a case mentioned by Dr. Baumgärtner (quoted by Dr. Christison), as well as some other circumstances, seem to favour the reverse opinion (see Dr. Christison's *Treatise*).

USES.—We are indebted to the Italians (Borda, Brugnatelli, and Rasori) for the introduction of hydrocyanic acid into the Materia Medica. It was first employed by them at the commencement of the present century; namely, from 1801 to 1806 (Granville, *Treatise on Hydrocyanic Acid*, 2d ed. 1820).

(*a.*) *Internal.*—By the founders of the theory of contrastimulus this acid was regarded as a powerful asthenic or contrastimulant, and, therefore, as peculiarly useful in all diseases dependent on, or connected with, excitement. Hence it was employed in inflammatory affections. But subsequent experience has fully shewn that in these cases it possesses little or no remedial power.

In this country the reputation of hydrocyanic acid, as a medicinal agent, is chiefly founded on its effects in alleviating certain anomalous stomach complaints. It appears, from Dr. Granville's statements (*op. cit.*), that laurel-water (which contains this acid) was used in these affections by Hufeland, Haller, Thuessen, Swediaur, and Sprengel, between the years 1780 and 1796. But the first person who actually recommends hydrocyanic acid for them is Sprengel (*Pharmacologia*), in 1814. In 1819, Dr. A. T. Thomson detailed a case, which led him to infer that this acid would be an important agent in the treatment of dyspeptic affections. But the profession are principally indebted to Dr. Elliotson (*Numerous Cases illustrative of the Efficacy of the Hydrocyanic Acid in Affections of the Stomach*, 1820) for a full investigation of its powers in these complaints.

Every practitioner is familiar with a stomach complaint in which pain of a spasmodic character is the leading symptom, but which is not essentially accompanied by pyrexia, as in gastritis—by tendency to faint, as in cardialgia—by indigestion, as in dyspepsia, nor by loss of appetite; though one or more of these conditions may attend it. By some nosologists (as Sauvages and Sagar) it has been regarded as a distinct disease, and has been termed *gastrodynia*. It is not unfrequently accompanied by vomiting and præcordial tenderness, which, however, cannot be regarded as indicative of inflammation, for various reasons; one of which is the alleviation of it often obtained by the use of stimulants and antispasmodics. What may be the precise pathological condition of this malady I know not. Dr. Barlow (*Cyclopædia of Practical Medicine*, art. *Gastrodynia*) thinks the primary disease to be irritation or excitement of the mucous membrane of the stomach, whereby a redundant, dense, membranous, and opaque mucus is secreted, which accumulates and oppresses the stomach. The pain he supposes to arise from a contractile effort of the stomach to detach and expel the offending matter: but the immediate and permanent relief sometimes obtained by the use of hydrocyanic acid, is, I conceive, almost fatal to this hypothesis. Some time since I prescribed the acid for a lady who had suffered for months with gastrodynia, and who was persuaded, from her sensations, she had some organic disease. The remedy acted in the most surprising manner: in a few hours, to the astonishment of herself and friends, she was apparently quite well, and has since had no return of her complaint. It can hardly be imagined, that irritation of stomach can be rapidly removed by a substance which is itself an irritant. For my own part, I conceive the affection to be, essentially, a disordered condition of the nerves supplying the stomach, or of the nervous centres from whence those nerves are derived: and that it is frequently, but not invariably, accompanied with the irritation of stomach alluded to by Dr. Barlow. But be the proximate cause of the disease what it may, the beneficial effects of the hydrocyanic acid, in some instances of gastrodynia, are most astonishing, while in others it totally fails. In all the cases in which I have tried it, I have obtained either perfect success or complete failure: I have met with no cases of partial relief. It not only allays pain, but relieves vomiting; and in the latter cases, frequently when all other remedies fail. Dr. Elliotson mentions the following as the stomach affections relieved by it:—1st. those in which pain at the stomach was the leading symptom: 2dly, those in which the gastrodynia was accompanied by a discharge of fluid, constituting what is called pyrosis, or the water-brash: 3dly, when the excessive irritability of the stomach produces vomiting; and, 4thly, those disorders of the stomach, which, in some of their symptoms, resemble affections of the heart. Dr. Prout has found it useful in gastrodynia connected with colica pictonum.

I have also found it useful in a painful affection of the bowels analogous to that of the stomach, and which, therefore, might with propriety be termed *enterodynia*. The most remarkable case of this kind which I have met with, was that of a gentleman, a relative of one of my pupils. He had suffered for several months excruciating pain in the bowels, commencing daily about two o'clock, and only ceasing at night. It was, apparently, a consequence of an ague. He had been under the care of several country practitioners, and had tried a number of remedies (including opium and sulphate of quinia) without the least benefit. I advised the employment of the hydrocyanic acid, and accordingly five minims were administered at the commencement of a paroxysm: the remedy acted like a charm: all the unpleasant symptoms immediately disappeared. Several doses of the acid were given before the time of the succeeding paroxysm, but the disease never returned; and after employing the acid for a few days longer, he went back to the country completely cured.

I have seen hydrocyanic acid used with great success to allay vomiting and purging in severe forms of the ordinary English cholera, when opium has completely failed. In Asiatic or malignant cholera it has occasionally appeared to be serviceable.

As a remedy for affections of the pulmonary organs, hydrocyanic acid was at one time in great repute. It was said to be capable of curing slight inflammation of the lungs without the necessity of blood-letting; of suspending or curing incipient phthisis, while in confirmed cases it smoothed the approach of death; of curing hooping-cough, and of removing all the symptoms of spasmodic asthma (see Dr. Granville's *Treatise* before referred to, and also Magendie's *Recherches sur l'emploi de l'Acide Prussique*, 1819). Experience has shown the fallacy of most of these statements. I have employed hydrocyanic acid in a considerable number of cases of phthisis, and have occasionally fancied that it relieved the cough and night-sweats; but these effects were only temporary. Cases of genuine spasmodic asthma are rare; but in two instances in which I have seen the acid employed, no relief was obtained. In allaying cough (especially the kind called spasmodic) I have, on several occasions, found it useful; but it has so frequently disappointed my expectations, that I now rarely employ it in any pulmonary diseases. I have never observed any ill effects from its use in these cases, though others assert they have.

It has been employed in affections of the nervous system. Cases of hysteria, epilepsy, chorea, and tetanus, have been published, in which this remedy has been found beneficial. I have seen it employed in the three first of these affections, but without any evident relief. It has been proposed and tried in hydrophobia: it apparently mitigated the symptoms. Dr. Hall (*Lect. on the Nerv. Syst.* p. 155) proposes that in addition to the use of this acid, tracheotomy, as suggested by Mr. Mayo, should be tried.

Hydrocyanic acid has been administered as an anodyne in several painful affections; namely, cancer, tic-douloureux, rheumatism, &c., but, with a few exceptions, it has not been found serviceable.

As an anthelmintic it has been extolled by Brera; but the following fact mentioned by Dr. Elliotson, will, I imagine, show its true value:—"I have frequently employed it perseveringly without expelling one worm, when a dose of calomel has instantly brought away hundreds."

(*b.*) *External.*—The local employment of the acid has not been attended with very great success.

In chronic skin diseases, especially impetigo, prurigo, and psoriasis, the acid has been recommended by Dr. A. T. Thomson to allay pain and irritation. Schneider, of Dusseldorf, has employed 1½ drachms of hydrocyanic acid, six ounces of spirit, and as much rose water, in scaly diseases attended with severe itching, especially in eruptions upon the genital organs. On several occasions I have tried hydrocyanic washes in prurigo, but without obtaining any obvious relief. Dr. Elliotson says he has found it efficacious in sores behind the ears, and in scabs of the face; and adds, to an irritable face it is very soothing, if employed before and after shaving. In cancer of the uterus, lotions containing this acid have been applied to allay the pain, by Frisch, of Nyborg. Osiander has also employed, in the same disease, cherry-laurel water, the active principle of which is this acid. In gonorrhœa, injections containing hydrocyanic acid have been employed with benefit. Schlegel has tried also the cherry-laurel water with the same result. Lastly, the dilute acid has been proposed as an effectual and agreeable mode of destroying vermin.

ADMINISTRATION.—The best mode of exhibiting this acid internally is in the form of mixture. I generally give from three to five minims of the dilute acid in about an ounce of some mild vehicle (simple water answers very well), and repeated three or four times a day. Gum or syrup and some flavouring ingredient (as orange-flower water, used on the continent) may be added. Some persons give it in almond emulsion.

As a wash, two fluidrachms of the dilute acid of the shops may be employed mixed with half a pint of distilled (or rose) water as a lotion in skin diseases. Frequently about half an ounce of rectified sprit is added, and Dr. Thomson recommends, in addition to this, sixteen grains of acetate of lead. The external use of this acid, in all cases (more especially if there be sores) requires great caution. Its effects on the nervous system and on the pulse must be carefully watched. In some cases it causes giddiness and faintness; and Mr. Plumbe says, in two instances it produced intermission of the pulse.

ANTIDOTES.—The most important agents in the treatment of poisoning by hydrocyanic acid, as well as by the substances which contain it (viz. the cherry-laurel, bitter almonds, the volatile oil of these substances, &c.), are *chlorine*, *ammonia*, *cold affusion*, and *artificial respiration*.

(*a*.) *Chlorine* is the most powerful of these. It was first proposed by Riauz in 1822. It has been subsequently strongly recommended by Buchner, Simeon, and Orfila. It should be applied both internally and externally if possible. If chlorine water (*aqua chlorinii*, Ph. D.) be at hand, this should be given in doses of one or two tea-spoonfuls properly diluted with water. In the absence of this, weak solutions of the chloride of lime or the chloride of soda may be administered. Nitro-hydrochloric acid largely diluted might be given where none of the above agents could be procured. The patient should be allowed to inhale, very cautiously, air impregnated with chlorine gas (developed by the action of dilute hydrochloric acid on chloride of lime). Enemata containing chlorine water or a solution of chloride of lime should also be employed.

(*b*.) *Ammonia*.—The spirit of sal ammoniac was proposed by Mead (*Mechan. Account of Poisons*, 5th edit. p. 275, 1756) as an antidote for laurel water. In 1822, ammonia was recommended by Mr. J. Murray as an antidote for hydrocyanic acid; and its value has been admitted by Buchner, Orfila, Dupuy, and Herbst: but it is certainly inferior to chlorine; and, therefore, should be used only in the absence of this. If the patient be able to swallow, the liquor ammoniæ, diluted with eight or ten parts of water, should be exhibited, and the vapour of ammonia or its carbonate inhaled: the latter practice is most important, and should not be omitted. Orfila says that ammonia is of no use when introduced into the stomach, but that the inhalation of the vapour will sometimes preserve life. Great caution is requisite in the employment of it (see p. 169). In the absence of ammonia the inhalation of the vapour of burnt feathers might be employed. Ammonia cannot be useful, as an antidote, by its chemical properties merely, since hydrocyanate of ammonia is a powerful poison.

(*c.*) *Cold affusion* has been strongly recommended by Herbst (*Archiv. f. Anat. et Phys.* 1828; quoted by Dr. Christison), and is admitted by Orfila to be a valuable remedy, though he thinks it inferior to chlorine. Herbst says that its efficacy is almost certain when it is employed before the convulsive stage of poisoning is over, and that it is often successful even in the stage of insensibility and paralysis.

(*d.*) *Artificial respiration* ought never to be omitted. Of its efficacy I am convinced from repeated experiments on animals. I once recovered a rabbit by this means only, after the convulsions had ceased, and the animal was apparently dead. It is an operation easily effected, and will be found a powerful assistant to chlorine or ammonia, by enabling it to get into the lungs when natural respiration is suspended. To produce respiration, make powerful pressure with both hands on the anterior surface of the chest, the diaphragm being at the same time pushed upward by an assistant. Inspiration is effected by the removal of the pressure and the consequent resiliency of the ribs.

Other remedies (as turpentine) have been recommended, but they will not bear comparison (if, indeed, they possess any efficacy) with those now mentioned. Blood-letting has been advised, in vigorous subjects, when respiration has been established, and the skin is livid (Devergie, *Méd. Lég.* t. ii. p. 825).

ORDER 8.—PHOSPHORUS AND PHOSPHORIC ACID.

Phos'phorus —Phos'phorus.

HISTORY.—This substance was discovered in 1669, by Brandt, an alchymist at Hamburgh; and received its name from being luminous in the dark (from φῶς, *light;* and φέρω, *I carry*).

NATURAL HISTORY.—Phosphorus is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—Phosphorus is comparatively rare in the mineral kingdom. Various phosphates are found native, but in small quantities: those of lime, lead, iron, copper, manganese, uranium, and yttria, may be mentioned as examples. Phosphate of lime is an important constituent of the organic exuviæ entombed in the fossiliferous rocks.

(*b.*) *In the organized kingdom.*—Phosphoric acid, free, or combined with lime, potash, or iron, is found in various vegetables (Decandolle, *Phys. Végét.* pp. 383, 387, and 390). Phosphorus is a constituent of animals: in some cases it is in combination with oxygen, and a base, as in the bones, urine, &c.: in other instances, as in the brain, it is uncertain in what form it exists.

PREPARATION.—Phosphorus is procured from bone-ash (*sub-* or $\frac{2}{3}$ *phosphate of lime*), by digesting it in sulphuric acid; by which sulphate and superphosphate of lime are procured: the first, for the most part, precipitates, while the latter remains in solution. The solution is to be evaporated nearly to dryness, then mixed with charcoal, dried, and distilled in an earthen retort. The charcoal abstracts the oxygen from the phosphoric acid of the superphosphate, setting free the phosphorus, which is volatilized.

PROPERTIES.—It is a pale yellow, semitransparent, crystallizable, highly combustible solid. Mitscherlich says the crystals are rhombic dodecahedrons; so that they belong to the regular or tessular system. Light, especially violet light, reddens it.

Its sp. gr. is 1·77.—At ordinary temperatures it is flexible, but at 32° is brittle. It melts at 105°, and boils at 550° F. It gives off a small quantity of vapour at ordinary temperatures. In the atmosphere its fumes are luminous in the dark, in consequence of a slow combustion: they have the odour of garlic. By keeping in water, phosphorus becomes coated by a white substance, by some regarded as an oxide, by others as the hydrate of phosphorus. Phosphorus is insoluble in water, but soluble in ether, and the oils both fixed and volatile. It may be reduced to powder by melting it under water, and shaking in a closed vessel until cold. Its equivalent by weight is 16.

CHARACTERISTICS.—Phosphorus in substance is easily recognized by its waxy appearance; by its fuming in the air, and being phosphorescent or luminous in the dark; by friction or gentle heat causing it to inflame; and, lastly, by its burning with a most intense white light and a white smoke of phosphoric acid. A solution of phosphorus in oil or ether, may be known by its garlicky odour, and, when rubbed on the skin, by its rendering the latter luminous in the dark.

PHYSIOLOGICAL EFFECTS.—(*a.*) *On vegetables.*—According to Marcet it is poisonous to plants.

(*b.*) *On animals generally.*—Water impregnated with phosphorus, acts as an aphrodisiac to drakes (Alph. Leroy, quoted by Bayle, *Biblioth. de Thérap.* t. ii. p. 28). Phosphuretted oil acts as a stimulant to horses: blood drawn from a vein had a phosphoric odour (Pilger, quoted by Bayle). If phosphuretted oil be injected into the jugular vein, or into the cavity of the pleura of a dog, white vapours of phosphorus are evolved from the mouth, and death shortly takes place. The phosphorous acid inflames the lungs in its passage through the delicate pulmonary vessels. Introduced into the stomach of animals, phosphorus acts as a caustic poison. The corrosion is supposed to depend on the action of the phosphorous acid (formed by the combination of the phosporus with the oxygen of the air contained in the alimentary canal) on the tissue with which it is in contact.—(Orfila, *Toxicol. Génér.*)

(*c.*) *On man.*—In *small doses*, phosphorus acts as a powerful and diffusible stimulant, exciting the nervous, vascular, and secreting organs. It creates an agreeable feeling of warmth at the epigastrium, increases the frequency and fulness of the pulse, augments the heat of skin, heightens the mental activity and the muscular powers, and operates as a powerful sudorific and diuretic. Its aphrodisiac operation has been recognized by Alphonse Leroy, and Bouttatz (Bayle, *op. cit.*), by experiments made on themselves. In *somewhat larger doses* it causes burning pain, vomiting and purging, with extreme sensibility of the stomach, which lasts for several days (see an experiment made by Sundelin on himself, *Handb. d. Heilm.* 2^{er}. Bd. s. 213). In *still larger doses*, it causes inflammation of the stomach and bowels. Its activity as a caustic poison depends, according to Orfila, on its absorbing oxygen, and thus becoming converted into an acid which acts as a corrosive, like the other mineral acids. Hence, therefore, etherial and oleaginous solutions are more active poisons, inasmuch as the oxidation of the phosphorus is effected more rapidly. Comparatively small doses have in some cases proved fatal. In Dr. Christison's *Treatise on Poisons* are references to several cases: in one $1\frac{1}{2}$ grains, in another instance 3 grains, caused death. Cases, however, are reported, in which 6, 10, and even 12 grains have been swallowed without any hurtful effects; but doubts have been entertained as to the correctness of the statements. Thus the authors of the *Dictionnaire de Matière Médicale* think that the phosphorus employed in these cases must have undergone some chemical change. I once administered 16 grains of phosphorus to a man without any injurious effect; and, judging from its physical characters, I should say the phosphorus was that usually met with in commerce. The man here alluded to was Chabert, some years ago renowned in London under the name of the "*Fire King*." I carefully weighed out 16 grains, placed them in a spoon, and put them in his mouth; and he washed them down with a tumblerful of water. He offered to take this dose daily. How he counteracted the ill effects, I know not; but I suspect he excited vomiting, for within ten minutes after swallowing the phosphorus, he left the room for about a quarter of an hour.

USES.—In this country, phosphorus is rarely employed, and, therefore, it will be unnecessary to enter minutely into its uses. It has been strongly recommended in those cases attended with great prostration of the vital powers, as in the latter stages of typhus fever, dropsies, &c.; in some chronic diseases of the nervous system, as epilepsy, paralysis, melancholy, mania, amaurosis, &c., when these occur in debilitated subjects. In some of the exanthemata, as measles, it has been administered to promote the re-appearance of the eruption when this, from some cause, had receded from the skin; in impotentia virilis of old and debilitated subjects; in cholera, &c. Paillard recommends phosphorus as a caustic, in the place of moxa, than which, he says, it is more convenient and safer. (*Med. Gaz.* vol. ii. p. 254).

ADMINISTRATION.—Phosphorus cannot be given with safety in the solid form. It may be administered dissolved in ether, and formulæ for the preparation of an ethereal solution (*tinctura etherea cum phosphoro*, Fr. Cod.) will be found in Magendie's *Formulaire*, and in the French *Codex*. But some objections have been raised to its use. It is said that upon the evaporation of the ether the phosphorus will be set free, and may inflame the stomach. A solution of phosphorus in fixed oil (*Oleum phosphoratum*, Ph. Boruss.) is, therefore, more commonly employed. Magendie's formula for this is the following:—Digest, during fifteen days, in a dark place, one part by weight of phosphorus, cut in very small pieces, in sixteen parts of olive or almond oil, in a stoppered bottle. To communicate an aromatic flavour, a few drops of the essence of bergamot may be added to the decanted liquid. The solution is termed *aromatic phosphorized oil* (*huile phosphorée aromatisée*). Of this oil from 25 to 30 drops may be given in 24 hours: it may be administered in some mucilaginous liquid, or in an emulsion.

ANTIDOTES.—In poisoning by phosphorus, our objects are to prevent or stop the oxidation of the phosphorus, and to neutralize the resulting acid as fast as it is formed. To fulfil the first of these indications, large quantities of mild demulcent liquids are to be exhibited, so as to envelop the phosphorus and exclude it from the air contained in the alimentary canal. Magnesia should be given, in order to neutralize the phosphorous and phosphoric acids. Parts burned with phosphorus are to be washed with a weak alkaline solution, to remove any adhering acid which might serve to keep up irritation.

Ac'idum Phosphor'icum.—Phos'phoric Ac'id.

History.—Phosphoric acid was first distinguished by Marggraf, in 1740.

Natural History.—(See Phosphorus).

Preparation.—In the London Pharmacopœia, dilute phosphoric acid (the only officinal form of phosphoric acid) is ordered to be prepared by adding an ounce of phosphorus to four fluidounces of nitric acid, mixed with ten fluidounces of distilled water, in a glass retort placed in a sand-bath; then apply heat until eight fluidounces are produced. Let these be again put into the retort that eight fluidounces may distil, which are to be rejected. Evaporate the remaining liquor in a platinum capsule until only two ounces and six drachms remain. Lastly, add to the acid, when it is cold, as much distilled water as may make it accurately measure twenty-eight fluidounces.

In this process six equivalents or 96 parts of phosphorus react on five equivalents or 270 parts of real nitric acid, and abstract fifteen equivalents or 120 parts of oxygen, with which they form six equivalents or 216 parts of phosphoric acid, while five equivalents or 150 parts of the binoxide of nitrogen are evolved.

INGREDIENTS REACTING.			RESULTS.	
5 eq. Nitric Acid 270	5 eq. Nitrogen	70	5 eq. Binox. Nitrogen	150
	10 eq. Oxygen	80		
	15 eq. Oxygen	120	6 eq. Phosphoric Acid	216
6 eq. Phosphorus		90		

If strong nitric acid be employed, instead of the dilute acid ordered in the Pharmacopœia, the re-action is so energetic that an explosion and combustion are sometimes the consequence. In such cases some nitrate of ammonia is usually developed: the ammonia being formed by the union of the nitrogen of the acid with the hydrogen of the water.

Properties.—The aqueous solution of phosphoric acid (*acidum phosphoricum dilutum*, Ph. L.) prepared as above, is a colourless and odourless liquid. It possesses the usual characteristics of an acid; that is, it is sour to the taste, reddens litmus, and neutralizes bases. Its sp. gr., according to Mr. Phillips, is 1·064. By evaporation it acquires the consistence of treacle (*hydrated phosphoric acid*): and when exposed to a higher temperature, it loses water and becomes *pyrophosphoric acid.* At a dull red heat a further evolution of water takes place, and a compound is formed, called *metaphosphoric acid:* this is fusible, and by cooling concretes into a transparent solid, called *glacial phosphoric acid.*

Characteristics.—If phosphoric acid be saturated with an alkali (soda) so as to form a soluble phosphate, it may be distinguished from all other acids by the following characters: it throws down, with the soluble salts of lime, lead, and baryta, white precipitates (phosphates) soluble in nitric acid: with the nitrate of silver it causes a yellow precipitate (subsesquiphosphate of silver) soluble in nitric acid and in ammonia: hydrosulphuric acid causes no change of colour or precipitate with it: if the soluble phosphate be heated to redness, it is converted into a pyrophosphate, which gives, with the nitrate of silver, a white precipitate (pyrophosphate of silver).

Purity.—Diluted phosphoric acid, prepared according to the Pharmacopœia, generally, if not invariably, contains traces of nitric acid. Sulphuric acid may be recognized by chloride of barium, which produces with it a white precipitate insoluble in nitric acid. Hydrochloric acid is detected by nitrate of silver, which causes a white precipitate also insoluble in nitric acid, but soluble in ammonia. The presence of metallic matter may be known by hydrosulphuric acid. Saturated with carbonate of soda, no phosphate insoluble in water should be thrown down.

Composition.—Pure anhydrous phosphoric acid is thus composed:—

	Eq.	Eq. Wt.	Per Cent.	Berzelius.	Dulong.	Davy.
Phosphorus	1	16	44·44	44·05	44·8	42·6
Oxygen	1½	20	55·56	55·95	55·2	57·4
Phosphoric Acid	1	36	100·00	100·00	100·0	100·0

Mr. Phillips says, that 100 grains of the dilute acid of the Pharmacopœia saturate 42 grains of [crystallized] carbonate of soda. If the whole of the free acid were phosphoric, the composition of the dilute acid would be as follows:—

Phosphoric Acid	10·5
Water	89·5
Dilute Phosphoric Acid	100·0

Physiological Effects. (*a.*) *On vegetables.*—This acid is poisonous to plants (Gœppert, quoted by Decandolle, *Phys. Végét.*)

(*b.*) *On animals*—Very few experiments have hitherto been made with it on animals. Orfila (*Toxicolog. Génér.*) found that a strong solution of it acted like sulphuric acid. Thrown into the veins of a dog, it coagulated the blood and killed the animal within ten minutes. Introduced into the stomach, it acted as a powerfully corrosive poison.

(*c.*) *On man.*—Diluted phosphoric acid produces the usual effects of the diluted mineral acids, and which I have before noticed (pp. 80, 84, and 96). It is, therefore, denominated tonic and refrigerant, and may be employed wherever the mineral acids are indicated. It is milder, more assimilable, and, therefore, less likely to disagree with the digestive organs than sulphuric acid, with which, in its action, it is usually compared. These qualities it perhaps derives from its being, as Burdach (*Arzneimittellehre*, Bd. 3, S. 395, 1809) expresses it, "less heterogeneous to the human organism, since it has a considerable share in the composition of it." The same authority also observes, that besides fulfilling the indications of the mineral acids, "it much exalts the excitability when the organism is weak."

Various effects have been ascribed to this acid, which require to be further investigated ere they are admitted. Thus Hecker (*Arzneimittel.* Bd. 2. S. 305) says, it has a specific operation on the nervous system, in virtue of which it possesses the power of allaying pain and spasm. Lentin (*Beitrage zur ausüb. Heilk.* Bd. 2. S. 139) considers it to be endowed with a specific power of influencing secreting surfaces and the bones, whereby it is enabled to ameliorate various morbid conditions of these parts. Sundelin (*Heilmittell,* Bd. 2, S. 234) regards it as a stimulant and tonic to the sexual organs. Various effects have been ascribed to it by Herder (*Hufeland's Journ.* Bd. 9, St. 3, S. 148).

USES.—Phosphoric acid has been employed in the same cases in which sulphuric and other mineral acids have been used, and under the same regulations. It may be employed for a longer period, without disturbing the digestive functions, than the other agents of this class.

It has been used in certain cases rather on theoretical than practical grounds. Thus its power of dissolving phosphate of lime has led to its employment in those forms of lithiasis attended with phosphatic deposits in the urine,—in ossification of the arteries and cardiac valves,—and in exostosis and other osseous tumours. Lentin used it as a local agent to check caries, from a notion that this disease depends on a deficiency of phosphoric acid in the part affected. Woulff applied it to promote the formation of bone.

There are several other diseases against which this acid has been administered. Thus it has been given in blenorrhœa and leucorrhœa, when the secreted fluid was thin and acrid (Sundelin),—in profuse suppuration, to diminish the quantity and improve the quality of the secreted matter,—in hysterical affections of young and irritable subjects, Sundelin has found it useful,—in impotency of the male (Berends),—in diabetes, and in jaundice.

ADMINISTRATION.—Internally the dilute phosphoric acid should be given in doses of from ten minims to half a drachm, properly diluted. Mixed with eight or ten times its volume of water, it may be employed as a wash in caries.

ANTIDOTES.—(See *Sulphuric Acid.*)

ORDER 9.—SULPHUR AND ITS NON-METALLIC COMPOUNDS.

Sul'phur.—Sul'phur or *Brimstone.*

HISTORY.—Sulphur has been known from the most remote periods of antiquity. It is mentioned by Moses (*Genesis,* xix. 24), Homer (*Iliad,* lib. xvi.) and other ancient writers.

NATURAL HISTORY.—It is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.—Native* or *virgin sulphur* occurs in two forms: either imbedded in rocks (*common native sulphur*), or produced by sublimation (*volcanic sulphur*). In Sicily it is found in beds in a blue clay formation, which, in the opinion of Dr. Daubeny, is more recent than chalk, but is of the same age with the gypsum beds in the neighbourhood of Paris. Solfatara (called by the ancients *Forum Vulcani* or the *Court of Vulcan*), a kind of half-extinct volcano, in the vicinity of

FIG. 47.

Warm Spring of Solfatara.

Naples, is celebrated for its native sulphur, which is collected in considerable quantities for the purposes of commerce (Sir W. Hamilton, *Campi Phlegræi*, 1776). Sulphur is also found in the mineral kingdom in a state of combination. Thus sulphurous acid gas rushes out from volcanoes. Sulphuric acid is found native both in the free and combined states: hydrosulphuric acid gas is evolved from the pure sulphurous or hepatic waters, and from the soil in some parts of Italy and other places: lastly, sulphur is found in combination with sulphur. Dr. Thomson (*Outlines of Mineralogy*, &c. vol. i. p. 76) mentions fourteen native sulphurets and seventeen sulphur salts.

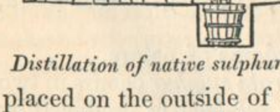
(*b.*) *In the organized kingdom.*—Sulphur is found in *Liliaceæ* (as in garlic); in *Cruciferæ* (as in mustard); in *Umbelliferæ* (as in asafœtida), and in many other orders of plants. The alkaline and earthy sulphates are frequently met with in vegetables. Sulphur is also a constituent of some animal substances (thus it is found in eggs, urine, &c.); sulphates are found in the urine.

PREPARATION.—Sulphur is procured in two ways; by the purification of native sulphur, or by the decomposition of the native sulphurets. The sulphur of British commerce is almost exclusively obtained in the first way. It is brought principally from Italy and Sicily. During the year 1830 no less than 236,338 cwts. of rough brimstone were imported from Italy and the Italian islands (*Parliam. Ret.* 367, ordered to be printed, April 1832).

(*a.*) *Purification of native sulphur.*—In Sicily, from whence most of this substance is procured, the native sulphur is submitted to a rude process of fusion: it is collected in heaps, which are set fire to on the surface: the heat developed by the combusion of one portion fuses another (Daubeny, *Description of Volcanoes*, p. 197).

Another mode of purifying native sulphur is to distil it in earthen pots. These are arranged in two rows in a large oblong furnace (fig. 48, 1, 1), the top of each pot, which serves for the introduction of the sulphur and for the removal of the residuum, being kept closed during the operation. The upper and lateral part of each pot communicates with an inclined tube of about two inches diameter and fourteen long. When the fire is lighted in the furnace, the sulphur fuses and sublimes, and passes through this tube into another pot (2), placed on the outside of the furnace, and perforated near its bottom to allow the melted sulphur to flow into a pail (3) containing water, where it congeals, and forms the rough or crude sulphur (*sulphur crudum*). (Dumas, *Traité de Chimie*, t. 1^{er}. p. 121).

FIG. 48.



Distillation of native sulphur.

Crude sulphur is purified in this country. The process formerly adopted was to submit it to fusion in an iron cauldron: the earthy impurities subside, and the liquid sulphur is ladled out and cast in moulds.

The improved method of purifying it is to submit it to distillation in a large cast-iron still: the receiver, which is made of iron, is kept cool by immersion in water. The sulphur obtained by this process is called *refined sulphur*. When cast in wooden moulds it constitutes *stick, roll*, or *cane sulphur* (*sulphur in baculis,—s. rotundum,—s. in rotulis*). If it be required to obtain the sulphur in a pulverent form, the above process of distillation is modified, thus:—The communication between the still and the iron receiver is shut off, while another is opened with a large chamber or sulphur-house, on the walls of which the sulphur condenses in a pulverent form: in this state it constitutes *sublimed sulphur*, or *flowers of sulphur* (*sulphur sublimatum*, seu *flores sulphuris*). When washed with water to separate a little adhering acid, it is termed *washed sulphur* (*sulphur lotum*). The method of purifying sulphur adopted at Marseilles, as described by Dumas (*op. cit.*), is somewhat different to that now described, and which I have seen practised in the neighbourhood of London.

(*b.*) *Decomposition of metallic sulphurets.*—In some places sulphur is procured by the decomposition of metallic sulphurets (iron or copper). In Anglesea it is (or was) prepared by roasting copper pyrites, by which part of the sulphur is burned, while the remainder is volatilized and collected in chambers connected with the domes of the furnaces by means of horizontal flues (*Aikin's Dict. of Chem.* vol. ii.)

The dregs remaining after the purification of sulphur are called *horse brimstone* (*sulphur vivum; sulphur caballinum; sulphur griseum*).

Properties.—At common temperatures, pure sulphur is a brittle, crystallizable solid, of a yellowish green colour, without smell, and with a very weak and almost imperceptible taste. The specific gravity of ordinary sulphur is about 1·99, but, when free from air-bubbles, 2·087. It is a bad conductor of electricity, and, therefore, by friction becomes powerfully electric. It is a bad conductor of heat, and when grasped in the warm hand crackles, and sometimes breaks to pieces. It is fusible, volatilizable, and combustible. In atmospheric air it burns with a pale blue flame, and emits a large quantity of fumes having a peculiar suffocating odour (*sulphurous acid.*)

It is called *dimorphous* because it has two distinct primary forms. The primary form of the crystals of native sulphur, or of those deposited from its solution in bisulphuret of carbon, is a right rhombic octahedron; while that of the crystals obtained by the fusion and slow cooling of sulphur, is an oblique rhombic prism. Now these two forms are incompatible, and cannot be derived the one from the other: the first belongs to the *rectangular* or *rhombic right prismatic system;* the second to the *rectangular* or *rhombic oblique prismatic system.*

When sulphur is heated to 340°, it becomes viscid; and by increasing the heat the viscidity increases, until the temperature arrives at between 400° and 500°. If while in this state it be suddenly cooled, as by throwing it into water, it remains quite soft, so that it may be drawn out into threads. The cause of this change, which seems to be merely physical, is not understood. The atomic weight of sulphur is about 16.

Characteristics.—Sulphur is easily distinguished from other bodies, by its colour, its fusibility, its volatility, and its burning with a blue flame, and the evolution of sulphurous acid gas, the odour of which can be easily recognized.

Impurities.—Rough sulphur is always mixed with variable quantities of foreign substances. Vauquelin (*Ann. de Chim.* 25, 50) distilled 200 grains, and obtained a residuum of 0·82, composed of silica, carbonate of lime, iron, bituminous charcoal, alumina, and magnesia, but the proportion of earthy matters is generally more considerable. Sulphur obtained from pyrites sometimes contains orpiment (*sesquisulphuret of arsenicum*). The purity of any specimen is determinable by dissolving it in oil of turpentine, which does not act on the foreign matters. It should be perfectly volatile.

Physiological Effects. (*a.*) *On vegetables.*—Sulphur does not appear to be injurious to vegetables, for seeds vegetate and produce thriving plants when sown in sulphur.

(*b.*) *On animals.*—The veterinary school at Lyons found that a pound of sulphur killed horses by producing violent inflammation, recognizable during life by the symptoms, and after death by the morbid appearances. (Christison's *Treatise on Poisons.*)

(*c.*) *On man.*—In *small* and *repeated doses* sulphur acts as a gentle stimulant to the secreting organs, especially to the skin and the mucous membranes, (particularly the bronchial membrane). It promotes the capillary circulation of these parts and increases their secretions. Sundelin (*Heilmittell.* Bd. 1, s. 196) says it operates specifically on the mucous membrane of the rectum, and thereby promotes critical hæmorrhoidal secretions. That it becomes absorbed is shewn by the odour of hydrosulphuric acid which it communicates to the sweat, urine, and milk, and by silver articles becoming blackened in the pockets of patients who are under the influence of it. By the Germans, sulphur is called a resolvent, and is ranked with the mercurial and antimonial preparations. (See Sundelin, *op. cit.*, and Vogt, *Pharmakodyn.*) That is, they regard it as an agent powerfully influencing the nutrition of organs, and, therefore, well adapted for ameliorating various disordered conditions, by what is usually denominated in this country an alterative action. "From mercurial and antimonial medicines," says Sundelin, "sulphur is distinguished by its great diffusibility, in virtue of which it comes near the exciting-tonic agents [*e. g.* the carminative fruit of Umbelliferæ], and also by its not possessing the defluxing (*verflüssigenden*) properties of these agents."

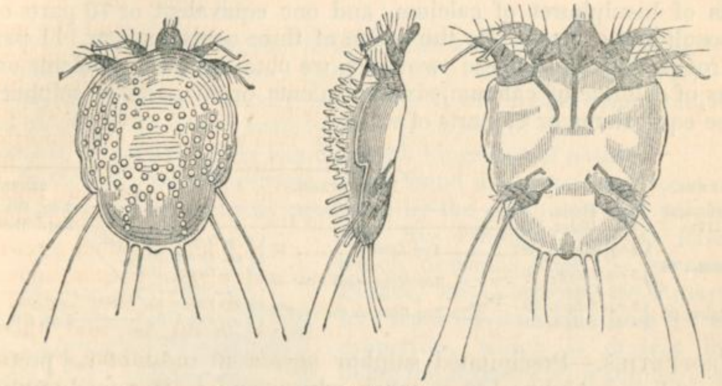
In *larger doses* (as one or two drachms) sulphur acts as a mild purgative, without exciting the pulse or occasioning griping. As the stools are usually solid, Dr. Paris (*Pharmacologia*, vol. i. art. *Cathartics*) concludes that the action of sulphur on the bowels is confined to the muscular coat.

Uses.—Sulphur is employed both internally and externally.

(*a.*) *Internally.*—It is given for various purposes. *In affections of the rectum*, as stricture, hæmorrhoids, and prolapsus, it is a valuable agent as a mild purgative. I have frequently employed it when patients had great disgust for castor oil. In order to promote its purgative effect, it will be sometimes necessary to conjoin magnesia or the bitartrate of potash. *In chronic cutaneous diseases*, more especially prurigo, impetigo, and scabies, the internal use of sulphur is sometimes attended with great benefit. *In pulmonary affections*, as chronic catarrhs and asthma, it is said to be sometimes useful. *In rheumatic and gouty affections* also. Some have employed it as an *anthelmintic*. Vogt (*op. cit.*) employs it as a *resolvent* in inflammation: as in croup, bronchitis, peripneumonia, and abdominal inflammation. In some constitutional diseases (as scrofula and secondary syphilis) it has been used as an *alterative*. Tortual has proposed sulphur as a preservative against measles: but, as might be expected, experience shews sulphur possesses no prophylactic power of this kind, and that the only preservative is isolation.

(*b.*) *Externally.*—Sulphur is a most valuable remedy in various skin diseases, more especially ***scabies;*** and notwithstanding many substitutes have been proposed for it in the latter disease, none are so generally successful. It is supposed by some that the curative powers of sulphur in this disease depend on its poisonous influence over the so-called ***itch-insect*** (***Sarcoptes hominis*** of Raspail, the ***Acarus Scabiei*** of other writers): a little parasite belonging to the class ***Arachnida*** of articulated animals, and, therefore, improperly termed an ***insect*** (Raspail, ***Mémoire sur l'Insecte de la Gale***, Paris 1834).

FIG. 49.



Sarcoptes hominis—(Raspail.)

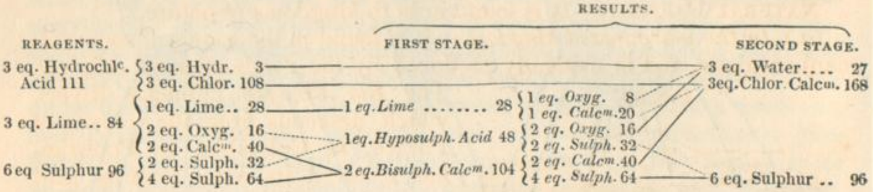
But before adopting this explanation of the ***modus medendi*** of sulphur, it is to be proved that the animal is the ***cause*** of the disease: for, at present, it has not been satisfactorily shewn whether it be the cause, effect, or mere accompaniment of itch. Rayer (***Treatise on Diseases of the Skin***, by Dr. Willis, p. 344) observes, that it is indubitable that the number of these insects bears no proportion to that of the vesicles. "It is, further," he adds, "rare to discover these insects on the abdomen and on groins, where the eruption of scabies is nevertheless very common and very apparent; moreover, scabies is known to continue when no more acari are to be discovered." Besides scabies, sulphur is a most valuable application to various other skin diseases, as porrigo, impetigo, &c.

ADMINISTRATION.—Internally, sulphur is usually given with syrup, or treacle, in the form of an electuary, or suspended in milk. The dose of it, as a purgative, is from one to three or four drachms. As an alterative and sudorific, the dose is about half a drachm. The preparation sold under the name of ***milk of sulphur***, or ***precipitated sulphur***, is a more convenient and agreeable preparation for internal use, than the ordinary sublimed sulphur.

Externally sulphur is principally employed in the form of ointment. The ***unguentum sulphuris*** (Ph. L.) consists of three ounces of sulphur to half a pound of lard: twenty minims of the oil of bergamot are added to counteract, in part, the unpleasant odour of sulphur. The *unguentum sulphuris compositum* is composed of half a pound of sulphur, two ounces of powdered white hellebore, half a pound of soft soap, a pound and a half of lard, and thirty minims of the oil of bergamot: it is a much more irritant application than the simple ointment of sulphur. Both are employed for the cure of itch, and, sometimes also, in the various forms of porrigo which affect the heads of children.

1. *SULPHUR PRÆCIPITATUM.*—This preparation, commonly termed *milk of sulphur* (*lac sulphuris*), was known to Geber. It may be prepared by boiling one part of sublimed sulphur, two parts of slacked lime, and eight parts of water. To the filtered solution add sufficient hydrochloric acid to precipitate the sulphur, which is to be washed and dried.

The *theory* of the process is the following:—When sulphur and lime are boiled in water, six equivalents or 96 parts of sulphur react on three equivalents or 84 parts of lime, and produce two equivalents or 104 parts of bisulphuret of calcium, and one equivalent or 76 parts of the hyposulphite of lime. By the action of three equivalents or 111 parts of hydrochloric acid on these two salts, we obtain three equivalents or 168 parts of chloride of calcium, six equivalents or 96 parts of sulphur, and three equivalents or 27 parts of water.



PROPERTIES.—Precipitated sulphur agrees in most of its properties with sublimed sulphur, but is much whiter, and is in a finely pulverent form. Berzelius says, that when melted, it gives out a little sulphuretted hydrogen; and on cooling, resumes the yellow colour it had before it was boiled with the alkali.

COMPOSITION.—It is composed of sulphur with a little water; and hence it is frequently termed *hydrate of sulphur.* According to Bucholz, however, when well dried, it contains hardly a trace of water, and, therefore, any present under ordinary circumstances must be regarded as hygroscopic; so that the term hydrate is hardly applicable to it.

IMPURITIES.—If sulphuric be substituted for hydrochloric acid, in the manufacture of this substance, sulphate of lime will be formed, and mixed with the precipitated sulphur. The impurity may be detected by volatilizing the sulphur in a crucible, or by solution in oil of turpentine or liquor potassæ.

The EFFECTS, USES, and DOSES, are the same as those of common sublimed sulphur.

2. *OLEUM SULPHURATUM.*—Sulphur is soluble in both volatile and fixed oils, and formulæ are still found in some continental works for the preparation of pharmaceutical compounds of them. A formula for sulphurated oil is still retained in the Edinburgh Pharmacopœia, but has been omitted in the last edition of the London Pharmacopœia. This preparation was formerly denominated *balsam of sulphur*.

It is prepared by boiling one part of sublimed sulphur in eight parts of olive oil. The compound thus procured cannot be regarded as a mere solution of sulphur in oil, since the odour of hydrosulphuric acid, which it possesses, proves that the oil has undergone partial decomposition: in fact, the heat to which the oil is raised in order to boil it, causes a chemical change.

It is a dark reddish-brown viscid substance, having an extremely unpleasant odour. Its local action is that of an acrid: its remote operation that of a stimulant, causing thirst and febrile heat. It has been supposed to possess expectorant and diaphoretic properties. It is applied to foul ulcers, and is employed internally in chronic pulmonary affections. The dose of it is from 40 to 50 drops: but its unpleasant taste and smell almost preclude its use.

Ac'idum Sulphu'ricum.—Sul'phuric Ac'id.

History.—This acid appears to have been known to Geber as early as the seventh century (Thomson's *Syst. of Inorg. Chem.* vol. ii. p. 29.) In the state in which we usually meet with it in English commerce, it is termed *oil of vitriol*, or the *protohydrate of sulphuric acid.*

Natural History.—It is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—It is found in the waters of some volcanic regions, and is evidently produced by the combustion of sulphur. The *Rio Vinagre* (Vinegar River), which descends from the volcano of Puracé, in Colombia, to Popayan, has received its name from its acid properties, which it derives from being impregnated with sulphuric and hydrochloric acids (A. de Humboldt, *Vues des Cordillères*, p. 220).

Fig. 50.

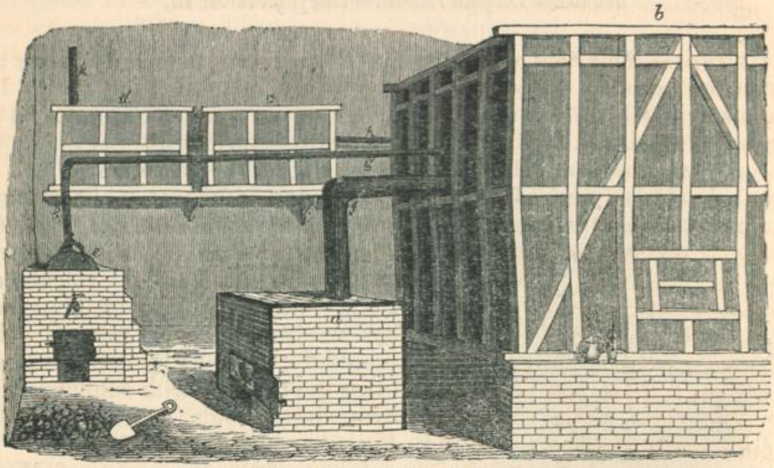
Cascade of Vinagre, in Colombia.

Issuing from the crater of Mont Ida, in Java, is a river which also contains this acid. Dr. Thomas Thomson (*Mineralogy*, vol. i. p. 75) states, that in Persia there is an earth so strongly impregnated with it, that it is used by the natives as an acidulous seasoner of food. This author also says (*op. cit.* p. 77), that there are no less than twenty-seven sulphates (consisting of combinations of sulphuric acid with one or more bases) in the mineral kingdom. The most abundant of these is the sulphate of lime.

(*b.*) *In the organized kingdom.*—The sulphates of lime, potash, and soda, have been found in plants (Decandolle, *Phys. Végét.* p. 390). The sulphates of potash and soda are mentioned by Berzelius (*Traité de Chim.* t. 7^{me}, p. 393) as constituents of human urine.

Preparation.—The most improved method of manufacturing oil of vitriol adopted in this country is the following:—Crude sulphur is burned on an iron plate in a furnace, and the gas (sulphurous acid), thereby produced, is conveyed by a pipe or chimney into a leaden chamber, the bottom of which is covered to the extent of four or five inches with water. The furnace door has two apertures to regulate the supply of atmospheric air. After combustion has continued for several hours, an iron pot containing a mixture of the nitrate of potash or soda and oil of vitriol, is introduced into the furnace, and steam is conveyed into the leaden chamber. So that sulphurous acid, nitric or nitrous acid (generated by the action of the oil of vitriol on the nitrate of potash, and volatilized by the heat produced by the combustion of the sulphur), and steam, are conveyed into the leaden chamber, and by their mutual reaction produce sulphuric acid, which is absorbed by the water at the bottom of the chamber. To prevent loss in the process, the residual gases are conveyed through two other small leaden chambers (also containing water) before they are allowed to escape into the air.

FIG. 51.



Oil of Vitriol Manufactory.

(*a*) Furnace.
(*b*) First leaden chamber.—In the manufactory from which the above sketch was made, this chamber was 70 feet long, 20 feet wide, and 20 feet high; but the size varies considerably in different establishments.
(*c*) Second ditto.
(*d*) Third ditto.
(*e*) Steam boiler.
(*f*) Pipe or chimney of the furnace.
(*g*) Steam pipe.
(*h*) Pipe conveying the residual gas from the first to the second leaden chamber.
(*i*) Pipe conveying the gas not absorbed in the first and second chambers into the third.
(*k*) Waste pipe conveying the unabsorbed gas into the atmosphere.
(*l*) Man-hole, by which the workmen enter the chamber when the process is not going on.
(*m*) Pipe for withdrawing a small portion of sulphuric acid from the chamber, in order to ascertain its sp. gr. by the hydrometer.

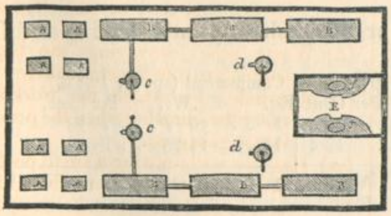
When the liquid in the leaden chamber has acquired a specific gravity of about 1·5, it is conveyed by leaden pipes into rectangular leaden boilers, where it is evaporated and concentrated until its sp. gr. is 1·70; but in some manufactories this part of the process is omitted. The final concentration is effected by boiling it down in *glass* or *platinum retorts*: the latter, notwithstanding their great cost, are now usually adopted. Their price, of course, depends on their size. Mr. Parkes (*Chem. Essays*, vol. i. p. 535) had one which held thirty gallons, and cost about £360;

but sometimes they are made so large, that they are worth £1000 each. In this apparatus the acid is deprived of a part of its water and some sulphurous acid, and when it has attained a sufficient degree of concentration, it is drawn off by means of a platinum syphon into carboys.

The theory of the process is the following:—When sulphurous and nitric acids come in contact, the first loses, the second gains, oxygen, by which sulphuric and nitrous acids are formed. Dry nitrous acid and sulphurous acid gases undergo no change when mixed; but, if a little moisture be admitted, re-action takes place, and a crystalline compound, of sulphuric acid, hyponitrous acid, and water, is formed. This, falling into water, is immediately decomposed: sulphuric acid is dissolved, and the hyponitrous acid is resolved into nitrous acid and binoxide of nitrogen, which escape with effervescence in a gaseous form. The nitrous acid thus disengaged, with that produced by the union of the binoxide with oxygen of the atmosphere, becoming mixed with more sulphurous acid and water, gives rise to a fresh portion of the crystalline compound. One part of the nitrous acid is converted by the water present into nitric acid and binoxide of nitrogen; while another portion loses the whole of its oxygen, by which a little nitrogen gas is disengaged. In oil of vitriol manufactories the crystalline compound is rarely formed, owing to the excess of aqueous vapour present. Sometimes, however, it is deposited in the pipe which conveys away the superfluous vapour, as in the instance mentioned by Dr. Henry (*Ann. Phil.* vol. xi. new series, p. 368). For further information respecting the manufacture of sulphuric acid, see the papers of Gaultier de Claubry, in *Ann. de Chim.* xlv. 284; and *Dict. de l'Indust.* tom. i. pp. 108, *et seq*).

The old method of manufacturing oil of vitriol, and, indeed, one still followed in some places, consists in burning a mixture of eight parts of sulphur and one part of nitrate of potash (or nitrate of soda) on iron or leaden plates, either within the leaden chamber or in a furnace on the outside of it (Parkes's *Chemical Essays*, vol. i. 465). Fig. 51 is the ground plan of a manufactory of this kind. Iron pyrites (bisulphuret of iron) is sometimes substituted for sulphur.

FIG. 52.



Plan of a Sulphuric Acid Manufactory.

A, Rectangular leaden boilers.
B, Leaden chambers.
E, Retort house.
c, Leaden pump for acid.
d, Water pump.

In this process the greater part of the sulphur combines with oxygen of the air to form sulphurous acid: but a portion abstracts oxygen from the nitric acid of the nitrate, and thereby becomes sulphuric acid, which, with the potash of the nitre, forms sulphate of potash. Binoxide of nitrogen is evolved by the decomposed nitric acid, and this, combining with oxygen of the air, becomes nitrous acid. The mutual action of sulphurous and nitrous acid gases has been before explained.

At Goslar, Nordhausen, and other parts of Saxony, sulphuric acid is made thus:—Crystallized sulphate of iron is calcined, by which the greater portion of its water of crystallization is expelled. It is then distilled in earthen vessels, by which *fuming sulphuric acid* is procured, while sesquioxide of iron is left in the retort. If this acid be heated in a glass retort, it yields real or anhydrous sulphuric acid.

PROPERTIES. (*a.*) *Of anhydrous sulphuric acid.*—It is a crystalline solid, having very much the appearance of asbestos. It gives out dense white fumes in the air, like fluoride of boron. It melts at 66° F. and boils at from 104° to 122° F. The sp. gr. of the liquid acid, at 78° F. is 1·97.

(*b.*) *Of the Nordhausen or fuming sulphuric acid.*—This is usually a dark brown oily-like liquid, which gives out copious white fumes in the air. Its sp. gr. is about 1·9. It is imported in stone bottles, having a stoneware screw for a stopper.

(*c.*) *Of oil of vitriol or English sulphuric acid.*—When pure it is a colourless, transparent, inodorous, highly acrid, and corrosive liquid. It possesses the usual properties of a powerful mineral acid in a very eminent degree, such as reddening the vegetable blues, saturating bases, and displacing other acids. Its affinity for water is most intense, and by virtue of this, it absorbs aqueous vapour from the atmosphere, and chars animal and vegetable substances. When mixed with water there is a mutual condensation with the evolution of heat. Various substances when heated in sulphuric acid decompose it; they abstract oxygen and evolve sulphurous acid. This is the case with charcoal, organic substances, phosphorus, sulphur, and several of the metals, as copper, tin, and mercury.

The sp. gr. of this acid at 60° F. is about 1·84. Genuine *commercial* acid should never surpass 1·8455; when it is denser, we may infer sophistication or negligence in the manufacture (Brande's *Man. of Chemistry*). Acid of sp. gr. 1·845 freezes at — 15° F. and boils at 620° F. In commerce the acid has frequently a sp. gr. of only 1·8433, and its boiling point is 545° F. (Phillips's *Transl.*)

COMPOSITION.—Pure or anhydrous sulphuric acid is thus composed:—

	Eq.	Eq.Wt.	Per Cent.	Berzel.		Vol.	sp. gr.
Sulphur	1	16	40	40·14	Sulphurous acid gas	1	2·22$\dot{2}$
Oxygen	3	24	60	59·86	Oxygen gas	0·5	0·55$\dot{5}$
Sulphuric acid	1	40	100	100·00	Sulphuric acid vapour	1?	2·77$\dot{7}$?

The composition of oil of vitriol or English sulphuric acid is as follows:—

	Strongest (sp. gr. 1·845)			Commercial (sp. gr. 1·8433).		
	Eq.	Eq.Wt.	Per Cent.	Eq.	Eq.Wt.	Per Cent.
Real sulphuric acid	1	40	81·6	1	40	78
Water	1	9	18·4	$1\frac{1}{4}$	11·25	22
Oil of vitriol	1	49	100·0	1	51·25	100

According to this statement the strongest oil of vitriol which can be procured (sp. gr. 1·845) is the *protohydrate of sulphuric acid*, while that met with in commerce is a $\frac{5}{4}$ *hydrate of sulphuric acid.*

The *German* or *Nordhausen sulphuric acid* consists of—

	Eq.	Eq.Wt.	Per Cent.			Eq.	Eq.Wt.
Real sulphuric acid	2	80	89·88	or	Real sulphuric acid	1	40
Water	1	9	10·11		Protohydrate sulphuric acid	1	49
Nordhausen sulphuric A^{d}.	1	89	99·99			1	89

CHARACTERISTICS.—Free sulphuric acid or the soluble sulphates are recognized by a solution of any of the barytic salts, which throws down a heavy white precipitate (sulphate of baryta) insoluble in acids or alkalies. If this precipitate (or any insoluble sulphate) be ignited with charcoal, it is decomposed and converted into a sulphuret, which, on the addition of hydrochloric acid, evolves hydrosulphuric acid, known by its odour and its blackening paper moistened with acetate of lead. If sulphuric acid be heated with organic matter, sulphurous acid is given out: this may be known by its odour, and by its occasioning the formation of the blue iodide of starch when mixed with iodic acid and starch.

To determine whether sulphuric acid is free or combined with a base, Dr. Christison (*Treatise on Poisons*, 3d ed. p. 142) recommends the liquid to be boiled with pure carbonate of lead. If any free sulphuric acid be present sulphate of lead will be formed, which, being insoluble in dilute nitric acid, may be thereby distinguished from carbonate of lead. But this test is liable to objection: alum and other supersulphates re-act on carbonate of lead like free sulphuric acid; and, furthermore, sulphate of ammonia is decomposed at a boiling temperature by carbonate of lead.

IMPURITIES.—Pure sulphuric acid should be colourless: the presence of organic matter, as cork, communicates a brownish or black colour. The acid of commerce usually contains traces of sulphate of lead: this may be detected either by adding water, when the white sulphate is precipitated; or by the addition of hydrosulphuric acid to the dilute sulphuric acid, when a very slight change of colour is observed, owing to the formation of sulphuret of lead. "What remains after the acid has been distilled to dryness does not exceed the $\frac{1}{400}$ part of its weight."—(*Ph. Lond.*) The residuum here referred to is sulphate of lead.

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—In the concentrated state sulphuric acid chars the parts of plants to which it is applied. In the dilute form it destroys vegetables in a few hours (Marcet, in Decandolle's *Phys. Végét.* p. 1345).

(*b.*) *On animals generally.*—The action of sulphuric acid on animals generally is precisely the same as that on man. Thrown into the veins of a dog, Orfila found that it coagulated the blood, and caused immediate death.—(*Toxicol. Génér.*)

(*c.*) *On man.*—Properly diluted and administered *in small but repeated doses,* sulphuric acid acts as a tonic and refrigerant, like the other mineral acids (see pp. 80, 84, 96). Thus it promotes the appetite, diminishes febrile heat, allays excessive thirst, checks profuse sweating, and, not unfrequently, reduces the frequency of the pulse. Sometimes it increases the secretion of urine, and likewise renders this fluid unusually acid. Under its use the milk frequently acquires a griping quality.

The continued use of it, however, generates a slow kind of gastro-enteritis: heat and pain are experienced in the throat, stomach, and intestines; the digestive functions become disordered; gripings are experienced; sometimes purging, and subsequently fever. Of all the mineral acids, save the phosphoric, this may be administered for the longest period without occasioning the above symptoms.

Concentrated sulphuric acid acts as an energetic caustic poison, promptly disorganizing the different tissues with which it is brought in contact. Its chemical action depends principally on its affinity for water, so that it chars or carbonizes the parts with which it is placed in contact. But its power of coagulating albuminous liquids, of combining with albumen to form a sulphate of this organic substance, and of dissolving fibrin, as well as coagulated albumen, contribute to its energetic escharotic action on the animal tissues. The parts to which the acid is applied become, in the first place, white; but by the more prolonged action of the poison, they assume a brownish or blackish appearance, so that we can thereby frequently distinguish poisoning by this from poisoning by nitric acid; since this last-mentioned agent produces a yellow colour when applied to the skin. Black spots are frequently observed in the stomachs of those who have swallowed the acid; and in the surrounding parts the blood is usually coagulated in the blood-vessels. Such are the topical chemical effects of this acid. But besides these there are other phenomena of a local nature which may be denominated vital, since they depend on the re-action of the living parts. I refer now to the acute inflammation set up in the tissues in the immediate neighbourhood of those destroyed.

When strong sulphuric acid has been swallowed the symptoms of poisoning are the following:—Alteration, or even destruction, of the soft parts about the mouth; burning pain in the throat, stomach, and bowels; frequently alteration of the voice, from the swelling and disorganization of the parts about the larynx; breath fœtid, from the decomposed tissues; constant and abundant vomiting of matters, which may be bloody or otherwise, but which effervesce by falling on a marble hearth; bowels variously affected, sometimes constipated, though usually purged, the stools being bloody. The constitutional symptoms are principally those arising from a disordered action of the vascular system: thus the pulse is frequent and irregular, feeble, often imperceptible; extremities cold; great feebleness, or even fainting, with cold sweats. The same constitutional symptoms are observed when the stomach is wounded or ruptured. One remarkable characteristic is, that the mental faculties are unaffected, even up to a few minutes before death.

USES.—1. *MEDICINAL.* (*a.*) *Internal.*—In *febrile diseases* it may be administered, largely diluted, as a refrigerant, to diminish thirst and preternatural heat; though, in most of these cases the vegetable acids are to be preferred. In the latter stage of fever (especially the kinds called typhoid) considerable benefit is sometimes gained by the use of a vegetable bitter (as calumba or cinchona) in combination with the diluted sulphuric acid. To assist the appetite and promote digestion, it is administered to patients recovering from fever. *To check profuse sweating* in pulmonary and other affections, whether phthisical or not, it is sometimes a valuable agent, as I have found on many occasions. No other remedy is so efficacious in relieving colliquative sweatings as this. In *hæmorrhages*, as those from the nose, lungs, stomach, and uterus, it is commonly administered as an astringent, but its efficacy is doubtful. So also in purpura hæmorrhagica it is given with the same intention; but though I have several times employed it, I have not observed any evident benefit derived therefrom.

In those forms of *lithiasis* attended with phosphatic sediments in the urine, the use of the mineral acids is at times beneficial. The sulphuric is preferred to the hydrochloric acid, since it can be continued for a longer period without occasioning gastric disorder. In *skin diseases*, especially lichen and chronic nettle-rash, it is sometimes serviceable. In those forms of *dyspepsia* connected with an alkaline condition of the stomach, as in pyrosis, the sulphuric has been found to succeed better than hydrochloric acid (Dr. R. D. Thomson, *British Annals of Med.* March 31, 1837).

(*b.*) *External.*—As a local agent, sulphuric acid is employed as a caustic, irritant, or astringent. As a caustic it has no advantage over many other agents, except that which arises from its liquid form, which, in most cases, renders it disadvantageous. For example, the difficulty of localizing it would be an objection to its employment in the production of an issue, but would be an advantage in applying it to wounds caused by rabid animals or poisonous serpents, since the liquidity of the acid enables it to penetrate into all parts of the bites. In entropium, or that disease in which the eyelid is inverted, or turned inwards upon the eye, this acid has been applied as a caustic. In this complaint the friction of the eyelashes on the globe is most distressing, giving rise not only to inflammation, but even ulceration of the cornea. Now, when the disease is permanent, two modes of curing it have been proposed; either to remove a fold of the integument by the knife, so that, by the subsequent cicatrization, the lid may be drawn outwards—or to destroy a portion of the skin by a caustic, as sulphuric acid. The latter plan of treatment has been practised successfully by several eminent oculists, among whom I may name Mr. Guthrie and Mr. Lawrence. So also in ectropium, in which the lid is everted or turned outward, Mr. Guthrie has applied the concentrated acid to the inner side of the everted lid with advantage.

An ointment containing sulphuric acid has been employed as a rubefacient in paralysis, and in the second stage of inflammation of the joints, when the violence of the disease has subsided; as a styptic to wounds, to suppress hæmorrhage from numerous small vessels; and as a cure for scabies. Lastly, this acid, properly diluted, is employed as an astringent gargle in ulcerations of the mouth and throat; but after using it the mouth should be well rinsed, to prevent the action of the acid on the teeth.

2. *PHARMACEUTICAL.*—Sulphuric acid is used in the manufacture of various preparations contained in the Pharmacopœia, as some of the acids, ether, the vegetable alkalies, several salts, &c.

ADMINISTRATION.—For internal use we generally make use of the *diluted sulphuric acid* of the Pharmacopœia, or the *elixir of vitriol.*

1. *ACIDUM SULPHURICUM DILUTUM.*—This compound is prepared by adding, gradually, a fluidounce and a half of sulphuric acid to fourteen fluidounces and a half of distilled water. Condensation ensues, and heat is evolved. Mr. Phillips states, that a fluidrachm of it contains about ten grains of the strong acid, and will saturate 28 grains of crystallized carbonate of soda. The dose of it is from ten to thirty minims diluted with two or three table spoonfuls of some mild liquid. A most convenient preparation of it is the *compound infusion of roses.* It is sometimes given with conserve of roses.

2. *ACIDUM SULPHURICUM AROMATICUM.*—This preparation, which is contained in the Edinburgh, Dublin, and United States Pharmacopœias, is known in the shops as *elixir of vitriol.* The Dublin formula for it is the following:—" Take of rectified spirit two pints, sulphuric

acid (by weight) six ounces. Add the acid to the spirit gradually: digest the mixture in a closed vessel, with an inferior heat, for three days; then add of cinnamon bark (bruised) an ounce and a half, ginger root (bruised) an ounce. Digest the mixture again for six days; and, lastly, filter through paper placed in a glass funnel." An analogous preparation, but containing a much greater number of aromatics, is contained in the French Codex, under the name of *tinctura aromatica sulfurica*. It has been usually supposed that some sulphuric ether was generated in this preparation, but the late Dr. Duncan observes—" I have ascertained that there is no reaction upon the sulphuric acid, at least that not a particle of gas is evolved by the mixture of alcohol and sulphuric acid in the proportions indicated." It is not improbable that some sulphovinic acid may be formed: the evolution of gas is not essential to the formation either of this compound or of ether. Elixir of vitriol is used in the same cases and doses as the dilute sulphuric acid.

3. *Unguentum Acidi Sulphurici* (*Ph. Dub.*)—This compound is prepared by mixing, in a glass or earthenware mortar, a drachm of sulphuric acid with an ounce of lard. The mixture is of a slight buff colour. It is a powerful stimulant.

Antidotes.—In cases of poisoning by sulphuric acid, the antidotes are, chalk, whiting, or magnesia suspended in water. In the absence of these, soap-suds, infusion of wood-ashes, weak solutions of the alkaline carbonates, white of eggs, gelatine, milk, oil, or in fact any mild diluent, should be instantly administered. The subsequent treatment is that for gastro-enteritis. External parts burnt with oil of vitriol should be washed with a solution of soap or simple water.

Ac'idum Sulphuro'sum.—Sul'phurous Ac'id.

History.—Homer (*Iliad*, xvi.) mentions sulphur fumigations: Stahl, Scheele, and Priestley, were the first to submit this acid to an accurate examination. It has been termed *volatile sulphurous acid*, and, from the old mode of procuring it, *spirit of sulphur by the bell* (*spiritus sulphuris per campanam*).

Natural History.—It escapes from the earth, in a gaseous form, in the neighbourhood of volcanoes.

Preparation.—For chemical purposes it is prepared by mixing two parts of mercury with three parts of strong sulphuric acid, applying heat, and collecting over mercury. The results are, the bipersulphate of mercury and sulphurous acid.

For medical purposes, however, it is rarely, if ever, necessary to procure it in this way. By the combustion of sulphur in atmospheric air this gas is readily obtained; and when we are about to employ it, either as a disinfectant or vapour bath, this method is always followed.

Properties.—At ordinary temperatures and pressures it is a colourless and transparent gas, and has a remarkable and well-known odour. It is neither combustible nor a supporter of combustion. It reddens litmus and bleaches some colouring matters, especially infusion of roses, but the colour is restored by sulphuric acid. It is irrespirable, and has a sp. gr. of 2·2. It readily dissolves in water: recently boiled water takes up 33 times its volume of this gas. By cold and pressure, sulphurous acid gas is readily condensed into a limpid liquid.

CHARACTERISTICS.—This acid is readily known by its peculiar odour (that of burning sulphur). If the puce-coloured or binoxide of lead be added to it, the white protosulphate of lead is formed. An aqueous solution of this acid, mixed with iodic acid, deoxidizes the latter, and sets iodine free, which may be recognized by its producing a blue colour with starch. The sulphates evolve sulphurous acid by the action of strong sulphuric acid.

CONSTITUENTS. RESULTING COMPOUND.

2 eq. Oxygen = 16 and 1 eq. Sulphur = 16. = 1 eq. Sulphurous Acid = 32.

COMPOSITION.—If 16 parts (by weight) of sulphur be burned in one volume or 16 parts (by weight) of oxygen gas, we obtain one volume or 32 parts (by weight) of sulphurous acid gas.

The composition of this substance may, therefore, be thus expressed:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.
Sulphur	1	16	50	49·968
Oxygen	2	16	50	50·032
Sulphurous Acid	1	32	100	100·000

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—It is a most powerful poison to plants even in very minute quantities (Christison, *On Poisons*, 3d ed. p. 750).

(*b.*) *On animals generally.*—The effects on animals have not been examined: but they are probably those of an irritant and an asphyxiating agent.

(*c.*) *On man.*—Applied to the skin this acid gas causes heat, pain, and itching. If an attempt be made to inhale it in the pure state, it excites spasm of the glottis. Diluted with air it may be taken into the lungs, and there acts as a local irritant, causing cough, heat, and pain.

USES.—It has been used as a disinfectant, as a remedy for the cure of itch, and as a nasal stimulant in syncope.

As a *disinfectant* it is mentioned by Homer. The mode of using it for this purpose is very simple. A pot containing burning sulphur is introduced into the room or place to be fumigated, and the doors and windows carefully closed.

As a remedy for itch, baths of sulphurous acid gas are mentioned by Glauber in 1659. They are commonly termed *sulphur baths*, and may be had at most of the bathing establishments of the principal towns of this country. At the Hôpital St. Louis, in Paris, a very complete apparatus for the application of this remedy in diseases of the skin has been erected by D'Arcet. It is a kind of box, inclosing the whole body, with the exception of the head. The sulphur is placed on a heated plate in the lower part of the box. From ten to twenty baths, or even more, are requisite for the cure of itch. "Sulphureous fumigations," says Rayer (*Treatise on Diseases of the Skin*, by Dr. Willis, p. 347), "which are employed in some hospitals, are not attended with expense, leave no unpleasant smell, and do not soil the linen; but the long continuance of the treatment necessary to relieve the disease, more than counterbalances these generally insignificant recommendations." There are various other diseases of the skin in which baths of sulphurous acid have been found more or less successful, such as chronic eczema, lepra, psoriasis, impetigo, and pityriasis. (For further information on this subject, consult

Mémoire et Rapports sur les Fumigations Sulphureuses, par J. C. Galés, 1816: *Observations on Sulphurous Fumigations*, by W. Wallace: *An Essay on Diseases of the Skin*, by Sir A. Clarke).

As a stimulant in syncope or asphyxia this gas has been recommended by Nysten. It is readily applied by holding a burning sulphur match under the nose.

ANTIDOTES.—When sulphurous acid gas has been inhaled, the patient should be made to respire the vapour of ammonia. A few drops of the solution of this substance should be swallowed.

Io'didum Sul'phuris.—I'odide of Sul'phur.

HISTORY.—This compound was first described by Gay-Lussac (*Ann. de Chimie*, xcl.)

PREPARATION.—It is prepared by heating gently four parts of sulphur with one part of iodine. Part of the iodine volatilizes, and the remainder unites with the sulphur.

PROPERTIES.—It is a black crystallizable compound, having the colour and radiated appearance of sesquisulphuret of antimony. It has the odour of iodine, and stains the cuticle, paper, &c. like this substance. Its elements are easily separated by heat.

COMPOSITION.—Its composition has not been determined. It is probably the following:—

	Eq.	Eq.Wt.	Per Cent.
Iodine	1	126	88·732
Sulphur	1	16	11·267
Iodide of sulphur	1	142	99·999

CHARACTERISTICS.—Boiled in water the iodine volatilizes with the steam, and the sulphur is deposited nearly in a state of purity.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—Dr. Cogswell (*Experim. Essay on Iodine and its Compounds*) gave three drachms to a bitch: the animal lost her appetite, was dull, and on the fourth day could not support herself properly upon her legs. On the twelfth day she was well.

(*b.*) *On man.*—It has not been exhibited internally. It probably operates like iodine. Its local operation is that of a powerful stimulant and resolvent.

USES.—Iodide of sulphur has been principally employed, in the form of ointment, in various skin diseases. In *lupus* it has been found most efficacious by Biett (Cazenove and Schedel, *Abrégé pratiq. sur les Malad. de la Peau*), as well as by Rayer (*Treatise on Diseases of the Skin*, translated by Dr. Willis.) The last mentioned writer places it in the foremost rank of local remedies for this disease. In *acne indurata* and *rosacea* it has proved highly useful in the hands of Biett (*op. cit.*), Rayer (*op. cit.* p. 476), and Dr. Copland (*Dict. of Pract. Med.* art. *Acne*, p. 31). In *lepra*, Rayer has observed good effects from its use; but in one case in which I tried it, it caused so much irritation that its use was obliged to be discontinued. In *herpes pustulosus labialis* it has been employed with great success by Dr. Volmar (Dierbach, *die neuesten Entdeck in d. Mat. Med.* 2te. Ausg. 1er. B. S. 449). In *tinea capitis* it has also been recommended (*Med. Gaz.* vol. xx. p. 879.)

Dr. Copland (*op. cit.* art. *Asthma*, p. 149) has employed the inhalation of the vapour of this substance in humoral asthma with temporary advantage.

ADMINISTRATION.—The *ointment of iodide of sulphur* is composed of iodide of sulphur and lard. The proportions vary according to circumstances: usually from 10 to 30 grains of the iodide to an ounce of lard. Magendie's formulæ are 1 part of iodide to 18 or 19 of lard.

Ammo'niæ Hydrosul'phas.—Hydrosul'phate of Ammo'nia.

HISTORY AND SYNONYMES.—This compound is said to have been first prepared in the seventeenth century by Boyle or Beguin: hence the terms *Boyle's fuming liquor* and *Beguin's sulphuretted spirit*, applied to one variety of it. The ordinary designation of it is *hydrosulphuret of ammonia*, or *hepatized ammonia*. Berzelius calls it *sulphuret of ammonium*.

NATURAL HISTORY.—It is evolved from decomposing animal matter, as in privies, with hydrosulphuric acid and nitrogen.

PREPARATION.—It is prepared, according to the Edinburgh, Dublin, and United States Pharmacopœias, by passing hydrosulphuric acid gas (sulphuretted hydrogen) into water of ammonia to perfect saturation.

PROPERTIES.—As thus prepared the solution of hydrosulphuret of ammonia is a liquid, having a greenish yellow colour, a very fœtid odour, and an acrid disagreeable taste. The mineral acids decompose it, evolve hydrosulphuric acid, and precipitate sulphur. A considerable number of metallic solutions have precipitates produced in them by the addition of hydrosulphate of ammonia. Thus with the salts of lead, bismuth, silver, and copper, the precipitates are blackish; with those of antimony, red; with those of cadmium and tin (persalts), and with the arsenites (on the addition of an acid), yellow; lastly, with the salts of zinc, white. In all these cases the precipitates are sulphurets of the respective metals.

By exposure to the air it attracts oxygen and deposits sulphur: its action on metallic solutions is then considerably modified. For example, if two or three fluidrachms be exposed to the air, in a wine-glass, for a day or two, the solution will then be found to have the property of causing a red precipitate with the salts of lead, yellow with tartar emetic, and white with arsenious acid.

CHARACTERISTICS.—Its odour will readily distinguish it. As a sulphuret or hydrosulphuret it is known by its action on the metallic solutions already noticed. Caustic potash causes the evolution of ammonia.

COMPOSITION.—It is composed of hydrosulphuric acid and ammonia, in the following proportions:—

	Eq.	Eq.Wt.	Per Cent.		Vol.
Hydrosulphuric Acid	1	17	50·00	Hydrosulphuric Acid gas	1
Ammonia	1	17	50·00	Ammoniacal gas	2
Hydrosulphate of Ammonia	1	34	100·00		

The fuming liquor (*liquor fumans Boyli*) obtained by distilling four parts of slacked lime, two of hydrochlorate of ammonia, and one of sulphur, contains, according to Gay-Lussac (*Cours de Chimie*, Leçon 20^e), hydrosulphate of ammonia, with excess of sulphur; but in what state of combination has not been determined.

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—The vapour of this compound is injurious to vegetation.

(*b.*) *On animals.*—I am unacquainted with any experiments made with it on animals; but analogy leads us to believe that its action is that of a powerful poison, analogous to other alkaline sulphurets, and to hydrosulphuric acid.

(*c.*) *On man.*—In *small but repeated doses* it acts powerfully on the secreting organs, the action of which it promotes, but at the same time modifies. Its principal influence is directed to the skin (on which it acts as a sudorific), and to the pulmonary mucous membrane. In *somewhat larger doses* it occasions nausea and giddiness. In *still larger doses* it causes nausea, vomiting, diminished frequency of pulse, giddiness, extreme languor, drowsiness, and sleep. *Excessive doses* would, of course, produce death, though I am unacquainted with any case of this kind.

In the gaseous state it acts, when inhaled, as a powerfully asphyxiating agent. Instances of its deleterious operation, in conjunction with hydrosulphuric acid, have occurred in France, in workmen exposed to the vapours from the pits of the necessaries. The symptoms are, sudden weakness, insensibility, and death; or where the vapours are less concentrated, there are sometimes delirium and convulsions.

USES.—In this country it has been principally employed in *diabetes mellitus*, with the view of reducing the morbid appetite and increased action of the stomach, as well of the system in general (*Rollo*, on *Diabetes Mellitus*, p. 28, ed. 2nd). Combined with alcohol, F. Hoffmann administered it under the name of *liquor anti-podagricus*, as a powerful sudorific in gout. It has also been used in old pulmonary catarrhs; and by Brauw and Gruithuisen in vesical catarrh (Vogt, *Pharmakodyn.*)

ADMINISTRATION.—It is given in doses of from four to six drops, in some proper vehicle (distilled water is the best). On account of its speedy decomposition, it should be dropped from the bottle at the time of using it.

ANTIDOTES.—The antidotes for hydrosulphate of ammonia, as well as for hydrosulphuric acid, are chlorine and the chlorides of lime and soda. In cases of asphyxia by the inhalation of these substances, the treatment consists in placing the patient on his back in the open air, with his head somewhat elevated; applying cold affusion to the face and breast; producing artificial respiration of air, through which chlorine is diffused, by pressing down the ribs and forcing up the diaphragm, and then suddenly removing the pressure; using strong friction in the course of the vertebral column, chest, soles of the feet, &c., and injecting into the stomach, stimulants; as, a weak solution of chlorine (or of chloride of lime) or brandy, &c. In the event of hydrosulphuret of ammonia being by accident swallowed in poisonous doses, dilute solutions of chlorine, or of the chlorides of lime or soda, should be immediately given, and the contents of the stomach removed by the stomach-pump as soon as possible.

ORDER 10. COMPOUNDS OF POTASSIUM.

Potas'sa.—Pot'ash.

HISTORY.—Caustic alkaline solutions were probably known to the Greeks and Romans. We learn from Pliny (*Hist. Nat.* lib. xxviii. cap. li.), that soap was made in his time from tallow and wood-ashes; and we may therefore conclude that some method was known of depriving the alkaline carbonate of its carbonic acid. Geber (*Invention of Verity*, ch. iv.) describes the method of making caustic alkali. Black, however, in the year 1756, first distinguished, chemically, the caustic alkalies from their carbonates. Potash was formerly called *kali*, or the *vegetable alkali*.

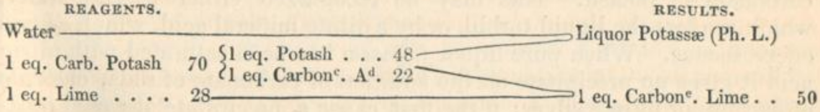
NATURAL HISTORY.—Potash in combination with acids is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—Potash is found, in the mineral kingdom, in combination with sulphuric, nitric, silicic, and perhaps carbonic acids. As an ingredient of rocks, it is more abundant than soda.

(*b.*) *In the organized kingdom.*—In organized beings potash is met with in combination with phosphoric, sulphuric, nitric, carbonic, and various organic acids. It occurs more abundantly in vegetables than in animals.

PREPARATION. (*a.*) *Of aquæ potassæ.*—To prepare a solution of caustic potash, add fresh burned lime to a solution of the carbonate of potash. In the London Pharmacopœia the proportions employed in the manufacture of *liquor potassæ* are fifteen ounces of the carbonate, eight ounces of lime, and a gallon of boiling distilled water. The lime, when slacked and mixed with half a gallon of water, is to be added to the carbonate of potash dissolved in the remaining half gallon of water. The mixture is to be kept in a close vessel, and frequently shaken. When cold, the supernatant clear liquor is to be poured off: this is the *liquor potassæ* of the Pharmacopœia.

In this process the lime abstracts carbonic acid from the carbonate of potash, and the potash thus set free dissolves in the water.



It is best to avoid filtering the liquid, but to decant it. If, however, a filter be employed, it should be of cotton or linen, and the atmospheric air should be, as much as possible, excluded; as the solution readily decomposes paper and woollen cloth, and abstracts carbonic acid from the air.

(*b.*) *Of hydrate of potash.*—If liquor potassæ be evaporated to dryness in a clean iron vessel, and the residual mass fused and poured into moulds, we obtain the *hydrate of potash* of the Pharmacopœia, and which was formerly called *potassa fusa, kali purum, lapis infernalis sive septicus*, or *cauterium potentiale.*

(*c.*) *Of potash with lime.*—To render the potash less deliquescent it is rubbed with an equal weight of lime, by which is procured the mixture termed *potassa cum calce.*

PROPERTIES. (*a.*) *Of hydrate of potash.*—The solid sold in the shops as *potassa fusa*, or hydrate of potash, is usually more or less coloured (brownish, greyish, or bluish), and not completely soluble in water and alcohol, in consequence of the presence of foreign matters; for pure hydrate of potash is white, and dissolves in both water and alcohol. During the solution in water heat is evolved. Its solubility in alcohol enables us to separate it from the carbonate and bicarbonate of potash, both of which are insoluble in this liquid. It has a strong affinity for water, which it rapidly attracts from the atmosphere, and in consequence becomes liquid. At a low red heat it fuses, and at a higher temperature is volatilized. It is odourless, but has a caustic, urinous taste. It rapidly decomposes organic substances. It possesses the properties of an alkali in an eminent degree.

(*b.*) *Of liquor potassæ.*—This liquid is limpid, colourless, transparent, and inodorous. Its taste is acrid: when prepared according to the London Pharmacopœia, its sp. gr. is 1·063. It has a soapy feel when rubbed between the fingers. It strongly attracts carbonic acid from the atmosphere, and, therefore, should be kept in close vessels. It corrodes flint glass, and is, on that account, directed to be kept in green glass bottles.

CHARACTERISTICS.—Potash free or combined is recognized by the following characters:—The hydrosulphurets, ferrocyanides, and carbonates, produce no precipitate with it. Tartaric (in excess), perchloric, and carbazotic acids, occasion precipitates of the bitartrate, perchlorate, and carbazotate of potash respectively. Chloride of platinum throws down a yellow precipitate with potash or its salts. Lastly, the potash salts communicate a violet tinge to the flame of alcohol.

The causticity of potash is shewn by its communicating a green colour to the infusion of red cabbage or syrup of violets; by its reddening turmeric, and restoring the blue colour of litmus reddened by an acid; by its not whitening lime water, or effervescing on the addition of an acid; by its soapy feel; by its solubility in alcohol; and by its dissolving alumina.

IMPURITIES.—Liquor potassæ usually contains a small quantity of carbonate of potash. This may be recognized either by lime-water, which renders the liquid turbid, or by a dilute mineral acid, which causes effervescence. When pure liquor potassæ has been saturated with nitric acid it gives no precipitate on the addition of carbonate of soda, chloride of barium, or nitrate silver: if the first cause a precipitate it would indicate some earthy or metallic impregnation; if there be a precipitate with the second, which is insoluble in nitric acid, we infer the presence of a sulphate; if the third cause a precipitate, soluble in ammonia, but insoluble in nitric acid, a chloride is present.

Potassa fusa of the shops contains various impurities, such as sesquioxide of iron, carbonate of potash, and silica. These, however, do not materially affect its medicinal value, and will not, therefore, require further notice.

COMPOSITION. — Pure *anhydrous potash* has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.
Potassium	1	40	83·34	83·05
Oxygen	1	8	16·66	16·95
Potash	1	48	100·00	100·00

The *hydrate of potash* is thus composed:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.
Potash	1	48	84·2	84
Water	1	9	15·8	16
Hydrate of Potash	1	57	100·0	100

The strength of the *liquor potassæ* may be ascertained by taking its sp. gr. The following extract from Mr. Dalton's table (*New System of Chem. Philos.* part ii. p. 476) illustrates this:—

Atoms.		Potash per cent. by weight.	Spec. Gravity.	Boiling Point.
Potash.	Water.			
1	8	39·6	1·47	265 deg.
1	10	34·4	1·42	246
		26·3	1·33	229
		19·5	1·23	220
		13·	1·15	215
		9·5	1·11	214
		4·7	1·06	213

Hence it appears that the liquor potassæ of the London Pharmacopœia, whose sp. gr. is 1·063, consists of—

Potash	4·7
Water	95·3
Liquor Potassæ (Ph. L.)	100·0

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—Caustic potash promptly destroys the parts of living plants with which it is placed in contact, and even in the dilute state kills haricots (*Phaseolus vulgaris*) in a few hours. (Marcet, in Decandolle, *Phys. Végét.*)

(*b.*) *On animals generally.*—It acts on animals generally as an energetic caustic poison. It is, says Orfila (*Toxicol. Génér.*), of all poisons that which most frequently perforates the stomach. He found that injected into the jugular vein of a dog it coagulated the blood, and caused speedy death. It is, however, remarkable that when mixed with the blood out of the body, it not only does not coagulate it, but actually prevents its spontaneous coagulation. Magendie has observed that by the exhibition of alkalies to dogs, the urine acquires alkaline properties.

(*c.*) *On man.*—The local action of caustic potash is exceedingly energetic. This is especially the case with solid potash. The alkali, of course, neutralizes any free acid in the part to which it is applied, and decomposes whatever ammoniacal salts may be present, causing the evolution of ammoniacal gas. Its chemical action on the organized tissues is most powerful, as may be well illustrated by experiments. Thus, if a little potash solution be rubbed between the fingers, the epidermis becomes corroded and dissolved, and a soapy feel is thereby produced. If a piece of fibrin (muscle, for example) be digested in a solution of potash, an unpleasant ammoniacal odour is evolved, a little alkaline sulphuret is formed, and the fibrin is dissolved: the compound of fibrin and potash thus formed may be termed *fibrate of potash*. The addition of an acid precipitates the fibrin somewhat altered in its properties, and combined with some of the precipitant. The same kind of effect is produced by the action of potash on albumen: thus, this substance unites with the alkalies to form soluble compounds, which may be termed *albuminates*. Gelatine is also readily dissolved by alkalies, with the deposition of any phosphate of lime which it may contain. These phenomena are to a certain extent comparable to those of saponification. It appears, therefore, that the caustic alkalies form soluble compounds with substances which enter largely into the composition of the organized tissues. Hence the observation of Orfila, that alkalies are of all corrosive poisons those which most frequently perforate the stomach, is readily accounted for; for the intestinal mucus readily dissolves in alkalies, whereas it is coagulated by acids; so that the former are much more quickly brought in contact with the living tissues. These resist, for a certain time, the chemical influence of the caustics, but the affinities being powerful, the vital properties soon cease to offer opposition—the part dies, and then the alkalies commence their chemical action on the tissues, which they speedily dissolve. Hence, if a large quantity of potash be swallowed, the most violent symptoms are observed, though they are of the same general kind as when the mineral acids have been taken.

When liquor potassæ is taken in small doses, and properly diluted, it saturates the free acids contained in the stomach, and which the recent investigations of physiologists have shown to be so essential to the digestive functions. Hence the continued use of alkalies must be always injurious, since they disorder the assimilative process by altering the chemical properties of the healthy ventricular secretion.

If the quantity of potash swallowed be more than sufficient to neutralize the free hydrochloric acid, but insufficient to have any chemical action on the living tissues, it acts as a slight irritant, increases the secretions of the alimentary canal, becomes absorbed, and alters the qualities of the secreted fluids, more particularly those of the urine. Moreover, the modification thus produced in the quality of the renal secretion is accompanied by an increase in the quantity, so that the alkalies rank among our most powerful diuretics—an effect which may be in part owing to the local stimulus which they communicate to the secreting vessels in their passage through them.

By continued use the alkalies give rise to increased activity of the different secreting organs, and of the absorbing vessels and glands; effects which are analogous to those caused by mercury. After some time the digestive function becomes disordered, the appetite fails, the blood becomes thinner and darker coloured, and loses its power of spontaneous coagulation when drawn from the body; the whole system, and more particularly the digestive organs, become enfeebled; and a state precisely similar to that of scurvy is brought on. It is said if the alkalies be temporarily suspended the blood speedily re-acquires its coagulability, but loses it again when we resume their employment. These phenomena deserve especial notice, as being precisely analogous to those of scurvy—a disease which has been usually supposed to be brought on by the use of salt and salted provisions, and to be prevented or cured by vegetable acids (especially the citric) and fresh provisions. It appears, therefore, in the highest degree probable, that scurvy, and the effects caused by the long-continued employment of the alkalies, are analogous conditions of system.

USES.—Caustic potash is employed for various purposes in medicine, the principal of which are the following:—

(*a.*) *As an escharotic.*—Potassa fusa is sometimes used as a caustic, though its employment is not free from objection; for its great deliquescence occasions some difficulty in localizing its action. It may be employed for the production of an issue, but we must proceed thus:—Apply to the part one or two layers of adhesive plaster, in the middle of which is an aperture of the exact size of the intended issue. Then moisten the *potassa fusa*, or the *potassa cum calce*, and rub on the part until discoloration is observed. Wash, and apply a linseed-meal poultice; and when the eschar is detached, insert the pea. In bites by poisonous animals—as venomous serpents, mad dogs, &c., this escharotic may be used with advantage. Mr. Whateley recommends the *potassa fusa* as the agent for arming caustic bougies to be applied in strictures of the urethra; but the practice appears so dangerous (particularly on account of the deliquescence and violent action of the caustic), that I believe it is now rarely, if ever, resorted to. There are many other cases in which this substance is employed as a caustic: for example, to destroy warts and fungoid growths of various kinds, and to open abscesses, more especially those in the groin; but for the latter purpose the lancet is to be preferred.

(*b.*) As an *antacid* we resort to the *liquor potassæ* in various affections of the digestive organs, which are attended with an inordinate secretion of acid, known by the acid eructations, cardialgia, and other dyspeptic symptoms. It must, however, be evident, that the neutralization of the acid is merely palliative. But the continued employment of alkalies frequently diminishes, temporarily, the tendency to acid secretion. Commonly it is found that the cases calling for the employment of alkalies are those benefited by tonics, and hence I believe the alkali is, in most cases, best given in some mild or tonic infusion; such, for example, as the infusion of calumba, or of gentian, or of quassia; the sulphate of quinia oftentimes disagreeing with the stomach in these cases; besides which, it would be decomposed by the alkali. The beneficial effects of alkalies are said to be particularly observed in those forms of dyspepsia which result from the inordinate use of spirituous liquors.

Of course the liquor potassæ would equally neutralize acid which may have been accidentally or purposely swallowed; but it is rarely given for this purpose, on account of its irritant qualities, and because many other agents (as chalk, whiting, magnesia, and soap) are equally efficacious as antacids, while they are free from the objections which exist in these cases to the use of the caustic alkalies.

(*c.*) *To modify the quality of the urine*, liquor potassæ is a most valuable agent. I have already stated that, under the employment of alkalies, not only may the natural acidity of the urine be destroyed, but even an alkaline property communicated to it; so that, whenever the secretion of lithic acid, or of the lithates, is inordinate, the alkalies present themselves to our notice as chemical agents for counteracting this condition. It has been supposed by some that the efficacy of the caustic alkalies in preventing the deposition of lithic acid gravel, consists in their holding it in solution — an explanation apparently inconsistent with the fact that the carbonated alkalies and magnesia are equally efficacious, though they are incapable of dissolving it. We are, therefore, led to the conclusion, that the alkalies, by their chemical influence, actually prevent the formation of this acid, or neutralize the free acid in the urine, which is the immediate cause of the precipitation of the lithic acid; whether by an action on the digestive organs or otherwise we know not. In resorting to these agents in urinary deposits, we should be careful to avoid employing them when there is any tendency to the deposition of the phosphates. The phosphate of lime, which naturally exists in the urine, is held in solution in this liquid by some acid, as seems proved by the fact, that the addition of a caustic alkali precipitates it. Berzelius thinks that the acid is the lactic; Mr. Brett (*Medical Gazette*, vol. xvii. p. 847), that it is the carbonic acid. The nature of the acid is, however, of secondary importance. It is generally admitted that the solvent is an acid, and that by the use of alkalies it may be obviated or neutralized, and the urine rendered alkaline. Now what will be the necessary consequence of this? Evidently the deposition of phosphate of lime; so that the use of alkalies may actually cause the appearance of *white sand* in the urine; and in patients predisposed to its formation, its quantity may be increased. These facts, then, have an important bearing on practice. "I have known," says Mr. Brande (*Quart. Journ. of Science*, vol. ii. p. 198), "soda-water exhibited in a case of stone in the bladder, *produce* abundance of white sand, which the ignorance of the patient and his medical attendant led them to refer to the solvent power of the medicine upon the stone, which they thought was gradually giving way and being voided; whereas great mischief was doing, by giving the urine more than its usual tendency to deposit the phosphates, and, consequently, to augment the size of the calculus." In the treatment of the lithic acid diathesis, it is to be remembered that the use of alkalies is, to a certain extent, a palliative mode of treatment, and that, to be successful, it should be conjoined with other means of cure.

(*d.*) The alkalies have been lately celebrated for producing beneficial effects in those *inflammations* which have a disposition to terminate in exudation and adhesion; that is to say, those that frequently give rise to the formation of false membranes or of adhesions; such, for example, as croup, pleurisy, and peritonitis. If experience should subsequently confirm the assertions already made respecting their efficacy, we shall have another analogy between the operation of alkalies and of mercury. Theoretically, it has been argued, the alkalies are likely to be beneficial in these diseases on two accounts; first, they have a tendency to diminish the supposed plasticity of the blood, which some have assumed (though without proof) to be connected with the exudation; and, secondly, we find these albuminous deposits readily dissolve, out of the body, in alkaline liquids: but arguments of this kind are to be received with great caution. In conclusion, I may add that Eggert recommends the alkalies as specifics against croup, though Sundelin (*Heilmittell.* 1er. Bd. S. 182) found them inoperative. Hellwag employed them to cause the removal of the deposited lymph; Memminger gave them with benefit in hooping-cough; Mascagni in pleurisy and peripneumony (Vogt, *Lehrbuch d.*

Pharmakodyn. 2er. Bd. p. 529). It is asserted that in the latter complaints the alkalies render the expectorated matter less viscid, and at the same time act powerfully as diaphoretics and diuretics.

(*e.*) In *induration* and *enlargement of the lymphatic* and *secreting glands* the alkalies have also been recommended: for example, in bronchocele, mammary tumors, affections of the testicle, diseases of the mesenteric glands, induration of the liver and salivary glands, &c. I have seen the liquor potassæ remarkably beneficial in excessive enlargement of the lenticular or glandular papillæ at the base of the tongue.

(*f.*) In *syphilis* and *scrofula* also the alkalies have been employed with advantage. Some of the most obstinate and troublesome forms of the venereal disease frequently occur in scrofulous subjects, in whom mercury will not only be useless, but absolutely prejudicial. In two or three cases of this kind I have seen the liquor potassæ, taken in the compound decoction of sarsaparilla, of great benefit. Though scrofula may be relieved by the use of alkalies, there is no ground for believing that they have any power of curing this malady, as some have asserted.

(*g.*) The alkalies have been employed as *diuretics in dropsy*, especially when this disease arises from glandular enlargements, or other causes likely to be relieved by these remedies.

(*h.*) In *irritable conditions of the urinary organs* a combination of liquor potassæ and tincture of opium will be frequently found most beneficial, notwithstanding that alkalies are classed among the incompatibles of opium.

(*i.*) There are several other diseases in which the employment of alkalies has been recommended; such as *skin diseases*, which are scaly (as lepra and psoriasis); *chronic rheumatism*; in *uterine complaints*, as an emmenagogue; and in some chronic *diseases of the lungs*. Sometimes a very dilute solution of potash has been used as a *stimulating wash* to ulcers.

Administration.—The mode of employing the *potassa fusa* in the making of an issue I have already described. For internal exhibition, the liquor potassæ is used in doses of ten drops gradually increased to the extent even of a drachm, carefully watching its effects. It may be administered in the infusion of orange-peel. Table beer is said, by Dr. Paris, to disguise completely the nauseous flavour of the alkali; but, of course, if the beer be at all sour, the acid will neutralize the alkali, and destroy its antacid properties. Veal broth is another liquid for its administration; and we are told that Dr. Chittick's nostrum for the stone was the fixed alkali in this liquid.

Antidotes.—In poisoning by the alkalies, the antidotes are either acids or oil, both of which form salts with the alkalies, and diminish their causticity. Chereau prefers oil, which should be given to the extent of several pounds. Vinegar, lemon or orange juice, even the very diluted mineral acids, should be resorted to, if oil be not at hand.

Potas'sii Io'didum.—I'odide of Potas'sium.

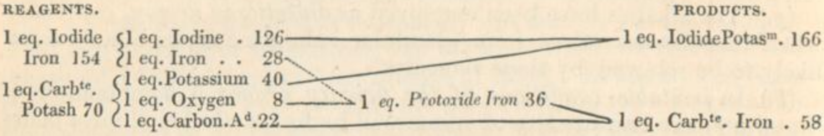
History.—This salt, called also *ioduret of potassium*, and more commonly *hydriodate of potash*, was first employed in medicine by Dr. Coindet.

Natural History.—Iodine and potassium are contained in sea-water, as well as in sea-weeds, but whether the iodine is in combination with potassium or with some other metal (sodium or magnesium) it is impossible to say with certainty.

Preparation.—There are two principal methods of procuring this salt.

(*a.*) *Process of the Pharmacopœia.* — This consists in adding two ounces of iron filings to six ounces of iodine mixed with four pints of water, stirring them frequently with a spatula for half an hour. Apply a gentle heat, and, when a greenish colour appears, add four ounces of carbonate of potash, first dissolved in two pints of water, and strain. Wash the residue with two pints of boiling distilled water, and again strain. Let the mixed liquor be evaporated, that crystals may be formed.

The *theory* of this process is as follows:—One equivalent or 126 parts of iodine combine with one equivalent or 28 parts of iron. The resulting iodide of iron is decomposed by one equivalent or 70 parts of carbonate of potash, by which one equivalent or 166 parts of iodide of potassium and one equivalent or 58 parts of protocarbonate of iron are procured.



(*b.*) *Dr. Turner's process.*—This is the simplest, and I believe the most eligible method. It consists in adding to a hot solution of pure potash as much iodine as the liquid will dissolve, by which means a reddish-brown fluid is obtained. Then pass hydrosulphuric acid through the liquid until it becomes colourless. Apply a gentle heat, to expel any excess of the acid; filter to get rid of the free sulphur, and exactly neutralize the free acid present, with potash; then crystallize. When the potash comes in contact with iodine two salts are formed, iodide of potassium and iodate of potash: the latter is decomposed by the hydrosulphuric acid, the hydrogen of which forms water, by combining with the oxygen of the iodate; sulphur is precipitated, and iodide of potassium remains in solution. This process has been subsequently modified thus: Iodate of potash is decomposed by exposing it to a red heat in a platinum crucible, instead of hydrosulphuric acid.

Properties.—This salt occurs in white, somewhat shining, transparent, or semi-opaque cubes, or octahedrons. Its taste is acrid saline, somewhat similar to common salt: it is without odour. It is readily fusible, and at a red heat volatilizes unchanged. It decrepitates when heated, in consequence of the water which is mechanically lodged between the plates of the crystal. Both water and alcohol readily dissolve it: it requires only two-thirds of its weight of water to dissolve it at 60° F. Iodine is readily dissolved by an aqueous solution of this salt.

Characteristics.—This salt is known to be an iodide by the following characters:—(*a.*) With a solution of bichloride of mercury it occasions a vermilion-red precipitate of the biniodide of mercury, which is very soluble in excess of iodide of potassium. (*b.*) With acetate of lead it forms a yellow precipitate of the iodide of lead. (*c.*) With the nitrate of silver, a yellow precipitate of the iodide of silver. (*d.*) With the protonitrate of mercury or with calomel a greenish yellow precipitate of the protiodide of mercury. (*e.*) On the addition of starch and a few drops of either sulphuric or nitric acid, or of a solution of chlorine, (according to Devergie, a mixture of chlorine and nitric acid succeeds best) the blue iodide of starch is formed. (*f.*) Chloride of platinum produces a brownish red solution of iodide of platinum.

That the base of this salt is potassium is shewn by the following characters:—(*a.*) Perchloric acid occasions a white precipitate of perchlorate of potash, while the supernatant liquid becomes yellowish brown. (*b.*) An excess of a strong solution of tartaric acid produces a white precipitate of the bitartrate of potash. (*c.*) Carbazotic acid forms yellow needle-like crystals of carbazotate of potash. (*d.*) If a pack-thread be soaked in a solution of the iodide, and the wetted end dipped into melted tallow, and applied to the exterior cone of the flame of a candle, this cone assumes a pale or whitish violet colour.

COMPOSITION.—This salt consists, as its name indicates, of iodine and potassium.

	Eq.	Eq.Wt.	Per Cent.	Gay-Lussac.
Iodine	1	126	76	76·2
Potassium	1	40	24	23·8
Iodide Potassium	1	166	100	100·0

The crystals contain no water of crystallization.

ADULTERATION.—Iodide of potassium is frequently largely adulterated with carbonate of potash. In 1829 I analyzed a sample which contained 77 per cent. of the latter salt (*Med. and Phys. Jour.* September, 1829.) In one specimen Dr. Christison procured 74·5 per cent. of carbonate of potash, 16 of water, and only 9·5 of iodide of potassium (*Treatise on Poisons*, 3d edit. p. 182.) It is reported that this adulterated salt is manufactured in the neighbourhood of Glasgow. The impure salt may be distinguished, by its wanting any regular crystalline form; by adding a few particles of it to lime-water a milky fluid is obtained, whereas the liquid remains transparent if the iodide be pure; by its destroying the colour of tincture of iodine, whereas the pure salt does not affect it; and lastly, by alcohol, which dissolves iodide of potassium, but not carbonate of potash.

Traces of the chlorides and sulphates are not unfrequent in commercial iodide of potassium. To detect the chlorides add nitrate of silver, which precipitates the carbonates, chlorides, and iodides, and digest the precipitate in ammonia, which re-dissolves the chloride, but not the iodide of silver. On the addition of nitric acid to the ammoniacal solution, the chloride is thrown down, while the carbonate is converted into nitrate of silver. The sulphates may be detected by chloride of barium, which will occasion a white precipitate (sulphate of baryta) insoluble in nitric acid.

I have met with a variety of iodide of potassium, which, by keeping, undergoes decomposition, evolves an odour of iodine, and becomes yellow. I have also samples of iodide of potassium (crystallized in octahedrons), containing traces of lead and tin, derived I presume from the vessels in which the salt has been made or crystallized.

PHYSIOLOGICAL EFFECTS. (*a.*) *On plants.*—The effects of this salt on vegetables have not been ascertained.

(*b.*) *On animals generally.*—The experiments of Devergie on dogs (referred to in his *Médecine Légale*, t. ii. p. 536), as well as those of Dr.

Cogswell on rabbits (*Experim. Essay on Iodine*, 1837), have shewn that, to these animals, iodide of potassium is a powerful poison. It operates as a local irritant, and thereby inflames the tissues with which it is placed in contact. Four grains injected into the jugular vein of a dog caused convulsions, and death within a minute. Two drachms introduced into the stomach gave rise to vomiting and great depression: the latter increased until death, which occurred on the third day: after death ecchymosis, ulceration, and redness of the stomach, were observed. (Devergie, *op. cit.* p. 506.) Dr. Cogswell injected three drachms of the iodide beneath the skin of the back of a dog: the animal died on the third day: on chemical examination iodine was detected in the blood from the heart, in the brain and spinal cord, the liver, spleen, stomach, muscles, tongue, and the bones freed from their appendages; likewise in the contents of the bladder. (Cogswell, *op. cit.* p. 91.)

(*c.*) *On man.*—Both the physiological effects and therapeutical uses of iodide of potassium shew that the operation of this salt is analogous to that of iodine.

The *local action* of iodide of potassium is that of an irritant. When taken internally in large doses it not unfrequently occasions nausea, vomiting, pain and heat of stomach, and purging. Applied to the skin in the form of ointment it sometimes produces slight redness. This salt is much less energetic in its action than free iodine, and, therefore, may be given in larger doses and continued for a longer period, without evincing the same tendency to produce disorder of the stomach and intestinal canal. Lugol (*Essays*, translated by Dr. O'Shaughnessy, p. 65) found that baths at 100° F. containing three ounces of iodide of potassium produced temporary itching only; whereas baths at the same temperature containing ten scruples of iodine caused prickling, then itchiness, smarting, rubefaction (which was not commensurate with the itchiness), punctuated, separated, or confluent, and subsequently desquamation of the epidermis. The chemical action of iodide of potassium on the tissues is slight, as indeed might be expected, seeing that no obvious changes are produced when a solution of this salt is mixed with albumen, fibrin, or gelatine, the three most abundant organic constituents of the animal body.

Iodide of potassium *becomes absorbed* and is carried out of the system by the different secretions, in which, as well as in the blood, it may be easily detected (Buchanan, *Med. Gaz.* vol. xviii. p. 519; Wallace, *Lancet*, for 1835-36, vol. ii. p. 6: the latter authority failed to detect it in the blood). Moreover, it deserves especial notice that it has been found in the urine several days after it has been swallowed. (Christison, *Treatise on Poisons*, 3rd ed. p. 185.)

The *remote* or *constitutional effects* of iodide of potassium are very analogous to those of iodine. Diuresis is a common consequence of its use. Relaxation of bowels is not unfrequent. Occasionally ptyalism has been observed. (Dr. Clendinning, *Med. Gaz.* vol. xv. p. 869, and Dr. Wallace, *Lancet*, for 1835 and 36, vol. ii. p. 8.) Dr. Wallace mentions irritation of throat as being produced by this salt. Atrophy of the mammæ is a very rare effect of it, but a case is mentioned by Mr. Nesse Hill, (*Edinb. Med. and Surg. Journ.* vol. xxv. 1826, p. 282.) Headache, watchfulness, and other symptoms indicative of the action of this salt on the nervous system, have been noticed by Dr. Clendinning and Dr. Wallace.

Increased secretion from, and pain of, the mucous membrane lining the nasal passages, have been observed. I have repeatedly remarked that the pocket-handkerchiefs used by patients who are taking this salt acquire a distinct odour of iodine.

Great discrepancy exists in the statements of authors as to the effects of given doses of iodide of potassium. "The average dose of this medicine," says Dr. Williams (*Med. Gaz.* vol. xiv. p. 42) "is eight grains; carried beyond that quantity it purges; and even limited to that quantity, it requires some management to obviate nausea." In two cases mentioned by Dr. Wallace (*Lancet*, for 1835-6, vol. ii. p. 9) a drachm of this salt taken in divided doses caused vomiting, colicky pains, slight diarrhœa, frequency of pulse, and exhaustion. These statements, then, shew that this salt possesses very active properties, and coincide with the experience of many practitioners, and with the results obtained from experiments on animals. But we have, in opposition to the above, the evidence of Dr. Elliotson (*Lancet*, vol. i. 1831-2, p. 728) and of Dr. Buchanan (*Med. Gaz.* vol. xviii. p. 519). The first tells us that six drachms may be given daily (in doses of two drachms) for many weeks without inconvenience; and the second states half an ounce may be given at a dose without producing pain of the stomach or bowels, purging, or any hurtful effect. Furthermore, both physicians vouch for the purity of the salt employed. It is difficult to explain such discrepant statements. But I cannot help thinking that peculiarities of constitution and morbid conditions of system (especially affections of the stomach) are principally concerned in modifying (either increasing or diminishing) the tolerance to this salt. I do not think that the different effects observed can be wholly ascribed to alterations in the quality or adulterations of the medicine employed, though I have published a case (*Med. Gaz.* vol. xvii. p. 839), shewing that the adulterated is much less active than the pure salt.

USES.—Having so fully detailed (p. 117 *et seq.*) the uses of iodine, it is unnecessary to notice at any length those of iodide of potassium, since they are for the most part identical. Thus it has been employed in bronchocele, scrofula, in chronic diseases accompanied with induration and enlargement of various organs, in leucorrhœa, secondary syphilis, periostitis, articular rheumatism, dropsies, &c. As a remedy for the hard periosteal node brought on by syphilis, it was first employed by Dr. Williams (*Med. Gaz.* vol. xiv. p. 42) who obtained with it uniform success. At the end of from five to ten days its mitigating effects are felt; the pains are relieved, the node begins to subside, and in the majority of cases disappears altogether. In these cases Dr. Clendinning (*Med. Gaz.* vol. xv. p. 833) has also borne testimony to its efficacy. In the tubercular forms of venereal eruptions, Dr. Williams found it beneficial. In Dr. Wallace's lectures (*Lancet*, for 1835-36, vol. ii. and for 1836 and 1837, vols. i. and ii.) are some valuable observations on the use of iodide of potassium in venereal diseases. In chronic rheumatism accompanied with alteration in the condition of the textures of the joint, it is, in some cases, remarkably successful (Dr. Clendinning, *Med. Gaz.* vol. xv. p. 866; and Dr. Macleod, *Med. Gaz.* vol. xxi. p. 361). As an ingredient for baths, Lugol (*Essays*, p. 75) found the iodide would not answer alone, but that it was useful as a solvent means for iodine.

ADMINISTRATION.—Iodide of potassium may be employed alone or in conjunction with iodine, forming what is called ioduretted iodide of potassium.

1. ***Of Iodide of Potassium.***—*Internally* it has been given in doses varying from three grains to half an ounce (see p. 283). To be beneficial, some think it should be given in small, others in large doses. Not having had any experience of the effects of the enormous doses before referred to, I can offer no opinion thereon. It may be administered dissolved in simple or medicated water, or in some bitter infusion. The more usual mode of exhibiting it is in combination with iodine, in the way presently to be noticed.

For *external application* iodide of potassium is used in the form of ointment. The *unguentum potassæ hydriodatis* of the Dublin Pharmacopœia consists of a scruple of iodide to an ounce of lard; but for ordinary purposes it should contain at least a drachm of iodide. By keeping, it undergoes decomposition and acquires a yellow colour, a little iodine being set free. It has an advantage over the compound iodine ointment of the London Pharmacopœia, that it does not stain the skin.

2. ***Of Ioduretted Iodide of Potassium.***—A solution of iodide of potassium readily dissolves free iodine, and the compound is usually termed ioduretted iodide of potassium. Iodine and iodide of potassium are also used together in the form of ointment.

For *internal administration* there are three preparations of ioduretted iodide of potassium which have been employed: the *ioduretted mineral water* of Lugol; the *compound solution of iodide of potassium* of the London Pharmacopœia; and the *compound tincture of iodine* of the same work.

(*a.*) *Ioduretted mineral water.*—This is Lugol's favourite preparation. He uses it of three different degrees of strength.

	No. 1.	No. 2.	No. 3.
Iodine	gr. ¾	i	i¼
Iodide of Potassium	gr. i½	ii	ii½
Distilled Water	℥ viii	℥ viii	℥ viii.

The solutions are yellowish or orange coloured, and are quite transparent. When sweetened it is readily taken by children, but the sugar should be added at the time of administration, as in the course of a few hours it effects a chemical change in the solution. From six to eight ounces should be taken daily.

(*b.*) *Compound solution of iodide of potassium.*—The *liquor potassii iodidi compositus* of the London Pharmacopœia consists of:—

Iodine	gr. v.
Iodide of Potassium	gr. x.
Distilled Water	℥ xx.

It is a brown coloured solution, and may be usefully employed in the diseases of children. Dose for adults from two to six or more fluidrachms.

(*c.*) *Compound tincture of iodine.*—The *tinctura iodinii composita* of the London Pharmacopœia consists of:—

Iodine	℥ i.
Iodide of Potassium	℥ ii.
Rectified Spirit	O ii.

This solution may be mixed with water without any deposition of iodine. The dose of it at the commencement is ten minims, which may be gradually increased.

For *external application* ioduretted iodide of potassium is used in the form of aqueous solution, or of ointment.

(*a.*) *Caustic, rubefacient, and stimulant solutions.*—These are employed by Lugol of the following strengths:—

	Stimulating Washes.			Rubefacient Solution.	Caustic Solution.
	No. 1.	2.	3.		
Iodine.	gr. ii.	gr. iii.	gr. iv.	ʒ iv.	℥ i.
Hydriodate Potash	gr. iv.	gr. vi.	gr. viii.	℥ i.	℥ i.
Distilled Water. .	lb. i.	lb. i.	lb. i.	℥ vi.	℥ ii.

Lugol uses the stimulating washes in scrofulous ulcers, ophthalmia, fistulous abscesses, &c. When the scrofulous surfaces require stronger excitement than usual, he employs the rubefacient solution. In tubercular tumors which have obstinately resisted all other means of treatment, the rubefacient solution may be applied in admixture with linseed meal (forming the *ioduretted cataplasm* of Lugol). To prepare the mixture, the poultice is first made in the ordinary manner; and when moderately cool, a sufficient quantity of the rubefacient liquid poured on it with a wooden measure. The caustic solution is used for touching the eyelids and nasal fossæ, to repress excessive granulations, &c.

(*b.*) *Ioduretted baths.*—These are employed by Lugol in the treatment of scrofula. They are to be made in wooden vessels.

IODURETTED BATHS FOR CHILDREN.

Age.	Water.	Iodine.	Iodide of Potassium.
	(Quarts.)	(Troy Grains.	(Troy Grains.)
4 to 7	36	30 to 36	60 to 72
7 . . 11	75	48 . . 60 . . 72	96 . . 120 . . 144
11 . . 14	125	72 . . 96	144 . . 192

IODURETTED BATHS FOR ADULTS.

Degree.	Water.	Iodine.	Iodide of Potassium.
	(Quarts.)	(Drachms Troy.)	(Drachms Troy.)
No. 1.	200	2 to 2½	4 to 5
No. 2.	240	2 . . 2½ . . 3	4 . . 5 . . 6
No. 3.	300	3 . . 3½	6 . . 7

(*c.*) *Ioduretted ointment.*—The *unguentum iodinii compositum*, Ph. L., is made by rubbing half a drachm of iodine with a drachm of iodide of potassium and a fluidrachm of rectified spirit: then mix with two ounces of lard.

ANTIDOTES.—No chemical antidote is known. In a case of poisoning, therefore, the first object will be to evacuate the contents of the stomach, exhibit demulcent and emollient drinks, combat the inflammation by the usual antiphlogistic measures, and appease the pain by opiates.

Potas'sii Bro'midum.—Bro'mide of Potas'sium.

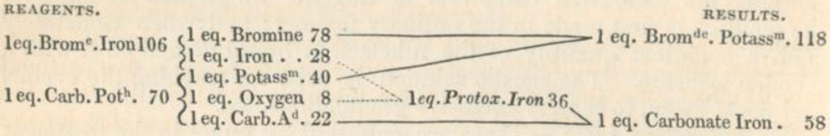
History.—This salt, also called *hydrobromate of potash*, was first described by Balard in 1826 (*Ann. de Chim.* xxxii.)

Natural History.—(See Iodide of Potassium).

Preparation.—The modes of preparing bromide of potassium are analogous to those of the iodide.

In the Pharmacopœia the bromide is directed to be made by adding first an ounce of iron filings and afterwards two ounces of bromine to a pint and a half of distilled water. Set them by for half an hour, frequently stirring with a spatula. Apply a gentle heat, and when a greenish colour is produced, pour in the carbonate of potash dissolved in a pint and a half of water. Strain and wash what remains in two pints of boiling distilled water, and again strain. Let the mixed liquors be evaporated so that crystals may be formed.

In this process bromide of iron is first formed, and afterwards decomposed by carbonate of potash, by which protocarbonate of iron and bromide of potassium are produced.



Another mode of procuring this salt is to mix bromine with a solution of caustic potash, by which bromide of potassium and bromate of potash are formed (see diagram, p. 123). The bromate of potash may be converted into bromide of potassium by heat or hydrosulphuric acid.

Properties.—This salt crystallizes in whitish transparent cubes, or rectangular prisms. It is inodorous: its taste is pungent, saline, and similar to common salt, but more acrid. It is permanent in the air. When heated it decrepitates, and at a red heat fuses without suffering decomposition. It is very soluble in both cold and hot water, and slightly so in alcohol.

Characteristics.—That this salt is a bromide is known by the characters before mentioned (see the characteristics of the bromides, at p. 124) That its base is potassium is shewn by the characters of this metal mentioned when noticing iodide of potassium (see p. 281.)

Composition.—This salt consists of bromine and potassium in the following proportions:—

	Eq.	Eq.Wt.	Per Cent.	Balard.	Liebig.
Bromine	1	78	66·1	65·56	67·42
Potassium	1	40	33·9	34·44	32·58
Bromide Potassium	1	118	100·0	100·00	100·00

The crystals contain water lodged mechanically between their plates, but no combined water (water of crystallization).

Purity.—The purity and goodness of this salt may be known by the following characters:—The form of the crystals, their freedom from colour, and their neutrality with respect to litmus and turmeric. A solution of this salt should give no precipitate with chloride of barium, shewing the absence of carbonates and sulphates. The method employed by Rose (*Journ. de Pharm.* t. 23, p. 489) for detecting minute quantities of the chlorides in bromides, is the following:—If pure bromide of potassium mixed with excess of bichromate of potash be distilled with concentrated sulphuric acid in a tubulated retort, to which is adapted a receiver containing excess of solution of caustic ammonia, pure brome distils over, and the ammoniacal liquor remains perfectly colourless. But if the bromide contained a chloride, both brome and the chromate of chloride of chromium distil over, and the ammoniacal liquor becomes yellow: chromic acid may be detected in the solution by the usual tests.

PHYSIOLOGICAL EFFECTS.—(*a.*) *On vegetables.*—The effects on plants have not been ascertained.

(*b.*) *On animals.*—Thirteen grains of bromide of potassium dissolved in water, and injected into the jugular vein of a dog, coagulated the blood, caused convulsions and death in a few minutes (Barthez, *Journ. de Chim. Méd.* t. 5^me^. p. 214). The same experimenter introduced a drachm of the salt into the stomach of a dog without any ill effects, save vomiting. But two drachms, and even a drachm and a half, killed dogs in three days, when retained in the stomach by a ligature of the gullet, with marks of inflammation in the gastro-intestinal membrane. Maillet (*Journ. de Chim. Méd.* t. 3, 2^e^. Serie, p. 225) gave two ounces to a dog without any ill effect; and he observes, that according to the principle, that the dose of a saline substance for the horse should be eight times that for the dog, a pound of bromide of potassium would have no ill effect on horses.

(*c.*) *On man.*—The effects of bromide of potassium on man require further investigation. They appear to be analogous to those of iodide of potassium. Dr. Williams (*Elements of Medicine*, vol. i. p. 338) gave five grains of this salt three times daily for fourteen months, without any injurious effect.

In most cases it acts as a diuretic. In irritable conditions of the alimentary tube it is apt to occasion diarrhœa. Three cases are mentioned by Dr. Williams, in which, on account of this state of the bowels, more than four or five grains could not be exhibited at a time, and even then it was occasionally necessary to give opium. Under the continued use of it, enlargements of the spleen and liver, and swellings of the lymphatic glands, have disappeared; so that it appears to agree with iodine, mercury, and the alkalies, in exercising that kind of influence over the nutrition of the body which has been designated by the terms resolvent, alterative, and deobstruent. Dr. Williams thinks that it possesses "unusual, if not specific, powers in the cure of diseases of the spleen."

USES.—In 1828, Pourché (*Journ. de Chim. Méd.* tom. iv. p. 594) employed this salt with benefit in the treatment of bronchocele and scrofula: it was taken internally, and applied externally in the form of ointment. In 1836 it was introduced into the London Pharmacopœia, in consequence of the great success obtained from the use of it in a case of enlarged spleen, under the care of Dr. Williams (*op. cit.*) In this, and in three other successful cases of the same disease, it was used internally only. Dr. Williams also gave it with success in a case of ascites. Magendie (*Formulaire*, 8^me^. ed. 1835) employs it as an anti-scrofulous remedy, as an emmenagogue, and against hypertrophy of the ventricles. Prieger (quoted by Dierbach, *die neuesten Entdeck. in d. Mat. Med.* 1837) applied it externally in the form of ointment in tinea capitis.

ADMINISTRATION.—It is exhibited in the form of pill or solution in doses of from four to ten grains three times a day. An ointment of this salt is made by mixing an ounce of lard with from a scruple to two drachms of the bromide. To this some persons add free brome.

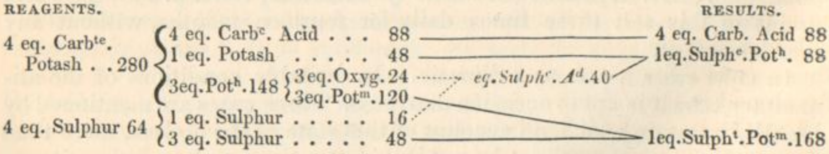
ANTIDOTES.—In a case of poisoning by this salt the treatment will be the same as for iodide of potassium.

Potas'sii Sulphure'tum.—Sul'phuret of Potas'sium.

HISTORY.—Geber (*Invention of Verity*, ch. vi.) was acquainted with the solubility of sulphur in an alkaline solution; but Albertus Magnus taught the method of procuring sulphuret of potassium by fusion. The preparation kept in the shops is a mixture of the sulphuret of potassium and sulphate of potash, and was formerly called *sulphuret of potash*, or *liver of sulphur*.

PREPARATION.—It is ordered to be prepared by rubbing one ounce of sulphur with four ounces of carbonate of potash, and heating them in a covered crucible until they have united.

In this process the water and carbonic acid of the carbonate of potash are expelled. The oxygen and potassium of a portion of the potash unite with separate portions of sulphur to form sulphuric acid and a sulphuret of potassium respectively. The sulphuric acid combines with some undecomposed potash to form sulphate of potash. Supposing the carbonate of potash to be anhydrous, and the sulphuret of potassium to consist of one equivalent of each of its constituents, the following diagram will explain the changes :—



Berzelius (*Traité de Chim.* t. 2^{me}. p. 301) says that if 100 parts of common anhydrous carbonate of potash be heated with 58·22 of sulphur, the products are tersulphuret of potassium and sulphate of potash. If less than this quantity of sulphur be employed, a portion of carbonate remains undecomposed.

PROPERTIES.—When fresh prepared, it has a liver-brown colour; and hence its name *hepar sulphuris*. Its taste is acrid, bitter, and alkaline. If quite dry it is inodorous, but when moistened it acquires the odour of hydrosulphuric acid. Exposed to the air, it undergoes decomposition, from the action of the aqueous vapour and oxygen. It becomes green and moist, and ultimately whitish. This change depends on the absorption of oxygen, in consequence of which part of the sulphur is deposited, while a portion of the sulphuret of potassium is converted into hyposulphite, afterwards into sulphite, and ultimately into sulphate of potash. Sulphuret of potassium is soluble in water.

CHARACTERISTICS.—Hydrochloric acid causes the evolution of hydrosulphuric acid gas and the precipitation of sulphur; the solution of the sulphuret in water produces a reddish or black precipitate with a solution of lead. That it contains potassium may be determined thus:—Add excess of hydrochloric acid to a solution of it; boil, and filter. The before-mentioned tests for potash may be then applied.

Composition.—According to Berzelius this preparation consists of *tersulphuret of potassium*, *sulphate of potash*, and *carbonate of potash*.

Physiological Effects. (*a.*) *On plants.*—There can be no doubt but that this compound is a powerful poison to plants, though I am not acquainted with any experiments made with it.

(*b.*) *On animals generally.*—From the experiments of Orfila (*Toxicol. Générale*) on dogs, sulphuret of potassium appears to be a powerful narcotico-acrid poison. Six drachms and a half, dissolved in water, and introduced into the stomach, caused convulsions and death in seven minutes.

(*c.*) *On man.*—In *small doses* (as from four to ten grains) it acts as a general stimulant, increasing the frequency of the pulse, augmenting the heat of the body, promoting the different secretions, more especially those of the mucous membranes, and sometimes exciting local irritation, marked by pain, vomiting, and purging. By continued use it acts as a resolvent or alterative, and on this account is employed in certain forms of inflammation.

In *large doses* it is an energetic narcotico-acrid poison. In two instances it proved fatal in fifteen minutes: the symptoms were, acrid taste, slight vomiting, mortal faintness, and convulsions, with an important chemical sign, the tainting of the air of the chamber with the odour of hydrosulphuric acid (Christison, p. 228).

Its local action is that of a powerful irritant: hence the acrid taste, burning pain, and constriction in the throat, gullet, and stomach, with vomiting and purging. But the nervous system also becomes affected, as is proved by the faintness, the almost imperceptible pulse, the convulsions, and (in some cases) sopor. These symptoms are analogous to those caused by the hydrosulphuric acid; which, in fact, is copiously developed in the stomach.

Uses.—Internally it has been administered in very obstinate skin diseases, such as lepra and psoriasis, which have resisted all the ordinary means of cure. It has also been employed as a resolvent in inflammations attended with lymphatic exudation, as croup, and in glandular enlargements. In chronic rheumatism, gout, hooping-cough, and various other diseases, against which it was formerly employed, it is now rarely if ever administered. It ought not to be given as an antidote for metallic poisoning, since it is itself a powerful poison.

Externally it is applied in the form of lotions, baths, or ointment. In chronic skin diseases, such as eczema, scabies, lepra, &c. it is employed as a bath, in the proportion of four ounces to thirty gallons of water. These baths are said to be particularly useful in the treatment of scabies in children, but twenty at least are requisite to effect a cure. (Rayer, *Treatise on Diseases of the Skin*, p. 346.) Lotions are sometimes made for local cutaneous affections, containing a larger quantity of the sulphuret (as an ounce to two quarts of water).

Administration.—Internally it may be administered in the dose of three or four grains gradually increased. It may be given either in solution or in the form of pill made with soap. For external use it is employed in solution in water, as already described, or in the form of ointment, composed of half a drachm of the sulphuret to an ounce of lard.

Antidotes.—In the event of poisoning by this substance the antidote is a solution of chloride of soda or of chloride of lime.

Potas´sæ Bisul´phas.—Bisul´phate of Pot´ash.

History and Synonymes.—The mode of preparing this salt was taught by Lowitz and Link at the latter end of the last century. The salt has had various names, such as *supersulphate of potash*, *sal enixum*, *acid vitriolated tartar*, and *sal auri philosophicum*.

Preparation.—It is ordered to be prepared by dissolving two pounds of the salt left after the distillation of nitric acid in four pints of boiling water, then adding one pound of sulphuric acid to it, boiling down the mixture, and setting aside to crystallize. It is also a product of various other manufactures.

Properties.—It is crystallizable, the primary form of the crystal being either a right rhombic prism, or the right rhombic octahedron. It has a very acid taste, and reacts strongly as an acid on vegetable colours, and decomposes the carbonates with effervescence. It is soluble in about twice its weight of water at 60°. By a red heat it evolves sulphuric acid, and is converted into the neutral sulphate of potash.

Composition.—It consists of—

	Eq.	Eq.Wt.	Per Cent.	Geiger.
Sulphuric Acid	2	80	54·80	54·77
Potash	1	48	32·87	32·53
Water	2	18	12·33	12·70
Crystallized Bisulphate Potash	1	146	100·00	100·00

Characteristics.—The presence of sulphuric acid may be recognized by the chloride of barium; while the potash may be detected by the characters already mentioned for this substance. From the neutral sulphate of potash it is distinguished by its acid taste, its action on litmus and the alkaline carbonates, and by its greater solubility.

Physiological Effects and Uses.—It is rarely used as a medicine. It possesses the combined properties of sulphuric acid and sulphate of potash. The excess of acid renders its local operation that of an astringent. When swallowed, it operates as a mild purgative, and may be employed in the same cases as the sulphate, over which it has the advantage of greater solubility. Conjoined with rhubarb it covers the bitter taste of the latter without injuring its medicinal properties. Dr. Barker (*Observations on the Dublin Pharmacopœia*, p. 138) says it may be used to form a cheap effervescing purgative salt, as follows:—73 grains of bisulphate of potash and 72 grains of crystallized carbonate of soda, to be separately dissolved in two ounces of water, and taken in a state of effervescence.

Administration.—The dose of it is from gr. x. to ʒij. properly diluted.

Potas'sæ Sul'phas.—Sul'phate of Pot'ash.

History and Synonymes.—The mode of preparing this salt was taught by Oswald Croll in 1643. It has been known by various appellations, such as *specificum purgans Paracelsi*, *Arcanum duplicatum*, *vitriolated kali*, *vitriolated tartar*, *sal polychrest* (literally signifying *salt of many uses* or *virtues*), *sal de duobus*, &c.

Natural History.—Sulphate of potash is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—It has been met with in small quantities in some mineral waters of Saxony and Bohemia, in native alum, in alum-stone, and in a mineral called *polyhalite*, in which Stromeyer found no less than 27·6 per cent. of the sulphate of potash.

(*b.*) *In the organized kingdom.*—It has been found in the root of Polygala Senega, Winter's bark, the bulb of garlic, myrrh, opium, &c. The blood and urine of man also contain it.

Preparation.—It is obtained from the residuum of the distillation of nitric acid, either by igniting it in a crucible to expel the excess of sulphuric acid, as directed in the Pharmacopœia, or by saturating it with carbonate of potash.

Properties.—It crystallizes in single or double six-sided pyramids, the primary form of which is the right rhombic prism. It is hard, inodorous, has a saline bitter taste, and is unchanged by exposure to the air. When heated it decrepitates. At 60° F. it requires sixteen times its weight of water to dissolve it: it is insoluble in alcohol. It is decomposed by tartaric acid, which forms with it crystals of bitartrate of potash.

Composition.—The crystals contain no water of crystallization. They are thus composed:—

	Eq.	Eq. Wt.	Per Cent.	Wenzel.
Sulphuric Acid	1	40	45·45	45·25
Potash	1	48	54·55	54·75
Sulphate of Potash	1	88	100·00	100·00

Characteristics.—I have already mentioned these, when describing the bisulphate.

Physiological Effects.—It acts as a very mild purgative, without occasioning any heat, pain, or other symptoms of irritation. Its operation is, in fact, too mild for ordinary use.

Uses.—It is particularly serviceable as a laxative in disordered conditions of the alimentary canal, as diarrhœa and dyspepsia, in hepatic disorders, and in hæmorrhoidal affections. It is best given in combination with rhubarb. Thus, from five to ten grains of rhubarb, with from fifteen grains to two drachms of this salt, will be found to act mildly and efficiently in many cases of dyspepsia and diarrhœa. It is an excellent aperient for children. The objections to its employment are its slight solubility, and that when given in large doses to children it is apt to produce vomiting. It is useful, on account of its hardness, for triturating and dividing powders, as in the *pulvis ipecacuanhæ compositus.*

Dose.—It is given in doses of from fifteen grains to four or five drachms.

Potas'sæ Ni'tras.—Ni'trate of Pot'ash.

History.—At what time this salt became known is difficult now to determine. As it is found in various parts of the East, on the surface of the earth, it appears probable that it must have been known at a very early period. Furthermore, if the Chinese and Hindoos were acquainted with the art of making gunpowder and fireworks at a very early period of history, they must have employed, and, therefore, been acquainted with, nitre. Geber, (*Invention of Verity*) however, is the first who distinctly mentions it. But the terms *neter* of the Old Testament (*Prov.* ch. xxv. 20; *Jer.* ch. ii. 22), translated *nitre,—νίτρον* of Herodotus (*Euterpe*, lxxxvii.) and Theophrastus (*De Igne*)—and *nitrum*, of Pliny (*Hist. Nat.* xxx. i.), appear to have been applied either partially or exclusively to *natron* (sesqui-carbonate of soda.) (See Beckman's *History of Inventions and Discoveries*, vol. iv.) The word *saltpetre*, usually applied to nitre, is evidently derived from *sal petræ*, literally signifying rock salt.

Natural History.—This salt occurs in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—In the East Indies, Egypt, Persia, Spain, and other parts of the world, large quantities of nitre are found in the soil. It would appear to be formed below, and to be brought to the surface of the soil by efflorescence. Some have thought that the nitric acid of the salt was formed by the union of the nitrogen and oxygen of the atmosphere, while others have supposed the presence of animal matters necessary to yield, by their decomposition, nitrogen. In some instances the latter opinion is probably correct: but it does not invariably hold good, for in a nitre cave at Ceylon, Dr. Davy (*Account of the Interior of Ceylon*) found nitre without any animal matter. The potash of the nitrate is in most cases easily accounted for, being found in some of the constituents of the soil, namely, feldspar and mica.

(*b.*) *In the organized kingdom.* This salt has been found in various plants, as in the roots of *Cissampelos Pareira*, *Geum urbanum*, &c. (Decandolle, *Phys. Végét.* p. 387.)

Preparation.—The nitrate of potash consumed in this country is imported from India, where it is obtained from natural sources. In some parts of Europe it is procured artificially.

1. *From natural sources.*—The district of Tirhût, in Bengal, is more productive of nitre than any other place in India. It is most abundant in those parts containing a redundancy of carbonate of lime. An average sample of the soil analyzed by Mr. Stevenson (*Journ. of the Asiatic Society of Bengal*, vol. ii. p. 23) gave the following composition:

Matter insoluble in three Mineral Acids	Silex	50·0
Matter soluble in ditto	Carbonate of Lime	44·3
Matter soluble in Water	Sulphate of Soda	2·7
	Muriate of ditto	1·4
	Nitrate of Lime	0·9
	Nitrate of Potash	0·7
		100·0

"In the month of November the *leonahs*, or native manufacturers of saltpetre, commence their operations, by scraping off the surface from old mud heaps, mud buildings, waste grounds, &c. where the saltpetre has developed itself in a thin white efflorescence, resembling frost rind. This saline earth being collected at the factories, the operator first subjects it to the process of solution and filtration. This is effected by a large mud filter, lined on the inside with stiff clay." It has a false bottom of bamboo, covered with close wrought grass mats, on which are placed vegetable ashes. Upon these the nitrous earth is laid. Water is then added to dissolve the saline matters of the earth, and the solution thus obtained, filtering through the mats, drops into the empty space between the real and false bottom, and is conveyed away into an earthen receiver. In its passage through the wood-ashes the carbonate of potash contained in the latter re-acts on the nitrate of lime of the solution, and produces nitrate of potash and carbonate of lime. The solution is afterwards evaporated in earthen pots, filtered, and put aside to crystallize. The impure nitre thus procured is termed *dhouah:* it contains from 45 to 70 per cent. of pure nitrate of potash. It is re-dissolved and crystallized by the native merchants, who supply the Calcutta bazaars, and when thus purified is called by the natives *kalmee.* (See Stevenson, *op. cit.*; also *India Jour. of Med. and Phys. Science*, new series, vol. i. p. 10, 1836.)

Saltpetre is imported into this country principally from Calcutta, but some comes from Madras. It is brought over in cloth bags which contain from 150 to 175 lbs. each. Its quality varies considerably. It is always more or less impure: but the common varieties, which have a dirty yellowish appearance, are termed *rough* or *crude saltpetre*, while the purer and cleaner looking kinds are called *East India refined.* The loss which it suffers in refining, or in other words the impurities which it contains, are technically designated *refraction.* This varies greatly in different samples, but is usually between 5 and 15 per cent. (For the methods of determining it, consult Dumas, *Traité de Chimie*, t. 2^{me}. p. 762; and Brande's *Manual of Chemistry*, 4th ed. p. 549.)

Nitre is purified by repeated crystallization. When it has been dissolved and crystallized once only it is called *singly refined nitre:* when twice, *doubly refined.* Its purity may be ascertained by testing it with nitrate of silver, chloride of barium, and oxalate of ammonia. The first detects the chlorides, the second the sulphates, and the third the calcareous salts.

2. *From artificial sources.*—The artificial preparation of nitre is practised in several parts of Europe. The establishments in which it is carried on are called *artificial Nitrières.* The mode adopted varies, however, in different places.

At Appenzel, a canton of Switzerland, nitre is formed from the urine of animals. A hole is dug near to stables, and in this is put a sandy kind of earth, which is kept moistened with the water running from the stables. In two or three years this earth yields nitre.

In Sweden, where each landed proprietor is compelled to furnish a certain quantity of nitre, it is prepared as follows:—Decomposing animal and vegetable matters, mixed with cinders, lime, or marl, are placed in heaps (called *nitre beds*) under cover, the mass being occasionally moved, or holes made in it, so that they are exposed to the air. From time to time they are watered with urine (a liquid containing more nitrogen than any other animal substance.) At the end of two or three years the nitrogen has combined with oxygen, and this with bases to form nitrates. By lixiviation the salts may be separated, and any nitrate of lime present may be converted into nitrate of potash by adding wood-ashes, which contain carbonate of potash.

In Prussia *nitre-walls* are employed instead of nitre-beds. These have two advantages,—they economize land, and they expose a large surface to the air, (Dumas, *op. cit.*)

PROPERTIES.—Nitrate of potash usually crystallizes in six-sided prisms with diëdral summits. Its primitive form is the right rhombic prism, and, therefore, it has two axes of double refraction along which a ray of light is not split into two.

Double system of rings seen by looking through a slice of nitre (cut perpendicularly to the axis of the crystal) placed between two plates of tourmaline (cut parallel to the axis of the crystal).

FIG. 52.

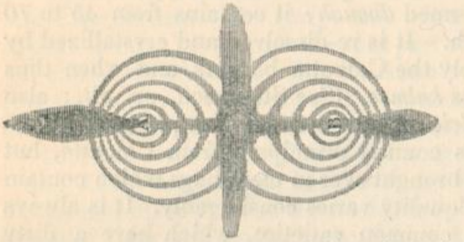


FIG. 53.

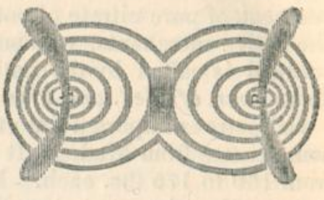


Fig. 52 is seen when the plane of the axis of nitre is parallel or perpendicular to the plane of polarization.—Fig. 53 is seen when the nitre is turned 45°.

When pure the crystals are transparent and colourless, have a sharp cooling taste, and undergo no change by exposure to the air. When heated, nitrate of potash fuses, and when cast in moulds forms the *nitrum tabulatum*, or *sal prunelle* of the shops. At a strong red heat it is decomposed, with the evolution of oxygen and the formation of hyponitrite of potash, which when rubbed to powder and mixed with sulphuric acid emits red fumes (composed of nitrous acid and binoxide of nitrogen.) One hundred parts of water at 32° dissolve 13·32 parts of this salt, but at 77° they dissolve 38 parts. During the solution cold is generated. In pure alcohol nitre is insoluble.

COMPOSITION.—Nitrate of potash has the following composition :—

	Eq.	Eq.Wt.	Per Cent.	Wollaston.			Eq.	Eq.Wt.	Per Cent.
Nitric Acid	1	54	52·9	53·332	or	Nitrogen	1	14	13·75
Potash	1	48	47·1	46·668		Oxygen	6	48	47·10
						Potassium	1	40	39·15
Nitrate of Potash	1	102	100·0	100·000			1	102	100·00

The crystals contain interstitial water, but no water chemically combined.

CHARACTERISTICS.—This salt is known to be a nitrate by the characters already detailed (p. 160) for this class of salts. That its base is potash is shewn by the tests before mentioned (p. 274) for this substance.

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—Nitrate of potash dissolved in 300 times its weight of water promotes vegetation : but a solution containing $\frac{1}{30}$ part of nitre is injurious to the growth of plants (Davy, *Agricult. Chemistry*).

(*b.*) *On animals generally.*—Orfila (*Toxicol. Gén.*) found that introduced into the stomach of dogs it acts as an irritant poison, and is capable of producing death, when it is not vomited, in doses of two or three drachms. Its operation is that of a narcotico-acrid poison. When applied to the cellular tissue it produces, according to this experimentalist, local effects only, and does not become absorbed. But Devergie (*Méd. Lég.*) states on the authority of J. E. M. Smith, that half an ounce applied to the thigh killed a dog in thirty-six hours. Eight ounces dissolved in a pint of water, and swallowed, killed a horse in twenty-four hours with all the symptoms of violent intestinal irritation, (Moiroud, *Pharm. Vétér.*) Veterinarians use nitre as a diuretic and refrigerant in doses of from two to four drachms.

(*c.*) *On man.*—In *very large doses* (such, for example, as one ounce or more) nitre has in several instances caused death; but the effects of it are not uniform, since, in other cases, this quantity has not appeared to have any very remarkable or obvious effect. For example, Dr. Christison knew an instance in which one ounce was taken without occasioning any other unpleasant symptom than vomiting; and it was retained on the stomach for above a quarter of an hour. In those cases where violent effects followed the ingestion of it, the symptoms were twofold: on the one hand, those indicating inflammation of the alimentary canal (such as pain, vomiting, and purging;) on the other hand, an affection of the nervous system (marked by giddiness, convulsions, failure of pulse, tendency to fainting, dilated pupil, insensibility, and palsy.) It is probable that the operation of nitre is influenced by the quantity of aqueous liquid in which the salt was dissolved, and that the more we dilute, the less powerfully does it act as a poison. In no other way can we reconcile the discrepant statements in regard to the effects produced by an ounce of nitre.

If nitre (or any other neutral alkaline salt) be mixed with dark-coloured venous blood out of the body, it communicates to it a florid or arterial hue. Now as this salt, when taken into the stomach becomes absorbed, it is not unreasonable to suppose that while mixed with the circulating blood it might have an analogous effect. Dr. Stevens (*Observations on the Blood*, p. 298) asserts, that in the last stage of fever, when the blood is black, it has this effect. Moreover, he tells us (p. 154) that in a case which occurred in America, where a person swallowed an ounce of nitre, by mistake, in place of Glauber's salts, the blood when drawn from a vein was completely florid, and remained as fluid as if the nitre had been added to it out of the body. (For some remarks on the effects of nitre on the blood, by Mr. Carlyon, see *Med. Gaz.* vol. viii. p. 626; and on nitre as a therapeutic agent, by Dr. Hancock, see *Lancet* for 1831-2, vol ii. p. 766.)

In *moderate doses* nitre acts as a refrigerant, diuretic, and diaphoretic. Its refrigerant properties are best seen when the body is preternaturally hot, as in febrile disorders. Mr. Alexander (*Essays*, pp. 105, *et. seq.*) in his trials with it, made on himself, experienced a sensation of chilliness after each dose, but he could not recognise by the thermometer any diminution of heat in the external parts of his body. He found in most of his experiments that it had a powerful influence over the vascular system, and surprisingly diminished, in a very short period of time, the number of pulsations. Thus on several occasions a drachm of this salt, within a few minutes, reduced the frequency of his pulse from 70 to 60 beats. Sundelin (*Heilmittell.* Bd. i. S. 59) says nitre diminishes the orgasm and plasticity of the blood perhaps by a chemical action on the cruor and fibrin. Diuresis is another, and very generally observed effect. As the nitre can be detected in the urine, its operation as a diuretic depends perhaps on the local stimulus which is communicated to the renal vessels while the nitre is passing through them. Like most of the neutral salts of the alkalies, the continued use of it promotes alvine evacuations. Full doses frequently produce pain in the stomach. As a diaphoretic it is usually given in combination with emetic tartar.

USES.—It follows from what has been now stated in regard to the physiological effects of nitre, that this substance is indicated when we wish to diminish preternatural heat, and to reduce the force and frequency of the pulse, as in febrile disorders, inflammatory affections (except perhaps those of the stomach, bowels, kidneys, and bladder), and hæmorrhages (especially hæmoptysis.) In continued fever it is frequently given in combination with emetic tartar, and sometimes also with calomel. It is not often used as a diuretic, because its activity in this respect is not very great, but it is adapted for those cases which are accompanied with arterial excitement. In sore throat it is mixed with white sugar and gradually swallowed. A mixture of nitre and powdered gum has long been a favourite remedy for diminishing the scalding of gonorrhœa. Nitre is rarely employed as an external agent, except as a means of producing cold. Thus five ounces of nitrate of potash, with five ounces of muriate ammonia, dissolved in sixteen ounces of water, will reduce the temperature 40° F.; that is, from 50° to 10°, according to Mr. Walker. Hence, therefore, we sometimes employ this mixture, placed in a bladder, as an external application (see p. 133.)

On the belief that fever, cholera, and other malignant diseases, were produced by a deranged state of the blood, and that this derangement depended on, or consisted in, a diminution or entire loss of the saline parts of the blood, Dr. Stevens employed nitre, chloride of sodium, and other alkaline salts, in the treatment of these diseases (see his *Observations*, pp. 296, 298, &c.) Nitre in large doses has been employed in the treatment of scurvy, and with considerable success, according to the statement of Mr. Cameron (*Medico-Chirur. Review*, March 1830, p. 483.)

ADMINISTRATION.—It may be given in doses of from ten grains to half a drachm in the form of powder mixed with sugar, or in solution. If administered as a refrigerant, it should be dissolved in water and immediately swallowed, in order that the coldness of the solution may assist the action of the salt. If employed as a diuretic, we ought to give liquids plentifully, and keep the skin cool.

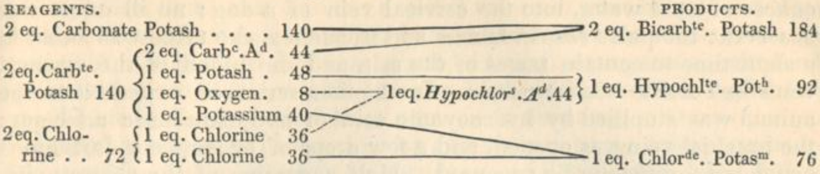
ANTIDOTE.—No chemical antidote is known for this salt. In case of poisoning, therefore, we should remove the poison from the stomach as speedily as possible, and administer tepid emollient drinks. Opiates perhaps may be advantageously administered. The inflammatory symptoms are to be combated by the usual antiphlogistic measures.

Potas'sæ Chlo'ras.—Chlo'rate of Pot'ash.

HISTORY.—Chlorate of potash (also called *oxymuriate* or *hyperoxymuriate of potash*) was first procured by Mr. Higgins, who seems to have confounded it with nitrate of potash. In 1786 it was distinguished by Berthollet.

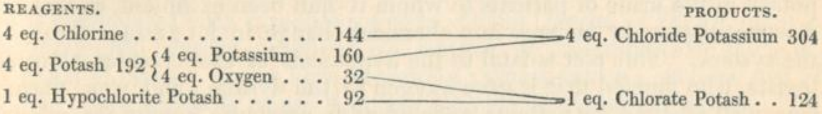
PREPARATION.—It is prepared by passing chlorine gas slowly through a cold solution of carbonate of potash placed in a Woulfe's bottle. The liquid is allowed to stand for twenty-four hours in a cool place, and is then found to have deposited crystals of chlorate of potash. These are to be drained, washed with cold water, dissolved in hot water, and recrystallized.

When chlorine gas comes in contact with a solution of carbonate of potash, three salts are formed: chloride of potassium, hypochlorite of potash, and bicarbonate of potash.



In proportion as the quantity of chlorine increases, the bicarbonate becomes decomposed: carbonic acid is evolved, and a further quantity of hypochlorite of potash and chloride of potassium is produced.

When the solution is strongly charged with hypochlorite, the action of the chlorine on the potash is somewhat changed: it abstracts the potassium from the potash, and thereby forms chloride of potassium, while the oxygen thus set free combines with some hypochlorite of potash, and thereby converts it into the chlorate, the greater part of which crystallizes.



The residual liquor contains a little chlorate, and a considerable quantity of hypochlorite of potash and chloride of potassium (Souberain, *Pharmacie*, t. 2^{me}. p. 430.)

PROPERTIES.—Chlorate of potash crystallizes in nearly rhomboidal plates, the primary form of which is an oblique rhombic prism. Its taste is cool, and somewhat similar to nitre. When rubbed in the dark it becomes luminous. 100 parts of water at 32° F. dissolve 3·5 parts of chlorate: at 59° F. 6 parts: at 120° F. 19 parts.

CHARACTERISTICS.—This salt is known to be a chlorate by the following characters:—When heated, it fuses, gives out oxygen, and is converted into chloride of potassium: when thrown on a red-hot coal, it deflagrates—a property, however, common to several other salts. Sulphuric acid gives it an orange red colour, evolves the chlorous acid (peroxide of chlorine), known by its yellow colour, and great explosive power when heated. Rubbed with sulphur or phosphorus it explodes violently. Mixed with hydrochloric acid and then with water, it forms a bleaching liquid. The base of the salt is known by the tests for potash, already mentioned.

COMPOSITION.—It is an anhydrous salt.

	Eq.	Eq.Wt.	Per Cent.	Berzelius.
Chloric Acid	1	76	61·30	61·5083
Potash	1	48	38·70	38·4917
Chlorate of Potash . . .	1	124	100·00	100·0000

IMPURITY.—Chloride of potassium is the usual impurity. This may be detected by a solution of nitrate of silver producing the white chloride of silver. The pure chlorate potash produces no obvious change in nitrate of silver.

Physiological Effects. (*a.*) *On animals generally.*—In one series of experiments, Dr. O'Shaughnessy (*Lancet* for 1831-2, vol. i. p. 369,) injected from 10 to 60 grains of chlorate of potash, dissolved in three ounces of tepid water, into the cervical vein of a dog: no ill effect was observed: the pulse rose in fulness and frequency, the urine was found in a short time to contain traces of the salt, and the blood of the tracheal veins had a fine scarlet colour. In another series of experiments the animal was stupified by hydrocyanic acid or hydrosulphuric acid gas: the brachial vein was opened, and a few drops of excessively dark blood could with difficulty be procured. Half a drachm of the chlorate dissolved in water of the temperature of the blood was injected slowly into the jugular vein: the pulsation of the heart almost immediately began to return, and in the course of eight minutes scarlet blood issued from the divided brachial veins. In twenty minutes the animal was nearly recovered, and passed urine copiously, which was found to contain the chlorate.

(*b.*) *On man.*—The action of this salt on man requires further investigation. It appears to be refrigerant and diuretic, analogous to that of nitrate of potash. Wöhler and Stehberger have recognized chlorate of potash in the urine of patients to whom it had been exhibited, so that it does not appear to undergo any chemical change in its passage through the system. This fact is fatal to the hypothesis of the chemico-physiologists, who fancied that it gave oxygen to the system, and was, therefore, well adapted for patients affected with scorbutic conditions, which were supposed to depend on a deficiency of this principle. Excessive doses of the chlorate, like those of the nitrate, would probably produce an affection of the nervous system; but I am not acquainted with any satisfactory case in proof. Duchateu (Merat and De Lens, *Dict. Mat. Méd.*) says that eighteen grains taken at thrice caused convulsions and delirium; but the observation is probably erroneous: for others have not experienced these effects, in much larger doses. Dr. Stevens (*On the Blood*, p. 155) says chlorate of potash gives a beautiful arterial colour to the venous blood, and reddens the gums much faster than mercury.

Uses.—Chlorate of potash was originally employed as a medicine for supplying oxygen to the system, where a deficiency of that principle was supposed to exist. With this view it was successfully administered by Dr. Garnett (Duncan's *Annals of Medicine*, 1797) in a case of chronic scorbutus. Dr. Ferriar also tried it in scurvy with success (*Med. Hist. and Reflect.* vol. iii. p. 250). It was subsequently applied in the venereal disease and liver complaints as a substitute for mercurials, whose beneficial effects were thought to depend on the oxygen which they communicated to the system (see the reports of Mr. Cruikshank and Dr. Wittman, in Dr. Rollo's *Cases of Diabetes Mellitus*, 2d ed. pp. 504 and 563: also Dr. Chisholm's letter in the same work, *Preface*, p. x). It has also been tried in cases of general debility, on account of its supposed tonic effects, but failed in the hands of Dr. Ferriar (*op. cit.*). In a case of dropsy under the care of the latter gentleman it operated successfully as a diuretic. More recently, it has been used by Dr. Stevens (*On the Blood*, p. 296) and others, as a remedy for fever, cholera, and other malignant diseases, which, he supposed, depend on a deficiency of saline matters in the blood, but as it was usually employed in conjunction with chloride of sodium (see the article on this salt, further on) and carbonate of soda, it is impossible to determine what share the chlorate had in producing the beneficial effects said to have been obtained by what is called the *saline* treatment of these diseases.

It appears, then, that all the uses of this salt have been founded on certain views of chemical pathology, some of which are now considered untenable. It is very desirable, therefore, that some person, unbiassed by theoretical opinions, would carefully investigate its effects and uses, which I am inclined to think have been much overrated.

ADMINISTRATION.—The usual dose of it is from ten or fifteen grains to half a drachm. Dr. Wittman, in one case, gave 160 grains daily, with a little hydrochloric acid immediately after it, to decompose it: the effects were hot skin, headache, quick, full, and hard pulse, white tongue, and augmentation of urine.

Potas'sæ Car'bonas.—Car'bonate of Pot'ash.

HISTORY.—It is probable that the ancient Greeks, Romans, and Egyptians, were acquainted with this salt. Pliny (*Hist. Nat.* lib. xiv. and xxviii.) describes some of the uses of wood-ashes, and mentions a lye of them (*cineris lixivium*). For a long period carbonate of potash was confounded with carbonate of soda. Geber (*Invent. of Verity*, ch. iv.), in the eighth century, describes the method of procuring it by the combustion of tartar. It has been known by various names; such as, *salt of tartar*, *mild vegetable alkali*, *fixed nitre*, and *subcarbonate of potash*.

NATURAL HISTORY.—Reuss (Gairdner, *On Mineral Springs*, p. 18) found carbonate of potash in the waters of the Wuissokow, and in the chalybeate of Twer.

It is formed, during the combustion of inland plants, by the decomposition of the vegetable salts of potash (the acetate, the malate, and the oxalate, but principally the first). Hence it is procured in great abundance from wood-ashes. In some few cases it has been supposed to exist ready formed in plants, as in a fern referred to by Mr. Parkes (*Chemical Essays*, vol. ii. p. 17), the expressed juice of which is employed by the poor weavers of Yorkshire, in the cleansing of cloth at the fulling mills.

PREPARATION.—It is principally obtained from *wood-ashes* (*cineres vegetabilium*, seu *cineres e lignis combustis*). These are procured by burning wood piled in heaps on the ground, sheltered from the wind, or in pits.—[For an account of the proportion and composition of wood-ashes, see Berthier, *Traité des Essais*, t. 1^{er}. p. 259).] The soluble constituents of the ashes are, carbonate, sulphate, phosphate, and silicate of potash, and chlorides of potassium and sodium. The insoluble constituents are, carbonate and subphosphate of lime, alumina, silica, the oxides of iron and manganese, and a dark carbonaceous matter. In America the ashes are lixiviated in barrels with lime, and the solution evaporated in large iron pots or kettles, until the mass has become of a black colour, and of the consistence of brown sugar. In this state it is called by the American manufacturers *black salts* (*cineres clavellati crudi*). The dark colour is said by Dumas to be owing to ulmate of potash.

To convert this substance into the *pot-ash* of commerce (*cineres clavellati calcinati*), it is heated for several hours, until the fusion is complete, and the liquid becomes quiescent. It is then transferred by large iron ladles into iron pots, where it congeals in cakes. These are broken up, packed in tight barrels, and constitute the pot-ashes of commerce. Its colour varies somewhat, but it is usually reddish, in consequence of the presence of sesquioxide of iron.

To make the substance called *pearl-ash* (*potassa impura*, Ph. L.) the mass called black salts, instead of being fused, is transferred from the kettles to a large oven-shaped furnace, so constructed that the flame is made to play over the alkaline mass, which in the meantime is stirred by means of an iron rod. The ignition is in this way continued until the combustible impurities are burnt out, and the mass, from being black, becomes dirty bluish white: this is pearl-ash (*United States Dispensatory*). The colouring matter is probably manganesiate of potash.

The following table shows the composition of various kinds of pot-ash and pearl-ash, according to Vauquelin (*Ann. de Chim.* xl. 273):—

Kinds of Potash.	Caustic Hydrate of Potash.	Sulphate of Potash.	Chloride of Potassium.	Insoluble residue.	Carbonic Acid and Water.
American Potash . .	857	154	20	2	119
Russian Potash. . .	772	65	5	56	254
American Pearlash .	754	80	4	6	308
Potash of Trèves . .	720	165	44	24	199
Dantzic Potash . . .	603	152	14	79	304
Potash of Vosges . .	444	148	510	34	16

In this table it will be observed, that the American pot-ash contains the largest quantity of caustic potash: this arises, probably, from the use of lime in its manufacture. Moreover, pearl-ash contains more carbonate of potash than pot-ash: this must arise from the absorption of carbonic acid during its preparation.—[For the mode of estimating the quantity of alkali present, see Mr. Faraday's *Chemical Manipulation*, art. *Alkalimetry*.] The pot-ash and pearl-ash employed in this country are principally imported from the British North American colonies, from Russia, and from the United States of America.

In the Pharmacopœia carbonate of potash is directed to be prepared as follows:—Dissolve two pounds of impure carbonate of potash (pearl-ash) in a pint and a half of water, and strain; then pour it off into a proper vessel, and evaporate the water, that the liquor may thicken; then stir it constantly with a spatula until the salt concretes. In this process the earthy impurities insoluble in water are got rid of. The same authority also states, that a purer carbonate may be prepared by heating the crystals of the bicarbonate to redness.

The high price of pearl-ash has occasionally led to the manufacture of carbonate of potash from *sal enixum* (bisulphate of potash), by heating it in a reverberatory furnace with charcoal. This yields sulphuret of potassium, in consequence of the carbon deoxidizing the bisulphate. By roasting, the sulphuret is decomposed, and converted into the carbonate of potash; the sulphur being dissipated, and the potassium combining with oxygen and carbonic acid.

PROPERTIES.—Carbonate of potash (the *salt of tartar* of the shops) is usually kept in a granular condition, on account of the difficulty of crystallizing it. It is white, inodorous, and strongly alkaline to the taste. It reacts powerfully as an alkali on turmeric or infusion of red-cabbage. It is fusible at a red heat; has a strong affinity for water, so that by exposure to the air it attracts water, and becomes liquid, forming the *oleum tartari per deliquium.* It is insoluble in alcohol, but is very soluble in water; and in the Pharmacopœia is an officinal solution, called *liquor potassæ carbonatis*, composed of twenty ounces of the salt dissolved in a pint of distilled water. The solution is colourless, inodorous, and has a sp. gr. of 1·473.

Pure carbonate of potash may be prepared by the combustion of bitartrate of potash and nitre (forming what is called *white flux*), lixiviating, concentrating by evaporation, and crystallizing. The primary form of the crystal is a rhombic octahedron.

Characteristics.—It is known to be a carbonate by its effervescing with the strong acids, and by a solution of it causing a white precipitate (soluble in acetic acid) with lime water or with chloride of barium. That it is a potash salt is determined by the tests for potash already mentioned. From the bicarbonate of potash it is distinguished by its causing a brick-red precipitate with a solution of bichloride of mercury, the precipitate being percarbonate of mercury. Sulphate of magnesia produces a white precipitate with the carbonate of potash, and not with the bicarbonate. This test, however, will not recognise the carbonate when mixed with a large quantity of bicarbonate.

Composition.—Mr. Phillips (*Pharmacopœia*) says, one hundred parts of the carbonate of potash of the shops loses about 16 parts of water when heated to redness. Hence supposing the carbonate to have been pure (which that of commerce never is) its composition would be as follows :—

	Eq.	Eq.Wt.	Per Cent.
Potash	1	48	57·6
Carbonic Acid	1	22	26·4
Water	1½	13·5	16·0
Pure Granulated Carb. Potash	1	83·5	100·0

The pure crystallized salt contains two equivalents of water of crystallization, and its equivalent weight, therefore, is 88.

Impurities.—The ordinary impurities in this salt are silicic acid, the chlorides, and sulphates. The first is detected by supersaturating with hydrochloric acid, evaporating, and igniting the residue: the silicic acid is insoluble in water. The other impurities are detected by supersaturating the salt with nitric acid: if the resulting solution give a white precipitate with nitrate of silver, the presence of chloride is to be inferred: if it produce a white precipitate with chloride of barium, a sulphate is present.

Physiological Effects.—Its effects are in *quality* precisely those of caustic potash already described, but their *intensity* is much less, on account of the presence of carbonic acid, which diminishes the alkaline properties of the base. When it is taken into the stomach in large quantities, it acts as a powerfully caustic poison, sometimes inducing death in twelve hours, and producing symptoms similar to those caused by the mineral acids: at other times, however, the patient recovers from the immediate effect of the alkali, but in consequence of the altered condition of the alimentary canal the assimilative process cannot be carried on; and after dragging on a miserable existence for a few weeks, the unfortunate sufferer dies of absolute starvation. And lastly, in some cases, the caustic operation of the poison is principally confined to the œsophagus, causing stricture and death. In one case, related by Sir Charles Bell (*Surgical*

Observations, part i. p. 82), a patient swallowed soap lees: this produced inflammation, which terminated in stricture. She lingered for 20 years, and died literally starved. Several other cases have been detailed. (Christison, *On Poisons.*) A weak solution of carbonate of potash produces no change in the sanguineous particles drawn from the body: a saturated solution slightly and gradually diminishes their size.

USES.—This salt is employed in medicine in most of the cases already mentioned when describing the uses of caustic potash. For example, as an antacid in dyspeptic affections; as a diuretic; as an antacid in that form of lithiasis which is accompanied with an increased secretion of lithic acid, or the lithates; in those forms of inflammation in which there is a tendency to the formation of false membranes; in gout, &c. Mixed with cochineal it is a popular remedy for hooping-cough. Externally, it has been applied in the form of a solution to wounds; as an injection in gonorrhœa; as a collyrium in some affections of the cornea, &c. Lastly, it is sometimes employed in the manufacture of the common effervescing draught, made with either the citric or tartaric acid. Twenty grains of carbonate of potash are saturated by about 17 grains of the citric acid of commerce, by 18 grains of tartaric acid, or by ʒiv. of lemon juice.

ADMINISTRATION.—It may be given either in the solid or liquid state. In the solid state it is given in doses of from gr. x. to ʒss. The doses of the *liquor potassæ carbonatis* of the Pharmacopœia is from ten minims to a fluidrachm.

ANTIDOTES.—When swallowed as a poison, the antidotes are oils or acids, as already mentioned for the caustic potash.

Potas'sæ Bicar'bonas.—Bicar'bonate of Pot'ash.

HISTORY.—This salt, formerly called *carbonate of potash* or *aerated kali*, was first prepared by Cartheuser in 1752.

PREPARATION. (*a.*) *Process of the Pharmacopœia.*—In the London Pharmacopœia we are directed to pass carbonic acid (generated by the action of equal weights of sulphuric acid and water in powdered chalk), through a solution of six pounds of the carbonate in a gallon of distilled water, to saturation. Apply a gentle heat, so that whatever crystals have formed may be again dissolved. Then set the solution aside that crystals may be formed, which are to be dried.

In this process, each equivalent of carbonate of potash unites with an additional equivalent of carbonic acid, and thereby forms the bicarbonate. The silicic acid is separated partly while the carbonic acid is passing through the solution, and partly during the crystallization of the bicarbonate.

(*b.*) *Cartheuser's Process.*—In the *Pharmacopée Raisonnée* of MM. Henry and Guibourt the following directions are given for performing this process:—Dissolve 500 parts of (pure) carbonate of potash in 1000 parts of distilled water, and filter: place the solution in a porcelain capsule in a salt-water bath, and gradually add 300 parts of pulverized carbonate of ammonia: slightly agitate the liquor until only a feeble disengagement of ammonia is perceived, then filter over a heated vessel, and put aside to cool. The proportions employed by Geiger (*Handbuch. d. Pharm.*) are somewhat different: they are, a pound of carbonate of potash, sixteen ounces of water, and six ounces of carbonate of ammonia. Mr. Brande (*Manual of Chemistry*) says Cartheuser's process is more expensive than that of the Pharmacopœia.

In this process the volatility of the ammonia, joined to the affinity of the carbonate of potash for more carbonic acid, causes the decomposition of the sesquicarbonate of ammonia: the ammonia with a small portion of carbonic acid is disengaged, while the remaining acid converts the carbonate into the bicarbonate of potash.

Properties.—It is a crystalline, colourless solid, the primary form of whose crystal is, according to Mr. Brooke, a right oblique-angled prism. It is inodorous, has an alkaline taste, and re-acts very feebly as an alkali on vegetable colours. It is soluble in four times its weight of water, at 60° F., but is insoluble in alcohol. When exposed to the air it undergoes no change. When exposed to a red heat it gives out half its carbonic acid, and becomes the carbonate.

Characteristics.—The presence of carbonic acid and potash in this salt is known by the tests for these substances before mentioned. From the carbonate of potash it is best distinguished by a solution of bichloride of mercury, which causes a slight white precipitate with it: whereas with the carbonate it causes a copious brick-dust precipitate. Sulphate of magnesia will not recognise the freedom of bicarbonate from carbonate, as I have before stated (p. 301.)

Composition.—The composition of this salt is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Berard.
Potash	1	48	47·58	48·92
Carbonic Acid	2	44	43·60	42·01
Water	1	9	8·82	9·07
Crystallized Bicarbonate Potash	1	101	100·00	100·00

Impurities.—The presence of chlorides and sulphates may be recognized in the way described when speaking of carbonate of potash. Bichloride of mercury may be employed to detect any carbonate of potash, with which it would form a brick-dust coloured precipitate.

Physiological Effects.—The effects of this salt are similar to those of the carbonate of potash, except that its local action is much less energetic, in consequence of the additional equivalent of carbonic acid; while the alkaline effect on the system is equally energetic, so that it is an exceedingly eligible preparation in lithiasis and other cases where we want its constitutional, and not its local, action.

Uses.—It may be employed for the same purposes that we use caustic potash (vide *potash*), except that of acting as an escharotic. Thus it is used as an antacid, to modify the quality of the urine, in plastic inflammation, in glandular diseases, affections of the urinary organs, &c. But its most frequent use is that for making effervescing draughts, with either citric or tartaric acid. The proportions are as follows:—20 grains of bicarbonate of potash will saturate about 14 grains of the citric acid of commerce, 15 grains of tartaric acid, or ʒiijss. of lemon juice. In the shops, a preparation, called *lemon and kali*, is kept: it is composed of sugar, dry citric acid, and the bicarbonate of potash. It is used as an extemporaneous effervescing draught. As it abstracts water from the atmosphere, it must be kept in a well-stopped bottle.

Where there is great irritability of stomach, I believe the effervescing draught, made with bicarbonate of potash and citric acid, to be more efficacious than that made with carbonate of soda and tartaric acid, the resulting citrate of potash being, in my opinion, a much milder preparation than the tartrate of soda. The citrate promotes slightly the secretions of the alimentary canal, the cutaneous transpiration, and the renal secretion: and like other vegetable salts of potash, renders the urine alkaline.

Administration.—This salt may be given in doses of from gr. x. to gr. xv. or to the extent of half a drachm, or even a drachm.

Liquor Potassæ Effervescens (Ph. L.)—The effervescing solution of (bicarbonate of) potash is ordered to be prepared by dissolving a drachm of bicarbonate of potash in a pint of water, and passing into the solution carbonic acid compressed by force, more than sufficient for saturation. The solution is to be kept in a well-stopped vessel. This preparation has been introduced as an agreeable form for exhibiting carbonate of potash, without diminishing its constitutional operation.

Potas'sæ Ace'tas.—Ac'etate of Pot'ash.

History.—It appears to have been first clearly described by Raymond Lully in the thirteenth century, and has been known by several appellations, such as *terra foliata tartari*, *diuretic salt*, &c.

Natural History.—Geiger (*Handbuch der Pharmacie*) says this salt is found in some mineral springs. It probably exists in most plants which, by incineration, yield carbonate of potash. The sap of the elm and of most trees, Winter's bark, linseed, senna leaves, the rhizome of ginger, &c. are said to contain it.

Preparation.—It is prepared by adding a pound of carbonate of potash to twenty-six fluidounces of acetic acid (Ph. L.) mixed with twelve fluidounces of distilled water, or sufficient acid to saturate the carbonate. Evaporate the strained liquor in a sand-bath, the heat being cautiously applied until the salt is dried.

In this process the acid unites with the potash of the carbonate, and disengages carbonic acid.

Properties.—It is usually met with as a colourless, white solid, with a foliated texture (which is given to it by fusion and cooling), odourless, but having a pungent saline taste, and a soapy feel. It is exceedingly deliquescent, and, therefore, ought to be preserved in a well-stopped bottle. It is very soluble both in water and alcohol; indeed, in water, it is one of the most soluble salts we are acquainted with. At 60°, 100 parts of the salt will dissolve in 102 parts of water. When heated, it fuses and is decomposed into *pyroacetic spirit*, and *carbonate of potash*. One equivalent of this spirit contains the elements of one equivalent of acetic acid, minus those of one equivalent of carbonic acid.

Characteristics.—(See the tests for the *acetates*, p. 222, and for *potash*, p. 274).

Composition.—Its composition is as follows :—

	Eq.	Eq. Wt.	Per Cent.	Wenzel.
Potash	1	48	48·5	50·15
Acetic Acid (dry)	1	51	51·5	49·85
Acetate of Potash	1	99	100·0	100·00

Purity.—It should be white and perfectly neutral. Frequently, however, it reacts as an alkali, owing to a slight excess of potash. The presence of chlorides may be detected by nitrate of silver; of sulphates, by chloride of barium; of metals, by hydrosulphuric acid or ferrocyanide of potassium.

PHYSIOLOGICAL EFFECTS.—Two or three drachms cause purging, which is sometimes accompanied with griping. In smaller doses, more especially if largely diluted, this salt acts as a mild diaphoretic. In its passage to the kidneys it becomes decomposed, and converted into the carbonate of potash, which may be detected in the urine. Probably the pulmonary excretions of those who employ it also become impregnated with this salt, since it has been said that in persons with delicate lungs it acts as an irritant to these organs.

USES.—In this country it is rarely employed, except as a diuretic in dropsical complaints. On the continent, however, it is administered in various other diseases, as an alterative or resolvent, in scirrhus of the pylorus, chlorosis, and visceral and glandular enlargements. It may be employed, in the lithic acid diathesis, to render the urine alkaline. It is of course exceedingly improper where phosphatic deposits are observed in the urine.

ADMINISTRATION.—It is given as a diuretic in doses of from a scruple to a drachm and a half, dissolved in some mild diluent. In larger doses, as two or three drachms, it acts as a purgative.

Potas'sæ Bitar'tras.—Bitar'trate of Pot'ash.

HISTORY.—In its impure form, as a deposit from wine, it must have been known at a very early period. " It is called *tartar*," says Paracelsus, " because it produces oil, water, tincture, and salt, which burn the patient as *hell* does." Scheele, in 1769, first explained its nature. Its synonymes are *cream of tartar*, *supertartrate of potash*, and *acidulous tartrate of potash*.

NATURAL HISTORY.—It is a constituent of many vegetables: thus it is found in grapes, tamarinds, *Cetraria islandica*, &c.

PRODUCTION.—All the bitartrate of commerce is obtained during the vinous fermentation. It exists in solution in grape juice; but being very slightly soluble in a mixture of alcohol and water, it deposits during fermentation (that is, when alcohol is produced), and forms a crust on the sides of the cask. In this state it is known in commerce under the name of *crude tartar* (*tartarus crudus*), or *argol*, and which is termed *white* or *red* (*tartarus albus* vel *tartarus ruber*), according as it is obtained from white or red wine.

Argol, or *crude tartar*, occurs in crystalline cakes of a reddish colour, and is composed of the bitartrate of potash, tartrate of lime (and sometimes racemate of potash), colouring and extractive matter, &c.

At Montpelier, bitartrate of potash is procured thus:—Argol is boiled in water, and the solution allowed to cool, by which a deposit of crystals is obtained; these are washed with cold water, and dissolved in boiling water, containing charcoal and alumina (clay); the latter substances being employed to remove the colouring matter with which they precipitate. The clear liquor is allowed to cool slowly, by which crystals of the bitartrate are formed. These constitute the *tartarus depuratus* or *crystalli tartari* of the older chemists. If a hot saturated solution of tartar be cooled, the surface of the liquid becomes coated by a layer of very fine crystals of bitartrate: hence this crust was called *cream of tartar* (*cremor tartari*.)

Properties.—As met with in commerce, this salt forms a white crystalline mass, without odour, but having an acidulous and gritty taste. The primary form of the crystals is a right rhombic prism. It is unaltered by exposure to the air; but when heated, it decomposes, swells up, evolves various volatile products, gives out an odour of caromel, and is converted into *black flux* (*fluor niger*),—a compound of charcoal and carbonate of potash. If the bitartrate be deflagrated with nitrate of potash, the residue is *white flux* (*fluor albus*), or carbonate of potash. Bitartrate of potash is very slightly soluble in water, and is insoluble in alcohol.

Characteristics.—One character of this salt is derived from the phenomena attending its conversion into black flux, as above mentioned. If black flux be digested in water we obtain a solution of carbonate of potash, known by the properties before mentioned (p. 301.) Another character of the bitartrate is its slight solubility in water, and the solution reddening litmus. The addition of caustic potash increases its solubility, whereas alcohol diminishes it. Acetate of lead added to a solution of the bitartrate forms a copious white precipitate; lime water has the same effect. Mixed with alkaline carbonates it produces effervescence. Boracic acid, or borax, very much increases the solubility of this salt in water, forming what has been termed *soluble cream of tartar* (*cremor tartari solubilis*), or *tartarus boraxatus* of some writers.

Composition.—Crystallized bitartrate of potash has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.
Potash	1	48	25·3	24·80
Tartaric Acid	2	132	70·0	70·45
Water	1	9	4·7	4·75
Crystallized Bitar^{te}. Potash	1	189	100·0	100·00

Impurity.—Bitartrate of potash usually contains from 2 to 5 per cent. of tartrate of lime, and hence a little carbonate of lime may be detected in black flux. This is of no material consequence in a medicinal point of view. If the powdered bitartrate be adulterated with either alum or bisulphate of potash, the fraud may be detected by chloride of barium, which causes a white precipitate (sulphate of baryta) insoluble in nitric acid.

Physiological Effects.—When taken in *small doses*, diluted with water, it acts as a refrigerant and diuretic: in *larger doses* (as two or three drachms) it purges, and frequently creates flatulence and griping. By continued use it disorders the digestive functions, and causes emaciation, most probably from defective nutrition. In *excessive doses* it produces inflammation of the stomach and intestines. A fatal case has been recorded by Mr. Tyson (*Med. Gaz.* vol. xxi. p. 177.) A man, to relieve the effects of drunkenness, swallowed four or five table-spoonfuls of cream of tartar. It caused violent vomiting and purging, and other symptoms of gastro-enteritis, and pain in the loins. The thighs and legs appeared paralyzed. He died on the third day. On a post-mortem examination the stomach and intestines were found inflamed.

Uses.—Bitartrate of potash is frequently employed in the form of *imperial* or *cream of tartar whey*, as a *refrigerant* drink in febrile and inflammatory diseases. It allays thirst, diminishes preternatural heat, and reduces vascular action. As a *diuretic* in dropsical complaints it is used in the same way. As a *purgative* it is not usually exhibited alone, but, in general, with jalap, sulphur, senna, or some other purgative. Thus, in dropsical complaints, a very valuable hydragogue cathartic is a mixture of jalap and bitartrate of potash. In skin diseases and affections of the rectum (as piles, stricture, and prolapsus) a very useful purgative is an electuary composed of sulphur, bitartrate of potash, and confection of senna. An effervescing aperient may be prepared by mixing three drachms of the bitartrate with two and a half drachms of carbonate of soda: the resulting salt is the potash-tartrate of soda. As a *tooth-powder*, bitartrate of potash is sometimes used on account of its gritty qualities: a very good dentrifice consists of equal parts of bitartrate, powdered rhatany root, and myrrh.

ADMINISTRATION.—As a hydragogue cathartic the dose is from four to eight drachms: as an aperient, one or two drachms: as a diuretic, in repeated doses of a scruple to a drachm. *Imperial* (*tisana imperialis*) is formed by adding boiling water to cream of tartar, and flavouring with lemon-peel and sugar. It may be taken, *ad libitum*, as a refrigerant drink in febrile complaints. *Cream of tartar whey* (*serum lactis tartarizatum*) is made by adding about two drachms of bitartrate to a pint of milk. It may be diluted with warm water, and taken in dropsical complaints. The *compound powder of jalap* (*pulvis jalapæ compositus*) of the London Pharmacopœia is composed of three ounces of jalap, six ounces of the bitartrate, and two drachms of ginger: the dose is from a scruple to a drachm in dropsical complaints.

Potas'sæ Tar'tras.—Tar'trate of Pot'ash.

HISTORY.—This salt was known to Lemery. It has been termed *tartarized tartar*, *tartarized kali*, *soluble tartar*, or *vegetable salt*.

PREPARATION.—It is readily prepared by saturating the bitartrate with the carbonate of potash. The proportions employed in the London Pharmacopœia are sixteen ounces (or as much as may be sufficient) of carbonate of potash dissolved in six pints of boiling water, and three pounds of powdered bitartrate of potash. After boiling, strain, and evaporate until a pellicle forms; then set aside to crystallize.

In this process the excess of acid in the bitartrate is saturated by the potash of the carbonate: the carbonic acid escapes.

PROPERTIES.—It is usually met with in the shops in a granular state, but it ought to be crystallized. The primary form of the crystals is a right oblique-angled prism. To the taste this salt is saline, and somewhat bitter. It deliquesces when exposed to the air, and is soluble in its own weight of water at 50°; the solution decomposes by keeping.

CHARACTERISTICS.—When heated to redness, it is decomposed, leaving as a residue charcoal and carbonate of potash. A solution of the tartrate produces a white precipitate with solutions of acetate of lead, nitrate of silver, and chloride of calcium; the precipitates being soluble in nitric acid. When heated, the salt evolves the odour of caromel. If an excess of any strong acid (as the sulphuric) be added to a solution of this salt, we obtain crystals of the bitartrate. Hence acids, and most acidulous salts, are incompatible with it: as also are tamarinds. The tartrate is readily distinguished from the bitartrate by its deliquescent property, its greater solubility, and its want of acidity.

Composition.—The following is the composition of this salt:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.
Potash	1	48	42·1	41·31
Tartaric Acid.	1	66	57·9	58·69
Tartrate of Potash	1	114	100·0	100·00

Impurity.—It may contain excess of acid or base, either of which is easily recognised; the one by litmus, the other by turmeric. The sulphates may be detected by chloride of barium throwing down a white precipitate insoluble in nitric acid.

Physiological Effects.—This salt is a gentle purgative, analogous in its action to the sulphate of potash, from which it differs in being milder in its operation, and partially digestible; for, like the other vegetable salts of the alkalies, it is decomposed in the system, and converted into the carbonate, in which state it is found in the urine.

It is said to have the power of preventing the griping of other more active cathartics; as senna and scammony; but, from my own personal observations, I doubt the correctness of this statement.

Uses.—It is employed as a mild purgative in dyspepsia, at the commencement of diarrhœa, in some liver complaints, &c. Sometimes it is used as an adjunct to other more active purgatives: as the infusion of senna.

Administration.—It may be given in doses of from two to three drachms to half an ounce, or even an ounce.

Order 11.—Compounds of Sodium.

So'dii Chlo'ridum.—Chlo'ride of So'dium.

History.—As this salt is a necessary and indispensable seasoning to our food, it doubtless must have been known to, and employed by, the first individuals of our race. The earliest notice of it occurs in the writings of Moses, (*Gen.* xix. 26; *Lev.* ii. 13) and Homer (*Iliad*, lib. ix. 214). It has received various names, such as *common salt*, *culinary salt*, and *muriate* or *hydrochlorate of soda*.

Natural History.—It occurs in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—An enormous quantity of this salt is contained in the waters of the ocean. At an average calculation sea water contains 2·5 per cent. of chloride of sodium (*vide* various analyses of this fluid in Thomson's *System of Chemistry*, 6th ed. vol. iii. p. 196). It is found also in great abundance in mineral waters (Gairdner, *On Mineral Springs*, p. 12). It has not hitherto been found in the oldest stratified rocks (De la Beche, *Researches in Theoret. Geol.* p. 31), but is met with in all the later formations. Thus Mr. Featherstonhaugh (*Phil. Mag.* N. S. vol. v. p. 139; vol. vi. p. 75; and vol. vii. p. 198) states that salt or brine springs occur in certain parts of the United States, in the *old transition slate rocks.* Salt springs occur in various parts of England, in the *coal measures* (Bakewell, *Introd. to Geology*, 4th ed. p. 252). The rock salt of Cheshire, and the brine springs of Worcestershire, occur in the *old red sandstone group* (*Trans. Geol. Society*, vol. i. p. 38, and vol. ii. p. 94). The salt of Ischel, in the Austrian Alps, belongs to the *oolitic group* (Sedgwick and Murchison, *Phil. Mag.* N. S. vol. viii. p. 102), as does also that found in the lias in Switzerland (Bakewell, *op. cit.* p. 253). The immense mass or bed of salt near Cardona in Spain, and which has been described by Dr. Traill (*Trans. Geolog. Society*, vol. iii. p. 404) occurs in the *cretaceous group* (De la Beche, *op. cit.* p. 293). The salt deposit of Wieliczka, near Cracow, belongs to the *supracetaceous group* (De la Beche, p. 270). Lastly, in the Crimea, salt is said to be daily accumulating in the inland lakes.

(*b.*) *In the organized kingdom.*—It is found in plants which grow by the sea side, in the blood and urine of man, &c.

PREPARATION.—The salt consumed in this country is procured by the evaporation of the water of brine springs. The salt districts are Northwich, Middlewich, and Nantwich, in Cheshire; Shirleywich, in Staffordshire; and Droitwich, in Worcestershire. In Cheshire the rock salt (called also *fossil salt*, *sal fossilis* or *sal gemmæ*) constitutes two beds which vary in thickness from 4 to 130 feet, and are separated by a bed of clay, 10 or 12 feet thick; the uppermost bed of salt being 30 or more feet from the surface of the earth. It is for the most part of a reddish colour, but is also met with in transparent colourless masses. It is called in commerce *Prussia rock*, and is largely exported for purification. Brine springs are met with both above and below the level of the beds of rock salt.

The brine is pumped up into cisterns or reservoirs, from which it is drawn when wanted into large, oblong, wrought-iron evaporating pans, which are usually worked with four or more fires. If the brine be not completely saturated with chloride of sodium, a little rock salt is added to it. By the evaporation of the water the salt deposits in crystals. The impurities separate in the form of a scum (which is removed by a skimming dish), and of a sediment called *pan-scale*, or *pan-scratch*. As all parts of the pan are not equally heated, the crystallization of the salt takes place in different parts at different times, and consequently in the same pan the grains or crystals vary considerably in size. The small-grained salt is formed by the strongest heat, and constitutes the *butter*, *stoved*, *lump*, or *basket salt* of commerce: while the larger crystals, forming the *bay* and *fishery salts* of commerce, are deposited in the coolest part of the pan. (For further information on the manufacture of common salt, consult Aikin's *Dictionary of Chemistry*, vol. ii. p. 118; Holland's *Agricultural Survey of Cheshire*; Mr. Furnival's *Wharton and Marston Patent Salt Refineries*, 1836; Dr. Brownrigg's *Art of making Common Salt*, 1748.)

In some parts of the world chloride of sodium is obtained from seawater: but the mode of extracting it varies according to circumstances. In warm countries it is procured by solar evaporation, and is then called *bay salt*. In cold countries congelation is resorted to as a means of concentrating sea water; for when a weak saline solution is exposed to great cold, it separates into two parts; one almost pure water, which freezes, and the other which remains liquid, and contains the larger proportion of salt. Another method of concentration is by *graduating houses*: these are skeletons of houses, in which the water is pumped up, and allowed to fall on heaps of brushwood, thorns, &c., by which it is divided and agitated with the air, and evaporation promoted. The further concentration is effected by heat.

Properties.—It crystallizes in colourless cubes, or more rarely in regular octahedrons. In the salt pans the little cubes are frequently so aggregated as to form hollow, four-sided pyramids, whose sides have some resemblance to a series of steps: these are technically called *hoppers*. The specific weight of salt is 2·17. The taste is pure saline. When free from all foreign matters, chloride of sodium is permanent in the air, but ordinary salt is slightly deliquescent, owing to the presence of small quantities of chloride of magnesium. When heated it decrepitates (more especially the coarse-grained or bay salt), at a red heat fuses, and at a still higher temperature volatilizes. Rock salt is transcalent or diathermanous: that is, it transmits radiant heat much more readily than many other transparent bodies, as glass. It is soluble in water, and slightly so in alcohol. Hot and even boiling water dissolves very little more salt than cold water. At 60° it requires about twice and a half its weight of water to dissolve it.

Characteristics.—Its characters as a soda salt are the following:—It produces no precipitate with the hydrosulphurets, ferrocyanides, phosphates, or carbonates. From the salts of potash it is distinguished by causing no precipitate with perchloric or tartaric acid, or with chloride of platinum, and by the yellow tinge which it communicates to the flame of alcohol. As a chloride it is known by nitrate of silver throwing down a white precipitate, soluble in ammonia, but insoluble in nitric acid. Lastly, chloride of sodium is odourless, and devoid of bleaching properties.

Composition.—Pure chloride of sodium has the following composition:

	Eq.	Eq.Wt.	Per Cent.	Ure.
Sodium	1	24	40	39·98
Chlorine	1	36	60	60·02
Chloride of Sodium	1	60	100	100·00

The crystals contain no water in chemical combination with them, but a little is frequently mechanically lodged between their plates.

Impurities.—The commercial salt of this country is sufficiently pure for all dietetical and therapeutical purposes; and its low price is a sufficient guarantee against its adulteration. In France, however, serious accidents have happened in consequence of the use of sophisticated salt. (Christison's *Treatise on Poisons*, 3d ed. p. 604, and Devergie, *Méd. Lég.* t. ii. p. 876.)

Physiological Effects. (*a.*) *On vegetables.*—In minute quantity chloride of sodium is injurious to very few, if any, plants, and to some it appears to be beneficial. Used moderately it is a most excellent manure to certain soils. In large quantities it is injurious, though unequally so, to all plants. (Davy, *Agricult. Chem.*, and Decandolle, *Phys. Vég.* pp. 1262 and 1343.)

(*b.*) *On animals.* To marine animals common salt is a necessary constituent of their drink. It is relished by most land animals. "The eagerness with which many quadrupeds and birds press towards salt springs and lakes, situated in inland districts, for the purpose of tasting their contents, indicates," says Dr. Fleming, (*Philosophy of Zoology*, vol. i. p. 316) "a constitutional fondness for salt." In the *Ruminantia* the salutary effects of salt are especially observed. "They contribute powerfully," observes Moiroud (*Pharmac. Vétérin.* p. 410), "to prevent, in these animals, the influence of rainy seasons and wet pasturage, as well as of damaged fodder. Given to animals intended for fattening, it gives more consistence to the fat and more taste to the meat." It appears to be offensive and injurious to many of the lower animals: hence when rubbed on meat, it prevents the attack of insects, and when applied to the skin of leeches causes vomiting.

(*c.*) *On man.*—Chloride of sodium serves some important and essential uses in the animal economy. It is employed, on account of its agreeable taste, by the people of all nations, from the most refined to the most barbarous; but the quantity taken varies with different individuals, inasmuch as some have a much greater relish for it than others. It is, I think, not improbable, that this unequal appetite for salt, in different individuals, is indicative of different wants of the system for this necessary substance;—for salt must serve some more important function than that of merely gratifying the palate. It is an invariable constituent of the healthy blood. Dr. Stevens (*On the Blood*) has shown that the red colour of the blood depends on the saline matters contained in it, for without these this fluid is black. Some of the properties of the sanguineous fluid, such as its fluidity, its stimulating qualities, and its power of self-preservation, are probably more or less connected with its saline constituents. The free hydrochloric acid found in the stomach, and which is so necessary to digestion, is probably derived from the salt taken in with the food, as is also perhaps the soda of the blood. The chloride of sodium found in some of the secretions, as the bile and tears, probably serves some important purposes.

It is said that persons who take little or no salt with their food are very subject to intestinal worms. Dr. Paris (*Pharmacologia*) tells us that Lord Somerville, in his address to the Board of Agriculture, states that the ancient laws of Holland "ordained men to be kept on bread alone *unmixed with salt*, as the severest punishment that could be inflicted upon them in their moist climate; the effect was horrible: these wretched criminals are said to have been *devoured by worms* engendered in their own stomachs." Mr. Marshall (*Med. and Phys. Jour.* vol. xxxix.) tells us of a lady who had a natural aversion to salt: she was most dreadfully affected with worms during the whole of her life.

Considered in a therapeutical point of view it is an irritant in its local operation. Thus applied to the skin and the mucous membranes it causes redness. Taken into the stomach in large quantity (as in the dose of a table-spoonful or more) it excites vomiting, and when thrown into the large intestines produces purging. In moderate quantities it promotes the appetite, and assists digestion and assimilation. If used too freely it occasions thirst. The long-continued employment of salted provisions occasions scurvy: of the correctness of this statement there cannot exist, I think, a shadow of doubt, notwithstanding the bold denial given to it by Dr. Stevens (*op. cit.* p. 262); a denial the more remarkable, since Dr. Stevens admits he has never seen a single case of the disease! His opinion is evidently founded on hypothetical grounds, and is in direct opposition to the best medical testimony we possess.

In some diseases the moderate use of salt produces the effects of a tonic. It acts as a stimulant to the mucous membranes, the absorbent vessels, and glands. Occasionally it seems to merit the designation of an alterative or resolvent.

Properly diluted and injected into the veins, in cholera, it acts as a powerful stimulant and restorative; the pulse, which was before imperceptible, usually becomes almost immediately restored, and, in some cases, reaction and recovery follow. A solution of common salt produces no change in the size and form of the sanguineous particles out of the body (Müller's *Physiology*). Dr. Macleod injected a solution of common salt into the jugular vein of a rabbit which had been asphyxied, but without restoring or producing resuscitation (*Med. Gaz.* vol. ix. p. 358).

USES.—The following are some of the most important therapeutical uses of chloride of sodium.

As *a vomit*, it has been recommended in malignant cholera, in preference to other emetics (Searle, *Med. Gaz.* vol. viii. p. 538; Sir D. Barry, *Med. Gaz.* vol. ix. pp. 321 and 407; Brailoff and Isenbeck, *ibid*, p. 490*). In narcotic poisoning, in the absence of the stomach-pump and the ordinary emetic substances, it may also be employed. The dose of it is one or two table-spoonfuls in a tumblerful of water. A tea-spoonful of flour of mustard assists its action. As a *purgative* it is seldom employed except in the form of enema. One or two table-spoonfuls of common salt dissolved in a pint of gruel form a very useful clyster for promoting evacuations from the bowels.

It has been used in some diseases with the view of *restoring the saline qualities of the blood*. Dr. Stevens (*op. cit.*) has shewn that the red colour of the blood depends on the presence of its saline constituents, and that when deprived of these, this fluid is black. Now, in cholera, the blood is remarkably black, incapable of coagulating, and contains more albumen and hematosine, but less water and saline parts, than natural; while the enormous discharges from the bowels consist of a weak solution of albumen containing the salts of the blood (Dr. O'Shaughnessy, *Report on the Chemical Pathology of the Malignant Cholera*, 1832). The obvious indications, therefore, in the treatment of this disease, are to restore the water and saline matters to the blood. Hence originated what has been called the *saline treatment* of cholera. This, at first, consisted in the exhibition of certain alkaline salts by the mouth, and in the form of enemata. The following are formulæ which have been recommended :—

Take of Carbonate of Soda . . half a drachm.
Chloride of Sodium . a scruple.
Chlorate of Potash . . 7 grains.

Dissolve in half a tumblerful of water. This to be repeated at intervals of from 15 minutes to an hour, according to circumstances (Dr. Stevens, *op. cit.* p. 459).

Take of Phosphate Soda . . . . . . 10 grains.
Chloride of Sodium . . . . 10 grains.
Carbonate of Soda . . . . 5 grains.
Sulphate of Soda . . . . . 10 grains.

Dissolve in six ounces of water. The mixture to be repeated every second hour (Dr. O'Shaughnessy, *op. cit.* p. 54).

This plan, however, was followed by that of injecting saline solutions into the veins: which was, I believe, first practised by Dr. Latta (*Med. Gaz.* vol. x. p. 257.) The quantity of saline solution which has been in some cases injected is enormous, and almost incredible. In one case "120 ounces were injected at once, and repeated to the amount of 330 ounces in 12 hours. In another, 376 ounces were thrown into the veins between Sunday at 11 o'clock A.M. and Tuesday at 4 P. M.; that is, in the course of 53 hours, upwards of 31 pounds. The solution that was used consisted of two drachms of muriate and two scruples of carbonate of soda to sixty ounces of water. It was at the temperature of 108° F. or 110° F." (*Med. Gaz.* vol. x. p. 257.) In another series of cases 40 lbs were injected in 20 hours ; 132 ounces in the first 2 hours ; 8 lbs. in half an hour! (*Med. Gaz.* vol. x. pp. 379-80.) The *immediate* effects of these injections, in a large majority of cases, were most astonishing: restoration of pulse, improvement in the respiration, voice, and general appearance, return of consciousness, and a feeling of comfort. In many instances, however, these effects were only temporary, and were followed by collapse and death. In some, injurious consequences resulted, as phlebitis (*Med. Gaz.* vol. x. p. 453), drowsiness, (*ibid.* p. 447), &c. The reports as to the ultimate benefit of the saline treatment in cholera are so contradictory, that it is exceedingly difficult to offer the student a correct and impartial estimate of its value. That it failed in a large proportion of cases, after an extensive trial, and greatly disappointed some of its staunchest supporters, cannot be doubted. (*Med. Gaz.* vol. x. p. 717.) Dr. Griffin (*Recollections of Cholera*, in *Med. Gaz.* vol. xxii. p. 319) states that all the published cases of injection which he can find recorded amount to 282, of which 221 died, while 61 only recovered: but he thinks that the average recoveries from collapse by this method of treatment "far exceeded the amount of any other treatment in the same district and under the same circumstances."

Common salt has been employed as an *anthelmintic*. For this purpose it is exhibited in large doses by the mouth, or, when the worms are lodged in the rectum, a strong solution is administered in the form of enema. When leeches have crept into the rectum, or have been accidentally swallowed, a solution of salt should be immediately used. As a *chemical antidote* chloride of sodium may be administered in poisoning by nitrate of silver. As an *alterative and tonic* it is useful in scrofula and glandular diseases. As an *astringent* in hæmorrhages, dysentery, and diarrhœa, it has been administered in combination with lime juice or lemon juice (*Memoir of the late Dr. Wright*, p. 322).

As an *external application* salt has been used for various purposes. Thus, a saturated solution of salt, applied with friction, is employed, as a counter-irritant and discutient, in glandular enlargements and chronic diseases of the joint; as a stimulant, it is rubbed on to the chest in fainting and asphyxia. A solution of salt is employed for baths (cold and warm), affusion, the douche, &c. Its action is more stimulant and tonic than simple water, and the reaction or glow more rapidly and certainly takes place. Consequently, the salt-water bath may be used for a longer period, without causing exhaustion, than the pure water bath. It is a popular opinion, which is probably well founded, that patients are less likely to take cold after the salt-water bath than after the common water bath.

ADMINISTRATION.—As a tonic and alterative, the dose of salt is from ten grains to a drachm. As an emetic, from two to three table-spoonfuls in five or six ounces of warm water. As a cathartic, from half an ounce to an ounce. In the form of clyster, it is used to the extent of two or even three table-spoonfuls. A solution of one part of salt in forty parts of water will form a bath of about the same strength as sea water.

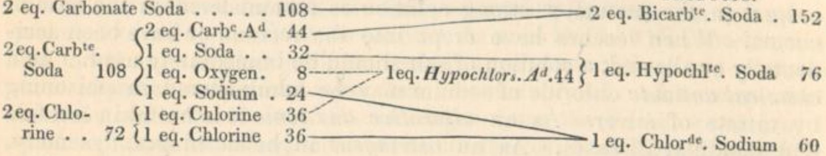
So'dæ Hypochlo'ris.—Hypochlo'rite of So'da.

HISTORY.—The disinfecting power of a solution of this substance was discovered by Labarraque about 1820 (Alcock, *Essay on the Use of the Chlorurets*, p. vi). In the London Pharmacopœia this solution is called *liquor sodæ chlorinatæ;* in the French Codex, *hypochloris sodicus aqua solutus.* It is commonly known in the shops under the name of *chloride of soda, liqueur de Labarraque*, or *Labarraque's soda disinfecting liquid.* Other synonymes for it are *chloruret of the oxide of sodium*, and *oxymuriate of soda.*

PREPARATION.—There are two methods in use for preparing a solution of hypochlorite of soda.

(*a.*) *Process of the Pharmacopœia.*—Dissolve a pound of carbonate of soda in two pints of water; then put four ounces of chloride of sodium and three ounces of binoxide of manganese, rubbed to powder, into a retort; and add to them four ounces of sulphuric acid previously mixed with three fluidounces of water, and cooled. Heat the mixture, and pass the chlorine, first through five fluidounces of water, and afterwards through the above prescribed solution of carbonate of soda.

When chlorine gas comes in contact with a solution of carbonate of soda, three salts are formed: chloride of sodium, hypochlorite of soda, and bicarbonate of soda.



The essential and characteristic properties of this solution depend on the hypochlorite of soda. The changes which take place in the manufacture of chlorine have been already explained (p. 105).

(*b.*) *Process of the French Codex.*—Diffuse one part of dry chloride of lime (hypochlorite of lime) through 30 parts of water. Then add two parts of crystallized carbonate of soda, previously dissolved in 15 parts of water. Filter the mixture. In this process a double decomposition is effected; hypochlorite of soda is formed in solution, while carbonate of lime precipitates. This process is more easy of execution than the previous one. By using the proportions here directed the solution is much weaker than that prepared by the process of the London Pharmacopœia.

PROPERTIES.—The solution of hypochlorite of soda (*liquor sodæ chlorinatæ* of the London Pharmacopœia) has a yellowish colour, an astringent taste, and an odour of chlorine. It destroys the colour of vegetable substances; as litmus, turmeric, and sulphate of indigo. Previous to bleaching them, it reacts as an alkali on turmeric paper, and infusion of red cabbage. By evaporation, crystals are obtained, which by re-solution in water re-produce the disinfecting liquid. By exposure to the air, the solution undergoes decomposition, and crystals of carbonate of soda are formed.

CHARACTERISTICS.—The following are the essential characters of the *liquor sodæ chlorinatæ*, Ph. L.:—It decolorizes sulphate of indigo. On the addition of hydrochloric acid it evolves chlorine and carbonic acid. A solution of nitrate of silver throws down a white precipitate (chloride of silver) soluble in ammonia, but insoluble in nitric acid. Lime water causes a white precipitate (carbonate of lime). Oxalate of ammonia occasions no precipitate, shewing the absence of lime. Chloride of platinum produces no yellow precipitate, proving the absence of potash and ammonia. That the base of the solution is soda may be shewn in two ways: evaporated to dryness, we obtain a residuum which renders the outer cone of the flame of a candle, or the flame of a spirit lamp, yellow: saturated with hydrochloric acid and evaporated to dryness, common salt is procured: this may be recognized by the characters before mentioned (p. 310).

COMPOSITION.—Some chemists regard the *liquor sodæ chlorinatæ*, Ph. L. as a mixture of chloride of soda and bicarbonate of soda. But the view usually taken of it is that it consists of hypochlorite of soda, chloride of sodium, and bicarbonate of soda.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—A solution of chloride of soda acts as a local irritant, more or less powerfully according to the degree of its concentration. From the experiments of Segalas (*Journ. de Chim. Med.* t. 1^er^. p. 271) it appears that besides the irritant operation, and its direct and sympathetic action on the organic solids, it exercises an evident influence over the blood, and, in consequence, over the whole economy, by means of absorption. In an experiment referred to by Dr. Christison, (*Treatise on Poisons*, 3d ed. p. 221) two ounces of Labarraque's solution introduced into the peritoneum of a dog excited palpitation, oppressed breathing, constant restlessness, and death in ten minutes.

(*b.*) *On man.*—I am unacquainted with any experiments made to determine the physiological effects of chloride of soda on man. That it would, *in large doses*, act as a powerful local irritant, and, if swallowed, give rise to symptoms of gastro-enteritis, cannot, I think, be doubted. Mérat and de Lens (*Dict. Mat. Méd.* t. ii. p. 257) state that the immediate consequence of, and predominating symptoms produced by, a glassful of *eau de javelle* (a solution of chloride of potash) was general rigidity, which gave way to demulcent drinks. This observation agrees with one made by Segalas (Christison, *op. cit.* p. 221) in his experiments on dogs, namely, that chloride of soda caused tetanic spasms. It is probable, therefore, that the chlorides (hypochlorites) of the alkalies exercise a specific influence over the nervous system.

Chloride of soda, in *moderate or small doses*, has been denominated stimulant, tonic, astringent, antiseptic, and febrifuge. But these terms give no real explanation of the nature of those organic changes produced by this remedial agent, whereby we obtain such benefit from its employment in various diseases. In fever I have seen dampness of the skin follow its use. Increased secretion of urine is a common effect of it. In fevers it improves the qualities of the evacuations. Under the continued employment of it, glandular enlargements and chronic mucous discharges have disappeared, from which circumstance chloride of soda has been denominated alterative and resolvent. All these effects depend probably on the alteration which the chloride gives rise to in the condition of the blood, and the change thereby produced in the action of the different organs. We must not overlook the important fact that the solution of chloride of soda used in medicine contains bicarbonate of soda, to which perhaps in many cases its beneficial effects are, in part at least, to be referred.

USES.—The solution of chloride of soda is employed as a *disinfectant*, *antiseptic*, and *antidote* (in cases of poisoning by the hydrosulphurets, and hydrosulphuric and hydrocyanic acids.) But for most of these purposes the chloride of lime is employed instead of chloride of soda, since its properties are analogous, and being manufactured on a very extensive scale for the use of bleachers, it can be obtained more conveniently and cheaply. On this account, therefore, and to avoid repetition, I must refer to the article HYPOCHLORITE OF LIME for information respecting the above uses of chloride (hypochlorite) of soda. I would remark, however, that in several cases where I have carefully tried and compared the two chlorides (hypochlorites) I give the decided preference to the chloride of soda. As an antiseptic, Labarraque also preferred the latter preparation, on the ground that by the process of disinfection it becomes chloride of sodium, which is not a deliquescent salt; whereas the chloride of calcium generated by chloride (hypochlorite) of lime, attracts water from the atmosphere, and thereby furnishes one of the conditions (viz. moisture) necessary to the putrefactive process. Hence, in his opinion, while chloride of lime will serve equally well for mere disinfection, chloride of soda is preferable where we wish at the same time to prevent a renewal of putrefaction.

Chloride of soda is employed internally in all diseases commonly termed *putrid* or *malignant*, as typhus fever, scarlatina maligna, &c. It is indicated where there are great prostration of strength, fetid evacuations, and a dry and furred tongue. In such cases I have seen it of essential service, improving the quality of the secretions, producing a moist state of the skin, preventing collapse, and altogether acting most beneficially. It may be administered both by the mouth and the rectum.

There are many other diseases in which the solution of chloride of soda has been administered internally with apparent success; but in which a more extended experience of its effects is required to enable us to place confidence in the results. I refer now to the employment of this substance as a substitute for the disulphate of quinia, in intermittents, recommended by Lalesque and Gouzée (*Brit. and For. Med. Rev.* April, 1838); to its use in the treatment of secondary syphilis, as practised by Dr. Scott (*Lond. Med. Rep.* N. S. vol. ii. 1826, p. 139), and by Cazenove, (*Journ. de Chim. Méd.* t. iv. p. 140): to its administration in chronic skin diseases, and as a substitute for chlorine in bilious disorders by Dr. Darling (*Lond. Med. Rep.* N. S. vol. ii.); in scrofula, by Godier (*Journ. Gén. de Méd.* 1829); and in plague, by Neljoubin (Richter, *ausf. Arzneim.* Suppl.-Bd. p. 539.) In some of these cases (as in syphilis and scrofula) the benefit obtained may have resulted from the bicarbonate of soda present in the chloride of the shops.

As a *local* remedy, we employ chloride of soda in all cases attended with fetid discharges, not merely as a disinfectant and antiseptic—that is, as a chemical agent destroying fetor, and preventing the putrefaction of dead matters (as gangrenous parts, the discharges from wounds and ulcers, &c.) though in these respects it is most valuable—but as a means of stopping or relieving morbid action by an impression produced on the living tissues. It frequently puts a stop to the further progress of gangrene; promotes the separation of the dead from the living parts; improves the quality of the secretions; and, at the same time, diminishes their quantity, when this is excessive. We apply it to ulcers of all kinds (whether common, phagedenic, cancerous, syphilitic, or scrofulous) when attended with foul discharges or a disposition to slough. We employ it with the greatest benefit in affections of the mucous surfaces. Thus it is used as a gargle to check ptyalism and ulceration of the mouth, whether arising from mercury or other causes. In scarlatina maligna we apply it to check ulceration and sloughing of the throat. In coryza and ozæna it has been injected into the nostrils with considerable benefit. In fetid and excessive discharges from the vagina, and neck of the uterus or bladder, it is employed as an injection with, at least, temporary relief. It has also been applied in some skin diseases, as tinea capitis, eczema, scabies, prurigo pudendi muliebris, &c. The above are only a few of the cases in which chloride of soda has been used with most marked benefit. In conclusion, I may justly add, that there are few, if any, remedies the uses of which, as local agents, are so valuable and extensive, as the chlorides of soda and lime.

ADMINISTRATION.—The *liquor sodæ chlorinatæ*, Ph. L. may be administered internally in doses of twenty drops or more, diluted with three or four ounces of some mild aqueous liquid. When used as a gargle, it should be diluted with eight or ten parts of water: as an injection into the vagina, it is to be mixed with from fifteen to thirty parts of water: as a wash, its strength must vary according to circumstances. In some sloughing ulcers I have used it mixed with its own volume of water, but in most cases it should, at the commencement of its use, be largely diluted.

ANTIDOTE.—(See CALCIS HYPOCHLORIS.)

So'dæ Sul'phas.—Sul'phate of So'da.

HISTORY.—Sulphate of soda (also called *natron vitriolatum*, *Glauber's salt*, *sal catharticus Glauberi*, or *sal mirabile Glauberi*) was discovered in 1658 by Glauber.

NATURAL HISTORY.—It occurs in both kingdoms of nature. As an efflorescence, the hydrous sulphate of soda is met with in various parts of the world. In the anhydrous state, mixed with a minute portion of carbonate of soda, it constitutes the mineral called *Thenardite*. Sulphate of soda is a constituent of many mineral waters; as those of Cheltenham, Leamington, and Spital. It is found in the ashes of some plants which grow by the sea-shore; as the *Tamarix gallica*. Lastly, it is found in some of the animal fluids; as the blood and urine.

PREPARATION.—It is a product of several chemical processes. In the Pharmacopœia it is directed to be prepared from the salt which remains after the distillation of hydrochloric acid. This salt consists of sulphate with some bisulphate of soda. It is to be dissolved in water, and to the solution carbonate of soda is to be added, to saturate the excess of acid in the bisulphate. The liquid is then to be boiled down, strained, and crystallized.

In consequence of the enormous consumption of sulphate of soda in the manufacture of carbonate of soda, makers of the latter article are obliged to procure sulphate purposely, by the addition of sulphuric acid to chloride of sodium.—[For the theory of this process, see p. 149.]

PROPERTIES.—The primitive form of the ordinary crystallized sulphate of soda is the oblique rhombic prism. To the taste this salt is cooling, and bitterish saline. By exposure to the air it effloresces. When heated it undergoes the watery fusion, gives out its water of crystallization, and thereby becomes a white solid, and at a red heat it again becomes liquid. One part of it dissolves in three parts of water at 60°, or one part of water at 212°. It is insoluble in alcohol.

CHARACTERISTICS.—Its constituents, sulphuric acid and soda, may be detected by the tests for these substances before mentioned (pp. 265 and 310). From the bisulphate of soda it is distinguished by its not reddening litmus, and by its less solubility. Crystals of anhydrous sulphate of soda are distinguished by their form being the rhombic octahedron.

COMPOSITION.—The ordinary crystals of sulphate of soda have the following composition:—

	Eq.	Eq. Wt.	Per Cent.	Berzelius.	Wenzel.
Soda	1	32	19·75	19·24	19·5
Sulphuric Acid	1	40	24·69	24·76	24·3
Water	10	90	55·56	56·00	55·2
Ordinary Crystals of Sulph^{te}. of Soda	1	162	100·00	100·00	99·0

PURITY.—The crystallized sulphate of soda of the shops is usually sufficiently pure for medical purposes. The presence of chlorides in it may be detected by nitrate of silver.

PHYSIOLOGICAL EFFECTS.—It is a mild but efficient cooling laxative or purgative salt, promoting secretion and exhalation from the mucous membrane of the stomach and bowels, without causing inflammation or fever.

USES.—It may be employed as a common purgative, either alone or added to other purgatives. It is applicable in fevers and inflammatory affections, where we want to evacuate the bowels without increasing or causing febrile disorder.

ADMINISTRATION.—The usual dose of it is from six to eight drachms. When dried, so as to expel the water of crystallization, three and a half drachms act as an efficient purgative.

So′dæ Bibo′ras.—Bibo′rate of So′da.

HISTORY.—Pliny (*Hist. Nat.* lib. xxxiii) describes a substance under the name of *chrysocolla*, which has been supposed by some to be biborate of soda. The term *bauracon* or *baurach* (from which our word *borax* is derived) first occurs in the writings of the Arabians. By some of these authors (as Mesue and Avicenna) it was applied to nitre (Beckmann, *Hist. of Invent. and Discov.* vol. iv. p. 559): it is not improbable, however, that Geber (*Search of Perfection*, ch. iii.) used it to indicate our borax. By modern chemists the salt has been termed *biborate, borate*, or *sub-borate of soda*.

NATURAL HISTORY.—Borax is a substance peculiar to the mineral kingdom. It has been found in some mineral waters; as those of San Restituta, in Ischia (Gairdner, *On Mineral Springs*, p. 414). It occurs also in the waters of certain lakes, especially those of Thibet and Persia.

PREPARATION.—Borax is obtained in two ways:—1st, by refining native borax; 2dly, by saturating native boracic acid with soda.

(*a*.) *By refining native or crude borax.*—About fifteen days' journey north from Teeshoo Lomboo, in Thibet, is a lake, said to be about twenty miles in circumference, and supplied by brackish springs rising from the bottom of the lake itself. In consequence of its high situation, during a part of the year this lake is frozen over. The water of it contains, in solution, both common salt and borax. The latter crystallizes on the edges and shallows of the lake, and is taken up in large masses, which are broken and dried.

It is imported, usually from Calcutta, under the name of *tincal* (a word derived from *tincana*, the Sanscrit name for borax; Royle's *Essay on Hindoo Medicine*, p. 97) or *crude borax* (*borax cruda* seu *nativa*), in the form of flattened six-sided prisms, coloured with a greasy unctuous substance, said, by Vauquelin, to be a fatty matter, saponified by soda; the colour is yellowish, bluish, or greenish. Mojon states that the greenish grey matter which surrounds some kinds of rough borax, contains native boron. Various methods have been contrived for refining borax; some calcine it, to destroy the fatty matter, others wash it with an alkaline solution (soda or lime), and then dissolve and crystallize. The product is called *refined borax* (*borax depurata* seu *purificata*).

(*b*.) *By saturating native boracic acid.*—In the year 1776, Messrs. Hoefer and Mascagni discovered boracic acid in the Lagoni of Tuscany, in a state of efflorescence, and also in solution in the waters with which the soil is impregnated. From the soil is constantly evolved aqueous vapour, impregnated with boracic and hydrosulphuric acids; formed, as it is supposed, by the action of water on sulphuret of boron contained in the interior of the earth,—by which part of the water is decomposed, the oxygen of which acidifies the boron, while the hydrogen forms hydrosulphuric acid with the sulphur, and the heat evolved causes the formation of some aqueous vapour. By washing the mud surrounding the *fumaroles*, or craters, decanting the liquor, and evaporating, *rough* or *Tuscany boracic acid* is obtained. To form borax from this, a solution of the carbonate of soda is saturated with the rough acid: effervescence takes place, and borax is formed.

PROPERTIES.—It occurs in large, colourless, transparent crystals, whose primary form is the oblique rhombic prism. In commerce we frequently meet with it in irregular shaped masses. Its taste is saline, cooling, and somewhat alkaline. It reacts on turmeric paper like an alkali. By exposure to the air it effloresces slowly and slightly. When heated it melts in its water of crystallization, swells up, and forms a light, white, porous substance, called *calcined borax* (*borax usta* seu *calcinata*). At a higher temperature it fuses into a transparent glass (*glass of borax*), which is anhydrous borax. It is soluble in twelve parts of cold, or in two parts of hot water.

CHARACTERISTICS.—Borax may be recognized by the following characters: it reddens turmeric paper; it fuses before the blowpipe into a glass, which may be readily tinged by various metallic solutions,—thus, rose red by chloride of gold, and blue by solutions of cobalt; if a few drops of sulphuric acid be added to powdered borax, and then spirit of wine, the latter will, when fired, burn with a green-coloured flame; lastly, if to a strong hot solution of borax, sulphuric acid be added, boracic acid will be deposited in crystals, as the liquid cools. The tests now mentioned for the most part only prove the salt to be a borate: the nature of the base is determinable by the tests for soda before described (p. 310).

COMPOSITION.—Chemists are not agreed as to the precise atomic constitution of borax, in consequence of a difference of opinion as to the equivalent of boron. In the following table the first column shows the number of equivalents according to Berzelius, Dumas, and Turner,—in the second, according to L. Gmelin, Brande, and Phillips.

	Eq.	Eq.	Eq. Wt.	Per Cent.	Berzelius.	L. Gmelin.
Soda	1	1	32	16·66$\dot{6}$	16·31	17·8
Boracic Acid	2	1	70	36·45$\dot{8}$	36·59	35·6
Water	10	10	90	46·87$\dot{5}$	47·10	46·6
Crystallized Borax	1	1	192	99·99$\dot{9}$	100·00	100·0

By a particular management of the crystallizing process, Payen has obtained borax in permanent octahedral crystals, containing only five equivalents of water. It is termed *octahedral borax*, in contra-distinction to the ordinary kind, which is called *prismatic borax*. Octahedral borax offers several advantages to the arts over the prismatic variety (Guibourt, *Hist. des Drog.* t. i. p. 191, ed. 3^{me}.)

PHYSIOLOGICAL EFFECTS.—The effects of borax have been imperfectly ascertained. Its *local* action is that of a mild irritant: applied to sores it excites smarting, and taken into the stomach, in large doses, excites vomiting.

The *constitutional effects* are probably those of a mild refrigerant and diuretic. Wöhler and Stehberger detected it in the urine, so that it passes out of the system unchanged.

By some writers it is regarded as an agent exercising a specific influence over the uterus; promoting menstruation, alleviating the pain which sometimes attends this process, facilitating parturition, diminishing the pain of accouchement, and favouring the expulsion of the placenta and lochia (Vogt's *Pharmakodynamik*). Further evidence, however, is wanting to enable us either to admit or deny the supposed uterine influence of borax. Some recent English writers seem to entertain no doubt as to its promoting uterine contractions (Dr. Copland, *Dict. of Pract. Med.* art. *Abortion*, and *Brit. and For. Med. Rev.* for July 1838, page 86).

Borax has also been regarded as producing the effects of alkalies on the system; principally, I believe, from an erroneous notion that it was a subsalt (Vogt, *op. cit.* and Sundelin, *Heilmittellehre*). When Homberg asserted that boracic acid was a sedative, borax was supposed to possess similar properties.

USES.—As a *local agent*, borax is employed, as a detergent, in aphtha and ulceration of the mouth. In some skin diseases it has been used with benefit: as pityriasis versicolor (called also *liver spots* or *chloasma*). A solution of it in rose-water is employed as a cosmetic. In gonorrhœa and leucorrhœa an aqueous solution has been occasionally used, as an injection, with success. Lastly, in the form of ointment it has been applied to inflamed and painful hæmorrhoidal tumors.

Internally it has been used to diminish the secretion of uric acid; to act as a diuretic in dropsical cases; and to influence the uterus in the cases before mentioned. To promote uterine contractions, Dr. Copland recommends it in conjunction with ergot of rye.

ADMINISTRATION.—The dose of it is from half a drachm to a drachm. As a detergent in aphtha it may be used in powder, mixed with sugar or with honey. The *MELLITE OF BORAX* (*mel boracis*, Ph. L.) consists of a drachm of powdered borax mixed with an ounce of clarified honey; it is the most eligible form for the employment of borax in the aphtha of children.

So'dæ Phos'phas.—Phos'phate of So'da.

HISTORY.—This salt was long known before its true nature was understood. In 1737 Hellot found it in the urine. It has been known by various names, such as *alcali minerale* and *sal mirabile perlatum*. In the shops it is sold as *tasteless purging salts*. Dr. Turner calls it *triphosphate of soda and basic water*. It is sometimes termed the *rhombic phosphate of soda*.

NATURAL HISTORY.—It has been found, in small quantities, in some mineral waters (Gairdner, *On Mineral Springs*, p. 19). It exists in many animal fluids, especially the urine of man.

PREPARATION.—It is procured as follows:—carbonate of soda is added to the impure solution of phosphoric acid, obtained by digesting bone-ash in sulphuric acid (*vide* p. 250) to saturation: the liquid is then filtered, evaporated, and put aside to crystallize. A slight excess of soda promotes the formation of fine crystals.

PROPERTIES.—The primary form of the crystals of this salt is the oblique rhombic prism. The crystals are transparent, but by exposure to the air effloresce and become opaque. Their taste is cooling saline. They react feebly on vegetable colours like alkalies. When heated, they undergo the watery fusion, give out water, and form a white mass which has been called *pyrophosphate of soda*: at a red heat this melts into a transparent glass, called *metaphosphate of soda*. The crystals of phosphate of soda require, for their solution, four times their weight of cold or twice their weight of hot water: they are nearly insoluble in alcohol.

CHARACTERISTICS.—The presence of soda in this salt is known by the tests for this base before mentioned (p. 310). The phosphoric acid in it is recognised as follows: a solution of the phosphate throws down a white precipitate with acetate lead, as well as with chloride of barium: the precipitate in both cases is a phosphate, and dissolves in nitric acid without effervescence: with nitrate of silver, the phosphate of soda occasions a yellow precipitate soluble both in nitric acid and ammonia: pyrophosphate of soda, obtained by heating the phosphate, produces a white precipitate with nitrate of silver: hydrosulphuric acid, as well as the hydrosulphates, occasion no change in a solution of phosphate of soda. Phosphate of lead fused upon charcoal, in the outer flame of the blowpipe, becomes distinctly crystalline upon cooling.

COMPOSITION.—Some difference of opinion exists as to the atomic constitution of this salt, as is obvious from the following table:—

	Brande and Phillips.			Graham and Turner.			Berzelius.
	Eq.	Eq.Wt.	PerCt.	Eq.	Eq.Wt.	PerCent.	(Experiment.)
Soda	1	32	18·2	2	62·6	17·20	17·67
Phosphoric Acid	1	36	20·5	1	71·4	19·94	20·33
Water	14	108	61·3	25	225·0	62·84	62·00
Crystallized Phosphate Soda	1	176	100·0	1	359·0	99·98	100·00

According to Mr. Graham, one of the twenty-five equivalents of water performs the function of a base to the acid.

PHYSIOLOGICAL EFFECTS.—In doses of an ounce, or an ounce and a half, it acts as a mild antiphlogistic purgative, like sulphate of soda. In small and continued doses it has been used with the view of altering the composition of the blood, and of promoting the deposit of phosphate of lime in the bones.

USES.—As a purgative it is employed in the diseases of children and delicate persons, in preference to other saline substances, on account of its slight taste and mild action on the stomach. It is well adapted for febrile and inflammatory disorders.

It is one of the substances which have been employed in cholera, to restore to the blood its deficient saline matters (Dr. O'Shaughnessy, *Report on the Chemical Pathology of the Malignant Cholera*, p. 54). On account of the phosphoric acid which it contains it has been supposed to be particularly applicable in those diseases in which there is a deficiency of phosphate of lime in the bones. It has also been administered in diabetes.

ADMINISTRATION.—As a purgative it is given in doses of from six to twelve drachms. It is best taken in broth or soup. As an alterative the dose is one or two scruples three or four times a day.

So'dæ Car'bonas.—Car'bonate of So'da.

HISTORY.—This salt, as well as the sesquicarbonate of soda, was probably known to the ancients under the term of *νίτρον*, or *nitrum* (vide *Potassæ Nitras*, p. 292; also *Sodæ Sesquicarbonas*). The *salt-alkali*, or *sagimen vitri* of Geber (*Invent. of Verity*, ch. iv., and *Search of Perfection*, ch. iii.) was a carbonate of soda: the word *sagimen* is a corruption of the Hindee term *sajjiloon*, (Dr. Royle, *Essay on Hindoo Medicine*, p. 41). In modern times this salt has had various appellations, such as *mild mineral* or *fossil alkali*, *aërated mineral alkali*, *subcarbonate of soda*, and *natrum carbonicum*.

NATURAL HISTORY.—It is found in crystals, or in the form of an efflorescent powder, in several parts of the world. According to Klaproth (quoted by Dr. Thomson, in his *Outlines of Mineralogy*, vol. i. p. 96), it occurs at Debrezin, in Hungary, and Montenuovo, near Naples. Beudant (quoted by Necker in his *Règne Minéral*, t. 2^{me}. p. 667) has analyzed three native carbonates of soda: one from Lac Blanc, in Hungary; a second from Egypt; and a third from Vesuvius. Carbonate soda is a constituent of some mineral waters, which are, in consequence, termed *alkaline*, or, when they also contain a large excess of carbonic acid, *acidulo-alkaline* (see p. 148).

PREPARATION.—It may be procured from *barilla*, from *kelp*, or from *sulphate of soda*.

1. *From barilla.*—The substance called *barilla* is an ash usually obtained by the combustion of plants belonging to the order *Chenopodiaceæ*; as the Salsolas, Salicornias, and Chenopodiums. These are cultivated on the coasts, and when ripe are cut, dried, and burned in heaps: the resulting ash is barilla. It is a hard greyish or bluish mass, not deliquescent, having an alkaline acrid taste, and a peculiar odour. It consists of carbonate and sulphate of soda, sulphuret and chloride of sodium, carbonate of lime, alumina, silica, oxide of iron, and carbonaceous matter which has escaped combustion. The carbonate of soda is produced by the decomposition of the oxalate and other organic salts of soda contained in the plants before combustion. Several varieties of barilla are known in the market: they are distinguished by the names of the places from whence they are imported; namely, the Grand Canary and Teneriffe Islands, Alicant, Sicily, Carthagena, and the East Indies. *Canary barilla* is procured from *Salsola Kali* (Loudon, *Encyclop. of Agricult.*); *Alicant barilla* (*soda hispanica, s. alicantina*) is obtained from *Salsola sativa*, *Chenopodium setigerum*, and other species (Lagasca, quoted in Decandolle's *Phys. Vég.* p. 388). It yields from 25 to 40 per cent. of carbonate of soda. *Sicily barilla* is procured principally from *Salsola sativa:* it furnishes, according to Fée (*Cours d'Hist. Nat.* t. 2nd. p. 488), 55 per cent. of carbonate of soda. Of the *French barillas* two only deserve notice; namely, that of Narbonne, obtained from *Salicornia herbacea*, and which yields 14 or 15 per cent. of carbonate; and that of Aiguemortes, called *Blanquette*, and which contains from 3 to 8 per cent. only of alkaline carbonate.

Carbonate of soda is procured from barilla by dissolving it in water, filtering the solution, evaporating, and crystallizing. The importation of barilla has very much fallen off of late years, in consequence of the extraction of carbonate of soda from sulphate of soda. In 1827 the quantity imported was 326,239 cwts. (*A General Statement of the Imports and Exports*, printed by order of the House of Commons, 24th Feb. 1829); whereas, in 1837, it was only 16,760 cwts. (*Trade List*, Jan. 9, 1838).

2. *From kelp.*—Kelp (called by the French *Varec* or *Normandy Soda*) is procured by the combustion of cryptogamic plants of the order *Algaceæ*. According to Dr. Greville (*Algæ Britannicæ*, p. xxi.) the species most valued for this purpose are *Fucus vesiculosus*, *nodosus* and *serratus*, *Laminaria digitata* and *bulbosa*, *Himanthalia lorea*, and *Chorda Filum*. These are burned in coffers of stone or in kilns. About 24 tons of sea-weed are required to produce one ton of kelp (Macculloch's *Western Islands*, vol. i. p. 123). The resulting ash is kelp. As met with in commerce, it consists of hard, dark grey or bluish masses, having an acrid caustic taste, and composed of chloride of sodium, about five per cent. of carbonate of soda (formed by the decomposition of the oxalate and other organic salts of soda), sulphates of soda and potash, chloride of potassium, iodide of potassium or sodium, and insoluble and colouring matters. By digestion in a small quantity of water, filtering and evaporating the solution, crystals of carbonate of soda may be procured. But as this salt can be procured at a lower price and of finer quality from artificial soda, kelp is now of little value as a source of soda. In the Orkney Islands, about 20,000 persons were, a few years since, occupied in the manufacture of kelp (Greville, *op. cit.*)

3. *From sulphate of soda.*—The principal manufactories are situated in the northern parts of the kingdom, and are conducted on a most extensive scale. The process adopted varies in some of its details in different places.

The sulphate of soda employed is, in part, obtained from manufacturers of chloride of lime, who procure a considerable quantity in the process for generating chlorine. But the greater part of it is made expressly by adding sulphuric acid to common salt (chloride of sodium). The hydrochloric acid which is evolved is allowed to escape into the atmosphere, and is most injurious to animal and vegetable life, as I have before stated (*vide* p. 150). In the report of a trial at Lancaster, March 21, 1838, the Queen *v.* Airey, in the *Times* newspaper, is contained a very humorous account of the unpleasant effects of this gas. For the sake of economy, manufacturers of carbonate of soda usually make their own sulphuric acid.

The sulphate of soda is usually decomposed by mixing it with chalk and some carbonaceous matter (small coal, charcoal, or sawdust), and heating the mixture in a reverberatory furnace. The proportions used by Leblanc (Dumas, *Traité de Chimie*, t. 2^{me}. p. 475) are 1000 parts of dry sulphate of soda, 1000 of chalk, and 550 of charcoal. In a large manufactory in the neighbourhood of London the proportions of the ingredients employed are nearly 2 parts sulphate, 1 part chalk, and 1 part small coal. The product of this operation has a dark grey or blackish appearance, and is called *English barilla* or *ball alkali.* By lixiviating with water and evaporating the resulting solution, a blackish crystalline mass is obtained, which, when roasted, is called *soda-ash.* This is digested in water, the solution evaporated, and the carbonate of soda afterwards crystallized in iron pans. For other modes of proceeding I must refer to the *Traité de Chimie* of Dumas, or Brande's *Manual of Chemistry*, and Duncan's *Edinburgh Dispensatory.*

The *theory* of the process is the following: the sulphuric acid of the sulphate is deprived of oxygen by the carbonaceous matter (coal or sawdust), while its sulphur is partly burnt and escapes as sulphurous acid, and partly combines with the calcium of the chalk to form sulphuret of calcium. The soda unites with carbonic acid produced by the decomposition of the chalk, as well as by the combustion of carbon. To purify the impure carbonate of soda of the shops, it is ordered, in the Pharmacopœia, to be dissolved, strained, and re-crystallized.

PROPERTIES.—Carbonate of soda usually forms large crystals, the primitive form of which is, according to Mr. Brooke, the oblique rhombic prism. They are transparent, and have a cooling alkaline taste. By exposure to the air they effloresce. When heated they undergo the watery fusion and give out their water of crystallization: at a red heat, the whole of the water is expelled, and when the resulting anhydrous carbonate has been rubbed to powder it constitutes the *sodæ carbonas exsiccata*, Ph. L.: 54 grains of which are equivalent to 144 grains of the crystallized salt. Carbonate of soda is insoluble in alcohol. It dissolves in twice its weight of water at 60°, and in less than its own weight at 212° F. The solution reacts as an alkali on vegetable colours.

CHARACTERISTICS.—As a carbonate it is known by the tests for this class of salts already stated (vide p. 301.) From the bicarbonates it is distinguished by the brick-red precipitate (percarbonate of mercury) which it throws down with bichloride of mercury. Sulphate of magnesia causes a white precipitate with it. As a soda salt it is recognised by the tests for this basic substance already stated (p. 310.)

COMPOSITION.—The perfect crystals of the ordinary carbonate of soda of commerce have the following composition:—

	Eq.	Eq. Wt.	Per Cent.	Klaproth.
Soda	1	32	22·25	22
Carbonic Acid	1	22	15·25	16
Water	10	90	62·5	62
Crystallized Carbonate of Soda	1	144	100·00	100

IMPURITY.—The ordinary impurities of this salt are sulphates and chlorides. These are detected as follows:—Supersaturate with nitric acid, and then add, to separate portions of the solution, chloride of barium and nitrate of silver: if the first occasion a white precipitate, it indicates the presence of a sulphate—if the second also produce a white precipitate, soluble in ammonia, it shews the presence of a chloride.

PHYSIOLOGICAL EFFECTS.—Carbonate of soda is less acrid, and has a milder and less unpleasant taste, than carbonate of potash; but in other respects the effects of these two salts on both vegetables and animals are the same.

USES.—Carbonate of soda is used in the same cases as carbonate of potash, over which it has the advantage of a less disagreeable taste. Fourcroy imagined that as soda is contained in animals in larger proportion than potash it was a better agent for medicinal use. Experience, however, has not confirmed this opinion, but has proved the reverse; for both Sir G. Blane (*Trans. of a Society for the improvement of Med. and Chirurg. Knowledge*, iii. 347) and Mr. Brande (*Quart. Journ. of Science*, vol. vi. p. 205) state that they obtained beneficial effects, in calculous complaints, from the use of potash, where soda failed to give any relief. Sir G. Blane accounted for this by assuming that soda becomes applied to the purposes of the economy before it reaches the kidneys, whereas potash is carried to these organs in order to be thrown out of the system.

ADMINISTRATION.—Crystallized carbonate of soda is exhibited in doses of from ten grains to half a drachm or a drachm, or five grains to a scruple of the dried carbonate, which may be given either in the form of powder or pills.

It is sometimes employed in the manufacture of the effervescing draught. A scruple of the crystallized salt saturates about 9¼ grains of the ordinary crystals of citric acid, 10½ grains of crystallized tartaric acid, or 2½ fluidrachms of lemon juice.

ANTIDOTES.—(*Vide* art. POTASSA, p. 279).

So'dæ Sesquicar'bonas.—Sesquicar'bonate of So'da.

In the province of Sukena, near Tripoli, is found a substance which the Africans call *Trona*—a word from which are probably derived the terms *νίτρον*, *nitrum*, and *natron* (vide POTASSÆ NITRAS and SODÆ CARBONAS). But the analyses of Klaproth (*Beitrage*, iii. 83), Phillips (*Quart. Journ. of Science*, vol. vii. 297), and Beudant (quoted by Necker, *Règne Minéral*,

ii. 668) show that the quantity of carbonic acid which it contains is larger than the carbonate, and less than the bicarbonate: hence Mr. Phillips denominated the salt a sesquicarbonate. From the analysis of MM. Mariano de Rivero and Bossingault (*Ann. de Chim.* xxix. 110) it appears that the substance termed *Urao,* and which occurs at the bottom of a lake at Lagunillas, near Merida, in South America, has a similar composition.—[For an account of this lake, see *Quart. Journ. of Science,* vol. i. p. 188.]

The white powder sold in the shops of this country for making *sodaic powders,* and which is denominated *carbonate, bicarbonate,* or *sesquicarbonate of soda,* is a compound of soda and carbonic acid; the quantity of the latter constituent being greater than that of the carbonate, but less than that of the bicarbonate. Hence in the Pharmacopœia this salt is denominated *sodæ sesquicarbonas,* and its composition has been supposed to be identical with the *trona* of Africa and the *urao* of South America. It is distinguished from the ordinary carbonate of soda by its not causing a white precipitate with a cold solution of sulphate of magnesia.

The so-called sesquicarbonate of soda of the shops, usually, if not invariably, contains carbonate and bicarbonate of soda; these may be detected as follows:—Wash with a small quantity of distilled water, and filter: the solution contains carbonate of soda (known by its throwing down a brick-dust red precipitate on the addition of bichloride of mercury)—while there remains on the filter bicarbonate of soda (recognized by its causing a white precipitate, or a slight milkiness or opalescence with bichloride of mercury.)* The relative proportions of carbonate and bicarbonate of soda are not constant—a fact which will explain the following remark made by Mr. Phillips (*Transl. of the Pharm.* 3rd. ed. 1838):—"I am informed by Mr. Everitt that bicarbonate of soda is now not unfrequently to be met with; and very commonly, instead of mere sesquicarbonate, a mixture of this salt and a large proportion of bicarbonate may be obtained from those who manufacture on a large scale." (For further information respecting the *sodæ sesquicarbonas,* Ph. L., see SODÆ BICARBONAS.)

The composition of native crystallized sesquicarbonate of soda is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Klaproth. *Trona.*	Boussingault. *Urao.*
Soda	1	32	38·55	37·0	38·62
Carbonic Acid	1½	33	39·76	38·0	40·13
Water	2	18	21·69	22·5	21·24
Sulphate Soda	—	—	—	2·5	—
Native Sesquicarbonate Soda	1	83	100·00	100·0	99·99

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* I have been recently informed by Mr. Scanlan that the salt called *Ammoniæ Sesquicarbonas* (vide p. 173) is resolved, by washing with water, into two salts, the carbonate of ammonia, which dissolves, and a mass of crystals of bicarbonate of ammonia having the form of the lump of sesquicarbonate employed. Mr. Scanlan has also obligingly furnished me with illustrative specimens of the above results. The crystals of what he has sent me as bicarbonate of ammonia have, however, a slight odour of ammonia; but he tells me, that when first prepared they were odourless. Dr. Dalton (*Mem. of the Lit. & Phil. Soc. of Manchester,* 2nd Ser. vol. iii. p. 18) seems to have been aware that the salt now called sesquicarbonate of ammonia was a mixture of two salts.

So'dæ Bicar'bonas.—Bicar'bonate of So'da.

History.—This salt was discovered by Valentine Rose. In some works it is termed *natron carbonicum perfecte saturatum seu acidulum*. Mixed or combined with carbonate of soda it constitutes the *sodæ sesquicarbonas* of the Pharmacopœia—the *carbonate* or *bicarbonate of soda* or the shops.

Natural History.—It is a constituent of the mineral waters called *acidulo-alkaline*, as those of Carlsbad and Seltzer.

Preparation.—There are several methods of procuring it. Of these I shall briefly notice three.

1. *Process of the Pharmacopœia.*—The substance called in the London Pharmacopœia *sodæ sesquicarbonas* is ordered to be prepared as follows:—Dissolve seven pounds of carbonate of soda in a gallon of distilled water, and strain: then pass carbonic acid into the solution to saturation, that the salt may subside. Dry this with a gentle heat, wrapped and pressed in cloth. According to Mr. Brande (*Manual of Chem.*) 160 lbs. of carbonate should be dissolved in 13 gallons of water, and carbonic acid thrown into the solution in a proper apparatus. About 50 lbs. of bicarbonate fall: and when separated should be dried in an hydraulic press, and afterwards by exposure to heat not exceeding 100° F. A fresh portion of carbonate is dissolved in the mother liquor, and the operation repeated as before.

The carbonic acid used in this process is usually procured artificially by the action of dilute sulphuric acid on carbonate of lime. In some countries, however, it is obtained from natural sources, as at Vichy, where it is collected from the mineral waters. (For a description and sketch of the apparatus used in the collection of the gas by D'Arcet, see *Dict. de l'Indust.* 3^{me}. t. p. 61.)

2. *Smith's process.*—This consists in placing the ordinary carbonate of soda in a box, and surrounding it by an atmosphere of carbonic acid gas under pressure. As the bicarbonate combines with much less water of crystallization than is contained in the carbonate, a considerable portion of water is liberated, which, saturated with part of the salt, is allowed to drain off: when the gas ceases to be absorbed, the salt is taken out and dried. On examination it is found to have retained the original form of the pieces; but they have become of a porous and loose texture, presenting the appearance of numerous crystalline grains, aggregated together, and having a snow-white colour. (*Journ. of the Philadelphia College of Pharm.* vol. i. quoted by Dr. Bache in the *United States Dispensatory*. For a sketch of the apparatus employed by Soubeiran in performing Smith's process, see his *Nouv. Traité de Pharm.* t. 2^{me}. p. 341.)

3. *Process by sesquicarbonate of ammonia.*—This is the process directed to be followed in the London Pharmacopœia for 1809. Sesquicarbonate of ammonia is to be added to a solution of carbonate of soda, and a heat of about 100° F. applied to drive off the ammonia: the solution is then to be set aside to crystallize. The proportions employed in the Pharmacopœia of 1809 were a pound of carbonate of soda, three ounces of sesquicarbonate of ammonia, and a pint of distilled water. Winckler (*Lehrb. d. Pharm. Chemie.* 1$^{er.}$ Th. S. 292) directs 4 parts of crystallized carbonate of soda, 1½ parts of sesquicarbonate of ammonia,

and 10 parts of water. The proportions ordered by MM. Henry and Guibourt (*Pharm. Raisonnée*, t. 2nd. p. 409, éd. 2me.) are 6 parts of the crystallized carbonate of soda, 2 parts of sesquicarbonate of ammonia, and 4 parts of water.

Properties.—Bicarbonate of soda usually occurs in the form of a white crystalline mass. The perfect crystals are, according to Dr. Thomson (*Chem. of Inorg. Bodies*, vol. ii. p. 54), oblique rectangular prisms. The taste of this salt, and its reaction on vegetable colours, are slightly alkaline. By exposure to the air it effloresces superficially. When heated it evolves carbonic acid and water, and becomes the anhydrous carbonate. It dissolves in 13 parts according to Rose, or 8 parts according to Berthollet, of cold water. By heat the solution loses first one-quarter, and subsequently one-half of its carbonic acid.

Characteristics.—To recognize the carbonic acid and soda of this salt, the tests are the same as before described (vide p. 324) for the carbonate of soda. From the latter salt the bicarbonate of soda is distinguished by its causing neither a brick-red precipitate with the bichloride of mercury, nor a white precipitate with the sulphate of magnesia. The sodaic powder of the shops (*sodæ sesquicarbonas*, Ph. L.) being a mixture of carbonate and bicarbonate produces a red precipitate with bichloride of mercury, but no precipitate with sulphate of magnesia; and when washed with a small quantity of cold distilled water, leaves a white powder (bicarbonate of soda), which, when dissolved in water, gives a white precipitate or slight opalescence to a solution of bichloride of mercury.

Composition.—Crystallized bicarbonate of soda has the following composition:—

	Eq.	Eq. Wt.	Per Cent.	Rose.	Berthollet.	Bérard.
Soda	1	32	34·04	37	31·75	29·85
Carbonic Acid	2	44	46·80	49	44·40	49·95
Water	2	18	19·14	14	23·85	20·20
Cryst^{d}. Bicarb. Soda	1	94	99·98	100	100·00	100·00

According to Dr. Thomson's analysis (*First Principles of Chemistry*, vol. ii. p. 268), this salt contains only one equivalent of water of crystallization.

Purity.—When quite pure, this salt occasions no precipitate with chloride of platinum, perchloric acid, or tartaric acid, by which its freedom from potash is demonstrated. When supersaturated with pure nitric acid, it gives no precipitate with either chloride of barium or nitrate of silver, by which the absence of sulphates and chlorides is shewn. Lastly, it occasions a white precipitate with bichloride of mercury, by which the freedom from a simple or mono-carbonate is shewn.

Physiological Effects.—The effects of this salt are analogous to those of bicarbonate of potash, than which it is regarded as having a somewhat less disagreeable taste and a slighter local action. It is of course less caustic and irritant than the sesquicarbonate, and still more so than the carbonate of soda. Its remote or constitutional effects are analogous to those of the caustic alkalies. (Vide Potassa, p. 275.)

Uses.—It is employed as an *antacid* in those forms of dyspepsia which are attended with an inordinate quantity of acid in the stomach; as a *lithontriptic* in those kinds of lithiasis which are accompanied with an excessive secretion of uric acid and the urates; as a *resolvent* or *alterative* in certain forms of inflammation, in glandular affections, in syphilis, and scrofula; and as a *diuretic* in some dropsical complaints. (For further particulars regarding these uses of bicarbonate of soda, vide POTASSA, p. 277, *et seq.*)

The principal consumption of bicarbonate of soda (*sodæ sesquicarbonas*, Ph. L.) is in the preparation of the effervescing draught, soda-powders, and Seidlitz powders: in these the bicarbonate is mixed with a vegetable acid (either citric or tartaric, usually the latter.) Taken in a state of effervescence, a solution of this kind is an agreeable and refreshing drink for allaying thirst, checking sickness, and diminishing febrile heat, as I have before mentioned (p. 193.) The resulting soda-salt (tartrate or citrate) undergoes partial digestion in its passage through the system, and is found in the urine in the state of carbonate. Hence, therefore, these effervescing preparations may be employed as diuretics and lithontriptics, instead of the simple carbonate or bicarbonate of soda, than which they are more agreeable. On the other hand they are highly objectionable, and are to be carefully avoided, in the treatment of phosphatic deposits in the urine. Alluding to these cases Dr. Prout (*Inquiry into the Nature and Treatment of Affections of the Urinary Organs*, 2d ed. p. 145) observes, "were I required to name the remedy calculated to do the most mischief, I should name the common saline draught, formed of potash or soda, and *some vegetable acid*."

ADMINISTRATION.—The dose of this salt is from ten grains to a drachm. In the preparation of effervescing draughts, a scruple of the powder sold in the shops as bicarbonate of soda (*sodæ sesquicarbonas*, Ph. L.) usually requires about 18 grains of crystallised tartaric acid, or about 17 grains of the ordinary crystals of citric acid, or four drachms of lemon juice, to saturate it.

1. *SODAIC POWDERS.*—These consist of half a drachm of bicarbonate of soda, contained in a blue paper, and 25 grains of tartaric acid, in a white paper. When taken they should be dissolved in half a pint of water. The flavour of the solution is improved by adding to the water, before dissolving the acid, one or two drachms of simple syrup, and either half a drachm of the tincture of orange-peel, or two or three drops of the essence of lemon. The *pulvis aërophorus e natro carbonico acidulo* of the Prussian Pharmacopœia consists of a drachm of the bicarbonate, two scruples of tartaric acid, and the like quantity of white sugar. *Ginger-beer powders* are made in the same way as sodaic powders, except that five grains of powdered ginger and a drachm of white sugar are mixed with the bicarbonate of soda.

2. *SEIDLITZ POWDERS.*—These consist of two drachms of tartarized soda and two scruples of bicarbonate of soda contained in a blue paper, and 30 grains of powdered tartaric acid in a white paper. These are to be taken dissolved in half a pint of water, while the liquid is in a state of effervescence. These form an agreeable and mild aperient. Why they are called *Seidlitz* powders I cannot divine, as they have no analogy to Seidlitz water.

3. *SODA WATER*, *properly so called: Liquor sodæ effervescens*, Ph. L.—The greater part of the liquid sold in the shops as *bottle-soda water*, and *soda water from the fountain* or *pump*, is merely a solution of carbonic acid in common water, effected by pressure, and, therefore, has no

claim to the denomination of *soda* water (*vide* p. 191). Some few makers, however, prepare it by condensing carbonic acid in a solution of carbonate or bicarbonate of soda: this is *soda water properly so called*, formulæ for which are given in all the British Pharmacopœias, as well as in the French Codex; but which I conceive are quite unnecessary, as this liquid can be prepared extemporaneously by adding bicarbonate of soda to the ordinary bottle-soda water. Thus, half a drachm of bicarbonate of soda and half a pint of bottle-soda water, will form a solution of the same strength as the *liquor sodæ effervescens* of the London Pharmacopœia, which is directed to be prepared by dissolving a drachm of sesquicarbonate of soda in a pint of distilled water, and forcing into it an excess of compressed carbonic acid gas. The *aqua carbonatis sodæ acidula* (Ph. Dublin) is of the same strength: the *aqua super-carbonatis sodæ* (Ph. Edinb.) contains 96 grains of carbonate of soda to a pound of water.

A fraudulent imitation of soda water is said to have been practised by adding a few drops of sulphuric acid to a solution of carbonate of soda in water, and instantly corking the bottle. The fraud may be detected by chloride of barium, which throws down a white precipitate insoluble in nitric acid.

Soda water properly so called (*liquor sodæ effervescens*, Ph. L.) is employed in the same cases as bicarbonate of soda. The additional quantity of carbonic acid contained in it, renders it more agreeable and not less effectual, as an alkaline agent, in its operation on the system generally. It is employed to counteract or prevent the inordinate secretion of uric acid and the urates; but both this and soda water powders are highly injurious in phosphatic deposits,—in the latter case, however, carbonic acid water (ordinary bottle-soda water) may be used (*vide* p. 198).

Potas'sæ So'dio-Tar'tras.—So'dio-Tar'trate of Pot'ash.

HISTORY.—This salt was discovered by Seignette, an apothecary at Rochelle, in 1672, and hence it is frequently termed *Seignette's salt* or *Sel de Seignette* (Beckmann's *Hist. of Invent.* vol. iv. p. 616). He called it *alkaline salt*, *sal polychrest*, and *Rochelle salt* (*sal rupellensis*). To distinguish it from the sal polychrest (sulphate of potash) of other writers, it is sometimes denominated *sal polychrestum Seignetti*. Its other names are, *tartarized soda* (*soda tartarizata* seu *natron tartarizatum*), or the *tartrate of potash and soda*. In the Pharmacopœia it is termed *sodæ potassio-tartras*.

PREPARATION.—The following are the directions for preparing this salt in the London Pharmacopœia:—Dissolve 12 ounces of carbonate of soda in four pints of boiling water, and add, gradually, 16 ounces of powdered bitartrate of potash. Strain the liquor; then apply a gentle heat until a pellicle floats, and set aside, that crystals may be formed. The liquor being poured off, dry these. Again evaporate the liquor, that it may yield crystals.

In this process the excess of acid in the bitartrate of potash is saturated by the soda of the carbonate, while the carbonic acid of the latter is disengaged.

PROPERTIES.—This salt is met with in large, transparent, and regularly-shaped crystals, whose primary form is the right rhombic prism: but curiously enough, the crystals are frequently produced in halves. Their taste is mildly saline and bitter. Exposed to the air they slightly effloresce. When heated they undergo the watery fusion, evolve their water of crystallization, and are decomposed: the residue consists of charcoal and the carbonates of potash and soda. They are readily soluble in cold, and still more so in hot water.

Characteristics.—This salt may be recognised by the shape and size of the crystals. Sulphuric acid added to the aqueous solution throws down small crystals of bitartrate of potash; perchloric acid throws down perchlorate of potash: the chlorides of barium and calcium occasion white precipitates, soluble in excess of water, and composed of soda, tartaric acid, and, in the one case, baryta, in the other lime: chloride of platinum produces a yellow precipitate of the platinum-chloride of potassium. Nitrate of silver occasions a white precipitate (tartrate of silver), soluble in excess of water. When heated, potash-tartrate of soda is decomposed, evolves various volatile substances, and gives out the odour of caromel. If the residuum be digested in hydrochloric acid, we obtain a solution of the chlorides of sodium and potassium: the chloride of potassium may be precipitated by chloride of platinum, leaving chloride of sodium in solution, which may be detected by the tests already mentioned for this salt (p. 310).

Composition.—The composition of this salt is as follows:—

	Eq.	Eq. Wt.	Per Cent.	Schulze.			Eq.	Eq. Wt.
Soda	1	32	10·6	13·3	or	Tartrate Potash	1	114
Potash	1	48	15·6	14·3		Tartrate Soda	1	98
Tartaric Acid	2	132	43·7	41·3		Water	10	90
Water	10	90	29·8	31·1				
Crystl^{d}.Sodio-Tart^{e}. of Potash	1	302	99·7	100·0			1	302

Dr. Thomson (*First Principles*, ii. 440) says, that when the crystals are free from all adhering moisture they contain only eight equivalents of water of crystallization, and their atomic weight is then 284.

Physiological Effects.—It is a mild, laxative, cooling salt, very analogous in its effects to the tartrate of potash. Sundelin (*Heilmittell.*) says it is uncertain as a purgative, sometimes failing, at others acting very slowly, but strongly, and with violent abdominal pain. He thinks it may be completely replaced in practice by a mixture of magnesia and sulphate of magnesia. Like the other vegetable alkaline salts, it undergoes partial decomposition in the system, and is converted into the carbonate, in which state it is found in the urine. Hence its use should be carefully avoided in persons suffering with phosphatic deposits in the urine.

Uses.—It is commonly employed as a mild aperient for females and other delicate persons. It may be used with advantage by those who are subject to excessive secretion of uric acid or the urates.

Administration.—It is given in doses of from half an ounce to an ounce. It should be exhibited largely diluted with water. A very convenient mode of exhibition is in combination with bicarbonate of soda and tartaric acid in an effervescing condition (*vide* ***Seidlitz Powders***, p. 329).

So'dæ Ace'tas.—Ac'etate of So'da.

History.—This salt was first described by Baron, in 1747 (Thomson's *Chemist. of Inorg. Bod.* vol. ii. p. 464): but according to Dulk (*die Preuss. Pharm. übers. u. erläut.*) its real discoverer was F. Meyer, in 1677. It was formerly called *terra foliata tartari crystallisata*, or *terra foliata mineralis*.

Preparation.—It may be readily procured by saturating carbonate of soda by distilled vinegar (as directed in the Dublin Pharmacopœia), evaporating the solution and crystallizing. In this process the acetic acid expels the carbonic acid with effervescence.

On the large scale acetate of soda is obtained by manufacturers of pyroligneous acid by the following process:—Rough or impure pyroligneous acid is saturated with either slacked lime or chalk. In this way there is formed an impure acetate of lime (commonly termed pyrolignate of lime). To the clear solution is added sulphate of soda. Double decomposition takes place: sulphate of lime precipitates, and acetate of soda remains in solution. The clear liquid is then evaporated and crystallized. The impure acetate of soda thus procured is purified by drying, solution in water, re-crystallization, fusion in an iron pot, expulsion of the water of crystallization by heat, incipient carbonization to decompose the impurities of the salt, re-solution, and re-crystallization.

Properties.—The primary form of the crystals of this salt is the oblique rhombic prism. Geiger (*Handb. d. Pharm.* 1 Bd. 150, 3 Aufl.) says that a saturated solution of this salt does not readily crystallize when cooled in a tall glass vessel unless some pointed or angular body be introduced. Its taste is cooling, saline, and bitterish. Exposed to the air, at ordinary temperatures, the crystals undergo little change; but in dry and warm air they effloresce and become anhydrous. When heated they first undergo the watery fusion, then give out their water of crystallization, and afterwards undergo the igneous fusion. At a red heat they are decomposed, and give, as a residue, a mixture of charcoal and carbonate of soda. They are soluble in about 3 parts of cold water; and are slightly soluble in alcohol.

Characteristics.—As an acetate it is recognized by the tests before mentioned (p. 222) for this class of salts. That the base is soda is shewn by the characters already described (p. 310) for the soda salts.

Composition.—The following is the composition of this salt:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.
Soda	1	32	23·36	22·94
Acetic acid	1	51	37·22	36·95
Water	6	54	39·41	40·11
Crystallized Acetate of Soda	1	137	99·99	100·00

Purity.—It should be white and perfectly neutral to test-papers (litmus and turmeric.) The presence of sulphuric acid may be recognized by chloride of barium, which occasions, with this acid, a white precipitate insoluble in nitric acid. If nitrate of silver cause a white precipitate insoluble in both water and nitric acid, but soluble in ammonia, the presence of a chloride is to be inferred. Potash may be recognised by the before-mentioned tests for this base (p. 274), as well as by the deliquescence of the suspected acetate.

PHYSIOLOGICAL EFFECTS.—Acetate of soda operates on the body like acetate of potash, but is pròbably somewhat milder in its action.

USES.—It is rarely employed for medicinal purposes. It may, however, be used as a substitute for acetate of potash, over which it has the advantage of not being deliquescent.

In pharmacy and the arts it is largely employed in the manufacture of acetic acid (vide p. 221), and on this account has been introduced into the Pharmacopœia, as the officinal source of this acid.

ADMINISTRATION.—The dose of it, as a diuretic, is from a scruple to two drachms.

Sa'po.—Soap.

HISTORY.—The Hebrew word *borith*, translated in our version of the Bible (*Jer.* ii. 22, and *Mal.* iii. 2), soap, is, by most commentators supposed to refer to a plant, or to the alkaline ashes of some plant. Pliny, who (*Hist. Nat.* xxviii.) mentions soap, says it is made of tallow and ashes, ascribes its invention to the Galls, and adds, that the Germans employed both thick and liquid soap (hard and soft soap ?) In the excavations made at Pompeii, a complete soap-boiler's shop was discovered, with the soap still perfect, though it must have been manufactured for more than 1700 years (Parkes, *Chem. Essays*, ii. 5, 2nd. ed.)

NATURAL HISTORY.—Soap is always an artificial product, unless the spontaneous formation of *adipocire*, from dead animal matter, be considered an exception to this statement. This substance appears, from the analysis of Chevreul, to consist of a small quantity of ammonia, of potash, and lime united to much margaric acid, and a very little oleic acid.

PREPARATION.—The manufacture of soap varies according to the quality of this substance intended to be produced.

The soaps employed in medicine are those which contain, as their base, potash, soda, ammonia, lime, or oxide of lead: the three first are called *soluble*—the two latter *insoluble soaps*. Of these five, two only require notice at present, viz. those which contain either soda or potash: and for an account of the three other soaps I must refer to the articles LINIMENTUM AMMONIÆ (p. 176), LINIMENTUM CALCIS, and EMPLASTRUM PLUMBI.

1. *OF SODA SOAP* (*sapo sodaicus: s. natrinus: s. durus: s. spissus* of Pliny ?) The quality of this kind of soap varies according to the kind of fatty or resinous matter used in its manufacture.

(*a.*) *Olive oil soda soap* (*sapo ex olivæ oleo et sodâ confectus*, Ph. L. *sapo durus*, Ph. Dub. *Sapo Hispanicus.*)—This is made by boiling olive oil with a solution of caustic soda (prepared by the action of lime on barilla or some other impure carbonate of soda) till the soap separates, to promote which common salt is sometimes added. It is then suffered to congeal, and afterwards remelted in water to remove any adhering alkali. When sufficiently cold it is run into *frames* (wooden troughs with moveable bottoms), and after it has acquired sufficient firmness, is cut into long cakes or bars by means of a wire. (For further details, consult Aikin's *Dict. of Chemistry*, art. *Soap.*)

There are two varieties of olive oil soda soap—one *white* (*sapo albus*)

—another, *marbled* or *mottled*. The soap sold in the shops as *Castile soap* (*sapo castiliensis*) is of the latter kind: "the marbled appearance which it presents is produced by the addition of sulphate of iron to a part of the alkaline ley, after the soap is fully boiled, which gives the blue colour; and the stirring in red oxide of iron, when the soap is almost made, gives the red colour." (Thomson's *London Dispensatory*.) The marbling, or mottling, therefore, is an impurity.

(*b.*) *Almond oil soda soap* (*sapo amygdalinus.* Fr. Codex.)—This is the medicinal soap (*savon médicinal*) of the French; directions for preparing which are contained in the French Codex.

(*c.*) *Animal oil soda soap* (*sapo sebaceus*, Geiger: *sapo vulgaris*, United States Ph.)—Of this two kinds are in common use in this country. The best is that called *white curd soap*, and which is prepared from pure or white tallow and soda: when scented it constitutes *Windsor soap*. The *common* or *domestic soap*, usually termed *mottled soap*, is made with refuse kitchen grease (commonly called *kitchen stuff*.)

(*d.*) *Resin soda soap.*—This is the *common yellow soap* of the shops, and is the commonest of the hard soaps of this country. It owes its peculiar properties to the admixture of resin and palm oil with animal fat.

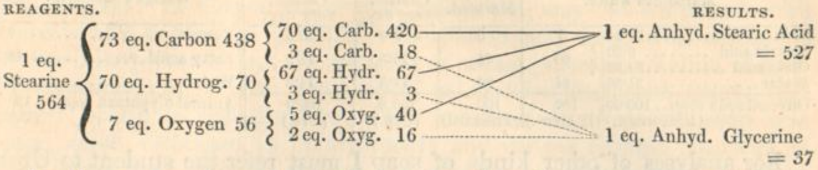
Besides the above, there are many other varieties of hard soap, termed *fancy soaps*, sold by perfumers. The patent *silica soap* consists of the usual kinds of soaps to which precipitated silica is added.

2. Of Potash Soap. (*sapo potassicus: s. kalinus: s. mollis: s. liquidus*, Pliny?)—This kind of soap is made with caustic potash instead of caustic soda.

(*a.*) *Olive oil potash soap* (*sapo mollis,—sapo, ex olivæ oleo et potassâ confectus*, Ph. L.)—No soap of this kind is made or known in London. I am informed by Messrs. Rowe, of Brentford (the most extensive manufacturers of soap in the neighbourhood of the metropolis), that they are unacquainted with it. On inquiry I find that a *white soft soap*, made by Mr. Taylor, 13, Newington Causeway, is used at Apothecaries' Hall, in the preparation of *Ung. Sulph. Co.* Ph. L.; but I have been unable to procure a sample of it. Mr. Taylor tells me it is only made to order, as there is very little demand for it, the principal consumption being at Apothecaries' Hall. He also informed me, that it was made from three fatty substances (olive oil, tallow, and some other oil), and two alkalies (potash and soda)—that it is white, and has the consistence of butter, but by keeping becomes harder.

(*b.*) *Animal oil potash soap.*—This is the *common soft soap* of the shops, and which is made with fish oil (whale or cod), tallow and potash. (For particulars respecting its manufacture consult Ure's *Dict. of Chem.*, art. *soap*.)

Theory of Saponification.—Soaps are to be regarded as alkaline salts, formed by the action of alkaline bases on fatty or resinous bodies. At one time it was supposed that they were mere compounds of fat or resin and of alkali; but it is now known that in the process of saponification, the organic constituents (*stearine, margarine*, and *olein*) of vegetable and animal fats undergo certain chemical changes by which acids (*stearic, margaric*, and *oleic*) are produced, which, combining with the bases, form the salts (*stearates, margarates*, and *oleates*) commonly termed *soaps;* and at the same time a sweet substance (*glycerine*) is generated. Thus it appears that, by the influence of an alkali, one equivalent or 564 parts of stearine are converted into one equivalent or 527 parts of anhydrous stearic acid, and one equivalent or 37 parts of anhydrous glycerine; the stearic acid unites with the alkali to form soap. The following diagram illustrates these changes:—



In the conversion of resin into soap the phenomena are different. Resins consist of one or more acids, which combine with alkalies to form resinous salts or soaps. Thus ordinary yellow resin (or rosin) consists of two acids, called respectively pinic and silvic acids; and a soda soap made of this substance would, therefore, be a mixture of pinate and silvate of soda.

PROPERTIES.—The consistence, colour, odour, and sp. gr. of soap vary in the different kinds. The taste of all is slightly alkaline. All the alkaline soaps are soluble both in water and alcohol. The substance called *transparent soap* is prepared by evaporating an alcoholic solution of pure soap. When heated soap fuses, swells up, and is decomposed, leaving a residuum of charcoal and alkaline carbonate. Most of the acids decompose soap: they unite with the alkaline base and separate the fatty acids. The earthy salts (as sulphate of lime, sulphate of magnesia, alum, &c.) also decompose soap: the fatty acids unite with the earth to form an insoluble earthy soap, while the alkali of the soap combines with the acid of the salt. The *hardness* of sea, spring, and well water, depends on the earthy salts (principally sulphate of lime) which decompose soap: hence tincture of soap may be used as a test of the hardness or softness of common waters. The metallic salts also decompose soap, and give rise to metalline soaps.

Olive oil soda soap may be either white or marbled, as before stated. When pure it has very little odour. It is hard, but in the fresh state may be easily worked or kneaded between the fingers: by keeping in warm air it becomes dry and pulverizable. It should not feel greasy, have a rancid odour, communicate an oily stain to paper, nor be covered with a saline efflorescence; but should dissolve completely and readily in both water and alcohol. The marbling, as I have before stated, is an impurity.

Animal oil potash soap (*common soft soap*) is of a brownish or yellowish colour; transparent, but interspersed with white specks, owing to the admixture of tallow.

CHARACTERISTICS.—Soap may be partly recognised by its physical properties, especially by its feel, which is so well known that it is usually called *soapy*. The solubility of soap in water and alcohol is an important character, as well as its detergent quality, which depends on its power of rendering fatty and other matters soluble in water. The effect of heat on it also deserves notice: if the carbonaceous residuum be digested in weak hydrochloric acid, and the solution filtered and concentrated by evaporation, the nature of the alkaline base may be ascertained by applying the tests for potash and soda before mentioned (pp. 274 and 310). Lastly, the action of acids and earthy and metallic salts on a solution of soap, as already noticed, serves to recognise soap.

Composition.—The following is the composition of several varieties of soap:—

OLIVE OIL SODA SOAP.					
Marseilles white.			Marseilles Marbled.	Foreign Castile, very dry.	London-made Castile, very dry.
Soda	10·24	6	6	9·0	10·5
Stearic acid	9·20	60	64	76·5	75·2
Oleic acid	59.20				
Water	21·36	34	30	14·5	14·3
Olive oil soda soap	100·00	100	100	100.0	100·0
	(Braconnot.)	(D'Arcet.)	(Thenard)	(Ure.)	(Ure.)

ANIMAL OIL POTASH SOAP.	
Glasgow soft soap.	
Potash	9·0
Fatty acids	43·7
Water	47·3
Animal oil potash soap	100·0
	(Ure.)

For analyses of other kinds of soap I must refer the student to Ure's *Dict. of Chemistry*, and Gmelin's *Handb. d. Chemie*. The atomic constitution of soap cannot be determined with accuracy, on account of the great variation in the quantity of water. The relative proportion of acid and base appear to be nearly one equivalent of the fatty acid to two of the alkali. Thus, olive oil soda soap may be regarded as a compound of one equivalent or 518 parts of oleic acid, and two equivalents or 64 parts of soda, exclusive of the water and the small quantity of stearate (or margarate) of soda present.

Purity.—The adulterations of soap are excess of water, lime, gypsum, or pipe-clay. The first may be known by the consistence of the soap, and the great loss of weight which this substance undergoes in dry air. The other impurities may be detected by alcohol, which leaves them undissolved.

Physiological Effects. (*a.*) *On vegetables.*—Soap, used as a manure, appears to promote vegetation (Decandolle, *Physiol. Végét.* p. 1343).

(*b.*) *On animals.*—It does not appear to be poisonous to animals. Veterinarians employ it as a diuretic, and, in large doses, as a purgative.

(*c.*) *On man.*—Soap acts very much like the alkalies (*vide* Potassæ, p. 275). Its local operation, however, is much less energetic than either the caustic or even the carbonated alkalies. Hence it may be administered in considerable doses without causing irritation or inflammation. When swallowed it very readily palls the appetite and disturbs the digestive functions, and in these qualities it is more powerful than the alkalies. Perhaps these effects depend on the fatty acids which must be disengaged in the stomach, in consequence of the union of the alkali of the soap with the free acids of the gastric juice. Probably the fatty acids become more or less completely digested, for soap acts on the general system like the alkalies; it promotes the secretion of urine, and communicates alkaline properties to this fluid. In large doses, soap acts as a purgative. I knew an idiot who had frequently eaten large lumps of soap without any ill effects; and I have heard of a pound of it being swallowed for a wager!

Uses.—As an *antacid*, soap is employed in poisoning by the mineral acids: it should be administered in the form of a strong solution, which effectually neutralizes the acid without acting as an irritant. So also in those forms of dyspepsia which are attended with an excessive formation of acid, soap may be usefully employed to neutralize it. External parts burnt with the strong mineral acids, or with phosphorus, should be washed with a solution of soap. As a *lithontriptic*, soap has been used in those forms of lithiasis in which uric acid or the urates prevail. A mixture of soap and lime-water was once considered a most powerful solvent for urinary calculi. The Hon. Horace Walpole (*Philosophical Transactions*, xlvii. 43 & 472) gained great relief from it. By the action of lime-water on soap, an insoluble calcareous soap and a solution of caustic soda are formed. As a *purgative*, soap is rarely exhibited alone: in combination with rhubarb it may be employed with considerable benefit in habitual constipation and disordered conditions of the biliary functions. In the form of enema, a strong solution of soap is sometimes used with great relief to dissolve hardened fæces, and relieve obstinate constipation. As a *resolvent* or *alterative*, soap was once much esteemed in enlargements and various chronic disorders of the viscera and glands; and as the alkalies have been found useful in the same diseases, any good effects which may have been obtained by soap are probably referrible to its alkaline base.

Externally, soap is frequently employed on account of its detergent, lubricating, and discutient qualities. Thus, in tinea capitis, scabies, and various other skin diseases, ablution night and morning with soap-water greatly contributes to the cure. On account of its lubricating qualities, soap is a most convenient adjunct to liniments. The uses of the liniment, cerate, and plaster of soap, are noticed below.

Lastly, soap is useful in pharmacy to render other medicines more soluble, or to give a proper consistence to various substances for the making of pills. Thus it is a constituent of various pills (e. g. *pil. rhei comp.*, *pil. sap. comp.*, and *pil. scillæ comp.*) In some cases it acts as the *adjuvans*, assisting and promoting the operation of other medicines; as a *corrigens*, correcting their operation; and as a *constituans*, imparting an agreeable or convenient form. The addition of soap to aloes or extract of jalap is cited by Dr. Paris (*Pharmacologia*) as an instance in which soap fulfils all three of these objects.

Administration.—The usual dose of soap, taken in a pilular form, is from five grains to half a drachm. In cases of poisoning by the mineral acids, half a pint of a strong solution of soap should be instantly administered.

1. ***Linimentum Saponis***, Ph. L. & D. (soap, ℥iii.; camphor, ℥i.; spirit of rosemary, f. ℥xvi.): *Tinctura Saponis Camphorata*, Ph. Ed. & U.S. (soap, ℥iv.; camphor, ℥ii.; oil rosemary, f. ℥ss.; alcohol, f. ℥xxxii.) Druggists frequently substitute soft soap (animal oil potash soap) for the olive oil soda soap of the Pharmacopœia. *Soap liniment* or *opodeldoc* is used as a stimulant and discutient, as well as, on account of its lubricating qualities, in local pains, sprains, bruises, rheumatism, &c. When mixed with three-fourths of its volume of tincture of opium, it constitutes the *anodyne liniment* (*linimentum saponis cum opio*, vel *linimentum anodynum*) of the Dublin Pharmacopœia.

2. ***Ceratum Saponis***, Ph. L. (soap, ℥x.; wax, ℥xiiss.; oxide of lead, powdered, ℥xv.; olive oil, Oj.; vinegar, Cj.)—The subacetate of lead, formed by boiling oxide of lead with vinegar, is decomposed by the soap, the soda of which combines with the acetic acid of the subacetate, while the fatty acids (oleic and margaric) unite with the lead. The wax and oil serve to give consistence to the preparation. *Soap cerate* is used as a mild cooling dressing for scrofulous swellings, and other local inflammations, as well as for fractured limbs: in the latter case its principal use is as a mechanical support.

3. ***Emplastrum Saponis***, Ph. L. & Dub. (soap, lb. ss.; lead plaster, lb. iii.) This quantity of soap is said to be too much by one half. This plaster, spread on leather, is employed as a discutient and mechanical support. When two parts of it are mixed with three parts of resinous plaster (*emplastrum resinæ*, Ph. L.), it constitutes the *emplastrum saponis compositum*, vel *emplastrum adhærens*, Ph. D., and which, when spread by a machine on linen, is sold in the shops by the name of *adhesive plaster* (Dr. Duncan, *Edinb. Dispensatory*).

Order 12. Compounds of Barium.

Bary tæ Car bonas.—Car'bonate of Bary ta.

History.—The earthy base called *baryta* was discovered in 1774 by Scheele. It was at first termed *terra ponderosa.* In 1783 Dr. Withering recognised the native carbonate of baryta, which has been called, after its discoverer, *Witherite.*

Natural History.—*Witherite* occurs in the lead mines of the north of England (as those of Anglesark, in Lancashire), and in various other localities. The mineral called *baryto-calcite* (a compound of carbonate of baryta and carbonate of lime) is found at Alston Moor, Cumberland. —[For some curious anecdotes respecting its discovery at the latter place, consult Parkes's *Chem. Essays*, vol. i. p. 324].

Preparation.—The native carbonate of baryta is sufficiently pure for the preparation of the other barytic salts, and is the kind meant in the Pharmacopœia. Absolutely pure carbonate may be prepared by the addition of a pure alkaline carbonate to a solution of some barytic salt; as the sulphuret (obtained from the decomposition of the sulphate by some carbonaceous matter), or the chloride; or it may be obtained by igniting (or boiling in water) finely powdered sulphate of baryta with three parts of carbonate of potash, and washing away the resulting sulphate of potash; or by decomposing sulphate of baryta by carbonate of ammonia.

Properties.—Native carbonate of baryta occurs massive, stalactitic and crystallized: the primary form of the crystals is the right rectangular prism. The sp. gr. of this mineral is 4·3. Heated before the blowpipe it melts into a white enamel, with the evolution of much light and the loss of carbonic acid. Artificially prepared, carbonate is a fine, tasteless, odourless powder. It is almost insoluble in both hot and cold water: 4,304 parts of cold, or 2,304 parts of hot water, being required to dissolve one part of carbonate. It is more soluble in carbonic acid water.

Characteristics.—It dissolves with effervescence in hydrochloric acid, forming a solution of chloride of barium: the evolved gas, when collected, is found to be carbonic acid (*vide* p. 190). The hydrochloric solution is not precipitated by ammonia, the hydrosulphurets, or the ferrocyanides; but the soluble sulphates, phosphates, and carbonates, throw down white precipitates, which are, respectively, sulphate, phosphate, oxalate, and carbonate of baryta: sulphate of baryta is insoluble in both water and nitric acid. The salt (chloride of barium) obtained by the evaporation of the hydrochloric solution, tinges the flame of alcohol greenish yellow.

Composition.—The following is the composition of this salt:—

	Eq.	Eq. Wt.	Per Cent.	Berzelius.	Berard.
Baryta	1	77	77·7̇	77·9	78
Carbonic Acid	1	22	22·2̇	22·1	22
Carbonate Baryta	1	99	99·9̇	100·0	100

Purity.—It should be white, odourless, and tasteless. Neither caustic ammonia nor hydrosulphuric acid should produce any precipitate or change of colour in the hydrochloric solution, by which the absence of alumina and metallic matter may be inferred. If excess of sulphuric acid be added to this solution, no precipitate should be occasioned by the subsequent addition of carbonate of soda, by which the absence of lime is shown.

Physiological Effects. (*a.*) *On vegetables.*—Germination does not take place in carbonate of baryta. (Vogel, in Decand. *Phys. Végét.* p. 1341.)

(*b.*) *On animals.*—Cows and fowls have been destroyed by swallowing the native carbonate. (Parkes, *Chem. Essays*, vol. i. p. 330.) Orfila (*Toxicol. Gén.*) says a drachm of the powder killed a dog in six hours; but C. G. Gmelin (*Versuche über d. Wirk. des Baryts*, &c. p. 8) gave two drachms to a dog: vomiting took place, and the animal was well the next day. A drachm killed a rabbit in three hours. When applied to a wound it has proved fatal. (Campbell, quoted by Christison, *Treatise on Poisons*, 3d ed. p. 532.) From the above experiments carbonate of baryta appears to act as an acro-narcotic poison: when swallowed it causes vomiting, inflames the alimentary tube, becomes absorbed, and acts specifically on the nervous system, causing convulsions, paralysis, and insensibility.

(*c.*) *On man.*—Only one case illustrating its action on the human subject has been published. (Dr. Wilson, *Med. Gaz.* vol. xiv. p. 487.) A young woman swallowed half a tea-cupful of the powdered carbonate: in two hours she had dimness of sight, double vision, ringing in the ears, pain in the head, and throbbing in the temples, a sensation of distension and weight at the epigastrium, distension of stomach, and palpitation. Subsequently she had pains in the legs and keees, and cramps in the calves. A day or two after the cramps became more severe. These symptoms slightly modified continued for a long time.

Uses.—Carbonate of baryta is employed in the preparation of the chloride of barium. It is not administered as a medicine.

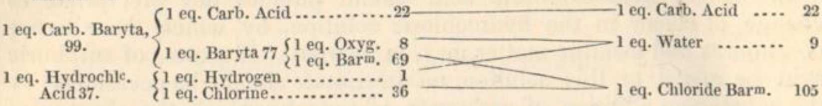
Antidote.—(Vide Barii Chloridum.)

Ba′rii Chlo′ridum.—Chlo′ride of Ba′rium.

History.—This compound was discovered by Scheele in 1775. It was at first termed *terra ponderosa salita*, and afterwards *muriate of barytes.*

Preparation. 1. *From the native carbonate of baryta.*—The following are the directions given in the London Pharmacopœia:—Add ten ounces of carbonate of baryta, broken in small pieces, to half a pint of hydrochloric acid mixed with two pints of distilled water. Apply heat, and when the effervescence has finished, strain and boil down, that crystals may be formed.

In this process one equivalent or 37 parts of hydrochloric acid react on one equivalent or 99 parts of carbonate of baryta: the products are one equivalent or 22 parts of carbonic acid, which escape; one equivalent or 9 parts of water, and one equivalent or 105 parts of chloride of barium.



2. *From the native sulphate of baryta.*—As a sulphate of baryta can be obtained in greater abundance and cheaper than the carbonate, manufacturers usually prepare the chloride, as well as other salts, of barium from it. There are several modes of proceeding, but the most common one is the following:—Make finely powdered sulphate into a paste with about an equal volume (or a sixth part of its weight) of flour (or charcoal); and expose it in a covered crucible to an intense heat for two hours. The carbon combines with the oxygen of the sulphuric acid and of the baryta, and forms carbonic oxide, which escapes. The residue digested in water forms a solution of sulphuret of barium. To the filtered liquor add hydrochloric acid, which causes the evolution of hydrosulphuric acid gas; filter the solution, evaporate, and crystallize. By re-solution, evaporation, and a second crystallization, the crystals may be obtained very pure and fine. Or sulphate of baryta may be decomposed by igniting it with chloride of calcium.

Properties.—Chloride of barium crystallizes in right rhombic plates or tables, sometimes in double eight-sided pyramids: the primary form of the crystals is the right rhombic prism. To the taste this salt is disagreeable and bitter. Its sp. gr. is 2·825. In dry warm air the crystals effloresce, but in the ordinary states of the air they undergo no change. When heated they decrepitate, lose their water of crystallization, and at a red heat fuse. At a white heat, according to Planiava, this salt volatilizes. It is soluble in both cold and hot water: 100 parts of water at 60° dissolve 43·5 of the crystallized salt,—at 222°, 78 parts. It is slightly soluble in ordinary rectified spirit, but is said to be insoluble in pure alcohol.

Characteristics.—That it is a chloride is readily known by nitrate of silver (vide p. 105.) The tests by which the nature of the base can be determined have been before mentioned (p. 338.)

Composition.—The crystals of chloride of barium have the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.	Phillips.
Barium	1	69	56·09	85·201	85·5
Chlorine	1	36	29·26		
Water	2	18	14·63	14·799	14·5
Cryst. Chlor. Barium	1	123	99·98	100·000	100·0

Purity.—The crystals should be colourless, neutral to test paper, permanent in the ordinary states of the air, (if they become moist or deliquesce, the presence of chloride of calcium, or chloride of strontium, may be suspected), and their aqueous solution should undergo no alteration of colour by the addition of ferrocyanide of potassium, hydrosulphuric acid, tincture of nutgalls, or caustic ammonia, by which the absence of metallic matter (as iron, lead, or copper), may be inferred. If excess of sulphuric acid be added, the filtered solution should be completely volatile when heated, and should occasion no precipitate on the addition of carbonate of soda, by which the absence of lime or magnesia is proved.

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—This salt is poisonous to plants. (Marcet, quoted by Decandolle, *Phys. Végét.*)

(*b.*) *On animals.*—The action of chloride of barium on animals is, according to Sir B. Brodie (*Phil. Trans.* 1812, p. 205), analogous to that of arsenic. Locally it operates as an irritant. After absorption it affects the nervous system, the organs of circulation, and the stomach. Its action on the nervous system is manifested by staggering, convulsions, paralysis, and insensibility; on the circulating system, by palpitations, with feeble and intermittent pulse; on the stomach, by vomiting from its application to a wound. According to Sir B. Brodie the affection of the stomach is slighter than that caused by arsenic. (See also the experiments of Orfila in the *Toxicol. Génér.*, and of C. G. Gmelin in his *Versuche über die Wirkungen*, &c.)

(*c.*) *On man.*—Administered in *small doses*, it at first produces no very obvious effects. In some cases the appetite appears to be improved. Soon we observe an increased secretion of urine, tendency to sweating, and not unfrequently loose stools. With no other obvious symptoms than these, glandular swellings or enlargements sometimes become softer and smaller, from which we infer that the absorbent system is stimulated to greater activity. If we persevere in the use of gradually increased doses, the appetite becomes disordered, nausea and vomiting, with not unfrequently griping and purging, come on: a febrile state, with dry tongue, is produced, the nervous system becomes affected, and the patient complains of giddiness and muscular weakness. Sometimes, according to Schwilgue (*Traité de Mat. Méd.* vol. i. p. 441, 3^me^. ed.) under the continued use of it, catarrhal discharges from the eye, nose, ear, &c. take place; inflamed or suppurating lymphatic glands evince signs of an augmented excitation, wounds assume a more healthy appearance, and, in some cases, cicatrize.

In *large medicinal doses* very unpleasant effects have been occasionally observed from its use; such as vomiting, purging, sometimes griping, contracted pulse, giddiness, and great muscular debility, almost amounting to paralysis, with trembling. (See an illustrative case in *Medical Commentaries*, xix. 267.)

In *excessive* or *poisonous doses* (as an ounce) the affection of the nervous system is more obvious. In one recorded case the symptoms were convulsions, pain in the head, deafness, and, within an hour, death. (*Journ. of Science*, vol. ix. p. 382.)

In conclusion, it may be observed, that considered medicinally chloride of barium is most analogous to, though more powerful than, chloride of calcium, and is applicable in the same cases: regarded toxicologically it may be compared to arsenic, but it acts less energetically on the stomach, and more rapidly on the nervous system, and causes death in a shorter time.

USES.—The principal medicinal use of chloride of barium is in the treatment of *scrofula*, for which it was introduced into medicine by Dr. Crawford in 1790 (*Med. Commentaries*, Dec. 2d, vol. iv. p. 433, and *Med. Communications*, vol. ii.), and was subsequently employed by Hufeland (*Erfahr. üb. d. Gebr. u. d. Kräfte d. salzs. Schwererde*, Berl. 1794: and *Vollst. Darstell. d. med. Kräfte u. d. Gebr. d. salzs. Schwererde*, Berl. 1794), with great benefit. The latter writer has employed it in all the forms of this disease, but especially in excited and inflamed conditions, (particularly of delicate and sensible parts, as of the lungs and eyes) in painful ulcers, indurations which are disposed to inflame, and cutaneous affections. It has also been administered as a resolvent, deobstruent, or alterative, in some other diseases: for example, *scirrhus* and *cancer*, *cutaneous diseases*, *bronchocele*, &c. As a local application, a solution of it has been used as a wash in herpetic eruptions, and as a collyrium in scrofulous ophthalmia.

In pharmacy and chemistry it is extensively employed as a test for sulphuric acid and the sulphates.

ADMINISTRATION.—It is used in the form of aqueous solution. The ***LIQUOR BARII CHLORIDI***, Ph. L. consists of a drachm of the salt dissolved in an ounce of distilled water. The dose is ten drops gradually and cautiously increased until nausea or giddiness are experienced. The officinal solutions of the Edinburgh and Dublin Pharmacopœias are about 2½ times stronger. Common water, and all liquids containing carbonates, phosphates, or sulphates, are incompatible with it.

ANTIDOTES.—The antidotes for the barytic salts are the sulphates, which form therewith an insoluble sulphate of baryta. Hence sulphate of soda, sulphate of magnesia, or well or spring water (which contains sulphate of lime) should be copiously administered. Of course the poison should be removed from the stomach as speedily as possible. To appease any unpleasant symptoms caused by the continued use of large medicinal doses, opiates may be employed.

ORDER 13. COMPOUNDS OF CALCIUM.

Calx.—Lime.

HISTORY.—Lime, and the mode of obtaining it by burning the carbonate, were known in the most remote periods of antiquity. Hippocrates (*Popularium*, ii. sect. 5) employed this earth in medicine. Dr. Black in 1755 first explained the nature of the process for making it. In 1808 Davy shewed that this substance was a metallic oxide, and hence it has been termed the *oxide of calcium*. To distinguish it from the hydrate of lime, it is termed *caustic* or *quicklime* (*calx viva*), or *burned lime* (*calx usta*.)

NATURAL HISTORY.—It occurs in both kingdoms of nature.

(*a*.) *In the inorganized kingdom*.—In the mineral kingdom lime is found in the form of carbonate, sulphate, phosphate, silicate, arseniate, tungstate, borate, and titanate. Its base, calcium, occurs in combination with fluorine. "Lime is also disseminated through sea water, though in small quantities; so that calcium is widely distributed in land and water, being principally abundant in the central and higher parts of the fossiliferous rocks, and widely dispersed, in small quantities, throughout the more ancient rocks, and in the waters of the ocean." (De la Beche, *Research. in Theor. Geol.* p. 21.)

(*b*.) *In the organized kingdom*.—In vegetables, lime (or calcium) is an invariable ingredient, except, it is said, in the case of *Salsola Kali*. (Decandolle, *Phys. Végét.* p. 382.) It is found combined with carbonic, sulphuric, phosphoric, nitric, and various organic acids (as oxalic, malic, citric, tartaric, and kinic): calcium occurs in combination with chlorine. In animals lime is found principally as carbonate and phosphate.

Preparation.—For use in the arts lime is usually obtained by burning the carbonate with coals, coak, or other fuel, in a kind of wind furnace called a *kiln* (vide Loudon's *Encycl. of Agricult.* 3d ed. p. 625; and Gray's *Operative Chemist.*) In the Dublin, Edinburgh, and United States Pharmacopœias, the officinal lime is the lime of commerce: but as this contains various impurities, the London Pharmacopœia directs lime to be prepared by exposing chalk to a very strong fire during an hour, by which the carbonic acid is expelled. White Carrara marble yields the purest lime.

Properties.—Lime (commonly termed *quicklime*) when pure is a white, or greyish white solid, having a sp. gr. of 2·3. It has an acrid, alkaline taste, and reacts powerfully on vegetable colours as an alkali. It is difficult of fusion: but by the oxy-hydrogen flame it may be both fused and volatilized. Exposed to the air it attracts water and carbonic acid. If a small portion of water be thrown on lime, part of it combines with the lime, and thereby causes the evolution of a considerable degree of heat, by which another portion of the water is vaporized. The lime swells up, cracks, and subsequently falls to powder: in this state it is called *slacked lime* (*calx extincta*), or the *hydrate of lime*. By heat the water may be again expelled.

Lime dissolves in water, forming *lime-water* or *aqua calcis*. It is prepared by first slacking lime and then adding more water: the proportions employed by the London College are half a pound of lime to three gallons of water. The solution should be kept in stopped glass vessels with the undissolved lime, and when used the clear liquor poured off. The solubility of lime in water is very remarkable; cold water dissolving more than hot. According to Mr. Phillips,

A pint of Water at	32° dissolves	13·25	grains of lime.
Ditto . .	60° . . .	11·6	ditto.
Ditto . .	212° . . .	6·7	ditto.

So that water at 32° dissolves nearly twice as much lime as water at 212°. Lime water is colourless and transparent, but by exposure to the air becomes covered with a film of carbonate of lime, which precipitating to the bottom of the vessel is succeeded by another. Its taste is unpleasant and alkaline, and it has an alkaline reaction on vegetable colours. When a cold saturated solution of lime is heated, small crystals of hydrate of lime are deposited: the same are also produced by evaporating lime water in the exhausted receiver of the air-pump.

Characteristics.—Lime water is recognized by its action on turmeric paper and on the infusion of red cabbage; by the milkiness produced in it on the addition of carbonic acid or a soluble carbonate, and by the white precipitate on the addition of a solution of oxalic acid or an oxalate. Sulphuric acid affords no precipitate with lime water. Solutions of the calcareous salts are known by the following characters:—The hydrosulphurets, ferrocyanides, and, if the solution be dilute, the sulphates, occasion neither a precipitate nor a change of colour: the soluble carbonates, phosphates, and oxalates, produce white precipitates. The calcareous salts (especially chloride of calcium) give an orange tinge to the flame of alcohol.

Composition.—The following is the composition of lime and its hydrate:—

	Eq.	Eq. Wt.	Per Cent.	Berzelius.
Calcium	1	20	71·42	71·91
Oxygen	1	8	28·57	28·09
Lime	1	28	99·99	100·00

	Eq.	Eq. Wt.	Per Cent.
Lime	1	28	75·67
Water	1	9	24·32
Hydrate of Lime	1	37	99·99

Purity.—The lime used in the arts is never absolutely pure, but usually contains variable quantities of carbonate of lime, silica, alumina, and oxide of iron, and sometimes magnesia.

Physiological Effects. (*a.*) *On vegetables.*—Quicklime is poisonous to plants. Notwithstanding this, however, it is sometimes used as a manure, its efficacy depending on its decomposing and rendering soluble the vegetable matter of the soil, during which the lime attracts carbonic acid and becomes innocuous. (Davy, *Agricult. Chemistry.*)

(*b.*) *On animals.*—On dogs, Orfila (*Toxicol. Gén.*) found that quicklime acted as a caustic poison, but not very energetically; and that it occasions death by producing inflammation of the texture with which it comes in contact.

(*c.*) *On man.*—Quicklime is an escharotic. Its chemical action on the tissues is analogous to that of the fixed alkalies, to which must be added its powerful affinity for water. Its use in promoting the decomposition of the bodies of persons who have died of contagious diseases, or on the field of battle, and its employment by the tanner to separate the cuticle and hair from skins, sufficiently establish its causticity. Its escharotic and irritant action is well seen in the ophthalmia produced by the lodgment of small particles of lime in the eye.

When applied to suppurating or mucous surfaces, lime water checks or stops secretion, and produces dryness of the part: hence it is termed a desiccant.

When administered internally, it neutralizes the free acid of the gastric juice, diminishes the secretions of the gastro-intestinal membrane, and thereby occasions thirst and constipation. It frequently gives rise to uneasiness of stomach, disordered digestion, and not unfrequently to vomiting. After its absorption it increases the secretion of urine, and diminishes the excessive formation or deposition of uric acid and the urates. With this exception, it does not, as the alkalies, promote the action of the different secreting organs, but, on the other hand, diminishes it, and has in consequence been termed an astringent. But it does not possess the corrugating action of the astringent vegetables, or of many of the metallic salts: it is rather a drying remedy, and might be more correctly termed a *desiccant* than astringent. In this respect lime differs from the alkalies, but is analogous to the oxide of zinc. Vogt (*Pharmak.*) considers it to be intermediate between the two. Weickard and others have ascribed to lime an antispasmodic property; and if this be true, its relation to zinc is still further proved.

A power of exciting and changing the mode of action of the absorbent vessels and glands has been ascribed to lime water, and probably with foundation. At any rate, under the use of it, glandular enlargements have become softer and smaller. Sundelin (*Heilmittell.*) says that the excessive use of lime does not, as in the case of the alkalies, bring about a scorbutic diathesis, but a general drying and constriction, analogous to that caused by zinc.

Lime in large doses acts as a poison: the symptoms in one case were thirst, burning in the mouth, burning pain in the belly, obstinate constipation, and death in nine days. (Christison.)

USES.—Quicklime has been employed as a *caustic*, but alone is now rarely resorted to. It is sometimes applied in the form of *potassa cum calce*, and is a constituent of the ordinary depilatories. As an *antidote*, lime water, in conjunction with milk, was recommended by Navier (*Contre-poison de l'arsenic*, &c. 1777, quoted by Richter, *ausf. Arzn.*) in poisoning by arsenious acid. In the absence of more appropriate antidotes, lime water may be administered in poisoning by the common mineral and oxalic acids. As a *lithontriptic* it possessed at one time considerable celebrity, partly from its being one of the active ingredients of Miss Joanna Stephens' *Receipt for the Stone and Gravel*, as well as from experiments and reports of professional men. As this lady had acquired no slight fame by her mode of treatment, a great desire was manifested to know the nature of her remedies, and she therefore offered to discover them on the payment of a suitable reward. A committee of professional men was appointed to examine the efficacy of her treatment, and her medicines were given to patients known to have calculi. The report made by the committee, as to the effects, was so favourable, that Parliament was induced to grant a reward of £5000, a notice of which appeared in the *London Gazette* of March 18, 1739! (D'Escherny, *A Treatise of the Causes and Symptoms of the Stone*, 1755.) The essential parts of her remedies were lime (prepared by calcining egg-shells and snails), soap, and some aromatic bitters; viz. camomile flowers, sweet fennel, parsley, and burdock leaves, &c. That the patients submitted to treatment obtained relief by the remedies employed cannot, I think, be doubted, but no cure was effected; that is, no calculus was dissolved, for in the bladder of each of the four persons whose cure was certified by the trustees, the stone was found after their death (Alston's *Lect. on the Mat. Med.* vol. i. p. 268). Notwithstanding the favourable reports to the contrary (Chevallier, *Med. Gaz.* vol. xx. p. 460), it appears to me that no rational ground of hope can now be entertained that lime water is capable of dissolving urinary calculi in the kidneys or bladder: but there is abundant evidence to prove that patients afflicted with the uric acid diathesis have sometimes experienced extraordinary benefit from its use (Van Swieten's *Commentaries upon Boerhaave's Aphorisms*, vol. xvi. p. 299). Its mode of action is analogous to that of the alkalies (*vide* pp. 9 & 279). Chevallier (*Med. Gaz.* vol. xx. p. 584) accounts for its efficacy in the treatment of gravel and stone by the circumstance of the combination of the lime with uric acid forming a very soluble salt, viz. urate of lime; and he even thinks that lime water may be useful in phosphatic calculi, either by depriving them of a portion of the uric acid which they contain, and thus rendering them less dense; by decomposing the ammoniacal salt which enters into the composition of some; or by acting on the animal matter which holds the molecules of these calculi together. As an *antacid* in dyspepsia accompanied by acidity of stomach, it is sometimes useful. "Mixed with an equal measure of milk, which completely covers its offensive taste, it is one of the best remedies in our possession for nausea and vomiting dependent on irritability of stomach. We have found a diet, exclusively of lime water and milk, to be more effectual than any other plan of treatment in dyspepsia, accompanied with vomiting of food. In this case one part of the solution to two or three of milk, is usually sufficient" (*United States Dispensatory*). In the dyspepsia of gouty and rheumatic subjects, and which is usually accompanied with a copious secretion of uric acid by the kidneys, I have seen lime water serviceable. As a *dessicant* or *astringent*, it is useful as a wash for ulcers attended with excessive secretion. In some scrofulous ulcers in which I have employed it, its power of checking secretion has been astonishing. In diarrhœa, when the mucous discharge is great, and the inflammatory symptoms have subsided, lime water is useful as an astringent. As an injection in leucorrhœa and gleet it sometimes succeeds where other remedies have failed. The internal use of lime water has also been serviceable in checking secretion from various other parts, as from the bronchial membranes, the bladder, &c.

Besides the above, lime water has been employed for various other purposes. Thus as an antispasmodic, in hypochondriasis and hysteria, with habitual excessive sensibility of the nervous system, it has been found useful by Weickard (Richter's *ausf. Arzneim.* iii. 585). It has also been given as an alterative in glandular enlargements and venereal affections, and to promote the deposit of bone earth in diseases accompanied with a deficiency of this substance. In skin diseases (tinea capitis, scabies, prurigo, &c.) it has been applied as a wash.

ADMINISTRATION.—From half an ounce to three or four ounces may be taken three times a day. As already mentioned, it may be conveniently administered in combination with milk.

LINIMENTUM CALCIS, Ph. Dub. & U. S.; *Oleum Lini cum Calce*, Ph. Ed. *Calcareous soap* or *oleo-margarate of lime* (lime water, linseed or olive oil $\overline{\text{aa}}$. equal parts).—This compound has been celebrated as an application to burns and scalds. From being used at the Carron Ironworks, in cases of burns, it is called *Carron oil*. It is almost invariably prepared with linseed oil, though in the Dublin Pharmacopœia olive oil is ordered. Turpentine may be sometimes advantageously added to it.

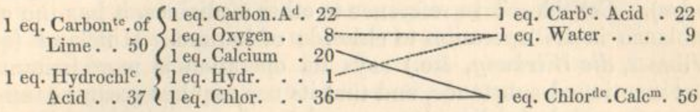
Cal'cii Chlo'ridum.—Chlo'ride of Cal'cium.

HISTORY.—This salt, obtained in the decomposition of sal ammoniac by lime, was known, according to Dulk (*Die Preuss. Pharm. übersetst*, &c. ii. 293) in the fifteenth century to the two Hollands, who called it *fixed sal ammoniac* (*sal ammoniacum fixum*). Its composition was not understood until the eighteenth century, when it was ascertained by Bergman, Kirwan, and Wenzel. It is commonly termed *muriate of lime*.

NATURAL HISTORY.—It is found, in small quantity, in sea and many mineral and well waters. It has also been detected, in a few instances, in vegetables: thus Pallas recognised it in the root of *Aconitum Lycoctonum*.

PREPARATION.—It is readily prepared by dissolving carbonate of lime in hydrochloric acid. The proportions ordered in the London Pharmacopœia are, five ounces of chalk, half a pint of hydrochloric acid, and the like quantity of water. When the effervescence has finished, the filtered solution is ordered to be evaporated to dryness, and the residue fused in a crucible. While in the liquid state it is to be poured on a clean flat stone, and when cold broken into small pieces, and preserved in a well-stopped vessel.

In this process one equivalent or 37 parts of hydrochloric acid react on one equivalent or 50 parts of carbonate of lime, and produce one equivalent or 22 parts of carbonic acid, which escapes in a gaseous form, one equivalent or 9 parts of water, and one equivalent or 56 parts of chloride of calcium. By the subsequent evaporation and fusion, both the water used and that formed are expelled, leaving anhydrous chloride of calcium.



Chloride of calcium is a secondary product in the manufacture of the hydrated sesquicarbonate of ammonia (p. 174).

Properties.—Anhydrous chloride of calcium is a white translucent solid, of a crystalline texture. Its taste is bitter and acrid saline. It is fusible, but not volatile. It deliquesces in the air, and becomes what has been called *oil of lime* (*oleum calcis*). When put into water it evolves heat, and readily dissolves in a quarter of its weight of this fluid at 60° F., or in a much less quantity of hot water. By evaporation the solution yields striated crystals (*hydrated chloride of calcium*), having the form of regular six-sided prisms, and which, therefore, belong to the rhombohedic system (p. 61). These crystals undergo the watery fusion when heated, are deliquescent, readily dissolve in water with the production of great cold, and when mixed with ice or snow form a powerful frigorific mixture. Both anhydrous and hydrous chloride of calcium are readily soluble in alcohol.

Characteristics.—This salt is known to be a chloride by the tests for this class of salts before mentioned (p. 105). The nature of its base is ascertained by the tests for lime (p. 343).

Composition.—The composition of this salt is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Ure.
Calcium	1	20	35·71	36·7
Chlorine	1	36	64·28	63·3
Chloride Calcium	1	56	99·99	100·0

	Eq.	Eq.Wt.
Chloride Calcium	1	56
Water	6	54
Cry^{t}.Chl^{de}.Calc^{m}.	1	110

Purity.—Chloride of calcium, when pure, is colourless, evolves no ammonia when mixed with lime, and undergoes no change of colour nor gives any precipitate with caustic ammonia, chloride of barium, hydrosulphuric acid, or ferrocyanide of potassium.

Physiological Effects. (*a.*) *On animals.*—Three drachms and a half given to a dog caused quick breathing and snorting, with convulsive but vain efforts to vomit, a profuse secretion of saliva, and death in six hours. The mucous membrane of the stomach and small intestines was very blood-shot, and in many places almost black, and converted into a gelatinous mass (Beddoes, *Duncan's Annals of Medicine*, vol. i. Lustr. ii. 208).

(*b.*) *On man.*—In *small doses* it promotes the secretions of mucus, urine, and perspiration. By continued use it appears to exercise a specific influence over the lymphatic vessels and glands, the activity of which it increases; for under its use glandular and other swellings and indurations have become smaller and softer, and ultimately disappeared altogether. In *larger doses* it excites nausea, vomiting, and sometimes purging; causes tenderness in the præcordium, quickens the pulse, and occasions faintness, weakness, anxiety, trembling, and giddiness. In *excessive doses* the disorder of the nervous system is manifested by failure and trembling of the limbs, giddiness, small contracted pulse, cold sweats, convulsions, paralysis, insensibility, and death (Vogt, *Pharmakodyn*). Considered in reference to other medicines, it has the closest resemblance in its operation to chloride of barium. Hufeland (quoted by Wibmer, *die Wirkung*, &c.) says its operation is more irritant than the last mentioned substance, and that its use requires greater caution,—a statement which is directly opposed to the experience of Dr. Wood (*Ed. Med. and Surg. Journ.* i. 147), and of most other practitioners.

USES.—It has been principally employed in scrofulous affections, especially those attended with glandular enlargements. Beddoes (*op. cit.*) gave it to nearly a hundred patients, and he tells us there are few of the common forms of scrofula in which he has not had successful experience of it. Dr. Wood (*op. cit.*) tried it on an extensive scale, and with decided benefit. It has been found most efficacious in the treatment of tabes mesenterica, checking purging, diminishing the hectic fever, allaying the inordinate appetite, and ultimately restoring the patient to perfect health. It has also been recommended in chronic arthritic complaints, in bronchocele, in some chronic affections of the brain (as paralysis), and in other cases where the object was to excite the action of the absorbents.

Occasionally, though rarely, it has been employed externally. Thus a bath containing two or three ounces of it, either alone or with chloride of sodium, has been used in scrofula (Vogt, *Pharmakodyn.*)

In pharmacy chloride of calcium is used in the rectification of spirit, (p. 197), on account of its strong affinity for water. In chemistry it is employed in the drying of gases, and in the crystallized state, mixed with half or two-thirds of its weight of ice or snow, for producing an intense degree of cold.

ADMINISTRATION.—Chloride of calcium is always used in the form of aqueous solution. The ***LIQUOR CALCII CHLORIDI***, Ph. L. consists of four ounces of the chloride dissolved in twelve fluidounces of distilled water. The dose of it is forty or fifty minims, gradually increased until slight nausea is produced.

Cal'cis Hypochlo'ris.—Hypochlo'rite of Lime.

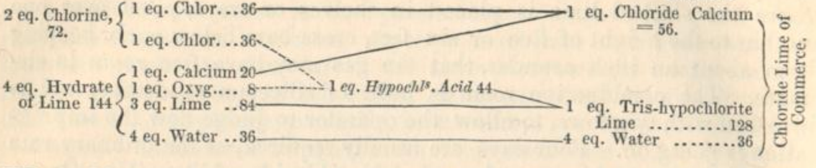
HISTORY.—In 1798, Mr. Tennant, of Glasgow, took out a patent for the manufacture of this substance as a bleaching powder, which in consequence was long known as *Tennant's bleaching powder*. According to the views entertained of its composition, it has been successively termed *oxymuriate of lime*, *chloride of lime* or *chloruret of the oxide of calcium*, *chlorite of lime* (Berzelius), and *chlorinated lime* (*calx chlorinata*, Ph. L.)

Preparation.—It is prepared by conveying chlorine gas into a vessel or chamber containing slacked lime. On the large scale the gas is generated in large, nearly spherical, leaden vessels heated by steam. The ingredients employed are binoxide of manganese, chloride of sodium, and diluted sulphuric acid. The gas is washed by passing it through water, and is then conveyed by a leaden tube into the combination room, where the slacked lime is placed in shelves or trays, piled over one another to the height of five or six feet, cross bars below each, keeping them about an inch asunder, that the gas may have free room to circulate. The combination room is built of siliceous sandstone, and is furnished with windows, to allow the operator to judge how the impregnation is going on. Four days are usually required, at the ordinary rate of working, for making good marketable chloride of lime (Ure, *Quart. Journ. of Science*, xiii. 1). At Mr. Tennant's manufactory at Glasgow, the lime is placed in shallow boxes at the bottom of the combination chambers, and is agitated during the process by iron rakes, the handles of which pass through boxes filled with lime, which serves as a valve (*American Journ. of Science*, vol. x. No. 2, Feb. 1826, and Dumas' *Traité de Chimie*, ii. 806). The theory of the process will be noticed when describing the composition of this substance.

Properties.—Chloride of lime, as met with in commerce, is a white or brownish white powder, having a feeble odour of chlorine, and a strong bitter and acrid taste. Exposed to the air it evolves chlorine, and attracts carbonic acid, and is thereby converted into a mixture of carbonate of lime and chloride of calcium, the latter of which deliquesces. Digested in water the chloride or hypochlorite of lime dissolves, as well as any chloride of calcium present, and a small portion of caustic lime: any carbonate and the excess of caustic lime remain undissolved. The solution, which has a slight yellow colour, first reacts on vegetable colours as an alkali, and afterwards bleaches them. Its bleaching and disinfecting properties depend on the oxidizement of the colouring or infectious matter: if an acid be employed in the process, chlorine is evolved, which produces oxygen at the expense of the elements of water, as before mentioned (p. 107): if, on the contrary, no acid be used, Balard (*Researches*, in Taylor's *Scientific Memoirs*, vol. i. p. 269) supposes that both the hypochlorous acid and lime give out their oxygen, and thereby become chloride of calcium. When chloride of lime is heated it evolves first chlorine and subsequently oxygen.

Characteristics.—Its smell and bleaching properties are most characteristic of it. The acids (as sulphuric or hydrochloric) separate chlorine from it. An aqueous solution of it throws down white precipitates with nitrate of silver, the alkaline carbonates, and with oxalic acid or the oxalates. The supernatant liquor from which chloride of silver has been thrown down by nitrate of silver possesses a decolorizing property.

Composition.—Chemists are not agreed as to the nature of the substance called chloride of lime. By most English chemists (Dalton, Thomson, Brande, Turner, and Phillips), it is supposed that when chlorine comes in contact with slacked lime combination takes place, and that the lime undergoes no decomposition. By others (Berzelius, Souberain, and Balard), however, it is supposed that part of the lime is decomposed; one portion of the chlorine uniting with the calcium to form chloride of calcium, and another with the oxygen to become hypochlorous (*chlorous*, Berzelius) acid, which combines with the undecomposed lime: so that the so-called chloride of lime is, according to this view, a mixture of chloride of calcium and hypochlorite (or rather a tris-hypochlorite) of lime and water. The following diagram illustrates the formation of these compounds according to the latter theory:—



When chloride of lime comes in contact with water, the tris-hypochlorite deposits two equivalents of hydrate of lime, while one equivalent of the chloride of calcium and one equivalent of the neutral hypochlorite of lime are dissolved.

The following table shews the composition of the so-called chloride of lime according to Soubeiran (*Nouv. Traité de Pharm.* ii. 365); Phillips, (*Transl.* 3d ed.); and Ure, (*op. cit.*)

SOUBEIRAN.			PHILLIPS.			URE.		
	Eq.	Eq.Wt.		Eq.	Eq.Wt.		*Ure's.*	*Commer.*
Chloride of Calcium	1	56	Bihydrated Chloride of Lime	1	82	Chlorine....	40·31	23
Tris-hypochlorite of Lime	1	128	Lime	1	28	Lime	45·40	46
Water..................	4	36				Water	14·28	31
Dry Chloruret of Lime ..	1	220	Chlorinated Lime	1	110	Chloride of Lime	99·99	100

CHLOROMETRY —The chloride of lime of commerce varies in the quantity of hypochlorite which it contains, and hence some chlorometrical process is necessary in order to ascertain its goodness. The two principal methods are, to determine the quantity of chlorine gas which it evolves on the addition of hydrochloric acid (Ure, *Quart. Journ. of Science*, xiii. 21) and to observe what quantity of sulphate of indigo it is capable of decolorizing (Gay Lussac, in Alcock's *Essay*, p. 136.) Dr. Ure says 10 grains of good bleaching powder should yield 3 or 4 cubic inches of chlorine.

PHYSIOLOGICAL EFFECTS.—The effects of chloride (hypochlorite) of lime on the system have not as yet been accurately ascertained. Its local action is that of an irritant and caustic. A solution of it applied to suppurating and mucous surfaces is a powerful desiccant, probably in part at least from the uncombined lime in solution. When the secretions are excessive and extremely fetid, it not only diminishes their quantity but much improves their quality; so that considered in reference to suppurating and mucous surfaces, it is not only a desiccant, but, in morbid conditions of these parts, a promoter of healthy secretion. Applied in the form of ointment (composed of a drachm of chloride to an ounce of fatty matter) to scrofulous swellings, Cima (Configliachi and Brugnatelli's *Giornale di Fisica*, 1825, quoted by Dierbach, *d. neust. Entd. in d. Mat. Med.* 1828, 2^te. Abt. 597), found that it provoked suppuration, caused strong redness, promoted the suppurating process, and dispersed the surrounding hardness.

Taken internally in *small doses* (as from 3 to 6 grains dissolved in one or two ounces of water) it sometimes causes pain and heat in the stomach, and occasionally, according to Cima, purging. Under the continued use of it, hard and enlarged absorbent glands have become softer and smaller, from which circumstance it has been supposed to exercise a specific influence over, and promote the healthy action of, the lymphatic system. During its employment, Cima says he did not find it necessary to give purgatives. Dr. Reid (*Trans. of the Associat. of Fellows and Licentiates of the College of Physicians in Ireland*, vol. v. 1828), gave it in the epidemic fever which raged in Ireland in 1826, and he tells that it rendered the tongue cleaner, abated the delirium, and promoted the cutaneous functions. In dysentery it soon put a stop to the bloody evacuations, the umbilical pain, and the tenesmus.

I am not acquainted with any facts respecting the effects of chloride of lime *in large or poisonous doses*. Analogy would lead us to expect that it would produce the combined effects of a caustic, and of an agent specifically affecting the nervous system.

USES.—The chlorides (hypochlorites) of lime and soda are extensively employed as disinfectants and antiseptics. I have already stated (p 107) that chlorine gas stands unrivalled for its power of destroying putrid odours and checking putrefaction, and where uninhabited chambers or buildings are to be purified, fumigations with this gas should be adopted. But its powerful action on the organs of respiration precludes its use in inhabited places, and, in such cases, the alkaline chlorides (chloride of lime, on account of its cheapness) are to be substituted. When these substances are in contact with organic matter, it is supposed the hypochlorite gives out oxygen, and is converted into a metallic chloride: the oxygen being the effective disinfecting and antiseptic agent. When, however, the solution of the chloride (hypochlorite) is exposed to the air, carbonic acid is attracted by the lime, and hypochlorous acid set free: this is decomposed by the calcium of the chloride, lime is formed, which combines with carbonic acid of the air, and chlorine (from both the hypochlorous acid and chloride of calcium) is disengaged, and furnishes oxygen to the putrefying matter at the expense of some water, with the hydrogen of which it combines. Hence these chlorides (hypochlorites) when exposed to the air evolve chlorine so slowly and in such moderate quantities, as not to produce any noxious effects, though their action on organic matters is very powerful. Their most obvious effect is that of destroying the unpleasant odour of putrid matter. Their action on hydrosulphuric acid, ammonia, and hydrosulphate of ammonia (substances evolved by decomposing animal matters) can be readily and easily demonstrated. Other odorous principles given out by putrid matters are, by the experience of most persons, admitted to be destroyed by the alkaline chlorides, though Piorry (*Journ. Chim. Méd.* ii. 601) has asserted they are only overpowered by the stronger smell of the chlorine.

The alkaline chlorides (hypochlorites) possess another valuable property—that of stopping or checking the putrefactive process; and hence they are called antiseptics. For various facts in proof of this I must refer to the late Mr. Alcock's *Essay on the Uses of the Chlorurets*.

These two properties, viz. that of destroying offensive odours and that of preventing putrefaction, render the alkaline chlorides most valuable agents to the medical practitioner. We apply them to gangrenous parts, to ulcers of all kinds attended with foul secretions, to compound fractures accompanied with offensive discharges, to the uterus in various diseases of this viscus attended with fetid evacuations; in a word, we apply them in all cases accompanied with offensive and fetid odours. As I have before remarked with respect to chloride of soda (p. 316) their efficacy is not confined to an action on dead parts, or on the discharges from wounds and ulcers: they are of the greatest benefit to living parts, in which they induce more healthy action, and the consequent secretion of less offensive matters. Furthermore, in the sick chamber, many other occasions present themselves on which the power of the chlorides to destroy offensive odours will be found of the highest value: as to counteract the unpleasant smell of dressings or bandages, of the urine in various diseases of the bladder, of the alvine evacuations, &c. In typhus fever, a handkerchief dipped in a weak solution of an alkaline chloride, and suspended in the sick chamber, will be often of considerable service both to the patient and the attendants.

The power of the chlorides (hypochlorites) to destroy infection or contagion, and to prevent the propagation of epidemic diseases, is less obviously and satisfactorily ascertained than their capability of destroying odour. Various statements have been made by Labarraque and others (vide Alcock's *Essay*, p. 55, *et seq.*) in order to prove the disinfecting power of the chlorides with respect to typhus and other infectious fevers. But, without denying the utility of these agents in destroying bad smells in the sick chamber, and in promoting the recovery of the patient by their influence over the general system, I may observe that I have met with no facts which are satisfactory to my mind as to the chemical powers of the chlorides to destroy the infectious matter of fever. Nor am I convinced by the experiments made by Pariset and his colleagues (*Bullet. des Sciences Méd.* xix. 233) that these medicines are preservative against the plague. Six individuals clothed themselves with impunity in the garments of men who had died of plague, but which garments had been plunged for six hours in a solution of chloride of soda. But, as Bouillaud (*Dict. de Méd. Prat.*, art. *Contagion*) has truly observed, the experiments, to be decisive, should have been made with clothing which had already communicated the plague to the wearers of it. In Moscow, chlorine was extensively tried and found unavailing, nay, apparently injurious, in cholera. "At the time," says Dr. Albers (*Lond. Med. Gaz.* viii. 410) "that the cholera hospital was filled with clouds of chlorine, then it was that the greatest number of the attendants were attacked." (See also Dierbach, *d. neust. Entd. in d. Mat. Med.* i. 411, 2te Ausg. 1837.) Some years ago chlorine was tried at the Small Pox Hospital, with a view of arresting the progress of erysipelas: all offensive smell, as usual, was overcome, but the power of communicating the disease remained behind. (*Lond. Med. Gaz.* viii. 472.) Bousquet (*Rev. Méd.* Fev. 1830, p. 264) mixed equal parts of a solution of chloride of soda and the vaccine lymph, and found that the latter still possessed the power of producing the usual cow-pock vesicle. These are a few of the facts which are adverse to the opinion that chlorine or the chlorurets possess the power of preventing the propagation of infectious, contagious, or epidemic diseases. In opposition to them there are but few positive facts to be adduced. Coster (Richter, *Auf. Arzneimittell.* Suppl. Band. 539) found that a solution of chloride of soda destroyed the infectious properties of the syphilitic poison, and of the poison of rabid animals.

The statements of Labarraque (Alcock's *Essay*, pp. 56, 58, &c.) and others as to the preservative powers of the chlorides in typhus, measles, &c. are too loose and general to enable us to attach much value to them.

Considered in reference to medical police, the power of the alkaline chlorides (hypochlorites) to destroy putrid odours and prevent putrefaction is of vast importance. Thus chloride of lime may be employed to prevent the putrefaction of corpses previously to interment, to destroy the odour of exhumed bodies during medico-legal investigations, to destroy bad smells, and prevent putrefaction in dissecting-rooms and workshops in which animal substances are employed (as cat-gut manufactories), to destroy the unpleasant odour from privies, sewers, drains, wells, docks, &c., to disinfect ships, hospitals, prisons, stables, &c. The various modes of applying it will readily suggest themselves. For disinfecting corpses, a sheet should be soaked in a pailful of water containing a pound of chloride, and then wrapped around the body. For destroying the smell of dissecting-rooms, &c. a solution of the chloride may be applied by means of a garden watering-pot. When it is considered desirable to cause the rapid evolution of chlorine gas, hydrochloric acid may be added to chloride of lime.

Chloride of lime (or chloride of soda) is the best *antidote* in poisoning by hydrosulphuric acid, hydrosulphuret of ammonia, sulphuret of potassium, and hydrocyanic acid. It decomposes and renders them inert. A solution should be administered by the stomach, and a sponge or handkerchief soaked in the solution, held near the nose, so that the vapour may be inspired. It was by breathing air impregnated with the vapour arising from chloride of lime that Mr. Roberts (the inventor of the miner's improved safety lamp), was enabled to enter and traverse with safety the sewer of the Bastile, which had not been cleansed for 37 years, and which was impregnated with hydrosulphuric acid. (Alcock's *Essay*.) If a person be required to enter a place suspected of containing hydrosulphuric acid, a handkerchief moistened with a solution of chloride of lime should be applied to the mouth and nostrils, so that the inspired air may be purified before it passes into the lungs.

A solution of chloride of lime has been used as a wash in some skin diseases. Derheims (*Journ. Chim. Méd.* iii. 575) used a strong solution with great success in scabies. This mode of curing itch is much cleaner, and more agreeable, than the ordinary method by sulphur frictions. It has likewise been found successful by Fantonetti (*Journ. de Chim. Méd.* ix. 305) in tinea capitis: where the discharge is copious, washes of the chloride may be used with advantage. In burns and scalds Lisfranc employed lotions of chloride of lime either immediately after the accident, or subsequent to the application of emollient poultices.

Solutions of chloride of lime have been employed with great benefit in ophthalmia. Dr. Varlez, surgeon to the military hospital at Brussels, (*Med. and Phys. Journ.* Nov. 1827) states that in 400 cases it never disappointed him once. Mr. Guthrie has also reported favourably of it in three cases; as have likewise MM. Colson, Delatte, and Raynaud. The solution used by Dr. Varlez was composed of from a scruple to three or four drachms of chloride, and an ounce of water. It was dropped into the eye or injected by a syringe, or applied by means of a camel's hair pencil. Of course other means (bleeding, purging, cold, and, in chronic cases, blisters) should be conjoined. I have found a weak solution of the chloride very successful in the purulent ophthalmia of infants. Gubian (*Journ. de Chim. Méd.* vi. 315) proposed to apply a solution of chloride of lime to prevent the pitting from small-pox. The fully maturated pustules are to be opened and washed with a weak solution of this salt: desiccation takes place very promptly, and no marks or pits are said to be left behind.

Chloride of lime may be employed *internally* in the same cases that chloride of soda is administered (p. 316.) It has been used with great success by Dr. Reid (*Trans. of the King and Queen's College of Physicians in Ireland*, v. 266) in the epidemic fever of Ireland. In some of the very worst cases it acted most beneficially, causing warm perspiration, rendering the tongue cleaner and moister, checking diarrhœa, and inducing quiet sleep. I also can bear testimony to the good effects of this remedy in bad cases of fever. In disease of the pulmonary organs resulting from febrile excitement, Dr. Reid also found it advantageous. In dysentery likewise it was most valuable. He used it by the mouth and also in the form of glyster. It corrected the intolerable stench of the evacuations, and improved their appearance. Cima (Richter, *ausf. Arzneimitt.* iv. 305) used it both internally and externally in scrofula.

ADMINISTRATION.—*Internally*, chloride of lime may be given in doses of from one grain to five or six grains, dissolved in one or two ounces of water, sweetened with syrup. As the dry chloride of the shops deposits hydrate of lime when put into water, the solution (of the hypochlorite of lime and chloride of calcium) should be filtered, to get rid of this. To destroy the unpleasant smell of the breath, *lozenges of chloride of lime* have been used. (*Journ. de Chim. Méd.* iii. 496.)

For *external* use (lotions and gargles) it is also generally employed in the form of *solution*, the strength of which must vary according to the quality of the chloride, and the nature and seat of the disease to which we intend to apply it. The average proportions are from one to four drachms of chloride to a pint of water. In the cure of itch, Derheims employed a wash composed of three ounces of chloride to a pint of water. The solution is to be filtered to separate the hydrate of lime. Cima employed an *ointment of chloride of lime* (composed of from a scruple to a drachm of chloride, and an ounce of fresh butter) by way of friction, to reduce scrofulous enlargements of the lymphatic glands which had resisted the use of mercurial ointment. When the evacuations from the bowels are very offensive, chloride of lime may be used in the form of *enema*. For this purpose, ten or fifteen grains or more may be added to the common enema.

ANTIDOTES.—Administer albuminous liquids (as eggs beat up with water) or milk, or flour and water, or oil, or mucilaginous drinks, and excite vomiting; combat the gastro-enteritis by the usual means. Carefully avoid the use of acids, which would cause the evolution of chlorine gas in the stomach.

Cal'cis Car'bonas.—Car'bonate of Lime.

History.—Some varieties of carbonate of lime were distinguished and employed in the most remote periods of antiquity. Marble was probably used for building 1050 years before Christ (1 Chron. xxix. 2.) Pliny (*Hist. Nat.* xxxvi.) tells us that Dipœnus and Scyllis were renowned as statuaries of marble in the 50th Olympiad (*i. e.* 557 years before Christ.) The *creta*, mentioned by Horace (*Sat.* iii. lib. 2), and Pliny (*Hist. Nat.* xxxvi. 58, Valp. ed.), was probably identical with our chalk. (On the chalk of the ancients, consult Beckmann's *Hist. of Invent.* i. 212.)

Natural History.—Carbonate of lime occurs in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—It forms a considerable portion of the known crust of the earth, and occurs in rocks of various ages. It is found in the inferior stratified rocks, but more abundantly in the different groups of the fossiliferous rocks, particularly towards the central and higher parts of the series (De la Beche, *Researches in Theoretical Geology*, 21.)

In the crystallized form it constitutes calcareous spar and arragonite. The first of these is most extensively distributed, and presents itself under many hundred varieties of shapes, the primitive form of all being the rhombohedron.

Granular carbonate of lime (the *granular limestone* of mineralogists) more commonly occurs in beds, but sometimes constitutes entire mountains. The whitest and most esteemed primitive limestone is that called *statuary marble*, or, from its resemblance to white sugar, *saccharoid carbonate of lime.* That from Carrara, on the eastern coast of the Gulf of Genoa, is the kind usually employed by the statuary, and being very pure, may be employed for pharmaceutical purposes.

Chalk constitutes the newest of the secondary rocks, and occurs abundantly in the southern parts of England. It lies in beds, and contains abundance of marine as well as terrestrial organic remains. The upper part of a considerable portion of the chalk of England contains numerous flints, which are supposed by some (Dr. Grant, *Lect. on Comp. Anat.* in the *Lancet*, Nov. 2, 1833) to have once belonged to poriferous animals.

There are various other native forms of carbonate of lime constituting the substances called by the mineralogist *schiefer spar*, *rock milk*, *earth foam*, *stalactitic carbonate of lime*, *anthraconite*, *oolite*, *pisolite*, *marl*, *tufa*, &c.

Carbonate of lime is an ordinary ingredient in mineral and common waters, being held in solution by carbonic acid, and, therefore, deposited when this is expelled by boiling or otherwise.

(*b.*) *In the organized kingdom.*—Carbonate of lime is a constituent of some plants, and is obtained from the ashes of most. It is an abundant constituent of animals, especially of the lower classes. Thus in the radiate animals we find it in the hard parts of corals, madrepores, &c.; in the molluscs, in the shells (as in the oyster). In the articulated animals it forms, with phosphate of lime, the crusts which envelop these animals (as the crab and lobster); in the higher classes it is found in bone, but the quantity of it is very small.

PREPARATION.—In the Dublin Pharmacopœia, carbonate of lime (*calcis carbonas præcipitatum*, Ph. D.) is ordered to be prepared by adding a solution of carbonate of soda to a solution of chloride of calcium: double decomposition takes place, chloride of sodium is formed in solution, and carbonate of lime precipitated. Thus prepared, carbonate of lime is directed to be used in the preparation of *hydrargyrum cum cretâ*. By some druggists it is employed, instead of prepared chalk, in the manufacture of aromatic confection.

Marble (*marmor*, Ph. L., *marmor album*, Ph. D. & Ed.), or hard carbonate of lime (*carbonas calcis durus*, Ph. L.) is employed for the production of carbonic acid (*vide* p. 190); and, in some Pharmacopœias, for the preparation of chloride of calcium. For the latter purpose, especially, white or statuary marble should be selected, on account of its freedom from iron.

Chalk (*creta*, Ph. L., *creta alba*, Ph. Dub. & Ed.) or friable carbonate of lime (*calcis carbonas friabilis*, Ph. L., *carbonas calcis mollior*, Ph. Ed.) is found in great abundance in the southern parts of England. To reduce it to a fine state of division, and to deprive it of its coarser parts, it is submitted to the process of elutriation, and is then called *prepared chalk* (*creta præparata*, Ph. L. & Dub., *carbonas calcis præparatus*, Ph. Ed. & U. S.)

Carbonate of lime is prepared, for medical purposes, from several molluscous animals; as from the shell of the oyster (*Ostrea edulis*), the gastric concretions (called *crabs' eyes* or *stones*) of the crawfish (*Astacus fluviatilis*), and the crustaceous envelope of the claws of the crab (*Cancer pagurus*). The carbonate procured from these sources is called, respectively, *testæ præparatæ* (Ph. L.), *lapilli cancrorum*, and *chelæ cancrorum*, and will be described in a subsequent part of this work (*vide Animal Materia Medica*).

PROPERTIES.—Pure carbonate of lime is a tasteless, odourless solid. When heated to redness in a current of air its carbonic acid is expelled, leaving quicklime. It is almost insoluble in water; one part of carbonate requiring 1600 parts of water to dissolve it. It is much more soluble in carbonic acid water: the solution reddens litmus, but changes the yellow colour of turmeric paper to brown; and by boiling, or exposure to the air, gives out its carbonic acid, by which the carbonate of lime is deposited.

Carbonate of lime is a dimorphous substance; that is, it crystallizes in two distinct and incompatible series of forms,—viz. those of the rhombohedric system (calcareous spar), and those of the right rectangular prismatic system (arragonite). According to Gustav Rose (*Lond. & Ed. Phil. Mag.* June 1838), both calcareous spar and arragonite may be formed in the humid way, but the first at a lower, the latter at a higher temperature: in the dry way, calcareous spar alone is formed. Both minerals doubly refract the rays of light, and expand unequally in their different parts when heated; but calcareous spar has only one axis of no double refraction, whereas arragonite has two.

Single system of rings seen by looking through a slice of calcareous spar (cut perpendicular to the axis of the crystal) placed between two plates of tourmaline (cut parallel to the axis of the crystal).

FIG. 54.

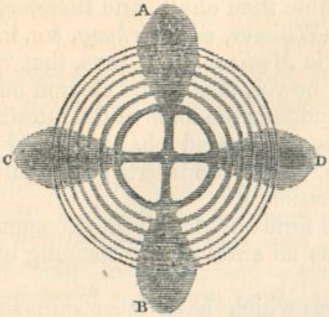


FIG. 55.

Fig. 54 is seen when the plane of the axis of the calcareous spar is parallel or perpendicular to the plane of polarization. Fig. 55 is seen when the calcareous spar is turned 45°.

Granular limestone (of which white marble is the purest kind) is massive, and consists of small grains or minute crystals, presenting a lamellar structure and brilliant lustre, but intersecting each other in every direction, and thereby giving a glimmering lustre to the mass.

Chalk is massive, opaque when pure white, and has an earthy fracture. It is usually soft to the touch, and adheres to the tongue.

CHARACTERISTICS.—Carbonate of lime is recognized as a carbonate by the tests already mentioned for this class of salts (p. 191). As a calcareous salt it is known by the characters before described (p. 343) for lime.

COMPOSITION.—Carbonate of lime has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Marcet.	Stromeyer.	Berzelius; Ure.
Lime	1	28	56	56·1	56·35	56·4
Carbonic Acid	1	22	44	43·9	43·65	43·6
Carbonate of Lime	1	50	100	100·0	100·00	100·0

PURITY.—Pure marble or chalk should be perfectly soluble, with effervescence, in hydrochloric acid, by which the absence of silica is shown. Ammonia should not cause any precipitate with this solution, by which its freedom from alumina, oxide of iron, &c. may be inferred: nor should a solution of sulphate of lime throw down any thing by which the absence of baryta and strontian is proved.

PHYSIOLOGICAL EFFECTS.—The local effects of chalk are those of an absorbent, antacid, and mild desiccant. When swallowed it neutralizes the free acid of the gastric juice, and in this way alone must, by continued use, injure the digestive functions. It causes constipation, an effect commonly observed from the use of a few doses in diarrhœa. By the action of the free acids (acetic and hydrochloric) of the alimentary canal, it is converted into two soluble calcareous salts (acetate of lime and chloride of calcium), which become absorbed. Hence the continued use of carbonate of lime is attended with the constitutional effects of the calcareous salts, and consequently the statements which have been made as to the influence of chalk over the lymphatic vessels and glands, and its effect in diminishing excessive secretion, may be correct. Sundelin (*Heilmittellehre*, i. 179) thinks it may even promote the deposit of bone-earth in diseases attended with a deficiency of this substance. Carbonate of lime, prepared from animal matter, has been erroneously supposed to be more digestible than chalk, and therefore less likely to occasion dyspeptic symptoms (Wibmer, *die Wirkung*, &c. ii. 10). Dr. A. T. Thomson (*Elements of Materia Medica*, ii. 82) says, that "after chalk has been used for some time, the bowels should be cleared out, as it is apt to form into hard balls, and to lodge in the folds of the intestines."

USES.—As an *absorbent* and *desiccant*, prepared chalk is used as a dusting powder in moist excoriations, ulcers, the intertrigo of children, burns and scalds, erysipelatous inflammation, &c.

As an *antacid* it is exhibited in those forms of dyspepsia accompanied with excessive secretion of acid; and as an antidote in poisoning by the mineral and oxalic acids.

It has also been used in some diseases which have been supposed to depend on, or be accompanied by, excess of acid in the system—as in gouty affections, which are usually attended with the excessive production of uric acid, and in rachitis, which some have ascribed to a preponderance of phosphoric acid, or to a deficiency of lime in the system.

To diminish alvine evacuations, it is employed in diarrhœa. Its efficacy can hardly be referred solely to its antacid properties; for other antacids are not equally successful. Moreover, in many cases of diarrhœa in which chalk is serviceable, no excess of acidity can be shown to exist in the bowels. Aromatics are useful adjuncts to chalk in most forms of diarrhœa. In old obstinate cases, astringents (as catechu or kino) may be conjoined with great advantage; and in severe cases, accompanied with griping pains, opium.

ADMINISTRATION.—Prepared chalk is given in the form of powder or mixture, in doses of from ten grains to one or two drachms. It enters into a considerable number of officinal preparations.

1. *MISTURA CRETÆ*, Ph. L. & Dub.; *Potio Carbonatis Calcis*, Ph. Ed.; *Mistura Calcis Carbonatis*, Ph. U. S. (Prepared chalk, ℥ss.; sugar, ʒiij.; mixture of acacia, f.℥iss.; cinnamon water, ℥xviii. *Ph. L.*) In the other Pharmacopœias the proportions are somewhat different. This is a very convenient form for the exhibition of chalk, and is in common use in diarrhœa. Aromatics (as the aromatic confection), astringents (as kino or catechu), or narcotics (as opium), are frequently combined with it. The dose is from one to three table-spoonfuls.

2. *PULVIS CRETÆ COMPOSITUS*, Ph. L. & Dub. (Prepared chalk, ℔ss.; cinnamon, ℥iv.; tormentil and acacia, āā. ℥iij.; long pepper, ℥ss.):—This preparation is aromatic and astringent, and is used in diarrhœa. The dose is from 10 to 20 grains. The *pulvis carbonatis calcis compositus* (Ph. Ed.) consists of chalk flavoured with nutmegs and cinnamon.

3. *CONFECTIO AROMATICA*, Ph. L. & Dub. (Prepared chalk, ℥xvi.; cinnamon and nutmegs, āā. ℥ij.; cloves, ℥j.; cardamoms, ℥ss.; saffron, ℥ij.; [water, ℔j., Ph. D.]) The London College order the water to be added when the preparation is used, in order to avoid fermentation, to which this compound is subject. Druggists sometimes substitute a strong infusion of saffron instead of the solid saffron here ordered; and those who are desirous of producing a very fine preparation, employ precipitated carbonate of lime instead of chalk. This preparation possesses the

combined properties of chalk and spices (p. 72). It is therefore antacid, aromatic, and stimulant. It is frequently added to the ordinary chalk mixture in diarrhœa, and is employed on various other occasions where spices are indicated. The dose of it is from 10 grains to a drachm.

Cal'cis Phos'phas.—Phos'phate of Lime.

History.—Scheele, in 1769, discovered phosphate of lime in bones.

Natural History.—Phosphate of lime is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—It is a constituent of the mineral termed *Apatite*, and of some mineral waters; as those of Karlsbad Sprudel, and of Franzensbrunn, near Eger.

(*b.*) *In the organized kingdom.*—It has been found in some plants, and much more frequently and copiously in animals. Thus it constitutes the principal part of the earthy matter of the bones of the vertebrata, and a portion of the crusts of the articulata.

Preparation.—Phosphoric acid combines with lime in several proportions, forming *basic*, *neutral*, and *acid* salts. The compound used in medicine is a *sub-* or $\frac{2}{3}$ *phosphate of lime.* When obtained by calcining bones in an open vessel, it is called *earth of bones* (*terra ossium*) or *bone-ash* (*ossa usta ulba; o. deusta; o. ad albedinem usta; o. calcinata; spodium album*), and contains some carbonate of lime and other matters mixed with it. If bone-ash be digested in diluted hydrochloric acid, and caustic ammonia added to the filtered solution, phosphate of lime, free from carbonate, is thrown down in a very minute state of division, and when washed and dried, it constitutes the *precipitated phosphate of lime* (*calcis phosphas præcipitatum*) of the Dublin Pharmacopœia. When the horns (*cornua*) of the deer (*cervus*) are calcined in a an open vessel until they become perfectly white, and the residual ash (sub-phosphate of lime) prepared by elutriation (as creta præparata) we obtain *burnt hartshorn* (*cornu ustum*, Ph. L.; *cornu ustum præparatum*).

Properties.—Subsesquiphosphate of lime is white, tasteless, odourless, insoluble in water, but soluble in nitric, hydrochloric, and acetic acids, from which solutions it is thrown down unchanged, in composition, by ammonia, potash, and their carbonates. When exposed to a very intense heat, it fuses, and undergoes no other change. The primary form of the crystals of apatite (native subsesquiphosphate of lime) is the six-sided prism.

Characteristics.—It is known to be a phosphate by its solubility in hydrochloric acid, and its being again thrown down as a white precipitate when the acid solution is supersaturated with caustic ammonia. If it be digested in a mixture of sulphuric acid and alcohol, sulphate of lime is precipitated, and an alcoholic solution of phosphoric acid obtained. The acid may then be recognised by the tests for it already mentioned (p. 253). If the precipitated sulphate of lime be dissolved in water, the solution may be known to contain lime by the tests before described for the calcareous salts (p. 343). The subsesquiphosphate of lime of bones is distinguished from the neutral phosphate by its fusing with greater difficulty, and dissolving more readily in hydrochloric acid. A very delicate test of the neutral phosphate is its crystallizing from hydrochloric acid by evaporation (Wollaston, *Phil. Trans.* for 1797, p. 396 & 397).

COMPOSITION.—The composition of subsesquiphosphate of lime is as follows:—

	Eq.	Eq. Wt.	Per Cent.	Berzelius. (Artificial.)	Fuchs. (Artificial.)	Vauquelin. (Apatite.)
Lime	1½	42	53·85	51·68	54·74	54·28
Phosphoric Acid	1	36	46·15	48·32	45·26	45·72
Subsesquiphosphate of Lime	1	78	100·00	100·00	100·00	100·00

Bone-ash obtained from the bones of the ox consists of subsesquiphosphate of lime, carbonate of lime, phosphate of magnesia, and a trace of fluoride of calcium.

PHYSIOLOGICAL EFFECTS.—Its effects are not very obvious. "As phosphate of lime is very difficultly soluble," observes Wibmer (*die Wirkung*, &c. ii. 9), "it is absorbed in small quantity only, and then acts more or less like lime, as a slight astringent on the tissues and the secretions, and increases, incontestibly, the presence of calcareous salts in the bones, the blood, and the urine. Large doses disorder the stomach and digestion by their difficult solubility."

USES.—It has been administered in rickets, with the view of promoting the deposition of bone-earth in the bones. The sesquioxide of iron may be advantageously conjoined with it.

ADMINISTRATION.—The dose of subsesquiphosphate of lime is from ten grains to half a drachm. For internal use the preparation of the Dublin College is to be preferred.

ORDER 14. COMPOUNDS OF MAGNESIUM.

Magne'sia.—Magne'sia.

HISTORY.—It was first chemically distinguished from lime in 1755, by Dr. Black, who also shewed the difference between magnesia and its carbonate. From the mode of procuring it, it is frequently termed *calcined* or *burnt magnesia* (*magnesia calcinata* seu *usta.*) It is sometimes called *talc earth* (*Talkerde*), or *bitter earth* (*Bittersalzerde.*)

NATURAL HISTORY.—It occurs in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.*—Magnesia is found native, in the solid state or in solution, in sea or some mineral waters, in combination with water and various acids (carbonic, sulphuric, boracic, silicic, and nitric.) Chloride of magnesium exists in sea water, as also in some springs.

(*b.*) *In the organized kingdom.*—Combined with acids it is found in some vegetables (as *Salsola Kali* and *Fucus vesiculosus*), and animals (as in the urine and some urinary calculi of man.)

PREPARATION.—Magnesia is obtained by exposing the subcarbonate to a full red heat for two hours in a crucible, so as to drive off the carbonic acid.

PROPERTIES.—It is a light, fine, white, colourless, odourless, and tasteless powder, having a sp. gr. 2·3. When moistened with water it reacts as an alkali on test papers. It is very slightly soluble in water, and like lime is more soluble in cold than in hot water. Dr. Fyffe states that it requires 5142 parts of cold, and 36000 parts of hot water to dissolve it. Unlike lime it evolves scarcely any heat when mixed with water. By the combined voltaic and oxy-hydrogen flames it has been fused by Mr. Brande (*Manual of Chemistry.*) It absorbs carbonic acid slowly from the atmosphere.

CHARACTERISTICS.—It is soluble in the dilute mineral acids without effervescence. The solution does not occasion any precipitate with the ferrocyanides, hydrosulphurets, oxalates, or bicarbonates. The neutral alkaline carbonates, when unmixed with any bicarbonate, throw down a white precipitate. Ammonia with phosphate of soda causes a white precipitate (ammoniacal-phosphate of magnesia.) Magnesia is insoluble in alkaline solutions, and is thereby distinguished from alumina. Its solution in sulphuric acid is remarkable for its great bitterness.

COMPOSITION.—Magnesia has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Wollaston.	Gay-Lussac.	Berzelius.
Magnesium	1	12	60	59·3	59·5	61·29
Oxygen	1	8	40	40·7	40·5	38·71
Magnesia	1	20	100	100·0	100·0	100·00

PURITY.—Its freedom from any carbonate is shewn by its dissolving in dilute mineral acids without effervescence. Its hydrochloric solution should occasion no precipitate with the oxalates, bicarbonates, and barytic salts, by which the absence of lime and sulphates may be inferred.

PHYSIOLOGICAL EFFECTS.—When taken into the stomach, magnesia neutralizes the free acids contained in the stomach and intestines, and forms therewith soluble magnesian salts. In full doses it acts as a laxative; but as it occasions very little serous discharge, Dr. Paris (*Pharmacologia*, vol. i. art. *Cathartics*) ranks it among purgatives "which urge the bowels to evacuate their contents by an imperceptible action upon the muscular fibres." Part of its laxative effect probably depends on the action of the soluble magnesian salts (chloride of magnesium and acetate of magnesia) which it forms by union with the acids of the alimentary canal. Magnesia exercises an influence over the urine analogous to that of the alkalies, namely, it diminishes the quantity of uric acid in the urine, and when continued for too long a period occasions the deposit of the earthy phosphates in the form of white sand. (W. T. Brande, *Phil. Trans.* 1810, p. 136; and 1813, p. 213.) On account of its greater insolubility, it requires a longer time to produce these effects than the alkalies. When taken in too large quantities and for a long period it has sometimes accumulated in the bowels to an enormous extent, and being concreted by the mucus of the bowels, created unpleasant effects. A lady took every night during two years and a half, from one to two teaspoonfuls of Henry's calcined magnesia (in all between 9 and 10 lbs. troy) for a nephritic attack, accompanied with the passage of gravel; subsequently she became sensible of a tenderness in the left side just above the groin, connected with a deep-seated tumor, obscurely to be felt on pressure, and subject to attacks of constipation, with painful spasmodic action of the bowels, tenesmus, and a highly irritable state of stomach. During one of these attacks she evacuated two pints of "sand;" and on another occasion voided soft light brown lumps, which were found to consist entirely of subcarbonate of magnesia concreted by the mucus of the bowels, in the proportion of 40 per cent. In another case a mass of a similar description, weighing from 4 to 6 lbs., was found imbedded in the head of the colon, six months after the patient had ceased to employ any magnesia. (E. Brande, *Quart. Journ. of Science*, i. 297.)

USES.—As an *antacid* it is as efficacious as the alkalies, while it has an advantage over them in being less irritant, and thereby is not so apt to occasion disorder of the digestive organs. It may be employed to neutralize acids introduced into the stomach from without, (as in cases of poisoning by the mineral acids) or to prevent the excessive formation of, or to neutralize when formed, acid in the animal economy. Thus it is administered to relieve heartburn arising from, or connected with, the secretion of an abnormal quantity of acid by the stomach: its efficacy is best seen in persons of a gouty or rheumatic diathesis, in which the urine contains excess of uric acid. It often relieves the headache to which such individuals are not unfrequently subject. It is most efficacious in diminishing the quantity of uric acid in the urine, in calculous complaints, and according to Mr. Brande (*Phil. Trans.* 1813, p. 213) it is sometimes effectual where the alkalies have failed. It will be found of great value in those urinary affections in which alkaline remedies are indicated, but in which potash and soda have created dyspeptic symptoms.

As a *laxative*, magnesia is much employed in the treatment of the diseases of children. It is tasteless, mild in its operation, and antacid,—qualities which render it most valuable as an infant's purgative. Independently of these, Hufeland ascribes to it a specific property of diminishing gastro-intestinal irritation by a directly sedative influence. In flatulency it is combined with some carminative water (dill or anise); in diarrhœa, with rhubarb. It is employed as a purgative by adults in dyspeptic cases—in affections of the rectum, as piles and stricture—and in diarrhœa. It is associated with the carminative waters—with some neutral salts, as sulphate of magnesia, to increase its cathartic operation—or in diarrhœa, with rhubarb.

ADMINISTRATION.—As a purgative, the dose, for adults, is from a scruple to a drachm; for infants, from two to ten grains. As an antacid, the dose is from ten to thirty grains twice a day. It may be conveniently given in milk. It is sometimes administered in combination with lemon juice: the *citrate of magnesia* thus formed acts as a pleasant and mild aperient.

Magne'siæ Subcar'bonas.—Subcar'bonate of Magne'sia.

HISTORY.—Subcarbonate of magnesia, also called *magnesia alba* and *carbonate of magnesia*, was exposed for sale at Rome at the commencement of the 18th century, by Count di Palma, in consequence of which it was termed *Comitissæ Palmæ pulvis*. In 1707, Valentini informed the public how it might be prepared.

NATURAL HISTORY.—Neutral carbonate of magnesia is found native in various parts of Europe, Asia, and America. It constitutes a range of low hills in Hindostan, from whence it has sometimes been imported in considerable quantities into this country, but has been found, as I am informed, unsaleable here. The samples offered for sale about two years since consisted of reniform, opaque, dull masses, adherent to the tongue, having a conchoidal fracture, and considerable hardness. Internally, they were whitish; externally, greyish or yellowish white. The same substance was brought over about a year ago in the calcined state, and was nearly white. It was called *calcined Indian magnesia*. Carbonate of magnesia is found in some mineral waters.

Preparation.—Subcarbonate of magnesia is prepared by mixing solutions of sulphate of magnesia (or chloride of magnesium) and carbonate of soda (or carbonate of potash). The directions of the London Pharmacopœia are as follow:—Dissolve separately four pounds of sulphate of magnesia, and four pounds and eight ounces of carbonate of soda, in two gallons of water, and strain: then mix the liquors, and boil for a quarter of an hour, constantly stirring with a spatula: lastly, having poured off the liquor, wash the precipitated powder with boiling distilled water, and dry it.

Two kinds of subcarbonate of magnesia are known and kept in the shops, the *light* and the *heavy*. *Heavy magnesia* (*magnesia ponderosa* of the shops) is thus prepared:—Add one volume of a cold saturated solution of carbonate of soda to a boiling mixture of one volume of a saturated solution of sulphate magnesia, and three volumes of water. Boil until effervescence has ceased, constantly stirring with a spatula. Then dilute with boiling water, set aside, pour off the supernatant liquor, and wash the precipitate with hot water on a linen cloth: afterwards dry it by heat in an iron pot. *Light magnesia* (*magnesia* of the shops) is prepared by employing dilute solutions of the sulphate of magnesia and carbonate of soda. If no heat be used, it is apt to be gritty. A *heavy and gritty* magnesia is prepared by separately dissolving 12 parts of sulphate magnesia and 13 parts of crystallized carbonate of soda in as small a quantity of water as possible, mixing the hot solutions, and washing the precipitate.

The *theory* of the process is as follows:—When sulphate of magnesia and carbonate of soda are mixed, double decomposition takes place: the sulphuric acid combines with the soda to form sulphate of soda, and the carbonic acid with the magnesia. The neutral carbonate of magnesia, which we presume to be first formed, is immediately resolved by the water into a subcarbonate, which, with some water, precipitates, and the bicarbonate which remains is dissolved in the cold liquid. 5 eq. of the neutral carbonate, with 4 eq. of water, produce 1 eq. of bicarbonate; while the 4 eq. of magnesia, 3 eq. carbonic acid, and 4 eq. of water, precipitate. If we mix the boiling solutions together, 4 eq. of the neutral carbonate give out 1 eq. of free carbonic acid, and a precipitate is formed consisting of 4 eq. of magnesia, 3 eq. of carbonic acid, and 4 eq. of water. The precipitate in both of these cases constitutes the subcarbonate of magnesia of the shops.

Properties.—Subcarbonate of magnesia, as usually met with, is in the form of a white, inodorous, and tasteless powder. The *light* variety occurs as a very fine light powder, or in large rectangular masses with bevelled edges, or in smaller cubical cakes. The *heavy* carbonate is, as its name indicates, of greater specific gravity than the light. Both kinds moistened with water have a feebly alkaline reaction on test paper, but when boiled in water do not communicate this property to water. Subcarbonate of magnesia is nearly insoluble in water: it readily dissolves in carbonic acid water.

Characteristics.—It is distinguished from caustic or calcined magnesia by the effervescence which takes place on the addition of a dilute mineral acid. Its other characteristics are the same as for the latter substance (vide p. 361.)

COMPOSITION.—The following is the composition of subcarbonate of magnesia of the shops:—

	Kirwan.	Bergman.	Klaproth.	Bucholz.		Berzelius.	Phillips.
				Light.	Heavy.		
Magnesia	45	45	40	33	42	41·60 to 43·2	40·8
Carbonic Acid	34	25	33	32	35	36·58 — 36·4	36·0
Water	21	30	27	35	23	21·82 — 20·4	23·2
Magnesia alba	100	100	100	100	100	100·00 — 100·0	100·0

Several reasons have led chemists to reject the idea of this compound being an ordinary subsalt (vide Berzelius, *Traité de Chém.* iv. 101); but they are not agreed as to the precise mode in which the constituents are combined, as the following table shews:—

Berzelius.			Brande.							Phillips.		
	Eq.	Eq. Wt.		Eq.	Eq. Wt.			Eq.	Eq. Wt.		Eq.	Eq. Wt.
Hydr^{d}. Carb. Magn.	3	148·59	Carb. Magn.	1	42	or	Hydr^{d}. Carb. Magn.	1	51	Hydr^{d}. Carb. Magn.	4	204
Hydr^{te}. Magnes...	1	29·72	Quadrihydr.	1	56		Trihydr^{te}. Magn. ..	1	47	Bihydr^{d}. Magn. ..	1	38
Magnesia alba	1	178·31		1	98			1	98		1	242

PURITY.—Subcarbonate of magnesia should be perfectly white and tasteless. The water in which it has been boiled should have no alkaline reaction on turmeric paper, nor throw down anything on the addition of chloride of barium or nitrate of silver: by which the absence of alkaline carbonates, sulphates, and chlorides, is proved. Dissolved in dilute sulphuric acid the oxalates and bicarbonates should occasion no precipitate, by which the non-existence of any calcareous salt is shewn.

PHYSIOLOGICAL EFFECTS.—The effects of subcarbonate of magnesia are nearly the same as those of pure magnesia. We can readily conceive that the local operation of the first is somewhat milder than that of the latter (as in the case of the alkalies and their carbonates), but the difference is hardly perceptible in practice. As the subcarbonate effervesces with acids it is more apt to create flatulence when swallowed.

USES.—The uses of the subcarbonate are the same as those of calcined magnesia; except where the object is to neutralize acid in the alimentary canal (as in cardialgia and in poisoning by the mineral acids), when the latter preparation is to be preferred on account of its not effervescing with acids, and thereby not causing flatulency.

In the Pharmacopœia, subcarbonate of magnesia is directed to be employed for the extemporaneous preparation of the so-called DISTILLED WATERS (*aquæ distillatæ*). A drachm of any distilled oil is to be carefully triturated with a drachm of subcarbonate of magnesia, and afterwards with four pints of distilled water; the water is then to be strained. For ordinary purposes no objection exists to the use of waters thus prepared, but they are incompatible with bichloride of mercury, on account of the small quantity of magnesia which they hold in solution.

ADMINISTRATION.—The dose of subcarbonate of magnesia, as a purgative, is from ten grains to a drachm; as an antacid, from five grains to a scruple.

AQUA MAGNESIÆ BICARBONATIS. (*Magnesia Water: Aerated Magnesia Water.*)—This solution is prepared by passing a stream of carbonic acid through water in which a given quantity of subcarbonate of magnesia is suspended. Or it may be made extemporaneously by adding subcarbonate of magnesia (or a mixture of sulphate of magnesia and carbonate of soda) to the ordinary bottle-soda water (carbonic acid water.) It is an agreeable mode of exhibiting magnesia in nephritic affections.

Magne'siæ Sul'phas.—Sul'phate of Magne'sia.

History.—This salt was originally procured from the Epsom waters by Dr. Grew in 1675. It has had a variety of names, such as *Epsom* or the *bitter purging salt, sal Anglicum, sal Seidlitzense, sal catharticum, vitriolated magnesia*, &c.

Natural History.—It is a constituent of sea and many mineral waters: it occurs as an efflorescence on other minerals, forming the *hair salt* of mineralogists; and with sulphate of soda and a little chloride of magnesium, constitutes *Reussite*.

Preparation.—The two great sources of the sulphate of magnesia of English commerce are *dolomite* and *bittern*. Dolomite or magnesian limestone is a compound of carbonate of lime and carbonate of magnesia. It occurs in enormous quantities in various counties of England (as those of Somerset, York, and Nottingham), and is employed for building. York Minster and Westminster Hall are built of it. Bittern is the residual liquor of sea-water, from which common salt (chloride of sodium) has been separated. It contains chloride of magnesium and sulphate of magnesia.

Sulphate of magnesia may be extracted from bittern by evaporation, a process practised at Lymington, in Hampshire (Dr. Henry, *Phil. Trans.* 1810, p. 94). If sulphuric acid be added to bittern, a further quantity of sulphate may be obtained by the decomposition of chloride of magnesium. Sulphate thus procured is preferred at Apothecaries' Hall for making magnesia, as it yields a whiter product than sulphate made from dolomite.

Various methods of manufacturing sulphate of magnesia from dolomite have been described. The usual method is to treat this mineral by dilute sulphuric acid: carbonic acid escapes, and a residue, composed of sulphate of magnesia and sulphate of lime, is obtained. These two salts are separated from each other by crystallization.

In 1816, Dr. William Henry, of Manchester (*Repert. of Arts*, vol. xxx. p. 142, 2nd Ser.) took out a patent for the following process:—Calcine magnesian limestone, so as to expel the carbonic acid; then convert the caustic lime and magnesia into hydrates by moistening them with water. Afterwards add a sufficient quantity of hydrochloric (or nitric or acetic) acid (or chlorine), to dissolve the lime, but not the magnesia, which, after being washed, is converted into sulphate by sulphuric acid (or, where the cost of this is objectionable, by sulphate of iron, which is easily decomposed by magnesia). Or the mixed hydrates of lime and magnesia are to be added to bittern: chloride of calcium is formed in solution, while two portions of magnesia (one from the bittern, the other from the magnesian lime) are left unacted on. Or hydrochlorate of ammonia may be used instead of bittern: by the reaction of this on the hydrated magnesian lime, chloride of calcium and caustic ammonia remain in solution, while magnesia is left undissolved: the ammonia is separated from the decanted liquor by distillation.

Carbonate of ammonia has also been employed to separate lime from magnesia: carbonate of lime is precipitated, and the magnesia remains in solution, from which it may be easily separated by ebullition (*Journ. of Science*, iii. 217; vi. 313; ix. 177). At Monte della Guardia, near

Genoa, sulphate of magnesia is manufactured from schistose minerals, containing sulphur, magnesia, copper, and iron. After being roasted, and moistened to convert them into sulphates, they are lixiviated, and the solution is deprived, first, of copper by refuse iron, and afterwards of iron by lime (Dr. Holland, *Phil. Trans.* 1816, p. 294). In Bohemia, sulphate of magnesia is procured, by evaporation, from the waters of Seidlitz and Saidschütz. Hermann (Poggendorff's *Annalen*, xi. 249) extracts it from liquids containing chloride of magnesium, by means of sulphate of soda. At Baltimore, sulphate of magnesia is procured from the siliceous hydrate of magnesia or *marmolite*, by reducing the mineral to powder, saturating with sulphuric acid, and calcining the dried mass to peroxidize the iron. It is then re-dissolved in water (from which solution the remaining iron is separated by sulphuret of lime), and crystallized. By a second crystallization it is obtained nearly pure (D. B. Smith, in the *Dispensatory of the U. S. of America*).

PROPERTIES.—The impure sulphate obtained from bittern is called *singles*, and when purified by re-crystallization, *doubles*. The sulphate usually met with in the shops is in small acicular crystals. By solution and re-crystallization we readily obtain tolerably large four-sided prisms, with reversed diëdral summits, or four-sided pyramids: the primary form of the crystals is the right rhombic prism. Both large and small crystals are colourless, transparent, and odourless, but have an extremely bitter taste. When heated they undergo the watery fusion, then give out their water of crystallization, become anhydrous, and at a high temperature undergo the igneous prism, and run into a white enamel, but without suffering decomposition. Exposed to the air the crystals very slowly and slightly effloresce. It dissolves in its own weight of water at 60°, and in three-fourths of its weight of boiling water. It is insoluble in alcohol.

CHARACTERISTICS.—It is known to contain sulphuric acid by the tests for the sulphates already mentioned (p. 265). The nature of its base is shown by the tests for magnesia before described (p. 361).

COMPOSITION.—The following is the composition of crystallized sulphate of magnesia :—

	Eq.	Eq. Wt.	Per Cent.	Gay-Lussac.	Wenzel.
Magnesia	1	20	16·26	16·04	16·86
Sulphuric Acid	1	40	32·52	32·53	30·64
Water	7	63	51·22	51·43	52·50
Cryst^{d}. Sulphate of Magnesia	1	123	100·00	100·00	100·00

PURITY.—The sulphate of magnesia met with in the shops is usually sufficiently pure for all medicinal and pharmaceutical purposes. It should be colourless, and undergo no change when mixed with ferrocyanides or hydrosulphurets. When obtained from bittern it is sometimes contaminated with chloride of magnesium, which, by its affinity for water, keeps the sulphate in a damp state. By digestion in alcohol the chloride is dissolved, and by evaporating the spirituous solution, may be obtained in the solid state. It is said, that occasionally small crystals of sulphate of soda are intermixed with those of sulphate of magnesia—a fraud I have never met with in English commerce, nor is it likely to occur at the present low price of the magnesian salt. Should such an adulteration be suspected, there are several methods of detecting it: the sophisticated salt would effloresce more rapidly than the pure salt, and would communicate a yellow tinge to the flame of alcohol. Boiled with caustic lime and water, all the magnesian sulphate would be decomposed, and the liquor being filtered, to separate the precipitated magnesia and sulphate of lime, yields, on evaporation, sulphate of soda. If shaken in the cold with carbonate of baryta, a solution of carbonate of soda would be obtained, easily recognized by its alkaline properties. 100 grains of pure sulphate of magnesia, dissolved in water, and mixed with a boiling solution of carbonate of soda, yields 34 grains of subcarbonate of magnesia when dried. If sulphate of soda were present, the precipitate would weigh less. (Phillips, *Transl. of Pharm.*)

PHYSIOLOGICAL EFFECTS.—Sulphate of magnesia is a mild and perfectly safe antiphlogistic purgative, which promotes the secretion as well as the peristaltic motion of the alimentary canal. It is very similar in its operation to sulphate of soda, than which it is less likely to nauseate, or otherwise disorder the digestive functions, while it acts somewhat more speedily on the bowels. It does not occasion nausea and griping, like some of the vegetable purgatives, nor has it any tendency to create febrile disorder or inflammatory symptoms; but, on the other hand, has a refrigerant influence: hence it is commonly termed a cooling purgative. In small doses, largely diluted with aqueous fluids, it slightly promotes the action of other emunctories: thus, if the skin be kept cool, and moderate exercise be conjoined, it acts as a diuretic; whereas if the skin be warm, it operates as a diaphoretic.

USES.—On account of the mildness and safety of its operation, its ready solubility, and its cheapness, sulphate of magnesia is by far the most commonly employed purgative, both by the public and the profession. The only objection to its use is its bitter and unpleasant taste. To state all the cases in which it is administered, would be to enumerate nearly the whole catalogue of known diseases. It must, therefore, be sufficient to mention, that it is excellently well adapted as a purgative for febrile and inflammatory diseases, obstinate constipation, ileus, lead colic, even incarcerated hernia, narcotic poisoning, &c. It may be used as an antidote in poisoning by the salts of lead and baryta.

ADMINISTRATION.—As a purgative it is usually administered in doses of from half an ounce to an ounce and a half; but if dissolved in a large quantity of water, a smaller dose will suffice. Thus, two drachms in half a pint or more of water, taken in the morning fasting, will act speedily, sufficiently, and mildly, in ordinary cases; and in delicate females, a drachm, or even less, in the above quantity of water, will usually produce the desired effect. Some carminative or aromatic (as peppermint water or tincture of ginger) is frequently conjoined to obviate flatulency. In febrile and inflammatory diseases, the solution may be acidulated with dilute sulphuric acid with great advantage; or the sulphate may be dissolved in the compound infusion of roses. It is frequently used as an adjunct to the compound infusion of senna, whose purgative effect it promotes, but whose griping tendency it is said to check. In dyspeptic cases, accompanied with constipation, it is conjoined with bitter infusions (as of quassia, gentian, calumba, &c.). As a purgative enema, an ounce or more of it may be added to the ordinary glyster.

The *bitter* purging saline waters (*vide* p. 174), as those of Seidlitz, Epsom, Beulah, Kilburn, and the Cheltenham pure saline, owe their purgative property principally to sulphate of magnesia.

ORDER 15. COMPOUND OF ALUMINUM.

Potas'sæ Alu'mino-Sul'phas seu *Alu'men.—Alu'mino-Sul'phate of Pot'ash* or *Al'um.*

HISTORY.—Although the term alum (*alumen* of the Romans—*στυπτηρία* of the Greeks) occurs in the writings of Herodotus (*Euterpe*, clxxx.), Hippocrates (*De fistulis, De ulceribus*, &c.), Pliny (*Hist. Nat.* xxxv.), Dioscorides (Lib. v. cap. 123), and other ancient writers, yet it is not satisfactorily proved that our alum was the substance referred to. On the contrary, the learned Beckmann (*Hist. of Invent.* i. 288) has asserted that the alum of the Greeks and Romans was sulphate of iron, and that the invention of our alum was certainly later than the 12th century. But Geber (*Search of Perfection*, ch. iii., and *Invention of Verity*, ch. iv.), who is supposed to have lived in the 8th century, was acquainted with three kinds of our alum, and describes the method of preparing burnt alum; and it is not, I think, improbable, that even Pliny was acquainted with our alum, but did not distinguish it from sulphate of iron, for he tells us that one kind of alum was white, and was used for dyeing wool of bright colours.—[For further information, consult Parkes's *Chemical Essays*, i. 625, and Thomson's *Hist. of Chem.* i. 125].

NATURAL HISTORY.—It is found native in the neighbourhood of volcanoes, and constitutes the mineral called *native alum*. Native alum occurs in bituminous shale and slate clay, at Hurlett, near Paisley, and near Whitby, in Yorkshire.

PREPARATION.—The method of preparing alum varies somewhat in different places. The mineral from which (in this country) it is procured is called *aluminous slate*, *aluminous shale*, or *aluminous schist* (*schistus aluminaris*). This substance varies somewhat in its composition in different localities, but always contains sulphuret of iron, alumina, carbon, and sometimes a salt of potash. The most extensive alum manufactory in Great Britain is at Hurlett, near Paisley. Here the aluminous schist lies between the stratum of coal and limestone (Williams, *Nat. Hist. of the Mineral Kingdom*, 2nd. ed. ii. 315). By the action of the air it undergoes decomposition, and falls down on the floor of the mine. The sulphur attracts oxygen, and is converted into sulphuric acid, which combines partly with the iron (oxidized by the air), and partly with the alumina. The solution obtained by lixiviating the decomposed schist is evaporated, and the sulphate of iron allowed to crystallize: to the mother liquor, which contains sulphate of alumina, sulphate of potash is added, by which crystals of alum are procured, which are purified by a second crystallization.

At Whitby, in Yorkshire, the method of making alum is somewhat different. The schist is piled in heaps, and burnt by means of a slow smothered fire. The calcined ore is lixiviated, and a salt of potash added to the solution after it has deposited sulphates of lime and iron, and earthy matters (Winter, in *Nicholson's Journal*, vol. xxv.)

PROPERTIES.—Alum crystallizes usually in regular octahedrons, frequently with truncated edges and angles, and sometimes in cubes. The ordinary alum of the shops consists of large crystalline masses, which do not present any regular geometrical form; but, by immersion in water during a few days, octahedral and rectangular forms are developed in its surfaces. (Daniel, *Quart. Journ.* i. 24.) Alum has an astringent and sweetish acid taste: its reaction on vegetable colours is that of an acid. Its sp. gr. is 1·7. By exposure to the air it slowly and slightly effloresces. Its transculent or diathermanous power is very slight.

When heated, alum undergoes the watery fusion, swells up, gives out its water of crystallization, and becomes a white spongy mass, called *dried* or *burnt alum* (ALUMEN EXSICCATUM, Ph. L., *alumen ustum*), which has a more astringent taste, and does not so quickly dissolve in water as the crystallized salt. If too much heat be applied a portion of the acid is expelled, and escapes, partly as sulphuric acid, partly in the form of oxygen and sulphurous acid, and the residue consists of alumina and sulphate of potash: the acid liquor obtained by heating alum was formerly termed *spirit of alum.* In the preparation of burnt alum care should be taken not to apply too great a heat in order that the acid may not be driven off. On this account a shallow earthen vessel is preferable to a crucible.

When alum is calcined with charcoal or some carbonaceous substance, as sugar, we obtain a spontaneously inflammable substance called *Homberg's Pyrophorus*, composed of sulphur, potassium, alumina, and charcoal.

Alum dissolves in 18 times its weight of cold and less than its own weight of boiling water.

The alum procured at Tolfa and other parts of Italy, and called *Roman alum* (*alumen Romanum*) is covered with a pale, rose-coloured efflorescence, composed of oxide of iron and an aluminous sulphate of potash. Under the name of *Roche* or *Rock alum* (*alumen rufeum*, seu *alumen de Rochi*, so called from Roccha, in Syria, whence a red-coloured alum was formerly brought) we find in English commerce crystalline fragments of alum, not larger than almonds, coloured externally with bole or rose-pink.

CHARACTERISTICS.—That alum is a sulphate is shewn by the tests for the soluble sulphates already mentioned (p. 265). It reddens litmus, and forms sulphate of lead when mixed with pure carbonate of lead: in these properties it agrees with the supersulphates. The nature of its basic constituents is shewn by the following tests:—The ferrocyanides, the oxalates, and hydrosulphuric acid, occasion no precipitate in a solution of alum. Hydrosulphuret of ammonia, the caustic alkalies and their carbonates, and phosphate of soda, throw down white precipitates: that produced by the alkalies is soluble in an excess of alkali, but is insoluble in solutions of the carbonated alkalies: these characters shew the presence of alumina. Potash is recognised by perchloric acid and chloride of platinum (vide p. 274.) Lastly, the crystalline form of the salt assists in recognising it.

COMPOSITION.—The composition of alum is as follows:—

	Eq.	Eq. Wt.	Per Cent.	Thomson.	Berzel.
Alumina	3	54	11·088	11·09	10·76
Potash	1	48	9·856	9·86	9·95
Sulphuric Acid	4	160	32·854	32·85	33·74
Water	25	225	46·201	46·20	45·55
Cryst^{d}. Potash-Alum	1	487	99·999	100·00	100·00

or

	Eq.	Eq. Wt.	Per Cent.
Sulphate of Alumina	3	174	35·728
Sulphate of Potash	1	88	18·069
Water	25	225	46·201
Cryst^{d}. Alumino-Sulph^{te}. Potash	1	487	99·998

In the above table I have assumed, with Thomson, Brande, and Phillips, alumina to be a protoxide of aluminum, and that its equivalent is 18. Berzelius and Turner regard it as a sesquioxide, and adopt 51·4 as its equivalent. According to the views of the latter chemists the equivalent for alum $\left(\dot{K}\dddot{S} + \underline{\dddot{Al}}\ \dddot{S}^3 + 25\,\dot{H}\right)$ is 474·95.

Purity.—Alum should be colourless, completely soluble in water (by which the absence of uncombined earthy matter is shewn), with a solution of caustic potash or ammonia should form a colourless precipitate of hydrate of alumina soluble in excess of alkali, and should not suffer any change of colour by the addition of tincture of nutgalls or hydrosulphuric acid. The ferro-sulphate of potash, sometimes mixed with alum, cannot be distinguished from the latter, by its form, colour, or taste; but is readily detected by potash, which throws down oxide of iron, and by tincture of nutgalls, which communicates a bluish black colour to it.

Physiological Effects. (*a.*) *On vegetables.*—Alum is probably injurious to plants. (Decandolle, *Physiol. Végét.* 1341).

(*b.*) *On animals.*—Dogs support large doses of alum with impunity. Orfila (*Ann. d'Hyg. Publiq. et de Méd. Lég.* i. 235) gave seven drachms of *crystallized* alum in powder to dogs: the animals retained it for from ten to thirty minutes, then vomited, and in an hour or two were apparently well. Two ounces of *burnt* alum in four ounces of cold water occasioned vomiting only. When the œsophagus was tied to prevent vomiting, death took place in five hours with symptoms of great exhaustion and diminished sensibility. On a post-mortem examination the mucous membrane of the stomach was found inflamed in the whole of its extent. One ounce of finely-powdered burnt alum applied to the subcutaneous cellular tissue of the thigh, caused excessive suppuration and death in fifteen hours. Devergie (*Méd. Légale*, ii. 653) found burnt alum somewhat more active: he says 6½ drachms killed a dog when the œsophagus was tied, and 2 ounces when it was not tied. Moreover, he found burnt alum suspended in cold water, more active than when dissolved in warm water. Veterinarians employ it in doses of from 1 to 6 drachms for large animals. Bourgelat has seen a phthisical condition induced in horses by the use of alum in too great quantities. (Moiroud, *Pharm. Vétér.* 225.)

(*c.*) *On man.*—The immediate topical effect of a solution of alum is that of an astringent, namely, corrugation of fibres and contraction of small vessels, by virtue of which it checks or temporarily stops exhalation and secretion, and produces paleness of parts by diminishing the diameters of the small blood-vessels. It is by these local effects that alum, when taken internally, causes dryness of the mouth and throat, somewhat increases thirst, checks the secretions of the alimentary canal, and thereby diminishes the frequency and increases the consistency of the stools, as observed by Wibmer (*die Wirkung*, &c. i. 114) in his experiments made on himself, with alum in doses of 3 grains dissolved in 5 drachms of water, and taken several times during the day.

But when alum is applied to a part in larger quantities, and for a longer period, the astriction is soon followed by irritation, the paleness by preternatural redness. And thus taken internally in large doses, alum excites nausea, vomiting, griping, purging, and even an inflammatory condition of the intestinal canal,—effects which may be perhaps induced by small quantities in persons endowed with unusual or morbid sensibility of the stomach and bowels, as in the case of the lady in whom dangerous gastro-enteritis was apparently induced by a single dose of a solution containing between 10 and 20 grains of burnt alum (*Ann. d Hyg. Publique et de Méd. Lég.* i.) Ordinarily, however, tolerably large doses of alum may be given without any unpleasant effects. Thus Professor Dumeril has given a drachm, properly diluted, in chronic diarrhœas, within twenty-four hours: Professor Marc, two drachms, in passive hemorrhages, within the same period of time: and MM. Kapeler and Gendrin have administered 3 drachms, at one dose, in colica pictonum. (Devergie, *Méd. Lég.* ii. 656.)

After its absorption, alum appears to act as an astringent or astringent-tonic on the system generally, and to produce more or less general astriction of the tissues and fibres, and a diminution of secretion. Such at least appears to be its effects in some passive hemorrhages and mucous discharges. Barbier (*Traité Elément. de Mat. Méd.* 2d ed. i. 440) says alum "irritates the lungs and often provokes cough," but I am not aware of any other practitioner having confirmed this statement. Kraus (*Heilmittellehre,* 255) observes, that the urine becomes remarkably acid from the use of alum.

USES.--Alum is employed both as an external or topical, and as an internal remedy.

(*a.*) *As a topical remedy.*—Burnt or calcined alum is employed as a very mild *escharotic* to destroy exuberant spongy granulations, commonly known by the name of proud flesh.

Solutions of alum are sometimes employed *to produce contraction or corrugation of the tissues*, and thereby to prevent displacements of parts, especially when accompanied with excessive secretion. Thus it is used as a gargle in relaxation of the uvula with evident advantage. In the early stage of prolapsus of the rectum, a solution of alum, applied as a wash, is sometimes of service, especially when the disease occurs in infants. Washes or injections containing alum are of occasional benefit in prolapsus of the uterus.

In hemorrhages, whether proceeding from an exhalation or exudation from the extremities or pores of the minute vessels, or from the rupture of a blood-vessel, a solution, or, in some cases, the powder of alum, may be used with advantage as a *styptic*, to constringe the capillary vessels, and close their bleeding orifices. Thus in epistaxis, when it is considered advisable to arrest the hemorrhage, assistance may be gained by the injection of a solution of alum into the nostrils, or by the introduction of lint moistened with the solution. Where this fails to give relief, finely powdered alum may be employed in the manner of snuff. In hemorrhage from the mouth or throat, gargles containing alum are useful. In hæmatemesis, as well as in intestinal hemorrhage, alum whey may be administered, though of course no reliance can be placed on it, as the hemorrhage usually depends on circumstances which astringents merely cannot be expected to obviate. In uterine hemorrhage a sponge soaked in a solution of alum may be introduced into the vagina with good effect. To check the hemorrhoidal flux when immoderate, washes or enemata containing alum may be employed. To stop the bleeding after leech bites in children, a saturated solution, or the powder of alum, may be applied to the punctures.

In certain inflammations, alum has been used as a *repellent*; that is, it has been applied to the inflamed part in order to produce contraction of the distended vessels, and thereby to diminish the quantity of blood in the seat of the disease in a manner almost mechanical. Thus, in the first stage of ophthalmia, it is sometimes considered expedient to cut short the disease by the application of a strong astringent solution (as a saturated solution of alum or of acetate of lead). "It is not to be denied," observes Dr. Jacob (*Cyclopædia of Prac. Med.* art. *Ophthalmia*), "that such applications may have the effect of arresting the progress of the disease at once; but if they have not that effect, they are liable to produce an increase of irritation." But, as the details necessary for making the student acquainted with all the circumstances respecting the use of stimulating or astringent applications in the first stage of ophthalmia are too lengthened and numerous to admit of their proper discussion in this work, I must refer for further particulars to the essay of Dr. Jacob before quoted, as well as to the treatises of writers on ophthalmic surgery. I may, however, add, that whatever difference of opinion exists as to the propriety of these applications in the first stage of ophthalmia, all are agreed as to their value after the violence of vascular action has been subdued.

In angina membranacea, called by Bretonneau (*Rech. sur l'Inflam. spéc. du Tissu Muqueux*, 1826) diptheritis, great importance has been attached to the employment of local applications. Of these hydrochloric acid, calomel, and alum, have, in succession, been highly praised by this writer. In order to promote the expulsion of the false membrane, he recommends the insufflation of finely-powdered alum. This is effected by placing a drachm of it in a tube, and blowing it into the throat. (See also Trousseau and Pidoux, *Traité de Thérap.* ii. 291). Velpeau has subsequently confirmed the statements of Bretonneau, and extended the use of alum to other inflammatory affections of the throat, as those arising in scarlatina, small-pox, &c. In these cases powdered alum may be applied to the affected parts by means of the index finger. Gargles containing this salt will be found useful in most kinds of sore throat, ulcerations of the mouth and gums, aphtha, &c. In inflammation of the vulva, accompanied with membraniform exudation, alum washes are serviceable both in children and adults (Trousseau and Pidoux, *op. cit.*)

Alum has been employed as an *astringent*, to diminish or stop excessive secretion from the mucous surfaces. Thus, a weak solution of this salt is used to repress the discharge in the latter stages of conjunctival inflammation; to check profuse ptyalism, whether from the use of mercury or other causes; and to remove gleet or leucorrhœa. In old-standing diarrhœas it has been administered, in combination with the vegetable astringents (kino, for example), with occasional advantage. It is also applied to check profuse secretion from ulcers.

(*b.*) *As an internal remedy.*—Alum has been employed, in conjunction with nutmeg, as a remedy for intermittents. Given just before the expected paroxysm, it has in some cases prevented it (Cullen, *Materia Medica*).

In the treatment of *lead colic*, alum has been found more successful than any other agent or class of remedies. It was first used in this disease by a Dutch physician, named Grashuis (*De Colica Pictonum*, Amst. 1752, et *Append.* 1755), and was afterwards administered in fifteen cases by Dr. Percival (*Essays, Med. & Exper.* ii. 194) with great success.

Its efficacy has been fully established by Kapeler, physician to the Hôpital St.-Antoine, in Paris, and Gendrin (quoted by Trousseau and Pidoux, *op. cit.*) and by Dr. Copland (*Dict. of Med.* i. 374), as well as by several other distinguished authorities. It allays vomiting, abates flatulence, mitigates pain, and opens the bowels more certainly than any other medicine, and frequently when other powerful remedies have failed. It should be given in full doses (as from a scruple to two drachms), dissolved in some demulcent liquid (as gum-water) every three or four hours. Opium and (according to Dr. Copland) camphor may be advantageously conjoined. Kapeler also employs oleaginous enemata. The modus operandi of alum in lead colic is not very clear. The benefit has been ascribed by some to the chemical action of the sulphuric acid on the lead supposed to be contained in the intestines; and in support of this view must be mentioned the fact, that other sulphates (as those of magnesia, soda, zinc, and copper) as well as free sulphuric acid, have been successfully employed in lead colic. But, on the other hand, the presence of lead in the primæ viæ or evacuations, and, consequently, the formation of sulphate of lead in saturnine colic, have not been demonstrated; though the experiments of Dr. C. G. Mitscherlich (*Müller's Archiv*, No. V. 353, 1836, quoted in *Brit. Ann. of Med.* vol. i. 204, 1837) have shown, that when the acetate of lead is swallowed, the greater part of it forms an insoluble combination with the gastro-intestinal mucus, and in this state may remain some time in the alimentary canal. Moreover, alum has been found successful by Kopp (*Denkwurdigkeit*, i. 342, quoted by G. A. Richter, *ausführ. Arzneim.* Suppl. Bd. 515) in other varieties of colic not caused by lead, and unaccompanied by constipation. Dr. Copland is disposed to ascribe the benefit of alum, and other sulphates in lead colic, to their "exciting the action of the partially paralysed muscular coat of the bowels, and thereby enabling them to expel retained matters of a morbid or noxious description,"—an explanation which is inconsistent with the observation of Kopp just quoted.

Alum is administered internally in several other diseases, of which a brief notice only can be given. In passive or asthenic hemorrhages from distant organs; as hæmoptysis, menorrhagia and other uterine hemorrhages, hæmaturia, &c. In colliquative sweating, diabetes, gleet, and leucorrhœa. Kreysig (*Die Krankh. d. Herzens*, Bd. ii. Abt. 2, S. 714, in Richter, *op. cit.*) has advised its use in dilatation of the heart and aortic aneurism. More recently Dzondi (*Aeskulap*. Bd. 1, St. 1, 1821, in Richter) has also recommended it in these diseases; and Sundelin (*Heilmittellehre*, ii. 278) has mentioned a case of supposed dilatation of the heart, in which relief was gained by the use of alum. In chronic diarrhœa, alum is occasionally serviceable.

ADMINISTRATION.—The dose of alum is from ten grains to one or two scruples. It may be taken in the form of powder, or made into pills with some tonic extract, or in solution. To prevent nausea, an aromatic (as nutmeg) should be conjoined. A pleasant mode of exhibition is in the form of *alum whey* (*serum aluminosum*, seu *serum lactis aluminatum*), prepared by boiling two drachms of powdered alum with a pint of milk, then straining: the dose is a wine-glassful. The *saccharum aluminatum* of the Prussian Pharmacopœia is composed of equal parts of white sugar and alum: it may be given to children as well as adults. In prescribing alum, it is to be recollected that the vegetable astringents decompose it; by which the astringent property of the mixture is probably diminished.

For topical uses, alum is used in the form of powder, solution, and poultice. The powder of burnt alum is sprinkled over ulcers, to destroy spongy granulations. Powder of crystallized alum is applied to the mouth and throat as before mentioned. Solutions of alum are made, for topical purposes, of various strengths, according to the object in view.

The ***Cataplasma Aluminis***, Ph. Dub. (*Alum curd of Riverius*, *Albumen Aluminosum*) is prepared by shaking the whites of two eggs with a drachm of alum. "In cases of chronic and purulent ophthalmia, it is applied to the eye between two folds of old linen. It has been praised as a good application to chilblains which are not broken" (Barker and Montgomery's ***Observations on the Dub. Pharm.***)

The ***Liquor Aluminis Compositus***, Ph. L. (*Aqua aluminosa Bateana*, or *Bates's alum water*) consists of alum, sulphate of zinc—each an ounce; boiling water, three pints: dissolve and strain. It is used as a detergent and astringent wash in old ulcers; when diluted, as a collyrium in mild conjunctival inflammation, as an injection in gleet and leucorrhœa, and as an application to chilblains and slight excoriations.

ANTIDOTE.—In a case of poisoning by alum, let the contents of the stomach be immediately evacuated. Promote vomiting by the use of tepid diluents. The inflammatory symptoms are to be combated by the usual antiphlogistic means. Magnesia has been employed, but is said by Devergie to be altogether useless.

ORDER 16. COMPOUNDS OF ARSENICUM.

Ac'idum Arsenio'sum.—Arse'nious Ac'id.

HISTORY.—Arsenious acid, commonly termed *white arsenic* (*arsenicum album*) or *oxide of arsenic*, is first distinctly mentioned by Geber (*Invent. of Verity*, ch. vii.), who seems to have been also acquainted with metallic arsenic (*Sum of Perfection*, book i. part iv. ch. ii.) Hippocrates (*De Ulceribus*) employed ἀῤῥενικὸν (*orpiment* or *sesquisulphuret of arsenicum*) and σανδαράκη (*realgar* or *sulphuret of arsenicum*) as topical remedies. Dioscorides (lib. v., cap. xxi.) is the first author who uses the word ἀρσενικὸν (*orpiment*).

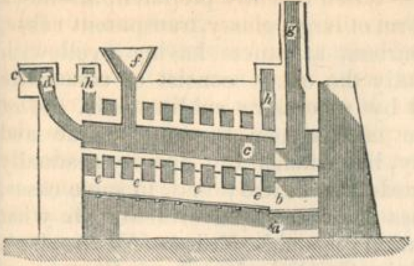
NATURAL HISTORY.—Arsenious acid occurs only in the mineral kingdom. It is rather a rare mineral, and is found at Andreasberg, in the Hartz; at Joachimsthal, in Bohemia; and at some few other places.

PREPARATION.—It is prepared in Silesia, Bohemia, Saxony, and Cornwall.

At Altenberg it is obtained from arsenical iron (*Mispickel*), a compound of arsenicum, iron, and sulphur. After being reduced to powder the ore is roasted in a muffle furnace (fig. 56), by which the arsenicum is converted into arsenious acid. This is conveyed in the state of vapour, called *flowers of arsenic* or *smeltinghouse-smoke* (*Hüttenrauch*), into the condensing chamber (fig. 57), where it is deposited in a pulverent form, and in this state is called *rough arsenious acid*, or *poison-flour* (*Giftmehl*).

The rough arsenious acid is refined by sublimation. This is effected in cast-iron pots, as shewn in fig. 58, p. 376, to which cylindrical iron

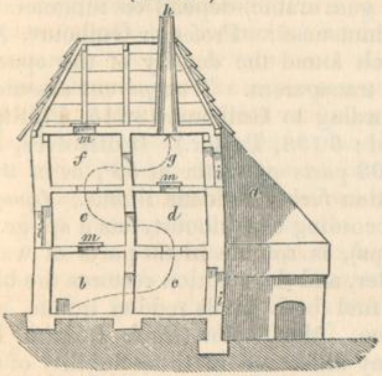
(Fig. 56.)



Section of the Roasting Furnace.

(*a*) Ash-pit. (*b*) Fire-place.
(*eee*) Brick arches for supporting the muffle.
(*c*) Earthen muffle for receiving the ore.
(*f*) Hopper for introducing the ore.
(*d*) Passage for the fumes into the condensing chamber.
(*hh*) Flue.
(*g*) Vent for protecting the workmen from the arsenical fumes.

(Fig. 57.)



Condensing Chamber.

(*b c d e f g h*) Course of the vapour.
(*i i i*) Doors into the chamber.
(*mmm*) Communications between the floors.

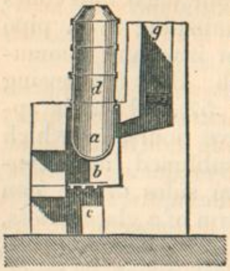
heads (*d*) are attached, which at the tops are contracted into cones (*e*), each terminating in a pipe made of sheet iron, and communicating with the condensing chamber (fig. 57). Heat is applied for twelve hours, by which the acid is sublimed and condensed on the sides of the iron head in the form of a glassy mass, called *glacial white arsenic* (*weissen Arsenikglas*), which is sometimes purified by a second, or even third sublimation. If it contain any sulphuret of arsenicum, a little potash is mixed with it, to prevent the sublimation of the sulphur.

At Reichenstein, arsenious acid is procured from the mineral called arsenical pyrites (a compound of arsenicum and iron, with a small portion of sulphur).

Arsenious acid is procured in some parts of Saxony as a secondary product in the roasting of cobalt ores (the arseniets of cobalt). It is deposited in long horizontal flues (*poison-flues*, or *Giftfängen*), and is purified by sublimation. (For other particulars consult the paper of J. H. Vivian, *Trans. Royal Geol. Society of Cornwall*, i. 60).

Arsenious acid is manufactured in Cornwall. In the impure state it is deposited in the long horizontal flues of the tin burning houses (Mr. J. Taylor, *Ann. Phil.* N.S. iii. 452); from which it is taken for the use of refiners, its value being about ten shillings per ton (*Quart. Min. Rev.* vol. ii. p. 88; and Mr. Davies Gilbert, *Paroch. Hist. of Cornwall*, iii. 305). In this condition it has a grey colour, and is either pulverent or in soft crystalline masses. Mr. Ferris, of Truro, (to whom I am indebted for samples of this impure acid obtained from Wheal Vor tin-mine), tells me that it is conveyed in open waggons to the arsenic-works, of which there are two in the neighbourhood of Truro; one in the parish of Perran Arworthall, the other at Bissow, in the parish of Kea; the former about half a mile, the latter more than a mile, from the Devoron and Carnon stream-works. Here it is purified by sublimation. The fumes from these works are most injurious to neighbouring vegetables and animals. In the human subject, eruptions, principally about the lips and nose, are produced by them. In 1826, eighty-three tons of manufactured arsenic were shipped at Penryn (*Trans. Royal Geol. Soc. of Cornwall*, iii. 360).

(Fig. 58.)



Refining Furnace.
(*c*) Ash-pit. (*b*) Fire-place.
(*a*) Cast-iron pot.
(*d*) Cylindrical head.
(*g*) The chimney.

Properties.—When recently prepared, arsenious acid is in the form of large, glassy, transparent cakes, sometimes colourless, at others having a yellowish tinge. Frequently the cakes consist of concentric laminæ, formed by successive sublimations. Most curiously, these masses soon become opaque and white externally, like enamel, the opacity gradually extending towards the centre; and, in some cases, the acid becomes friable and pulverulent. On what does this alteration depend? Krüger (*Kastn. Arch.* ii. 473, quoted in Gmelin's *Handb. d. Chem.*), ascribes the change to the absorption of water from the atmosphere, for he says it only takes place in moist air, and is attended with an increase of weight, but only to the extent of $\frac{1}{163}$ of the whole mass. Mr. Phillips (*Transl. of the Pharm.* 3d. ed. 1838) has taken the same view of the subject. But, as Berzelius has observed, the augmentation of weight is too trivial to admit of this explanation. Moreover, I find the opacity takes place in an air-tight vessel. Does not the opacity (as in opaque gum arabic) depend on innumerable cracks, imperceptible from their minuteness? Professor Guibourt, Mr. Phillips, and Mr. Taylor, have each found the density of the opaque variety to be less than that of the transparent. *Transparent* arsenious acid has a sp. gr. of 3·7391, according to Guibourt (3·715, Phillips; 3·208 to 3·333, Mitchell and Durand; 3·798, Taylor.) It dissolves, according to the same authority, in 103 parts of water at 59°, or in 9·33 parts of boiling water, and the solution feebly reddens litmus. *Opaque* arsenious acid, on the other hand, according to Guibourt, has a sp. gr. of 3·695 (3·529, Taylor; 3·620, Phillips), is soluble in 80 parts of water at 59°, or in 7·72 parts of boiling water, and the solution restores the blue colour of reddened litmus. But I find both kinds redden litmus, and Dr. Christison has observed the same. Mr. Taylor (*Guy's Hospital Reports*, vol. ii. p. 83), did not find any difference in the solubility of the two varieties. He found that water boiled for an hour on this substance dissolved $\frac{1}{24}$ of its weight; that this water on perfect cooling did not retain more than $\frac{1}{40}$ of its weight; and that water at ordinary temperatures will dissolve from about $\frac{1}{1000}$ to $\frac{1}{500}$ of its weight. It appears, then, that water perfectly cooled from a boiling saturated solution will retain from ten to twenty or more times the quantity of acid in solution than it will take up at common temperatures without heat,—a fact which is as curious as it is inexplicable (*op. cit.* p. 96.) Arsenious acid is soluble in alcohol and oils. It is of importance to know that the presence of organic matters very much impairs the solvent power of water for this acid—a circumstance which readily explains why arsenious acid has not, in some cases, been found in the liquid contents of the stomach of persons poisoned by it. Arsenious acid has little or no taste, as Plenck (*Toxicologia*, ed. $2^{nda.}$ 26), Addison, and Christison, have remarked: and neither in the solid nor vaporous form has it odour. The acid may be readily obtained in a crystalline condition by sublimation or by cooling a boiling saturated solution: the crystals are transparent, usually regular octahedra, sometimes tetrahedra or acicular. At a temperature of 380° F. it volatilizes: when heated under pressure it liquefies, and is converted into a transparent glass.

Characteristics.—These may be conveniently and usefully discussed under three heads:—(*a.*) The characteristics of solid arsenious acid; (*b.*) the characteristics of a pure solution of arsenious acid; (*c.*) the characteristics of arsenious acid in organic mixtures.

(*a.*) *Of Solid Arsenious Acid.*—The characteristics of solid arsenious acid are (besides its physical properties before mentioned) principally three—its volatility, the garlic odour evolved by throwing it on ignited charcoal, and the qualities of the metallic crust obtained by reducing the acid.

1. *Its volatility.*—Heated on the point of a penknife in the flame of a spirit lamp arsenious acid produces a white smoke, and speedily disappears. If the acid be heated in a test tube, a crystalline sublimate is obtained: the crystals when examined by a magnifying glass are found to be regular octahedra. The *impediments* to the operation of this test are alkaline or earthy bases which retain a portion of the arsenious acid, and prevent its rising in vapour: boracic acid may be used to counteract their influence. The *fallacy* of this test is, that other white solids (as hydrochlorate of ammonia, oxalic acid, &c.) are volatile, and produce a white smoke when heated.

2. *Garlic odour.*—If arsenious acid or an arsenite be put on a red-hot cinder (placed for convenience in a saucer), it evolves a scarcely visible vapour (of metallic arsenicum) having a garlic odour, and which, at the distance of an inch or two from the cinder, is converted into a dense, white, odourless smoke (arsenious acid.) The deoxidation of the acid is essential to the production of the garlic odour: hence no odour is perceived when arsenious acid is placed on a heated metallic or glass plate. The *impediment* to the action of this test is the presence of organic matter (as flour): this, by burning, developes a strong odour, which masks the smell of the vapour of arsenicum. The *fallacy* attending it is, that some other bodies (as phosphorus, with certain of its compounds and some organic matters) evolve when heated a garlic odour. Vauquelin, Barruel, and Orfila, have shewn that a compound of albumen and fat, which exhaled this odour when heated, did not contain a particle of arsenious acid. "It is true," say these experimenters, "that arsenicum does evolve a garlic odour when volatilized; but even when this is well characterized, it is insufficient to establish the existence of the oxide of arsenic, since it belongs to some other substances; and it is not impossible that there may be developed in the stomach, during digestion, substances which exhale an analogous odour, when heated."

Fig. 59.

Berzelius's Red^{n}. tube.

3. *Formation of a metallic crust. Reduction test.*—If arsenious acid be intimately mixed with freshly-ignited but cold charcoal, and heated in a glass tube, the acid is deoxidized, and yields arsenicum, which is sublimed into a cooler portion of the tube, where it condenses, and forms a metallic crust. A common cylindrical test tube answers very well, but the reduction tube of Berzelius (fig. 59) is to be preferred. The characters of the arsenical crust are—the brilliancy of its outer surface, which is frequently equal to polished steel or looking-glass; the crystalline appearance and greyish white colour of its inner surface; its volatility; its conversion, by sublimation, up and down the

tube, into octahedral crystals of arsenious acid, which may be dissolved in distilled water, and tested by the liquid re-agents presently to be mentioned; and its yielding arsenic acid by dissolving it in nitrohydrochloric acid, and carefully evaporating the solution to dryness. The arsenic acid is known by the red precipitate (arseniate of silver) produced on the addition of nitrate of silver: but if the evaporation has not been carried on sufficiently far, some hydrochloric acid or chlorine will be left, which will form a white precipitate (chloride of silver) with nitrate of silver. The arseniate of silver may be reduced, if necessary, by mixing it with charcoal and boracic acid, and heating it in a glass tube.

In some cases the metallic crust is imperfectly formed, or is masked by some decomposed organic matter. Whenever any doubt respecting its nature is entertained, proceed as follows:—Cut off with a file the portion of the tube which contains the suspected crust, roughly powder it, introduce it into another glass tube, and apply heat.

The *fallacies* to which this test is liable are principally two—a charcoal crust may, by an inexperienced experimenter, be mistaken for the arsenical crust; and I have seen students confound a stratum of globules of mercury (obtained by reducing calomel) with the arsenical crust. Careful examination, especially by a magnifying glass, will, however, easily enable the experimenter to distinguish them: the inner surface of the charcoal crust is brown, powdery, and dull, whereas that of the arsenical crust has a crystalline texture, grey colour, and shiny appearance: the sublimate obtained by reducing calomel or mercurial compounds has all the brilliancy of arsenicum, but by a glass is found to consist of minute globules which may be made to coalesce by the point of a knife. Lastly, the arsenical may be distinguished from all other crusts by oxidating it, as before directed, and converting it into arsenious or arsenic acid which can be readily recognised by the tests already mentioned:—*a proceeding which ought never to be omitted.*

As a deoxidizing agent I have directed freshly ignited charcoal to be employed to convert arsenious acid into arsenicum. If carbonate of soda or of potash be mixed with the charcoal, a part only of the arsenicum is disengaged, an arseniuret of sodium or of potassium being formed: hence when the quantity of acid to be reduced is small, charcoal only should be employed. "Where the quantity of material, however, is considerable, it is preferable to employ the black flux, or still better, as not being deliquescent, a mixture of charcoal and carbonate of soda, deprived of water of crystallization by heat." (Christison's *Treatise on Poisons,* 3d ed. 237.) If the substance to be reduced be an arsenite (as of silver, copper, or lime), or an arseniate (as of silver), a mixture of charcoal and boracic acid should be used. For the reduction of the arsenical sulphurets (as the precipitate obtained by passing hydrosulphuric acid gas through a solution of arsenious acid) a mixture of 2 parts of ignited carbonate of soda and 1 of charcoal should be employed. The alkali is here essential in order to combine with the sulphur. Black flux (prepared by deflagrating 1 part of nitre and 2½ of bitartrate of potash) is objectionable on account of its deliquescent property. Various other deoxidizing agents have been recommended, as formate of soda by Goebel (Griffin's *Chem. Recreat.* 8th ed. 140), oxalate of lime by Du Menil (*Handb. d. Reag. u. Zerlegungslehre*, ii. 268), and oxalate of soda by Dr. M'Gregor (*London Med. Gaz.* xxii. 613.) I find that binoxalate of potash answers very well. None of these, however, present any advantage over charcoal save that of not soiling the tube (an occurrence easily avoided by using a glass funnel, as recommended by Dr. Christison, or which may be obviated by wiping the tube, after the introduction of the mixture, with a wisp of paper), while their comparative scarcity and greater cost are objections to their employment. (For further details concerning the reduction process, consult Dr. Christison's *Treatise*, so frequently referred to.)

(*b.*) *Characters of a pure aqueous solution of Arsenious Acid.*—A clear watery solution of white arsenic may be recognized by certain liquid reagents which give rise to peculiar precipitates, as well as by nascent hydrogen, which causes the formation of a gas (arseniuretted hydrogen) possessed of remarkable and peculiar properties. The liquid reagents which deserve notice are four only—namely, *lime water*, *ammoniaco-sulphate of copper*, *ammoniaco-nitrate of silver*, and *hydrosulphuric acid*. Their relative delicacy, as stated by Devergie, (*Méd. Lég.* ii. 718), and the delicacy of the nascent hydrogen test, as ascertained by Mohr (*Journ. de Pharm.* xxiii. 566), are as follows:—

	Dilution of arsenious solution.
Lime water ceases to act at	2·000
Ammoniaco-sulphate of copper, ditto at	5·200
Hydrosulphuric acid, ditto at	200·000
Ammoniaco-nitrate of silver, ditto at	400·000
Marsh's nascent hydrogen test, ditto at	500·000

1. *Lime Water.*—Lime water occasions a white precipitate (arsenite of lime), with a solution of arsenious acid. The precipitate is soluble in most acids. The *impediments* to the operation of this test are, a large quantity of water and free acids, which hold it in solution, and gelatinous and oleaginous liquids, which keep it suspended. The *fallacies* of this test are, carbonates, oxalates, tartrates, &c. which also throw down white precipitates with lime water. On the whole, it is a test of very little value.

2. *Ammoniaco-sulphate of Copper.*—If a dilute solution of ammoniaco-sulphate of copper be added to a solution of arsenious acid, a pale green precipitate (arsenite of copper, or Scheele's green) is obtained, and sulphate of ammonia remains in solution. This test is prepared as follows:—Add (cautiously) liquor ammoniæ to a solution of the sulphate of copper, so as to re-dissove the oxide of copper, which it at first throws down. Care must be taken not to employ too much alkali, otherwise the test will not act. Moreover, the solution must not be concentrated, or no precipitate will be obtained. The *impediments* to the action of this test are astringents, as tea, infusion of galls, &c. which prevent its acting characteristically. The *fallacies* to be guarded against, are, yellow-coloured and other organic fluids, which give a green colour, and slight precipitate, even though no arsenic be present.

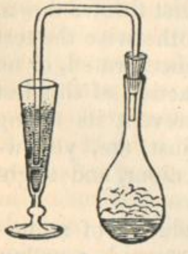
3. *Ammoniaco-nitrate of silver: Hume's test.*—If a solution of ammoniaco-nitrate of silver be added to a solution of arsenious acid, a yellow precipitate (arsenite of silver) takes place, and nitrate of ammonia remains in solution. The precipitate is soluble in liquid nitric acid, ammonia water, and a solution of nitrate of ammonia. The mode of preparing this test is as follows:—Add a few drops of liquor ammoniæ to a solution of nitrate of silver, so that the oxide of silver which the alkali at first throws down may be nearly, but not entirely, redissolved. Great care is requisite to add neither too much nor too little; for if too much be employed, the solution will not occasion any precipitate with arsenious acid; and if too

little, it will produce a precipitate with phosphate of soda similar in colour to that produced with arsenious acid. The only certain way of knowing when the proper quantity has been employed is to test it. Arsenious acid, but not phosphate of soda, ought to occasion a precipitate with it. The *impediments* to the operation of this test, are, free acids (as hydrochloric nitric, acetic, citric, or tartaric), chlorides, and organic matters. The acids may be readily neutralized by an alkali. If common salt, or other metallic chloride be present, ammoniaco-nitrate of silver throws down a white precipitate (chloride of silver), even though a considerable quantity of arsenic be present. To obviate this, add a few drops of nitric acid, then an excess of a solution of nitrate of silver. Filter to get rid of the precipitated chloride of silver, and apply the ammoniaco-nitrate of silver. The presence of much organic matter impedes the action of this test. Ammoniaco-nitrate of silver, when properly prepared, does not occasion a yellow precipitate with any substance save arsenious acid; and hence is not subject to any *fallacy* of that kind. If, however, it be not properly prepared, it may occasion a yellow precipitate (subphosphate of silver) with phosphate of soda. There is an optical fallacy, against which the student should be put on his guard: if ammoniaco-nitrate of silver be added to certain yellow liquids containing common salt, a white precipitate (chloride of silver) is produced, which, seen through a yellow medium, might, by a careless observer, be mistaken for a yellow precipitate.

4. *Hydrosulphuric Acid* (*Sulphuretted Hydrogen*).—If this gas be passed through a solution of arsenious acid, a yellow precipitate of sesquisulphuret of arsenicum (orpiment) is produced, while the oxygen of the arsenious acid, and the hydrogen of the hydrosulphuric acid, unite to form water. In order, however, for this effect to be produced, it is necessary that the liquid be slightly acidified by some acid (as the hydrochloric). If the liquid be already acid, we must neutralize it by cautiously adding an alkali, and then acidify by hydrochloric acid.

In applying this test we may place the suspected liquid in a test-tube, or conical wine or ale-glass (fig. 60); the gas being developed in a common Florence flask (or two-necked bottle, as recommended by Dr. Christison): the mouth of the flask is closed by a cork, perforated by a tube curved twice at right angles. The ingredients for developing the gas are a metallic sulphuret (as of iron or of antimony) and sulphuric or hydrochloric acid. I prefer the sulphuret of iron with sulphuric acid diluted with water. These are to be introduced into the flask previous to the adaptation of the cork. After the gas has passed through the arsenical liquid for a few minutes, portions of the yellow sesquisulphuret of arsenicum (orpiment) begin to fall down. The separation of the precipitate is promoted by ebullition, and the exposure of the solution for a few hours to the air. The essential characters of the precipitate are, its yellow colour, its rapid solution in liquor ammoniæ, forming a colourless and very limpid liquid, and its yielding metallic arsenicum when dried and heated with black flax, or a mixture of ignited carbonate of soda and charcoal. When the quantity of sesquisulphuret is small, some difficulty may be

FIG. 60.



Mode of passing Hydrosulphuric Acid through an arsenical solution.

experienced in removing it from the filter for reduction. The readiest way is that recommended by Devergie:—Collect it on the filter in as small a space as possible, then wash it with liquor ammoniæ, which dissolves it. The filtered liquid may then be evaporated in a capsule or watch-glass: the ammonia flies off, and leaves the sesquisulphuret.

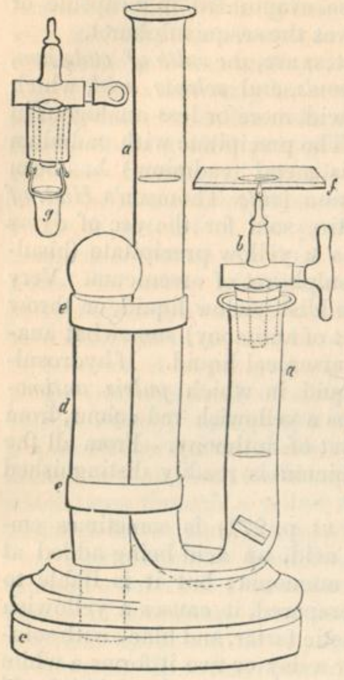
The *fallacies* of the hydrosulphuric acid test are, the *salts of cadmium*, the *persalts of tin*, the *antimonial compounds*, and *selenic acid*, which occasion precipitates with hydrosulphuric acid, more or less analogous in colour to that produced by arsenious acid. The precipitate with cadmium closely resembles that with arsenic. This metal (cadmium) has been detected in some of the preparations of zinc (*vide* Thomson's *Hist. of Chemistry*, ii. 220). The perchloride of tin, sold for the use of dyers under the name of *spirit of tin*, occasions a yellow precipitate (bisulphuret of tin) somewhat resembling sesquisulphuret of arsenicum. Very weak solutions of emetic tartar form a reddish yellow liquid, or throw down a reddish precipitate (sesquisulphuret of antimony) somewhat analogous in appearance to that formed by an arsenical liquid. If hydrosulphuric acid be transmitted through a liquid in which *pulvis antimonialis* has been boiled, the solution acquires a yellowish red colour, from the formation of some sesqui- or bisulphuret of antimony. From all the above precipitates sesquisulphuret of arsenicum is readily distinguished by the reduction test already mentioned.

Hydrosulphate of ammonia (described at p. 271) is sometimes employed as a substitute for hydrosulphuric acid, an acid being added at the time of applying it, to neutralize the ammonia; but it is liable to several serious objections. When fresh prepared, it causes a yellowish precipitate with arsenious acid, red with emetic tartar, and black with solutions of lead; but by exposure to the air for a day or two it forms a white precipitate with arsenious acid, yellow with emetic tartar, and red with lead!

5. *Nascent Hydrogen: Marsh's test.*—If arsenious acid be submitted to the action of nascent hydrogen, it is deoxidized, and the metallic arsenicum thereby obtained, combining with hydrogen, forms arseniuretted hydrogen gas.

This test, which is the discovery of Mr. Marsh, of Woolwich (*Trans. of the Soc. of Arts*, li. 66; also *Lond. Med. Gaz.* xviii. 650), may be thus applied:—Mix a small portion of the suspected liquid with some diluted sulphuric acid (1 oil of vitriol and 7 water), and pour the mixture over some pieces of zinc previously introduced into a proper apparatus: bubbles of gas immediately make their appearance. If no arsenious acid be present, the evolved gas is hydrogen; but if the liquor hold arsenic in solution, arseniuretted hydrogen gas is formed. This gas is recognised by the following characters: it has an alliaceous odour, and burns in the air with a bluish white flame, and the deposition of black metallic arsenicum and white arsenious acid. If a plate of mica, or of common window-glass, or of porcelain (as a white saucer), be held a short distance above the flame, arsenious acid, in a finely pulverent state, is deposited on it: if the plate be depressed so as to touch the flame, and thereby slightly to impede the combustion of the gas, a blackish deposit of metallic arsenicum is obtained. Or both these deposits may be readily procured by holding vertically over the flame a tube of glass, 9 or 10 inches long, and a quarter or half an inch in diameter: the tube becomes lined for the space of several inches with metallic arsenicum and arsenious acid, and the garlic odour can be detected at either end of the tube. To obtain solutions of the acid, let the flame successively play beneath three or four drops of water placed on the under side of a plate of mica; then apply the liquid tests for arsenic before mentioned (Herapath, *Med. Gaz.* xviii. 889).

FIG. 62. & FIG. 61.

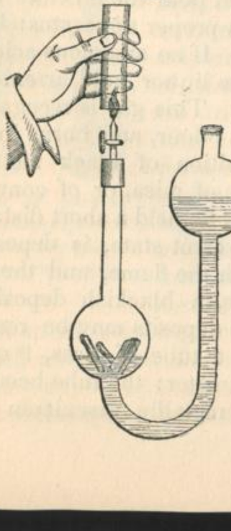


(*a*) A syphon tube.
(*b*) Stop-cock.
(*c*) Wooden block.
(*d*) The pillar.
(*ee*) Caoutchouc slips, to fasten the tube to the pillar.
(*f*) Place of mica or glass.

Fig. 62.—(*g*) Small glass bucket.

Various forms of apparatus may be used for this experiment. That employed by Mr. Marsh is a simple glass tube, bent like a syphon (fig. 61). A bit of glass rod is dropped into the shorter leg, then a piece of clean sheet zinc: the stop-cock and jet are afterwards to be inserted. The suspected liquid, mixed with the dilute acid before mentioned, is to be then poured into the long leg. Effervescence is produced, and after allowing the air to be expelled, the stop-cock is to be closed, and when a sufficient accumulation of gas has taken place, it is again to be opened, and the gas ignited. Where the matter to be examined is very small in quantity, Mr. Marsh puts the suspected liquid, the acid, and the zinc, in a little glass bucket (fig. 62), attached to the stop-cock by a platinum wire, and then introduces it into the short leg of the syphon, previously filled with common water. A modification (fig. 63) of Mr. Marsh's apparatus is supplied with two bulbs, one in each leg of the instrument, and presents some advantages over the simple syphon tube: thus it enables us to collect a larger quantity of gas, while the bulb assists in checking the frothing by breaking the bubbles. But the simplest, cheapest, and often the most useful form of apparatus, is a two-ounce wide-mouthed phial, with a cork perforated by a glass tube or tobacco-pipe, as in fig. 64, p. 383, annexed. It presents this great advantage, that we can employ a fresh apparatus for every experiment, and thus avoid all possibility of contamination from arsenical liquids used in previous experiments.

FIG. 63.



The *impediments* to the operation of Marsh's test are, organic liquids (as porter, soup, contents of the stomach, &c.), which occasion great frothing, and choke up the jet. The means of obviating this are, greasing or oiling the interior of the short leg of the apparatus, putting a layer of alcohol or oil on the surface of the liquid in the short limb, and placing the apparatus aside for an hour or two, to allow the bubbles to burst.

FIG. 64.

The *fallacy* of the test is, that if a solution of emetic tartar be employed instead of an arsenical liquid, we obtain antimoniuretted hydrogen gas, which coincides in many of its properties with arseniuretted hydrogen (Mr. L. Thompson, *Lond. & Edinb. Phil. Mag.*, May 1837). Thus it has a peculiar odour, not very unlike that of arseniuretted hydrogen, and burns in the air with a pale bluish flame, and the deposition of metallic antimony and the white oxide (on mica or glass held over it), which resemble, in their general appearance, arsenicum and arsenious acid: moreover, the action of hydrosulphuric acid and of ammoniaco-sulphate of copper on the oxide of antimony, produces colours resembling those generated by the action of these tests on arsenious acid. The two metals may, however, be distinguished by adding a drop of nitric acid to the crusts, and evaporating to dryness: a white powder is left in each instance. A few drops of a dilute solution of the nitrate of silver being now added, and the whole exposed to the fumes arising from a stopper moistened with ammonia, the arsenical crust will give the well known canary-yellow flocculi (Mr. L. Thompson, *op. cit.*) Moreover, the greater volatility of arsenicum, and its conversion into octahedral crystals of arsenious acid (Dr. E. Turner's *Chemistry*, by W. Turner) may serve, in some cases, to distinguish it from antimony. Furthermore, the solubility of the arsenious acid, and the reaction of the before-mentioned liquid tests on the solution, will distinguish it from oxide of antimony, which is insoluble.

In performing Marsh's test great care must be taken that the apparatus be perfectly clean, and that fresh zinc and acid liquor be used for every experiment. The experimenter should be fully alive to the possibility of the acid, zinc, or even the brasswork of the apparatus, containing minute traces of arsenic; hence the necessity of examining the qualities of the hydrogen flame before adding the suspected arsenical liquid. It has been shown by Mohr (*Journ. de Pharm.* xxiii. 563) that zinc which had been once used, but afterwards carefully washed both in water and acid, retained sufficient arsenic to produce the usual effects on the hydrogen flame.

3. *OF ARSENIOUS ACID IN ORGANIC MIXTURES.*—I shall confine myself to a brief notice of the modes of detecting arsenious acid when mixed with the contents and tissues of the stomach, and must refer the reader to Dr. Christison *On Poisons*, and to his paper in the *Edinb. Med. & Surg. Journ.* xxii. 60, as well as to Devergie's *Méd. Lég.* ii. 718, for further details, especially in reference to other organic mixtures.

When the stomach is laid open we sometimes observe in it a white powder or white particles; these are, of course, to be carefully removed; and if they be arsenious acid, no difficulty will be experienced in recognising them by the tests already mentioned.

If no solid arsenious acid be observed, cut the stomach into small pieces, and boil it with the contents of this viscus for half an hour in distilled water, to which a small quantity of liquor potassæ has been added: then filter, first through muslin, and afterwards through paper. Fibrin is insoluble in water, and, by boiling, albumen is coagulated, so that (with the exception of small portions of these principles held in solution by the alkali) the filtered liquor is free from both fibrin and albumen. A little acetic acid is now to be added, and the liquid boiled, by which any caseum present will be coagulated, and got rid of by filtering a second time. Sometimes the liquor is now found sufficiently free from organic matters to enable us to detect the arsenious acid very readily by the ammoniaco-nitrate of silver. Dr. Christison says, that if this test act characteristically, that is, gives a copious yellow precipitate, the liquid is sufficiently free from foreign matter. If, however, it give no indication, or at least only imperfect ones of arsenious acid, evaporate to dryness by a gentle heat (as a water-bath), and boil the residue in repeated portions of distilled water. We thus obtain a solution of arsenious acid, which, after being acidulated with acetic or hydrochloric acid, is to be decomposed by passing a current of hydrosulphuric acid through it. The precipitated orpiment (sesquisulphuret of arsenicum) is to be collected, and reduced in the way already described (p. 378).

Arsenious acid in organic liquids may sometimes be readily detected by the developement of arseniuretted hydrogen when zinc and sulphuric acid are added to the suspected liquor (*vide* p. 381). But the frothing produced by the organic matter creates considerable difficulty. I have already pointed out the best methods of obviating it.

COMPOSITION.—The following is the composition of arsenious acid:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.	Mitscherlich.
Arsenicum	1	38	76	75·782	75·73
Oxygen	1½	12	24	24·218	24·27
Arsenious Acid	1	50	100	100·000	100·00

PURITY.—Powdered arsenious acid is sometimes adulterated with chalk or sulphate of lime. The fraud is readily detected by heat, which volatilizes the acid, but leaves the impurities.

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—The effects of arsenious acid on plants have been studied by Jäger (*Diss. Inaug.* Tubingæ, 1808, quoted by Marx in his *Die Lehre von den Giften*, ii. 99); Marcet; Macaire, *Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève* t. iii.), and by others; and from their observations we learn that it is poisonous to all the higher and most of the lower families of plants. It appears that seeds which have been soaked in a solution of arsenious acid are incapable of germinating, and that buds which have been plunged in it are no longer capable of expanding. If roots or stems be immersed in this solution the plants perish; death being preceded by drooping and alteration of the colour of the leaves and petals. If the stem of the common barberry (*Berberis vulgaris*) be placed in dilute hydrocyanic acid, or in an aqueous solution of opium, the stamens lose their remarkable contractile power, but remain flexible. If, however, we employ a solution of arsenious acid, the plant equally dies, but the stamens become stiff, hard, and retracted, and on any attempts being made to alter their position, they readily break. These curious facts appear to prove that the effects produced by this acid on vegetables are very different from those caused by hydrocyanic acid and opium; for the latter seem to exhaust the irritability, while the former appear to give rise to a condition very analogous to the spasm of animals. Jäger has seen a small plant (supposed by Decandolle, in his *Phys. Vég.* p. 1329, to be *Mucor imperceptibilis*) grow in water which contained $\frac{1}{32}$ of its weight of arsenic. And, more recently, Gilgenkrantz (*Journ. de Pharm.* xxiii. 38) says he has seen an algaceous plant, of the genus either *Leptomitus* or *Hygrocrocis*, develope itself in a solution of arsenic. These are most remarkable exceptions to the general effects of this poison on vegetables, and deserve further examination. Jäger has shewn that arsenic is absorbed by plants: for he found that on burning vegetables destroyed by this poison he obtained a garlic odour.

(*b.*) *On animals generally.*—Arsenious acid is poisonous to all classes of animals. No exceptions, I believe, are known to exist to this statement. The most extensive series of experiments on this subject are those performed by Jäger (*op. cit.*) From them we learn that in all animals, from the infusoria up to man, death from arsenic is invariably preceded by inordinate actions and increased evacuations, especially from the mucous membranes. In most animals the stools were frequent and fluid; and in those in which mucus is secreted on the surface, it was remarkably increased. The power of voluntary motion and susceptibility of external stimuli were decreased; and after death the muscles soon ceased to be influenced by the galvanic agency. In animals which breathe by lungs, respiration became difficult and laborious; and in warm-blooded animals great thirst was experienced. In birds and mammals convulsions came on, preceded by vomiting, except in those animals (as the rabbit) which cannot vomit. Enormous quantities of arsenious acid have been sometimes administered to horses with impunity. Berthe (*Recueil de Méd. Vét.* Oct. 1825) gave 2 and afterwards 3 drachms to a mare, for the cure of an obstinate skin disease, without any injurious effects. Beissenhirz (quoted by Wibmer, *die Wirkung*, &c. i. 317) gave successively, on different days, 1, 4, 3, 2, and 8 drachms of arsenious acid to a horse: the animal did not die until the ninth day after taking the last-mentioned dose. Yet notwithstanding these and some other analogous facts, which seem to prove that arsenic has comparatively little effect on horses, the best informed veterinarians agree in considering it an energetic poison to these animals. (See the evidence of Mr. Bowles, in the *Ed. Med. and Surg. Journ.* viii. 351.)

(*c.*) *On man. α. Of very small* or *therapeutical doses.*—In very small quantities (as $\frac{1}{16}$ or $\frac{1}{12}$ of a grain) no obvious effects are usually produced by the use of arsenic, unless it be continued for a long period. Indeed some writers (*e. g.* Vogt, *Pharmakodyn.*) go so far as to assert that it is a strengthening remedy, and that it improves the appetite, invigorates digestion, promotes assimilation and secretion, excites the muscular and nervous functions,—in a word, acts as a *tonic*. I cannot, however, subscribe to this doctrine, because I have never been able to see the effects here asserted. It is, indeed, true that patients sometimes experience a temporary increase of appetite from the use of small doses of arsenic; and it is also certain that this remedy is frequently beneficial in agues and other diseases in which tonics have been found efficacious. But the analogy between the action of arsenious acid and that of the vegetable tonics (as cinchona, to which Vogt compares it) stops here. I have sought in vain for other evidences of a tonic operation. I have seen very minute doses of arsenic given to patients affected with lepra, and continued for many days, without being able to detect the least indication of its action on the system, except the amelioration of the disease. When the dose was slightly increased, the appetite in some cases appeared to be increased; but this effect was neither universal nor continued. Very shortly afterwards, a sensation of heat in the throat, œsophagus, and stomach, came on, occasionally with nausea, but seldom with vomiting; in a few cases with gastrodynia; a febrile condition of the body was set up; there were dryness of the skin, increased secretion of urine, relaxed bowels, sometimes with griping; the patients usually complained of great languor, inaptitude for employment, and want of sleep; and sometimes these symptoms were accompanied with, or followed by, redness of the eyes and certain swellings especially of the face, (*œdema arsenicalis*)—effects which are so different from those produced by the remedies called strengthening, that I cannot regard arsenic as a tonic. In proof of the beneficial effects of this substance, we are gravely told that the country people of Upper Styria, in Austria, use arsenic as a stomachic, and condiment for many kinds of food—for example, cheese; and a healthy peasant himself tells us that he was accustomed to take two grains of arsenic daily, without which, he assures us, he could not live! (*Med. Jahrb. d. österr. Staates.* 1822, i. 99, quoted from Wibmer.) In further proof of this strengthening action of arsenic, Vogt says that it promotes the appetite, the activity, and the power of old enfeebled horses, and mentions that Jäger noticed the same effects on a pigeon. To the first of these statements, namely, the beneficial effects from the use of arsenic as a condiment, I confess I do not give credence; and with respect to the action of arsenic on horses, every well-informed veterinarian knows that it operates on these animals as a virulent poison.

Dr. Fowler (*Med. Reports of the Effects of Arsenic*, p. 98) gives the following summary of the effects of the arsenical solution in more than 320 cases:—In about $\frac{1}{3}$ no operation: "somewhat more than $\frac{1}{3}$ were attended with nausea; and nearly $\frac{1}{3}$ with an open body; and about $\frac{1}{3}$ with griping. Vomiting, purgings, swellings, and anorexia, were but rare in comparison with the preceding effects, and their less frequent occurrence were generally found in the order in which they are here enumerated, swellings and anorexia being the seldomest. About $\frac{1}{5}$ of the cases attended with nausea, and $\frac{1}{4}$ of those attended with an open body, were unconnected with any other effects. Griping did not often occur alone; purging and anorexia seldom or never; and vomiting was always accompanied with more or less nausea." In some cases salivation has been produced by the medicinal use of arsenic, as will be noticed presently.

β. *Of long-continued small doses, or of large medicinal doses* (*slow or chronic poisoning.*)—If the use of small doses of arsenious acid be continued for a long period, it acts as a slow poison; and if persevered in, will ultimately occasion death. The same effects take place, in a shorter period, from the administration of large medicinal doses. Sometimes the digestive apparatus, at other times the nervous system, first shews symptoms of the poisonous operation of this agent.

Hahnemann (quoted by Dr. Christison) has graphically described the condition of slow poisoning by arsenic as "a gradual sinking of the powers of life, without any violent symptom; a nameless feeling of illness, failure of the strength, an aversion to food and drink, and all the other enjoyments of life."

On some occasions the first symptoms which I have observed of its poisonous operation have been thirst, redness of the conjunctiva and eyelids, followed by a cutaneous eruption. At other times irritation of stomach is the leading symptom. In some cases ptyalism is brought on. Marcus (*Ephemeriden*, 1809) noticed this effect: as also Dr. Ferriar (*Med. Hist. and Refl.* iii. 306.) Mr. Furley (*Lond. Med. Gaz.* xvi.) has published five illustrative cases of it. Trousseau and Pidoux (*Traité de Thérap.* ii. 148) also mention this symptom as produced by the long-continued use of feeble doses of arsenic. This effect acquired some importance in the celebrated Bristol case of poisoning. (*Lond. Med. Gaz.* xv. 519, and *Trans. Prov. Assoc.* iii. 432.)

The following is an abstract of the symptoms produced by the long-continued employment of small doses of arsenious acid, but which are more or less modified in different cases:—Disorder of the digestive functions, characterized by flatulence, sensation of warmth, or actual pain, in the stomach and bowels; loss of appetite; thirst, nausea, and vomiting; purging, or at least a relaxed condition of the bowels, and griping; furred tongue, with dryness and tightness of the mouth and throat, or with salivation. The pulse is quick, small, and sometimes irregular; the respiration oppressed, and accompanied with a dry cough. The body wastes; the stomach being frequently so irritable that no food can be retained in it. Headache, giddiness, and want of sleep, are frequently observed. The limbs become painful, feeble, trembling, subject to convulsions; occasionally benumbed, and ultimately paralyzed. The cutaneous system is, in some cases, affected, an eruption makes its appearance, and now and then the hair and nails fall off. Swelling of the feet and of the face is not unfrequently observed; and under these symptoms the patient gradually sinks, in some cases retaining his consciousness to the last, but at other times delirium or stupor supervening.

γ. *Of excessive or poisonous doses* (*acute poisoning.*)—The symptoms produced by the ingestion of a large dose of arsenious acid are not invariably alike, but put on three forms. In some cases the principal or leading ones are those indicating gastro-enteritis; the nervous system being not obviously, or at least only slightly, affected. In others, the gastro-enteritic symptoms are absent, and the principal operation of the poison is on the vascular and nervous systems. Lastly, there are other cases in which we have both gastro-enteritic symptoms with an affection of the nervous and vascular systems.

Form 1st: Acute poisoning with symptoms of gastro-enteritis.—In this form of arsenical poisoning, nausea and vomiting come on soon after the poison has been swallowed, and are attended with burning pain in the throat and stomach, and which soon extends over the whole abdomen. Pain and vomiting, however, are not invariably present. The matters vomited vary in their nature and appearance; sometimes being bilious, at other times tinged with blood. Frequently there is a sense of heat, dryness, tightness, and constriction of the throat, accompanied with incessant thirst, and occasionally with an almost hydrophobic difficulty of swallowing. The lower part of the alimentary canal soon becomes affected, indicated by the burning pain, which is increased on pressure—by the hard and tense condition of the abdomen—by the diarrhœa (the stools occasionally being bloody)—by the tenesmus—and by the occasional heat and excoriation of the anus. When the lower part of the alimentary canal is powerfully irritated, the urino-genital apparatus becomes affected; and thus there may be difficulty in passing the water, with burning pain in the genital organs. The constitutional symptoms are, in part, such as might be expected from this violent local disorder: thus the pulse is quick, but at the same time small, feeble, and irregular: there are cold clammy sweats; the action of the heart is irregular, giving rise to palpitation; the breathing is short, laborious, and often painful; the tongue is dry and furred; and the membrane lining the air-passages feels hot, and oftentimes painful.

Although, in this form of acute arsenical poisoning, the gastro-enteritis is the principal, and in some cases almost the only affection, yet there are generally observed some symptoms indicative of disorder of the cerebro-spinal system: sometimes in the form of tremblings or cramps of the limbs, or delirium, and even, in the last stage, insensibility. Occasionally, also, eruptions take place.

In this form of poisoning, death usually occurs in from twenty-four hours to three days after the administration of arsenic; but Dr. Christison says that Pyl has recorded a case where death occurred in three hours after swallowing the poison.

Form 2d: Acute poisoning with narcotism, without any remarkable symptoms of gastro-enteritis.—In some cases of poisoning, in both man and animals, the symptoms are those indicating disorder of the cerebro-spinal and vascular systems: abdominal pain, vomiting, and purging, being either altogether absent or very slight. The symptoms are usually faintness, or perhaps actual syncope, convulsions, or paralysis; and, sometimes, insensibility; at other times, delirium. These symptoms constitute the state called *narcotism*. Of this form of arsenical poisoning (which is somewhat rare) Dr. Christison has given an abstract of twelve recorded cases. In most of them the quantity of arsenious acid taken was very large; for example, half an ounce, or even an ounce.

Form 3d: Acute poisoning with symptoms of gastro-enteritis, followed by an affection of the cerebro-spinal system.—In this form of poisoning we have at first the usual gastro-enteritic symptoms, and which I have already described under the first form of poisoning. When, from the smallness of the dose, or from other circumstances, the patient recovers from the gastro-enteritis, symptoms of a cerebro-spinal affection sometimes make their appearance. The kind of disorder, however, varies considerably in different individuals. "The most formidable," says Dr. Christison, "is coma; the slightest, a peculiar imperfect palsy of the arms or legs, resembling what is occasioned by the poison of lead; and between these extremes have been observed epileptic fits, or tetanus, or an affection resembling hysteria, or madness."

In a medico-legal point of view it is important to determine *what is the smallest fatal dose of arsenious acid.* It is not easy, however, to give a positive answer to this question. Dr. Christison says, "the smallest actually fatal dose I have hitherto found recorded is $4\frac{1}{2}$ grains. The subject was a child four years old, and death occurred in six hours. In this instance, however, the poison was taken in solution." The powerful effects sometimes produced by $\frac{1}{8}$, $\frac{1}{4}$, or $\frac{1}{2}$ a grain, lead us to suspect that 1 grain *might* produce death; but we have no recorded case of this. Hahnemann says, 1 or 2 grains may prove fatal in a few days; and Dr. Christison remarks, that this statement cannot be very wide of the truth. Of course a *repetition* of much smaller quantities might cause death. However, under certain circumstances, enormous quantities have been swallowed with very trivial effects. Some years ago I opened the body of a man who destroyed himself by taking arsenic, and I was informed by the friends that about a fortnight previous to his death, he made an attempt to destroy himself by swallowing a quantity of powdered arsenic, which they found, on inquiry at the druggists of whom it was purchased, to have weighed half an ounce. It was taken immediately after dinner, and the only effect produced was violent vomiting. Here it is evident that the distension of the stomach with food saved the patient's life. This unfortunate individual repeated the attempt, and death was the result. Another remarkable case of recovery, after the ingestion of half an ounce, has been recorded by Dr. Skillman (*Lond. Med. Gaz.* xix. 238, from *Amer. Journ. of Med. Sciences*, Aug. 1836).

MORBID APPEARANCES PRODUCED BY ARSENIOUS ACID.—When arsenious acid kills by its narcotic operation (constituting the second form of arsenical poisoning), no morbid condition is observable after death. In other cases, however, various alterations are observed, which may be most conveniently arranged under the following heads :—

(*a.*) *Morbid appearances of the alimentary canal.*—The alterations observed in the condition of the intestinal canal vary with the quantity of the poison taken, and probably with other circumstances, but they are all indicative of inflammation: thus we have redness as one symptom, sometimes accompanied with extravasations of blood into the tissue of the canal; ulceration is also frequently observed, sometimes softening of the mucous coat, effusion (of lymph or blood), and occasionally even gangrenous spots.

(*b.*) *Morbid appearances of the vascular system.*—The blood is sometimes, though not invariably, fluid after death, and dark coloured. The heart is mostly flabby, and it is asserted that on its inner surface (especially the carneæ columnæ and valves, particularly of the left side), is observed redness, sometimes diffused, sometimes in the form of spots, and which penetrates a line in depth into the substance of the heart. The pericardium usually contains serum.

(*c.*) *Morbid appearances of the respiratory system.*—These are neither very remarkable nor constant, and principally consist in redness of the pleura, effusion of lymph or serum into the cavity of the pleura, red spots, and occasional congestion of the lungs, and redness of the membrane lining the air tubes.

(*d.*) The *morbid appearances of other parts* deserve little attention. In some cases inflammation, and even gangrene, of the *genital* organs have been observed; the *conjunctiva* is sometimes very vascular, and alterations are occasionally observed in the condition of the *skin*. Redness, extravasation of blood, and effusion of serum, are said to have been seen in the *brain*.

In connexion with the morbid appearances produced by arsenic, the following remarks, made by Orfila (*Dict. de Méd.* ed. 2, art. *Arsenic*) deserve notice. "Under certain circumstances the mucous membrane of the stomach and intestines is lined with a multitude of brilliant points, composed of fat and albumen: placed on burning coals these grains decrepitate on drying, and produce a noise which has been improperly denominated *detonation:* they inflame as a fatty body when they contain a notable quantity of fat, and exhale an odour of burned animal matter. These *fatty* and *albuminous* globules may be met with in the bodies of individuals who have not been poisoned, and require attentive examination in order to distinguish them from arsenious acid. The best method of avoiding this error is to digest these granular parts with water, and to apply the tests proper for demonstrating the existence of arsenious acid."

INFLUENCE OF ARSENIOUS ACID ON THE PUTREFACTIVE PROCESS.—Until the commencement of the present century it was supposed that the bodies of animals poisoned by arsenious acid were unusually prone to putrefaction. This, however, has been satisfactorily disproved by the experiments and observations of Klank, Kelch, Hünefeld, and others (quoted by Wibmer, in his *Wirkung d. Arzneim. u. Gifte*; and by Dr. Christison, in his *Treatise on Poisons*); and it appears, that when placed in contact with animal textures, it acts as an antiseptic. "I have kept a bit of ox's stomach four years in a solution of arsenic," says Dr. Christison, "and, except slight shrivelling and whitening, I could not observe any change produced in it." This antiseptic property of arsenious acid, which has been, in my opinion, fully and satisfactorily proved, sufficiently accounts for the good state of preservation in which the alimentary canal has been frequently found some months after death in those poisoned by this acid, where it was not evacuated by vomiting or purging.

But there is another effect said to be produced on the bodies of animals, which is not so easily accounted for: I mean their conversion into a kind of mummy-like or adipocirous matter. The following is an abstract of the phenomena, as deduced from numerous experiments and observations, several of which are recorded in Dr. Christison's invaluable *Treatise*. After death putrefaction commences, and is attended with the usual odour; but, instead of increasing in the customary manner, it seems for a time to be at a stand-still, and then a series of changes commences of a peculiar character: the soft parts become firmer and drier, at the same time retaining their structure; the putrid odour is frequently succeeded by one resembling garlic; the skin becomes brown and parchment-like; the muscular fibres and cellular tissue (especially of the abdominal parietes) are changed into a tallowy cheesy-like mass; the liver, spleen, and heart, become dry, while the bowels, lungs, and brain, form a greasy mass. During these processes it is said that the quantity of arsenic diminishes, probably by exhalation,—a circumstance very probable, when we bear in mind the garlic odour emitted by the body, and which has been observed by several writers. The diminution, however, must be exceedingly small. After some time the cheesy smell disappears, and the body becomes dry and hard. In some cases the alimentary tube has been found little changed or decomposed, although other parts of the body had been completely mummified.

I ought, however, to remark, that some writers do not ascribe these phenomena to the influence of arsenious acid, but to other causes. Jäger (quoted by Wibmer, *op. cit.* i. 305) tells us that in his experiments the putrefaction of the bodies of animals poisoned by arsenic seemed neither to be retarded nor hastened, whether they were buried or not; but he admits that parts in contact with an arsenical solution seem preserved from putrefaction. Seemann (quoted by Dr. Christison, *op. cit.* p. 322; also Wibmer, *op. cit.* i. 322) likewise states, that the bodies of three dogs underwent the usual kind of putrefaction after death. However, that in many cases arsenic modifies the putrefactive process, can hardly, I think, be doubted by those who carefully examine the evidence adduced in favour of this opinion.

Does this mummifying process depend on the chemical influence of the arsenic, or ought we to refer it to a change effected by arsenic on the body, during life, causing " a different disposition and affinity among the ultimate elements of organized matter, and so altering the operation of physical laws in it?" The latter hypothesis, though advocated by Dr. Christison, appears to me untenable; for, in the first place, there is no evidence of any peculiar change of this kind during life; secondly, that this does not take place appears probable, from the putrefactive process commencing after death as usual; and it would appear that the peculiar influence of the arsenic does not commence, or at least is not evident, until this process has existed for some time, and when a garlic odour is evolved by the body. It is, indeed, true that the quantity of arsenic which has been detected in the body after death, is, as Dr. Christison remarks, " almost inappreciably small;" but it is probable that the quantity is much larger than chemists have yet been able to recognize; and it is not at all unlikely that the arsenious acid may enter into new combinations while within the dead body, and in this way become diffused, probably in a gaseous state: the garlic odour which is evolved favours this notion, as well as the statement made by some, that the quantity of arsenic in the body diminishes during the progress of the mummifying process.

MODUS OPERANDI.—When we consider that arsenious acid operates as a poison to whatever part of the body it be applied, the nerves and muscular fibres excepted; that the quickness with which it acts is in proportion to the absorbing powers of the part, and that the most soluble are the most energetic preparations, we can have little difficulty in admitting that absorption into the blood-vessels is necessary to the action of this potent agent. But the detection of arsenic in the solids and fluids of the body has hitherto not been effected in a satisfactory manner. Lassaigne (quoted by Wibmer, *op. cit.* i. 321) states, that he detected it in the infiltrated pleura of a horse; and Fodéré (quoted by Dr. Christison) twice got indications of its presence in the urine: but Hardegg and Schubarth, on the other hand, failed to recognize it, and therefore further evidence of its existence in the body is necessary, to enable us to place confidence in the results of Lassaigne and Fodéré. An acquaintance of Beissenhirz (quoted by Wibmer, *op. cit.* i. 318) obtained nearly three grains of metallic arsenic from the stomach, cœcum, lungs, liver, heart, and brain of a horse poisoned by six drachms of arsenious acid, taken at divided doses: but the extraction of this substance from the stomach and cœcum is no evidence of its absorption.

Arsenious acid appears to exercise a specific influence over several parts of the body, especially the alimentary canal, the heart, and the nervous system. That the *alimentary canal* is specifically affected is shown by the inflammation of the stomach, induced by the application of arsenic to wounds, and which, according to Sir B. Brodie (*Phil. Trans.* for 1812, 205), is more violent, and more immediate, than when this poison is taken into the stomach itself. That the *heart* is also specifically acted on by arsenious acid is proved by the symptoms (the anxiety at the præcordia, the quick irregular pulse, &c.), and by the post-mortem appearances (red spots in the substance of this viscus), and by the diminished susceptibility to the galvanic influence. The specific affection of the *nervous system* is inferred from the symptoms: thus, the headache, giddiness, wandering pains, impaired sensibility of the extremities, and delirium or coma, are indications of the cerebral affection; while the feebleness, lassitude, trembling of the limbs, and the paralysis or tetanic symptoms, are evidences of the disordered condition of the true spinal or excito-motory system of Dr. Hall.

The alimentary canal, heart, and nervous system, are not the only parts on which this acid appears to exercise a specific influence: the lungs, the skin, the salivary glands, &c. are also specifically affected. The disorder of the *lungs* is inferred from the local pain, cough, and occasional inflammatory appearances after death. The eruptions and other altered appearances of the *skin*, and the falling off of the hair and nails (sometimes noticed), have led to the idea of the specific influence of arsenious acid on the cutaneous system,—an opinion which seems further supported by the fact of the remarkable influence it exercises in some cutaneous diseases, especially lepra. The salivation noticed by Marcus, Ferriar, Mr. Furley, Cazenave, and others, seems to shew that the *salivary* glands are sometimes specifically influenced. The swelling of the face, and the irritation and redness of the eyelids, also deserve notice in connexion with the specific effects of this poison.

USES.—So powerful a poison as arsenic necessarily requires to be employed with great caution, and to have its effects carefully and attentively watched; for it has on more than one occasion proved fatal when used as a medicinal agent.

In *intermittent fevers and other periodical diseases*, arsenic has been employed with great success. For its introduction into practice in these cases in this country, we are indebted to the late Dr. Fowler, of Stafford (*Med. Rep. of the Effects of Arsenic*, 1786); but Lemery and Wepfer appear to have first mentioned its febrifuge property. Dr. Fowler was led to its use from the beneficial effects obtained by the use of the "*Tasteless Ague Drop*," and from the information of Mr. Hughes, that this patent medicine was a preparation of arsenic. The reports published by Dr. Fowler, of the good effects of arsenic in periodical diseases, as observed by himself, by Dr. Arnold, and by Dr. Withering, have been amply confirmed by the subsequent experience of the profession generally. No remedy has been more successful in the treatment of ague. It will not unfrequently put a stop to the disease, even when cinchona or the sulphate of quinia have failed. Dr. Brown (*Cyclopædia of Practical Medicine*, ii. 228) who has used it in many hundreds of cases, never saw any permanently ill effect arise from it: he considers it superior to crude bark, but inferior to quinia: over both it has the advantages of cheapness and tastelessness. It should be given three times a day. It is not necessary to intermit its use during the febrile paroxysm, for I have repeatedly seen it given with the best effects during the attack. In agues, accompanied with inflammatory conditions, in which cinchona and sulphate of quinia are apt to disagree, arsenic may, according to Dr. Brown, be sometimes administered with the best effects. It is also very successful in relapses after the use of the above remedies. Dr. Macculloch (*An Essay on the Remitt. and Intermitt. Diseases*, 1828) states that $\frac{1}{16}$ of a grain of white arsenic given three or four times a day will sometimes cure ague when the liquor potassæ arsenitis fails. A combination of arsenic and cinchona, or arsenic and sulphate of quinia, sometimes succeeds, where these agents used separately fail. When the stomach is very irritable, opium is occasionally advantageously conjoined with arsenic. If the bowels be confined during the use of the remedy, gentle laxatives should be employed. Arsenic has been beneficially employed in various other periodical diseases, as periodical headaches, intermittent neuralgias, &c.

In various *chronic affections of the skin*, particularly the scaly diseases (lepra and psoriasis), eczema, and impetigo, arsenic is one of our most valuable agents. I can confidently recommend it in lepra, having seen a large number of cases treated by it without a single failure. Frequently the disease is relieved without any obvious constitutional effect: sometimes a febrile condition of the body is brought on, with a slight feeling of heat in the throat, and thirst; occasionally with an augmentation of appetite: the urine and cutaneous secretion often promoted; the bowels may be constipated or relaxed, and occasionally, as I have already noticed, salivation takes place. If the patient complain of swelling and stiffness about the face, or itching of the eyelids, the use of the medicine ought to be immediately suspended. Ichthyosis and elephantiasis are said to have been benefited by the use of it. (For further information on the use of arsenic in skin diseases, consult Rayer, *Treatise on Diseases of the Skin*, by Dr. Willis, p. 80.)

Various chronic affections of the nervous system have been treated by the arsenious acid, and with occasional benefit: for example, neuralgia, epilepsy, chorea (Dr. Gregory, *Med. Chirurg. Trans. of London*, xi. 299), and even tetanus. I have seen arsenic used in a considerable number of epileptic cases, and in none was the disease cured. In some the fits occurred less frequently, but I am not sure that this was the effect of the medicine. In chorea, I have seen advantage now and then accrue from the use of this agent. It has also relieved angina pectoris.

In bites of venomous snakes and of rabid animals, arsenious acid has been recommended. In India, the Tanjore pill (the basis of which is arsenious acid) has long been celebrated for the cure of the bite of the Cobra di Capello, and other venomous serpents. Arsenic has been employed as an internal agent in various other diseases—as *chronic rheumatism*, especially when attended with pains in the bones; *in diseases of the bones*, particularly venereal nodes (Colhoun and Baer, *Amer. Med. Record*. iii. & iv.); *in syphilis; in passive dropsies;* in the last stage of *typhus* (Ferriar, *Med. Hist*. i. 84).

Arsenious acid has long been employed as an *external application*. Notwithstanding that it has been applied and recommended by Sir A. Cooper, Dupuytren, and other high authorities, some doubt may be fairly entertained as to the propriety of its use, especially as in most, if not in all instances, we may derive equal advantage by the employment of other less dangerous applications. M. Roux, a celebrated surgeon at Paris, states (*Nouv. Elém. de Méd.*) that he amputated the breast of a girl 18 years of age, on account of a scirrhus of considerable magnitude. After the cicatrix had been several days completed, ulceration commenced, accompanied with darting pains. To avoid frightening the girl by the use of the actual cautery, he applied an arsenical paste over a surface of about an inch in diameter. Colic, vomiting, and alteration of countenance, came on the next day, and in two days afterwards she died in violent convulsions. "I am convinced," says M. Roux, "that this girl died poisoned by arsenic." I could quote several other cases illustrative of the same fact, but shall content myself with referring to Wibmer's work (*Die Wirkung.* &c.) for an account of them. The following case, related by Desgranges (Orfila's *Toxicol. Gén.*) shews the danger of applying arsenic externally, even when the skin is sound:—A chamber-maid rubbed her head with an arsenical ointment, to destroy vermin. Though the skin was perfectly sound, the head began to swell in six or seven days after; the ears became twice their natural size, and covered with scabs, as were also several parts of the head; the glands of the jaw and face enlarged; the face was tumefied, and almost erysipelatous. Her pulse was hard, tense, and febrile; the tongue parched, and the skin dry. To these were added excruciating pain, and a sensation of great heat. Vertigo, fainting, cardialgia, occasional vomiting, ardor urinæ, constipation, trembling of the limbs, and delirium, were also present. In a day or two after, the body, and especially the hands and feet, were covered with a considerable eruption of small pimples, with white heads. She finally recovered, but during her convalescence the hair fell off.

Though employed as a caustic, yet it produces no known chemical change in the animal tissues. Hence it is termed by some a *dynamical* caustic, in opposition to those acting obviously by chemical agencies. Mr. Blackadder (*Observ. on Phaged. Gangren.*) asserts that the danger of employing arsenic consists in not applying a sufficient quantity. A small quantity, he says, becomes absorbed, whereas a large quantity quickly destroys the organization of the part, and stops absorption.

Arsenic has been extolled as a remedy for *cancer*. Justamond esteemed it a specific. Various empirical compounds, which gained temporary notoriety in the treatment of this affection, owe their activity to either arsenious acid or the sesquisulphuret of arsenicum. But by the best surgeons of the present day it is never employed, because experience has fully shewn that it is incapable of curing genuine cancer, while it endangers the lives of the unfortunate patients. It cannot, however, be denied that diseases resembling cancer have been much relieved, if not cured, by it, and that the progress of cancer itself has occasionally been somewhat checked by its use.

In some forms of severe and unmanageable ulceration, especially *lupus* or *noli me tangere*, arsenical applications are employed with occasional benefit, where all other local remedies fail. In such cases arsenic is not to be regarded as a mere caustic, for other, and far more powerful agents of this kind, are generally useless. It must act by substitution: that is, it sets up a new action in the part incompatible with that of the disease. The late Baron Dupuytren employed an arsenical dusting powder (composed of 99 parts calomel and 1 part arsenious acid) in lupus, not as an escharotic, but rather as a specific. Mixed with gum-water or with fatty matters, it has been sometimes used as a paste or ointment. These applications are to be allowed to fall off spontaneously, and to be repeated five or six times. Sir A. Cooper (*Lancet*, i. 264) recommends an arsenical ointment (arsenious acid; sublimed sulphur, āā ʒj.; spermaceti cerate, ℥j.) to be applied, on lint, for 24 hours, and then to be removed. When the slough comes away, the ulcer is to be dressed with simple ointment, and will generally heal in a short time. Cazenave says he has seen arsenical applications used by Biett, and has himself employed them many times, without having met with one instance of injurious consequences. The arsenical paste (arsenious acid, cinnabar, and burnt leather, made into a paste with saliva or gum-water) is used where a powerful action is required: but, besides the danger of causing constitutional symptoms, to which all arsenical compounds are liable, it is apt to occasion erysipelas.

Arsenious acid, or sesquisulphuret of arsenicum, is a constituent of most of the preparations sold as depilatories; as *Delcroix's Poudre Subtile*, which, according to Dr. Paris, consists of quicklime, sulphuret of arsenic, and some vegetable powder. Such applications are exceedingly dangerous.

Administration.—Arsenious acid may be administered, in substance, in doses of from one-sixteenth to one-eighth of a grain, made into pills, with crumb of bread. In making a mass of pills, great care should be taken that the arsenic be equally divided; for this purpose it should be well rubbed in a mortar with some fine powder (as sugar) before adding the bread crumb. A much safer mode of exhibition is to give this potent remedy, in the form of solution, with potash (as the *liquor potassæ arsenitis*). But I have already mentioned, that Dr. Macculloch found solid arsenic more efficacious than this solution: and Dr. Physick, of the United States, thinks "that they act differently, and cannot be substituted for one another" (*United States Dispensatory*). Whether given in the solid or liquid form, it is best to exhibit it immediately after a meal, when the stomach is filled with food; for when given on an empty stomach (as in the morning fasting), it is much more apt to occasion gastric disorder. It is sometimes advisable to conjoin opium, either to enable the stomach to retain it, or to check purging. In debilitated constitutions, tonics may be usefully combined with it. An emetic (as ipecacuanha), or a laxative (as rhubarb), may be employed where the stomach is overloaded, or the bowels confined. Its effects are to be carefully watched, and whenever any unpleasant symptoms (as vomiting, griping, purging, swelling or redness of the eyelids, dryness of throat, ptyalism, headache, or tremors) make their appearance, it will of course be advisable to diminish the dose, or suspend for a few days the use of the remedy. Indeed, when none of these symptoms occur, it is not proper to continue its use more than two weeks without intermitting its employment for a day or two, in order to guard against the occasional ill consequences resulting from the accumulation of the poison in the system.

1. ***LIQUOR POTASSÆ ARSENITIS***, Ph. Lon. & U.S.; *solutio arsenicalis*, Ph. Ed.; *Fowler's* or the *mineral solution* (arsenious acid, carbonate of potash, āā gr.lxxx.; compound tincture of lavender, ʒv.; water, ℥xx.) The arsenious acid and carbonate of potash are to be boiled, with the water, in a glass vessel: arsenite of potash is formed, and carbonic acid evolved; but the quantity of carbonate of potash is not sufficient to saturate the acid. The compound tincture of lavender, which is used as a colouring and flavouring ingredient, is to be added to the solution when cold, and afterwards more distilled water, to make the whole amount exactly to a pint; (*i. e.* twenty ounces). The dose of this solution is four or five minims, gradually and cautiously increased. I have known 15 minims taken three times a day for a week, without any ill effects. Dr. Mitchell, of Ohio, has given from 15 to 20 drops, three times a day, in intermittents (*United States Dispensatory*). But as some persons are peculiarly susceptible of the influence of arsenic, we ought always to commence with small doses. It has been given to children, and even pregnant women. Dr. Dewees (*Philadelphia Journ. of Med. & Phys. Sc.* xiv. 187) adminis-

tered it successfully to a child only six weeks old, affected with a severe tertian ague. Dr. Fowler (*Med. Rep. of the Effects of Arsenic*) drew up the following table of doses for patients of different ages:—

Ages.	Doses.
From 2 to 4 years	from 2 or 3 to 5 drops.
5 — 7 ,,	,, 5 — 7 ,,
8 — 12 ,,	,, 7 — 10 ,,
13 — 18 ,,	,, 10 — 12 ,,
18, and upwards	12 ,,

But it may be remarked, that the quantities here indicated are larger than it will be safe, in most cases, to commence with.

The *liquor arsenicalis* of the Dublin Pharmacopœia is one-sixteenth weaker than the corresponding preparation of the London and Edinburgh Pharmacopœia.

2. *CERATUM ARSENICI*, Ph. U. S. (arsenious acid, ℈j.; simple cerate, ℥j. M.) This preparation, which is used as a dressing to cancerous ulcers, should be employed with great circumspection.

ANTIDOTES.—In cases of poisoning by arsenic, the first object is to expel the poison from the stomach. For this purpose the stomach-pump should be immediately applied. If this be not in readiness, and vomiting have not commenced, tickle the throat with a feather or the finger, and administer an emetic of sulphate of copper or sulphate of zinc. Promote vomiting by diluent and demulcent liquids; as milk, white of egg and water, flour and water, gruel, sugared water, and broths. Charcoal, magnesia, and other inert powders, when swallowed in large quantities, may be occasionally of service, by enveloping the particles of arsenic, and preventing their contact with the gastric surface. Olive oil, on which, according to Dr. Paris (*Pharmacologia*), the Cornish miners rely with confidence, can only act mechanically in the way just mentioned.

Hydrated sesquioxide of iron was proposed, in 1834, by MM. Bunsen and Berthold, as an effectual chemical antidote (*Journ. de Pharm.* xx. 567). Its efficacy was confirmed by the experiments of Souberain and Miquel (*Journ. de Chim. Méd.* i. 2^{e}. Ser. p. 3); of Orfila and Lesueur (*ibid.* p. 45); of Bouley, jun. (*ibid.* 46); and of Borelli and Demaria (*ibid.* p. 393), as well as by some cases of arsenical poisoning in the human subject, in which this remedy was employed (*Journ. de Pharm.* xxi. 98 & 681; *Lond. Med. Gaz.* xv. 447; xvi. 832; and xix. 177). To be efficacious it must be given in very large doses; and when the poison has been swallowed in a solid form, 15 or 20 drops of liquor ammoniæ should be conjoined with each dose of the antidote, to transform the acid into a soluble arsenite, on which the oxide may act. It may also be exhibited in the form of enema. Hydrated sesquioxide of iron may be procured by adding ammonia or potash, or their carbonates, to a solution either of pernitrate of iron (obtained by dissolving iron in nitric acid over the fire in a pipkin), or of persulphate of iron (prepared by boiling a solution of the common sulphate of iron with nitric acid): the precipitate is to be washed with water, and swallowed undried. Mr. Brett (*Lond. Med. Gaz.* xv. 220) denies the efficacy of the antidote, and states, moreover, that carefully prepared arsenite of iron is poisonous.

The subsequent part of the treatment of poisoning by arsenic consists in neutralizing or counteracting its effects, and which is to be effected on general principles, as we have no counter-poison. When the gastro-enteritis is marked, our principal reliance must be on the usual antiphlogistic measures, particularly blood-letting, both general and local, and blisters to the abdomen. One drawback to the success of this treatment is the great depression of the vascular system, so that the patient cannot support large evacuations of blood. Opium is a very valuable agent. Indeed Jäger seems to regard it in the light of a counterpoison. However, on this point he has probably taken a too exaggerated view of its efficacy; but it is undeniable that on many occasions it is of great service. If the stomach reject it, we may employ it in the form of clysters. If constipation and tenesmus be troublesome, mild laxatives, especially castor oil, should be exhibited.

Arsen'ici Io'didum.—I'odide of Arsen'icum.

This compound is prepared by gently heating, in a tubulated retort placed in a sand-bath, a mixture of one part finely pulverized metallic arsenicum and three parts of iodine: the iodide is afterwards to be sublimed, to separate the excess of arsenicum. The compound thus obtained is an orange-red solid, volatile, and soluble in water. If the solution be rapidly evaporated to dryness, we reprocure the iodide; but if we concentrate, and then place the solution aside, white pearly plates are obtained, which by Plisson are regarded as a periodide of arsenicum, but by Serullas as a compound of oxide and iodide of arsenicum (Souberain, *Nouv. Traité de Pharm.* ii. 613; and Serullas, *Journ. de Chim. Méd.* iii. 601). Iodide of arsenicum is probably composed of $1\frac{1}{2}$ eq. iodine = 187·5, and 1 eq. arsenicum = 38. It has been employed by Biett in the form of ointment (composed of iodide of arsenicum, gr. iij.; lard, ℥j.) as an application to corroding tubercular skin diseases (Magendie, *Formulaire*).

ORDER 17. COMPOUNDS OF ANTIMONY.

Antimo'nii Sesquisulphure'tum.—Sesquisul'phuret of An'timony.

HISTORY.—Black sulphuret of antimony was known in the most ancient times, being used by the Asiatic and Greek ladies as a pigment for the eyebrows (2 *Kings*, ix. 30; *Ezekiel*, xxiii. 40; Pliny, *Hist. Nat.* xxxiii.) It was formerly called *stimmi* (στίμμι vel στίμμις, *stibium* (στίβι), or *platyophthalmon* (πλατυόφϑαλμον), Dioscorides, v. 99.) In the native state it is technically termed *antimony ore*, and when fused out of its gangue, *crude antimony*, or *sulphuret of antimony*.

NATURAL HISTORY.—Sesquisulphuret of antimony is found native in various parts of the world, especially in Hungary, in the Hartz, in France, in Cornwall, and in Borneo. From the latter place it is imported into this country by way of Singapore, being brought over as ballast to the vessels. In the years 1835-36, and 37, the quantities of ore imported were respectively 645, 825, and 659 tons (*Trade List*, Jan. 10, 1837, and Jan. 9, 1838).

PREPARATION.—The old method of separating the sesquisulphuret from its siliceous gangue was to melt it in a covered crucible or pot, in the bottom of which there are several holes, through which the fused sulphuret passes into an inferior or receiving pot. According to Gensenne's method, the melting pots are placed in a circular reverberatory furnace, and are connected by curved earthen tubes with the receiving pots which are on the outside of the furnace. At La Vendée neither vessels nor tubes are used: the ore is placed on the bed of a reverberatory furnace, in which is an aperture to allow of the passage of the fused sesquisulphuret which flows into a receiving vessel placed externally to the furnace. (Dumas, *Traité de Chimie*, iv. 160.)

PROPERTIES.—The fused sesquisulphuret (called *common or crude antimony*) occurs in commerce in roundish masses, called loaves or cakes: these when broken present a striated crystalline appearance, a dark steel or lead grey colour, and a metallic brilliancy. The commercial sesquisulphuret is opaque, tasteless, odourless, brittle, easily pulverizable, and has a sp. gr. of about 4·6. Its powder is black, but that of pure sesquisulphuret is reddish black. It is a little less fusible than metallic antimony. It is volatile but cannot be distilled, and it appears to be partially decomposed by heat, for when heated in an earthen crucible for an hour it loses from 10 to 20 per cent. of its weight (Berthier, *Traité des Essais*, ii. 490). By roasting it is converted into *antimony-ash* or *cinis antimonii* (a mixture of antimonious acid and sesquioxide of antimony, with more or less unburned sesquisulphuret: Liebig, *Handwörterb. de Chemie*, i. 419) and sulphurous acid, the latter of which escapes. When reduced to a very fine powder by levigation and elutriation it constitutes the *antimonii sulphuretum præparatum* of the Edinburgh, Dublin, and United States Pharmacopœias.

CHARACTERISTICS.—It fuses and is dissipated before the blow-pipe with the smell of sulphurous acid and the formation of a white smoke. Digested in hydrochloric acid it evolves hydrosulphuric acid, and forms a solution of sesquichloride of antimony, which produces a whitish precipitate (*powder of Algaroth*, or oxychloruret of antimony) with water, and an orange red one with hydrosulphuric acid. If a current of hydrogen gas be passed over heated sesquisulphuret of antimony, metallic antimony and hydrosulphuric acid gas are obtained: the metal decomposes nitric acid and yields a white powder: it readily dissolves in nitrohydrochloric acid.

COMPOSITION.—Sesquisulphuret of antimony has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.	Thomson.
Antimony	1	65	73	72·8	73·77
Sulphur	1½	24	27	27·2	26·23
Sesquisulphuret of Antimony	1	89	100	100·0	100·00

IMPURITIES.—The crude antimony of commerce is rarely, if ever, quite pure. It frequently contains the sulphurets of iron, lead, arsenicum, and copper, and on this account is not adapted for medicinal use. When pure it is completely soluble in hydrochloric acid: but when mixed with sulphuret of arsenicum this remains undissolved, and may be detected by reducing it with a mixture of charcoal and carbonate of soda (*vide* p. 378.) If the hydrochloric solution be diluted with water (so as to precipitate the greater part of the antimony), and filtered, the presence of lead, iron, or copper, may be determined by the appropriate tests for these metals, hereafter to be mentioned.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—Rayer (*Dict. de Méd. et Chir. Pratiq.* iii. 54) introduced half an ounce of it into the cellular tissue of the back of a dog; but no effects resulted from it. Fifteen grains placed in the peritoneal sac caused inflammation, and in 24 hours death, but without any peculiar symptoms. Moiroud (*Pharm. Vétér.* 428) says, that given to horses, in doses of from 2 to 4 ounces, it acts as an excitant, causing increased frequency of pulse and respiration, and softer stools.

(*b.*) *On man.*—In most cases it produces no obvious effects, even when taken in very large doses. Rayer (*op. cit.*) gave half an ounce of it in powder, for several days, without the slightest effect. Cullen (*Treat. of Mat. Med.* ii. 482), however, has seen it cause nausea and vomiting in one or two instances in which it was largely employed. Rayer says that the decoction of the sesquisulphuret is much more active than an equal quantity of the same preparation in powder. How are these facts to be explained? Rayer ascribes the activity of the decoction to arsenious acid formed by boiling sulphuret of arsenicum (contained in the ordinary crude antimony) with water; for Guibourt obtained in this way $1\frac{44}{100}$ grs. of arsenious acid by boiling an ounce of crude antimony. But the presence of arsenic is not necessary to explain the greater activity of the decoction, since by long-continued boiling with water, the sesquisulphuret of antimony yields hydrosulphuric acid and sesquioxide of antimony (Geiger, *Handb. d. Pharm.*) The occasional nausea and vomiting may arise from the decomposition of the sulphuret by the fluids in the alimentary canal.

Uses.—As a medicinal agent it is occasionally employed as a diaphoretic and alterative in some skin diseases, especially lepra and scabies, in scrofula and glandular affections, and in rheumatism and gout.

As a pharmaceutical and chemical agent it is a most important substance, being the source from which the metal, and all its compounds, are procured.

Administration.—The usual dose of it, when taken internally, is from ten to thirty grains of the powder; but several drachms of it have been taken without much effect. The *tisan de Feltz*, which is occasionally used in skin diseases, is prepared by boiling sarsaparilla, ℥j., and crude antimony (tied up in a bag) ʒj., in a pint and a half of water; then add isinglass, ʒiv., previously dissolved in water, and reduce the whole (by boiling) to a pint, which is to be taken during the day (Rayer, *Treatise on Diseases of the Skin*, by Dr. Willis, 1223).

Antimo'nii Sesquichlo'ridum.—Sesquichlo'ride of An'timony.

History.—Basil Valentine was acquainted with this preparation, which has had various appellations; such as *oil* or *butter of antimony* (*oleum* seu *butyrum antimonii*), *muriate* or *hydrochlorate of antimony*.

Preparation.—The impure hydrated sesquichloride, sold in the shops as butter of antimony, is usually prepared by dissolving roasted sesquisulphuret of antimony (*cinis antimonii*) in hydrochloric acid, and adding pernitrate of iron to the solution as a colouring matter.

In the Dublin Pharmacopœia an analogous compound is prepared (in the manufacture of the *nitro-muriatic oxide of antimony*) by digesting, and afterwards boiling, 20 parts of sesquisulphuret of antimony in a mixture of 100 parts hydrochloric acid and 1 part of nitric acid. One equivalent or 89 parts of sesquisulphuret of antimony require an equivalent and a half or 55·5 parts of hydrochloric acid for their complete decomposition: the products are, an equivalent and a half or 25·5 parts of hydrosulphuric acid, and one equivalent or 119 parts of sesquichloride of antimony. The nitric acid is employed to decompose the hydrosulphuric acid remaining in the liquor; this it does by converting the hydrogen into water, and precipitating the sulphur.

Pure sesquichloride of antimony is not used in medicine: its preparation need not, therefore, be described in this work.

Properties.—The butter of antimony of the shops is a transparent liquid, varying in its colour (which depends on the presence of iron) from yellow to deep red. Its specific gravity is 1·2 to 1·5. It fumes in the air (especially when ammonia is present), in consequence of containing an excess of hydrochloric acid. It reacts on vegetable colours as a powerful acid.

Characteristics.—Mixed with water it throws down a yellowish white powder called *powder of Algaroth*, or *mercury of life* (oxychloruret of antimony). The hydrosulphurets produce an orange-red precipitate: alkalies a white precipitate (sesquioxide of antimony). Nitrate of silver occasions a white precipitate, composed of chloride of silver and sesquioxide of antimony: the latter is dissolved by digestion in hydrochloric acid.

Composition.—Sesquichloride of antimony is thus composed:—

	Eq.	Eq. Wt.	Per Cent.	Göbel.	H. Rose.
Antimony	1	65	54·62	54·98	53·27
Chlorine	1½	54	45·37	45·02	46·73
Sesquichloride Antimony	1	119	99·99	100·00	100·00

The butter of antimony of the shops contains *sesquichloride of antimony*, *free hydrochloric acid*, *water*, and *iron*. It may also contain other impurities derived from the sesquisulphuret from which it is directly or indirectly prepared. Serullas says he never found arsenic in it.

Physiological Effects.—It acts as an energetic caustic, but I am not acquainted with any cases of poisoning by it. It cannot be diluted without undergoing decomposition.

Uses.—In medicine it is employed only as a caustic. It usually acts without much pain or inflammation, and, after the separation of the eschar, produces a clean healthy surface. It is sometimes used as an application to parts bitten by rabid animals or venomous serpents: its liquidity enabling it to penetrate into all parts of the wound. It is also applied to ulcers to repress excessive granulations. Richter and Beer have employed it in staphyloma: the mode of applying it is as follows:—Dip a camel's hair pencil, or a point of lint, into the liquid, and apply it to the tumor until a whitish crust is perceived, when the whole is to be immediately washed away by means of a larger pencil dipped first into milk and afterwards into milk and water.

Antidotes.—The treatment of poisoning by this preparation is the same as for the mineral acids (*vide* pp. 154 and 268.) After the use of antacids, vegetable astringents (tea and infusion of nutgalls) should be administered to neutralize the effect of the powder of Algaroth separated in the stomach. Gastro-enteritis is of course to be combated by the usual means.

Antimo'nii Oxysulphure'tum.—Oxysul'phuret of An'timony.

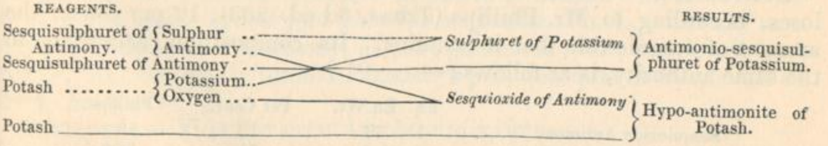
History.—Basil Valentine (*Triumphant Chariot of Antimony*, by Kirkringius, p. 131) was acquainted with this preparation; and probably also knew the substance called *Kermes mineral*, though he does not mention it in his writings. Glauber, in 1658, and Lemery, in 1707, are both said to be discoverers of the latter substance; but it is hardly possible for Basil Valentine to have been unacquainted with it.

Natural History.—Kermes mineral, which is an oxysulphuret of antimony, though not identical with, yet nearly allied to, the preparation of the Pharmacopœia, is found native in Saxony and other places: it is called by mineralogists *red antimony* or *native kermes*.

Preparation.—If black or sesquisulphuret of antimony be boiled in an alkaline liquid, a solution is obtained which, on cooling, deposits a reddish powder called *kermes mineral*. If a dilute mineral acid be added to the filtered mother liquor, an orange red precipitate is produced, called the *golden sulphuret of antimony*. If the acid be added before the kermes has deposited, we obtain the orange red precipitate, called in the Pharmacopœia *oxysulphuret of antimony*.

The oxysulphuret of antimony, Ph. L. is prepared by mixing together 7 ounces of powdered sesquisulphuret of antimony, 4 pints of solution of potash, and 2 gallons of distilled water: boil for two hours, frequently stirring, distilled water being often added, that it may fill the same measure. Strain the liquor, and gradually drop into it as much sulphuric acid as may be sufficient to throw down the oxysulphuret: then wash away the sulphate of potash with water, and dry what remains with a gentle heat.

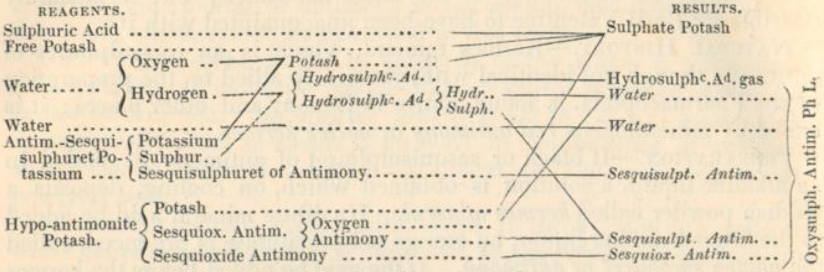
Theory of the Process.—When sesquisulphuret of antimony and potash are heated together, the latter gives oxygen to the antimony, and potassium to the sulphur of the sesquisulphuret; and thus sesquioxide of antimony and sulphuret of potassium are produced. The sesquioxide combines with some undecomposed potash, forming hypo-antimonite of potash, and the sulphuret of potassium with sesquisulphuret of antimony, forming a double sulphur salt (the antimonio-sesquisulphuret of potassium). These changes are explained in the subjoined diagram:—



The solution contains free potash, the antimonio-sesquisulphuret of potassium, and part of the hypo-antimonite of potash. There is a dark-red, undissolved residuum (similar to *crocus antimonii*) composed of hypo-antimonite of potash and oxysulphuret of antimony: this is got rid of by filtering.

On the addition of sulphuric acid, sulphate of potash is produced by the combination of the acid with free potash,—with some potash formed by the union of the potassium of the sulphuret with the oxygen of some decomposed water,—and with the potash of the hypo-antimonite. By these changes sesquisulphuret and sesquioxide of antimony are set free:

the whole of the first, and part of the second, precipitate. The hydrogen of the decomposed water, with the sulphur of the sulphuret of potassium, forms hydrosulphuric acid, a portion of which escapes in a gaseous form, while the remainder, reacting on some sesquioxide of antimony, produces water and sesquisulphuret, which are precipitated along with some water of the solution. These changes will be better comprehended by reference to the following diagram :—



For further details respecting the theory of this process I must refer the student to Berzelius's *Traité de Chimie*, ii. 501, and Liebig and Poggendorf's *Handwörterb. d. Chemie*, i. 439.

PROPERTIES.—Oxysulphuret of antimony, Ph. L. is a bright red, odourless, almost tasteless powder. It is insoluble in cold water, and only slightly soluble in liquor ammoniæ. Boiled in nitro-hydrochloric acid, chloride of antimony is formed in solution, and some sulphur remains undissolved. Heated in the air it burns, evolves sulphurous acid, and leaves a greyish residuum.

CHARACTERISTICS.—When heated with concentrated hydrochloric acid it evolves hydrosulphuric acid, shewing it to be a sulphuret. From the other sulphurets or oxysulphurets of antimony it is to be distinguished partly by its colour. Its hydrochloric solution is shewn to contain antimony by the tests before mentioned for the sesquichloride of this metal (*vide* p. 400.) When boiled in a solution of bitartrate of potash we obtain a solution of emetic tartar, which may be recognized by the characters hereafter to be mentioned for this salt. It may be reduced by hydrogen and heat (*vide* p. 409.)

COMPOSITION.—When boiled in a solution of bitartrate of potash, it loses, according to Mr. Phillips (*Trans.* 3d ed. 203), 12 per cent. : the amount of sesquioxide that it contains. Its composition, according to the same authority, is as follows :—

	Eq.	Eq.Wt.	Per Cent.	Phillips.
Sesquioxide Antimony	1	77	13	12
Sesquisulphuret Antimony	5	445	75	76·5
Water	8	72	12	11·5
Oxysulphuret Antimony	1	594	100	100·0

But the sesquisulphuret and sesquioxide are probably only mechanically mixed.

The commercial oxysulphuret is of a brighter colour than that obtained according to the process of the Pharmacopœia. A manufacturer of it informs me it is prepared by boiling sulphur along with the sesquisulphuret of antimony and potash, and precipitating by an acid in the usual way.

Kermes antimonii consists of 2 equivalents of sesquisulphuret of antimony and 1 equivalent of sesquioxide of antimony (consequently it has the same composition as *red antimony ore*), and commonly contains also from 1 to 1½ per cent. of alkali combined with sesquioxide of antimony. By continued washing with water the hypo-antimonite of potash and sesquioxide of antimony may be extracted, leaving the sesquisulphuret only. (Liebig, *Handwörterb. d. Chemie*, i. 427.) *Golden sulphuret of antimony* is the persulphuret of antimony, and consists of 1 equivalent of antimony and 2½ equivalents of sulphur.

PURITY.—Recently precipitated oxysulphuret of antimony is readily and completely soluble in liquor potassæ: but the oxysulphuret of the shops leaves a white residuum. Boiled in hydrochloric acid, it is dissolved with the evolution of hydrosulphuric acid gas: the solution is opalescent or slightly milky, but becomes quite transparent on the addition of a small quantity of nitric acid. It should not effervesce with dilute sulphuric acid.

PHYSIOLOGICAL EFFECTS.—The medicinal activity of this preparation is principally or wholly owing to sesquioxide of antimony; and as the quantity of this is probably inconstant, the preparation is uncertain in its operation. The obvious effects are precisely analogous to those of emetic tartar; namely, vomiting, purging, and sweating. In small doses it is employed as an alterative, expectorant, and diaphoretic: in somewhat larger doses it causes nausea and sweating, and sometimes vomiting: in still larger quantities it excites both vomiting and purging. (For some experiments and observations on the action of *Kermes mineral* and the *golden sulphuret*, consult Rayer, in *Dict. de Méd. et Chir. Prat.* iii. 57, *et seq.*)

USE.—It is principally employed as an *alterative* in chronic diseases, particularly cutaneous affections, glandular enlargements, secondary syphilis, rheumatism, and diseases of the liver. In these complaints it is usually associated with mercurials (especially calomel) and sometimes with guaiacum or narcotics. Kermes mineral has been employed as an antiphlogistic in inflammatory affections of the respiratory organs, and sometimes as an *emetic*.

ADMINISTRATION.—As an alterative the dose is from one to three or four grains: as an emetic from five grains to a scruple. It is a constituent of the *pilulæ hydrargyri chloridi compositæ*, Ph. L. (chloride mercury; oxysulphuret of antimony, a̅a̅ ʒii.; guaiacum resin, powdered, ℥ss.; treacle, ʒii.) commonly termed *Plummer's pill*, the dose of which is from five to ten grains.

ANTIDOTES.—Vide POTASSÆ ANTIMONIO-TARTRAS.

Pul'vis Antimo'nii Compos'itus.—Com'pound Pow'der of An'timony.

HISTORY.—Dr. James, who died in 1776, prepared a celebrated patent medicine, long known as the *fever powder of Dr. James* (*pulvis febrifugus Jacobi*), or *Dr. James's Powder* (*pulvis Jacobi*). The discovery of it was subsequently claimed for a German of the name of Schwanberg (*Affidavits and Proceedings of W. Baker*, Lond. 1754). The specification which Dr. James lodged in the Court of Chancery is so ambiguously worded, that we cannot prepare his powder by it. Hence the present preparation has been introduced into the Pharmacopœia as a succedaneum for it. In preceding editions of the London Pharmacopœia it was termed *pulvis antimonialis* (*antimonial powder*); but in the edition for 1836 this name was unnecessarily (as I conceive) altered to *pulvis antimonii compositus*. In the Edinburgh Pharmacopœia it is denominated *oxydum antimonii cum calcis phosphate;* in the French Codex, *pulvis cum stibio compositus*.

Preparation.—In the London Pharmacopœia it is directed to be prepared by throwing a mixture of one pound of sesquisulphuret of antimony in powder, and two pounds of hartshorn shavings, into a crucible red hot in the fire, and stirring constantly until vapour no longer arises. Rub that which remains to powder, and put it into a proper crucible. Then apply fire, and increase it gradually, that it may be red hot for two hours. Rub the residue to a very fine powder.

The process of the Dublin Pharmacopœia is analogous to the above, as are also those of the Edinburgh Pharmacopœia and French Codex, with the exception that in the two latter works equal parts of sesquisulphuret and hartshorn shavings are used.

Manufacturers usually substitute bone sawdust for hartshorn shavings.

The following is the *theory* of the process: the gelatinous matter of the horn (or bones) is decomposed and burned off, leaving behind the earthy matter (sub- or $\frac{2}{3}$, phosphate of lime, with a little calcareous carbonate). The sulphur of the sesquisulphuret is expelled in the form of sulphurous acid, while the antimony attracts oxygen from the air, forming antimonious acid, and a variable quantity of sesquioxide of antimony. By the subsequent heating the sesquioxide is, for the most part, converted into antimonious acid; but one portion is usually left unchanged, while another is volatilized. The carbonate of lime of the horn is decomposed by the united agencies of heat and antimonious acid: carbonic acid is expelled, and a small quantity of antimonite of lime formed. The sides of the crucible in which the second stage of the process has been conducted, is found, at the end of the operation, to be lined with a yellow glaze, and frequently with yellow crystals of sesquioxide.

Properties.—Antimonial powder is white, gritty, tasteless, and odourless. Boiling water extracts the antimonite (and superphosphate, *Dr. Maclagan*) of lime: the liquid becomes cloudy on cooling. Hydrochloric acid, digested in the residue, dissolves the subphosphate of lime, all the sesquioxide of antimony, and a portion of the antimonious acid.

Characteristics.—The solution obtained by boiling antimonial powder in distilled water occasions white precipitates, soluble in nitric acid, with oxalate of ammonia, nitrate of silver, and acetate of lead: hydrosulphuric acid gas transmitted through the solution, produces an orange red precipitate. If the portions of antimonial powder not dissolved by distilled water be digested in boiling liquid hydrochloric acid, a solution is obtained, which, on the addition of distilled water, becomes turbid, and deposits a white powder: at least I have found this to take place with several samples of antimonial powder which I have examined, and the same is noticed by Dr. Barker (*Observations on the Dublin Pharmacopœia*, 204); but neither Mr. Phillips (*Ann. Phil.* iv. N. S. 266) nor Dr. Maclagan (*Edinburgh Med. & Surg. Journ.* No. 135) have observed it. Hydrosulphuric acid gas, transmitted through the hydrochloric solution, causes an orange red precipitate: if this be separated by filtering, and the solution boiled to expel any traces of hydrosulphuric acid, a white precipitate (phosphate of lime) is thrown down on the addition of caustic ammonia. That portion of antimonial powder which is not dissolved by hydrochloric acid is antimonious acid: if it be mixed with charcoal, and heated to redness, it is converted into sesquioxide, or metallic antimony.

COMPOSITION.—*Dr. James's Powder* has been analysed by Dr. Pearson (*Phil. Trans.* lxxxi. for 1791, p. 317); by Mr. Phillips (*Ann. Phil.* N. S. vi. 187); by Berzelius (*Traité de Chimie*, iv. 481); by M. Pully (*Ann. de Chim.* 1805, lv. 74); by Dr. D. Maclagan (*Edinb. Med. & Surg. Journ.* xlix. 462); and was imperfectly examined by Mr. Chenevix (*Phil. Trans.* for 1801, p. 57). *Antimonial powder* has been analysed by Mr. Phillips (*Ann. Phil.* N. S. iv. 266), and by Dr. D. Maclagan (*op. cit.*) Their results are, for the most part, shown in the following table:—

	JAMES'S POWDER.					ANTIMONIAL POWDER.		
	Pearson	Phillips	Berzel.	Maclagan		Phillips		Maclagan
		Newbury's		Newbury's	Butler's	1st samp.	2d do.	
Antimonite of Lime [with some superphosphate, *Maclagan*]	—	—	1	3·40	2·25	—	—	0·8
Sesquioxide of Antimony	57	56·0	66	2·89	9·80	—	—	3·98
Antimonious Acid	43	42·2	33	43·47	34·21	35	38	50·09
Subphosphate of Lime ..	—	—	—	50·24	53·21	65	62	45·13
Loss [Sexquioxide of Antimony and impurity, *Phillips*]	—	—	—	—	0·53	—	—	—
	100	100·0	100	100·00	100·0	100	100	100·00

Pully found sulphate of potash and hypo-antimonite of potash in James's powder. Mr. Brande has found as much as 5 per cent. of sesquioxide of antimony in the antimonial powder of the shops.

The *antimonite of lime* is obtained in solution by boiling antimonial powder in distilled water: the greater part of it deposits as the solution cools. The existence of *superphosphate* was inferred by Dr. Maclagan, from the precipitates produced with the salts of lead and nitrate of silver. Mr. Phillips assumed the non-existence of *sesquioxide of antimony*, because the hydrochloric solution did not let fall any precipitate on the addition of water: an assumption which is certainly not correct, since a small quantity of sesquioxide may be dissolved in this acid without our being able to obtain any evidence of its presence by the action of water. Dr. Maclagan (*op. cit.*) has shown, that if hydrosulphuric acid gas be transmitted through the solution, an orange red precipitate is obtained, which he supposes to be an indication of the presence of sesquioxide. But unless the antimonial powder be boiled *repeatedly* in water, to remove completely the antimonite of lime, this test cannot be relied on: for if the least trace of this salt be present, an hydrated hydrochlorate of antimonious acid is obtained, which, it is well known, not only produces an orange red precipitate with hydrosulphuric acid, but even causes a white precipitate on the addition of water (Gmelin, *Handb. der Chemie*, ii. 986).

PHYSIOLOGICAL EFFECTS.—Antimonial powder is most unequal in its operation,—at one time possessing considerable activity, at another being inert, or nearly so. This depends on the presence or absence of sesquioxide of antimony, which may be regarded as constituting its active principle, and which, when present, is found in uncertain and inconstant quantity. Moreover, this variation in the composition of antimonial powder cannot be regarded as the fault of the manufacturer, since it depends, as Mr. Brande (*Manual of Pharmacy*, 3d. ed. p. 292) has justly observed, " upon slight modifications in the process, which can scarcely be controlled."

Mr. Hawkins gave ʒj. morning and evening without any obvious effect; and the late Dr. Duncan, jun. administered ℈j. and ʒss. doses, several times a-day, without inducing vomiting or purging (*Edinb. New Dispensat.* 11th ed.) Dr. Elliotson (*Cases illustrative of the Efficacy of the Hydrocyanic Acid*, p. 77) found even 120 grains nearly inert; nausea alone being in some of the cases produced. In these instances I presume it contained little or no sesquioxide.

But, on the other hand, a considerable number of practitioners have found it to possess activity. Dr. Paris (*Pharmacologia*) observes, that " it will be difficult for the chemist to persuade the physician that he can never have derived any benefit from the exhibition of antimonial powder." I have above stated that the experiments on which Mr. Phillips founds his assertion that this preparation contains no sesquioxide, are inconclusive, as Dr. Maclagan (*op. cit.*) has shown. I am acquainted with one case in which it acted with great activity. A workman employed in the manufacture of this powder in the laboratory of an operative chemist in London, took a dose of it (which, from his account, I estimate at half a teaspoonful), and, to use his own words, " it nearly killed him." It occasioned violent vomiting, purging, and sweating.

Dr. James's powder, which some practitioners consider as more active and certain than our antimonial powder, appears to be equally inconstant in its operation. Dr. D. Monro (*Treatise on Med. & Pharm. Chem.* i. 367), who frequently used this powder, and saw Dr. James himself, as well as other practitioners, administer it, observes—" like other active preparations of antimony, it sometimes operates with great violence, even when given in small doses; at other times a large dose produces very little visible effects. I have seen three grains operate briskly, both upwards and downwards; and I was once called to a patient, to whom Dr. James had himself given five grains of it, and it purged and vomited the lady for twenty-four hours, and in that time gave her between twenty and thirty stools; at other times I have seen a scruple produce little or no visible effect." Dr. Cheyne (*Dubl. Hosp. Rep.* i. 315) thought highly of it in the apoplectic diathesis: but he used it in conjunction with bleeding, purgatives, and a strict antiphlogistic regimen.

The preceding facts seem to me to show the propriety of omitting the use of both antimonial and James's powder, and substituting for them some antimonial of known and uniform activity; as emetic tartar.

USES.—Antimonial powder is employed as a sudorific in fevers and rheumatic affections. In the former it is given either alone or in combination with mercurials: in the latter it is frequently conjoined with opium as well as with calomel. In chronic skin diseases it is sometimes exhibited with alteratives.

ADMINISTRATION.—The usual dose of it is from 3 or 4 to 8 or 10 grains, in the form of powder or bolus.

Potas'sæ Antimo'nio-Tar'tras.—An'timony-Tar'trate of Pot'ash.

History.—This salt was first publicly noticed in 1631, by Adrian de Mynsicht (*Thesaurus Medico-Chymicus.*) It has been known by various appellations, as *tartarized antimony* (*antimonium tartarizatum*), *emetic tartar* (*tartarus emeticus*), *stibiated tartar* (*tartarus stibiatus*), and *potassio-tartrate of antimony* (*antimonii potassio-tartras*, Ph. L.)

Preparation.—Antimony-tartrate of potash is prepared by boiling bitartrate of potash and sesquioxide of antimony (or some antimonial preparation which contains it, as the oxychloride or an oxysulphuret) with water: the sesquioxide combines with the bitartrate to form antimony-tartrate of potash.

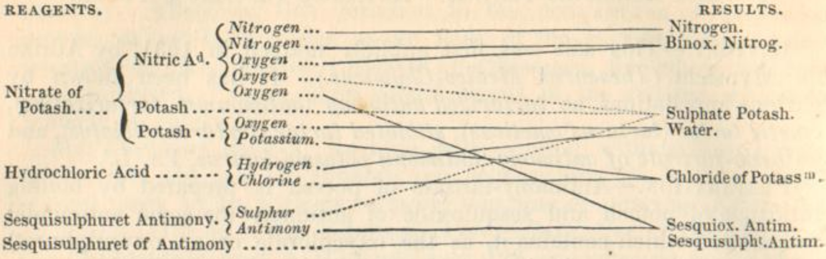
Antimony-ash (*cinis antimonii*), procured by roasting the sesquisulphuret, is employed to yield the sesquioxide in a manufactory in London. As already stated (p. 398), this compound is a mixture of sesquioxide, antimonious acid, and some undecomposed sesquisulphuret. The proportions of ash and bitartrate used vary according to the quality of the former: the average being equal parts. This is the cheapest method of obtaining emetic tartar.

In the Dublin and United States Pharmacopœias the oxychloride (*oxydum antimonii nitro-muriaticum*, Ph. Dub.), commonly called Algaroth's powder, is employed. This is procured by pouring the sesquichloride (common butter of antimony, *vide* p. 399) into a large quantity of water, and washing the precipitate. In the preparation of the sesquichloride a small quantity of nitric acid should be employed to decompose the hydro-sulphuric acid remaining in the liquor, and which would impair the colour of the precipitate.

In the London Pharmacopœia an oxysulphuret, very similar in composition to the old *saffron of antimony* (*crocus antimonii*) is used. It is thus prepared: two pounds of powdered sesquisulphuret of antimony are to be accurately mixed with the like quantity of powdered nitrate of potash: four fluidounces of hydrochloric acid are then to be added, and the powder, ignited, spread out on an iron plate. The residue is to be rubbed to a very fine powder, and, when cold, washed with boiling water until it is void of taste.

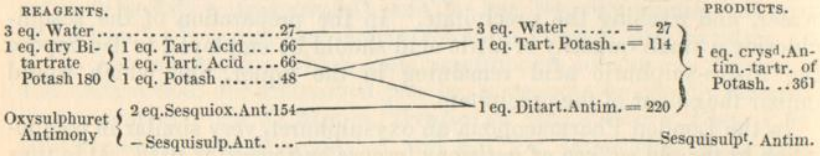
It is then to be boiled for half an hour with fourteen ounces of bitartrate of potash in a gallon of distilled water. The liquor is to be strained while hot, and set aside to form crystals.

The *theory* of the process is this: part of the sulphur and of the antimony are oxidized at the expense of the oxygen of the acid of the nitrate, by which sulphuric acid and sesquioxide of antimony are formed, while nitrogen and binoxide of nitrogen escape. The sulphuric acid unites with part of the potash of the nitrate. The hydrochloric acid reacts on another portion of potash, and produces water and chloride of potassium. If no hydrochloric acid had been employed, the potash would react on some undecomposed sesquisulphuret, and generate antimonio-sesquisulphuret of potassium and sesquioxide of antimony. The residuum of this operation is, then, sulphate of potash, chloride of potassium, sesquioxide of antimony, and some undecomposed sesquisulphuret. By washing, the sulphate and chloride are got rid of. The following diagram, though imperfect, may perhaps assist the student in comprehending the foregoing changes:—



The reacting equivalents have been omitted in the above diagram: but the results may be explained by assuming that 6 equivalents of nitrate, 7 equivalents of sesquisulphuret, and $1\frac{1}{2}$ equivalents of hydrochloric acid, are employed. The products will be 6 eqs. of binoxide of nitrogen, $4\frac{1}{2}$ eqs. of sulphate of potash, $1\frac{1}{2}$ eqs. of water, $1\frac{1}{2}$ eqs. of chloride of potassium, 3 eqs. sesquioxide of antimony, and 4 eqs. sesquisulphuret.

The changes in the second stage of the process are readily comprehended: two equivalents or 154 parts of sesquioxide of antimony combine with one equivalent or 180 parts of dry bitartrate of potash, to form one equivalent or 334 parts of dry emetic tartar, which, in crystallizing, unite with three equivalents, or 27 parts of water. The sesquisulphuret is unacted on by the bitartrate of potash.

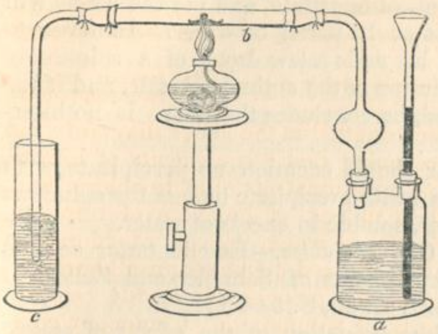


PROPERTIES.—Emetic tartar crystallizes in white, transparent, inodorous, rhombic octahedrons, whose lateral planes are striated. By exposure to the air they become opaque, probably by giving out an equivalent of water. Their taste is feebly sweetish, then styptic and metallic. They dissolve in 14 or 15 parts of water at 60° F. ($12\frac{65}{100}$ at 70°, Brandes),—and in 2 parts ($2\frac{78}{100}$ parts, Brandes) at 212°. Their aqueous solution slightly reddens litmus and undergoes decomposition by keeping, like that of tartaric acid and most tartrates. Alcohol will not dissolve this salt. By calcining emetic tartar in close vessels we obtain a pyrophoric alloy of antimony and potassium. They decrepitate in the fire.

CHARACTERISTICS.—Heated in a porcelain or glass capsule it chars: shewing it contains an organic substance (tartaric acid.) If the charred salt be heated in a glass tube by a blowpipe, globules of antimony are obtained.

If a stream of hydrosulphuric acid gas be transmitted through a watery solution of emetic tartar (*vide* fig. 65, p. 409), the latter becomes orange-red: if a small quantity of hydrochloric acid be then added, a flocculent orange-red precipitate (hydrated sesquisulphuret of antimony) takes place. This precipitate is to be collected and dried, and introduced into a green glass tube. Then transmit a current of hydrogen gas over it, and after a few minutes apply the heat of a spirit lamp to the sesquisulphuret: hydrosulphuric acid and metallic antimony are produced. A portion of the latter is [spuriously ?] sublimed. The metal is known to be antimony by dissolving it in nitro-hydrochloric acid: the solution forms a white precipitate (powder of Algaroth) on the addition of water, and an orange-red one with hydrosulphuric acid gas, or hydrosulphate of ammonia. The mode of reducing the sesquisulphuret will be readily understood by the accompanying diagram (fig 65). This process was proposed by the late Dr. E. Turner.

Fig. 65.



(*a*) Vessel for generating hydrogen. (*b*) Reduction tube. (*c*) Vessel containing solution of acetate of lead to detect the hydrosulphuric acid which is formed.

A solution of emetic tartar forms *white* precipitates with oxalic and the strong mineral acids, the alkalies and their carbonates, and lime water: *greyish* or *yellowish white* (*tannate of antimony*), with infusion of nutgalls: and *reddish* with the soluble hydrosulphates. Their relative delicacy, as well as the delicacy of hydrosulphuric acid, has been thus determined by Devergie. (*Méd. Lég.* ii. 770.)

	Dilution of the Solution.
Hydrochloric acid does not form a precipitate at	2,500
Sulphuric (or oxalic) acid ditto	1,000
Tincture of nutgalls . . ditto	1,000
Lime water . . . . stops at	1,200
Potash (soda, ammonia, or carbonate of ammonia) stops at	2,000
Hydrosulphuric acid (or hydrosulphate of ammonia) ditto	100,000

The sesquioxide of antimony thrown down by the alkalies is soluble in an excess of the precipitant. The precipitate formed by sulphuric or nitric acid is the sesquioxide combined with a small quantity of the acid. Acetic acid does not occasion any precipitate.

Composition.—The following is the composition of this salt:—

	Eq.	Eq. Wt.	PerCt.	Wallquist.	R.Phill.	Thoms.
Sesquioxide of Antimony	2	154	42·65	42·99	43·35	42·62
Potash	1	48	13·29	13·26	49·25	57·38
Tartaric Acid	2	132	36·56	38·61		
Water	3	27	7·47	5·14	7·40	
Emetic Tartar	1	361	99·97	100·00	100·00	100·00

or

	Eq.	Eq. Wt.	Per Cent.
Ditrartrate of Antimony	1	220	60·94
Tartrate Potash	1	114	31·57
Water	3	27	7·47
Antimonio-Tartrate of Potash	1	361	99·98

We regard this compound, then, as a double salt, in which the ditartrate of antimony performs the function of the electro-negative or acid constituent, —the tartrate of potash, the electro-positive or basic constituent.

Purity.—In the crystalline state the purity of this salt is easily determined. The crystals should be well formed, perfectly colourless, transparent, or opaque, and when dropped into a solution of hydrosulphuric acid have an orange-coloured deposit formed on them.

When pure the powder of this salt is perfectly white. Some ignorant druggists prefer a yellowish white powder, and I am informed by a manufacturer of this salt that he is obliged to keep two varieties (one white, the other yellowish white), to meet the demands of his customers! The yellow tint is owing to the presence of iron, which is readily detected in the salt by the blue colour immediately produced in its solution by adding first a few drops of dilute sulphuric acid, and then ferrocyanuret of potassium.

Emetic tartar is sometimes adulterated with bitartrate of potash. According to Mr. Hennell (Phillips's *Transl. of the Pharm.* 3d ed.) the antimonial salt may contain 10 per cent. of bitartrate, and yet the whole will dissolve in the proper quantity (14 or 15 parts) of water. In order to detect any uncombined bitartrate, he adds a few drops of a solution of carbonate of soda to a boiling solution of the antimonial salt, and if the precipitate formed be not dissolved, he concludes that there is no bitartrate of potash present.

A pure solution of emetic tartar should occasion no precipitate with chloride of barium: it produces a white precipitate (unless the solutions be very dilute) with nitrate of silver, soluble in excess of water.

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—Emetic tartar acts as a poison to plants (*vide* the experiments of Schübler and Zeller, in *Schweigger's Journ. f. d. Chem.* 1827, B. 50, S. 54-66.)

(*b.*) *On animals.*—An extended examination of the effects of emetic tartar on the different classes of animals is still a desideratum. Hitherto experiments with it have been principally confined to dogs, rabbits, horses, oxen, sheep, and cats. Moiroud (*Pharm. Vétér.* 287) has given two drachms to horses, and gradually increased the dose to six ounces, without perceiving any remarkable and permanent derangement in the exercise of the principal functions. Gilbert (quoted by Moiroud) has exhibited ten drachms to a cow and four to a sheep without any remarkable effect: but six drachms killed an animal of the latter species. Magendie (in Orfila's *Toxicol. Gén.*) examined its effects on dogs. He found that from six to ten grains introduced into the stomach killed the animals in from two to three hours, when the gullet was tied: those who were able to get rid of it by vomiting took as much as a drachm without experiencing any bad effects, and in some cases half an ounce caused no ill effects. From his experiments it appears to operate locally and by absorption, its principal action being on the intestinal canal and lungs: for nausea, vomiting, alvine evacuations, difficulty of respiration, and accelerated respiration, were produced by injecting a solution of the salt into the veins, by introducing it into the stomach, as well as by applying it in the solid state to the cellular tissue. Traces of pneumonia, gastritis, and enteritis, were found after death. These experiments have been repeated by Rayer and Bonnet (*Dict. de Med. et de Chir. Prat.* iii. 69) on rabbits; but without obtaining the lesion of the lungs mentioned by Magendie: in some cases no appreciable lesion was observed in any organ. Dr. Campbell (quoted by Dr. Christison) found no pulmonary inflammation in a cat killed by this salt. According to Flourens (*Journ. de Chim. Méd.* ix. 21) emetic tartar injected into the veins of ruminants causes efforts to vomit, but not actual vomiting; of the four stomachs possessed by these animals, the *reed* or true stomach is the only one affected by it.

(*c.*) *On man.* α. *Local effects.*—Emetic tartar is a powerful local irritant, but not a caustic; that is, it does not exercise any known chemical influence over the parts with which it is placed in contact. Its irritant properties may be regarded as of a peculiar or specific kind, at least if we are to judge from its well-known effects when applied to the epidermis. To observe these, we may sprinkle the powder over a plaster, or employ the salt in the form of solution or of ointment. By any of these modes of application we obtain an eruption of painful pustules, resembling those of variola or ecthyma. The smaller ones are semiglobular; the larger ones, when at their height, are flattened, are surrounded with an inflammatory border, contain a pseudo-membranous deposit and some purulent serum, and have a central dark point. When they have attained their greatest magnitude, the central brown spots become larger and darker, and, in a few days, desiccation takes place, and the crusts are thrown off. The largest are produced by using the powder sprinkled over a plaster; the smallest are developed by applying the solution. They are usually very painful. I am acquainted with no pharmacological agent producing an eruption precisely similar. The facility with which this eruption is produced varies considerably in different individuals, and in the same individual at different times.

In consequence of the internal use of it, a similar pustular eruption has been met with in the mouth, œsophagus, and small intestines, and white aphthous spots have been observed on the velum and tonsils (Lepelletier, *De l'Emploi du Tart. Stibié*, p. 171). But these effects are rare.

We have further evidence of the local irritation produced by emetic tartar, in its action on the stomach and intestines. When swallowed in full doses it gives rise to vomiting and purging, pain in the epigastric region, and, after death, redness of the gastro-intestinal membrane has been found. However, it would appear from the experiments of Magendie, before referred to, that part of this effect should be referred to the specific influence which emetic tartar exerts over the stomach, independent of its direct local irritation, since the same symptoms have been induced by the application of this substance to wounds, or by its injection into the veins.

Occasionally constitutional effects (nausea, vomiting, and griping pains) have appeared to result from the application of emetic tartar to the skin (*Journ. de Chim. Méd.* iv. 478). In one instance death resulted from its employment: the patient was an infant two years of age, and death occurred in forty-eight hours (*Med. Repos.* xvi. 357). These effects, if really produced by this salt, occur very rarely. I have applied to the skin emetic tartar (in the form of solution, ointment, and plaster) in more than a hundred cases, without having observed any constitutional effect; though I have occasionally fancied that it ameliorated pulmonary affections, even when no eruption or redness was produced, and which might arise from absorption.—(See some experiments on this subject in *Mem. of the Med. Soc. of Lond.* vols. ii. iv. and v.)

β. Remote or *constitutional effects.*—Taken internally, *in small doses*, emetic tartar increases secretion and exhalation of the gastro-enteritic membrane, and of the liver and pancreas. Subsequently it acts powerfully on other emunctories: thus it causes sweating, without any very marked vascular excitement; it renders the mucous membranes (especially the aërian membrane) moister, and, when the skin is kept cool, promotes the secretion of urine. These effects are produced more certainly and speedily by this salt than by any other antimonial preparation.

In somewhat larger doses it excites nausea, frequently with vomiting, disorders the digestive functions, gives rise to an uneasy sensation in the abdominal region, depresses the nervous functions, relaxes the tissues (especially the muscular fibres), and occasions a feeling of great feebleness and exhaustion. These symptoms are accompanied or followed by increased secretion and exhalation from the different emunctories, but especially from the skin, as above mentioned. Of all emetic substances this creates the most nausea and depression.

In excessive doses emetic tartar has, in a few instances, acted as an irritant poison, and even occasioned death. In one case a scruple, in another 27 grains, nearly proved fatal (Orfila, *Toxicol. Gén.*) In a third 40 grains caused death (*ibid.*) The symptoms in the latter case were vomiting, hypercatharsis, convulsions, epigastric pain and tumefaction, and delirium. Death occurred four days after the ingestion of the poison.

Were the above cases not well authenticated, we should be disposed to ascribe the dangerous symptoms, and death, to some other circumstance than the use of the above-mentioned quantities of emetic tartar; for of late years this salt has been extensively employed in enormous and repeated doses with perfect safety. Rasori (Bayle's *Bibliothèq. de Thérap.* i. 198) has given many drachms in twenty-four hours, and many ounces during the course of a disease, without occasioning either vomiting or abundant alvine evacuations. Laennec (*Treatise on Diseases of the Chest*, by Dr. Forbes, p. 249) has confirmed, to a certain extent, the statements of Rasori. He gave a scruple, two scruples, and even a drachm and a half within twenty-four hours (usually in doses of one, two, or three grains) without ever having seen any injurious consequences. The usual effects which I have observed from the continued use of one or two grain doses, are, nausea, vomiting, and purging, which in most cases are much diminished, or entirely cease, in a day or two. Perspiration I have found to be a frequent effect. In all the instances above referred to, in which these large doses were administered, the patients were affected with inflammatory diseases. Now it is to this morbid state, or *diathesis*, that, according to Rasori (*op. cit.*) we ought to ascribe the *tolerance* of, or capability or *aptitude* of bearing, these immense quantities of so powerful a medicine (*vide* p. 33, for some remarks on the Italian *theory of contra-stimulus*). Consequently, if the opinion be worth any thing, the susceptibility to the influence of the medicine should increase as the disease subsides; a circumstance which Rasori asserts really takes place. But in this the theoretical views of this distinguished Italian have probably led him to overlook the fact. "It is certainly true," observes Laennec (*op. cit.*), "that after the acute period of the disease [peripneumonia], the tolerance diminishes, or sometimes entirely ceases; but it is more common to find the patient become habituated to the medicine, insomuch that during convalescence, and when he has begun to use food as in health, he will take daily, without knowing it, six, nine, twelve, or even eighteen grains of the emetic tartar." Though I have seen this salt extensively employed in both public and private practice, I have never met any satisfactory cases supporting Rasori's assertion of the diminished tolerance when the patient becomes convalescent. Moreover, large doses have been taken by healthy individuals without any remarkable effects. Alibert (*Nouv. Elém. d. Thérap.* 5^{me} ed.

i. 259) saw, at the Hôpital St. Louis, a man who took a drachm of this salt, in order to poison himself, but suffered no remarkable inconvenience from it. Lebreton (Orfila's *Toxicol. Gén.*) reports the case of a girl who swallowed six drachms at once as a poison: oil was immediately given; vomiting took place, and she soon recovered. Other published cases might be brought forward in proof of the slight effects of large doses of this salt, but I must content myself with referring to the Memoir of Magendie (*De l'influence de l'emetique*) for notices of them. I may add, however, that this distinguished physiologist concludes, that the comparative slightness of the effects arose from the evacuation of the salt a few moments after its ingestion; but in several, at least, of the cases, this was not proved; and in one it certainly did not happen—it was that of a man who swallowed 27 grains of this salt, and did not vomit.

The action of large doses of emetic tartar on the circulation and respiration is usually that of a sedative. This has been very frequently, though not constantly observed. In one case of peripneumonia, the daily use of from six to eight grains of this salt reduced the pulse, in nine days, from 120 to 34 beats per minute, and diminished the number of inspirations from 50 to 18 (Bouneau et Constant, quoted by Lepelletier, *De l'emploi du Tart. Stib.* 84). In another the pulse descended, in three days, from 72 to 44 beats per minute (Trousseau, quoted by Lepelletier).

MODUS OPERANDI.—Though emetic tartar has not hitherto been detected by its chemical characters in the solids or fluids of the body, yet analogy is much in favour of Magendie's statement, that it gets into the circulation, and in this way produces its constitutional effects. M. Barré, (quoted by Rayer, *Dict. de Méd. et de Chir. Prat.* iii. 69) has endeavoured to prove the reverse of this; namely, that emetic tartar cannot be absorbed by the healthy mucous membrane of the alimentary canal; but, in my opinion, neither his experiments nor his inferences are worth much. A fact mentioned by Minaret (*Lond. Med. Gaz.* xiii. 496) strongly supports the common opinion of absorption. A young woman labouring under pleuritis took emetic tartar, which operated on the child at her breast as well as on herself.

Several parts of the body are influenced by this salt. The specific affection of the *alimentary canal* (especially of the stomach) is shown by the vomiting and sometimes purging produced, not only when the medicine is swallowed, but when it is injected into the veins or into the windpipe, or when applied to the serous coats of the intestines, or to the cellular tissue. If it purge or occasion sweating, it usually causes thirst, but not commonly otherwise. The appetite and digestion are frequently unimpaired. After the use of it for some days, patients sometimes complain of irritation in the mouth and throat, with a metallic taste: this has been considered a sign that the system is saturated with antimony, and that the use of it should be suspended. A pustular eruption has occasionally appeared in the mouth, as I have already mentioned (p. 411).

Magendie ascribes to emetic tartar a specific power of causing engorgement or inflammation of the *lungs;* for he found, on opening the bodies of animals killed by it, that the lungs were of an orange red or violet colour, incapable of crepitating, gorged with blood, and here and there hepatized. Moreover, it has been assumed that the same effects are produced in the human pulmonary organs; and in support of this opinion a case noticed by Jules Cloquet (Orfila, *Toxicol. Gén.*) has been referred to: it is that of a man who died of apoplexy, but who, within five days of his death, had taken 40 grains of tartar emetic. "In the lungs were observed blackish spots, very irregular, which extended more or less deep into the parenchyma of this organ." Furthermore, it is argued, unless we admit a specific influence of antimony over the lungs, we cannot well explain the beneficial effects of this remedy in peripneumonia. In opposition to this view, I would remark, that in cases of poisoning by this substance in the human subject, no mention is made of difficulty of breathing, cough, pain, or other symptom, which could lead to the suspicion that the lungs were suffering; and in the case of poisoning related by Recamier (Orfila, *op. cit.*) we are distinctly told that the thorax was sound. Besides, we should expect that if emetic tartar had a tendency to inflame the lungs, or at least to occasion pulmonary engorgement, that large doses of it would not be very beneficial in acute peripneumonia. It would even seem that this substance must have an influence over the human lungs of an opposite kind to that supposed by Magendie; for, as already related, it reduces the frequency of respiration in a considerable number of instances.

The sedative influence of emetic tartar over the *circulatory system* has been already noticed: it is, however, not always evident.

The great depression of the muscular power, the diminution of the frequency of the pulse and fainting, the epigastric pain sometimes experienced under circumstances that almost preclude the supposition of gastric inflammation, the cramps and convulsions, the delirium and insensibility, caused by emetic tartar in poisonous doses, are referrible to the influence of this substance over the *nervous system*.

The *absorbent system* is supposed to be stimulated to greater activity by emetic tartar, in consequence of the disappearance of serous and synovial effusions under its use. Moreover, Laennec (*op. cit.* p. 203) ascribed the efficacy of it in peripneumonia to the increased activity of the interstitial absorption.

The influence of it over the *secreting organs* has been before referred to. Every one is familiar with its diaphoretic properties. Its diuretic effect is best seen when the skin is kept cool, and when neither vomiting nor purging supervene. Magendie says, it augmented the secretion of saliva in dogs; and the same effect has been observed in man by Drs. Griffith and Jackson. The menstrual discharge is not checked by it; but occasionally has come on under its use.

USES.—As an *emetic*, this salt is usually administered by the stomach, but it is sometimes used as an enema, and injected into the veins. When administered by the stomach, it is generally given in doses of one or two grains, frequently in combination with ten or fifteen grains of ipecacuanha. When our object is merely to evacuate the contents of the stomach, and with as little constitutional disorder as possible (as in cases of narcotic poisoning), other emetics (as the sulphates of zinc and copper) are to be preferred, since they occasion less nausea and depression of system, while they excite speedy vomiting. On the other hand, when we use vomiting as a means of making an impression on the system, and thereby of putting a sudden stop to the progress of a disease, emetic tartar is by far our best vomit. It is with this view that it is sometimes employed in the early stages of fever, especially when accompanied by gastric or bilious disorder. It is most efficacious when given at the very commencement of the symptoms, and before the disease is fully formed. In such cases it occasionally puts an entire stop to the progress of fever. But, unfortunately, the practitioner is not usually called in to see the patient until the proper period for the exhibition of an emetic has passed by,—that is, until the disease is fully established. Emetic tartar is used as a vomit with considerable success in the early stage of inflammatory diseases, especially in croup, tonsillitis, swelled testicle, bubo, and ophthalmia. Here also the success of the remedy is in proportion to its early application. In croup it should be given to excite in the first instance vomiting, and afterwards prolonged nausea. Under this plan of treatment I have seen two or three slight cases completely recover without the use of any other remedial agent. Dr. Copland (*Dict. of Pract. Med.* i. 467) also bears testimony to the success of the practice. In most cases it will be found advisable to precede the use of this medicine by blood-letting. Dr. Cheyne (*Essay on Cynanche Trachealis*, 1801) advises the employment of emetic tartar in the second stage of croup, for the purpose of moderating vascular action, and of promoting the separation of the adventitious membrane. But I am disposed to rely chiefly on calomel (given so as speedily to occasion ptyalism) and blood-letting. Dr. Cheyne recommends half a grain of emetic tartar to be dissolved in a table-spoonful of water, and given to a child two or three years of age, every half hour till sickness and vomiting are produced; and in two hours after the last act of vomiting the same process is to be recommenced, and so repeated while the strength will admit. Another disease which is relieved by the occasional use of emetics is *hooping-cough*. They should be administered at the commencement of the disease, every, or every other day. They diminish the violence and length of the fits of spasmodic coughing, and promote expectoration. Emetic tartar is particularly valuable in this disease in consequence of being tasteless, and, therefore, peculiarly adapted for exhibition to children. In derangements of the hepatic functions indicating the employment of emetics, this salt is usually preferred to other vomiting agents, on account of its supposed influence in promoting the secretion of bile.

Clysters containing emetic tartar have been employed to occasion vomiting, but they are very uncertain in their operation. Rayer has frequently employed from 6 to 12 grains without producing either nausea or vomiting.

It has been repeatedly *injected into the veins* to excite vomiting. The usual dose is two or three grains dissolved in two ounces of water; but in some cases six grains have been employed. The effects are unequal: when vomiting does occur it is not always immediate; frequently it does not take place at all (Dieffenbach, *Transf. d. Blut. u. d. Infus. d. Arzn.* 105.) In several cases of choking from the lodgment of pieces of meat in the œsophagus, this remedy has been applied with great success: vomiting was produced, and with it the expulsion of the meat. It has also been used in epilepsy and trismus: frequently with dangerous consequences (Dieffenbach, *op. cit.* 49.) Meckel employed it to restore animation in asphyxia by drowning (*ibid*).

As a *nauseant*, to reduce the force of the circulation and the muscular power, emetic tartar is frequently of considerable service. Thus in dislocations of the larger joints (the hip and shoulder, for example), blood-letting, and nauseating doses of emetic tartar, are employed to diminish the resistance of the muscles opposing the reduction.

Emetic tartar, in large doses, is a most powerful and valuable remedy in the treatment of inflammation, especially peripneumonia. As an emetic, nauseant, or diaphoretic, it has long been in use in this disease; having been employed by Riverius in the 17th century, and subsequently by Stoll, Brendel, Schroeder, and Richter, in Germany; by Pringle, Cullen, and Marryat, in England. But as a remedy for inflammation, independent of its evacuant effects, we are indebted for it to Rasori (see the French translation of his Memoir, in Bayle's *Biblioth. de Thérap.* i. 198), who first used it in the years 1799 and 1800, in an epidemic fever which raged at Genoa. Subsequently he exhibited it much more extensively, and in larger doses, in peripneumonia. This mode of treatment was tried and adopted in France, first by Laennec (*Treat. on Dis. of the Chest*, translated by Dr. Forbes); in this country by Dr. Balfour (*Illust. of the Power of Emet. Tart.* 2d edit. 1819). Its value as an antiphlogistic is now almost universally admitted. Practitioners, however, are not quite agreed as to the best method of using it. Rasori (*op. cit.*), Laennec (*op. cit.*), Recamier (*Gaz. Méd.* 1832, p. 503), Broussais (*Cours de Path. et de Thérap. gén.* ii. 521), Bouillaud (*Dict. de Méd. et de Chir. pratiq.* xiii. 395), Dr. Mackintosh (*Pract. of Phys.* i. 426), Drs. Graves and Stokes (*Dubl. Hosp. Rep.* v. p. 48), Dr. Davis (*Lect. on Dis. of the Lungs and Heart*, 188), and most practitioners of this country, employ blood-letting in peripneumonia, in conjunction with the use of emetic tartar. But by several continental physicians the abstraction of blood is considered both unnecessary and hurtful. Thus Peschier (Bayle, *Bibl. Thér.* i. 246) advises us on no account to draw blood: and Trousseau (*Dict. de Méd.* 2d edit. iii. 220) observes, that blood-letting, far from aiding the action of emetic tartar, as Rasori, Laennec, and most practitioners, imagine, is, on the contrary, singularly injurious to the antiphlogistic influence of this medicine. On these statements I would observe, that few practitioners in this country have ventured to trust to emetic tartar alone in the treatment of violent pulmonary inflammation. Of its efficacy when used alone, in several slight cases of pneumonia, I can bear testimony; but in severe cases I have invariably conjoined blood-letting, and I believe most British practitioners have done the same. Louis (*Rech. de la Saignée*) has published some numerical results of the treatment of inflammation of the lungs by blood-letting and by emetic tartar; from which it appears that this substance, given in large doses, where blood-letting appeared to have no effect, had a favourable action, and appeared to diminish the mortality (*op. cit.* p. 62). But he particularly states that blood-letting must not be omitted (p. 32).

Laennec's mode of using this salt, and which, with some slight modification, I believe to be the best, is the following:—Immediately after bleeding give one grain of emetic tartar, dissolved in two ounces and a half of some mild fluid [cold weak infusion of orange flowers], sweetened with half an ounce of syrup of marshmallows: this is to be repeated every two hours for six times, and then suspended for seven or eight hours, if the symptoms are not urgent, or if there be any inclination to sleep. But if the disease has already made progress, or if the oppression is great, or the head affected, continue the medicine until amendment takes place; and in severe cases increase the dose to two, or two and a half grains. The only modification in this plan, which I would venture to propose, is, to begin with a somewhat smaller dose (say one-third or one-half of a grain), and gradually increase it; for in consequence of the violent vomiting which one grain has sometimes produced, I have found patients positively refuse to continue the use of the medicine.

From my own experience I should say, that emetic tartar is nearly as serviceable when it causes moderate sickness and slight purging, as when it occasions no evacuation: but many practitioners deny this. Laennec observes, that "in general the effect of emetic tartar is never more rapid, or more efficient, than when it gives rise to no evacuation; sometimes, however, its salutary operation is accompanied by a general perspiration. Although copious vomiting and purging are by no means desirable, on account of the debility and hurtful irritation of the intestinal canal which they may occasion, I have obtained remarkable cures in cases in which such evacuations had been very copious" (*op. cit.* p. 251). A few drops of tincture of opium may be sometimes conjoined with the antimony, to check its action on the alimentary canal.

The attempts which have been made to explain the *modus medendi* of emetic tartar in pneumonia and other inflammatory diseases, are most unsatisfactory. Whilst almost every writer, even Broussais, admits its efficacy in inflammation, scarcely two agree in the view taken of the mode by which the good effects of this remedy are produced; as the following statement proves. Rasori explains its operation according to the principles of the theory of contra-stimulus (*vide* p. 33), of which he may be regarded as the founder. He considers emetic tartar endowed with the power of directly diminishing the inflammatory stimulus; of destroying the diathesis, and of being, therefore, a real contra-stimulus. Broussais, Bouillaud, and Barbier, ascribe its curative powers to its revulsive or derivative action on the gastro-intestinal membrane. Laennec thinks that it acts by increasing the activity of interstitial absorption. Fontaneilles supposes that the antiphlogistic effect depends on alterations in the composition of the blood. Eberle (*Mat. Méd.* i. 66) refers it to the sedative effects, first, on the nervous system, and consecutively on the heart and arteries. Teallier thinks that, like many other therapeutic agents, it influences the organism by concealed curative properties. Dr. Macartney (*A Treatise on Inflammation*, 1838) regards it as a medicine diminishing the force of the circulation, by the nausea which it occasions. These examples are sufficient to show the unsatisfactory condition of our present knowledge as to the mode by which emetic tartar produces its curative effects. But this is no argument against the existence of remedial powers. Shall we deny the efficacy of blood-letting in inflammation, of mercury in syphilis, of cinchona in intermittents, of arsenic in lepra, of sulphur in scabies, of hydrocyanic acid in gastrodynia, and of a host of other remedies, simply because we cannot account for their beneficial effects? The fact is, that in the present state of our knowledge we cannot explain the *modus medendi* of a large number of our best and most certain remedial means.

In *pleurisy* emetic tartar does not succeed so well as in inflammation of the substance of the lungs. "It, indeed, reduces speedily the inflammatory action," says Laennec (*op. cit.* p. 259); "but when the fever and pain have ceased, the effusion does not always disappear more rapidly under the use of tartar emetic than without it." I have sometimes conjoined opium (always after copious blood-letting) with advantage. In *bronchitis* (both acute and chronic) it may be most usefully employed, in conjunction with the usual antiphlogistic agents (*vide* also Dr. Kemp, *Lond. Med. Gaz.* xix. 300, and Mr. Ellis, *op. cit.* p. 369). In *rheumatism* (especially the kind called *articular*), next to peripneumonia, emetic tartar has been found by some practitioners (especially by Laennec, *op. cit.*) more efficacious than in any other inflammatory affection: the usual duration of the complaint, when treated by this remedy, was found by Laennec to be only seven or eight days (see also Bayle's *Bibl. Thérap.* i. 311, and Lepelletier, *De l'Emploi du Tart. Stib.* p. 220). In muscular rheumatism it succeeds less perfectly. Synovial effusions (whether rheumatic or otherwise) have, in some cases, given way rapidly to the use of emetic tartar (Laennec, *op. cit.* p. 263, and Gimelle, *Brit. & For. Med. Rev.* for July 1838, p. 224). My own experience of the use of this medicine in rheumatism is not so favourable to its employment as the above reports would lead us to expect. In *arachnitis*, Laennec has seen all the symptoms disappear, under the use of emetic tartar, in 48 hours. In three instances of acute hydrocephalus, all the symptoms disappeared in the same space of time. In *phlebitis* (Laennec, *op. cit.*); in *inflammation of the mammæ*, occurring after delivery (Dr. E. Kennedy, Mr. Lever, and Dr. Ashwell, *Lond. Med. Gaz.* xx. 761); in *ophthalmia*, and various other inflammatory affections, emetic tartar has been successfully employed as an antiphlogistic.

In continued fever emetic tartar is of considerable service. Mild cases are benefited by the use of small doses (as from one-sixteenth to one-fourth of a grain), as a diaphoretic. In the more severe form of this disease, accompanied with much vascular excitement, emetic tartar, in the dose of half a grain or a grain, may be usefully administered as an antiphlogistic; but its use should, in general, be preceded by blood-letting. In the advanced stages of typhus fever, accompanied with intense cerebral excitement, manifested by loss of sleep, delirium, &c. Dr. Graves (*Lond. Med. Gaz.* xx. 538) has obtained most beneficial results from the use of emetic tartar and opium. The same combination has been employed with great success in delirium tremens, as well as in delirium of erysipelas, scarlatina, and measles, by Dr. Law (*Lond. Med. Gaz.* xviii. 538 & 694).

Emetic tartar is one of our most valuable sudorifics, being oftentimes available when other agents of this class are inadmissible: for example, in fevers and other diseases, where we are desirous of producing diaphoresis, but which are accompanied with preternatural vascular action about the head, the use of those sudorifics (the compound ipecacuanha powder, for example) which contain a narcotic substance, is objectionable; whereas emetic tartar may be employed with safety, since it has no tendency to increase disorder of the nervous system, but to reduce cerebral excitement. On the other hand, when much gastric or enteritic irritation is present, the narcotic sudorifics are generally to be preferred to antimony.

As an expectorant, in various pulmonary affections, small doses of this salt are frequently employed with advantage.

In some spasmodic complaints, the use of it has been followed, in the few instances in which it has been tried, with good effects (*vide* Laennec, *op. cit.* p. 260; Jacobi, *Lond. Med. Gaz.* iii. 784; and Mr. Ackerley, *Lond. Med. Gaz.* xxi. 56). In *apoplexy* it has been employed to depress cerebral vascular action, but its tendency to occasion vomiting renders it objectionable.

As a local irritant, applied to the skin, it may be employed in the form of aqueous solution, ointment, or plaster. It is used in the same cases as vesicatories, over which it has the advantage of not affecting the urino-genital organs. When it is desirable to keep up long-continued irritation, blisters are in some cases preferable. In *chronic diseases of the chest* it is used with the greatest advantage. I have found it much more serviceable than blisters, or any other kind of counter-irritant. I sometimes order one part of the chest to be rubbed until the eruption is produced; and then, after the interval of a day or two, apply it to another part, thus keeping up irritation by a succession of applications to different parts of the chest for several months. In this way it is most serviceable in chronic catarrhs, peripneumonies, and pleurisies. Even in lingering phthisis I have seen the cough and pain alleviated by the occasional use of antimonial frictions. In *hooping-cough* it is also serviceable. Autenrieth recommended it as a means of diminishing the frequency of the paroxysms and the violence of the cough. In *laryngitis* it is occasionally of great service: as also in various *affections of the joints*, especially chronic inflammation of the capsular ligament, or of the synovial membrane, hydrops articuli, particularly when connected with inflammation, and tumors of various kinds about the joints. In *tic douloureux* (Hausbrandt, *Brit. & For. Med. Rev.* Jan. 1837, 230) it has also been employed with benefit.

A *stimulating wash*, composed of one scruple of tartar emetic to an ounce of water, was proposed by the late Sir William Blizard, in the year 1787, to cleanse foul ulcers, repress fungous growths and venereal warts, and as an application to tinea capitis. A weak solution (as half a grain to the ounce of water) has been employed as a stimulant in chronic ophthalmia, and in spots on the cornea.

Administration.—The dose of emetic tartar, in substance, is, as a diaphoretic and expectorant, $\frac{1}{12}$ to $\frac{1}{6}$ of a grain; as a nauseant, from $\frac{1}{4}$ to $\frac{1}{2}$ a grain; as an emetic, from 1 to 2 grains; as an antiphlogistic, from $\frac{1}{2}$ a grain to 3 or 4 grains. This salt is, however, rarely employed in substance. Sometimes a grain of it, mixed with ten or fifteen grains of powdered ipecacuanha, is employed as an emetic. A mixture of one grain with sixteen grains of sulphate of potash may be employed, in doses of from two to four grains, as a substitute for antimonial powder, to promote diaphoresis.

In *solution*, it is commonly employed, as an expectorant, diaphoretic, nauseant, or emetic, in the form of antimonial wine. When used as an antiphlogistic, an aqueous solution of greater strength may be administered: it should be made with boiling distilled water in a glass vessel (as a Florence flask.)

For external use, emetic tartar is employed in the form of liniment, ointment, or plaster. A saturated solution is a very useful liniment: it is prepared by pouring an ounce and a half of boiling water over a drachm of emetic tartar, and allowing the solution to stand till cold. In many cases it will be found preferable to the ointment; being the mildest, least painful, and cleanest. Another mode of employing emetic tartar externally is by sprinkling from ten to thirty grains of the salt in fine powder over a Burgundy pitch plaster.

1. ***Vinum Antimonii Potassio-tartratis***, Ph. L.; *Vinum Antimonii*, Ph. U. S. (Emetic tartar, ℈ij.; Sherry wine, f℥xx.) *Liquor Tartari Emetici* (emetic tartar, ℈j.; hot distilled water, f℥viij.; rectified spirit, f℥ij.) The Edinburgh formula is essentially the same as that of London. In all these formulæ the solution contains two grains of emetic tartar to one fluidounce of the liquid. It is important that Sherry, and not an inferior kind of wine, be employed: for the latter frequently contains matters which precipitate the sesquioxide of antimony. If the wine be good, and the salt pure, no precipitate is formed in the solution, unless it be kept for a long period, when decomposition of the salt ensues. The Dublin formula is objectionable on account of its want of colour.

Antimonial wine is used, as a diaphoretic or expectorant, in doses of from ten to thirty drops frequently repeated; as a nauseant, from one to two fluidrachms; as an emetic, about half a fluidounce, or two fluidrachms given at intervals of about ten minutes for four or five times, or until the desired effect is produced; as an emetic for children, from thirty drops to a fluidrachm; as an antiphlogistic in peripneumonia, from two or three fluidrachms to an ounce; but for this purpose an extemporaneous but carefully made aqueous solution is to be preferred.

2. ***Unguentum Antimonii Potassio-Tartratis***, Ph. L. (Emetic tartar, in fine powder, ʒj.; lard, ℥iv. M.) *Unguentum Tartari Emetici*, Ph. Dub. (Half the strength of the London formula.) In the preparation of this ointment it is important that the emetic tartar be in the state of a very fine powder, in order to avoid the irritation produced by rubbing gritty particles on the skin. A portion of ointment about the size of a small nut is to be rubbed on the skin night and morning. After the use of it for two or three times, the painful condition of the part thereby induced commonly prevents further employment of friction. It is sometimes applied, spread on linen, without rubbing. By either of these methods a crop of painful pustules is produced: but the facility and rapidity with which they are developed varies considerably in different individuals. Occasionally adventitious eruptions have appeared in other parts of the body, which have been ascribed to absorption of antimony into the system (*Gaz. Méd.* 1832, p. 842.) But I believe with Rayer (*Treat. on Diseases of the Skin*, by Dr. Willis, p. 540), that they arise from the inadvertent application of the ointment to these parts. This ointment is used as a counter-irritant in various chronic maladies: thus it is applied to the chest in pulmonary affections, and to the joints in chronic diseases (whether rheumatic or otherwise). It should only be applied to sound portions of skin, and, therefore, leech-bites, the scarifications from cupping, wounds, &c. are to be carefully avoided: for severe inflammation and even gangrenous ulceration may be produced by not attending to this caution. I have before mentioned (p. 411) that in a very few cases severe and even fatal constitutional disorder has appeared to have resulted from the use of antimonial ointment.

ANTIDOTE.—Promote vomiting by tepid bland liquids. The antidote is said to be tannic acid, and vegetable substances which contain it (as yellow bark, tea, nutgalls, &c.) Faure (*Lond. Med. Gaz.* xvi. 703) recommends the decoction in preference to other preparations of yellow bark. But though cinchona decomposes emetic tartar it does not destroy its activity. Some years since, at the General Dispensary, I saw from 1 to 2 grains of this salt, mixed with either powder or decoction of yellow bark, given by Dr. Clutterbuck to nearly 100 patients: and in almost every instance nausea and vomiting occurred. The experience of Laennec (*Diseases of the Chest*, Forbes's Translation, 257), as well as of Rayer (*Dict. de Méd. et Chir. Prat.* iii. 57), is to the same effect. Opium is a most valuable agent for checking excessive evacuations. Venesection and the warm bath are also important means of relieving the gastro enteritis.

ORDER 18. GOLD AND ITS COMPOUNDS.

Au'rum.—Gold.

HISTORY.—Gold has been known from the most remote periods of antiquity. It was in common use 3,300 years since (*Exodus*, xi. 2), and was probably the first metal with which mankind was acquainted. The alchymists termed it *Sol* or *Rex metallorum*.

NATURAL HISTORY.—It is found only in the metallic state; commonly alloyed with other metals, especially with silver, tellurium, copper, and iron. It occurs in veins in primitive rocks; and is also found in alluvial deposits in small lumps or particles called *gold dust*. It is found in several parts of Europe, Asia, and Africa, but principally in America, especially the southern part.

PREPARATION.—The mode of extracting gold varies in different places, principally according to the nature of the gangue. The ore is freed as much as possible from foreign matters, by mechanical processes (stamping, washing, &c.); and sometimes by roasting; and is then smelted with some flux, as borax, to separate the stony matters. Or it is fused with lead, and afterwards submitted to cupellation: or amalgamated with mercury, and, after straining, distilled.

The separation of gold from silver (*parting*) may be effected in the *dry way* by fusion, either with sulphur, by which metallic gold and sulphuret of silver are procured, or with sesquisulphuret of antimony, by which sulphuret of silver and an alloy of gold and antimony are procured: the last mentioned metal may be separated by heating the alloy in the air, as well as by other methods. Gold may also be freed from silver in the *wet way* by the process of *quartation*: that is, by treating an alloy of three parts of silver and one of gold with nitric acid, which dissolves the silver.

PROPERTIES.—The crystalline forms of native gold are the cube, the regular octahedron, and their modifications. Pure gold has a rich yellow colour, a sp. gr. of 19·2 to 19·4, is soft, very ductile, and malleable, fuses at a bright red heat (2016° F. according to Daniell) and in the liquid state has a brilliant greenish colour. Its equivalent is somewhat uncertain: Gmelin fixes on 66,—Thompson, 100,—Berzelius, 99·6,—Turner, 199·2,—and Brande, 200: I shall adopt the last.

CHARACTERISTICS.—Gold is readily distinguished by its colour and softness, by its being unacted on by nitric acid, and by its ready solubility in nitro-hydrochloric acid. The solution is yellow, stains organic matters (as the skin) purple, throws down, by the addition of protosulphate of iron, metallic gold in the finely divided state, by protochloride of tin, a dirty purple precipitate (the *purple powder of Cassius*), and by protonitrate of mercury, a black precipitate: borax which has been touched with it acquires a pink or rose colour when fused with the blowpipe.

PHYSIOLOGICAL EFFECTS.—Gold, like other metals, has been frequently supposed to be inert while it retains its metallic condition, but in this as well as in some other instances the accuracy of the assumption has been denied. Both Chrestien (*Sur un Nouv. Remède dans le Traitm. des Mal. Vén.* Paris, 1811) and Niel (*Rech. et Observ. sur les Effets des Prép. d'Or*, Paris, 1821), as well as other writers, assert that finely divided metallic gold (*pulvis auri*) produces the same constitutional effects as those caused by the various preparations of this metal, but in a milder degree, while it excites little or no local irritation. It is said to promote the secretions of the skin, kidneys, and salivary glands.

USES.—It has been employed as an antivenereal and antiscrofulous remedy by Chrestien, Niel, and others, with considerable success. It is said to be preferable to the other preparations of this metal in delicate and nervous subjects, females, and infants. Gold leaf (*aurum foliatum* seu *lamellatum*) is used by dentists for filling decayed teeth, and formerly by apothecaries for covering pills (*ad inaurandas* seu *obducendas pilulas.*)

ADMINISTRATION.—It has been administered internally in doses of from a quarter of a grain to a grain three or four times a day. Chrestien used it by way of friction on the tongue and gums. Niel employed it endermically (that is, applied it to the skin deprived of the epidermis) in the form of ointment composed of one grain of gold and thirty grains of lard.

PULVIS AURI (Fr. Cod.) is prepared by rubbing leaf gold (*aurum in laminas exilissimas complanatum*) with sulphate of potash, sifting and washing with boiling water to remove the sulphate: or by adding protosulphate of iron to chloride of gold, and washing the precipitate, first with water, then with dilute nitric acid.

Au'ri Terchlo'ridum.—Terchlo'ride of Gold.

PREPARATION.—In the French Codex this is ordered to be prepared by dissolving, with the aid of heat, one part of gold in three parts of nitrohydrochloric acid. The solution is to be evaporated until vapours of chlorine begin to be disengaged, and then allowed to crystallize.

PROPERTIES AND COMPOSITION.—Chloride of gold is in the form of small crystalline needles, of an orange-red colour, inodorous, and having a strong, styptic, disagreeable taste. It is deliquescent, on which account it should be preserved in a well-stoppered bottle: it is soluble in water, alcohol, and ether. When heated it evolves chlorine, and is converted, first into protochloride, and then into metallic gold, which is left in the spongy state. It reddens litmus, stains the cuticle purple, is reduced by many metals (as iron, copper, tin, zinc, &c.), by several of the non-metallic elementary substances (as phosphorus), by some metallic salts (as protosulphate of iron), and by many organic bodies (as charcoal, sugar, gum, gallic acid, extractive, &c.), all of which, therefore, are incompatible with it. Nitrate of silver occasions a precipitate of chloride of silver and oxide of gold: hydrochloric acid removes the latter.—(For other characteristics, *vide* p. 422). Terchloride of gold consists of 1 eq. gold $= 200 + 3$ eqs. chlorine, 108. The before-mentioned crystals also contain hydrochloric acid: hence they are regarded by some as constituting a double chloride of hydrogen and gold.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—Orfila (*Toxicol. Gén.*) examined the effects of the chloride of gold on animals, and infers from his experiments, that when introduced into the stomach it acts as a corrosive, but with less energy than the bichloride of mercury, and destroys animals by the inflammation of the coats of the alimentary canal which it sets up.

(*b.*) *On man.*—On man its effects are analogous to those of bichloride of mercury. In *small doses* it acts, according to Dr. Chrestien, more energetically as a stimulant, though less powerfully as a sialogogue, than corrosive sublimate. It promotes the secretions of the skin, the salivary glands, and the kidneys. Taken to the extent of one-tenth of a grain daily, it has occasioned violent fever. "This excitation," says Chrestien, "I regard as indispensably necessary for the cure of the diseases against which I administer gold: restrained within proper limits, it is never accompanied with any remarkable or even sensible lesion of the functions. The mouth is good, the tongue moist, the appetite continues, the bowels are not disordered, and there is ordinarily only augmentation of urine and transpiration: but if carried too far, we incur the risk of producing general erethism, inflammation of this or that organ, according to the predisposition of the patient, which will not only check the treatment, but may even induce a new disease, often more troublesome than the original one. The suspension or modification of the remedy should be governed by the unusual and sustained heat of skin." Cullerier, the nephew (Magendie, *Formulaire*, 8^{me} ed. p. 365), has seen one-fifteenth of a grain excite, at the second dose, gastric irritation, dryness of the tongue, redness of the throat, colic, and diarrhœa. When it promotes the secretion of saliva it does not, as mercury, affect the teeth and gums (Grötzner, *Rust's Magaz.* B. 21, quoted by Wibmer). Magendie (*op. cit.*) has seen violent gastritis, accompanied by nervous symptoms (cramps and pains in the limbs, agitation, and loss of sleep), and afterwards great heat of skin, obstinate sleeplessness, and fatiguing erections. In *large doses* it would probably occasion symptoms analogous to those produced by the use of poisonous doses of bichloride of mercury.

USES.—It has been employed, with variable success, as a substitute for mercury in the treatment of the secondary symptoms of syphilis. A more extended experience of it is, however, necessary to enable us to speak of its remedial powers with confidence. In the hands of Chrestien (*op. cit.*), Niel (*op. cit.*), Cullerier (*Dict. des Sciences Méd.* xxxvii. art. *Or*), Legrand (*De l'Or, de son emploi dans le Traitement de la Syphilis*, Paris, 1832), and others, it has proved most successful.

It has also been used in scrofulous affections, bronchocele, chronic skin diseases, scirrhous tumors, &c. Duportal (*Ann. de Chimie*, lxxviii. 55) cured a case of obstinate ulceration of the face, regarded by him as cancerous, and which had resisted all the ordinary methods of cure.

Legrand (*Lond. Med. Gaz.* xx. 414) has used chloride of gold, acidified with nitric acid, as a caustic, in syphilitic, scrofulous, and scorbutic ulcers, cancerous growths, and ulcerations of the neck of the uterus.

ADMINISTRATION.—Internally it has been given in doses of one-twentieth of a grain, made into pills with starch. But as organic matters decompose it, it is better to use it in solution in distilled water, or apply it by friction to the mouth, in quantities of one-sixteenth to one-sixth of a grain.

Antidote.—The same as for poisoning by bichloride of mercury.

So'dii Au'ro-Terchlo'ridum.—Au'ro-Terchlo'ride of So'dium.

In the French Codex this is ordered to be prepared by dissolving 85 parts by weight of terchloride of gold, and 16 parts of chloride of sodium, in a small quantity of distilled water: the solution is to be evaporated by a gentle heat until a pellicle forms, and then put aside to crystallize.

The auro-terchloride of sodium crystallizes in orange-coloured quadrangular, elongated prisms, which are permanent in the air; but when they contain any uncombined terchloride of gold, they are slightly deliquescent. They are soluble in water. When heated, chlorine is evolved, and a mixture of gold and chloride of sodium is left behind. They consist of 1 eq. terchloride of gold = 308; 1 eq. of chloride of sodium = 60, and 4 eqs. of water = 36.

Its effects and uses are analogous to the terchloride of gold, over which it has the advantages of being more constant and less costly; in consequence of which it is the most used of the auric preparations. It is exhibited internally in doses of one-twentieth to one-tenth of a grain, made into pills with starch or lycopodium. Mixed with twice its weight of orris powder or lycopodium, it may be used in frictions on the tongue and gum. An ointment (composed of one grain to thirty-six grains of lard) may be applied, endermically, to the skin, deprived of its epidermis by a blister.

Au'ri Terox'ydum.—Terox'ide of Gold.

This substance, sometimes called *peroxide of gold* or *auric acid*, is ordered, in the French Codex, to be prepared by boiling 4 parts calcined magnesia with 1 part terchloride of gold and 40 parts of water. Then wash, first with water, to remove the chloride of magnesium, afterwards with dilute nitric acid, to dissolve the excess of magnesia.

Teroxide of gold is brown; in the state of hydrate reddish yellow. It is reduced by heat and solar light. It is insoluble in water, but is soluble in hydrochloric acid (forming terchloride of gold), and in alkalies (forming aurates). It consists of 3 eqs. oxygen, 24 + 1 eq. gold = 200.

It is used internally, in venereal and scrofulous diseases, in doses of from one-tenth of a grain to a grain, made into the form of pills with extract of mezereon.

Aurate of Ammonia. Ammoniuret of teroxide of gold: fulminating gold.—This is prepared by adding ammonia to a solution of chloride of gold. It is a yellowish brown powder, which explodes when heated to 400°. It has been employed in the same cases as the preceding compounds, as well as in fevers, nervous affections, &c. In some cases it has produced very serious and even fatal results (Plenck, *Toxicologia*, ed. 2^{nda}. 230).

Purpura Mineralis Cassii. Purple of Cassius: Aurum Stanno paratum, Fr. Cod.—The nature of this compound is so imperfectly known, that it is impossible at present to assign to it its proper chemical name. Its active principle is probably oxide of gold. There are several methods of preparing it: the simplest is to add a solution of protochloride of tin to a solution of chloride of gold, until a precipitate is no longer produced. Filter and dry the precipitate.

The purple of Cassius is soluble in ammonia, and does not form an amalgam with mercury: hence it does not appear to contain any metallic gold. Its composition varies according to the mode of procuring it. Gold, oxygen, and tin, are its essential constituents.

This preparation is used in the same cases as the other preparations of gold.

Au'ri Io'didum.—Io'dide of Gold.

This is ordered to be prepared, in the French Codex, by adding a solution of iodide of potassium to a solution of chloride of gold. Double decomposition takes place, and iodide of gold falls down. This is to be collected on a filter, and washed with alcohol, to remove the excess of iodine which precipitates with it.

Iodide of gold is of a greenish yellow colour, insoluble in cold water, but slightly soluble in boiling water. Heated in a crucible it evolves iodine vapour, and is converted into metallic gold. It is probably composed of 1 eq. iodine = 126, and 1 eq. gold = 200.

It has been employed internally, in venereal affections, in doses of from one-fifteenth to one-tenth of a grain. Externally it has been applied in the form of ointment to venereal ulcers (Pierquin, *Journ. de Progrès.*)

Au'ri Tercyan'idum.—Tercy'anide of Gold.

The directions for preparing this salt, in the French Codex, are somewhat diffuse. The process consists essentially in very carefully adding a solution of pure cyanide of potassium to a solution of chloride of gold, until a precipitate (cyanide of gold) ceases to be formed. The chloride of gold, prior to solution, should be deprived of all excess of acid by heating it in a salt-water bath.

Cyanide of gold is a yellow powder, which is insoluble in water. It consists, probably, of 3 eqs. cyanogen = 78, and 1 eq. gold 200. It has been used in venereal and scrofulous affections, both externally and internally. The dose is from one-fifteenth to one-tenth of a grain, made into a pill, with some inert powder.

ORDER 19. SILVER AND ITS COMPOUNDS.

Argen'tum.—Sil'ver.

HISTORY.—Silver, like gold, has been known from the most remote periods of antiquity, being mentioned in the earliest books of the Old Testament (*Genesis*, xliv. 2; *Job*, xxii. 25). It was termed by the alchymists and astrologers, *Diana* or *Luna*.

NATURAL HISTORY.—It is found in the mineral kingdom in various states; sometimes nearly pure; or alloyed with other metals (especially gold, antimony, tellurium, arsenicum, and copper); or combined with sulphur, selenium, iodine, or chlorine; or united to oxygen and carbonic acid. Of these, native silver and the sulphuret are by far the most abundant.

PREPARATION.—The processes followed for the extraction of silver vary in different places, according to the nature of the ore: they are principally *amalgation* and *cupellation*. At Freyberg the ore is mixed with common salt, and roasted, by which the sulphuret of silver is converted into the chloride of this metal: water and iron are then added, to remove the chlorine, and the disengaged silver is finally dissolved in mercury (*amalgamation*), and the solution submitted to distillation, by which the mercury is volatilized, and the silver left behind (J. H. Vivian, in Taylor's *Records of Mining*, p. 21). The process of amalgamation followed in America is somewhat different (Boussingault, *Ann. de Chim.* li. 337; also Ward, *Mexico in* 1827, vol. ii. 437).

Silver is obtained from argentiferous galena, as follows:—The ore is first roasted to expel the sulphur, and afterwards smelted with charcoal. The argentiferous lead is then submitted to cupellation, by which the lead becoming oxidized, is partly volatilized, and partly sinks into the cupel (*cineritium*), leaving the silver. (On the smelting processes of Hungary, Saxony, &c., consult Taylor's *Records of Mining*, p. 51).

Pure silver is obtained by immersing a copper rod in a solution of the nitrate. The precipitate is to be digested in caustic ammonia, to remove all traces of copper, and afterwards washed with water.

PROPERTIES.—In the native state, silver occurs crystallized in the cube and regular octahedron. When pure this metal is white, with a slight shade of yellow; inodorous and tasteless. It is moderately hard and elastic; very ductile and malleable: a single grain may be drawn out into 400 feet of wire, and leaf silver (*argentum in laminas extensum; argentum foliatum*) may be procured, whose thickness is only $\frac{1}{1000000}$ of an inch. Its sp. gr. is 10·474. It melts at a bright red heat (1873° F. according to Daniell). When exposed to the air it does not oxidate, but readily tarnishes by sulphureous vapours. Its equivalent is 108.

CHARACTERISTICS.—It is soluble in nitric acid: the solution thus obtained throws down a white precipitate—[see the properties of this chloride, p. 105]—with hydrochloric acid or the chlorides; white also with the alkaline carbonates, oxalates, and ferrocyanides; yellow with the phosphates and arsenites; red with the arseniates; olive-brown with the alkalies or lime water; metallic silver with phosphorus or copper; black with hydrosulphuric acid.

PURITY.—The silver of the shops usually contains traces of gold and copper.

PHYSIOLOGICAL EFFECTS.—Silver in the metallic state is totally inert.

USES.—In pharmacy it is used for the preparation of the nitrate which is employed as a medicine and as a test.

Silver leaf is used for filling the hollows of decayed teeth, and was formerly employed to cover pills. An amalgam of silver is also used by some dentists for stopping teeth. It is objectionable on account of its blackening them.

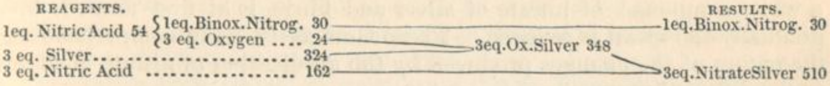
Argen'ti Ni'tras.—Ni'trate of Sil'ver.

History.—Geber (*Invent. of Verity*, ch. xxi.) describes the method of preparing crystallized nitrate of silver. When this salt is fused, it is termed *the infernal stone* (*lapis infernalis*) or *lunar caustic* (*causticum lunare*).

Preparation.—In the London Pharmacopœia it is directed to be prepared by dissolving one ounce and a half of silver in a mixture of one fluidounce of nitric acid and two fluidounces of distilled water. The solution is afterwards to be evaporated to dryness, and the dried nitrate fused and poured into proper moulds.

The fusion may be more readily and safely effected in a Berlin porcelain capsule over a spirit or gas lamp, by means of Griffin's lamp furnace, than in a crucible over a slow fire, as directed in the Pharmacopœia.

The *theory* of the process is readily comprehended. Three equivalents or 324 parts of silver abstract three equivalents or 24 parts of oxygen from one equivalent or 54 parts of nitric acid, thereby disengaging one equivalent or 30 parts of binoxide of nitrogen, and forming three equivalents or 348 parts of oxide of silver, which unite with three equivalents or 162 parts of nitric acid to form three equivalents or 510 parts of nitrate of silver.



Properties.—Nitrate of silver forms transparent, colourless crystals, whose primary form is the right rhombic prism. Its taste is strongly metallic and bitter. When heated it fuses: if the temperature be increased, decomposition ensues; nitric acid and oxygen are evolved, leaving metallic silver. It is soluble in both water and spirit. It does not deliquesce: when exposed to the atmosphere and solar light it blackens, probably from the action of organic matter, hydrosulphuric acid, or water contained in the atmosphere. Mr. Scanlan (*Athenæum*, Aug. 25, 1838) finds that nitrate of silver in a clean dry glass tube, hermetically sealed, undergoes no change of colour by exposure to solar light: the contact of organic matter readily occasions it to become black.

Characteristics.—It is known to be a nitrate by its deflagration when heated on charcoal, and the evolution of nitrous fumes. Its characters as a silver salt have been already described (p. 426.)

Composition.—Nitrate of silver is thus composed:—

	Eq.	Eq.Wt.	Per Cent.	Proust.
Oxide of Silver	1	116	68·23	69·5
Nitric Acid	1	54	31·76	30·5
Nitrate of Silver	1	170	99·99	100·0

Purity.—Nitrate of silver should be white, and completely soluble in distilled water. By the action of organic matters it blackens from a partial reduction. The presence of copper may be detected in its solution by the blue colour produced with caustic ammonia. The watery solution from which the silver has been thrown down by hydrochloric acid should be unchanged by the addition of hydrosulphuric acid, shewing the absence of lead and copper; and be completely volatilized by heat: if any saline residuum be obtained, the nitrate was adulterated. The white precipitate produced with either hydrochloric acid or chloride of sodium should be readily dissolved by caustic ammonia: if chloride of lead be present the effect will be otherwise.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—Orfila (*Toxicol. Gén.*) found that it acted on animals as a powerfully corrosive poison. When dogs were made to swallow it, gastro-enteritis was induced. No symptoms indicating its absorption were observed. Dissolved in water, and thrown into the jugular vein, it produced difficult respiration, convulsive movements, and speedy death.

(*b.*) *On man.*—The *local action* of nitrate of silver is that of a caustic or corrosive. This might be expected, from observing its action on albumen and fibrin—substances which form the principal part of the animal textures. If a solution of nitrate of silver be added to an albuminous liquid, a white curdy precipitate is formed, composed of nitrate of silver and albumen, insoluble in caustic ammonia; and after some time becoming coloured and ultimately blackish, from the partial or complete reduction of the silver: a soluble compound of albumen and nitrate of silver is formed simultaneously with the insoluble one. The action of nitrate of silver on fibrin is analogous to that on albumen: that is, a white compound of nitrate of silver and fibrin is at first formed, but gradually the metal is reduced. These facts assist us in comprehending the nature of the changes produced by the application of nitrate of silver to the different tissues.

Applied to the skin it produces first a white mark (owing to its union with the coagulated albumen of the cuticle): gradually this becomes bluish grey, purple, and ultimately black, owing to the partial reduction of the silver. If the integument be moistened, and the nitrate applied three or four times, it causes at the end of some hours vesication, which is attended with less pain than that produced by cantharides. In some cases it excites acute pain. In one instance in which I applied it freely to the scalp for a cutaneous affection, fever with delirium was produced, which endangered the life of the patient (a girl of six years.) This is deserving of notice, because in Mr. Higginbottom's work (*Essay on the Use of the Nitrate of Silver*, 2d ed. p. 198) we are told that nitrate of silver applied as a vesicant "causes scarcely any constitutional irritation, even in children." In a few days the black and destroyed cuticle cracks and falls off, without any destruction of the subjacent cutis vera.

Applied to the hair or nails the nitrate stains them black, as in the case of the cuticle; and, in consequence, it is one of the substances employed as a hair-dye. When recently applied, the black tint of the hair, and even of the cuticle, may be removed by washing with a solution of chloride of sodium, and then with ammonia-water, to dissolve the chloride of silver which is produced (*Journ. de Chim. Méd.* vii. 542.) To detect silver in stained hair, the latter is to be treated with chlorine, by which chloride of silver is produced, which is soluble in ammonia, and precipitable from its solution by nitric acid (Devergie, *Méd. Leg.* ii. 933.) Part of the black colour of the hair stained by the nitrate probably depends on the formation of sulphuret of silver.

When nitrate of silver is applied to an ulcer it produces a white film (owing to its union with the albumen, and perhaps also with the chloride, of the secretion.) This film in a few hours assumes a dark colour, and ultimately forms a black eschar. This hardens, and in few days becomes corrugated, separates at the edges, and at length peels off altogether, leaving the surface of the sore beneath in a healed state (Higginbottom, *op. cit.* p. 10.) The intensity of the pain varies much in different cases; but it is, on the whole, very much less than might be imagined by those who have not tried this remedy.

When applied to mucous membranes, a similar white compound of the nitrate with the animal matter of the secreted mucus is formed, and this defends the living tissue from the action of the caustic, so that the effects are not so violent as might be expected. Thus the solid nitrate may be applied to the mucous surface of the vagina, and even to the os uteri, in cases of leucorrhœa and gonorrhœa, oftentimes without exciting any pain or inflammation: in some instances, however, it produces smarting pain, which lasts for several hours, but no serious effects have resulted from its use, even when, by accident, two drachms of nitrate have been left to dissolve in the vagina. (Dr. Hannay, *Lond. Med. Gaz.* xx. 185; also Mr. Bell, *ibid.* 473; and Dr. Jewel, *Prat. Observ. on Leucorrhœa.*)

Its chemical effects on the other mucous membranes are analogous to those just mentioned; but the pain which it produces varies with different membranes, and in the same membrane under different states. Its application to the conjunctiva is attended with acute pain, (especially when inflammation is going on) though in general it soon subsides. On all these surfaces it acts as an astringent.

The safety with which, in most cases, large doses of the nitrate are administered internally, must depend on the presence of the mucus which lines the internal coat of the stomach; the animal matter of which combining with the nitrate prevents its action on the living tissue. It is deserving of especial notice that larger doses may be exhibited without inconveniencing the stomach, in the form of pill, than in that of solution. Dr. Powell (*Med. Trans. of the College of Phys.* iv. 85) in some cases was enabled to give 15 grains at a dose in the form of pills, while he rarely found stomachs that could bear more than five grains in solution. Fouquier (*Dict. Mat. Méd.* i. 403) has also remarked the greater activity of the solution. If cautiously exhibited, beginning with small doses and gradually increasing them, it may be exhibited for a considerable period without producing any obvious changes in the corporeal functions, though it may be exercising a beneficial influence over the constitution, evinced by its amelioration of certain diseases, as epilepsy. In some cases it has caused an eruption (Sementini, *Quart. Journ. of Science*, xii. 189; Copland, *Dict. Pract. Med.* i. 68.) If the dose be too large it causes gastrodynia, sometimes nausea and vomiting, and occasionally purging. Taken in an excessive dose it acts as a corrosive poison; but cases of this kind are very rarely met with. Boerhaave mentions an instance in which it caused excruciating pain, gangrene, and sphacelus of the first passage.

All the above-mentioned symptoms are referrible to its local action, and from them we have no evidence of its absorption, or of the nature of its influence over the general system. But the discoloration of the skin, presently to be noticed, fully proves that absorption does take place when the medicine is exhibited in small but long-continued doses. It exercises a specific influence over the nervous system; at least I infer this, partly from the effects observed by Orfila when it was injected into the veins of animals, and partly from its occasionally curative powers in affections of his system, as epilepsy and chorea.

The blueness, or slate colour, or bronze hue of the skin just alluded to, has been produced in several patients who have continued the use of the nitrate during some months or years (*Medico-Chirurg. Trans.* vii. and ix.) In some of the cases the patients have been cured of the epilepsy for which they took the medicine; in others the remedy has failed (Rayer, *Treatise on Skin Diseases, by Willis*, 961). In one instance which fell under my notice, the patient, a highly respectable gentleman, residing in London, was obliged to give up business in consequence of the discoloration; for when he went into the street, the boys gathered around him, crying out "there goes the blue man." In this instance no perceptible diminution of the colour had occurred for several years, but in some cases it fades in intensity. The corion is the essential seat of it. Dr. Baddeley (*Med.-Chir. Trans.* ix. 238) found that blisters rose white,—a proof that in his patient the colouring matter was below the epidermis. But in some instances the cuticle and corpus mucosum of the face and hands participate in the tint. In one instance the mucous membrane of the stomach and intestines was similarly tinted. A case is mentioned by Wedemeyer (*Lond. Med. Gaz.* iii. 650) of an epileptic who was cured by nitrate of silver, but eventually died of diseased liver and dropsy: all the internal viscera were more or less blue, and Mr. Brande obtained metallic silver from the plexus choroides and pancreas. The discoloration of the skin is usually regarded as permanent and incurable; but I have been informed that in one instance washes of dilute nitric acid diminished it. If this observation be correct, I would suggest the exhibition of nitric acid internally, as well as its external use. Dr. A. T. Thomson (*Elem. of Mat. Med.* i. 715) suggests that if nitric acid were conjoined with nitrate of silver, the discoloration might be prevented; and the suggestion certainly deserves attention. But I would observe, that if the acid should prove efficacious, his hypothesis, that the colour depends on blackened chloride of silver, will be disproved; for nitric acid can neither prevent the action of the compounds of chlorine on the salts of silver, nor can it dissolve the white chloride or the black subchloride.

USES.—Nitrate of silver has been employed *internally* in a very few cases only; and of these the principal and most important are epilepsy, chorea, and angina pectoris. Its liability to discolour the skin is a great drawback to its use; indeed, I conceive that a medical man is not justified in risking the production of this effect without previously informing his patient of the possible result.

In *epilepsy* it has occasionally, perhaps more frequently than any other remedy, proved successful. Dr. Sims (*Mem. of the Med. Soc. of Lond.* iv. 379), Drs. Baillie, R. Harrison, Roget, and J. Johnson (*Treat. on Nerv. Dis.* by J. Cooke, M.D. ii. Pt. 2, 147), have all borne testimony to its beneficial effects. Its *methodus medendi* is inexplicable. This, indeed, is to be expected, when it is considered that the pathology and causes of epilepsy are so little known, and that, as Dr. Sims has justly observed, every thing concerning this disease is involved in the greatest doubt and obscurity, if we except the descriptions of a single fit, and that it returns at uncertain intervals. In this state of ignorance, and with the already-mentioned facts before us, as to the curative powers of this salt, the observation of Georget (*Physiol. du Système Nerv.* ii. 401), that he has great difficulty in conceiving how the blindest empiricism should have led any one to attempt the cure of a diseased brain by cauterizing the stomach, is, I conceive, most absurd, and unwarranted. The cases which have been relieved by it are probably those termed by Dr. M. Hall (*Lect. on the Nerv. System*, p. 143) eccentric. In the few instances in which I have seen this remedy tried, it has proved unsuccessful; but it was not continued long, on account of the apprehended discoloration of the skin.

In *chorea* it has been successfully employed by Dr. Powell (*Med. Trans. of the College of Phys.* iv. 85), Dr. Uwins (*Ed. Med. and Surg. Journ.* viii. 407), Dr. Crampton (*Trans. of the King and Queen's College of Phys.* iv. 114), Lombard (*Rust's Magaz.* xl.), and others. In *angina pectoris* it has been administered in the intervals of the paroxysms with occasional success by Dr. Cappe (*Duncan's Annals of Med.* iii.), and by Dr. Copland (*op. cit.*) *In chronic affections of the stomach* (especially morbid sensibility of the gastric and intestinal nerves) it has been favourably spoken of by Autenreith (Dierbach's *Neust. Entdeck. in d. Mat. Med.* 1837, i. 528), Dr. James Johnson (*On Indigestion*, 2d ed. p. 87), and Rueff (Diebach, *op. cit.*; also *Americ. Journ. of Med. Scien.* May 1837, p. 225). It has been employed to allay chronic vomiting connected with disordered innervation, as well as with disease of the stomach (scirrhus and cancer), and to relieve gastrodynia. The foregoing are the most important of the diseases against which nitrate of silver has been administered internally.

As an *external agent* its uses are far more valuable, while they are free from the danger of staining the skin. It is employed sometimes as a *caustic*, and as such it has some advantages over potassa fusa and the liquid corrosives. Thus, it does not liquify by its application, and hence its action is confined to the parts with which it is placed in contact. It is used to remove and repress spongy granulations in wounds and ulcers, and to destroy warts, whether venereal or otherwise. It is applied to chancres on their first appearance, with the view of decomposing the syphilitic poison, and thereby of stopping its absorption, and preventing bubo or secondary symptoms. This practice has the sanction of Mr. Hunter. I have several times seen it fail, perhaps because it was not adopted sufficiently early. The nitrate should be scraped to a point, and applied to every part of the ulcer. This mode of treating chancres has been recently brought forward by Ratier (*Arch. Gén. de Méd.* xv. 47, and xvi. 62) as if it were new, and as forming part of Bretonneau's *ectrotic* (*ectrotica*, ἐκτιτρώσκω, *I abort*,) method of treating diseases!

The application of nitrate of silver to *punctured wounds* is often attended with most beneficial effects, as Mr. Higginbottom (*op. cit.*) has fully proved. It prevents or subdues inflammatory action in a very surprising manner. It is equally adapted for poisoned as for simple wounds. To promote the healing of *ulcers* it is a most valuable remedy. In large indolent ulcers, particularly those of a fistulous or callous kind, it acts as a most efficient stimulant. To small ulcers it may be applied so as to cause an eschar, and when at length this peels off, the sore is found to be healed. Mr. Higginbottom (*op. cit.* p. 11,) asserts that "in every instance in which the eschar remains adherent from the first application, the wound or ulcer over which it is formed invariably heals." Dry lint will, in general, be found the best dressing for sores touched with the nitrate.

Nitrate of silver was proposed by Mr. Higginbottom as a topical remedy for external inflammation. It may be applied with great advantage to subdue the inflammatory action of erythema, of paronychia or whitlow, and of inflamed absorbents. In some cases it is merely necessary to blacken the cuticle; in others, Mr. Higginbottom recommends it to be used so as to induce vesication. In what way it subdues inflammation—in other words, its *methodus medendi*—is completely unknown.

Bretonneau and Serres (*Arch. Gén. de Méd.* viii. 220 and 427) recommend the *cauterization of variolous pustules* by nitrate of silver, in order to cut short their progress. It is principally useful as a means of preventing pitting, and should be employed on the first or second day of the eruption. The solid caustic is to be applied to each pustule after the apices have been removed. This etrotic method has also been employed in the treatment of *shingles* (herpes zoster): in one case the disease was cured in a few hours (*Arch. Gén. de Méd.* xviii. 439). Some good rules for its application have been laid down by Rayer (*Treatise on Skin Diseases*, by Willis, p. 260).

In some diseases of the eye nitrate of silver is a most valuable remedial agent. It is used in the solid state, in solution, and in ointment: the solution may be used as a wash or injection, or applied by a camel's hair pencil. In deep ulcers of the cornea, the solid nitrate should be applied,—in superficial ones, a solution (of from 4 to 10 grains of the salt to an ounce of distilled water) may be employed (Mackenzie, *On the Diseases of the Eye*, 2d ed. 578). There is one drawback to the use of this substance in ulcers of the cornea, as well as other affections of the eye; viz. the danger of producing dark specks in the cornea, or of staining the conjunctiva (Jacob, *Dubl. Hosp. Rep.* v. 365). In both acute and chronic ophthalmia, Mr. Guthrie (*Lond. Med. and Phys. Journ.* lx. 193, lxi. 1) employs this salt in the form of ointment (Arg. Nitr. gr. ij. ad gr. x.; Liq. Plumbi Subacet. gtt. xv.; Ung. Cetacei, ℥j.) Of this he directs a portion (varying in size from a large pin's head to that of a garden pea) to be introduced between the lids by the finger or a camel's hair pencil. It causes more or less pain, which sometimes lasts only half an hour, at others till next day. Warm anodyne fomentations are to be used; and the application of the ointment repeated every third day. In acute cases, two or three applications will arrest the disease. With this treatment, blood-letting, and the use of calomel and opium, are preceded or conjoined. (For some judicious remarks on this practice, consult the article *Ophthalmia*, by Dr. Jacob, in the *Cyclop. of Pract. Med.* iii. 201). While many surgeons hesitate to use nitrate of silver in the first stage of acute purulent ophthalmia, all are agreed as to its value in the second stage of the disease, as well as in chronic ophthalmia. Besides the diseases of the eye already mentioned, there are many others in which the oculist finds this salt of the greatest service, as a caustic, astringent, or stimulant. (Vide Dr. Mackenzie's *Treat. on Diseases of the Eye;* and Mr. Ryall's paper, in the *Trans. of the King and Queen's College of Phys.* v. 1).

In *inflammatory affections and ulcerations of the mucous membrane of the mouth and fauces*, nitrate of silver is sometimes a most valuable application (Hunt, *Lond. Med. Gaz.* xiii. 129). When the fibrinous exudation of croup commences on the surface of the tonsils and arches of the palate, its further progress may be stopped, according to Mr. Mackenzie (*Edin. Med. and Surg. Journ.* xxiii. 294), by the application of a solution composed of a scruple of nitrate of silver and an ounce of distilled water. The solid nitrate has been introduced through an aperture in the trachea, and applied to ulcers on the inner surface of the larynx, in a case of phthisis laryngea, with apparent benefit, (Liston, *Elements of Surgery*, part ii. p. 256).

In some forms of *leucorrhœa* the application of nitrate of silver, either in the solid state or in solution, is attended with beneficial effects. This practice was first recommended by Dr. Jewel (*Pract. Observ. on Leucorrhœa*, 1830). It is, I believe, most successful in cases dependent on local irritation or subacute inflammation, and not arising from constitutional debility. The solution may be applied by a piece of lint or sponge, or may be injected by means of a syringe with a curved pipe. Its strength must vary according to circumstances. Dr. Jewel generally employs three grains of the nitrate to an ounce of water; but in the Lock Hospital, solutions are sometimes used containing half a drachm or even two scruples to the ounce. In some cases the solid nitrate has been applied to the cervix uteri and vagina by means of a silver tube. In *gonorrhœa of the female* a solution of nitrate of silver, or even this caustic in the solid state, has been used with the best effects. It was first employed by Dr. Jewel, but subsequently, and on a much more extended scale, by Dr. Hannay (*Lond. Med. Gaz.* xx. 185), and without any injurious consequences. In many cases the discharge ceased, never to return, in twenty-four hours. The fear of ill effects has prevented the general adoption of this practice. In *gonorrhœa of the male*, the introduction of a bougie, smeared with an ointment of nitrate of silver, is, occasionally, a most effectual cure: but the practice is dangerous. In one case I saw acute and nearly fatal urethritis brought on by its employment. The individual was a dresser at one of the London hospitals, and had practised this mode of treatment in many instances on the hospital patients with the happiest results. An aqueous solution of the salt has been successfully used in chronic gonorrhœa (Rognetta, *Lancette Française*, Mar. 31, 1836).

In *fissured or excoriated nipples* the application of the solid nitrate of silver is of great service. It should be insinuated into all the chaps or cracks, and the nipple afterwards washed with tepid milk and water. (*Lond. Med. Gaz.* v. 207; xiv. 674, 719, and 754).

The application of solid nitrate of silver is a most effectual remedy for the different forms of *porrigo* which affect the heads of children. The caustic should be well rubbed into the parts. I have never known the practice to fail, or to cause the loss of hair. Where the greater portion of the scalp is involved, the different spots should be cauterized successively at intervals of some days; for, as already mentioned, I have seen fever and delirium produced in a child from the too extensive use of the remedy. In *psoriasis* the same medicine was found by Dr. Graves (*Lond. Med. Gaz.* vii. 520) most effectual. An aqueous solution of the nitrate is also valuable as an astringent wash in other skin diseases, as *impetigo*. The solid nitrate is sometimes employed to stop the progress of irritative or erysipelatous inflammation, by applying it in a circular form around, and at a little distance from, the inflamed portion; but I have frequently observed the inflammation extend beyond the cauterized part. Mr. Higginbottom (*op. cit.*) reports favourably of the effects of applying the nitrate to *burns* and *scalds;* and his observations have been confirmed by those of Mr. Cox (*Lond. Med. Gaz.* x. 672).

In strictures of the urethra and œsophagus, bougies armed with lunar caustic in their points (*the caustic* or *armed bougie*) are occasionally employed with great advantage, at least in urethral stricture. When the common bougie (*cereolus simplex*) is formed, the point of it should be heated with a conical piercer, and the caustic introduced while the composition is quite soft. The point of the bougie should then be rubbed smooth on a piece of polished marble till no inequality in the size of it appear (Dr. Andrews, *Observ. on the Applic. of Lunar Caustic to Strictures*, 1807, p. 126.) Notwithstanding that the application of nitrate of silver to stricture of the urethra has been advocated by Mr. Hunter, Sir E. Home, Mr. Wilson, Dr. Andrews, and others, it is now but little employed; yet of its efficacy and safety in many obstinate cases, where the simple bougie fails, I am assured by repeated observation. It is commonly supposed that it acts by burning or destroying the stricture: such is not the fact. It induces some change in the vital actions of the part, which is followed by relaxation of the narrowed portion of the canal, but which change is as difficult to explain as is the subduction of external inflammatory action by the application of this salt. Of the use of the caustic bougie in stricture of the œsophagus I have no experience.

ADMINISTRATION.—Nitrate of silver may be exhibited in doses of $\frac{1}{6}$ of a grain, gradually increased to three or four grains, three times a day. As before mentioned, Dr. Powell has augmented the dose to fifteen grains. The usual mode of administering it is in the form of pills made of bread-crumb; but the chloride of sodium, which this contains, renders it objectionable: some mild vegetable powder with mucilage is preferable. Common salt or salted foods should not be taken either immediately before or after swallowing these pills. Dr. Johnson (*Essay on Morbid Sensibility of the Stomach and Bowels*, 2d ed. p. 90), asserts "that there is no instance on record where the complexion has been affected by the medicine when restricted to three months' administration." It is advisable, however, not to continue the use of it beyond a month or six weeks at a time.

For external use an aqueous solution is employed of strengths varying from a quarter of a grain to two scruples, in an ounce of distilled water. The formula for Mr. Guthrie's ointment has already been given.

LIQUOR ARGENTUM NITRATIS, Ph. Lond. (Nitrate of silver, ʒj.; distilled water, f℥j. dissolve and strain. The solution is to be preserved from the light in a well-closed vessel.) It has been introduced into the Pharmacopœia merely as a test.

ANTIDOTE.—The antidote for nitrate of silver is common salt (chloride of sodium.) When this comes in contact with lunar caustic, nitrate of soda and chloride of silver are produced: the latter compound is, according to the experiments of Orfila (*Toxicol. Gén.*), innocuous; though it has been said to possess antisyphilitic powers (Serre, *Lond. Med. Gaz.* xvi. 703). The contents of the stomach should be removed, and the inflammatory symptoms combated by demulcents, bloodletting, and the usual antiphlogistic means.

When the local use of nitrate of silver causes excessive pain, relief may be gained by washing the parts with a solution of common salt. Pieces of caustic have been left in the vagina and urethra without unpleasant consequences resulting. Injections of a solution of common salt are the best means of preventing bad effects.

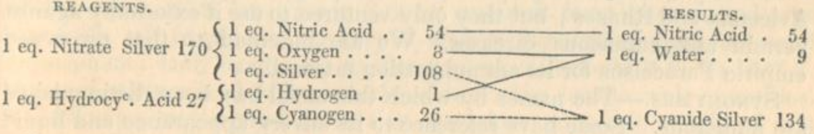
To diminish the slate-coloured tint of the skin arising from nitrate of silver, acids or the super-salts offer the most probable means of success. The external and internal use of dilute nitric acid, or the internal employment of bitartrate of potash, may be tried: the discoloration is said to have yielded to a steady course of the last-mentioned substance (*United States Dispensatory*).

Argen'ti Cyan'idum.—Cy'anide of Sil'ver.

History.—This compound, sometimes called *hydrocyanate, cyanuret,* or *cyanodide of silver*, or *argentum zootinicum*, has been studied by Scheele, Ittner, and Gay-Lussac.

Preparation.—In the London Pharmacopœia this compound is directed to be prepared by adding a pint (f℥xx.) of diluted hydrocyanic acid to a solution of two ounces and two drachms of nitrate silver in a pint of distilled water. The precipitate is to be washed with distilled water, and dried.

In this process one equivalent, or 27 parts of hydrocyanic acid react on one equivalent, or 170 parts of nitrate of silver: thereby generating one equivalent, or 134 parts of cyanide of silver, and one equivalent, or 9 parts of water, and setting free one equivalent, or 54 parts of nitric acid.



Properties.—When first thrown down it is a white curdy precipitate, which by drying becomes pulverent. It is insipid, insoluble in water, but dissolves in caustic ammonia. It is decomposed by hydrochloric and hydrosulphuric acid, both of which develope with it hydrocyanic acid. It combines with other metallic cyanides to form the *argento-cyanides.* By exposure to the atmosphere and solar rays it assumes a violet tint. It is not decomposed by mixture with neutral vegetable substances (*Journ. de Chim. Med.* 2nde Ser. iii. 407.)

Characteristics.—It is insoluble in cold nitric acid, but soluble in the boiling acid. When carefully dried and then heated in a glass tube it yields cyanogen gas (which is readily known by its combustibility and the bluish-red colour of its flame) and a residuum of metallic silver. The latter is recognised by the before-mentioned tests for this metal.

Composition.—The following is the composition of this substance:—

	Eq.	Eq.Wt.	Per Cent.
Silver	1	108	80·60
Cyanogen	1	26	19·40
Cyanide of Silver	1	134	100·00

Physiological Effects and Uses.—I am unacquainted with any experiments made to determine its effects on man or animals. Serre, of

Montpellier (*Journ. de Chim. Méd.* 2nde Ser. iii. 408) gave it in syphilitic maladies, in doses of one-tenth and even of one-eighth of a grain, without the least inconvenience. It has been introduced into the London Pharmacopœia, at the suggestion of Mr. Everitt, as a source of hydrocyanic acid (*vide* p. 237.)

Order 20. Mercury and its Compounds.

Hydrar′gyrum.—Mer′cury or *Quick′silver.*

History.—No mention is made of quicksilver in the Old Testament; nor does Herodotus allude to it. From this we might infer that both the ancient Hebrews and Egyptians were unacquainted with it. But we are told on the authority of an Oriental writer, that the Egyptian magicians, in their attempts to imitate the miracles of Moses, employed wands and cords containing mercury, which under the influence of the solar heat, imitated the motion of serpents (D'Herbelot, *Bibliothèque Orient.* art. *Moussa*). Both Aristotle and Theophrastus (*De Lapidibus*) mention ἄργυρος χυτὸς, (*argentum liquidum*): and the first of these naturalists says that Dædalus (who is supposed to have lived about 1300 years before Christ) communicated a power of motion to a wooden Venus by pouring quicksilver into it. We are also told that Dædalus was taught this art by the priests of Memphis. Pliny (*Hist. Nat.* lib. xxxiii.) and Dioscorides (lib. v. cap. cx.) also speak of mercury, and the latter writer describes the method of obtaining it from cinnabar.

Mercury was first employed medicinally by the Arabian physicians Avicenna and Rhazes; but they only ventured to use it externally against vermin and cutaneous diseases. We are indebted to that renowned empiric Paracelsus for its administration internally.

Synonymes.—The names by which this metal has been distinguished are numerous. Some have reference to its silvery appearance and liquid form; as ὑδράργυρος, *hydrargyrus* and *hydrargyrum*, (from ὕδωρ, *aqua*, and ἄργυρος, *silver*); others to its mobility and liquidity, as well as its similarity to silver, such as *argentum vivum*, *aqua argentea*, *aqua metallorum*, and *quicksilver*. It has been called *Mercury*, after the messenger of the gods, on account of its volatility.

Natural History.—Mercury is comparatively a rare substance. It is found in the metallic state, either pure (*native* or *virgin mercury*), in the form of globules, in the cavities of the other ores of this metal, or combined with silver (*native amalgam*). Bisulphuret of mercury (*native cinnabar*) is the most important of the quicksilver ores, since the metal of commerce is chiefly obtained from it. The principal mines of it are those of Idria in Carniola, and Almaden in Spain. The latter yielded 10,000 lbs. of cinnabar annually to Rome in the time of Pliny (*Hist. Nat.* xxxiii.) Protochloride of mercury (*mercurial horn ore* or *corneous mercury*) is another of the ores of mercury. Traces of this metal have also been met with in common salt, during its distillation with sulphuric acid, by Rouelle, Proust, Westrumb, and Wurzer (Gmelin, *Handb. d. Chemie*, i. 1282).

Preparation.—The extraction of quicksilver is very simple. In some places (as in the Palatinate and the duchy of Deux-Ponts) the native cinnabar is mixed with caustic lime, and distilled in iron retorts. In this process the lime abstracts the sulphur (forming sulphuret of calcium), and the disengaged mercury distils over. At Almaden the ore is roasted, by which the sulphur is converted into sulphurous acid, and the mercury volatilized. At Idria a modification of this process is followed (Dumas, *Traité de Chimie*, iv. 305).

COMMERCE. — Quicksilver is imported in cylindrical, wrought-iron bottles (holding from 60lbs. to 1 cwt.), the mouth of each being closed by an iron screw; and also in goat-skins, two or three times doubled. The quantities imported in the years 1827 and 1830, and the places from which the metal was brought, are thus stated in the parliamentary papers (*Statement of Imports and Exports*, for 1827 and 1830).

	1827.	1830.
Spain and the Balearic Islands	653,374	1,675,652
Gibraltar	121,320	—
Italy and the Italian Islands	108,567	331,416
	883,261	2,007,068

PROPERTIES.—At ordinary temperatures quicksilver is an odourless, tasteless, liquid metal, having a whitish colour, like silver or tin. Its sp. gr. is 13·5 or 13·6 When intimately mixed with pulverent or fatty bodies, it loses its liquid character, and it is then said to be *killed*, *extinguished*, or *mortified*. When cooled down to 38·66° F. it freezes, and crystallizes in needles and regular octahedrons. In this state it is ductile, malleable, and tenacious. At 656° F. it boils, and produces an invisible elastic vapour, whose sp. gr. is 6·976. Mr. Faraday (*Quart. Journ. of Science*, x. 354) has shown, that at common temperatures, and even when the air is present, mercury is always surrounded by a mercurial atmosphere; and, according to Stromeyer, at from 140° F. to 160° F. mercury, when mixed with water, is volatilized in considerable quantities. Chemists are not agreed as to the equivalent or atomic weight of this metal. Thus Dr. Thomson assumes 100; Gmelin, 101; Berzelius, 101·43; Brande, 200; Turner and Phillips, 202. I shall adopt the latter.

CHARACTERISTICS. (*a*.) *Of metallic mercury.*—In its metallic state mercury is distinguished by its liquidity at common temperatures, and by its volatility. When invisible to the naked eye, and in a finely divided state, it may be readily detected by the white stain (called by workmen *quickening*) communicated to gold and silver. Mercurial vapour may be detected by exposing gold or silver to its influence. If mercury be in combination with other metals, and the tests now mentioned be not applicable, we may dissolve the suspected substance in nitric acid, and proceed as for the mercurial salts.

(*b*.) *Of mercurial compounds.*—When heated with potash or soda, or their carbonates, globules of metallic mercury are obtained, which may be recognised by the properties already described. Solutions of the mercurial salts, placed for some time in contact with a piece of bright copper, and afterwards rubbed off with paper, leave a silvery stain behind, which disappears when heated to redness. Those compounds which are of themselves insoluble in water may be dissolved by digesting them with nitric acid; and the copper test may then be applied. In this way the mercury contained in calomel, vermilion, subsulphate and iodide of mercury, may be readily recognised. Sulphuretted hydrogen produces, with mercurial solutions, a black precipitate.

Solutions of the protosalts of mercury yield, with caustic potash or soda, a grey or black precipitate; and, with iodide of potassium, a greenish or yellow precipitate.

Solutions of the persalts yield, with caustic potash or soda, a yellow or reddish precipitate; and, with iodide of potassium, a scarlet one.

PURITY.—The purity of this metal is ascertained by its brilliancy and great mobility. Mechanical impurities—such as adhering dirt or dust—are instantly detected, and may be separated by straining through flannel, or by filtering through a small hole in the apex of an inverted cone of paper. The presence of lead, tin, zinc, or bismuth, may be suspected by the rapidity with which the metal tarnishes in the air, and by its small parts *tailing*, instead of preserving a spherical form. These impurities may be got rid of by distillation in an earthen retort.

PHYSIOLOGICAL EFFECTS. 1. *OF METALLIC MERCURY.* (*a.*) *On vegetables.*—Mercurial vapours are fatal to plants (Decandolle, *Phys. Vég.* 1332).

(*b.*) *On animals.*—From the experiments of Moulin (*Phil. Trans.* for 1691, No. 192), Haighton (Beddoes, *On Pulmonary Consumption*, 1799), Viborg (quoted by Wibmer, *Wirkung d. Arzneim*, iii. 88), and Gaspard (Magendie, *Journ. de Physiol.* i.), it appears that when *injected into the veins*, mercury collects in the small vessels of the neighbouring organs, and acts as a mechanical irritant. Thus, if thrown into the jugular vein, peripneumonia is excited; and, on examination after death, little abscesses and tubercles have been found in the lungs, in each of which was a globule of quicksilver as the nucleus.

(*c.*) *On man.*—Some difference of opinion exists as to the *effects of liquid mercury when swallowed;* one party asserting that it is poisonous, another that is innocuous. The truth I believe to be this: so long as it retains the metallic state it is inert; but it sometimes combines with oxygen in the alimentary canal, and in this way acquires activity. Avicenna, Fallopius, and Brasavola, declared it harmless; Sue (*Mém. de la Facult. Méd. d'Emulat.* 4th year, p. 252) states that a patient took for a long time two pounds daily without injury; and I could refer to the experience of many others who have seen it employed in obstructions of the bowels, without proving noxious; but the fact is so generally known and admitted, as to require no further notice. In some instances, however, it has acted powerfully, more especially where it has been retained in the bowels for a considerable time; no doubt from becoming oxidized. Thus Zwinger (*Miscell. Curiosa Decur.* 2^{nda}. Ann. 6, 1688) states that four ounces brought on profuse salivation four days after swallowing it. Laborde (*Journ. de Méd.* i. 3) also tells us, that a man who retained seven ounces in his body for fourteen days, was attacked with profuse salivation, ulceration of the mouth, and paralysis of the extremities; and other cases of a similar kind might be quoted.

Dr. Christison considers the question set at rest by the Berlin College of Physicians, and that the metal is innocuous.

Applied externally, liquid mercury has sometimes produced bad effects. Dr. Scheel has related a fatal case, attended with salivation, brought on from wearing at the breast during six years a leathern bag, containing a few drachms of liquid mercury, as a prophylactic for itch and vermin (Richter, *Ausführ. Arzneim.* Supplem. Bd. 615).

The injurious effects of *mercurial vapours*, when inhaled or otherwise applied to the body, have been long known. They are observed in water gilders, looking-glass silverers, barometer-makers, workmen employed in quicksilver mines, and in others exposed to mercurial emanations. In most instances an affection of the nervous system is brought on, and which is indicated by the *shaking palsy* or *tremblement mercuriel* (*tremor mercurialis*), which is sometimes attended with stammering (*psellismus metallicus*), vertigo, loss of memory, and other cerebral disorders, which frequently terminate fatally. The first symptom of shaking palsy is unsteadiness of the arm, succeeded by a kind of quivering of the muscles, which increases until the movements become of a convulsive character. In all the cases (about five or six in number) which have fallen under my notice, the shaking ceased during sleep. I have not seen the least benefit obtained by remedial means, although various modes of treatment were tried. This is not in accordance with the experience of Dr. Christison, who says the tremors "are cured easily though slowly." If the individual continue his business, other more dangerous symptoms come on, such as delirium or epilepsy, or apoplexy (*apoplexia mercurialis*); and ultimately death takes place.

In some instances salivation, ulceration of the mouth, and hæmoptysis, are produced by the vapour of mercury. The following remarkable case is an instance in point. In 1810, the Triumph man-of-war, and Phipps schooner, received on board several tons of quicksilver, saved from the wreck of a vessel near Cadiz. In consequence of the rotting of the bags the mercury escaped, and the whole of the crews became more or less affected. In the space of three weeks 200 men were salivated, two died, and all the animals, cats, dogs, sheep, goats, fowls, a canary bird,—nay, even the rats, mice, and cock-roaches, were destroyed (*Ed. Med. and Surg. Journ.* xxvi. 29).

As metallic mercury in the liquid state is not active, it has been thought that mercurial vapour must also be inactive. Thus Dr. Christison thinks that the activity of the emanations arises from the oxidation of the metal before it is inhaled. I believe, however, with Buchner (*Toxicologie*), Orfila (*Toxicol. Gén.*), and others, that metallic mercury, in the finely divided state in which it must exist as vapour, is itself poisonous.

2. *Of Mercurial Compounds.*—Probably all the mercurial compounds are more or less noxious. The only doubtful exception to this is in the case of the sulphurets of this metal, which, according to Orfila (*Arch. Gén. de Méd.* xix. 330), are inert.

(*a.*) *Local effects.*—For the most part, the local action of the mercurial compounds may be regarded as alterative, and more or less irritant. Many of the preparations (as the bichloride, the nitrates, &c.) are energetic caustics. The protoxide and protochloride (calomel) are very slightly irritant only: indeed, Mr. Annesley (*Diseases of India*) asserts, from his experiments on dogs, and his experience with it in the human subject, that the latter substance is the reverse of an irritant; in other words, that when applied to the gastro-intestinal membrane it diminishes its vascularity. But I suspect some error of observation here.

(*b.*) *Remote effects.*—In *small* and *repeated doses*, the first obvious effect of mercurials is an increased activity in the secreting and exhaling apparatus. This is particularly observed in the digestive organs; the quantity of intestinal mucus, of bile, of saliva, of mucus of the mouth, and probably of pancreatic liquid, being augmented. The alvine discharges become more liquid, and contain a larger proportion of bile. The operation of the medicine does not stop here: the pulmonary, urino-genital, and conjunctival membranes, become moister, the urine is increased in quantity, the catamenial discharge is sometimes brought on, the skin becomes damper and at the same time warmer. The absorbent or lymphatic system seems also to be stimulated to increased activity; for we frequently observe that the accumulations of fluid in the shut sacs (as the pleura, the peritoneum, the arachnoid, and synovial membranes) diminish in quantity, and in some cases rapidly disappear. At the same time, also, glandular swellings and indurations of various kinds are dispersed. These are the cases in which the mercurials are called ***alteratives***—that is, they indirectly induce healthy action in a very slow, gradual, and incomprehensible manner.

When our object is to obtain the ***sialogogue*** operation of mercurials, we give them in *somewhat larger doses*. To a certain extent the effects are the same as those already mentioned, but more intense. Of all the secretions, none are so uniformly and remarkably augmented as those of the mucous follicles of the mouth and the salivary glands; and the increased secretion of these parts is accompanied with more or less tenderness and inflammation, the whole constituting what is termed ***salivation*** or *ptyalism* (*salivatio*, *ptyalismus*, *sialismus*). The first symptoms of this affection are slight tenderness and tumefaction of the gums, which acquire a pale rose colour, except at the edges surrounding the teeth, where they are deep red. Gradually the mouth becomes exceedingly sore, and the tongue much swollen; a coppery taste is perceived, and the breath acquires a remarkable fœtidity. The salivary glands soon become tender and swollen; the saliva and mucus of the mouth flow abundantly, sometimes to the extent of several pints in the twenty-four hours. During this state, the fat is rapidly absorbed, and the patient becomes exceedingly emaciated. The blood when drawn from a vein puts on the same appearance as it does in inflammatory diseases.

The quantity of saliva and buccal mucus discharged by patients under the influence of mercury, varies according to the quantity of the medicine employed, the susceptibility of the patient, &c. Formerly salivation was carried to a much greater extent than it is at the present day. Thus Boerhaave (*Aphorismi*) considers a patient should spit three or four pounds in twenty-four hours; and Turner (*Pract. Dissert. on the Ven. Disease*, 1737) says from two to three quarts are "a good and sufficient discharge." Modern experience has shewn that all the good effects of mercurials may be gained by a very slight affection of the mouth. Several analyses have been made of saliva from patients under the influence of mercury. Fourcroy, Thomson, Bostock, and Devergie, failed to detect the least trace of mercury in it. But some other persons have been more successful, as will be hereafter mentioned. The following are the constituents of saliva during mercurial ptyalism, according to Dr. Thomson (*Annal. of Phil.* vi. 397):—

Coagulated Albumen	0·257
Mucus, with a little Albumen	0·367
Chloride of Sodium	0·090
Water	99·286
	100·000

It was an opal fluid, having a sp. gr. of 1·0038, and by standing deposited flakes of coagulated albumen. The nitrates of lead and mercury produced copious precipitates with it; but the ferrocyanuret of potassium and infusion of galls had no effect on it. Dr. Bostock (*Medico-Chirurg. Trans.* xiii. 73) found the saliva discharged under the influence of mercury to differ from that of the healthy state, in being less viscid, and in containing a substance analogous to coagulated albumen, such as it exists in the serum of the blood; so that it would seem the mercurial action alters the secretion of the salivary glands, and makes it more analogous to the exhaled fluids of the serous membranes.

The effects of mercury hitherto described are such as are occasionally produced for the cure of diseases; but occasionally other phenomena present themselves in individuals who have been subjected to the influence of this metal, and which have been considered as constituting a peculiar malady, to which the name of *mercurial disease* (*morbus mercurialis, hydrargyriasis* seu *hydrargyrosis, cachexia mercurialis,* &c.) has been given. The *pseudo-syphilis,* or *cachexia sypholoidea* of some writers, is supposed to be syphilis, more or less modified by the mercurial disease. The following are the ill effects which have been ascribed to this metal, and which Dieterich (*Die Merkurialkrankheit,* 1837) regards as so many forms of the mercurial disease:—

1. *Mercurial fever* (*febris mercurialis,* Dieter.)—Under this name Dieterich has included two febrile states. One of these (*febris erethica; f. salivosa*) comes on a few days after the use of large doses of mercury, and is characterized by great restlessness, dryness of the mouth, headache, loss of appetite, nausea, hot and dry skin, quick pulse, red gums, swollen tongue, &c.: it usually terminates in a critical discharge (as profuse salivation, purging, or sweating), or an eruption makes its appearance. The affection which Mr. Pearson (*Observ. on the Effects of various Articles of the Mat. Med.* p. 131) denominated *mercurial erethism* (*erethismus mercurialis*), is regarded by Dieterich as an adynamic mercurial fever (*febris adynamica*). It is characterized by great depression of strength, a sense of anxiety about the præcordia, frequent sighing, trembling, partial or universal, a small quick pulse, sometimes vomiting, a pale contracted countenance, a sense of coldness; but the tongue is seldom furred, nor are the vital or natural functions much disordered. When these symptoms are present, a sudden and violent exertion of the animal power will occasionally prove fatal.

2. *Excessive salivation* (*ptyalismus stomachalis mercurialis,* Dieter. *stomatis*).—I have already noticed mercurial salivation as far as it is ever purposely induced for the cure of diseases. But it sometimes happens, either from the inordinate employment of mercury, or from some peculiarity in the constitution of the patient, that the mouth becomes violently affected: the gums are tumefied and ulcerated; the tongue is swollen to such an extent, that it hangs out of the mouth, incapacitating the patient from either eating or speaking; the salivary glands are enlarged and most painful, and the saliva flows most copiously from the mouth. In one instance sixteen pounds are said to have been evacuated in twenty-four hours. In some cases (Dieterich, *op. cit.*) the gums slough, the teeth loosen and drop out, and occasionally necrosis of the alveolar process takes place. During this time the system becomes extremely debilitated and emaciated; and, if no intermission be given to the use of mercury, involuntary actions of the muscular system come on, and the patient ultimately dies of exhaustion.

In some cases, active inflammation, succeeded by ulceration and sloughing of the fauces takes place (*angina mercurialis*). In one instance, which fell under my notice, this condition was brought on by the use of a few grains of blue pill, taken for a liver complaint. Recovery took place, but the contraction of the mucous membrane in the neighbourhood of the anterior arches of the palate was so great, that the patient was unable to open her mouth wider than half an inch. Several operations were performed, by different surgeons, to remedy this, but the relief was only temporary.

Salivation is occasionally induced by other substances (hydrocyanic, nitric, or arsenious acids, emetic tartar, foxglove, iodine, &c.), and sometimes occurs spontaneously. The peculiar odour of the breath, the brassy or coppery taste, and the sponginess of the gums, are usually considered to be characteristic of mercurial salivation. But in some cases these symptoms are insufficient to enable us to distinguish it. I have seen about a dozen instances of apparently spontaneous salivation, yet presenting the characters of ptyalism from mercury. They occurred in Dispensary patients, and mostly in females. The greater part of them had not (according to their own account) taken medicine of any kind for months. Sloughing phagedena of the mouth (*stomacace gangrænosa*) cannot, in some cases, be distinguished from the sloughing produced by mercury (*stomacace mercurialis*). A remarkable case, in proof, I have recorded in the *London Medical Gazette* (vol. xviii. 389).

3. *Mercurial purging* (*diarrhœa mercurialis*).—Violent purging is a very frequent consequence of the use of mercury. It is frequently attended with griping, and sometimes with sanguineous evacuations. In some cases there is fullness of the left hypochondrium, burning pain and tenderness of the region of the pancreas, and the evacuations are frothy, whitish, tough, and often greenish, at least in the commencement, from the intermixed bile. These symptoms may fairly be referred to an affection of the pancreas, analogous to that of the salivary glands. Dieterich (*op. cit.*) terms it *ptyalismus pancreaticus mercurialis* (*diarrhœa salivalis, sialorrhœa alvina, ptyalismus abdominalis*).

4. *Urorrhœa mercurialis.*—Excessive secretion of urine, from the use of mercury, is very rare. Two cases only are recorded, both by Schlichting (*Ephemerid.* A.C.L. Nuremburgæ, 1748, tom. viii. Obs. viii. p. 25, quoted by Dieterich, *op. cit.*)

5. *Hidrosis mercurialis.*—Profuse sweating is another occasional effect of mercury.

6. *Skin diseases.*—Several forms of skin diseases, both acute and chronic, have been regarded as part of the ill effects of mercury.

(*a.*) *Eczema mercuriale*, Pearson; (*erythema mercuriale*, Spens and Mullins; *lepra mercurialis*, Stokes and Moriarty; *hydrargyria*, Alley, Rayer; *erysipelas mercuriale*, Cullerier, Lagneau; *spilosis mercurialis*, Schmalz).—This disease appears occasionally during the progress of a mercurial course. Some writers have frequently met with it:—thus, Alley (*Observ. on the Hydrargyria*, 1810) saw forty-three cases in ten years, and of this number eight terminated fatally. Rayer confesses, that in twenty years he never saw but three instances of it. During the ten years that I was connected with the General Dispensary, I saw only two cases of it. The disease consists of innumerable, minute, and pellucid vesicles, which have been mistaken for papulæ. These give the appearance of a diffused redness to the skin, and a sensation of roughness to the touch. Sometimes it is preceded, and attended by febrile disorder. In two or three days the vesicles attain the size of a pin's head, and the included serum becomes opaque and milky. It soon extends over the body, and is accompanied by tumefaction, tenderness, and itching. It usually terminates by desquamation: but in some cases a copious discharge takes place from the excoriated and tender surface; and when this ceases, the epidermis comes off in large flakes: in some instances the hair and nails fall off, and the eyes and eyebrows become entirely denuded. There is usually some affection of the respiratory organs, indicated by dry cough and tightness of the præcordia.

(*b.*) *Miliaria mercurialis.*—A miliary eruption has been observed by both Peter Frank and Dieterich, apparently as a consequence of the use of mercury.

(*c.*) *Chronic skin diseases* (*herpes*, *psydracia*, and *impetigo*).—These are doubtful consequences of the use of mercury. They have occurred after the employment of this metal; but considerable doubt exists, as to whether they ought to be regarded as the effect of the remedy, or of the disease for which they have been exhibited, or of some other condition of system. *Herpes præputialis* has been ascribed, by Mr. Pearson, to the previous use of mercury (Bateman, *Pract. Synopsis of Cutaneous Diseases*, 6th ed.), and his opinion has been adopted by Dieterich (*op. cit.*); but it certainly now and then occurs, when no mercury has been exhibited. The *psydracia mercurialis* and *impetigo mercurialis* of Dieterich (*op. cit.*) are still more doubtful effects of mercury.

7. *Inflammation of the eye, fauces, and periosteum*, have been ascribed by some writers to the use of mercury; but by others the power of this agent to produce these diseases is denied. That they have followed the use of mercury cannot be doubted, but *post hoc* is not *ergo propter hoc*. Dieterich regards the maladies referred to as states of congestion, not of inflammation, and therefore calls them *symphoreses* (from *συμφόρησις*, *an*

accumulation). The inflammation of the conjunctiva (*conjunctivitis mercurialis; symphoresis conjunctivæ oculi mercurialis*, Dieter.), ascribed by Von Ammon (*Rust's Magazin*, 1830) to the use of mercury, should probably be referred to some other cause. He says it is characterized by a lilac tint around the cornea; that it sometimes precedes salivation, disappearing when this is established, and is commonly regarded as a catarrhal symptom. The mercurial iritis (*iritis mercurialis: symphoresis ireos mercurialis*, Dieter.; *iritis rheumatico-mercurialis*, Jaeger), described by Mr. Travers (*Surgical Essays*, i. 59), was, in all probability, an iritis arising from some other cause than mercury (Mackenzie, *On Diseases of the Eye*, 2d edit. p. 496). The so-called mercurial retinitis (*symphoresis retinæ oculi mercurialis*, Dieter.) may be explained in the same way. An inflammation of the fauces sometimes occurs after the use of mercury (*angina mercurialis; symphoresis faucium mercurialis*, Dieter.) It may come on in five or six days after the use of mercury, and assume an acute form, with a tendency to slough (Colles, *Pract. Observ. on the Vener. Disease*, p. 45); or it may appear after the employment of mercury for five or six weeks, and take on a chronic form (Dieterich, *op. cit.* p. 273). Inflammation of the bone or periosteum, and the consequent production of nodes (*symphoresis periostei mercurialis*, Dieter.), has been ascribed to mercury. But the disease is rarely or never seen after the use of this mineral, except when it has been given for the cure of a venereal affection, to which, in fact, it ought with more propriety to be referred (Mr. Lawrence, *Lect. on Surg. in Med. Gaz.* v. 805; Colles, *op. cit.* p. 189).

8. *Hypertrophies* (*Hypertrophiæ*, Dieter.).—Enlargement of the inguinal, axillary, and mesenteric absorbent glands (*adenophyma inguinale mercuriale; ad. axillare merc.; ad. meseraicum merc.* Dieter.), as well as of some of the secreting glands, viz. the parotid glands, the pancreas, the testicles, and liver (*adenophyma parotideum merc.; ad. pancreaticum merc.; ad. testiculi merc.; hepatophyma merc.*), and condyloma and ganglion (*condyloma et ganglion mercuriale*, Dieter.), have been ascribed by some (Mathias, *op. cit.* and Dieterich, *op. cit.*) to the use of mercury, but, as I believe, on insufficient grounds.

9. *Ulceration and sloughing.*—Ulceration of the mouth is a well-known effect of mercury. Ulceration of the throat is likewise a consequence of the use of this mineral (*mercurial ulcerated throat*, Mathias; *mercurial sore throat*, Bacot, in *Med. Gaz.* iii. 312). Sloughing of the same parts may also be induced. It is well known that venereal sores (especially those called phagedenic) at times assume a sloughing disposition, in consequence of the improper use of mercury (Sir A. Cooper, *Lectures on Surgery*, in *Lancet*, iv. 42; Carmichael, *On Venereal Diseases*, p. 165, et seq. 2nd. ed.) Ulceration of the fibrous membranes (*ulcus membranæ fibrosæ mercuriale*), and ulceration of the absorbent glands (*ulcus glandularum mercuriale*), has been ascribed to the use of mercury (Dieterich, *op. cit.* p. 376).

10. *Neuroses mercuriales.*—Various symptoms indicating a disordered condition of the nervous system, are met with in persons who have been exposed to the baneful influence of mercury: such as wandering pains (*neuralgia mercurialis*); a tremulous condition of the muscular system (*tremor mercurialis*), sometimes accompanied with stammering (*psellismus metallicus*), and occasionally terminating in paralysis (*paralysis mercurialis*), epilepsy or apoplexy (*apoplexia mercurialis*). To these, Dieterich (*op. cit.*) adds asthma (*asthma mercurialis*), of which he only saw one case, amaurosis (*amaurosis mercurialis*), and hypochondriasis (*hypochondriasis mercurialis*).

Of these, the best known is the shaking palsy (*tremor mercurialis; tremblement mercuriel*), a remarkable affection which occurs among workmen exposed to the action of the vapour of mercury, such as miners, gilders, barometer-makers, looking-glass silverers, &c. The first symptom of it is unsteadiness of the arm, succeeded by a kind of quivering of the muscles, which increases until the movements become of a convulsive character. In all the cases which I have seen, the movements were suspended during sleep.

11. *Cachexia* (*cachexia mercurialis*).—This condition is characterized by disorder of the digestive organs, loss of appetite, wasting, incapability of much exertion, with increased secretion from all the organs, especially from the salivary glands.

The foregoing are the most important of the ill effects ascribed to the use of mercury. As I have already stated, some of them ought probably to be referred to other causes, and not to the use of this mineral; but as doubt must necessarily be entertained on this point, I have thought it more advisable to mention them. The student will find some pertinent observations concerning them, in a paper by Dr. Musgrave (*Edin. Med.*

and Surg. Journ. vol. xxviii.), and in Dr. Currie's pamphlet (*Examination of the Prejudice commonly entertained against Mercury*).

In excessive doses: acute poisoning.—When *large doses* of some of the soluble salts of mercury have been swallowed, *gastro-enteritis* is observed. The patient complains of an acrid styptic taste in the mouth, and of a feeling of burning and tightness in the throat; the face is usually flushed and sometimes swelled, violent vomiting and purging (frequently of bloody matters) soon come on, the vomiting being increased by every thing taken into the stomach; oftentimes there is irritation of the urinary passages, and sometimes even suppression of urine; the pulse is small, frequent, and contracted; the respiration difficult; the extremities cold. In some cases *salivation* is produced: this seldom comes on during the first 24 hours; and in those instances in which it does occur, is seldom delayed beyond the fourth day. Towards the termination of the case, some indications of *disorder of the cerebro-spinal system* come on, such as slight drowsiness or stupor, or even coma; tremors and twitchings of the muscles, and sometimes even violent convulsions; in some cases paraplegia. These symptoms terminate in death. Post-mortem examination discovers inflammation, and its consequences, of the gastro-intestinal membrane.

THEORY OF THE ACTION OF MERCURY. — There are many disputed points connected with the action of mercurials, which it will be convenient to examine under this head.

1. *Absorption of mercury.*—By the external or internal use of mercury, this metal becomes absorbed (in what state has not been ascertained), and is subsequently either deposited in some of the solids of the body, or thrown out of the system by some of the excretories.

The accuracy of this statement is proved by the following facts:—

(*a.*) *Mercury has been detected in the blood* by Zeller, Buchner, Schubarth (quoted by Dr. Christison, *On Poisons*, 3rd. ed. p. 366), Colson (*Arch. Gén.* xii. 68), and Dieterich (*op. cit.*). It appears to be in such intimate combination with this vital fluid that it cannot be recognised by the ordinary tests. Destructive distillation is in most cases necessary for its detection.

(*b.*) *Mercury has been found in the secretions,* viz. in the perspiration, the saliva, the gastro-intestinal secretion, the bile, the urine, and the fluid of ulcers (Christison, Colson, and Dieterich, *op. cit.*) The blackening of the skin, mentioned both by Harrold (*Meckel's Archiv.* iii. 532) and Rigby (*Lond. Med. Rep.* April 1837), as having occurred in consequence of the use of mercury subsequent to the employment of sulphur, establishes the existence of mercury in the cutaneous transpiration. The sulphur and the mercury were thrown out of the system by the skin, and immediately they were out of the sphere of the vital powers, they entered into union and formed the black sulphuret of mercury, which was deposited on the integument in a pulverent form.

(*c.*) *Mercury has been found in the reguline state in the organic solids,* viz. in the bones, brain, synovial capsules, the pleura, the humours of the eye, the cellular tissue, the lungs, &c. (Christison, *op. cit.*; Wibmer, *Wirkung d. Arzneim.* iii. 85; Colson and Dieterich, *op. cit.*) In what part of the system reduction is effected, has not been made out.

2. *The constitutional effects of mercury are consequences of its absorption.* For, in the *first* place, mercurials affect the general system to

whatever part of the body they be applied, whether to the mucous membranes, the cutaneous system, or the cellular tissue, or injected into the veins. *Secondly*, the action of mercurials on the system is assisted by the use of bloodletting and emetics;—agents which promote absorption. *Thirdly*, when mercurials are administered by the stomach, and excite purging, they rarely affect the general system, apparently in consequence of the function of absorption being suspended.

3. *After absorption, mercury effects changes in the qualities of the blood, and in the action of the whole organism, but especially the apparatus of organic life.*—Soon after salivation has been established, the blood exhibits an inflammatory crust. At a later period its colour deepens, and its coagulability is diminished: the proportion of clot, and therefore of fibrin, to serum becomes smaller. "The formation of albumen and mucus," says Dieterich (*op. cit.* 80), "sinks to that of serum; the whole organic formation of the patient is less consistent and cohesive." The same authority also tells us, that under the influence of mercury the electrical condition of the blood changes from the negative (healthy) state to that of positive. The evacuations from all the secreting and exhaling organs, especially from the mucous follicles and salivary glands, is much increased. The secretion of bile is also promoted. Dr. Wilson Philip (*On the Influence of Minute Doses of Mercury*, p. 14) says, "mercury has a specific operation on the liver,—a power not merely of exciting its functions, but of correcting the various derangements of that function in a way which it does not possess with respect to any other organ, and which no other medicine possesses with respect to the liver." I confess I am not acquainted with any facts warranting this assertion. The purgative effects of mercury arise partly from the increased secretion of bile, and partly from the stimulus given to the mucous lining of the alimentary tube; more particularly to its follicular apparatus. The *nervous system* appears also to be specifically affected by mercurials. This is to be inferred partly from the effects produced in those who are subjected to the vapours of this metal, such as the shaking palsy, &c. and partly from the effects of the soluble salts, when given in enormous doses. The *heart* and *lungs* are, in some cases, remarkably affected. This was particularly observed by Sir Benjamin Brodie (*Phil. Trans.* for 1812) in his experiments on animals with corrosive sublimate; as also by Smith, Orfila, and Gaspard. The affection of the *urinary organs* in poisoning by corrosive sublimate is also not to be forgotten.

4. *The nature of the influence exercised by mercury over the organism* has been a fertile source of discussion. One class of writers has regarded it as mechanical, a second as chemical, a third as dynamical.

(*a.*) *Mechanical hypothesis.*—Astruc (*De Morb. Ven.* ii. 149) and Barry (*Med. Trans.* i. 25) fancied that mercury acted by its weight, its divisibility, and its mobility; and thus getting into the blood separated its globules, rendered it more fluid and fit for secretion, made the lymph thinner, and overcame any existing obstructions.

(*b.*) *Chemical hypotheses.*—Some have advocated the chemical operation of mercurials, and have endeavoured to explain their curative powers in the venereal disease by reference to their chemical properties, but without success. Thus Mitié, Pressavin (quoted by Richter, *Ausführ. Arzneim.* iv. 305), and Swediaur (*Prac. Observ. on Venereal Complaints*), assumed that mercury acted chemically on the syphilitic poison, as acids and alkalies do on each other; while Girtanner (*Abhandl. ü. d. Vener. Krankh.*) supposed that the efficacy of mercurials depended on the oxygen they contain. To both hypotheses the same objection applies: if they were true, the larger the quantity of mercury used, the more effectually would the venereal disease be cured. Now this is not found to be the case. Dr. Cullen (*Treat. of the Mat. Med.* ii. 446) endeavoured to account for the action of mercury on the salivary glands, in preference to other organs, by assuming that it has a particular disposition to unite with ammoniacal salts, with which it passes off by the various excretions; and as the saliva was supposed to contain more of these salts than other secretions, he thus accounted for the larger quantity of mercury which passed off by these glands, and which being in this way applied to the excretories, occasioned salivation. But the whole hypothesis falls to the ground, when it is known that mercury has no "particular disposition" to unite with the ammoniacal salts; and that, even if it had, other secretions are as abundantly supplied with these salts as the saliva. Dr. John Murray substituted another hypothesis, but equally objectionable:—mercury, says he, cannot pass off by the urine, because of the phosphoric acid contained in this fluid, and which would form, with the mercury, an insoluble compound. It must, therefore, be thrown out of the system by other secretions, particularly by the saliva, which facilitates this transmission by the affinity which the muriatic acid, the soda, and the ammonia of the secretion, have for the oxide of mercury, and by which a compound soluble in water is formed. The answer to this hypothesis is, that mercury *is* thrown out of the system by the urine, and probably in larger quantity than by the saliva; secondly, the saliva also contains phosphatic salts, according to Tiedemann and Gmelin.

(*c.*) *Dynamical hypotheses.*—Some writers have principally directed their attention to the quality of the effects induced by mercury, and have termed this mineral stimulant, sedative, both stimulant and sedative, tonic or alterative. Those who assume mercury to be a *stimulant* or *excitant* are not agreed as to whether particular parts or the whole system are stimulated, and, if particular parts, what these are. Thus Hecker fixes on the lymphatic system, Schöne on the arterial capillary system, Reil on the nerves (Richter, *op. cit.* v. 306). The simple answer to all of them is, that other stimulants are not capable of producing the same effects on the constitution as mercury; nay, are frequently hurtful in the very cases in which this metal is beneficial.

On the other hand, Conradi, Bertele, and Horn (quoted by Richter, *op. cit.* v. 307), considered it to be a *weakening agent*, or *sedative*. Hence those who adopt this hypothesis must assume that the diseases in which mercury is beneficial are of a phlogistic or hypersthenic character; and that syphilis, therefore, is of this kind,—an explanation not at all satisfactory, nor consistent with facts. Of late years, the sedative operation of some of the mercurial preparations (calomel and mercurial ointment) has been assumed (particularly by our countrymen practising in the East), from the circumstance that these agents allay vomiting and diarrhœa in yellow fever, cholera, and other dangerous diseases. But even admitting that mercurials do produce these effects, this is hardly a sufficient ground for denominating them sedatives.

Some think that mercurials, in *small* or moderate doses, are *stimulants*, but in *excessive* doses, *sedatives;* and that this sedative operation is common to all substances when employed in large quantities. This is the opinion of Dr. Wilson Philip (*op. cit.*)

Dr. Murray (*Syst. of Mat. Med.*) calls mercury a tonic; Vogt (*Pharkodynamik*) terms it an alterative resolvent; Sundelin (*Heilmittellehre*) places it among the resolvent alteratives, under the designation of liquefacient (*verflüssigende*). Mr. Hunter (*Treatise on the Venereal Disease*) accounts for its beneficial effects in syphilis, by saying it produces an irritation of a different kind from that caused by the venereal disease, and that it counteracts the latter by destroying the diseased action of the living parts.

USES. 1. *OF METALLIC MERCURY.*—Liquid mercury has been used as a *chemical* agent, to dissolve silver coin which may have been accidentally swallowed; *secondly*, as a *mechanical* agent, to remove obstructions of the bowels; for example, intus-susception, or intestinal invagination. But neither theory nor experience seem favourable to its use; for in the greater number of cases the intus-susception is progressive—that is, the superior portion of the gut is insinuated into the lower portion, and, therefore, the pressure of the metal on the sides of the intestine cannot give relief; and even in cases of retrograde intus-susception, —that is where the lower portion of the bowels passes into the upper, mercury, instead of pressing the intus-suscepted portion back, might push it further on, by getting into the angle of reflection between the containing and inverted gut (Hunter, *Trans. of a Society for the Improvement of Med. and Chir. Knowledge*, i. 103). *Lastly*, water, which had been boiled with mercury (*aqua mercurialis cocta*), was at one time used as an anthelmintic; but if the metal be pure, the water takes up no appreciable quantity of it. Moreover, it would appear that mercury has no particular anthelmintic powers; for persons who were salivated have not been freed from their worms, and Scopoli very frequently found ascarides in the workers of the quicksilver mines of Idria (Bremser, *Sur les Vers. Intest.* 428).

Administration.—When taken internally it has been administered in various doses, from an ounce to a pound or more.

2. *OF THE PREPARATIONS OF MERCURY.*—As *ERRHINES* or *EMETICS*, mercurials are never resorted to now, though formerly the *subsulphate* was used for these purposes.

As *ALTERATIVES*, they are given in small doses in various chronic diseases; such, for example, as dyspepsia, gout, chronic skin diseases, scrofula, &c. Calomel is said to be less beneficial as an alterative than blue pill, on account of its more irritating action on the bowels. The *hydragyrum cum cretâ* is an excellent alterative, especially for children.

Certain preparations of mercury (as blue pill, calomel, and the *hydragyrum cum cretâ*) are employed as *PURGATIVES*. They promote secretion from the mucous follicles of the intestines, from the liver, and the pancreas. They are rarely, however, used alone; being, in general, either combined with or followed by other cathartics (as jalap, senna, colocynth, or the saline purgatives). Thus it is a common practice to exhibit a blue or calomel pill at night, and an aperient draught the following morning, the object being to allow the pill to remain as long as possible in the bowels, in order that it may the more effectually act on the liver. Mercurial purgatives are administered for various purposes, sometimes as anthelmintics, sometimes to assist in evacuating the contents of the alimentary canal; but more commonly with the view of promoting the secretions, particularly of the liver, or of producing counter-irritation, and thereby to relieve affections of other organs, as the skin or head.

The great value of mercurials is as **SIALOGOGUES.** Formerly it was supposed, that the beneficial effects of mercury were proportionate to the degree of ptyalism, and thus to eradicate particular affections it was thought necessary to cause the evacuation of a given quantity of saliva. "I have heard," says Dr. Wilson Philip (*op. cit.* p. 19), the late Dr. Monro, of Edinburgh, state the quantity of saliva which must be discharged daily, to eradicate particular affections." Modern experience has proved the incorrectness of this notion; and we now rarely find it necessary to excite a high degree of salivation; indeed, frequently it would be prejudicial, but we sometimes find it requisite to keep up this effect for several weeks, particularly in diseases of a chronic character.

Production of sore mouth and salivation.—One of the most efficacious methods of putting the system under the influence of mercury is *friction* with the *unguentum hydrargyri;* but the troublesome and unpleasant nature of the process is a strong objection to it in practice, more especially in venereal diseases, in which patients usually desire secresy. Full directions for its employment will be given hereafter (vide *Ung. Hydrargyri*). In the year 1779, Mr. Clare (*Essay on the Cure of Abscesses by Caustic, also a New Method of introducing Mercury into the Circulation*, 1779) proposed a new method of causing salivation by friction, and which consists in rubbing two or three grains of calomel, or of the protoxide of mercury, on the inner surface of the cheeks and gums. It is said that the metal quickly becomes absorbed, and causes salivation, and if care be taken not to swallow the saliva, diarrhœa does not occur. Notwithstanding that Hunter, Cruikshank, and others, have tried this plan, and reported favourably of it, and that it is free from the objections made to the use of mercurial ointment, it has never been a popular remedy. *Fumigation,* as a means of affecting the general system, is an old method of treating venereal diseases. Turner (*On the Venereal Disease*) employed for this purpose cinnabar; Lalouette (*Nouv. Method. de traiter les Malad. Vénér.* 1776) calomel; and the late Mr. Abernethy (*Surgical and Phys. Essays*) the protoxide. Mr. Colles (*op. cit.* p. 58) has frequently seen fumigation fail in exciting salivation. He says, an easy mode of fumigating any part is by using mercurial candles (composed of cinnabar or oxide of mercury mixed with melted wax, with a wick, and burnt under a curved glass funnel). Baumé used *mercurial pediluvia* to excite salivation, composed of half a grain of corrosive sublimate dissolved in a pint of distilled water, and in a solution of this strength the patient immersed his feet for the space of two hours; several objections, however, exist to the practice, which has been rarely followed. Upon the whole, the most convenient method of producing salivation is by the *internal use of mercurials,* particularly of those preparations which are mild in their local action, as blue pill, calomel, and the *hydrargyrum cum cretâ.*

Treatment before and during salivation.—Formerly the use of mercurials was preceded by antiphlogistic measures, such as blood-letting, purging, warm bathing, and low diet, but they are now rarely resorted to, though useful, by facilitating absorption. Mr. Colles (*Practical*

Observations on the Venereal Disease, p. 28) thinks that these preparatory measures have been improperly omitted, and that the want of them has, of late years, contributed to bring this valuable remedy into much disrepute—in which opinion I am disposed to join him. Occasionally great difficulty is experienced in affecting the mouth, a circumstance which may arise from the irritable condition of the bowels; and when this is the case, inunction should be resorted to, or opium or vegetable astringents conjoined. Sometimes, however, the system appears insusceptible to the influence of mercury, and this may arise from idiosyncrasy, or from the presence of some disease, particularly fever. Emetics and blood-letting are useful in these cases, as they promote absorption; and as the influence of the former depends on the state of nausea produced, tartar emetic will be the best vomit, since it is the most powerful nauseant. Varying the mode of administering the mercury will also sometimes facilitate its operation on the system: thus, if it have been employed internally, inunction should be tried, and *vice versâ*.

During the time that the patient's mouth is sore, he should, if possible, confine himself to the house, use warm clothing, avoid exposure to cold, take light but nourishing food, and regulate the state of his stomach and bowels. Mr. Hunter thought that during a mercurial course the manner of living need not be altered: but Mr. Colles (*op. cit.* p. 34) has properly, I think, objected to this. If the discharge become excessive, or ulceration of the gums take place, the further use of mercury is of course to be stopped; and, in order to moderate the effect already produced, the patient should be freely exposed to a cool but dry air, use purgatives and opium, and wash his mouth with some astringent and stimulating liquid. I have generally employed, as a gargle, a solution of the chloride of soda or of lime; but in the absence of these, a solution of alum, or of sulphate of copper, may be used. With regard to internal remedies, I have no confidence in any as having a specific power of stopping salivation, though iodine, sulphur, nitre, and other substances, have been strongly recommended. Sometimes sulphate of quinia is administered with advantage.

Accidents during salivation.—Occasionally, during salivation, certain effects result from mercury, which are in no way necessary or useful in a therapeutical point of view: on the contrary, some of them are highly prejudicial. Thus, sometimes, *excessive salivation, with ulceration of the gums*, takes place, as already noticed: not unfrequently *gastro-intestinal irritation* (or actual inflammation) comes on, and which may require the suspension of the use of mercury, or its employment by way of inunction, or its combination with opium or vegetable astringents. I have already noticed *fever*, *eczema mercuriale*, *mercurial erethysm* of Pearson, &c. as other occasional effects. In feeble and irritable habits, mercury sometimes disposes sores to *slough*. Occasionally a kind of *metastasis* of the mercurial irritation is observed: thus, swallowing a large quantity of cold water, or exposing the body to cold and moisture, has caused a temporary cessation of salivation, attended with violent pains or convulsions, or great irritability of stomach.

Curative action of salivation.—Though no surgeon ascribes the curative action of mercury to the salivation, yet, without this effect, the curative influence is not usually observed. Hence, though the one cannot be considered to stand to the other in the relation of cause and effect, yet the two are usually contemporaneous: so that when we fail to induce some affection of the mouth, we do not observe the beneficial effects of mercury. (On this subject consult Colles, *op. cit.* p. 31).

Diseases for which salivation is employed.—Having offered these general remarks on salivation as a remedial agent, I proceed to notice its use in particular diseases.

(*a.*) *Fever.*—It has been said that salivation diminishes the susceptibility to the contagion of fever, whether common or specific; but that it is not an absolute preventive is shown by the fact, that patients under the full influence of mercury have caught fever and died of it, as will be found noticed by my friend, Dr. Clutterbuck, in his *Inquiry into the Seat and Nature of Fever.* I have several times used mercurials as sialogogues in fever; I believe, for the most part, with advantage. I have only used them when there was some marked local determination or inflammatory condition. I have seen three fatal cases of fever in which mercurials were used profusely, without having any effect on the mouth; but in other instances, in which the mouth became affected, recovery took place. My experience, therefore, agrees with that of Dr. Copland (*Dict. of Pract. Med.* i. 929), namely, that death, after salivation has been established, is very rare. Whether the recovery was the consequence of the mercurial action, or the salivation the result of the mitigation of the disorder, as Dr. Bancroft (*On Yellow Fever*) and Dr. Graves (*Lond. Med. Gaz.* xx. 147) assert, cannot be positively proved, though I think the first more probable. Dr. Graves (*op. cit.*) declares the use of mercury in fever to be both injudicious and unnecessary, unless inflammation of some organ be set up. In this opinion I cannot agree with him. Dr. Macartney (*Treatise on Inflammation*, p. 162), on the other hand, says, "In no single instance have I known it [mercury] fail in arresting the progress of the disease, provided the fever be not combined with visceral affections, or characterized from the beginning with unusual prostration of strength." The great indisposition of the system, in fever, to take on the mercurial action, is frequently a most annoying circumstance. It may sometimes be overcome by the employment of mercurials both internally and externally. Mr. Lempriere (*Pract. Observ. on Diseases of the Army of Jamaica*), who practised in Jamaica, finding that calomel was often exhibited in immense quantities, without exciting any apparent action, was induced to employ corrosive sublimate in doses of the eighth part of a grain, with the addition of ten drops of laudanum, and this quantity was repeated every hour until some affection of the mouth was observed, or until the more alarming symptoms had considerably abated.

The beneficial influence of mercurials has been more particularly experienced in the fevers of warm climates, especially those of the East Indies (Johnson, *On Diseases of Tropical Climates*, pp. 32, 96, 97, 122, &c. &c. 3d. ed.; Annesley, *On the Diseases of India*, p. 391, 2d. ed.) It has been said by several writers (Johnson, *op. cit.* p. 37; Bancroft, *On Yellow Fever*; Musgrave, *Edinb. Med. & Surg. Journ.* xxviii. 40), that in the yellow fever of the West Indies its beneficial effects are not equally evident.

(*b.*) *Inflammation.*—Of late years various forms of inflammation have been most successfully combated by the use of mercury. Hence this mineral is termed an *antiphlogistic*. We are principally indebted to Dr.

Hamilton (Duncan's *Med. Comm.* vol. ix.), Dr. Yeats (Duncan's *Ann. of Med.* vol. vii.), Dr. Wright (*Med. Facts & Observ.* vol. vii.), and Rambach (*Dissert. Usus Mercurii in Morb. Inflamm.* 1794) for its introduction into use in this form of disease. Its influence is that of a profoundly acting alterative (*vide* p. 10). Its curative power is not satisfactorily accounted for by the equalization of the circulation, the augmentation of the secretions, or the increased activity of the absorbents caused by mercury.

Mercury is not equally serviceable in all inflammations, but it is exceedingly difficult to generalize; that is, to point out in what circumstances those inflammations agree which are benefited by it. It appears, however, that the *nature of the tissue*, the *structure of the organ affected*, and the *quality* or *kind* of inflammation, are points of considerable importance as affecting its use.

Thus it appears that inflammations of *membranous tissues* are those principally benefited by a mercurial plan of treatment; and more especially those in which there is a tendency to the exudation of coagulable lymph or of serous fluid—as meningitis, pleuritis, pericarditis, and peritonitis (particularly of puerperal women). In inflammation of the lining membrane of the air-tube, but more especially in croup, or, as it is sometimes termed, plastic inflammation of the larynx, mercury is one of our most valuable remedies; and as this disease is one which terminates rapidly, no time should be lost in getting a sufficient quantity of mercury into the system. Calomel is usually employed; but when the bowels are very irritable, the *hydrargyrum cum cretâ*, or even mercurial inunction, may be resorted to. In inflammation of the tunics of the eye, particularly iritis, mercury (next to blood-letting) is the only remedy on which much confidence can be placed; and we use it not merely with a view of putting a stop to the inflammatory action, but also in order to cause the absorption of the effused lymph (Lawrence, *Lectures on Diseases of the Eye*, in *Lancet*, vol. x. p. 198; Mackenzie, *On Diseases of the Eye*, 2d. ed. pp. 389, 394, 503). In inflammation of the synovial membranes, mercury has been employed, and in some cases with manifest advantage. In dysentery, mercury has been extensively used, especially in warm climates. By some, calomel has been employed merely as a purgative (Jackson, Ballinghall, Bampfield, and Annesley); by others, to produce its sialogogue effects (Johnson and Cunningham).

The *structure of the organ* influences the effect of mercury: at least it is well known that this mineral is more beneficial in inflammation of certain organs (especially those of a glandular structure, as the liver) than of others; and we refer it to some peculiarity in the structure of the part affected. In hepatitis of either temperate or tropical climates (particularly of the latter), mercury is advantageously employed (Sir James M'Grigor, *Medical Sketches*; Johnson, *On Tropical Climates*; Annesley, *On Diseases of India*). Blood-letting, however, should be premised, particularly in the disease as usually met with in this country. In peripneumonia, more especially when hepatization has taken place, the best effects have sometimes resulted from its use; of course after the employment of blood-letting. When hepatization has taken place, Dr. Davies (*Lect. on the Diseases of the Lungs*, &c. p. 191) recommends the use of blue pill and opium. In inflammation of the substance of the brain, also, mercury may be advantageously resorted to, after the usual depletives.

The *nature* or *quality of the inflammation* also influences the effects, and thereby the uses, of mercury. Thus, in syphilitic inflammation, mercurials are of the greatest utility; less so in rheumatic inflammation; still less in scrofulous; and most decidedly objectionable in cancerous or scorbutic diseases. The treatment of rheumatism by calomel and opium was proposed by Dr. Hamilton (*op. cit.*), and has found many supporters (*vide* Dr. Hope, *Lond. Med. Gaz.* xix. 815); and, undoubtedly, when the febrile action does not run too high, or when the pericardium becomes affected, calomel and opium, preceded by blood-letting, will be found serviceable. It appears to be best adapted to the fibrous or diffuse form of the disease, and to fail in the synovial (Dr. Macleod, *Lond. Med. Gaz.* xxi. 361). The scrofulous habit is, for the most part, unfavourable to the use of mercury given as a sialogogue, but there are cases in which it is not only admissible but serviceable—as scrofulous ophthalmia, when of an acute kind. In all maladies of a malignant character (as cancer, fungoid disease, &c.) mercurials are highly objectionable.

(*c.*) *Venereal diseases.*—It was formerly the opinion of surgeons that the symptoms of venereal diseases were progressive, and never disappeared until mercury was administered; but it has, of late years, been clearly proved that this notion is erroneous: and we are indebted to some of our army surgeons—namely, to Messrs. Ferguson, Rose, Guthrie, (*Med. Chirurg. Trans.* vols. iv. and viii.), Hennen (*Military Surgery*), and Bacot (*On Syphilis*, 1821), and to Dr. Thomson (*Ed. Med. and Surg. Journ.* xiv.)—for showing that the venereal disease, in all its forms, *may* be cured without an atom of mercury. Moreover, it is fully established by the experience of almost every surgeon, that while in some instances mercury exercises a beneficial influence hardly to be observed with respect to any other disease or any other remedy, yet, that in some cases it acts most injuriously; and it is generally supposed that many of the bad venereal cases formerly met with, arose, in great part, from the improper use of mercury. It is a point, therefore, of considerable importance, to determine what cases are best adapted for a mercurial, and what for a non-mercurial, method of treatment; for in admitting the *possibility* of a cure without this agent, it is not to be inferred that the method is either *eligible* or *expedient;* nay, the very persons who have proved this possibility, admit that in some cases this mineral, given so as to excite moderate salivation, is advisable. One fact is, I think, now tolerably well established—viz. that the cure of venereal diseases without the aid of mercury is much slower and less secure against relapses than by a mercurial treatment (vide Colles, *Pract. Observ. on the Vener. Disease*, p. 318). It is not easy to lay down rules to guide us in the selection of the one or the other of these methods of treatment. Mr. Carmichael (*On Venereal Diseases*, 2d ed. 1825) relies principally on the eruption, and, next to this, on the appearance of the primary ulcer; and of the four forms of the venereal disease which he has described, namely, the *papular*, the *pustular*, the *phagedenic*, and the *scaly*, full courses of mercury are required, he says, in one only--namely, the scaly; in which the primary sore is the Hunterian chancre or callous ulcer, and the eruption partakes of the characters of lepra or psoriasis. But it has been satisfactorily proved by experiments made in the military hospitals, that even this scaly form of the disease may get well without mercury; and, on the other hand, in the pustular and papular forms, mercury is often a most valuable agent. Hennen, Rose, Guthrie, and Thomson, advise the employment of moderate quantities of mercury whenever the disease does not readily subside under the use of ordinary methods of treatment. But unless some special circumstances contra-indicate the use of mercury, it is, I think, advisable to affect the mouth slightly in most forms of the disease.

The circumstances which deserve attention, as affecting the use of mercury, are numerous. The following are the principal:—

α. *Scrofula.*—Some of the worst and most intractable forms of the venereal disease occur in scrofulous subjects; and in such, mercury is in general prejudical. I have seen numerous instances of its injurious effects. One case which fell under my notice was that of a medical student, who, after three years' suffering, died; having been made much worse on two occasions by what I conceived to be the improper use of mercury, once by his own act, and a second time by the advice of the surgeon of his family. Mr. Colles (*op. cit.* p. 236), however, denies the baneful influence of mercury in scrofula, and advises its use for the cure of syphilis in scrofulous subjects; but he admits that the profession generally entertain a contrary opinion.

β. *Condition of the primary ulcer.*—Another point deserving attention in deciding on the use of mercury, is the condition of the primary sore: if it be much inflamed, or of an irritable nature—if it be of the kind called phagedenic, or at all disposed to slough—mercury must be most carefully avoided, as it increases the disposition to sloughing. In one case that fell under my notice, a gentleman lost his penis by the improper use of mercury, under the circumstances just mentioned.

γ. *Extreme debility with hectic fever.*—This condition is usually believed to contra-indicate the employment of mercury. But Mr. Colles (*op. cit.* p. 206) asserts, "that a patient affected with secondary symptoms, even though extremely attenuated, and, as it were, melting away under the effects of hectic, can with perfect safety and advantage at once commence a course of mercury; by which not only shall his venereal symptoms be removed, but at the same time his general health be re-established."

(*d.*) *Cholera.*—Writers on the spasmodic cholera, both of this country and of India, speak for the most part favourably of the effects of mercury, especially in the form of calomel. I may refer to the works of Drs. Johnson, Venables, and Hamett, and of Messrs. Annesley, Orton, and Searle, in proof. I have met with no writers who attribute ill effects to it. Unfortunately those who advocate its use are not agreed as to the dose, or frequency of repetition; some advising it as a purgative; some as a sedative, in combination with opium; others, lastly, using it as a sialogogue. It is deserving of especial notice, that when salivation takes place, the patient in general recovers. Dr. Griffin (*Lond. Med. Gaz.* xxi. p. 882), however, has shown that this is not invariably the case. (For further information on the use of mercurials in cholera, vide HYDRARGYRI CHLORIDUM).

(*e.*) *Dropsy.*—In this disease, mercurials may do either good or harm. Thus when the dropsical effusion depends on inflammation, they may be employed with the best effects, as when hydrocephalus arises from meningitis, or hydrothorax from pleuritis. When ascites is occasioned by an enlarged liver, which compresses the vena portæ, and thereby gives rise to effusion, mercurials are sometimes beneficial. On the contrary, when dropsy occurs in old subjects, and when it depends on, or is accompanied by, general debility, salivation is almost always hurtful. Moreover, when the effusion arises from mechanical causes not removable by mercury, as obliteration of any of the venous trunks, or pressure of malignant tumors, salivation is injurious. Occasionally dropsical effusion takes place without any appreciable cause, and then, of course, if mercury be employed, it must be in part on speculation. In such cases calomel is not unfrequently employed in combination with squills or foxglove.

(*f.*) *In chronic diseases of the viscera*, especially those arising from or connected with inflammation, mercury is frequently serviceable. Thus, in enlargement or induration of the liver, in hepatization of the lungs, &c. In those diseases commonly termed malignant, as cancer and fungus hæmatodes, and also in diseases of a non-malignant character, but occurring in debilitated subjects, mercurials, given so as to excite salivation, are objectionable.

(*g.*) *In chronic diseases of the nervous system.*—Mercury has been recommended in paralysis, and on some occasions has proved exceedingly efficacious. I have seen hemiplegia, with impaired vision and hearing, headache, and cramps of the extremities, recover under the use of mercury, after blood-letting, purgatives, &c. had failed. The patient (a young man) was kept under the influence of the medicine for two months. Mr. Colles (*op. cit.* p. 327) has likewise found it most efficacious in paralysis. In tetanus, mania, epilepsy, hysteria, tic douloureux, and other affections of the nervous system, mercury has been used with occasional benefit.

The foregoing are some of the more important diseases against which mercurials have been successfully administered as sialogogues.

Hydrar'gyrum cum Cre'tâ.—Mer'cury with Chalk.

History.—This compound (called also *mercurius alcalisatus*, or *æthiops absorbens*) is first mentioned, I believe, by Burton, in 1738.

Preparation.—It is prepared by rubbing three ounces of mercury with five ounces of chalk, until globules are no longer visible. On account of the tediousness of the process, the friction is usually effected by steam.

If this powder be digested in acetic acid, the lime of the chalk is dissolved, and the carbonic acid escapes; but the greater part, if not the whole of the mercury, is insoluble in the acid, and hence is not the protoxide. If examined by a lens, the residuum is found to consist of minute separate globules, which readily whiten silver and gold, showing they are in the metallic state. Hence it is probable that the quicksilver is, for the most part, mechanically divided only, but a small portion may perhaps be oxidized.

Properties and Characteristics.—It is a greyish powder, which effervesces on the addition of acetic acid, yielding a solution of lime, which may be distinguished by the tests for the calcareous salts already mentioned. By digestion in nitric acid, we obtain a solution known to contain mercury by the characters already detailed for the mercurial preparations generally. By heat the mercury is volatilized, leaving the chalk.

Composition.—It consists of mercury and chalk, with perhaps a little protoxide of mercury. It contains three parts of mercury and five of chalk.

Physiological Effects.—It is an exceedingly mild but valuable mercurial. In full doses it acts as a gentle laxative, promoting the secretion of bile and intestinal mucus, but sometimes creating a little sickness. The chalk renders it antacid. By repeated use it occasions the constitutional effects of mercury already described.

Uses.—It is a valuable remedy in *syphilis infantum*. It is frequently employed to promote and improve the secretions of the liver, pancreas, and bowels, in various disordered conditions of the digestive organs, accompanied by clay-coloured stools or purging. In strumous affections of children (especially enlarged mesenteric glands), and other chronic maladies, it is administered with great advantage as an alterative.

Administration.—To adults it is given in doses of from five grains to a scruple, or half a drachm. For children the dose is two or three grains. Rhubarb, carbonate of soda, or, in some cases, Dover's powder, may be conjoined with it.

Hydrar'gyrum cum Magne'siâ.—Mer'cury with Magne'sia.

Under this name there is a compound in the Dublin Pharmacopœia, prepared by rubbing two parts of mercury with two parts of manna until the globules disappear, and then washing out the manna with water, and adding eight parts of subcarbonate of magnesia. Its effects and uses are analogous to the preparation just described.

Pil'ulæ Hydrar'gyri.—Pills of Mer'cury.

History.—The oldest formula for mercurial pills is that of Barbarossa (at one time admiral of the Turkish fleet, and afterwards governor or king of Algiers), and which was communicated by him to Francis the First, king of Franconia, who made it public. The common name for this preparation is *blue pill*, or *pilulæ cæruleæ*.

Preparation.—In the London Pharmacopœia it is ordered to be prepared by rubbing two drachms of purified mercury with three drachms of confection of roses, until globules are no longer visible, and then adding a drachm of powdered liquorice-root. In the Dublin Pharmacopœia extract of liquorice is substituted for the root. In the Edinburgh Pharmacopœia one part of mercury, one of confection of roses, and two of starch, are employed. The friction is usually effected by steam power. By trituration the metal is reduced to a finely-divided state, and becomes intimately mixed with the confection and liquorice powder.

Properties.—It is a soft mass, of a convenient consistence for making into pills, and has a dark blue colour. When rubbed on paper, or glass, it ought to present no globules; but applied to gold it communicates a silvery stain.

Composition.—Three grains of this pill contain one grain of mercury.

Impurity.—If any sulphuric acid should have been added to the confection to brighten its colour, some subsulphate of mercury will be formed—a compound which possesses very energetic properties.

PHYSIOLOGICAL EFFECTS.—In full doses (as fifteen grains) it frequently acts as a purgative. In small doses it is alterative, and, by repetition, produces the before-mentioned constitutional effects of mercurials.

USES.—The practice of giving a blue pill at night, and a senna draught the following morning, has become somewhat popular, in consequence of its being recommended by the late Mr. Abernethy, in various disorders of the chylopoietic viscera. As an alterative, in doses of two or three grains, blue pill is frequently resorted to. Lastly, it is one of the best internal agents for exciting salivation, in the various diseases for which mercury is adapted.

ADMINISTRATION.—The usual mode of exhibiting it is in the form of pill, in the doses already mentioned; but it may also be administered when suspended in a thick mucilaginous liquid. If the object be to excite salivation, we may give five grains in the morning, and from five to ten in the evening; and to prevent purging, opium may be conjoined.

Unguen'tum Hydrar'gyri.—Oint'ment of Mer'cury.

HISTORY.—Mercurial ointment was known to, and employed by, the ancient Arabian physicians—for example, Abhenguefith, Rhazes, and Avicenna: so that it has been in use certainly 1000 years. However, Gilbertus Anglicus, who lived about the commencement of the thirteenth century, was the first who gave a detailed account of the method of extinguishing mercury by fatty matters. Besides its more common appellation of *mercurial ointment*, it was formerly termed *blue* or *Neapolitan ointment*.

PREPARATION.—In the London, Dublin, Edinburgh, and United States Pharmacopœias, the *unguentum hydrargyri fortius* is prepared by rubbing two pounds of mercury with an ounce of suet and twenty-three ounces of lard, until globules are no longer visible. To promote the extinction of the mercury, the metal should be previously triturated with some old mercurial ointment. Rancid lard also assists the extinction of the globules.

Some assert that the mercury is in a finely-divided metallic state, though, if well prepared, there are no appearances of globules when the ointment is examined by a lens. In favour of this view Guibourt (*Pharm. Raisonnée*, ii. 140) states, that by digesting ether on mercurial ointment, the fatty matter may be dissolved and liquid mercury obtained in equal weight to that used in making the ointment. Now it is unlikely, if the mercury had been previously oxidized, that the ether could deoxidize it; and therefore, this experiment (supposing the results to be those mentioned) appears almost decisive that the mercury is in the metallic state; but on repetition of the experiment, I have not obtained the results stated by M. Guibourt. Mr. Donovan, however, thinks that part of the mercury attracts oxygen, and that the oxide thus formed unites with the fatty matter. I have seen no satisfactory explanation of the efficacy of old mercurial ointment in extinguishing the mercury; Guibourt offers the following:—By trituration, both lard and mercury assume oppositely electrical states, the lard becoming negative, the mercury positive; these states, he supposes, determine a more intimate mixture of the particles, and a greater division of the mercury. Now rancid lard and old mercurial ointment, having attracted oxygen from the air, more readily take on the negative condition, and hence their efficacy in promoting the extinction of the mercurial globules. Guibourt also asserts, that mortars of marble or wood are better adapted for making this ointment than those of metal, on account of their power of conducting electricity being less.

PROPERTIES.—It is an unctuous fatty body of a bluish grey colour, and if properly prepared, gives no traces of globules when rubbed on paper, and examined by a microscope; but when rubbed on gold, it quickens it.

COMPOSITION.—This compound contains half its weight of mercury.

PHYSIOLOGICAL EFFECTS.—Mercurial ointment possesses very little power of irritating the parts to which it is applied; but when either swallowed or rubbed into the integuments, readily produces the constitutional effects of mercury. Thus Cullerier says, that three or four pills, containing each two grains of this ointment, and taken successively, have often sufficed to excite violent salivation. He also tells us, that if the object be to produce ptyalism, in a very short space of time, we may effect it by giving half a drachm of the ointment in the space of twenty-four hours.

When rubbed on the surface of the body, it produces the same constitutional effects as the other preparations of mercury; but if the lard which it contains be not rancid, no obvious local effect is usually produced. Applied to ulcerated surfaces, mercurial ointment is a stimulant, and in syphilitic sores is oftentimes a very useful and beneficial application.

USES.—It is rarely or never administered *internally* in this country, but has been much used on the continent, and with great success. It certainly well deserves a trial where the system appears insusceptible to the influence of mercury; for Cullerier says, the difficulty with him has been rather to check than to excite salivation by it.

Applied *externally*, it is employed either as a local or constitutional remedy. Thus as a *local* agent it is used as a dressing to syphilitic sores, or rubbed into tumors of various kinds (not those of a malignant nature, as cancer and fungus hæmatodes), with the view of exciting the action of the lymphatic vessels. Sometimes, also, it is employed to destroy parasitic animals on the skin. As a *means of affecting the constitution* we use mercurial inunctions in syphilis, in inflammatory diseases, and, in fact, in all the cases (already noticed) in which our object is to set up the mercurial action in the system, more especially when the irritable condition of the digestive organs offers an objection to the internal employment of mercurials. It may be laid down as a general rule, that mercury may be used with more safety by the skin than by the stomach; but reasons of convenience, which I have already alluded to, frequently lead us to its internal use.

ADMINISTRATION.—*Internally*, it is given in doses of from two to five grains, made into pills, with either soap or some mild powder, as liquorice. *Externally*, when the object is to excite very speedy salivation, half a drachm may be rubbed into the skin every hour, washing the part each time, and varying the seat of application. If, however, it be not desirable or necessary to produce such a speedy effect, half a drachm or a drachm, rubbed in night and morning, will be sufficient.

During the whole course of inunction the patient should wear the same drawers night and day.

When the friction is performed by a second person, the hand should be enveloped with soft oiled pig's bladder, turned inside out (Colles, *op. cit.* p. 42). In making use of mercurial frictions, it is to be recollected they ought not to be violent, but long continued, and had better be carried on near a fire, in order to promote the liquefaction and absorption of the ointment. In syphilis, and other diseases in which our sole object is the constitutional affection, it matters little to what part of the body the ointment is applied, provided the cuticle be thin (for this inorganized layer offers an impediment to absorption in proportion to its thickness). The internal parts of the thighs are usually, therefore, selected. However, in liver complaints, the inunctions are made in the region of the organ affected. The occasional use of the warm bath promotes absorption when the ointment is applied to the skin.

UNGUENTUM HYDRARGYRI MITIUS (Ph. Lond. & Dublin).—This is prepared by mixing a pound of strong mercurial ointment with two pounds of lard. It contains a sixth part of its weight of mercury. This preparation is applied as a dressing to ulcers and cutaneous diseases.

CERATUM HYDRARGYRI COMPOSITUM (Ph. Lond.: stronger ointment of mercury; soap cerate, $\overline{aa}$ ℥iv.; camphor, ℥j. M.)—Its uses are similar to those of the following preparation:—

LINIMENTUM HYDRARGYRI COMPOSITUM (Ph. Lond.: stronger ointment of mercury; lard, of each, ℥iv.; camphor, ℥j.; rectified spirit, f.ʒj.; solution of ammonia, f.℥iv. M.)—It is used (by way of friction) in chronic tumors, chronic affections of the joints, &c., where the object is to excite the action of the lymphatic vessels. It is stated to cause salivation more readily than the common mercurial ointment, owing to the camphor and ammonia.

Emplas′trum Hydrar′gyri.—Plas′ter of Mer′cury.

In the London Pharmacopœia, this is ordered to be prepared by adding eight grains of sulphur to a fluidrachm of heated olive oil, stirring until they unite. Then rub the mercury with the oil until the globules are no longer visible, and add a pound of melted lead plaster. In this process the sulphur of the sulphurated oil forms with the mercury a sulphuret, while the remainder of the metal is mechanically divided. Each drachm of the plaster contains fifteen grains of mercury.

It is supposed to stimulate the lymphatic vessels of the parts to which it is applied, and is used as a discutient in glandular enlargements and other swellings, whether venereal or otherwise, and also to the region of the liver in hepatic complaints. Dr. Wilson Philip (*op. cit.*) has seen it induce salivation.

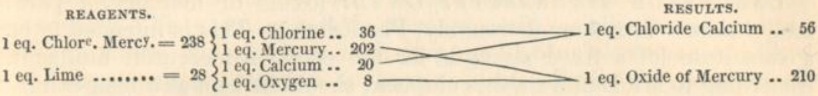
EMPLASTRUM AMMONIACI CUM HYDRARGYRO (Ph. Lond.)—This is prepared in a similar manner to the last preparation, except that the gum-resin ammoniacum is substituted for the lead plaster. The preparation of the Dublin Pharmacopœia consists of ammoniacum, lb. j.; purified mercury, ℥iij.; common turpentine, ʒij. M. It is a more powerful compound than the last, and is employed in the same cases, especially in venereal buboes.

Hydrar'gyri Ox'ydum.—Ox'ide of Mer'cury.

History.—The mode of preparing this compound was taught by Moscat in 1797. This oxide is sometimes termed the *protoxide, suboxide, ash, grey*, or *black oxide* (*hydrargyri oxydum cinereum, hydrargyri oxidum nigrum*).

Preparation.—In the London Pharmacopœia it is prepared by adding one ounce of calomel to a gallon of lime water: then frequently shake them, set by, and when the oxide has subsided, pour off the supernatant liquor, and wash the precipitate with distilled water: afterwards dry it (wrapped in bibulous paper) in the air.

In this process double decomposition takes place: chloride of calcium is formed in solution, while oxide of mercury precipitates.



In the Edinburgh Pharmacopœia one-fourth more lime-water is employed, and the mixture boiled for a quarter of an hour. In the Dublin Pharmacopœia, one part of calomel and four of water of caustic potash are employed. In this case chloride of potassium is formed in solution.

Properties.—Pure oxide of mercury is black, or nearly so. The present preparation, however, is frequently greyish, owing to the presence of some undecomposed calomel. It is readily decomposed by light (especially by the solar rays), becomes olive coloured, and is resolved into metallic mercury and the binoxide. It is odourless, tasteless, insoluble in water and the alkalies, but soluble in nitric acid and acetic acid. By the action of hydrochloric acid it forms water and calomel. When heated it is first decomposed, and then completely dissipated.

Characteristics.—Heated in a glass tube it evolves oxygen, while metallic globules are sublimed. Dissolved in nitric acid it forms a protomercurial salt, known by the before-mentioned characters for these substances.

Composition.—The composition of this oxide is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Sefström.
Mercury	1	202	96·19	96·2
Oxygen	1	8	3·81	3·8
Oxide of Mercury	1	210	100·00	100·0

Purity.—Digested, for a short time, in dilute hydrochloric acid, the solution, when filtered, should form no precipitate with either potash or oxalate of ammonia. If any binoxide had been dissolved, the potash would throw it down as a reddish or yellowish hydrate. If any carbonate of lime had been precipitated, the oxalate would recognise it.

Physiological Effects.—Pure oxide of mercury is one of the least irritating of the mercurial preparations, and, therefore, when swallowed, does not produce much disorder of the alimentary canal. In small doses it acts as an alterative and purgative. When taken in repeated doses, its constitutional effects are similar to those of other mercurials.

Uses.—Mr. Abernethy employed it as a fumigating agent. The following are his directions for using it:—Place the patient in a vapour bath, in a complete suit of under garments, with a cloth around his chin. Two drachms of the oxide are then to be put on a heated iron within the machine in which the patient is sitting. After continuing in the bath for about fifteen or twenty minutes, the body is found to be covered with a whitish powder. The patient should be placed in bed, and lie in the same clothes till morning, and then go into a tepid bath. By this mode of proceeding, Mr. Abernethy says, he has known salivation induced in forty-eight hours.

Oxide of mercury is rarely employed as an internal remedy; indeed, its varying composition is a strong objection to its use. As an external application it has been used in the form of *ointment,* and also suspended in a weak solution of chloride of calcium, under the name of *black-wash*.

ADMINISTRATION.—For internal use the dose is from half a grain to two or three grains.

UNGUENTUM HYDRARGYRI OXYDI (oxide of mercury, 1 part; lard, 3 parts: mix them thoroughly, Ph. Edinb.)—This is intended to be a substitute (of a fixed strength) for the common mercurial ointment. According to Mr. Donovan, this ointment should be kept at a temperature of 350° F., for the space of two hours, in order that the oxide and the fatty matter may enter into union. It is used as a substitute for mercurial ointment.

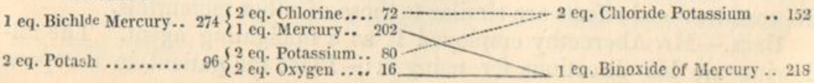
LOTIO NIGRA (*black-wash; aqua mercurialis nigra; aqua phagedenica mitis*).—This is prepared by adding calomel to lime-water. The proportions of the ingredients may be varied, but in general one drachm of calomel is used to a pint of lime-water. Oxide of mercury precipitates, and chloride of calcium remains in solution. As the efficacy of the wash depends on the oxide, the bottle must be well shaken every time of using it. This compound is a favourite application to venereal sores of almost all kinds,—in most being serviceable, in few or none being hurtful.

Hydrar'gyri Binox'ydum.—Binox'ide of Mer'cury.

HISTORY.—This is the *peroxide* or *red oxide of mercury* of some writers. Geber (*Sum of Perfection*, book i. part iv. ch. 16) describes the method of making that variety of it which is prepared by calcination, and which was formerly called *red precipitate per se* (*mercurius præcipitatus ruber per se*) or *calcined mercury* (*hydrargyrum calcinatum*). He calls it *coagulated mercury*.

PREPARATION. (*a*.) *By precipitation*.—In the London Pharmacopœia this compound is directed to be prepared by adding 28 fluidounces of solution of potash to four ounces of bichloride of mercury, dissolved in six pints (120 fluid ounces) of distilled water. The precipitated powder is to be washed with distilled water until the latter comes off tasteless, and is then to be dried.

In this process one equivalent or 274 parts of bichloride of mercury are decomposed by two equivalents or 96 parts of potash, and yield one equivalent or 218 parts of binoxide of mercury, and two equivalents or 152 parts of chloride of potassium.



(*b.*) *By calcination.*—In the Dublin Pharmacopœia, *hydrargyrum oxydum rubrum* is directed to be prepared by exposing mercury to a heat of 600°, in an open glass vessel, with a narrow mouth and broad bottom, until it is converted into red scales. The heat vapourizes the mercury, which in this state attracts oxygen from the air, and forms this red or binoxide. The long neck of the vessel prevents the escape of the vapours or newly-formed oxide.

The process is a very tedious one, occupying several weeks; so that Geber's remark was correct, that " it is a most difficult and laborious work, even with the profoundness of clear-sighted industry." The apparatus which Mr. Boyle contrived for the manufacture of it, was long termed " *Boyle's Hell*," from a notion that the mercury was tortured in it.

Properties.—When prepared by precipitation it is in the form of an orange-red powder; but when made by calcination, occurs in small brilliant scales of a ruby red colour. Both varieties agree in the following properties:—They are odourless, have an acrid metallic taste, are insoluble in water, but soluble in both nitric and hydrochloric acids. They are decomposed and reduced by heat and solar light: the precipitated variety is more readily acted on by solar light than the variety made by calcination.

Characteristics.—When heated in a glass tube by a spirit lamp, it is decomposed into oxygen and mercury: the first may be recognised by a glowing match, the second condenses in small globules. It dissolves completely in hydrochloric acid: the solution contains bichloride of mercury, which may be known by the tests hereafter to be mentioned for this substance (*vide* Hydrargyri Bichloridum).

Composition.—The composition of this substance is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Sefström.	Donovan.
Mercury	1	202	92·66	92·68	92·75
Oxygen	2	16	7·34	7·32	7·25
Binoxide of Mercury	1	218	100·00	100·00	100·00

Binoxide of mercury prepared by precipitation usually contains some water.

Purity.—Binoxide of mercury should be completely dissipated by heat, and be insoluble in water. Its solution in nitric acid should be unaffected by nitrate of silver, by which the absence of any chloride is shown. If an insufficient quantity of potash be employed in the preparation of the precipitated variety, the product is brownish or brick-dust coloured, and contains oxichloride of mercury (composed, according to Souberain, of 1 eq. bichloride of mercury and 3 eqs. of binoxide: Dumas, *Traité de Chimie*, iii. 615).

Physiological Effects.—Binoxide of mercury is a powerful irritant, and when taken internally, even in small doses, readily excites vomiting and purging; large doses would excite gastro-enteritis. Orfila (*Toxicol. Gén.*) found that binoxide, obtained by precipitation from four grains of bichloride, killed a dog in eighteen minutes. The constitutional effects of this preparation are the same as those of mercurials generally.

Uses.—Binoxide of mercury is rarely employed as a medicine. It has been applied as an escharotic, either in the form of powder or ointment. Internally it was formerly exhibited to excite salivation in venereal diseases, but is objectionable, especially where the bowels are morbidly irritable. It is rarely or never used now.

In pharmacy it is employed in the preparation of bicyanide of mercury (*vide* HYDRARGYRI BICYANIDUM).

ADMINISTRATION.—The dose of it is from a quarter of a grain to a grain, given in the form of pill, in combination with opium.

***LOTIO FLAVA*:** *Lotio* (seu *aqua*) *phagedænica* : *yellow wash*.—This compound, which was formerly in frequent use, is prepared by adding bichloride of mercury to lime-water. The proportions vary in different formulæ. The quantity of bichloride should not, I think, exceed two grains to an ounce of lime-water: the usual proportions are thirty grains of bichloride to sixteen ounces of lime-water. The preparation, then, consists of the yellow hydrated binoxide of mercury (which precipitates), chloride of calcium, and caustic lime; the two latter being in solution. But if the quantity of bichloride exceed $3\frac{7}{10}$ grains to an ounce of lime-water, the precipitate is brown or brick-dust coloured, and contains oxichloride of mercury, while the clear liquor holds in solution some hydrargyro-chloride of calcium; that is, a saline combination, in which chloride of calcium is the base, and bichloride of mercury the acid (Guibourt, *Journ. Chim. Méd.* iii. 377; also *Pharm. Raisonnée*, i. 563; and Souberain, *Nouv. Traité de Pharm.* ii. 529). Yellow or phagedenic wash is applied, by means of lint, to venereal and scrofulous ulcers. Dr. Hintze (*Brit. and For. Med. Rev.* April 1836) used it with advantage in chronic ulcers which succeed to burns. It should be well shaken, and used in the turbid state.

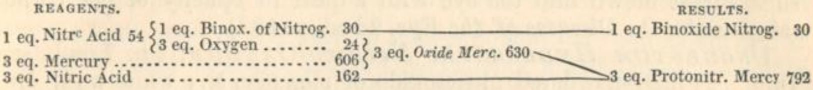
Hydrar′gyri-Ni′trico-Ox′ydum.—Ni′tric-ox′ide of Mercury.

HISTORY.—This preparation was known to Raymond Lully in the latter part of the thirteenth century. It is commonly termed *red precipitated mercury* (*mercurius præcipitatus ruber*), or, for brevity, *red precipitate*. It is the *oxidum hydrargyrum rubrum per acidum nitricum* of the Edinburgh Pharmacopœia.

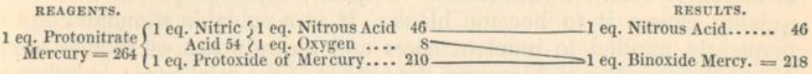
PREPARATION.—In the London Pharmacopœia this compound is directed to be prepared by dissolving three pounds of mercury in a mixture of a pound and a half of nitric acid and two pints (℥xl.) of distilled water. The solution is to be evaporated to dryness, and the residue reduced to powder; which is to be put in a shallow vessel, and heated by a slow but gradually increased fire, until red vapours cease to arise.

This compound is best prepared on the large scale, for it cannot be so well procured of the bright orange-red colour and crystalline or scaly appearance usually considered desirable, when only small quantities of materials are employed. Some advise a larger quantity of nitric acid to be employed than is directed in the London Pharmacopœia. The reduction of the nitrate to powder is objectionable, as it diminishes the crystalline appearance of the oxide. Mr. Brande (*Manual of Chemistry*) says, " the nitrate requires to be constantly stirred during the process, which is usually performed in a cast-iron pot." But in general a shallow earthen dish is employed, with a second one inverted over it, and care is taken not to disturb the nitrate during the operation. The heat of the sand-bath is employed. Indeed, some have asserted that the finest product is obtained when the calcination is performed in the same vessel in which the nitrate was formed, and without stirring, as directed in the Dublin Pharmacopœia (Dr. Barker, *Observ. on the Dubl. Pharm.*)

When quicksilver and the diluted nitric acid are digested together, the metal is oxidized at the expense of part of the acid, while binoxide of nitrogen escapes, and, combining with oxygen of the air, becomes nitrous acid. The oxidized metal unites to some undecomposed acid to form a nitrate. If no heat be applied, a nitrate of the protoxide only is procured; but when heat is employed, a portion of nitrate of the peroxide is also produced. The following diagram will explain the formation of the protonitrate:—



When nitrate of mercury is heated, decomposition takes place: the nitric acid is resolved into oxygen and nitrous acid, the first of which combines with the protoxide of mercury, forming therewith the binoxide, while the nitrous acid escapes.



Some pernitrate of mercury usually remains undecomposed, but the quantity is small. Mr. Brande states that 100 pounds of mercury with 48 lbs. of nitric acid (sp. gr. 1·48) yielded 112 pounds of nitric-oxide of mercury. Hence 3 pounds of nitric acid must have remained in combination with the oxide.

Properties.—It occurs in bright tile-red or scarlet crystalline grains or scales. When quite free from nitrate of mercury, it is insoluble in water; but owing to the presence of a small quantity of nitrate, the nitric-oxide of mercury of commerce is usually slightly soluble in water. Dr. Barker (*op. cit.*) found that 1000 parts of water took up 0·62 of this oxide. The other properties and characteristics of this compound are the same as those of the last-mentioned preparation (*vide* Hydrargyri Binoxydum)

Purity.—The presence of some undecomposed nitrate may be recognised by heating the suspected nitric-oxide of mercury, when nitrous vapours are evolved, and by boiling in water, when a solution is obtained, from which lime-water and hydrosulphuric acid throw down precipitates. The nitric-oxide of mercury is completely dissipated by heat: hence the presence of non-volatile matters (as red-lead) might be readily detected. Heated before the blow-pipe on charcoal, the mercurial oxide is reduced and dissipated, but if red-lead be present, globules of metallic lead will be left behind.

Physiological Effects.—Its local action is that of a powerful irritant (*vide* Hydrargyri Binoxydum). When the nitric-oxide contains nitrate of mercury, its topical influence is rendered more energetic. Its constitutional effects are the same as those of other mercurials.

Fabricius Hildanus, Bartholinus, Langius, and Jacobs (quoted by Wibmer, *Wirkung d. Arzneim.* iii. 69), have reported cases in which the external use of this agent gave rise to salivation and other constitutional effects of mercury. In the case mentioned by Jacob, death resulted from the application of it to a wart on the face.

Frederic Hoffmann, Ploucquet, Girtanner (Wibmer, *op. cit.*), and more recently Mr. Brett (*Lond. Med. Gaz.* xiii. 117), have related instances of poisoning by its internal employment.

Uses.—Internally it has been administered in the form of pill in venereal diseases, but the practice is highly objectionable.

As an external agent it is used in the form of powder (obtained by levigation) or ointment; the latter is officinal. As a caustic, it is sprinkled over spongy excrescences, venereal warts, chancres, indolent fungous ulcers, &c. Mixed with eight parts of finely-powdered white sugar, it is blown into the eye with a quill in opacity of the cornea (Mackenzie, *On Diseases of the Eye*, 2d ed. p. 584).

UNGUENTUM HYDRARGYRI NITRICO-OXYDUM, Ph. Lond. and Dub. (Finely-powdered nitric-oxide of mercury, ℥j.; white wax, ℥ij.; lard, ℥vj. Mix. The *unguentum oxidi hydrargyri rubri*, Ph. Ed. consists of nitric oxide of mercury, one part; lard, six parts. Mix.)—This ointment undergoes decomposition by keeping; its colour changing from red to grey, in consequence of the partial deoxidation of the nitric-oxide of mercury. Dr. Duncan (*Edinb. Dispens.*) says the presence of resin quickly causes it to become black. It is a valuable stimulant, and is frequently applied to indolent sores and ulcers, when we require to increase the quantity and improve the quality of the discharge; to inflamed eye-lids (*ophthalmia tarsi*); chronic conjunctivitis, &c.

Hydrar'gyri Chlo'ridum.—Chlo'ride of Mer'cury.

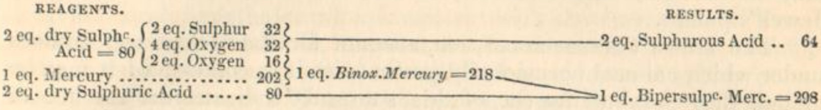
History.—Beguin in 1608, and Oswald Croll in 1609, are the first Europeans who mention this compound. Mr. Hatchett (Brande's *Manual of Pharmacy*, 2d edit. 328) says it had been long known to the natives of Thibet. Its discoverer is unknown. It has had a great variety of names. The term *calomel* (*calomelas*, from καλὸς, *good*, and μέλας, *black*) was first applied to it by Sir Theodore de Mayenne (who died in 1655), in consequence, as some say, of his having had a favourite black servant who prepared it; or according to others, because it was a *good* remedy for the *black* bile. *Drago mitigatus*, *aquila alba*, *manna metallorum*, and *panchymagogum minerale*, are some of the appellations for it. *Mercurius dulcis*, *hydrargyrum muriaticum mite*, *submuriate of mercury*, and *subchloride*, *protochloride*, or *dichloride of mercury*, are some of the more modern synonyms of it.

Natural History.—*Native calomel* or *corneous mercury* occurs in crusts, and also crystallized in four-sided prisms terminated by pyramids. It is found at Deux-Ponts, Carniola, and in Spain.

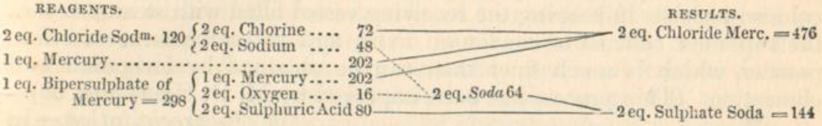
Preparation. (*a.*) *By sublimation.*—Chloride of mercury is prepared by sublimation from a mixture of sulphate of mercury and chloride of sodium.

In the London Pharmacopœia, two pounds of mercury are directed to be boiled with three pounds of sulphuric acid, to dryness, by which bipersulphate of mercury is obtained. When cold, this is mixed, first with two pounds of mercury, then with a pound and a half of chloride of sodium, and afterwards sublimed. The sublimate is to be washed with boiling distilled water, and dried.

In the first stage of this process one equivalent or 202 parts of mercury decompose two equivalents or 80 parts of dry sulphuric acid; and, abstracting two equivalents or 16 parts of oxygen, to form one equivalent or 218 parts of binoxide of mercury, disengage two equivalents or 64 parts of sulphurous acid. The binoxide combines with two equivalents or 80 parts of undecomposed sulphuric acid, forming one equivalent or 298 parts of bipersulphate of mercury.



If one equivalent or 298 parts of bipersulphate, one equivalent or 202 parts of reguline mercury, and two equivalents or 120 parts of chloride of sodium, be intimately mixed and sublimed, reaction takes place, and we obtain two equivalents or 476 parts of chloride of mercury, and two equivalents or 144 parts of sulphate of soda.



Mr. Phillips (*Translation of Pharmacopœia*, 1836) explains the process somewhat differently. He assumes that the trituration of bipersulphate with mercury converts this salt into the protosulphate of mercury, and that this yields chloride of mercury by the action of chloride of sodium. But the mere trituration of bipersulphate of mercury with metallic mercury cannot be admitted to be sufficient to convert this salt into protosulphate. It is not improbable that bichloride of mercury is first formed by the mutual reaction of bipersulphate of mercury and chloride of sodium; and that this subsequently combines with mercury, both being in the state of vapour, to form calomel. For some bichloride is always found mixed with the sublimed calomel, and calomel may be readily obtained by subliming bichloride and mercury: as in the process of the Edinburgh Pharmacopœia.

At Apothecaries' Hall, 50 lbs. of mercury are boiled with 70 lbs. of sulphuric acid to dryness in a cast-iron vessel; 62 lbs. of the dry salt are triturated with 40½ lbs. of mercury, until the globules disappear, and 34 lbs. of common salt are then added. The mixture is submitted to heat in earthen vessels, and from 95 to 100 lbs. of calomel are the result. It is washed in large quantities of distilled water, after having been ground to a fine and impalpable powder.

The subliming apparatus varies in different manufactories. In some it consists of a large earthen retort, with short but wide neck, opening into an earthen elliptical receiver, in the bottom of which is water. The retort is placed in sand, contained in an iron pot set in a furnace.

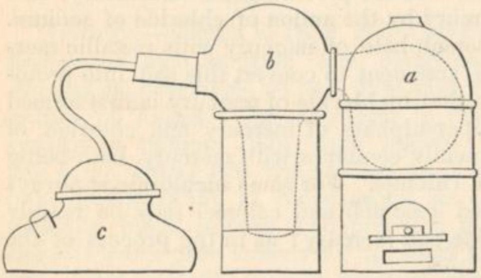
"The form in which calomel sublimes," observes Mr. Brande, "depends much upon the dimensions and temperature of the subliming vessels. In small vessels it generally condenses in a crystalline cake, the interior surface of which is often covered with beautiful quadrangular prismatic crystals (Brooke, *Annals of Philosophy*), transparent, and of a texture somewhat elastic or horny: in this state it acquires, by the necessary rubbing into powder, a decidedly yellow or buff colour, more or less deep, according to the degree of trituration which it has undergone. If, on the contrary, the calomel be sublimed into a very capacious and cold receiver, it falls in a most impalpable and perfectly white powder, which only requires one elutriation to fit it for use; it then remains perfectly colourless. By a modification of the process, it may be suffered, as it sublimes, to fall into water, according to Mr. Jewell's patent.

"The above circumstances, too, account for the various appearances under which calomel occasionally presents itself in commerce: it may be added, that the buff aspect of this substance indicates the absence of corrosive sublimate; though it by no means follows as a consequence that when snow-white it contains it. When the surface of massive sublimed calomel is scratched, it always exhibits a buff colour: it also becomes yellow when heated, but loses its tint as it again cools." (*Manual of Chemistry*, 4th ed. p. 788).

Mr. Jewell's process (*Repert. of Arts*, xiii. 79, 2d Series) for preparing calomel consists in keeping the receiving vessel filled with steam, so that the vaporous calomel is condensed in it, and takes the form of a fine powder, which is much finer than can be obtained by levigation and elutriation. This process has been improved by M. O. Henry (fig. 66).

Henry's modification of Jewell's apparatus for preparing calomel by steam (Hydrosublimate of mercury).

Fig. 66.



(*a*) Furnace, containing an earthen retort (having a wide and short neck), in which the ingredients for making calomel are placed.
(*b*) An earthen receiver, having three tubulures: one connecting with the retort; a second dipping into water in an earthen jar, and a third connected to a steam-pipe.
(*c*) Steam-boiler.

(*b.*) *By precipitation.*—In the Dublin Pharmacopœia, a process is given for procuring precipitated calomel. It consists in mixing seven parts of chloride of sodium, dissolved in 400 parts of boiling water, with 17 parts of purified mercury, dissolved in 15 parts of diluted nitric acid. Double decomposition takes place: one equivalent or 60 parts of chloride of sodium decompose one equivalent or 264 parts of protonitrate of mercury, and produce one equivalent or 238 parts of chloride of mercury, and one equivalent or 86 parts of nitrate of soda.

Properties.—The primary form of the crystals of calomel is the right square prism. The appearance of the crystalline cake of sublimed calomel has been already noticed. As met with in the shops, it is in the form of a fine odourless or tasteless powder, whose sp. gr. is 7·176 (7·2, Brande). When prepared by Jewell's process it is perfectly white, but when obtained in the ordinary way has a light buff or ivory tint. It volatilizes by heat, and, under pressure, fuses. It is insoluble in cold water and alcohol. According to Donovan (*Ann. Phil.* xiv. 323) and others (Gmelin, *Handb. d. Chemie*, i. 1299; Geiger's *Handb. d. Pharm.* by Liebig, i. 561), calomel suffers partial decomposition by long boiling in water, and a solution is obtained which contains mercury and chlorine (bichloride of mercury ?).

By exposure to light, calomel becomes dark coloured, in consequence, according to Dumas (*Traité de Chimie*, iii. 605), of the transformation of a small portion into mercury and bichloride. Others have ascribed this change to the evolution of chlorine and combination of the metal with oxygen. Both hypotheses are inconsistent with the statement of Vogel (Landgrebe, *Ueber das Licht*, 97), that this blackened calomel is insoluble in nitric acid. Is it not probable that the change depends on the formation of a subchloride, as Wetzlar has shown to be the case with chloride of silver? By digestion in hot and concentrated hydrochloric acid, we obtain bichloride of mercury and reguline mercury. Boiling sulhpuric acid forms bipersulphate and bichloride of mercury, with the evolution of sulphurous acid.

CHARACTERISTICS.—Iodide of potassium produces at first a greyish, afterwards a greenish-yellow precipitate (iodide of mercury). When heated in nitric acid, calomel is converted into bichloride and bipernitrate of mercury; and on the application of the tests already mentioned for mercurial preparations generally, we readily obtain evidence of the presence of mercury. Having thus shown it to be a mercurial compound, we may easily prove it to be calomel by observing that it is insoluble in water, and that on the addition of lime-water a blackish grey precipitate (protoxide of mercury) is obtained, while the supernatant liquor is found, on the addition of the nitrate of silver, to give evidence of the presence of chlorine in solution. Protochloride of tin, added to calomel, abstracts the chlorine, and becomes bichloride of tin, while globules of metallic mercury are obtained.

COMPOSITION.—The following is the composition of calomel :—

	Eq.	Eq.Wt.	Per Cent.	Turner, Davy, Zaboada.
Mercury	1	202	84·87	85
Chlorine	1	36	15·12	15
Chloride of Mercury	1	238	99·99	100

PURITY.—When pure, calomel is completely vaporized by heat. Water or alcohol which has been digested on it, should occasion no precipitate or change of colour on the addition of lime-water, caustic potash, ammonia, nitrate of silver, or hydrosulphuric acid, by which the absence of bichloride of mercury may be inferred. I have met with calomel which, in consequence of being imperfectly washed, contained bichloride. It had been given to several patients before its purity was suspected, and had operated on them most violently. When mixed with potash it became black, like pure calomel: the quantity of bichloride being insufficient to produce any perceptible alteration in the colour of the precipitate. But water which had been digested on it, gave, with the above-mentioned tests, the characteristic indications of bichloride of mercury.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—Wepfer (*Hist. Cicutæ Aquat.*), Viborg, Flormann (Wibmer, *Wirk. d. Arzn.*), Gaspard (Magendie, *Journ. de Physiol.*), and Annesley (*Diseases of India*), have examined the effects of calomel on dogs, horses, and pigs, but without any remarkable results. Viborg gave half an ounce, with six pounds of water, to a horse: the effects were cough, heaving of the flanks, quick pulse, enfeebled appetite, and in twenty-four hours loose stools. Annesley asserts, from his experiments on dogs, that large doses of calomel diminish the vascularity of the gastro-intestinal membrane.

(*b.*) *On man.*—Calomel may be ranked among the mild preparations of mercury; for although, in its local action, it is somewhat more powerful than the oxide, or than those preparations which contain mercury in a finely divided state (as blue pill), yet it is much milder than any of the other salts of mercury. In *small doses*, as a few grains, it occasionally excites no obvious effects, though more commonly it acts as a purgative; and in very susceptible persons, especially females, it sometimes produces nausea, griping, and great faintness. It appears, from the experience of most practitioners, that adults are more susceptible of the influence of calomel than children. When given to the latter, it frequently produces green stools, (the so-called *calomel stools* of Kraus),—an effect which is more frequently observed in suckling infants, and which is usually supposed to arise from the action of calomel on the liver; though Zeller (quoted by Kraus) thinks it depends on alterations produced in the condition of the blood; and Kraus (*Heilmittellehre*, 161) is disposed to refer it to the operation of calomel on the milk contained in the alimentary canal. (*On the Effects of Calomel in producing Slimy Stools*, consult *Lond. Med. and Surg. Journ.* Apr. 1829, 344). Like other mercurials, it increases the action of the secreting organs, and thus promotes the secretion of bile and of intestinal mucus; and we also presume it has a similar influence over the secretion of the pancreatic fluid. Neumann (Gräfe and Walther's *Journal*, Bd. ii. H. 3. S. 432, quoted by G. A. Richter, *Ausführ. Arzneim.* v. 492) states, that a man took two, then three, and subsequently four grains of calomel, daily, for the space of two months, without inducing salivation; but that three months afterwards he became affected with chronic vomiting, the consequence of a scirrhous pancreas, of which he died in four months. From the manner in which the case is related, it is clear the narrator attributed the disease of the pancreas to the use of mercury; whether justly or not, however, is impossible to determine.

The repeated and continued use of calomel, in small doses, is attended with the constitutional effects of mercurial preparations generally, before described.

In *large doses*, it has been regarded as an irritant poison; and, judging from the fatal effects ascribed to it by several writers, not without reason. Thus Hellweg (Wibmer, *op. cit.* iii. 71) has reported a case in which a few grains of calomel, taken as a laxative, caused death; Vagnitius (Wibmer, *op. cit.*) saw fifteen grains prove fatal; and Ledelius (*ibid.*), half an ounce. Fr. Hoffmann has also related two fatal cases (*ibid.*)

"Whytt, Odier, Quin, Wilmer, Leib, and others," says Gölis (*Treatise on the Hydrocephalus Acutus*, by Dr. Gooch), "gave calomel internally in far larger doses; as two, three, and more grains at a time; and continued its use many days in the same dose, without considering the many evacuations from the alimentary canal, or the violent colic pains; and they affirm that they have never remarked, from the effect of this agent given in these large doses, any bad consequences in the abdomen.

Melancholy experience compels me to contradict them. Many times I saw, under those large and long-continued doses of calomel, the hydrocephalic symptoms suddenly vanish, and inflammation of the intestines arise, which terminated in death. Still oftener I observed this unfavourable accident from an incautious use of calomel in croup: viz. where all the frightful symptoms of this tracheal inflammation, which threatened suffocation, suddenly vanish, and enteritis develope itself, which passed rapidly into gangrene, and destroyed the patients."

In the *Times* newspaper of the 26th April, 1836, there is the report of a coroner's inquest on the body of a Mrs. Corbyn, who was destroyed by swallowing 20 grains of calomel, she having previously taken a moderate dose without its exciting what she considered a sufficient effect; and in the *India Journal of Medical Science* (*Lond. Med. Gaz.* xviii. 484) is a case of a lad, aged 14, a native of Nepal, in whom six grains of calomel apparently produced inflammation and ulceration of the mouth, enormous swelling of the face, mercurial fœtor of the breath, mortification, and death. There was no ptyalism.

In Pierer's *Annalen* for April 1827 (quoted by Wibmer, *op. cit.* 72), is the case of a lady, who by mistake swallowed fourteen drachms of calomel at once. Acute pains in the abdomen came on, accompanied by frequent vomiting and purging. These symptoms were allayed by oleaginous demulcents; but on the second day salivation and ulceration of the mouth took place. In three weeks, however, she was perfectly recovered. Other violent effects are noticed by Wibmer, Gmelin, and others; but the instances adduced are sufficient to show that dangerous and even fatal effects may result from large doses, and therefore that Teichmeyer, Buchner, and others, are justified in ranking it among poisons.

Of late years, however, immense quantities of calomel have been administered medicinally, without giving rise to any symptoms of irritant poisoning,—nay, apparently with the opposite effect; for we have the concurrent testimony of many practitioners, that in yellow fever, cholera, and other dangerous diseases, calomel, in doses of a scruple and upwards, allays vomiting and purging; and on this account has been denominated a *sedative*. So that while in small doses (as from two to five grains) calomel is almost universally admitted to be an irritant to the bowels, it is asserted that larger ones are actually sedative. These statements appear to me to be almost inconsistent, and yet they are fair deductions from the experience of numerous intelligent practitioners. We must, therefore, endeavour to accumulate more facts, in order to illustrate the effects of calomel, and for the present confess we have very imperfect information respecting the nature of its action.

In a case published by Mr. Roberts in the *London Medical Gazette* (xxii. 611), an ounce of calomel was swallowed by mistake, and retained on the stomach for two hours before the error was discovered. The only effects were slight nausea and faintness. Subsequently, emetics, lime-water, and purgatives, were administered; calomel was vomited up, and the day but one afterwards the patient was quite well. Neither salivation nor the slightest affection of the gums occurred.

The largest quantity of calomel given as a medicinal agent, at one dose, is, I believe, three drachms; " and it was followed," says Dr. Christison (*Treatise on Poisons*), from whom I quote the case, which occurred in America, " by only one copious evacuation, and that not till after the use of an injection." I have now before me reports of eighteen cases of spasmodic cholera, admitted in the year 1832 into the Cholera Hospital at Bethnal Green, in this metropolis, in which enormous quantities of calomel were employed by the house-surgeon, Mr. Charles Bennett (formerly one of my pupils), with very slight physiological effects. When a patient was brought into the hospital, two drachms of calomel were immediately given, and afterwards one drachm every one or two hours, until some effect was produced. In 17 out of 18 cases in which this plan was tried, the vomiting and purging diminished, and the patients recovered. Several of them took from 20 to 30 drachms without the subsequent ptyalism being at all excessive. In one case (a female aged 36 years), 30½ drachms were administered within forty-eight hours, moderate ptyalism took place, and recovery. In the unsuccessful case which I have alluded to, 53 drachms of calomel were administered within forty-two hours, without the least sensible effect.

Dr. Griffin (*Lond. Med. Gaz.* xviii. 880) also tells us, that in several cases of cholera he gave calomel hourly, "in scruple doses, to the amount of two or three drachms or upwards, without eventual salivation; and I recollect," he adds, "one instance in particular, in which I gave two drachms within an hour and a half with perfect success, and without affecting the system."

I do not pretend to reconcile these cases with those recorded by Hellweg, Vagnitius, Ledelius, Hoffman, and Gölis; in fact they appear to me irreconcilable. Dr. Christison, however, suggests that in those cases in which violent effects occurred, the calomel might contain corrosive sublimate.

Mr. Annesley (*Diseases of India*) accounts for the increased quantity of bile found in the stools after the use of calomel, by supposing that the gall-bladder sometimes becomes distended in consequence of the tenacity of the mucous secretion, by which the mouth of the *ductus communis choledochus* is closed; and that calomel acts chemically on the mucus, and detaches it. But the hypothesis is, I think, devoid of foundation.

USES.—Calomel is very frequently used as an *alterative*, in glandular affections, chronic skin diseases, and disordered conditions of the digestive organs, more particularly in those cases connected with hepatic derangement. For this purpose it is usually taken in combination with other alteratives, as in the well-known Plummer's pill, which I shall presently notice.

It is very frequently employed as a *purgative*, though, on account of the uncertainty of its cathartic effects, it is seldom given alone; generally in combination with other drastic purgatives—such as jalap, scammony, compound extract of colocynth, &c. whose activity it very much promotes. We employ it for this purpose when we are desirous of making a powerful impression on the alimentary canal, and thereby of relieving affections of other organs, on the principle of counter-irritation, before explained. Thus in threatened apoplexy, in mental disorders (Finch, *Lond. Med. Gaz.* iii. 692), in dropsical affections, and in chronic diseases of the skin. In torpid conditions of the bowels, where it is necessary to use powerful cathartics to produce alvine evacuations, as in paralytic affections, it is advantageously combined with other purgatives. Sometimes we use it to promote the biliary secretion—as in jaundice and other affections of the liver, in chronic skin diseases, and in various disordered conditions of the alimentary canal not accompanied by inflammation. Moreover, in the various diseases of children requiring the use of purgatives, it is generally considered to be very useful; and its being devoid of taste is of course an advantage.

As a *sedative* it has been administered in yellow fever, spasmodic or malignant cholera, dysentery, and liver affections (vide p. 469). Dr. Griffin (*Lond. Med. Gaz.* xxi. 880) asserts that calomel was a most successful medicine in cholera, controlling or arresting its progress, in 84 cases out of 100, if administered while the pulse was perceptible at the wrist; but, on the contrary, detrimental when given in collapse. The practice was tested in 1448 cases. The dose was from one to two scruples every hour or half-hour.

As a *sialogogue*, it may be used in the cases in which I have already mentioned (p. 448) that mercurials generally are employed: with the view of preventing irritation of the alimentary canal, it is usually given in combination with opium, unless, indeed, the existence of some affection of the nervous system seem to contraindicate the use of narcotics. This combination is employed in peripneumonia, pleuritis, croup, laryngitis, hepatitis, enteritis, and other inflammatory diseases; in fever, syphilis, chronic visceral diseases, &c.

Calomel is frequently combined with other medicines, to increase their effects; as with squills, to produce *diuresis*, in dropsy; or with antimonials, to promote *diaphoresis*.

As an *anthelmintic* it is in frequent use, and forms one of the active ingredients of many of the nostrums sold for worms; though it does not appear to have any specific influence over parasitic animals.

The *local uses* of calomel are numerous. In diseases of the Schneiderian membrane, it is applied as a snuff. It is sometimes blown into the eye, to remove spots on the cornea. Dr. Fricke (*Lond. Med. Gaz.* xxii. 397) has used it with great success in chronic cases of rheumatic, catarrhal, and scrofulous ophthalmia; but in two instances bad consequences resulted from its use. It is sometimes suspended in thick mucilage, and used as a gargle in venereal sore-throat, or injected into the urethra in blenorrhœa. Now and then it is used as a substitute for cinnabar in fumigation. As a local application, in the form of ointment, calomel is one of the most useful remedies we possess for the cure of some forms of skin diseases, as will be presently noticed.

ADMINISTRATION.—When used as an *alterative*, it is given in doses of from half a grain to a grain, frequently combined with oxysulphuret of antimony (as in *Pil. Hydr. Chlor. Co.*) or antimonial powder, and repeated every or every other night; a mild saline laxative being given the following morning; as a *purgative*, from two to five grains, usually in combination with, or followed by, the use of other purgatives, especially jalap, senna, scammony, or colocynth; as a *sialogogue*, in doses of one to three or four grains, generally combined with opium or Dover's powder, twice or thrice a day; and, as a *sedative*, from a scruple to half a drachm, or even more than this, as already mentioned. Biett (*Lond. Med. Gaz.* viii. 540) has sometimes employed it as an *errhine*, in syphilitic eruptions. It is mixed with some inert powder, and given to the extent of from 8 to 20 grains daily. The use of acids with calomel frequently occasions griping. Calomel is most extensively employed in the diseases of children, and may be given to them in as large or larger doses proportionally as to adults. Salivation is a rare occurrence in them: indeed, Mr. Colles (*Pract. Observ.* p. 281) asserts, that mercury *never* produces ptyalism, or swelling or ulceration of the gums, in infants.

PILULÆ HYDRARGYRI CHLORIDI COMPOSITÆ, Ph. Lond.; *Pilulæ Calomelanos Compositæ*, Ph. Dubl.; *Pilulæ Sub-muriatis Hydrargyri Compositæ*, Ph. Edinb.; *Plummer's Pills*, or *Pilulæ Plummeri* (chloride of mercury; oxysulphuret of antimony, āā ʒij.; guaicum resin, powdered, ℥ss.; treacle, ʒij. M. The Edinburgh College uses mucilage of gum arabic instead of treacle).—These pills are frequently employed as alteratives in chronic skin diseases, in the papular and pustular forms of the venereal disease, in chronic liver affections, and inv arious disordered conditions of the digestive organs. The dose is from five to ten grains.

PILULÆ CATHARTICÆ COMPOSITÆ, Ph. U. S. (Compound extract of colocynth, ℥ss.; extract of jalap, in powder; calomel, āā ʒiij.; gamboge, in powder, ℈ij. M. Divide into 180 pills). This pill is intended to combine smallness of bulk with efficiency and comparative mildness of purgative action, and a peculiar tendency to the biliary organs (*United States Dispensatory*). Each pill contains one grain of calomel. Three pills are a full dose.

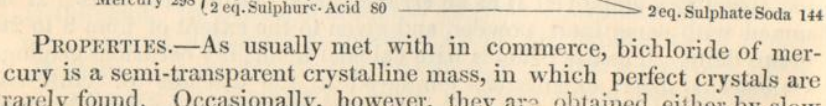
UNGUENTUM HYDRARGYRI CHLORIDI (calomel, ʒj.: lard, ℥j. M.) This is a most valuable application in porrigo favosa, impetigo, herpes, and the scaly diseases (psoriasis and lepra). Indeed, if I were required to name a local agent pre-eminently useful in skin diseases generally, I should fix on this. It is well deserving a place in the Pharmacopœia.

Hydrar'gyri Bichlo'ridum.—Bichlo'ride of Mer'cury.

HISTORY.—We have no account of the discovery of this preparation. Geber (*Inv. of Ver.* viii. 252) described the method of preparing it; but it is supposed to have been known long anterior to him. Like calomel, it has had various synonymes, of which the principal are the following: *chloride, hydrochlorate* or *muriate of mercury* (*hydrargyri chloridum, hydrochloras* seu *murias*), *corrosive sublimate* (*mercurius sublimatus corrosivus*), *corrosive muriate of mercury* (*hydrargyri murias corrosivus*), and *acidum chloro-hydrargyricum*).

PREPARATION.—Mercury and sulphuric acid are boiled together, as in the process for making calomel; and the bipersulphate of mercury is sublimed with chloride of sodium, without the addition of metallic mercury. The sublimation is usually effected in an earthen alembic, placed in sand.

The nature of the changes which occur in the manufacture of bipersulphate of mercury have been already explained (p. 465). When this salt is sublimed with chloride of sodium, double decomposition takes place, and we obtain bichloride of mercury and sulphate of soda.



PROPERTIES.—As usually met with in commerce, bichloride of mercury is a semi-transparent crystalline mass, in which perfect crystals are rarely found. Occasionally, however, they are obtained either by slow sublimation, or from a solution of the salt. Their primary form is the right rhombic prism. The sp. gr. of this salt is about 5·2 (5·14 to 5·42, Liebig). The taste is acrid, coppery, and persistent. When heated it fuses, boils, and volatilizes: the vapour is very acrid. It is soluble in about three times its weight of boiling, and in about eighteen or twenty times its weight of cold water: the acids (especially hydrochloric) and the alkaline chlorides increase its solubility. It is soluble in seven parts of cold or three and a half parts of boiling alcohol. Ether dissolves it more readily than alcohol, and will even separate it from its watery solution; and hence is sometimes employed to remove it from organic mixtures.

An aqueous solution of bichloride of mercury readily undergoes decomposition, especially when exposed to solar light; calomel is precipitated, and hydrochloric acid set free. This change is facilitated by the presence of organic substances,—as gum, extractive, or oil; whereas it is checked by the presence of alkaline chlorides.

Albumen forms a white precipitate with an aqueous solution of bichloride of mercury. This precipitate is slightly soluble in water, and consists, according to Lassaigne (*Journ. de Chim. Méd.* iii. 2d series, 161), of albumen, 93·45, and bichloride of mercury, 6·55; so that it is a *hydrargyro-chloride of albumen*. Fibrin forms a similar white compound with corrosive sublimate. When albuminous and fibrinous textures are immersed in a solution of this salt, combination takes place, the tissue contracts, increases in density, becomes whiter, and does not putrefy. Hence it is employed by the anatomist for hardening and preserving certain parts of the body—as the brain.

Bichloride of mercury possesses some of the characters of an acid. Thus it reddens litmus, and unites with the chlor-bases (as chloride of sodium), which in consequence restore the blue tint of litmus, which had been reddened by the mercurial bichloride. The salts which result from the combination of the two chlorides are called *hydrargyro-chlorides*.

CHARACTERISTICS.—Bichloride of mercury is known to be a mercurial compound by the following characters:—

1. *Heated* in a tube by a spirit lamp, with caustic potash, an alkaline chloride is formed, oxygen gas is evolved, and metallic mercury is sublimed and condensed in the form of globules on the sides of the tubes.

2. *Lime-water* causes a lemon-yellow precipitate; an additional quantity of the precipitant water produces a brick-dust red precipitate, while a further quantity restores the yellow colour. The yellow-coloured precipitate is the hydrated binoxide; the reddish-coloured precipitate is the oxychloride.

3. *Caustic ammonia*, added to a solution of bichloride, causes hydrochlorate of ammonia to be formed in solution, while a white powder (*hydrargyri ammonio-chloridum*) is thrown down.

4. The *alkaline carbonates* throw down a brickdust-coloured precipitate: the bicarbonates a white one.

5. *Iodide of potassium* occasions a scarlet precipitate of the biniodide of mercury; but the precipitate frequently appears at first of a yellow colour, though it quickly becomes scarlet. Dumas (*Traité de Chimie*, iii. 619) thinks these yellow and red states of the biniodide depend on some isomeric phenomena requiring farther examination. If an excess of

iodide of potassium be employed, the red precipitate disappears, owing to the formation of a soluble double salt, in which the biniodide of mercury acts the part of an acid, and the iodide of potassium that of a base. This double salt may be called the *hydrargyro-iodide of potassium.* Bichloride of mercury and the biniodide of mercury also form a double salt: hence, if a great excess of the former salt be employed, the red precipitate disappears, owing to the formation of a soluble double salt.

6. *Protochloride of tin* occasions, with bichloride of mercury, a white precipitate of calomel, while perchloride of tin remains in solution. Very shortly this protochloride of mercury is converted into reguline mercury, which falls down in a finely divided state as a greyish powder.

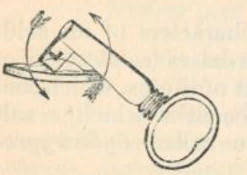
7. *Hydrosulphuric acid* in excess, passed through a solution of bichloride of mercury, occasions a black precipitate of the bisulphuret of mercury: a solution of hydrochloric acid is formed. If the hydrosulphuric acid be not in excess, a white precipitate of the *chloro-sulphuret of mercury* is obtained, and which consists of two atoms bisulphuret of mercury and one of the bichloride.

8. *Ferrocyanide of potassium* causes a white precipitate (ferrocyanide of mercury).

9. *Albumen* is another test for corrosive sublimate, though not one of much value, since it will produce the same white precipitates with many other substances.

10. *Galvanism.*—Drop the suspected solution on a piece of gold, as a sovereign, and apply a key, so that it may touch, simultaneously, the gold and the solution; an electric current is immediately produced, the bichloride is decomposed, the mercury attaches itself to the negative electrode (or pole), namely the gold, while the chlorine unites with the iron of the positive electrode (or pole) to form chloride of iron. The relative position of the gold, the key, and the solution, will be evident from the fig. 67; and the arrows point out the direction of the electric current. The silver stain left on the gold is readily removed by heat. In Dr. Christison's work will be found other methods of applying galvanism; but the one just mentioned is perhaps the most useful, since it can always be readily made use of; whereas a more complicated apparatus is found in the hands of a few persons only. Thus it might be applied at a moment's notice to detect corrosive sublimate in the matters vomited by a patient.

Fig. 67.



The relative delicacy of some of these tests is thus stated by Devergie (*Méd. Lég.* ii. 676):—

		Degree of Dilution.
Ferrocyanide of potassium	stops at	1,500
Lime water	,,	4,000
Potash or its carbonate	,,	7,000
Iodide of potassium	,,	8,000
Ammonia	,,	36,000
Hydrosulphuric acid, or hydrosulphate of ammonia	,,	60,000
Protochloride of tin, or galvanic pile	,,	80,000

The preceding tests have not determined the nature of corrosive sublimate, further than that it is a permercurial salt. To prove that it is a chloride, the simplest method of proceeding is to add to the suspected solution, lime-water, or carbonate of soda; then filter, and test the clear liquid with *nitrate of silver*, which causes a white precipitate if any chloride be present (*vide* p. 105). If nitrate of silver be added to a solution of bichloride of mercury, we obtain a white precipitate of chloride of silver, but mixed with calomel; and it is to avoid the production of the latter substance that I prefer the method of testing just mentioned.

COMPOSITION.—The composition of this salt is as follows:—

	Eq.	Eq. Wt.	Per Cent.	Turner.
Mercury	1	202	73·72	73·53
Chlorine	2	72	26·27	26·47
Bichloride of Mercury	1	274	99·99	100·00

PURITY.—Pure bichloride should be white, dry, totally vapourized by heat, and completely soluble in water, alcohol, or ether.

PHYSIOLOGICAL EFFECTS. (*a.*) *On vegetables.*—The effects of solutions of bichloride of mercury on plants have been examined by Seguin, and subsequently by Marcet and Macaire (Decandolle, *Phys. Vég.* 1332), and from their experiments it appears, that when growing plants are immersed in a solution of this salt, part of the poison is absorbed, a change of colour takes place in the leaves and stems, and death is produced; the effect on the irritable stamina of the *Berberis vulgaris*, and on the leaves of the *Mimosa pudica*, being the same as that produced by arsenic (p. 384). Bichloride of mercury is equally poisonous to cryptogamic plants. Hence vegetable tissues soaked in a solution of it are no longer adapted for the development of the *Merulius lachrymans*, and of other fungi known under the name of the *dry-rot*. This, in fact, is the principle adopted by Mr. Kyan (*Lond. Med. Gaz.* xvi. 630) for the preservation of timber, and which is now practised by the *Anti Dry-rot Company*.—(*Vide* Dr. Dickson's *Lecture on Dry-rot*, 1837.)

(*b.*) *On animals generally.*—The effects of corrosive sublimate on animals have been examined by Ettmuller, Wepfer, Sprœgel, Sir Benjamin Brodie (*Phil. Trans.* for 1812), Campbell, Lavort, Smith, Gaspard, Orfila (*Toxicol. Gén.*), Schubarth, and Bostock. An abstract of these will be found in the works of Wibmer (*Wirk. d. Arzn. u. Gifte*), and Christison (*Treat. on Poisons*). Dogs, cats, horses, rabbits, and frogs, are the animals on which the experiments have been tried, and on which sublimate has been found to exercise a poisonous operation, and the same kind of effect is presumed, from analogy, to be produced on all other animals. The results of these experiments have been so briefly yet clearly stated by Dr. Christison, that I cannot do better than quote his words:—"Corrosive sublimate causes, when swallowed, corrosion of the stomach; and in whatever way it obtains entrance into the body, irritation of that organ and of the rectum, inflammation of the lungs, depressed action, and perhaps also inflammation of the heart, oppression of the functions of the brain, and inflammation of the salivary glands." I may add, that mercurial fœtor and salivation have been observed in horses, dogs, and rabbits.

(*c.*) *On man.*—*α. In small or therapeutic doses*, as from one-eighth to one-fourth of a grain, it frequently exerts a beneficial effect on diseases (syphilitic eruptions, for example), without producing any obvious alteration in the actions of the different organs. Occasionally, especially when the stomach and bowels are in an irritable condition, it gives rise to a sensation of warmth in the epigastrium, and causes nausea, griping, and purging. In such cases it is best to diminish the dose, and conjoin opium. By repetition we frequently observe that the pulse becomes somewhat excited, and if the skin be kept warm, perspiration is oftentimes brought on; at other times the quantity of urine is increased. Continued use of it causes salivation: but it is said, that corrosive sublimate has less tendency to occasion this effect than other preparations of mercury. Maximilian Locher (Van Swieten's *Commentaries upon Boerhaave's Aphorisms*, xvii. 294), who, from the year 1754 to 1762, cured 4,880 patients affected with the venereal disease, at St. Mark's Hospital, Vienna, by the exhibition of this remedy, says, that no person died, or experienced the least painful or dangerous symptoms, in consequence of its use. He was, however, exceedingly cautious and careful in its employment, and always stopped using it on the first appearance of salivation. Van Swieten says, "I am convinced, from repeated experience, that the menstrual evacuation is not disturbed by the use of this remedy."

β. Chronic poisoning.—In somewhat larger doses, or by the long-continued use of the before-mentioned small doses, gastro-enteritis and all the usual constitutional effects of mercury are brought on. Thus heat and griping pain in the alimentary canal (particularly in the stomach and rectum), loss of appetite, nausea, vomiting, purging, and disordered digestion, are the gastro-enteritic symptoms. The pulmonary organs also not unfrequently become affected; the patient complains of dry cough, pain in the chest, disordered respiration, and bloody expectoration. Coupling these symptoms with the specific effects said to be produced on the lungs of animals by the use of corrosive sublimate, we have an important caution not to administer it to patients affected with pulmonary disorders,—a caution, indeed, which Van Swieten gives; "for those," says he, "who have a husky dry breast, are troubled with a cough, whose nervous system is excessively irritable, and are subject to a hæmorrhage, bear not this remedy without detriment."

γ. Acute poisoning.—In *very large doses* corrosive sublimate acts as a caustic poison, in virtue of its affinity for albumen, fibrin, and other constituents of the tissues. I shall follow Dr. Christison, and admit two varieties of poisoning by it; in one of which "the sole or leading symptoms are those of violent irritation of the alimentary canal. In another variety the symptoms are at first the same as in the former, but subsequently become conjoined with salivation and inflammation of the mouth, or some of the other disorders incident to mercurial erethysm, as it is called."

First variety: Gastro-enteritis.—In this variety the symptoms are analogous to those of other corrosive poisons: namely, violent burning pain in the mouth, throat, œsophagus, and stomach; difficulty of deglutition; sense of suffocation; nausea; violent vomiting (increased by every thing taken into the stomach) of mucous, bilious, or sanguineous matters. The pain soon extends from the stomach over the whole abdomen, which becomes acutely sensible to the slightest impression; violent purging, often of blood; inexpressible anxiety; flushed countenance; restlessness; pulse quick, small, and contracted; cold sweats; burning thirst; short and laborious respiration; urine frequently suppressed; and, lastly, various indications of a disordered condition of the nervous system, such as a tendency to stupor, or even actual coma; convulsive movements of the muscles of the face and extremities; sometimes diminished sensibility of one of the limbs, or of the whole body; or even paraplegia. Occasionally death appears to result from the powerful effect produced on the nervous system, or from exhaustion, or from mortification of the bowels.

Dr. Christison points out the following characters as serving to distinguish poisoning by bichloride of mercury from that by arsenious acid :—

1. The symptoms begin much sooner.
2. The taste is much more unequivocal and strong.
3. The acridity and irritation in the gullet is much greater.
4. The countenance is flushed, and even swollen; whereas, in poisoning by arsenic, it is usually contracted and ghastly.
5. Blood is more frequently discharged by vomiting and purging.
6. Irritation of the urinary passages is more frequent.
7. Nervous affections are more apt to come on during the first inflammatory stage.
8. The effects are more curable than those of arsenic.
9. Deviations in the symptoms are more rare.

Second variety: Gastro-enteritis, accompanied with or followed by mercurial erethysm.—I here use the term erethysm in the sense in which it is employed by Dr. Chistison—namely, to indicate all the secondary effects of mercury. In this variety, the symptoms first observed are those mentioned for the last variety, but they are followed, sooner or later, by those of inflammation of the salivary glands, and of the mouth and its neighbouring parts; profuse salivation, ulceration of the mouth, great fœtor of breath, and other symptoms of this kind, already described, (p. 444.)

Uses.—*Internally*, it has been employed as a sialogogue, alterative, and diaphoretic.

The celebrated Baron Van Swieten (*op. cit.*) may be regarded as the principal introducer of corrosive sublimate into practice as a remedy for *venereal diseases*. He seems to have been led to its employment from a suspicion that salivation was not requisite for curing this class of diseases; and hence he was desirous of obtaining some mercurial "that could be dilated at will, and so tried in a very small dose." Now corrosive sublimate possessed these properties, and hence he commenced his experiments with it, and, meeting with great success, recommended it to Maximillian Locher, whose results I have already stated. (For further historical details respecting its use, *vide* Pearson's *Observations on the Effects of various Articles of the Mat. Med.* p. 99, et seq.) The balance of evidence is decidedly favourable to the employment of this medicine as an internal remedy for venereal diseases. By its partizans it has been asserted to be a safe and efficacious mercurial, to remove venereal symptoms in a very short space of time, and without causing salivation, merely by exciting diaphoresis. Its opponents (*vide* Pearson, *op. cit.*) state, on the other hand, that other mercurials are quite as effectual and speedy; that the cure by corrosive sublimate is not permanent; and, lastly, that its corrosive and irritant properties render its employment objectionable. One of the latest advocates for its use is Dzondi, of Halle (*Neue zuverläss. Heilart. d. Lusts. in allen ihren Formen*, &c. 1826, in in Richter, *Ausf. Arzn.* v. 596), who states, the best mode of using bichloride of mercury is in the form of pills made with crumb of bread; and he gives the following formula for their preparation:—℞ Hydr. Sublim. Corros. gr. xij., solve in Aq. Distill. q. s., adde Micæ Panis Albi, Sacchari Albi, aa. q. s. ut ft. pilulæ numero CCXL. Of these pills (each of which contains one-twentieth of a grain of corrosive sublimate), four are to be administered daily, and increased until thirty (containing one grain and a half) are taken at a dose. The best time of exhibiting them is after dinner. In irritable subjects and painful affections, a few drops of the tincture of opium may be taken with each dose. During the time the patient is under their influence, he should adopt a sudorific regimen (as is also recommended by Van Swieten), and take decoction of sarsaparilla.

In *acute diseases* few have ventured to employ bichloride of mercury; however, Schwartz gave it in hepatitis after the fever and pain had subsided; Sauter employed it in an epidemic scarlet fever; and Berends administered it in asthenic malignant fevers (Richter, *Ausführ Arzneim.* v. 581). I have already noticed (p. 446) Mr. Lempriere's proposal to use it in fever, as a sialogogue.

In various *chronic diseases* it has been given as an *alterative* and *diaphoretic*, with occasional success. Thus in rheumatism, diseases of the bones, periodical pains, skin diseases, scrofulous affections, disorders of the nervous system, &c. In such it should be associated with diaphoretics (as antimony, sarsaparilla, &c.), warm clothing, &c. Not unfrequently opiates should be combined with it.

As an *external* remedy it has been applied as a *caustic* in substance (either alone or combined with arsenic) to cancerous ulcers, to parts bitten by rabid animals, to chancres, &c.: used in this way, however, it is mostly objectionable. In onychia maligna it is used with great advantage, mixed with an equal weight of sulphate of zinc, and sprinkled thickly upon the surface of the ulcer, which is then to be covered with a pledget of lint saturated with tincture of myrrh (*United States Dispensatory*). A *solution* has been employed for various purposes: thus by Baumé, as already mentioned (p. 448), for pediluvia, to produce salivation; as a lotion in chronic skin disease (as lepra, psoriasis, scabies, rosacea, &c.); as a wash to ulcers, particularly those of a venereal nature; as an injection in discharges from the urinary organs; as a collyrium in chronic diseases of the eye, especially those of a venereal nature; and as a gargle in ulcers of the tonsils. A solution is sometimes used as a preventive for the venereal disease.

Administration.—It may be used internally, in substance or solution. The dose of it in substance is from one-sixteenth to one-eighth of a grain. Some advise it to be given to the extent of one-fourth of a grain; but in this dose it is very apt to gripe and purge. Dzondi's formula, already given, may be employed when we wish to administer it in substance.

In solution it may be exhibited dissolved in water (vide *liquor hydrargyri bichloridi*), alcohol, or ether.

For *external use*, a watery solution may be employed, containing from half a grain to two or three grains, dissolved in one ounce of water.

Liquor Hydrargyri Bichloridi, Ph. L. (Bichloride of mercury; hydrochlorate of ammonia, āā gr. x; distilled water, ℥xx. Dissolve).—Hydrochlorate of ammonia is used to increase the solvent power of the water. Each fluidounce contains half a grain of corrosive sublimate. The dose of this solution is from half a fluidrachm to two or three fluidrachms, taken in some bland liquid, as linseed tea.

Antidotes.—Several substances which decompose corrosive sublimate have been employed as antidotes. These are, *albumen*, *gluten of wheat* (as contained in wheaten flour), *milk*, *iron filings*, *and meconic acid*.

I have already alluded to the decomposition of corrosive sublimate by *albumen*. The compound which results from their mutual action appears to be inert, or nearly so. In Dr. Christison's *Treatise on Poisons* will be found several cases noticed, in which albumen has been most effectual: one of the most interesting of which is that of Baron Thenard, the celebrated chemist, who inadvertently swallowed a concentrated solution of corrosive sublimate, but by the immediate use of whites of eggs suffered no material harm. Peschier states, that one egg is required for every four grains of the poison. *Gluten of wheat* has been recommended by Taddei, and may be employed when albumen is not procurable. Wheaten flour (which contains gluten) will probably answer as well as the pure gluten. *Milk*, in the absence of albumen or flour, may be used. *Iron filings* are stated to be useful, by reducing the corrosive sublimate to the metallic state. *Meconic acid* is also said to be an antidote, by forming an insoluble meconate of mercury. But a knowledge of the fact is of little practical value, since the acid is not generally procurable; and tincture of opium, which contains it, cannot be safely used in sufficient quantity; for Dr. Christison finds that five grains of corrosive sublimate require an infusion of 33 grains of opium to precipitate the whole of the mercury.

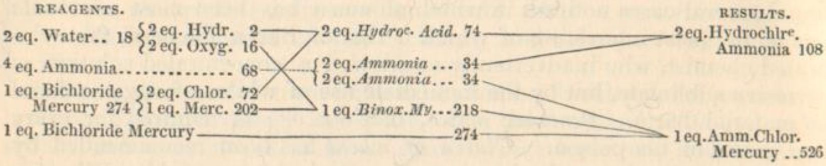
The other parts of the treatment for acute poisoning by corrosive sublimate are the same as for other irritant poisons, and consist of the usual antiphlogistic system—the warm baths, opiates, &c.

Hydrar'gyri Ammo'nio-Chlo'ridum.—Ammo'nio-Chlo'ride of Mer'cury.

History.—This compound was discovered by Raymond Lully, in the thirteenth century. Lemery pointed out two modes of procuring it, and hence it is sometimes termed *Lemery's white precipitate*, to distinguish it from precipitated calomel, also called on the Continent white precipitate. It has had various other appellations, as *cosmetic mercury* (*mercurius cosmeticus*), *white precipitated mercury* (*hydrargyrum præcipitatum album*); and, according to the view taken of its composition, it has been called *muriate of ammonia and mercury*,—*ammoniated submuriate of mercury* (*hydrargyri submurias ammoniatum*, Ph. Dub.), *ammoniated mercury*, (Ph. U. S.), *ammonio-chloride of mercury* (*hgdrargyri ammonio-chloridum*, Ph. Lond.), *ammoniacal oxychloruret of mercury* (Guibourt).

Preparation.—It is directed, in the London Phamacopœia, to be procured by adding eight fluidounces of solution of ammonia to six ounces of chloride of mercury previously dissolved, by the aid of heat, in six parts of distilled water, and allowed to cool. The precipitated powder is to be washed until void of taste, and then dried.

The explanation of the changes which occur in this process varies according to the view taken of the constitution of the resulting compound. Sal ammoniac (hydrochlorate of ammonia), but no mercury, is certainly left in solution, so that the precipitate cannot contain so much chlorine as bichloride of mercury. It is probable, therefore, that the mercury from which the chlorine has been removed becomes oxidized by the water, though, according to Dr. Kane (*Trans. Royal Irish Acad.* xvii. 423,) this does not take place. The binoxide of mercury, with some mercurial bichloride, and ammonia, precipitate in combination. The following diagram explains the changes according to this view:—



If we suppose two equivalents or 18 parts of water to be given out by one equivalent or 526 parts of ammonio-chloride of mercury, the residue will have the precise elementary composition assigned by Dr. Kane to white precipitated mercury.

PROPERTIES.—It occurs in commerce in masses or in powder. It is white, inodorous, has a taste at first earthy, afterwards metallic. It is decomposed and dissipated by heat, giving out ammonia, nitrogen, calomel, and water. It is insoluble in alcohol. By boiling in water we obtain a solution of hydrochlorate of ammonia, and a yellow powder (white precipitated mercury and binoxide of mercury.—*Kane.*) It is soluble in sulphuric, nitric, or hydrochloric acid.

CHARACTERISTICS.—When heated with caustic potash, it gives out ammonia, and forms a yellow powder (white precipitated mercury and binoxide of mercury,—*Kane*). The solution contains chloride of potassium, and with nitrate of silver causes a white precipitate (chloride of silver), insoluble in nitric acid, but soluble in ammonia. Protochloride of tin decomposes white precipitated mercury, and separates metallic mercury. To these characters must be added the effect of heat, water, and acids, on it, as above mentioned.

COMPOSITION. — The analyses of Mr. Hennell (*Quart. Journ. of Science*, xviii. 297) and Mitscherlich (*Ann. Chim.* xxxv. 428), agree in showing the constituents of white precipitate to be those of binoxide of mercury and hydrochlorate of ammonia, in the following proportions:—

	Eq.	Eq.Wt.	Per Cent.	Hennell.	Mitscherlich.
Binoxide of Mercury	1	218	80·14	80	82·2
Hydrochloric Acid	1	37	13·60	20	10·7
Ammonia	1	17	6·25		7·1
White Precipitate	1	272	99·99	100	100·0

This composition is adopted by Berzelius. But in explaining the theory of the formation of white precipitate, I have assumed, with Mr. Phillips (*Transl. of the Lond. Pharm.*), a somewhat different view of the subject. Two equivalents of white precipitate, according to Mr.

Hennell, minus two equivalents of water, are equal to one equivalent of the same compound, according to Mr. Phillips.

	Eq.	Eq.Wt.	Per Cent.
Bichloride of Mercury	1	274	52·09
Binoxide of Mercury	1	218	41·44
Ammonia	2	34	6·46
White Precipitate (Phillips)	1	526	99·99

If two more equivalents of water be abstracted, we have the composition of white precipitate, according to Dr. Kane.

	Eq.	Eq.Wt.	Per Cent.
Bichloride of Mercury	1	274	53·93
Binoxide of Mercury	1	234	46·06
White Precipitate (Kane)	1	508	99·99

PURITY.—This compound is largely adulterated with sulphate of lime. I have one sample containing one-third of its weight of this substance. Carbonate of lime and of lead are sometimes employed to adulterate white precipitate. Pure white precipitate, thrown on a red-hot shovel, is dissipitated without any residuum: whereas the above impurities remain. The carbonates are recognised by the effervescence on the addition of hydrochloric acid. Sulphate of lime may be detected by boiling the suspected substance in distilled water, and applying the tests for sulphates and calcareous salts, as before directed (pp. 265 and 343).

PHYSIOLOGICAL EFFECTS.—Its action on the body is very imperfectly known, no modern experiments having been made with it. It is usually considered to be highly poisonous, and somewhat similar in its operation to bichloride of mercury. Palmarius and Naboth (Wibmer, *Wirk. d. Arzn.* iii. 64) have reported fatal cases of its use (*vide* also Gmelin, *App. Medicam.* ii. 166).

USES.—It is employed as an external agent only; commonly in the form of an ointment. It is an efficacious application in various skin diseases—as porrigo, impetigo, herpes, and even scabies; also in ophthalmia tarsi. Among the lower classes it is commonly used to destroy pediculi.

UNGUENTUM HYDRARGYRI AMMONIO-CHLORIDI, Ph. Lond., Dubl. and U. S. (ammonio-chloride of mercury, ʒj.; lard, ℥iss. M.)—It is a stimulant, alterative, and detergent.

Hydrar'gyri Io'didum.—I'odide of Mercury.

PRERARATION.—This compound, sometimes called *protiodide of mercury*, is directed, in the London Pharmacopœia, to be prepared by rubbing together an ounce of mercury and ten drachms of iodine, adding gradually as much alcohol as may be sufficient, until globules are no longer visible.

In this process the mercury and iodine enter into combination. The alcohol facilitates the union by dissolving the iodine.

PROPERTIES.—It is a greenish-yellow powder, whose sp. gr. is 7·75. It is insoluble in water, alcohol, or an aqueous solution of chloride of sodium; but is soluble in ether, and slightly so in an aqueous solution of iodide of potassium. When heated quickly, it fuses and sublimes in red crystals, which subsequently become yellow. Solar light decomposes it, and changes its colour. Heated with potash, it yields iodide of potassium and reguline mercury.

Composition.—It consists of

	Eq.	Eq.Wt.	Per Cent.
Mercury	1	202	61·58
Iodine	1	126	38·41
Iodide of Mercury	1	328	99·99

Physiological Effects.—It is a powerfully irritant poison. A scruple killed a rabbit within twenty-four hours, and a drachm destroyed a pointer-dog in five days (Cogswell, *Essay on Iodine and its Compounds*, 160).

In small but repeated doses, it appears to exercise a specific influence over the lymphatic and glandular system. Two grains taken daily caused salivation in two instances (Biett, *Lancette Française*, Juin 1831).

Uses.—It has been used in syphilis and scrofula, especially when they occur in the same individual. Lugol (*Essays on the Effects of Iodine in Scrofulous Disorders*, by Dr. O'Shaughnessy, p. 170) employed an ointment of it in those forms of external scrofulous disease which resemble syphilis. Ricord (*Lancette Franç.* 1834, No. 65) gave it internally with good effect in *syphilis infantum.* Biett (O'Shaughnessy's *Transl. of Lugol's Essays,* p. 201) has successfully employed it in syphilitic ulceration and venereal eruptions.

Administration.—The dose of it for adults is from one grain gradually increased to three or four. Ricord gave from one-sixth to one-half of a grain to children of six months old. Biett employed it internally, and also externally, in the form of ointment, to the extent of twelve or fourteen grains daily, by the way of friction.

Pilulæ Hydrargyri Iodidi, Ph. Lond. (iodide of mercury, ʒj.; confection of dog-rose, ʒiij.; ginger, powdered, ʒj. M.)—Five grains of these pills contain one grain of the iodide. The dose, therefore, will be from five grains to a scruple.

Unguentum Hydrargyri Iodidi, Ph. Lond. (iodide of mercury, ʒj.; white wax, ℥ij.; lard, ℥vj. M.)—This is used as a dressing for scrofulous ulcers, or for syphilitic ulcers in scrofulous subjects. It is also employed in tubercular skin diseases, as lupus, rosacea, and sycosis. (Rayer, *Treat. on Skin Diseases.*)

Hydrar'gyri Binio'didum.—Bini'odĭde of Mer'cury.

Preparation.—There are two methods of preparing this compound. The process given in the London Pharmacopœia is as follows:—An ounce of mercury and ten drachms of iodine are to be rubbed together, alcohol being gradually added until the globules are no longer visible. The powder is to be dried with a gentle heat, and kept in a well-stopped vessel. The alcohol facilitates the combination of iodine and mercury, as in the process for making the protiodide.

Biniodide of mercury may also be prepared by adding a solution of bichloride of mercury to one of iodide of potassium so long as any precipitate takes place. 274 grains of bichloride will be required to decompose 332 grains of iodide of potassium: these proportions are about 8 of the first to 10 of the second. In this process double decomposition takes place: biniodide of mercury precipitates, while chloride of potassium remains in solution. If excess of iodide of potassium be employed, it retains some biniodide of mercury in solution. It is better, however, to have a slight excess of iodide of potassium, in order to obtain the mercurial biniodide free from corrosive sublimate.

PROPERTIES.—It is a scarlet red powder, whose sp. gr. is 6·32. It is insoluble in water, but soluble in alcohol, some acids, alkalies, and solutions of iodide of potassium, chloride of sodium, and of many of the mercurial salts. From its solution in boiling rectified spirit it is deposited, on cooling, in rhombic prisms. When heated it fuses, forming a ruby-red liquid, sublimes in crystals, which are at first yellow but afterwards become red, and furnish a scarlet-red powder. It combines with other alkaline iodides (as iodide of potassium) forming a class of double salts, called the *hydrargyro-iodides*.

CHARACTERISTICS.—Heated with potash in a tube it yields metallic mercury, which is volatilized: the residue is iodide of potassium, recognisable by the tests before described (p. 280.) From the protiodide of mercury it is distinguished by its colour and its solubility in a solution of chloride of sodium. The effects of heat on it, and its solubility in iodide of potassium, are other characters which serve to recognise it.

COMPOSITION.—Its composition is as follows :—

	Eq.	Eq.Wt.	Per Cent.
Mercury	1	202	44·5
Iodine	2	252	55·5
Biniodide of Mercury	1	454	100·0

PURITY.—The presence of bisulphuret of mercury in it may be recognised by fusion with caustic potash in a glass tube, by which a mixture of sulphuret and iodide of potassium is obtained: the existence of sulphur may be proved by the evolution of hydrosulphuric acid on the addition of a mineral acid.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—A scruple killed a rabbit in twenty-four hours: the stomach was found preternaturally reddened. Ten grains, dissolved in a solution of iodide of potassium, and given to a dog, caused vomiting, pain, tenesmus, and depression: in four or five days the animal was well (Cogswell, *Essay on Iodine*, p. 164). Maillet (*Journ. de Chim. Méd.* iii. 543, 2de. Série) has also made some experiments with it.

(*b.*) *On man.*—It is a powerful irritant and caustic. It is nearly as powerful as the bichloride of mercury; indeed, Rayer (*Treatise on Skin Diseases*, by Dr. Willis, p. 79) considers it more active than the latter. Applied to ulcers, in the form of ointment, I have known it cause excruciating pain. Left in contact with the skin for a while, it induces, says Rayer, a most intense erysipelatous inflammation. When administered internally, it must be done with great caution. Like other mercurial compounds, its repeated use causes salivation.

USES.—It has been employed in the same cases (*i. e.* syphilis and scrofula) as the protiodide of mercury, than which it is much more energetic. Breschet (O'Shaughnessy's *Transl. of Lugol's Essays*, p. 204) applied it, in the form of ointment, with great success in a case of obstinate ulceration (thought to have been carcinomatous) of the angle of the eye. In the form of a dilute and thin ointment (composed of biniodide of mercury, gr. ii.; cerate, ℈ii.; and almond oil, ℈i.) it has been used in opacity of the cornea (Graefe and Walther's *Journ. f. Chir.* Bd. 13). In obstinate ophthalmia tarsi, with thickening of the meibomian glands, it has also been successfully employed.

ADMINISTRATION.—It should be given in doses of one-sixteenth of a grain, gradually increased to one-fourth of a grain. It may be exhibited in the form of pills, or dissolved in alcohol or ether.

UNGUENTUM HYDRARGYRI BINIODIDI, Ph. L. (biniodide of mercury, ℥j.; white wax, ℥ij.; lard, ℥vj. M.)

Hydrar'gyri Bisulphure'tum.—Bisul'phuret of Mer'cury.

HISTORY.—It is mentioned in the Old Testament (*Jerem.* xxii. 14). Theophrastus (*De Lapidibus*) says that *cinnabar* (κιννάβαρι) was accidentally discovered, by Callius, about ninety years before the magistracy of Praxibulus, of Athens—that is, 494 years before Christ. Geiger (*Handb. d. Pharm.*, by Liebig) found it in the colouring matter of the old Egyptian tombs. It was formerly called *minium*. It is commonly termed *red sulphuret of mercury*; and, when in powder, *vermilion*.

NATURAL HISTORY.—The principal repositories of native cinnabar (*cinnabaris nativa*) are Idria, in Carniola, and Almaden, in Spain. It occurs both massive and crystallized; the primary form of its crystals being the acute rhombohedron.

PREPARATION.—Artificial cinnabar (*cinnabaris factitia*) is prepared by mixing two pounds of mercury, with five ounces of melted sulphur, in an iron pot over a fire; and, as soon as the mass begins to swell, it is to be removed from the fire, and covered, to prevent inflammation. When large quantities of sulphur and mercury are heated together, a slight explosion and flame are produced. When cold, it is rubbed to powder and sublimed in earthen pots (*Ann. Chim.* iv.; Aikin's *Dictionary of Chemistry*).

In this process the heat enables the mercury and sulphur to combine, and form the bisulphuret.

PROPERTIES.—Artificial cinnabar has, in the mass, a dark reddish brown crystalline appearance; but, when reduced to a fine powder, is of a beautiful scarlet-red colour, and is then termed *vermilion*. It is tasteless, odourless, insoluble in water or alcohol, and unalterable in the air. It is fusible and volatile. It burns in the air with a blue flame, the sulphur uniting with oxygen to form sulphurous acid, while the mercury is dissipated in a vaporous form.

CHARACTERISTICS.—Heated in a glass tube, with potash, it evolves mercurial vapour, which condenses into liquid globules of this metal. The residue, which is sulphuret of potassium, gives out hydrosulphuric acid on the addition of hydrochloric acid. The colour of cinnabar deepens under the influence of heat.

COMPOSITION.—Its composition is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Guibourt.	Sefström.
Mercury	1	202	86·32	86.21	86·29
Sulphur	2	32	13·67	13·79	13·71
Bisulphuret of Mercury	1	234	99·99	100·00	100·00

PURITY.—Pure cinnabar is totally evaporated by heat, and is insoluble in nitric or hydrochloric acid. If minium or red lead be intermixed, we may recognise it by boiling in acetic acid, by which acetate of lead is procured in solution: this forms a black precipitate with hydrosulphuric acid,—white with the sulphates,—and yellow with iodide of potassium. Realgar, or sulphuret of arsenicum, may be detected by boiling the suspected cinnabar in solution of caustic potash, supersaturating with nitric acid, and passing a current of hydrosulphuric acid through it, by which a yellow precipitate (orpiment or sesquisulphuret of arsenicum) is obtained. Earthy impurities are not volatile.

PHYSIOLOGICAL EFFECTS.—According to Orfila (*Archiv. Gén. de Méd.* xix. 330), pure cinnabar is inert; for he found no effects were produced on dogs, by half an ounce, when either applied to wounds, or taken into the stomach. These results being opposite to those obtained by Smith (Christison, *Treat. on Poisons*, 3d. ed. 395), it has been presumed that the latter must have employed an impure sulphuret.

The vapour obtained by heating cinnabar in the air is poisonous; but this is not in opposition to Orfila's experiments, since this vapour is not bisulphuret of mercury, but a mixture of the vapour of mercury (either in the metallic or oxidized state) and of sulphurous acid gas. Schenkius (*Observ.* L. vii.) has related the case of a young man who died from the use of this vapour; and Hill (*Edinb. Med. Essays*, iv.) saw cough, violent salivation, diarrhœa, &c. produced by its inhalation.

USES.—Cinnabar is used merely as a fumigating agent, in venereal ulcerations of the nose and throat. The method of using it is this:—About half a drachm is placed on a heated iron, and the fumes inhaled as they arise. In the shops, a copper apparatus, with iron heater, is sold for the purpose. In the absence of this, the bisulphuret is to be placed on a hot iron shovel, and the vapour inhaled by the patient through a funnel. The irritating nature of the sulphurous vapour usually excites coughing, and is injurious in persons disposed to phthisis. Hence the oxide of mercury is to be preferred for fumigating.

ADMINISTRATION.—When employed internally, cinnabar has been given in doses of from ten grains to half a drachm. For the purpose of fumigation, half a drachm may be employed.

Hydrar'gyri Bisulphure'tum cum Sul'phure.—Bisul'phuret of Mer'cury with Sul'phur.

HISTORY.—It is stated that the Chinese used this remedy long before it was known to Europeans. Harris, in 1689, first taught the method of preparing it by trituration. Its most common name is *Æthiops mineralis*; but it is also called *black sulphuret of mercury* (*hydrargyri sulphuretum nigrum*, Ph. Dub., Ed. and U. S.) or *sulphuret of mercury with sulphur* (*hydrargyri sulphuretum cum sulphure*, Ph. Lond.)

PREPARATION.—Equal weights of mercury and sulphur are rubbed together until globules are no longer visible. In this process part of the sulphur enters into chemical combination with the mercury, to form the bisulphuret, which is mechanically mixed with the remaining sulphur.

PROPERTIES.—It is a heavy, black, tasteless, odourless powder, insoluble in water. When heated it fuses, and is completely dissipated.

CHARACTERISTICS.—By boiling in caustic potash liquor we obtain a solution of sulphuret of potassium (*vide* p. 288). The residue is black, but possesses all the chemical characteristics of cinnabar (*vide* p. 484); such as being insoluble in nitric acid, volatile, &c.

COMPOSITION.—If this compound be, as Mr. Brande (*Man. of Pharm.* 3d ed. 329) supposes, a mixture of bisulphuret of mercury and sulphur, the proportions must be—

Bisulphuret of Mercury	58
Sulphur	42
Hydrargyri Sulphuretum cum Sulphure, Ph. Lond. . . .	100

PURITY.—Free mercury may be detected by its communicating a white stain to gold. Charcoal may be detected by its not volatilizing by heat. Animal charcoal, by this character, as well as by the presence of phosphate of lime in the residue (*vide* p. 359). Sesquisulphuret of antimony may be recognised by boiling in hydrochloric acid, and applying the before-mentioned (p. 400) tests for sesquichloride of antimony.

PHYSIOLOGICAL EFFECTS.—According to the experiments of Orfila, this preparation, like the last, possesses little or no activity. The late Dr. Duncan (*Edinb. Dispensatory*) also tells us, that he has given it in doses of several drachms, for a considerable length of time, with scarcely any effect. It is commonly regarded as alterative.

USES.—It has been used in glandular diseases, especially of children; and also in cutaneous diseases.

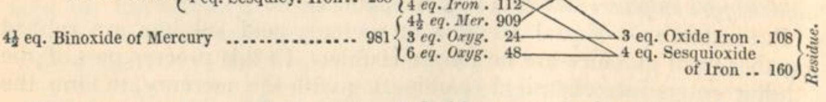
ADMINISTRATION.—The dose for adults is from 5 to 30 grains.

Hydrar'gyri Bicyan'idum.—Bicy'anide of Mer'cury.

HISTORY.—This salt was discovered by Scheele. Its real nature was first pointed out by Gay-Lussac in 1815. It has been known by various appellations, as *Prussian mercury* (*hydrargyrum borussicum*), *prussiate*, *hydrocyanate*, *cyanuret*, or *cyanodide of mercury* (*hydrargyri prussias*, *hydrocyanas*, *cyanuretum*, seu *cyanodidum*).

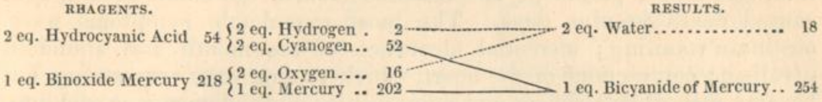
PREPARATION.—Two methods have been adopted for the preparation of it.

(*a.*) *Proust's process.*—In the Pharmacopœia, eight ounces of ferrosesquicyanide of iron, or Prussian blue (ferri percyanidum, Ph. L.) are directed to be boiled with ten ounces of binoxide of mercury and four pints of water. The mixture is to be strained and evaporated, so that it may crystallize. The undissolved residuum is to be washed with boiling distilled water, filtered, and evaporated, so as to yield crystals.



The awkwardness of the use of half an equivalent may be easily obviated by doubling all the above numbers; but several reasons have induced me to retain it in the above diagram.

(*b.*) *Winckler's process.*—Bicyanide of mercury may be obtained more economically, and purer, by adding as much finely-pulverized binoxide of mercury to hydrocyanic acid (obtained by distilling ferrocyanide of potassium with diluted sulphuric acid, *vide* p. 236) as will saturate it, filter, and crystallize. In this process double decomposition takes place, the resulting products being water and bicyanide of mercury.



Properties.—The primary form of the crystals of this salt is the right square prism. The crystals are heavy, white, colourless, transparent or opaque, inodorous, and have a strong metallic taste. They are soluble in water, both hot and cold, and very little, if at all so, in alcohol.

Characteristics.—Perfectly dry bicyanide of mercury when heated yields metallic mercury and cyanogen gas. The latter is known by the violet or biuish red colour of its flame. Heated with hydrochloric acid it evolves hydrocyanic acid. It is not decomposed by nitric acid or the alkalies. Its solution throws down a black precipitate with hydrosulphuric acid, and pearly crystalline plates (*hydrargyro-iodo-cyanide of potassium*) with a concentrated solution of iodide of potassium (*vide* p. 239).

Composition.—Its composition is as follows:—

	Eq.	Eq. Wt.	Per Cent.	Gay-Lussac.
Mercury	1	202	79·52	79·91
Cyanogen	2	52	20·47	20·09
Bicyanide of mercury	1	254	99·99	100·00

Purity.—When prepared from ferrosesquicyanide of iron (Prussian blue) the crystals are usually yellowish, from the presence of some oxide of iron.

Physiological Effects. (*a.*) *On vegetables.*—It acts on plants like bichloride of mercury (Gœppert, in Decand. *Phys. Vég.* 1334).

(*b.*) *On animals.*—Coulon (*Traité sur l'Acide Prussique*, quoted by Wibmer, *Wirk d. Arzneim.* iii. 30) found that it acted on dogs, cats, sparrows, frogs, snails, &c. like hydrocyanic acid. After death, inflammation of the stomach was observed. Ollivier d'Angers (*Journ. de Chim. Méd.* i. 269) tried its effects on dogs. Seven grains, dissolved in water, killed a small dog in ten minutes, under attempts to vomit, general convulsions, and exhaustion, manifested alternately; respiration and circulation at first accelerated, afterwards diminished. Similar effects were produced by applying the salt to the cellular tissue, or injecting it into the veins. Tiedemann and Gmelin (*Versuche ü. d. Wege auf welch. Subst. aus d. Magen u. Darmk. ins Blut gelang.*) detected mercury in the blood of the splenic vein of a horse to whom the bicyanide had been administered.

(*c.*) *On man.*—Taken in *small doses*, it very readily excites nausea and vomiting. Parent (*Journ. de Chim. Méd.* viii. 473) says it does not produce the epigastric pain which the bichloride of mercury readily occasions. Continued use causes salivation. In one case, one-eighth of a grain twice a day caused ptyalism in three days (Neumann, in Dierbach's *Neueste. Entd. in d. Mat. Med.* ii. 483, 1828). Mendaga (*Decades Medico-chirurgicas y Farmaceuticas*, vi. 319, in Richter's *Ausführ Arzneim.* v. 477) says it acts directly on the skin and bones, and hence it sometimes very speedily allays the pain of and disperses nodes.

In large doses, especially in very susceptible persons, it affects the nervous system, and causes fainting, anxiety, and cramps. Twenty-three and a half grains in one instance (*Journ. de Chim. Méd.* i. 210) caused death in nine days. The most remarkable symptoms were, obstinate vomiting; mercurial ulceration of the mouth and abundant ptyalism; contractions of the heart, which at first were very strong, but became successively slower and more feeble; the abdomen was yielding, and not tender, notwithstanding the constant tenesmus; suppression of urine; semi-erection of the penis, and ecchymosis of this organ, as well as of the scrotum; and, ultimately, convulsive movements.

USES. (*a.*) *Medicinal.*—It has been employed as an *antivenereal* medicine, and was first used as such by Brera (Richter, *op. cit.*) Parent (*Journ. de Chim. Méd.* viii. 473) administered it as a substitute for the bichloride of mercury, over which it has several advantages. Thus, being more soluble, it ought to be more readily absorbed; it does not give rise to epigastric pain; and, lastly, it is not so readily decomposed; for alkalies, several salts, and many solutions of organic matters, which decompose corrosive sublimate, have no effect on it. It may be applied in the form of aqueous solution or ointment to venereal sores.

It has been employed in induration of the liver, in some chronic skin diseases, in obstinate headache, and in other maladies, as an antiphlogistic.

(*b.*) *Pharmaceutical.*—Its principal use in this country is as a source of hydrocyanic acid (*vide* p. 237) and of cyanogen gas.

ADMINISTRATION.—Internally it may be employed in doses of one-sixteenth of a grain gradually increased to one-half of a grain. It may be administered in the form of pills (made with crumb of bread) or alcoholic solution. It will be frequently advisable to conjoin opium, to prevent nausea or vomiting. When used as a *gargle* or *wash*, we may employ ten grains to a pint of water. An *ointment* may be prepared of ten or twelve grains to an ounce of lard.

ANTIDOTE.—I am unacquainted with any antidote for it. Albumen does not decompose it. Perhaps ammonia might be found serviceable, to diminish the effect on the nervous system. Opium relieves the vomiting. Our principal object must be to remove the poison from the stomach, which is to be effected by the stomach-pump, emetics, tickling the throat, &c.

Unguen'tum Hydrar'gyri Nitra'tis.—Oint'ment of Ni'trate of Mer'cury.

HISTORY.—This ointment is sometimes termed *citrine ointment* (*unguentum citrinum*). Another name for it is *mercurial balsam.*

PREPARATION.—It is prepared by dissolving mercury in nitric acid and adding the solution to some kind of fatty matter. The relative quantities of acid and metal employed, as well as the nature of the fatty matter used, are various in different formulæ. The following are the proportions directed to be employed in the British and United States Pharmacopœias.

	London	*Dublin*	*Edinburgh*	*United States.*
Mercury	℥j.	℥j.	1 part	℥j.
Nitric Acid	fʒxj.	ʒxiss.	[nitrous acid] 2 parts	fʒxi.
Lard	℥vj.	℥iv.	3 parts	℥iij.
Olive oil	f℥iv.	Oj.	9 parts	Neat's-foot oil f℥ix.

The London Pharmacopœia directs the solution to be mixed while hot with the lard and oil melted together. The Edinburgh and United States Pharmacopœias order the solution to be added to the mixture of lard and oil when it begins to stiffen.

The *theory* of the process is as follows:—By the mutual action of mercury and strong nitric acid, a nitrate of the binoxide, as well as of the protoxide of mercury, is formed, while binoxide of nitrogen is generated. Part of the latter escapes, and, combining with atmospheric oxygen, forms nitrous acid; the remainder reacts on the free nitric acid, and forms with it hyponitrous or nitrous acid. The liquor then is a mixture of *nitric acid* in excess, probably of *nitrous acid*, of the *nitrate* and *hyponitrite of the binoxide of mercury*, and *nitrate of the protoxide of mercury*.

When this solution is added to the fatty matter (lard and olive oil), the nitrous acid, or the hyponitrous acid which it contains, converts the olive oil into a more consistent and less fusible fatty body, which Boudet (*Journ. de Chim. Méd.* viii. 641) calls *elaïdine*, (from ἐλαῒς, ἐλαΐδος, *an olive tree.*) The stearine and elain of the lard also acquire greater consistency in consequence of undergoing an analogous change. There is also a yellow colouring matter produced, and which may be separated by alcohol. By the saponification of a portion of the elaïdine a small quantity of mercurial soap (elaïdate of mercury) is produced The hyponitrous acid of the hyponitrite is capable of producing the same effect as the free acid.

Boudet is of opinion that these changes are effected by the *physical* influence of the nitrous acid, for he asserts that the decomposition of the acid is not essential to the formation of the elaïdine. In this I suspect he is in error.

By keeping, this ointment is apt to become hard, pulverizable, and thereby unfit for use. This depends principally on the change which the olive oil suffers. Hence in the United States Pharmacopœia neatsfoot oil has been substituted for olive oil. The editors of the *United States Dispensatory* observe, that they had in their " possession, upwards of four months, a pot of ointment made according to the process of the Pharmacopœia, and though it had, at the end of this time, partially assumed a greenish colour, it preserved a uniform, soft, unctuous, consistence."

The fatty bodies exercise a deoxidizing influence on the acids (free or combined) of the solution, and which is supposed to be independent of the formation of elaïdine; and, in consequence of this, nitrogen or binoxide of nitrogen is evolved. They also deoxidize the oxides of mercury, reducing the binoxide to the state of protoxide, and, in time, converting the protoxide into metallic mercury; which, being in a finely-divided state, gives to the mass a greyish colour. This latter change is proved by two facts—first, the change of colour which the ointment undergoes; and secondly, by digesting old citrine ointment in ether, the fatty matters are dissolved, leaving behind metallic mercury.

It is to prevent this change that Guibourt (*Pharm. Raisonnée*, ii. 146) and Dr. Duncan (*Edinb. Dispensat.*) direct more nitric acid to be used than is contained in the official formulæ.

Properties.—When fresh prepared this ointment has a fine golden yellow colour, a butyraceous consistence, and a remarkable nitrous odour. It is very apt to become grey when mixed with other ointments, in consequence of their deoxidizing powers. It should be spread with wooden or ivory spatulas.

Composition.—When fresh prepared this compound contains the following substances:—

Elaïdine.
Yellow matter soluble in alcohol.
Elaïdate of mercury (mercurial soap.)
Nitrate of mercury.

Elaïdine is a white saponifiable fat, fusible at 97° F. very soluble in ether, but requiring 200 times its weight of boiling alcohol to dissolve it. When mixed with potash or soda it is converted into glycerin and elaïdic acid.

Physiological Effects.—It is an irritant and slight caustic. When it has undergone decomposition by keeping, it irritates ulcers exceedingly, and even excites slight erysipelatous inflammation.

Uses.—We employ it as a stimulant and alterative in *chronic diseases of the skin*, more particularly those affecting the hairy scalp, as the different forms of porrigo, in which it is exceedingly efficacious. It is also used as a *dressing to ulcers*—to stimulate and cleanse them—as in foul syphilitic sores and phagedænic ulcers. Lastly, it is employed in *ophthalmic diseases*—more particularly ophthalmia tarsi, or psorophthalmia, in which it is applied (mixed with its own weight of almond oil) by means of a camel's-hair pencil to the lids, frequently with such advantage that some have regarded it a specific in this complaint.

Hydrar'gyri Ace'tas.—Ac'etate of Mer'cury.

History.—This compound was known to Lefebure in the 17th century.

Preparation.—In the Dublin Pharmacopœia the directions for procuring it are the following:—Add eleven parts of diluted nitric acid to nine parts of mercury, and when the effervescence has ceased let the mixture be digested that the metal may be dissolved. Add this to a boiling solution of nine parts of acetate of potash in a hundred of distilled water acidulated with vinegar; filter through a double hair-cloth, and let it cool, that crystals may form. Wash them with cold distilled water, and dry on paper with a gentle heat. In the Edinburgh Pharmacopœia a larger quantity of nitric acid is used and the vinegar omitted, as well as the directions for filtering through linen.

By the mutual action of diluted nitric acid and mercury we obtain a protonitrate of mercury (*vide* p. 463.) When this is mixed with acetate of potash double decomposition takes place: nitrate of potash and protoacetate of mercury being formed. To prevent precipitation of the yellow subnitrate of mercury, excess of acid (acetic, Ph. Dub., nitric, Ph. Ed.) should be employed: and by filtering, while hot, any which may be formed would be separated before the acetate has deposited.

Properties.—This salt occurs in white, micaceous, flexible scales, which are inodorous, but have an acrid taste. It blackens by light. When heated it is resolved into carbonic acid, acetic acid, and mercury.

It is very slightly soluble only in water, requiring 300 times its weight of this liquid to dissolve it, according to Dumas. It is insoluble in cold alcohol: boiling alcohol abstracts part of its acid.

Characteristics.—Its appearance, its slight solubility in water, and the action of heat on it. Heated with sulphuric acid the vapour of acetic acid is evolved. The fixed alkalies precipitate the black oxide of mercury. Chloride of sodium forms calomel with it.

Composition.—It has the following composition:—

	Eq.	Eq. Wt.	Per Cent.	Dumas.
Protoxide of Mercury	1	210	80·46	80·66
Acetic Acid	1	51	19·54	19·34
Acetate of Mercury	1	261	100·00	100·00

Physiological Effects.—It is one of the mild mercurial preparations. From the reports of Guarin, Colombier, and Vogler (Wibmer, *Wirk. d. Arzneim.* iii. 67) it appears to have acted in some cases with great violence, and to have occasioned violent vomiting, purging, abdominal pain, bloody evacuations, &c. These effects probably arose from the presence of some acetate of the binoxide of mercury.

Uses.—It was introduced into practice in consequence of being supposed to be the active ingredient of Keyser's antivenereal pills. But Robiquet has subsequently ascertained that Keyser employed the acetate of the binoxide (Dumas, *Traité de Chimie*, v. 178). It is occasionally used in syphilitic affections.

Administration.—The dose of it is from one to five grains. A solution composed of one grain of the acetate dissolved in an ounce of water, may be used as a *wash*. An *ointment* is prepared by dissolving two or three scruples in an ounce of olive oil.

Hydrar'gyri Subsul'phas Fla'vus.—Yel'low Subsul'phate of Mer'cury.

History.—This compound was known to Croll in the sixteenth century. It has been termed *Turpeth* (or *Turbith*) *mineral* (*Turpethum minerale*), from its resemblance in colour to the root of the *Ipomœa Turpethum.*

Preparation.—It is prepared by adding one part of persulphate of mercury (the mode of preparing which has been described at p. 464) to twenty parts of warm or boiling water. A supersulphate of mercury is formed in solution, and a subsulphate precipitates.

Properties.—It is a heavy, lemon-yellow, inodorous powder, having an acrid taste. It requires 2000 parts of water at 60°, or 600 parts at 212°, to dissolve it.

Characteristics.—When heated in a tube, sulphurous acid is evolved, and globules of mercury sublimed. Boiled with caustic potash or soda, the red binoxide precipitates, and a solution of sulphate of potash is obtained, known to be a sulphate by chloride of barium (*vide* p. 265).

Composition.—Its composition is as follows:—

	Eq.	Eq. Wt.	Per Cent.	Braamcamp and Siqueira-Oliva.
Binoxide of Mercury	1	218	84·5	84·7
Sulphuric Acid	1	40	15·5	15·
Subsulphate of Mercury	1	258	100·0	99·7

Physiological Effects.—In small quantities it occasions nausea, vomiting, and ptyalism. Taken into the nostrils it excites sneezing, and sometimes salivation. Stenzel (Wibmer, *Wirk. d. Arzneim.* iii. 66) mentions a fatal case from its internal use.

Uses.—It is sometimes used as an emetic in cases of swelled testicle, to promote absorption by its nauseating and emetic action (*Observ. on the Dublin Pharmacopœia*). It was formerly given at the commencement of a mercurial course. As an errhine it has been administered in chronic ophthalmia and affections of the brain, as incipient hydrocephalus. As an alterative it has been given in the scaly diseases (lepra and psoriasis).

Aministration.—As an alterative, the dose should not exceed half a grain, or at most a grain. As an emetic it is given to the extent of five grains; in which dose it causes violent vomiting. As an errhine, a grain should be mixed with four or five of some mild powder, as starch or liquorice powder. It is rarely given for any other purposes.

Order 21.—Copper and its Compounds.

Cu'prum.—Cop'per.

History.—Cuprum, or copper, received its name κύπρος, from the island of Cyprus, where it was first discovered, or at least worked to any extent. It seems to have been known in the most remote ages of antiquity, for Moses (*Job*, ch. xxviii.) speaks of brass (an alloy of copper and zinc). The alchymists called it *Venus*.

Natural History.—It is found in both kingdoms of nature.

(*a.*) *In the inorganized kingdom.* — Copper is found in the metallic or reguline state, combined with oxygen, with sulphur, with selenium, with chlorine, or with oxygen, and an oxyacid (carbonic, arsenic, phosphoric, sulphuric, or silicic).

(*b.*) *In the organized kingdom.*—It has been discovered in the ashes of most plants, as of stavesacre, rhatany, flax, nux vomica, hemlock, &c. Sarzeau has detected it in the blood of animals (*Ann. de Chim.* xliv. 334).

Preparation.—The copper of commerce is usually prepared from copper pyrites or grey copper ore (both sulphurets). These are roasted and then smelted, by which *coarse metal* is procured. This is calcined and again smelted, by which we obtain *fine metal*, or, when cast in sand, *blue metal*. By re-roasting and smelting, *coarse copper* is produced. These processes, of roasting and smelting, effect the expulsion of the sulphur and the oxidizement of the iron. The copper thus produced is melted and exposed to the air, to drive off any volatile matters by which *blistered copper* is obtained. It is *refined* or *toughened* by melting it and stirring with a birchpole (J. H. Vivian, *Ann. of Philosophy*, N.S. v. 113).

Properties.—It is a crystallizable, brilliant, red metal, crystallizable in regular octahedra and cubes, having a specific gravity of 8·86 to 8·89; malleable and ductile; it has a nauseous, styptic taste, and a peculiar and disagreeable smell. It fuses at 1996° F. (*Daniel*); at a higher temperature it may be volatilized. Its equivalent is 32. It is combustible. It is readily oxidated. Acid, alkaline, saline, and fatty bodies, when placed in contact with it in the air, promote its union with oxygen; and, by dissolving a portion of the newly-formed oxide, acquire poisonous properties.

Characteristics.—Copper is easily recognized by its colour, by its communicating a green tinge to flame, and by dissolving it in nitric acid. The solution possesses the following properties: it is blue, or greenish blue; potash or soda occasions a blue precipitate of the hydrated oxide of copper; a small quantity of ammonia produces a similar bluish white precipitate, but an excess redissolves it, forming a deep blue liquid: ferrocyanide of potassium occasions a reddish brown precipitate of the ferrocyanide of copper; the hydrosulphurets throw down the black sulphuret; and, lastly, a polished iron plate plunged into the liquid, becomes coated with metallic copper.

Physiological Effects.—(*a.*) *Of metallic copper.*—Metallic copper appears to produce no pernicious effects when taken internally, so long as it retains its metallic state, as many cases are recorded where coins of this metal have been swallowed and retained for a considerable time without any ill effects arising; and Drouard (*Exper. et Observ. sur l'Empoisonnem. par l'Oxide de Cuivre*, Paris, 1802) gave as much as an ounce of finely powdered copper to dogs of different ages and sizes, but none of them experienced any inconvenience.

Notwithstanding these facts, however, various effects have been attributed to it. Thus, Cothenius (Voigtel, *Arzneimittellehre*) says, copper filings operate by stool, urine, and saliva; and the late Professor Barton (Chapman's *Elem. of Therap.* ii. 457) was accustomed to relate an instance of a child, who, having swallowed a cent, continued for some time to discharge several pints of saliva. Lastly, Portal (Orfila, *Toxicol. Gén.*) mentions a case in which copper filings, incorporated with crumb of bread, acted powerfully on the system. I have no doubt but that the effects here mentioned arose from the oxidation of the metal by the acids of the alimentary canal.

(*b.*) *Of the Cupreous Compounds.*—If the cupreous preparations be used in *very small* doses, they sometimes give relief in certain diseases (principally of the nervous system), without obviously disordering the functions; in other words, in these instances the only apparent effect is the modification observed in the morbid condition. These are the cases in which these preparations have been termed *tonic*, *antispasmodic*, or *alterative*, according to the nature of the disease; thus, in ague they have been termed tonic, in epilepsy antispasmodic, in dropsy alterative. The beneficial operation is presumed to be owing to some influence exerted by the remedy over the nervous system. The effects produced by the long-continued use of small doses of the preparations of copper have not been satisfactorily determined; they are said to be various affections of the nervous system (such as cramps or paralysis), alteration of the colour of the skin, chronic inflammation of the respiratory and digestive apparatus, slow fever, and wasting of the body. These symptoms constitute what has been termed *slow*, or *chronic poisoning by copper*. The smelters and workers in copper do not suffer from the vapour or emanation of this metal, as the workmen employed in the preparation of mercury, of arsenic, or of lead do, from the vapours of these metals; this, indeed, might be expected, when we consider how much more volatile the latter and their preparations are, than copper and its compounds. In *larger*, or full medicinal doses, these remedies act as *emetics*, exciting speedy vomiting, with less nausea than tartar emetic produces. In *still larger* quantities these bodies act as poisons, giving rise to gastro-intestinal inflammation, and disordering the functions of the nervous system (especially the cerebro-spinal portion), constituting *acute poisoning by copper*. The usual symptoms are, a coppery taste, eructations, violent vomiting and purging, griping pains, cramps in the legs and thighs, headache, giddiness, convulsions, and insensibility: jaundice is occasionally observed. In some cases the cerebro-spinal symptoms precede those which indicate inflammation of the alimentary canal. In experiments made on animals, it has been observed that death was sometimes produced without any marks of local irritation; the symptoms being those indicative of a disordered condition of the nervous system. By some toxicologists these preparations are ranked among the *irritant* poisons, though Buchner (*Toxicologie*), judging from Reiter's experiments, terms them *astringent*.

Drouard, and others, were of opinion that the preparations of copper do not become absorbed, but Lebkuchner (Christison, *Treat. on Poisons*, 3d ed. 433), has detected copper in the blood of the carotid artery of a cat, into whose bronchial tubes he had injected four grains of the ammoniacal sulphate; and Wibmer, (*Wirk. d. Arzn.* ii. 244), has found it in the liver of animals to whom he had given the acetate for several weeks.

Post-mortem appearances.—In animals killed rapidly by these poisons, no morbid appearances are found, in consequence of death being produced by their action on the nervous system; but when the death was slow, marks of gastro-intestinal inflammation, and occasionally indications of inflammation of the brain, have been observed.

USES. (*a.*) *Of metallic copper.*—Copper filings, in doses of three or four grains, were formerly used in rheumatism, and also as an antidote against the effects of the bite of a mad dog.

(*b.*) *Of the cupreous compounds.*—These preparations are used both as external and as internal remedies; externally as stimulants, astringents, styptics, and caustics; internally, as emetics and tonics, or antispasmodics. The particular cases will be noticed when treating of the individual preparations.

ANTIDOTES.—The chemical antidote for the cupreous preparation is *albumen*; hence, the whites of eggs, and in the absence of these, milk, or even wheaten flour, should be employed. *Iron filings* have been proposed by Navier, by Payen and Chevallier, and subsequently by Dumas and Milne Edwards. The iron decomposes the cupreous salt, and precipitates the copper in the metallic (and, therefore, in an inert) state. The *ferrocyanide of potassium* is also said to be a good antidote: a drachm or two of it may be taken with safety, for it is not so poisonous as was at one time imagined. *Sugar* was proposed by Marcelin Duval as an antidote; its efficacy, though denied by Orfila and Vogel, has been lately reasserted by Postel. The alkaline sulphurets formerly used are worse than useless, since they are active poisons. The inflammatory symptoms are of course to be subdued by the usual means. (For further details on this subject consult Christison's *Treat. on Poisons.*)

Cu'pri Sul'phas.—Sul'phate of Cop'per.

HISTORY.—This substance was probably employed by Hippocrates (*De ulceribus*), under the name of χαλκῖτις κυανέη (*chalcitis cærulea*), to promote the healing of ulcers. Pliny (*Hist. Nat.* xxxiv. 32.) also was doubtless acquainted with it, though he seems to have confounded it with sulphate of iron. His *chalcanthum cyprium* was, perhaps, sulphate of copper. This salt has had various synonymes, such as *blue vitriol* (*vitriolum cæruleum*) *Roman vitriol, blue copperas, blue stone, bisulphate of copper.*

Natural History.—It occurs in copper mines (as those of Cornwall, &c.) and is formed from sulphuret of copper by the joint agency of air and water. The cupreous solutions of copper mines are termed *waters of cementation.*

Preparation.—It may be prepared by evaporating the water found in, or issuing from, copper mines. It is also produced by roasting copper pyrites, lixiviating the residuum to dissolve the sulphate, and evaporating so as to obtain crystals. In this process both the sulphur and the copper of the pyrites abstract oxygen from the air, and become, the one sulphuric acid, the other oxide of copper: these by their union constitute the sulphate of copper.

Properties.—This salt occurs in fine blue crystals, whose primary form is the doubly oblique prism. Its sp. gr. is 2·2. It has a styptic metallic taste, and reacts on litmus as an acid. By exposure to the air it effloresces slightly, and becomes covered with a greenish white powder. When heated it loses its water of crystallization, and becomes a white powder (*pulvis sympatheticus.*) By a very intense heat it is decomposed,—sulphurous acid and oxygen are evolved, and oxide of copper left. It dissolves in about 4 parts of water at 60°, and 2 parts of boiling water. It is insoluble in alcohol.

Characteristics.—Its characteristics are those of the sulphates (*vide* p. 265), and of the cupreous compounds (*vide* p. 493.)

Composition.—Its composition is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Thomson.	Berzelius.
Oxide of Copper	1	40	32	32	32·13
Sulphuric Acid	1	40	32	32	31·57
Water	5	45	36	36	36·30
Crystallized Sulphate of Copper	1	125	100	100	100·00

Impurity.—The commercial sulphate of copper sometimes contains traces of sulphate of iron. It may be detected by excess of ammonia, which throws down the oxide of iron, but dissolves the oxide of copper.

Physiological Effects. (*a.*) *On vegetables.*—It is poisonous to plants (Decandolle, *Phys. Vég.* 1335): hence its use in preventing dry rot (*Merulius lachrymans*), by soaking timber in it, according to Mr. Margary's patent; and in destroying or preventing the smut (*Uredo segetum*), or bunt (*U. caries*), in corn, by immersing the grain in a weak solution of it: the solution is not made sufficiently strong to injure the seed.

(*b.*) *On animals.*—This salt operates as a poison to animals. Six grains killed a dog in half an hour, without producing any appearance of inflammation (Drouard). Applied to a wound it destroyed the animal in twenty-two hours, and the body was every where in a healthy state (Duncan, in Christison *on Poisons*, 432). Orfila (*Tox. Gén.*) also found that it proved fatal in a few hours when applied to wounds. The only symptoms mentioned are dulness, loss of appetite, and sometimes purging. Inflammation of the mucous membrane of the stomach and rectum was found after death.

(*c*.) *On man.*—In *very small doses* it has no sensible operation on the body, though it occasionally ameliorates certain diseases, such as epilepsy and ague: in these cases it has been denominated an antispasmodic and tonic. The local action on the alimentary tube is that of an astringent. Dr. Elliotson (*Lond. Med. Gaz.* xii. 557) has known a patient to take it for three years, for a particular kind of diarrhœa, without any constitutional effect. In *larger doses* it is a safe and useful emetic, acting very speedily, and without exciting any great disorder of the general system. In *excessive doses* it becomes a poison, producing inflammation of the alimentary canal, and disordering the functions of the nervous system, as noticed when describing the action of the cupreous preparations generally. In a case mentioned by Dr. Percival (*Trans. Lond. Coll. Phys.* iii. 88) two drachms proved fatal: the patient was violently convulsed. In a more recent case (*Lond. Med. Gaz.* xviii. 624 and 742) there were vomiting and insensibility, but no convulsions or purging: the child died in four hours.

Its topical action is stimulant, astringent, styptic, and caustic. Its causticity depends on its union, either as a neutral or basic salt, with one or more of the constituents of the tissues. Thus it combines with albumen to form a pale bluish green compound, which produces with caustic potash a violet-coloured solution (Dr. C. G. Mitscherlich, *Brit. Ann. of Med.* i. 751 and 817, and ii. 51).

Uses.—Where speedy vomiting without much nausea is required, as in cases of narcotic poisoning, sulphate of copper is a tolerably sure and valuable *emetic*. It has also been used, with success, to provoke vomiting in croup, and thereby to promote the expulsion of the false membrane, (*Brit. and For. Med. Rev.* i. 568.)

As an *astringent* it has been used in chronic diarrhœa and dysentery by Dr. Elliotson (*Lond. Med. Gaz.* viii. 378, and xii. 557; also *Med. Chir. Trans.* xiii. 451), who found it succeed where the ordinary vegetable astringents fail. It should be given in doses of from half a grain to two grains twice or thrice a day, in combination with opium. It is also used as an astringent to check excessive secretion from the bronchial and urino-genital mucous membranes. Dr. Wright (*Lond. Med. Journ.* i. and x.) found it serviceable in dropsy.

As a *tonic* or *antispasmodic* it has been given in intermittent diseases, as the ague; and in some maladies of the nervous system (epilepsy and chorea). In epilepsy it has recently been strongly recommended by Dr. F. Hawkins (*Lond. Med. Gaz.* viii. 183).

As a *topical* agent, it is often employed in substance as an application to ulcers, either for the purpose of repressing excessive soft and spongy granulations, commonly denominated "proud flesh," or of hastening the process of cicatrization; and for either of these purposes it is one of the best agents we can employ. Solutions of it are frequently applied to mucous membranes, to diminish excessive secretion: thus to the conjunctiva, in chronic ophthalmia, and to the mucous lining of the vagina or urethra, in discharges from these parts. In superficial ulcerations of the mucous membranes (especially of the mouth), one or two applications of the sulphate of copper, in substance, are generally sufficient to heal them.

As a *styptic* a solution of this salt is sometimes used to repress hæmorrhages from a number of small vessels. Rademacher applied with good effect brandy impregnated with sulphate of copper in a case of alopecia, or baldness, which occurred in a young man; but it failed in the hands of Dr. T. J. Todd (*Cyclop. of Pract. Med.* i. 52.)

Administration.—The dose of it, as an *emetic*, is from three or four grains to fifteen; as an *astringent*, or *tonic*, from a quarter of a grain to one or two grains. Solutions used for external purposes vary considerably in their strength in different cases, but usually from one or two grains to eight or twelve, dissolved in an ounce of water.

Antidotes.—*Vide* Cuprum.

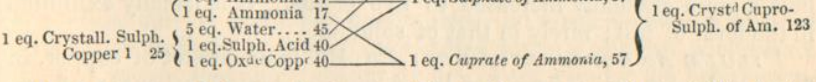
Solutio Sulphatis Cupri Composita, Ph. Ed. (sulphate of copper; alum, āā ℥iij; water, lb. ij.; sulphuric acid, ℥iss. Boil until the sulphates are dissolved; then filter, and add the acid.)—It is employed as a styptic, to arrest hæmorrhage; and, when diluted, in the purulent ophthalmia of children.

Ammo'niæ Cu'pro-Sul'phas.—Cu'pro-Sul'phate of Ammo'nia.

History.—Boerhaave was acquainted with an ammoniacal solution of copper. In 1757 Weissman gave imperfect directions for its preparation. In 1799 Acoluth published a better process. Dr. Cullen introduced this substance into practice in this country. It is frequently called *ammoniated copper* (*cuprum ammoniatum*, Ph. Dubl. and U. S.) or *ammoniuret of copper* (*cupri ammoniaretum*, Ph. Ed.) In the London Pharmacopœia it is termed *ammonio-sulphate of copper* (*cupri ammonio-sulphas*).

Preparation.—In all the British Pharmacopœias, this compound is directed to be prepared by rubbing an ounce of sulphate of copper with an ounce and a half of sesquicarbonate of ammonia until carbonic acid ceases to evolve.

The *theory* of the process is imperfectly understood. The proportions of ingredients employed are about two equivalents of sulphate and three and one-fifth equivalents of sesquicarbonate. When rubbed together, these salts give out part of their water of crystallization, by which the mass becomes moist; and, at the same time, a portion of carbonic acid of the sesquicarbonate escapes, producing the effervescence alluded to; and the compound becomes of a deep azure-blue colour. This colour is probably owing to cuprate of ammonia; for oxide of copper with caustic ammonia forms a similarly-coloured liquid. If this notion be correct, the decomposition may be thus explained:—Two equivalents or 118 parts of hydrated sesquicarbonate of ammonia react on one equivalent or 125 parts of crystallized sulphate of copper, and produce one equivalent or 57 parts of cuprate of ammonia, one equivalent or 57 parts of sulphate of ammonia, seven equivalents or 63 parts of water, and three equivalents or 66 parts of carbonic acid. The cuprate and sulphate of ammonia with one equivalent of water represent the crystallized cupro-sulphate of ammonia (*cuprum ammoniacale* of some authors).



Properties.—It has a deep azure-blue colour, a styptic metallic taste, and an ammoniacal odour. It reacts on vegetable colours as an alkali:

thus it reddens turmeric, and restores the blue colour of litmus, which has been reddened by an acid. By exposure to the air, ammonia is evolved, and a green powder is left, composed of sulphate of ammonia and carbonate of copper. To prevent this, therefore, it should be preserved in a well-stoppered bottle. It is soluble in water; but unless excess of sesquicarbonate of ammonia be present, the solution, when much diluted, lets fall a subsulphate of copper.

CHARACTERISTICS.—Dissolved in water it forms a green precipitate (*arsenite of copper*) with a solution of arsenious acid. When heated, all its constituents are dissipated, save the oxide of copper. Boiled with caustic potash a solution of sulphate of potash is obtained, the hydrated oxide of copper is thrown down, and ammonia is disengaged. Sulphuric acid may be recognised in the solution by the barytic salts.

COMPOSITION.—The essential part of this compound is the cupro-sulphate of ammonia. This, in the crystalline state, has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.	Brandes.
Oxide of Copper	1	40	32·52	34·00	33·017
Ammonia	2	34	27·64	26·40	21·410
Sulphuric Acid	1	40	32·52	32·25	31·753
Water	1	9	7·32	7·35	13·358
Cupro-sulphate of Ammonia	1	123	100·00	100·60	99·538

The cupri ammonio-sulphas, Ph. L., usually contains some undecomposed sesquicarbonate (bicarbonate?) of ammonia, and probably some sulphate (subsulphate?) of copper.

PHYSIOLOGICAL EFFECTS.—Its action is, for the most part, similar to sulphate of copper. Wibmer (*Wirk. d. Arzneim.* ii. 256) examined its effects on horses and dogs. Four grains dissolved in water, and injected into the veins, killed a dog. The respiration and circulation were quickened by it. In some cases vomiting and purging were produced; weakness, tremblings, and paralysis, indicated its action on the nervous system. Its general effects on man are like those of sulphate of copper, but it is thought to be less disposed to occasion nausea and vomiting. An over-dose, however, readily acts as an emetic. Its action is probably somewhat more stimulant to the general system than the sulphate. It is employed in medicine as a tonic and antispasmodic.

USES.—*Internally* it has been principally employed in chronic spasmodic affections; such as epilepsy, chorea, catalepsy, hysteria, spasmodic asthma, and cramp of the stomach. In epilepsy it has been much esteemed, and was found useful by Dr. Cullen (*Treat. on Mat. Med.*), and other accurate observers; but, like all other remedies for this curious disease, it frequently fails. It has also been used in ague and dropsy. As a *topical* remedy, a solution of it has been employed as an injection in gonorrhœa and leucorrhœa; and as a collyrium to remove opacity of the cornea.

ADMINISTRATION.—It may be administered internally in doses of from half a grain gradually increased to five grains. It is usually exhibited in the form of pill; rarely in that of solution.

PILULÆ AMMONIARETI CUPRI, Ph. Ed. (ammoniaret of copper, in fine powder, gr. xvj.; crumb of bread, ℈iv.; water of carbonate of ammonia, q. s. Beat into a mass, and divide into thirty-two equal pills).—

Each pill contains half a grain of ammoniaret of copper. The dose is from one to five or six pills.

Liquor Cupri Ammonio-sulphatis, Ph. Lond. *Cupri ammoniati aqua*, Ph. Dub. (Ammoniated copper, ʒj.; distilled water, ℥xx. Dissolve and strain. In the Dublin Pharmacopœia one part of the salt is used to a hundred parts of distilled water).—It is applied to indolent ulcers as a stimulant and detergent; and, when diluted, to the eye, to remove slight specks of the cornea.

Cu′pri Subace′tas.—Subac′etate of Cop′per.

History.—Hippocrates employed *verdigris*, which he terms χαλκοῦ ἰὸς, or *rust of copper*, in diseases of the eyes, and as an astringent in hæmorrhoids (Ed. Fæs. 635, 636 & 894). Theophrastus (*De Lapidibus*), Dioscorides (lib. v. cap. xci.), and Pliny (*Hist. Nat.* xxxiv.) describe the method of procuring it. The Romans called it *ærugo*. It is frequently termed *diacetate of copper;* but this name is objectionable, since verdigris frequently occurs as a *subsesquiacetate* mixed with the *trisacetate*. I prefer the less precise, though more accurate term, *subacetate of copper*.

Preparation.—At Montpellier it is thus made:—The refuse of grapes is allowed to ferment with sour wine, and is then laid in alternate strata with plates of copper: acetous fermentation takes place, and the metal becomes oxidized by the combined influence of the air and acid. In about fifteen days the plates are covered with the acetate of copper; they are then wetted, and exposed for a month to the air: the acetate absorbs the water, and uniting with more oxide of copper, forms a subacetate, which is scraped off, and packed in leathern sacks for exportation. At Grenoble verdigris is obtained by sprinkling plates of copper with ready-made vinegar (Dumas, *Traité de Chim.* v. 169). In this country it is prepared by exposing thin plates of copper to the action of acetic acid, or its fumes: the method now practised consists in alternating plates of copper with pieces of woollen cloth steeped in acetic acid; they gradually become corroded, and superficially covered with verdigris, which is from time to time removed, and the operation repeated, as long as the plate lasts (Brande's *Manual of Chemistry*). French verdigris is imported in sacks, weighing from 25 to 30 pounds.

Properties.—It occurs in masses or in powder. One variety is of a pale bluish green colour; another is blue. Its taste is astringent and metallic; its odour is somewhat similar to, though more disagreeable, than acetic acid. It is insoluble in alcohol. Water resolves it into a soluble acetate and an insoluble trisacetate. Hence the *cupri subacetas præparatum* of the Dublin Pharmacopœia, and which is directed to be prepared by levigation and elutriation, is in fact the trisacetate, the verdigris having undergone a chemical change by the action of water.

Characteristics.—When digested with strong sulphuric acid, it evolves acetic acid, which is readily distinguished by its odour. Heated in a glass tube it gives out acetic acid; the residue contains metallic copper. If verdigris be boiled in distilled water a solution is obtained, which is known to contain copper by its colour, and by the before-mentioned tests for the cupreous compounds (*vide* p. 493).

Composition.—The blue verdigris is a hydrated diacetate of copper.

Verdigris with a greenish tint consists of the subsesquiacetate and the trisacetate (Berzelius, *Traité de Chimie*, iv. 347 & 349). The composition of these salts is as follows:—

	DIACETATE.			SUBSESQUIACETATE.			TRISACETATE.		
	Eq.	Eq.Wt.	Per Cent.	Eq.	Eq.Wt.	Per Cent.	Eq.	Eq.Wt.	Per Cent.
Oxide of copper	2	80	43·24	1½	60	43·48	3	120	63·5
Acetic Acid	1	51	27·57	1	51	36·96	1	51	27·0
Water	6	54	29·19	3	27	19·56	2	18	9·5
	1	185	100·00	1	138	100·00	1	189	100·0

PHYSIOLOGICAL EFFECTS.—The action of verdigris on the system is very similar to that of the other preparations of copper: thus, taken in small and repeated doses, it acts on the nervous system, and is called tonic and antispasmodic; in larger doses it operates as an emetic; and, in excessive doses, is a powerful poison, producing both gastro-enteritis (indicated by vomiting, purging, and pain), and an affection of the nervous system (marked by insensibility, convulsions, and even tetanus).

USES.—Verdigris, when taken into the stomach, being variable and dangerous in its operation, is never administered internally. It was formerly employed in obstinate syphilis, when mercurials failed.

The *powder* is sometimes employed as an escharotic. It is sprinkled over foul and indolent ulcers, or, when mixed with savin, is applied to destroy venereal warts. When used for the latter purpose it rarely fails.

LINIMENTUM ÆRUGINIS, Ph. Lond. *Oxymel cupri subacetatis*, Ph. Dubl. (verdigris, powdered [prepared subacetate, *Dubl.*], ℥j.; vinegar [distilled, *Dubl.*] f.℥vij.; clarified honey, ℥xiv. Dissolve the verdigris in the vinegar, and strain the solution through linen; afterwards, the honey being added, boil down to a proper consistence).—This was formerly called *Mel Ægyptiacum*, *Unguentum Ægyptiacum*, or *Oxymel Æruginis*. It is stimulant, detergent, and slightly escharotic. It is applied by means of a camel's-hair pencil to venereal ulcers of the throat, as well as to other indolent ulcers. Diluted with water it is employed as a gargle.

UNGUENTUM CUPRI SUBACETATIS, Ph. Dubl.; *unguentum cupri subacetatis*, Ph. Ed. (Prepared subacetate of copper, ℥ss.; olive oil, ℥j.; ointment of white resin, ℔j. M. *Ph. Dubl.*—Resinous ointment, 15 parts; subacetate of copper, in very fine powder, 1 part. M. *Ph. Ed.*)—This is a stimulant and mild escharotic. It is used as an application to foul ulcers, in ophthalmia tarsi, as a cure for the obstinate forms of ring-worm, and as an application to corns.

ANDIDOTES.—*Vide* CUPRUM.

Cu'pri Ace'tas.—Ac'etate of Copper.

This salt is commonly, though very improperly, termed *distilled* or *crystallized verdigris*, and is met with in the shops crystallized on sticks. It is usually prepared by dissolving common verdigris in acetic acid, and crystallizing. The crystals are oblique rhombic prisms. They consist of one equivalent of oxide of copper, one equivalent of acetic acid, and one equivalent of water. This salt is completely soluble in water, by which it is distinguished from common verdigris. In most other properties it agrees with the latter. It is included in the list of materia medica of the Dublin Pharmacopœia, but for what reason I cannot divine, since it is never used in medicine.

ORDER 22.—BISMUTH AND ITS COMPOUNDS.

Bismu'thum.—Bis'muth.

HISTORY.—This metal is first mentioned by Agricola, in 1529. It has been termed *Marcasita*, *Tectum Argenti*, or, by the Germans, *Wismuth.* "The old miners called it Wismuth," says Matthesius, "because it blooms as a beautiful meadow (*Wiesematte*), on which variegated flowers of all kinds are glittering," (Schwartze, *Pharm. Tabellen*).

NATURAL HISTORY.—Bismuth occurs only in the mineral kingdom. It is found in Cornwall, Saxony, Bohemia, &c. It is met with in the metallic state nearly pure (*native bismuth*), and in combination with sulphur and with oxygen.

PREPARATION.—It is chiefly obtained from native bismuth by melting the metal out of its gangue.

PROPERTIES.—It is a reddish white metal, without taste or smell, composed of brilliant broad plates, and readily crystallizable in cubes or regular octahedrons. Its sp. gr. is 9·83 to 9·88. It is moderately hard, brittle, pulverizable, fusible at 476° F. When strongly heated in the air it takes fire, and burns with a faint blue flame, emitting a yellow smoke (the oxide). In close vessels it may be volatilized. Its equivalent is 72.

CHARACTERISTICS.—It is distinguished by its brittleness, its ready fusibility, its solubility in nitric acid, and by the characters of the nitric solution, which throws down a white precipitate on the addition of water, and a black one when hydrosulphuric acid or the hydrosulphates are added to it.

PURITY.—Any arsenicum, which may be mixed with bismuth, is insoluble in nitric acid: it is converted by the acid into an insoluble arseniate. Copper may be detected by precipitating the nitric solution with ammonia; the supernatant liquor is blue if copper be present.

PHYSIOLOGICAL EFFECTS AND USES.—In the metallic state, bismuth is inert. Its only use is in the preparation of the trisnitrate.

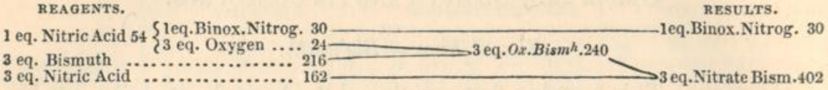
Bismu'thi Trisni'tras.—Trisni'trate of Bis'muth.

HISTORY.—This compound was first prepared by Lemery. It has had various appellations, such as *pearl* or *flake white*, *magistery of bismuth* (also a name for submuriate of bismuth), *Spanish white*, *subnitrate* or *tetarto-nitrate of bismuth.*

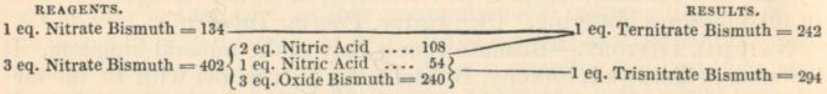
PREPARATION.—In the London Pharmacopœia it is directed to be prepared by dissolving one ounce of bismuth in a fluid ounce and a half of nitric acid, to which six drachms of water have been added. After the solution has been filtered, about three pints of distilled water are to be added: the subnitrate precipitates, and is to be collected, washed, and dried.

In the Dublin Pharmacopœia, seven parts of bismuth are dissolved in twenty parts of diluted nitric acid, and the solution added to a hundred parts of water.

In the first part of this process we obtain a nitrate of bismuth by the re-action of three equivalents or 216 parts of bismuth, on four equivalents or 216 parts of nitric acid. One equivalent or 30 parts of binoxide of nitrogen are evolved, and three equivalents or 402 parts of nitrate of bismuth formed.



When nitrate of bismuth is mixed with water, two bismuthic salts are produced; a soluble supersalt (*ternitrate*), and an insoluble subsalt (*trisnitrate*).



PROPERTIES.—It is a dull white, inodorous, tasteless powder, which consists of very fine silky needles. It is nearly insoluble in water, but is readily dissolved by nitric acid. By exposure to light it becomes greyish.

CHARACTERISTICS. — Hydrosulphuric acid, or the hydrosulphates, blacken it, by forming the sulphuret of bismuth. It dissolves in nitric acid without effervescence. Heated on charcoal by the blowpipe flame it gives out nitrous acid, and yields the yellow oxide of bismuth; and, by a continuance of the heat, the oxide is reduced, globules of metallic bismuth being obtained, which may be readily distinguished from globules of lead by their brittleness; for, when struck sharply by a hammer on an anvil, they fly to pieces: from antimony they are distinguished by their solubility in nitric acid.

COMPOSITION.—Its composition, according to Mr. Phillips (*Phil. Mag.* Dec. 1830, p. 409,) is as follows:—

	Eq.	Eq.Wt.	Per Cent.	R. Phillips.
Oxide of Bismuth	3	240	81·64	81·92
Nitric Acid	1	54	18·36	18·28
Trisnitrate of Bismuth	1	294	100·00	100·00

PURITY.—Its freedom from any carbonate (as of lead) is distinguished by its solution in nitric acid without effervescence. Sulphuric acid added to the solution throws down a white precipitate, if lead be present.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—It acts as a local irritant and caustic poison. Moreover it appears to exercise a specific influence over the lungs and nervous system (Orfila, *Toxicol. Gén.*)

(*b.*) *On man.*—In *small doses* it acts locally as an astringent, diminishing secretion. On account of the frequent relief given by it in painful affections of the stomach, it is supposed to act on the nerves of this viscus as a sedative. It has also been denominated tonic and antispasmodic. Vogt (*Pharmakodynamik*, i. 288, 2^te Aufl.) says, that when used as a cosmetic, it has produced a spasmodic trembling of the muscles of the face, ending in paralysis.

Large medicinal doses disorder the digestive organs, occasioning pain, vomiting, purging, &c.; and sometimes affecting the nervous system, and producing giddiness, insensibility, cramps of the extremities, &c.

The following is the only reported case of poisoning with it. A man took two drachms by mistake, and died therefrom on the ninth day. In addition to the usual symptoms of gastro-enteritis, there was a disordered condition of the nervous system, indicated by cramps of the hands and feet, disordered vision, and delirium. It is deserving also of remark, that there were difficulty of breathing, and salivation. Post-mortem examination showed inflammation throughout the alimentary canal; the spinal vessels were gorged with blood, particularly towards the cauda equina; there was fluid in the cerebral ventricles; and the inner surface of both ventricles of the heart was very red (Christison's *Treatise on Poisons*).

We have not at present sufficient evidence before us to determine whether this medicine affects the general system by absorption or through the intervention of the nervous system: its insolubility has led to the conclusion that it does not become absorbed.

USE.—It has been principally employed in those chronic affections of the stomach which are unaccompanied with any organic disease, but which apparently depend on some disordered condition of the nerves of this viscus; and hence the efficacy of the remedy is referred to its supposed action on these parts. It has been particularly used and recommended to relieve gastrodynia and cramp of the stomach, to allay sickness and vomiting, and as a remedy for the waterbrash. It has also been administered in intermittent fever, in spasmodic asthma, &c. Hahnemann has recommended a portion to be introduced into a hollow tooth, to allay tooth-ache. I have used it, with advantage, in the form of ointment, applied to the septum nasi, in ulceration of this part, and as a local remedy in chronic skin diseases.

ADMINISTRATION.—The usual dose of this remedy is from five grains to a scruple, exhibited in the form of a pill. The ointment which I have just referred to was composed of one drachm of the subnitrate, and half an ounce of spermaceti ointment.

ANTIDOTES.—No chemical antidote is known. Emollient drinks should be administered, and the poison evacuated from the stomach as speedily as possible. The antiphlogistic plan is to be adopted, to obviate inflammation.

ORDER 23.—TIN.

Stan'num—Tin.

HISTORY.—Tin has been known from the most remote periods of antiquity. It is mentioned by Moses (*Numbers*, xxxi. 22) and by Homer (*Iliad*, xi. 25). The alchymists called it *Jove*, or *Jupiter*.

NATURAL HISTORY.—It is peculiar to the mineral kingdom. It occurs in two states; as an oxide (the *tin stone* and *wood tin* of mineralogists), and as a sulphuret (*tin pyrites*). It is found in both states in Cornwall, which has long been celebrated for its tin works. The Phœnicians, who were perhaps the first people who carried on commerce by sea, traded with England and Spain for tin at least 1000 years before Christ.

PREPARATION.—In Cornwall, *stream tin* (a variety of *tin stone*) is smelted with charcoal. The metal thus procured is subsequently made hot, and then let fall from a height, by which it splits into a number of irregular prisms, somewhat like a basalt pillar. This is called *grain tin*. *Mine tin* (another variety of *tin stone*) is ground, washed, roasted, and afterwards smelted with Welsh culm and limestone, by which *block tin* is procured; the finest kind of which is called *refined tin* (Mr. John Taylor, *Ann. Phil.* iii. 449).

Besides the two varieties of tin just described, other kinds are met with in commerce. *Malacca tin* occurs in quadrangular pyramids, with flattened bases. *Banca tin* is met with in wedge-shaped pieces.

PROPERTIES. — In its massive form it is a yellowish-white metal, having a peculiar odour when rubbed or handled. Its sp. gr. is 7·29. It melts at 442° F. and at a white heat is volatilized. It is malleable, and forms *sheet tin* and *tin foil* (*stannum foliatum*), but is sparingly ductile. Its equivalent is 58.

Tin may be reduced to powder, by pouring melted tin into an iron mortar, and rubbing until it is cold; or by shaking melted tin in a wooden box, the inside of which has been rubbed with chalk. In this state it constitutes *powdered* or *granulated tin* (*pulvis stanni*, Ph. Dub., Ed. and U. S.) This as well as *tin filings* (*stanni limatura*, Ph. Ed. seu *rasura stanni*) have been used in medicine.

CHARACTERISTICS.—Boiled in strong hydrochloric acid, we obtain a solution of protochloride of tin, which possesses the following characters:—Potash causes a white precipitate, soluble in excess of the precipitant; hydrosulphuric acid, a brown; and chloride of gold, a purple precipitate (the *purple powder of Cassius*). If protochloride of tin be heated with nitric acid, we obtain a perchloride which causes a yellowish precipitate with hydrosulphuric acid.

PHYSIOLOGICAL EFFECTS.—In the mass, tin has no operation on the body, except that arising from its form and weight. Powdered tin is not known to produce any disorder in the functions of the body. It appears, however, that acid, fatty, saline, and even albuminous substances, may occasion colic and vomiting by having remained for some time in tin vessels. Oxide of tin is poisonous, according to Orfila (*Toxicol. Gén.*); but Schubarth (quoted by Dr. Christison, *Treat. on Poisons*) found it inactive.

USES.—Powdered tin has been employed with great success by various eminent practitioners, as a vermifuge, particularly in tape-worm. Dr. Alston (*Med. Essays*, v. 89, 92; also *Lect. on Mat. Med.* i. 150) explains its operation on mechanical principles: he supposes that the powder of tin gets betwixt the worms and the inner coat of the alimentary canal, and causes them to quit their hold, so that purgatives easily carry them away with the fæces. It has, however, been asserted that water in which tin has been boiled is anthelmintic, at least so says Pitcairn and Pietsch (quoted by Richter, *Ausf. Arzneim.* iv. 553); wine which has been digested in a tin vessel is also said to be noxious to worms. If these statements be true, the before-mentioned mechanical explanation is inadmissible. Some have, therefore, supposed that the efficacy must depend on the tin becoming oxidized in the alimentary canal; others have fancied that arsenic, which is frequently found in tin, is the active agent; while, lastly, some have imagined that the metal, by its action on the fluids of the canal, generated hydrogen, or hydrosulphuric acid, which destroyed these parasites.

Dr. D. Monro (*Treat. on Med. and Pharm. Chem.* i. 289), Fothergill, and Richter, have used powdered tin in epilepsy produced by worms, and, as it is stated, with advantage.

ADMINISTRATION.—The usual mode of exhibiting it is mixed with treacle: the dose usually stated in pharmacological works is one or two drachms, but Alston gave much larger quantities; his mode of employing it as a vermifuge was the following:—The patient was well purged with senna, and on the following morning *one ounce* of tin powder was given in four ounces of treacle; on each of the two following days half this quantity was taken, and then the patient again purged. However, tin powder is certainly much inferior to oil of turpentine as a remedy for tape-worm.

ORDER 24.—LEAD AND ITS COMPOUNDS.

Plum'bum.—Lead.

HISTORY.—This metal was known in the most remote ages of antiquity. It is mentioned by Moses (*Job*, xix. 23, 24.) The Greeks called it μόλιβδος; the alchymists, *Saturn*.

NATURAL HISTORY.—It is found in the metallic state (*native lead*), combined with sulphur (*galena*), with selenium, with chlorine (*horn lead*), with oxygen (*native minium*), and with oxygen and an acid, forming an oxy-salt (*carbonate, phosphate, sulphate, tungstate, molybdate, chromate, arseniate*, and *aluminate*.)

PREPARATION.—It is usually extracted from galena, which is roasted in reverberatory furnaces, by which it is converted into a mixture of sulphate and oxide of lead, and afterwards smelted with coal and lime, the first to abstract oxygen, the second to remove the sulphur.

PROPERTIES.—It has a bluish-gray colour and considerable brilliancy. It may be crystallized by cooling in four-sided pyramids. It is malleable, but not ductile. Its sp. gr. 11·35. It has a peculiar odour when handled. It fuses at 612° F. and at a red heat boils and evaporates. Its equivalent is 104. By exposure to the air it attracts, first oxygen, and then carbonic acid, so as to form carbonate of lead.

Pure distilled water has no action on lead, if the gases (as air and carbonic acid) be excluded; but if these be admitted, a thin crust of carbonate is soon formed. It is remarkable that the presence of most neutral salts—sulphate of soda and chloride of sodium, for example—impairs the corrosive action of air and water. Hence, therefore, we can easily comprehend the reason why leaden cisterns and pipes do not more frequently give a metallic impregnation to water; and why rain-water is more apt than spring-water to become impregnated with lead. The latter, however, by long keeping in leaden vessels, may also become contaminated with lead.

CHARACTERISTICS.—If lead be dissolved in nitric acid, we may easily recognise its presence in the solution by the following tests:—Alkalies, their carbonates, sulphuric acid and the sulphates, and ferrocyanide of potassium, produce white precipitates; chromate of potash and iodide of potassium occasion yellow precipitates; hydrosulphuric acid and the hydrosulphates form black precipitates of the sulphuret of lead; lastly, a piece of zinc throws down metallic lead in an arborescent form.

The delicacy of these tests is, according to Devergie (*Méd. Lég.* ii. 779), as follows:—

		Degree of Dilution.
Sulphate of Soda	stops at	5,000
Iodide of Potassium		10,000
Ferrocyanide of Potassium		18,000
Potash		20,000
Carbonate of Soda or of Potash		60,000
Chromate of Potash		100,000
Hydrosulphuric Acid		500,000

PHYSIOLOGICAL EFFECTS.—1. *Metallic lead.*—I believe that so long as lead retains its metallic form it is inert. In a French journal (*Journ. de Méd. de Leroux*, xxiii. 318) we are told that three ounces and six drachms of this metal have been given to a dog without any obvious effects. As, however, it is a metal which is readily oxidated, it occasionally proves active when swallowed, in consequence of its being acted on and oxidized by the contents of the alimentary canal. An instance of this kind is mentioned by Paulini (*Miscell. Nat. Cur. Dec.* ii. Ann. vi. App. p. 7. quoted by Voigtel, *Arzneimitellehre*), in which colic was produced by swallowing a leaden bullet. Proust (*Ann. de Chim.* lvii. 84) says, that the alloy of lead and tin may be swallowed with impunity, in consequence of its being much less easily oxidated than the pure metal.

2. *Of the preparations of lead.* (*a.*) *On vegetables.*—Marcet found the solution of acetate of lead injurious to plants; but Wiegmann declares it to be inert, and ascribes its inertness to the formation of an insoluble salt (carbonate) of lead by the carbonic acid of the roots of plants.

(*b.*) *On animals.*—The preparations of lead are, for the most part, energetic poisons. The *sulphuret*, however, appears to be inactive, or nearly so; for Orfila (*Toxicol. Gén.*) gave an ounce of it to dogs without observing any ill effects; four ounces have even been given to horses without any unpleasant results. The *sulphate*, also, according to Orfila, is inactive. Our knowledge of the effects of the salts of lead on animals is derived from experiments made with the acetates, nitrate, and carbonate. The first two act as corrosives: all affect the nervous system, manifested by convulsions, palsy, and colica pictonum. (Christison, *Treat. on Poisons*, 506 et seq. 3d ed.)

(*c.*) *On man.*—Mr. Braid (Christison, *op. cit.* 518) states that workmen who dig and pulverize the ore (sulphuret of lead), at the lead-mills in Lancashire, never have the lead colic until they work at the smelting furnaces.

Most, if not all, the other preparations are more or less active; the effects and symptoms, however, vary with the dose.

In *small doses* these preparations act on the alimentary canal as astringents; checking secretion and causing constipation. These may be regarded as the local effects. When absorbed, the constitutional effects of lead are observed: the arteries become reduced in size and activity, for the pulse becomes slower and smaller; the temperature of the body is diminished; and sanguineous discharges, whether natural or artificial, are frequently checked, or even completely stopped. This constringing and sedative effect seems extended to the secreting and exhaling vessels; the discharges from the mucous membranes, the exhalation from the skin, and the urine, being diminished in quantity. Thus we observe dryness of the mouth and throat, thirst, greater solidity of the alvine evacuations, diminution of the bronchial secretion, and of cutaneous exhalation. From all these circumstances it would appear that these preparations give rise to a contracted state of the coats of the blood-vessels (at least of the arteries.) It is not at all improbable that the coats of the absorbents are similarly affected, as has been asserted. If this be the case, some obstruction would probably be offered to the passage of lymph ; the functions of absorption would be carried on with less energy, and the lymphatic glands would perhaps become in consequence affected: the wasting of the body produced by lead in these small doses has been denominated *tabes saturnina*, or *tabes sicca*.

The long-continued use of the preparations of lead rarely fails to give evidence of its effect on the muscular and nervous systems, and which is manifested by a curious train of symptoms, commencing with colic, and terminating in palsy or apoplexy. *Lead* or *painter's colic* (*colica pictonum*) is variable in its mode of attack ; at one time commencing suddenly, and without any very marked premonitory symptoms, at another being preceded by dyspeptic symptoms—such as diminished appetite, with a painful and constipated state of the bowels, the fæces being very hard. During an attack, there is usually obstinate constipation, with acute pain, much increased at intervals ; but sometimes a relaxed condition of the bowels has been met with. Merat (*Traité de la Colique Métallique*) refers the continued pain to the small intestines, while the more violent and intermitting kind resides principally in the transverse portion of the colon. Pressure rarely increases, and very commonly relieves, the pain. Cases, however, do occur (and I have seen several) in which there is great tenderness of the bowels. The abdomen is strongly retracted, sinks in about the navel, and feels very hard. To these symptoms may be added vomiting, cramps of the lower extremities, hard and generally slow pulse, though sometimes it has been found frequent.

De Haen and Merat, on examining the bodies of patients who have died affected with lead colic, found a contracted condition of the colon, and this was considered by the last-mentioned writer to indicate the seat of the disease. But Sir G. Baker, Andral (*Path. Anat.* by Townsend and West, ii. 140), Louis, and Copland (*Dict. Pract. Med.* i. 366), have not, in some cases, found any alteration. Moreover, it would appear probable from Dr. Abercrombie's observations on ileus (*On Diseases of the Abdom. Viscera*) that the empty and collapsed portion of the intestine was not the seat of the colic, but another part found in a state of distension,—for the collapsed or contracted state is the natural condition of healthy intestine when empty ; while the distended portion is, in ordinary cases of ileus, the primary seat of the disease, the distension arising from a paralytic condition of the muscular fibres, whereby it is unable to contract and propel its contents onward. Now this view of the case is the more probable, since the action of lead on the muscular fibres of the intestine is regarded as of the same kind as that on the fibres of the voluntary muscles. Some have found intus-susception, others have noticed marks of inflammation.

Another effect of poisoning by lead is an affection of the cerebro-spinal system, generally manifested by *paralysis*, but occasionally by giddiness, convulsions, and coma, and now and then by apoplexy. The palsy may occur without colic, or it may come on while the patient is suffering with it, but in general it succeeds colic. It may happen in both upper and lower extremities, though more frequently in the former; and it affects the extensor more than the flexor muscles, so that the hands are generally bent on the arms, which hang dangling by the side. Frequently pain is experienced in the paralyzed part, and sometimes in the region of the spine also. On examining the bodies of persons who have died with this disease, no lesion has hitherto been discovered in the spinal marrow. The muscles of the affected limb are observed to be wasted and very pale, and have sometimes the appearance of a white fibrous tissue.

In *very large doses*, some of the plumbeous preparations (the acetate, for example) act as irritant and caustic poisons; giving rise to the usual symptoms indicative of gastro-enteritis. However, none of them equal, in the intensity of their local action, the mercurial or even the cupreous compounds.

MODUS OPERANDI.—Tiedemann and Gmelin (*Vers. über d. Wege, wie Subst. aus d. Mag. ins Blut. gelang.*) found lead in the blood of the splenic, mesenteric, and hepatic veins of dogs killed by the acetate; they also found it in the contents of the stomach and intestines, but neither in the chyle nor the urine. Wibmer (Christison's *Treatise on Poisons*, 3d edit. p. 509) detected it in the liver, muscles, and spinal cord.

The local or corrosive action of the soluble salts of lead depends on the affinity of these bodies for the organic constituents of the tissues (*vide* PLUMBI ACETAS).

The nervous system is specifically affected by lead. The paralysis of the voluntary muscles, the pain in the course of the spine, the occasional giddiness, coma, or apoplexy, seem to establish this. The colic as well as the astringent influence of lead over the coats of vessels are probably secondary effects of the action of lead over the nervous system.

The constitutional effects of lead may be produced in various ways: as, when taken with articles of food and drink into the stomach; when inhaled in the form of dust or vapour with the air; when applied to mucous membranes, ulcers, &c. Hence the persons most liable to these effects are those whose occupations bring them in contact with this metal; for example, painters, plumbers, roasters and smelters of lead, the manufacturers of the plumbeous preparations, glass-blowers, potters, lapidaries, &c.

Dr. Anthony Todd Thomson (*Lond. Med. Gaz.* v. 538, and x. 689) is of opinion, that carbonate of lead is the only preparation of this metal that can produce colic: and though he has, I think clearly, shewn that lead colic more frequently arises from the carbonate than from any other salt of lead, he has, in my opinion, failed in proving that no other preparation of lead *can* produce it. Indeed, if his opinion were true, it would constitute an exception to the general effects of the metallic preparations; for we do not find that the specific effects of arsenic, or of mercury, or of copper, or of antimony, are produced by one preparation only; so that, *à priori*, analogy is against the opinion. Furthermore, it is well known that the vapour of the oxide of lead taken into the lungs may produce colic, and that the ingestion of the acetate, citrate, or tartrate of lead, is capable of exciting the same effect. Now Dr. Thomson explains these facts by assuming that the oxide of lead unites with carbonic acid in the lungs, and is thus converted into carbonate: and that the acetate, citrate, and tartrate, are decomposed in the alimentary canal, and converted into carbonates. But it appears to me to be much more simple and consistent with analogy, to admit that these preparations are of themselves capable of producing colic, than to assume that they undergo the changes here supposed. Moreover, in some instances in which colic was produced, it is unlikely that these changes could have occurred, owing to the excess of acid taken with the salt of lead.

Uses.—The uses of the preparations of lead may be in part inferred from the foregoing account of their effects. These agents are employed when we wish to constringe the capillary vessels and to diminish their vital activity. Thus we administer them internally to check excessive secretion and exhalation, as in catarrhal affections of the mucous membranes of a chronic nature; in profuse secretion of pus; in sanguineous exhalations from the mucous membranes; and in colliquative sweating. They have also been applied, in some instances with success, in certain chronic affections of the nervous system, as epilepsy; but the practice is altogether empirical, as we have no rational principles to guide us in using them. As topical remedies, we employ the preparations of lead to diminish vascular excitement, to allay preternatural heat, and to check excessive secretion. Thus we apply them to inflamed parts to promote resolution, and to ulcers and other secreting surfaces as astringents or desiccants. During the internal employment of lead, attention must be paid to the condition of the stomach and bowels, as we find the traces of their injurious effects in these organs. Constipation is a very frequent result of their medicinal employment. Loss of appetite, indigestion, and griping pains, are also often noticed. The tendency to colic is diminished, according to Dr. A. T. Thomson, by conjoining acetic acid.

Antidotes.—Poisoning by lead usually puts on one of three forms—*irritant poisoning*, *lead colic*, and *paralysis*.

1. *Irritant poisoning.*—Administer diluents holding in solution some sulphate (as sulphate of soda, of magnesia, or of potash or alum), so that a sulphate of lead may be formed. If vomiting have not already come on, tickle the throat, and administer emetics of the sulphate of zinc or of copper, or the stomach-pump may be employed.

2. *Lead colic.*—Here the best remedy is alum (*vide* pp. 372, 373). But in this country lead colic is frequently treated by the combined use of purgatives and anodynes, the purgatives being either castor oil or salts and senna, the anodyne being opium. When the vomiting is very troublesome, and liquid medicines do not remain on the stomach, we may give the compound extract of colocynth, with opium, in the form of pill. In several cases in which the pulse was full and strong, the face flushed, and the tongue furred and dry, I have used blood-letting with evident advantage. The sulphates have been recommended, as also mercury.

3. *Lead paralysis.*—Nux vomica, and its active principles—strychnia and brucia, are perhaps of all internal remedies most deserving of trial, because of their specific effect on the spinal marrow; and the chance of their success is, of course, much increased by the circumstance of there being no discoverable lesion of this portion of the nervous system. Mercury has been recommended by Dr. Clutterbuck. Various local measures have been tried, but without much benefit; for example, electricity and irritants (such as ammonia and cantharides).

Plum'bi Ox'ydum.—Ox'ide of Lead.

History.—The ancients were acquainted with oxide (or *protoxide*) of lead. Hippocrates (*De Morb. Mul.* ii.) employed the semi-vitrified oxide (*litharge*, λιθάργυρον). Dioscorides (lib. v. cap. cii.) and Pliny (*Hist. Nat.* xxxiv. 53) both mention litharge: the latter calls it *molybdæna*.

Preparation.—Litharge is usually obtained as a secondary product in the cupellation of argentiferous lead. The alloy is melted on a porous vessel, called a *test* or *cupel*, and exposed to the blast of a bellows, by which the lead is oxidized, half vitrified, and driven off into hard masses of a scaly texture, and is called, in that state, *litharge* or *silver stone* (Watson's *Chem. Essays*, iii. 325, 6th ed.)

The compound called in the London Pharmacopœia *hydrated oxide of lead* (*plumbi oxydum hydratum*) is prepared by mixing six pints (or as much as may be sufficient) of solution of potash with six pints of solution of diacetate of lead and three gallons of distilled water. The precipitate is to be washed until nothing alkaline remains. In this process the potash combines with acetic acid, and forms acetate of potash, which remains in solution; while a white compound, called by Mr. Phillips hydrated oxide of lead, is precipitated. But it is stated, that "oxide of lead does not form a hydrate with water, the white powder which caustic alkalies throw down in solution of lead being a basic (sub) salt" (Geiger's *Handb. d. Pharm.* von J. Liebig).

Properties.—Oxide of lead presents itself in several forms. One of these is yellow, and is termed *Massicot* (*cerussa citrina*). When semi-vitrified (*plumbi oxydum semivitreum*), it is called *litharge* (*lithargyrum*), which occurs in the form of small yellow or reddish scales or flakes, and, according to its colour, is called *gold* or *silver litharge* (*lithargyrum aureum* [*chrysitis*] seu *argenteum* [*argyritis*]). The *plumbi oxydum hydratum*, Ph. Lond., is a perfectly white powder.

Oxide of lead is fusible, and at a very high temperature volatile. When heated in contact with charcoal or carbonaceous bodies, it is readily reduced to the metallic state. It is insoluble in water.

Characteristics.—Heated on charcoal by the blowpipe, it is readily reduced to the metallic state. It is blackened by hydrosulphuric acid, and completely dissolves in nitric acid. The characteristics of this solution have been already described (*vide* p. 505). The varieties of the oxide are distinguished by their physical peculiarities.

Composition.—Oxide of lead is thus composed:—

	Eq.	Eq. Wt.	Per Cent.	Berzelius.	Berthier.
Lead	1	104	92·85	92·85	93·3
Oxygen	1	8	7·14	7·15	6·7
Oxide of Lead	1	112	99·99	100·00	100·0

Physiological Effects.—Inhaled in the form of vapour, or fine dust, it produces the before-mentioned constitutional effects of lead (*vide* p. 506).

The effects of this substance, when swallowed, are but little known. It possesses very slightly irritant properties. "The experimentalists of

Lyons found litharge to be irritant in large doses of half an ounce," (Christison, *op. cit.* p. 509).

From its external use ill consequences have sometimes resulted.

Uses.—The oxides of lead are never employed internally. Litharge is sometimes sprinkled over ulcers, as an astringent and desiccating substance.

In pharmacy, litharge is used in the preparation of EMPLASTRUM PLUMBI, CERATUM SAPONIS, ACETAS PLUMBI, and LIQUOR PLUMBI DIACETATIS.

The *plumbi oxydum hydratum*, Ph. Lond., is directed to be used in preparing Quinæ Sulphas. But the Pharmacopœial process for making the latter substance has not been found by manufacturers to answer, and, therefore, the hydrated oxide of lead is, in fact, not employed in pharmacy.

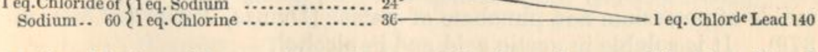
Hair Dye.—Various powders, pastes, and liquids, have been prepared for dyeing the hair brown or black (*Journ. de Chém. Méd.* ii. 250, 2nde Ser.) In general a mixture, or rather compound, of litharge and lime is employed. The preparation sold as *Orfila's hair dye* is of this kind. The proportions are one part of each, or three parts of litharge and two of lime. Sometimes carbonate of lead is partially or wholly substituted for litharge. The mixture is made into a paste with hot water or milk, and applied to the hair for four or five hours, the part being enveloped in oil-skin or a cabbage leaf. The water causes the oxide of lead to combine with the lime, and thereby form a saline compound, called *plumbite of lime*. The lime is useful by removing the fatty matter of the hair, while the oxide of lead forms, with the sulphur contained in the oil of the hair, a black sulphuret of lead. Dyed hair is dry and crisp. The mode of detecting stained hair has been described by the late Dr. Cummin (*Lond. Med. Gaz.* xix. 215), and by Devergie (*Méd. Lég.* ii. 931).

Plum'bi Chlo'ridum.—Chlo'ride of Lead.

Natural History.—Chloride of lead occurs in the mineral kingdom.

Preparation.—In the London Pharmacopœia this compound is directed to be prepared as follows:—Dissolve 19 ounces of acetate of lead in three pints of boiling distilled water, and 6 ounces of chloride of sodium in one pint of boiling distilled water: mix. Wash the precipitate when cold with distilled water, and dry it.

In this process one equivalent or 163 parts of dry acetate of lead are decomposed by one equivalent or 60 parts of chloride of sodium; by which one equivalent or 140 parts of chloride of lead are precipitated, and one equivalent or 83 parts of acetate of soda remain in solution.



Hydrochloric acid occasions the precipitation of more chloride of lead after the action of the chloride of sodium is over; so that there must be some compound of lead in solution (Phillips, *Transl. of Pharm.* 3rd ed.)

Properties.—It is a white crystalline powder (*magisterium saturni Crollii*), soluble in thirty parts of cold or twenty-two parts of boiling water. When heated it fuses; and by cooling forms a semitransparent horny-like mass, called *horn lead* (*plumbum corneum*).

Characteristics.—Its aqueous solution causes a white precipitate with nitrate of silver, soluble in ammonia but insoluble in nitric acid: hence it is shown to be a chloride. The solution is known to contain lead by the before-mentioned tests for this metal (*vide* p. 505).

Composition.—The following is its composition:—

	Eq.	Eq.Wt.	Per Cent.	J. Davy.
Lead	1	104	74·3	74·22
Chlorine	1	36	25·7	25·78
Chloride of Lead .	1	140	100·0	100·00

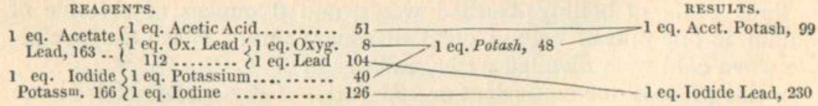
Use.—It is employed in the preparation of hydrochlorate of morphia.

Plum'bi Io'didum.—I'odide of Lead.

History.—This compound was introduced into medicine by Cottereau and Verdé-Delisle.

Preparation.—It is prepared by adding a solution of iodide of potassium to a solution of acetate of lead. The reacting proportions are 166 parts of iodide and 190 of crystallized acetate. In the London Pharmacopœia, the proportions directed to be employed are seven ounces of iodide of potassium and nine ounces of acetate of lead: the quantity of iodide of potassium is, therefore, larger than theory would dictate, supposing the acetate to be neutral. This excess is disadvantageous, since it retains a portion of the iodide of lead in solution. To prevent the formation of an oxyiodide of lead, a little acetic acid should be added to the acetate of lead, before adding the iodide of potassium. The precipitate should be washed and dried.

By the mutual reaction of one equivalent or 163 parts of dry acetate of lead, and one equivalent or 166 parts of iodide of potassium, we obtain one equivalent or 230 parts of iodide of lead, and one equivalent or 99 parts of dry acetate of potash.



Properties.—It is a fine yellow powder, very sparingly soluble in cold water, but readily soluble in boiling water; from which it for the most part separates, as the solution cools, in the form of golden yellow, brilliant, small scales. It is fusible. It combines with the alkaline iodides, forming a class of double salts, called the *plumbo-iodides* (*iodo-plumbates*, Thomson). Caustic potash dissolves it, and forms a plumbo-iodide of potassium and plumbate of potash (Dumas, *Traité de Chim.* iii. 379). It is soluble in acetic acid and in alcohol.

Characteristics.—When heated, it first forms a yellow vapour (iodide of lead), and afterwards a violet vapour (iodine), leaving a residue (lead), which, when dissolved in nitric acid, gives all the characters of a solution of lead (*vide* p. 505). Boiled with carbonate of potash, it forms carbonate of lead and iodide of potassium.

COMPOSITION.—Its composition is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Henry.
Lead	1	104	45·21	45·1
Iodine	1	126	54·78	54·9
Iodide of Lead	1	230	99·99	100·0

PURITY.—It should be completely soluble in boiling water.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—Twenty-four grains of iodide of lead were given to a cat at two doses, with an interval of four hours: the animal suffered violent colic, and died in three days; but no signs of irritation were observed after death (Paton, *Journ. de Chim.* iii. 41, 2^{nde} Ser.) Iodide of lead was given in doses of from gr. v. to ʒss. to a bull-dog: no effect was observed until the fifteenth day, when the animal refused food, and kept in the recumbent posture. He died on the eighteenth day, having swallowed altogether ten drachms and fifty grains of iodide. During the whole period, he had only three or four intestinal evacuations (Cogswell, *Essay on Iodine*, 143).

(*b.*) *On man.*—Its effects on man have been imperfectly determined. It does not appear to act as an irritant when applied to the skin or ulcerated surfaces. Under the continued external and internal use of it, enlargements of the lymphatic glands have disappeared, from which we infer a specific influence over the glandular and lymphatic system. In some cases it appeared to occasion irritation of the stomach. I have seen constipation induced by it.

USES.—It has been principally employed to reduce the volume of indolent tumors, especially enlargements of the cervical, axillary, and mesenteric glands. In these cases it should be simultaneously administered internally and externally. I have used it in two cases of enlarged cervical glands, but without benefit. Velpeau (Lugol's *Essays*, by Dr. O'Shaughnessy, p. 206) and others, however, have been more successful.

ADMINISTRATION.—The dose is half a grain gradually increased. Dr. O'Shaughnessy (Lugol's *Essays*, p. 207) says, ten-grain does are easily borne, without the slightest annoyance.

UNGUENTUM PLUMBI IODIDI, Ph. Lond. (iodide of lead, ℥j.; lard, ℥viij. M.)—This is applied, by way of friction, to scrofulous and other indolent swellings.

Plum'bi Car'bonas.—Car'bonate of Lead.

HISTORY.—This substance was employed by Hippocrates (*De Morbis*, lib. ii.), under the name of ψιμμίθιον. Theophrastus (*De Lapidibus*) described the method of making it. Dioscorides (lib. v. cap. ciii.) and Pliny (*Hist. Nat.* lib. xxxiv.) also mention it.

It has been known by several names, as *psimmythium*, *ceruse* (*cerussa*), *magistery of lead* (*magisterium plumbi*), *white lead*, and *subcarbonate of lead*.

NATURAL HISTORY.—This salt is found native, crystallized, or massive, in Scotland, England, &c. It is called *white-lead ore*.

PREPARATION.—The old method of obtaining it is by exposing coils of lead-plate, placed perpendicularly in earthen pots, to the vapour of acetic acid. The pots, in the bottom of which is contained the acid, are buried in stable litter or tanners' bark. The plates become corroded and covered with carbonate of lead. In this process, the lead, when in contact with acetic vapour, rapidly abstracts oxygen from the air, and the oxide which is formed, combining with some acetic acid, forms a subacetate, which is decomposed by the carbonic acid of the air, forming carbonate and the neutral acetate of lead. The latter is reconverted into a subsalt, and is then decomposed by carbonic acid. At the end of the process, a small quantity of acetate of lead remains mixed with the carbonate, and is removed by washing.

Pure carbonate of lead may be procured by adding a solution of an alkaline carbonate to a solution of acetate of lead.

Carbonate of lead may be also procured by passing carbonic acid (obtained by the combustion of charcoal or coal) through a solution of subacetate or subnitrate of lead.

Properties.—The primary form of the crystals of the native carbonate of lead is a right rhombic prism. Artificial carbonate is a heavy, snow-white, tasteless powder, or in white chalk-like masses. It is insoluble in water, but dissolves in caustic potash. When heated it gives out carbonic acid, and forms the yellow oxide.

Characteristics.—Heated before the blow-pipe, on charcoal, it yields metallic lead. It is blackened by hydrosulphuric acid. It dissolves in nitric acid with effervescence. The solution possesses the general characters of the plumbeous solutions already described (*vide* p. 505).

Composition.—Its composition is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.
Oxide of Lead	1	112	83·58	83·5
Carbonic Acid	1	22	16·42	16·5
Carbonate of Lead	1	134	100·00	100·0

Purity.—Carbonate of lead of commerce is rarely pure. It is usually adulterated with earthy or metallic sulphates (as of lime, baryta, or lead.) These are detected by their insolubility in diluted nitric acid. Chalk (which is by some used to adulterate it) may be detected as follows:—Dissolve the suspected substance in nitric acid, and precipitate the lead by hydrosulphuric acid. Boil and filter the solution, in which will be contained nitrate of lime (if chalk had been present), recognizable by oxalic acid or oxalate of ammonia (*vide* p. 343.)

Physiological Effects.—Its *local* effects are not very powerful: applied to ulcerated surfaces, it acts as a desiccative and astringent substance: swallowed in large quantities, it does not act as a local irritant, like the acetate. Its *constitutional* effects are similar to those of the other preparations of lead, already described. It appears probable (*vide* p. 508) that carbonate of lead more frequently produces colic than the acetate of lead—a circumstance which Dr. Christison thinks may be owing to the great obstinacy with which its impalpable powder adheres to moist membranous surfaces, and the consequent greater certainty of its ultimate absorption.

Uses.—It is never administered internally.

Externally it is employed as a dusting powder in excoriations of children and lusty persons; but the practice is objectionable, on account of the danger of absorption. In one case, related by Kopp (Richter, *Ausführ. Arzneim.* iv. 613) a child was destroyed by it.

UNGUENTUM PLUMBI CARBONATIS, Ph. Dubl. and Ed. (Carbonate of lead, reduced to very fine powder, ℥ij.; ointment of white wax, lbj. M. The Edinburgh formula is one part of carbonate of lead, and five parts of simple ointment.)—This ointment is valuable as a cooling and desiccative application to excoriated surfaces or burns.

An ointment or plaster of carbonate of lead has been known to give relief in some cases of neuralgia (*Journ. de Pharm.* xx. 603).

Plum'bi Ace'tas.—Ac'etate of Lead.

HISTORY.—Raymond Lully and Isaac Hollandus were acquainted with this salt in the 13th century. It has been known by several appellations, as *sugar of lead* (*saccharum saturni*), *acetated ceruse* (*cerussa acetata*), and *superacetate of lead* (*plumbi superacetas*).

PREPARATION.—Though directions are given in the Pharmacopœia for its preparation, it is never made by the apothecary, but is procured from persons who manufacture it on a large scale.

It is sometimes made by immersing lead in acetic acid. The metal attracts oxygen from the air and combines with the acid. It may also be procured by dissolving carbonate of lead in acetic acid, filtering the solution, and evaporating so that it may crystallize. But it is almost exclusively obtained now by dissolving oxide of lead (litharge or massicot) in acetic (pyroligneous) acid. This process is the one followed in the London Pharmacopœia; where four pounds and two ounces of powdered litharge are directed to be dissolved, by the aid of a gentle heat, in a mixture of four pints of acetic acid and four pints of distilled water. The solution is to be strained, and evaporated so that it may yield crystals. In this process, the oxide, in virtue of its affinity for acetic acid, combines with the latter, and forms a definite compound.

PROPERTIES.—The primary form of the crystals of this salt is the right oblique-angled prism. Their taste is sweetish and astringent. In a dry and warm atmosphere they slightly effloresce. When heated they fuse, give out their water of crystallization, and, at a higher temperature, are decomposed; yielding acetic acid, *pyroacetic spirit* (or *acetone*), carbonic acid, inflammable gas, and water: the residuum is a mixture of lead and charcoal. Acetate of lead is soluble in both water and alcohol. The aqueous solution feebly reddens litmus, though it communicates a green colour to the juice of violets. A solution of the neutral acetate is partially decomposed by carbonic acid: a small quantity of carbonate of lead is precipitated, and a portion of acetic acid is set free, which protects the remaining solution from further change.

CHARACTERS.—When heated with sulphuric acid, the vapour of acetic acid is disengaged. Its solution is known to contain lead by the tests for this metal already mentioned (*vide* p. 505). If a small quantity of acetic acid be added to the solution, a current of carbonic acid occasions no precipitate. The ordinary acetate of the shops usually throws down a scanty white precipitate (carbonate of lead) with carbonic acid. When charred, it readily yields globules of metallic lead on the application of the blowpipe flame.

Composition.—This salt, when properly prepared, has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.
Oxide of Lead	1	112	58·9	58·71
Acetic Acid	1	51	26·8	26·97
Water	3	27	14·3	14·32
Crystall^{d} Acetate of Lead	1	190	100·0	100·00

Purity.—It should be readily and completely soluble in water. Sulphuric acid, or sulphuretted hydrogen in excess, being added to the solution, to throw down the lead, the supernatant liquor should be completely volatilized by heat: any fixed residue is impurity.

Physiological Effects. (*a.*) *On vegetables.*—(*Vide* p. 506.)

(*b.*) *On animals.*—Orfila (*Toxicol. Gén.*) found that in large doses the acetate of lead acted on dogs as an irritant, and caused vomiting, pain, and death. When the action was slower, and absorption took place, an affection of the nervous system was observed, marked by difficult progression, and in some cases convulsive movements. The mucous membrane lining the alimentary canal was found whitened (owing to the chemical influence of the poison), and, where the action was more prolonged, reddened. Injected into the veins, or applied to wounds, it affects the nervous system. Schloepfer (quoted by Dr. Christison, p. 507) produced colica pictonum, paralysis, and convulsions, in dogs, by the repeated use of small doses. Dr. A. T. Thomson (*Lond. Med. Gaz.* x. 691) gave successively, one, two, three, and six drachms to a dog without any ill effect.

(*c.*) *On man.*—Applied to ulcers, mucous membranes, or other secreting surfaces, it acts as a desiccative and astringent. It reacts chemically on the albumen of the secretions and of the living tissues, and forms therewith compounds, which are for the most part insoluble in water and acids (Dr. C. G. Mitscherlich, *Brit. Ann. of Med.* i. 204). Hence the difficulty with which this salt becomes absorbed. Some of its compounds with organic substances are, however, rendered soluble in water by acids (as the acetic, hydrochloric, and lactic). In large quantities, acetate of lead taken into the stomach acts as an irritant, and causes symptoms of inflammation of the stomach, viz. vomiting, burning in the gullet and stomach, and tenderness at the pit of the stomach; but these are usually accompanied with colica pictonum, and are not unfrequently followed by convulsions, coma, or local palsy (Christison, *Treat. on Poisons*, 3d edit. p. 512). Ten grains taken daily for seven days caused tightness of the breast, metallic taste, constriction of the throat, debility, sallow countenance, slow respiration and circulation, gums turgid and tender, ptyalism, tightness and numbness in the fingers and toes, no nausea, pains of the stomach and abdomen, bowels confined (Laidlaw, *Lond. Med. Repos.* N. S. vi. 292). The observations of Dr. A. T. Thomson and others (Van Swieten, Reynolds, Latham, Laidlaw, Daniell, Christison, &c.) have, however, shewn that injurious effects from the use of large doses are very rare. Dr. Christison has given eighteen grains daily for eight or ten days without any unpleasant symptoms whatever, except once or twice slight colic. Whenever this salt gives rise to any obvious effects, they are those of the plumbeous preparations in general, and which have been already described (p. 506.) Its medicinal action, therefore, is sedative and astringent.

USES.—Acetate of lead is administered *internally* to diminish the diameter of the capillary vessels, and lessen circulation, secretion, and exhalation. Thus we employ it in profuse discharges from the mucous membranes; as from the lungs, alimentary canal, and even the urino-genital membrane. In the mild cholera, so common in this country towards the end of summer, I have found acetate of lead in combination with opium most efficacious where the chalk mixture failed. I have used this combination in a few cases of malignant cholera, and in one or two with apparent benefit. In colliquative diarrhœa and chronic dysentery it occasionally proves serviceable. In phthisis it has been found beneficial, but only as a palliative, namely, to lessen the expectoration, check the night sweats, or stop the harassing diarrhœa. Dr. Latham (*Med. Trans. Coll. Phys.* v. 341) speaks most favourably of the use of sugar of lead and opium in checking purulent or semipurulent expectoration. Though I have repeatedly seen it diminish expectoration, I have generally found it fail in relieving the night sweats, though Fouquier supposed it to possess a specific power of checking them: they are more frequently benefited by diluted sulphuric acid. In sanguineous exhalations from the mucous membranes, as epistaxis, hæmoptysis, and hæmatemesis, and in uterine hæmorrhage, it is employed with the view of diminishing the calibre of the bleeding vessels, and thereby of stopping the discharge; and experience has fully established its utility (Reynolds, *Trans. Coll. of Phys. London*, iii. 217; Davies, *Med. and Phys. Journ.* Jan. 1808, p. 8; also, Mitchell, *ibid.* p. 69; Latham, *op. cit.*). It may be employed in both the active and passive states of hæmorrhage. It is usually given in combination with opium. It has been employed also as a remedy for mercurial salivation (Daniell, *Lond. Med. Repos.* N. S. vi. 308). It had already been applied for this affection in the form of gargle by Sommé (*Archiv. Gén. de Méd.* i. 483). Unless care be taken to wash the mouth carefully after its use, it is apt to blacken the teeth. On the same principles that we administer it to check excessive mucous discharges, it has been employed to lessen the secretion of pus in extensive abscesses attended with hectic fever.

There are some other cases in which experience has shewn acetate of lead is occasionally serviceable, but in which we see no necessary connexion between its obvious effects on the body and its remedial powers; as in epilepsy, chorea, intermittents, &c.

As a *topical* remedy, we use acetate of lead as a sedative, astringent, and desiccative. An aqueous solution of it is applied to inflamed parts, or to secreting surfaces, to diminish profuse discharges. Thus we use it in phlegmonous inflammation, in ophthalmia, in ulcers with profuse discharges, in gonorrhœa, and gleet. In the sloughing and ulceration of the cornea which attend purulent and pustular ophthalmia, its use should be prohibited, as it forms a white compound which is deposited on the ulcer, to which it adheres tenaciously, and in the healing becomes permanently and indelibly imbedded in the structure of the cornea. The appearance produced by this cause cannot be mistaken: its chalky impervious opacity distinguishes it from the pearly semi-transparent structure of even the densest opacity produced by common ulceration (Dr. Jacob, *Dubl. Hosp. Rep.* v. 369). The white compound consists of oxide (acetate?) of lead, animal matter, much carbonate of lead, traces of phosphate, and chloride of the same metal (Dr. Apjohn, *op. cit.* p. 402).

ADMINISTRATION.—Acetate of lead is administered internally in doses of from one grain gradually increased to three, four, or more, even to eight or ten grains, repeated twice or thrice daily. Dr. A. T. Thomson advises its exhibition in diluted distilled vinegar, to prevent its change into carbonate, which renders it more apt to occasion colic. It is usually exhibited in the form of pill, frequently in combination with opium. Acetate of lead and opium react chemically on each other, and produce acetate of morphia and meconate, with a little sulphate of lead. Experience, however, has fully established the therapeutic value of the combination. Sulphuric acid (as in infusion of roses), sulphates (as of magnesia, and soda, and alum), phosphates, and carbonates, should be prohibited. Sulphuric acid, the sulphates, and phosphates, render it inert: the carbonates facilitate the production of colica pictonum. Common (especially spring) water, which contains sulphates, carbonates, and chlorides, is incompatible with this salt. The liquor ammoniæ acetatis is incompatible with it, on account of the carbonic acid usually diffused through this solution.

CERATUM PLUMBI ACETATIS, Ph. Lond.; *Unguentum Plumbi Acetatis*, Ph. Dubl. and Edinb. (Acetate of lead. powdered, ʒij.; white wax, ℥ij.; olive oil, f℥viij. M. Ph. Lond. The *Dublin College* mixes an ounce of the acetate of lead with a pound and a half of ointment of white wax. The *Edinburgh College* uses twenty parts of simple ointment and one part of acetate of lead in very fine powder.)—It is an excellent soothing application to irritable ulcers, painful excoriations, and blistered surfaces.

ANTIDOTE.—*Vide* PLUMBUM.

Li'quor Plum'bi Diaceta'tis.—Solu'tion of Diac'etate of Lead.

HISTORY.—This compound was known to Basil Valentine in the fifteenth century. It owes its reputation, as a medicine, principally to the praises bestowed on it by M. Goulard, in the latter end of the last century. He called it *extract of Saturn* (*extractum Saturni*). It is frequently termed *Goulard's extract*, or *liquor plumbi subacetatis*.

PREPARATION.—In the London Pharmacopœia it is directed to be prepared by boiling together two pounds and three ounces of acetate of lead, one pound and four ounces of oxide of lead (litharge) rubbed to powder, and six pints of water; frequently stirring: when the liquor is cold, add as much distilled water as may be sufficient to measure with it six pints. The acetate of lead combines with an additional equivalent of oxide of lead, to form the diacetate. This process yields a uniform preparation.

In the Dublin Pharmacopœia it is ordered to be prepared by boiling one part of semivitrified oxide of lead with twelve parts of distilled vinegar, until eleven parts of the fluid remain; and when the impurities have subsided, the liquid is to be filtered. The acetic acid of the distilled vinegar combines with the oxide of lead to form a subacetate of lead. This process is objectionable, since the strength of the solution depends on the strength of the vinegar, which is subject to variation.

PROPERTIES.—It is a transparent and colourless liquid. Prepared according to the London Pharmacopœia, its specific gravity is 1·260:

according to the Dublin Pharmacopœia, it is 1·118. Its taste is sweet and astringent. By evaporation it yields crystals of the diacetate of lead, which, according to Dr. Barker, are flat rhomboidal prisms, with dihedral summits.

CHARACTERISTICS.—The presence of lead and of acetic acid in this solution may be known by the tests before mentioned (p. 515) for acetate of lead.

From the neutral acetate it is distinguished by the more abundant precipitate which it produces with carbonic acid, and by the copious precipitate which it affords with mucilage—an effect not produced with the neutral acetate. Solution of the diacetate of lead forms a precipitate with most vegetable colouring matters.

COMPOSITION.—This liquid is an aqueous solution of the diacetate of lead. The hydrated diacetate has, according to Dr. Thomson, the following composition:—

	Eq.	Eq. Wt.	Per Cent.
Oxide of Lead	2	224	61·37
Acetic Acid	1	51	13·97
Water	10	90	24·66
Hydrated Diacetate of Lead	1	365	100·00

PURITY.—When this compound has been prepared with common vinegar it has a brown colour.

PHYSIOLOGICAL EFFECTS.—Its effects are analogous to the acetate. Dr. A. T. Thomson (*Lond. Med. Gaz.* v. 538 ; x. 693) asserts, from his experiments on animals, that it has more tendency to cause colic than the neutral acetate, because it is more readily converted into carbonate of lead. It is employed in medicine as a local astringent and sedative. Paralysis is said to have resulted from its external use.

USES.—It is used, when diluted, to promote the resolution of external inflammation, to check profuse discharges from suppurating, ulcerated, and mucous surfaces, and to alleviate local pains. Thus it is applied to parts affected with either phlegmonous or erysipelatous inflammation, to whitloes, to inflamed tendons, aponeuroses, or absorbent glands; in ophthalmia, to contusions, sprains, burns, wounds, whether incised or lacerated, to blistered surfaces, ulcers, abscesses, &c.

It is said to have been successful, internally, in hydrophobia.

ADMINISTRATION.—It is employed diluted with water, added to poultices, or mixed with fatty matters, and applied as an ointment.

LIQUOR PLUMBI DIACETATIS DILUTUS, Ph. Lond. *Plumbi subacetatis liquor compositus*, Ph. Dub. (Solution of diacetate of lead, f℥iss.; distilled water, Oj.; proof spirit, ʒij. M.)—This preparation is an imitation of the *water of Saturn*, or *vegeto-mineral water* of Goulard. It is commonly termed, in the shops, *Goulard water*. It should be transparent and colourless; but when prepared with common water it is more or less milky, owing to the formation of carbonate, sulphate, and chloride of lead. The small quantity of spirit employed can be of no service. The quantity of the solution of diacetate of lead employed in making Goulard water is much too small; it should be, at least, three times, and in some cases I have used six times, as much. I have never seen any ill effects from its use, though it is said to have become absorbed in some cases. The same objection applies to the use of this compound as to that of the neutral acetate in ulceration of the cornea (*vide* p. 517.)

Goulard water is used as a cooling, sedative, and astringent wash in the cases already enumerated for the Goulard's extract. A poultice, composed of crumb of bread, boiled in Goulard water, is sometimes a very useful application to phlegmons, painful wounds, irritable ulcers, &c. &c.

Ceratum Plumbi Compositum, Ph. Lond. (Solution of diacetate of lead, f℥iij.; wax, ℥iv.; olive oil, Oss.; camphor, ʒss. M.).—This is the *cerate of Saturn* of M. Goulard, and is commonly called *Goulard's cerate*. It is employed as a dressing to wounds and ulcers, for the purpose of allaying irritation and appeasing pain. With the same views it is also applied to excoriated surfaces, burns, scalds, blistered surfaces, and irritable cutaneous affections. Opium is sometimes advantageously combined with it.

Ceratum Saponis, Ph. Lond.—This contains a subacetate of lead. It has been before described (p. 337).

Emplas'trum Plum'bi.—Plas'ter of Lead.

History.—This compound was known to the ancients: both Pliny (*Hist. Nat.* xxxiv. 53) and Celsus (*De Medicina*, lib. v. cap. xix.) give a formula for a plaster used by the Roman surgeons, which is almost identical with that for the officinal plaster of lead.

It is termed *emplastrum lythargyri* in the Dublin Pharmacopœia, and is commonly sold in the shops as *diachylon* or *diachylum*.

Preparation.—In the London Pharmacopœia it is directed to be prepared by mixing six pounds of oxide of lead (litharge), rubbed to a very fine powder; a gallon of olive oil; and two pints (℥xl.) of water. These are to be boiled together over a slow fire, constantly stirring, to a proper consistence.

In this process the oil becomes saponified, and converted, by the aid of the elements of water, into *glycerine*, *oleic acid*, and *margaric acid*. The glycerine remains in solution in the water, while the two fatty acids combine with the oxide of lead to form the oleo-margarate of lead or plaster of lead.—(For further particulars respecting the theory of saponification, *vide* p. 334).

The water used in this process serves two purposes; it moderates the heat, and facilitates the union of the acids with the oxide of lead.

Properties.—It is met with in the shops in cylindrical rolls, of a greyish or yellowish-white colour, brittle when cold, but softening and ultimately fusing by heat. It is insoluble in water, and nearly so in alcohol. It has no taste, but a slight though peculiar odour.

Characteristics.—When heated it fuses, then decomposes, gives out inflammable gas, and leaves a carbonaceous residue, which, when heated in a close vessel, yields globules of lead. Ether dissolves the oleate but not the margarate of lead.

Composition.—Berzelius (*Traité de Chim.* v. 373) says this compound is to be regarded as a tribasic salt: that is, as consisting of one equivalent of the fatty acids (oleic and margaric) and three of the oxide of lead.

Effects and Uses.—This plaster is employed in surgery, on account of its adhesiveness and the mildness of its local action; for it rarely excites irritation. It is used to keep the edges of wounds together in persons with delicate skins. Spread on calico it forms a good *strap-*

ping for giving support and causing pressure in ulcers of the leg,—a most successful mode of treating them, and for which we are indebted to Mr. Baynton.

In pharmacy it serves as a basis for various other plasters.

Emplastrum Resinæ, Ph. Lond. *Emplastrum Lithargyri cum Resina*, Ph. Dubl. *Emplastrum Resinosum*, Ph. Ed. (Resin, Oss.; plaster of lead, Oiij. M. Ph. Lond. The proportions used in the Dublin and Edinburgh Pharmacopœias are slightly different).—This is the common *adhesive plaster* (*emplastrum adhæsivum*), and is kept in the shops ready spread. It is employed to retain the lips of wounds in contact, as in cuts, surgical operations, &c. It is more adhesive than lead plaster, but at the same time somewhat more irritant, and occasionally causes excoriation. It is sometimes employed as a *strapping* for dressing ulcers, on Baynton's principles.

Emplastrum Saponis, Ph. Lond. and Dub.—The lead plaster is a constituent of the soap plaster already described (p. 338).

Unguentum Plumbi Compositum, Ph. Lond. (Prepared chalk, ℥viij.; distilled vinegar, f℥vj.; plaster of lead, lb. iij.; olive oil, Oj. Mix the chalk with the vinegar, and when the effervescence has ceased, add gradually the solution to the plaster and oil melted with a slow fire, and stir constantly until they are cooled).—By the action of the acetic acid on the chalk, an acetate of lime is procured, and carbonic acid evolved, and the acetate of lime is then mixed with lead plaster and oil. This compound is an imitation of *Kirkland's neutral cerate*, used as a dressing to indolent ulcers. It is employed by Mr. Higginbottom (*Essay on the Use of Nitrate of Silver*, 2d ed. p. 119), under the name of *neutral ointment*, as a defence for ulcers after the application of nitrate of silver.

ORDER 25.—ZINC AND ITS COMPOUNDS.

Zin'cum.—Zinc.

HISTORY.—Although the ancients were acquainted with the method of converting copper into brass by means of an ore of zinc, yet they were unacquainted with metallic zinc, one of the constituents of this alloy. Albertus Magnus, who died in 1280, is the first who expressly mentions this metal.

It has various appellations, such as *contrefeyn*, *golden marcasite*, *Indian tin* (*stannum indicum*), *spiaulter*, *speltre* or *spelter* (*speltrum*).

NATURAL HISTORY.—It occurs only in the mineral kingdom. It is found in the form of oxide (*red zinc*), of sulphuret (*blende* or *black jack*), of carbonate (*calamine*), of sulphate (*white vitriol*), of silicate (*electric calamine*), and aluminate (*automalite* or *gahnite*).

PREPARATION. — It is obtained from the sulphuret, carbonate, and silicate. The sulphuret is roasted, by which part of the sulphur is expelled, and the metal oxidized: it is then mixed with some carbonaceous substance, introduced into an earthen crucible, the bottom of which is perforated by an iron tube which passes into a vessel of water situated in an apartment below. The zinc is reduced in the pot, sublimes, and passes through the tube, dropping into the water beneath. This is called *distillatio per decensum*. Zinc is also procured from the carbonate and silicate of this metal, by treating it as above described for roasted blende.

The zinc used in this country is principally imported in ingots and plates from Silesia, by way of Hamburg, Antwerp, Dantzic, &c. The only zinc-works at present in this country are at Maestag, near Margam, Glamorganshire.

PROPERTIES.—It is a bluish-white metal, of considerable lustre. It crystallizes in four-sided prisms and needles; its texture is lamellated and crystalline. Its sp. gr. is from 6·8 to 7·2. At common temperature it is tough; from 212° to 300° it is ductile and malleable, and may be readily rolled into thin leaves (*sheet zinc*); at 400° it is so soluble that it may be reduced to powder. It readily fuses, and, at a white heat, may be volatilized.

CHARACTERISTICS.—It is soluble in dilute sulphuric acid, with the evolution of hydrogen gas. Ferrocyanide of potassium forms, in this solution, a gelatinous white precipitate (ferrocyanide of zinc): if iron be present the precipitate is bluish-white. If the liquid be neutral, hydrosulphuric acid and the soluble hydrosulphates also occasion a white or yellowish-white precipitate (sulphuret of zinc). Alkalies and their carbonates likewise throw down white precipitates: that occasioned by the alkalies (oxide of zinc) is soluble in excess of alkali. The delicacy of these tests is, according to Devergie (*Méd. Lég.* ii. 787), as follows:—

		Degree of Dilution.
Ferrocyanide of Potassium	stops at	4,000
Ammonia	,,	6,000
Potash, or Carbonate of Ammonia	,,	8,000
Carbonate of Potash, or Hydrosulphate of Ammonia	,,	10,000
Hydrosulphuric Acid	,,	15,000

PHYSIOLOGICAL EFFECTS.—In the *metallic* state it is inert. The *compounds of zinc* are somewhat analogous, in their action on the system, to those of copper, silver, and bismuth, but are much less energetic. They act topically, according to their degree of concentration, as desiccatives, astringents, irritants, and caustics. Taken internally, they excite, more or less readily, nausea and vomiting, and in large doses operate as irritant and caustic poisons. They exercise a specific influence over the nervous system, though this is much less obvious than in the preparations of the other metals just referred to. The stupor and inactivity, mentioned by Orfila (*Toxicol. Gén.*), as being produced by the sulphate, are evidence of an affection of the nervous system. The antispasmodic power evinced by zinc, in certain diseases, can only be explained by referring it to the action of this metal on the nervous centres.

USES.—As *topical* agents we employ the compounds of zinc as caustics, astringents, and desiccatives. Thus the chloride is used as a caustic, the sulphate and acetate as an astringent, and the oxide and carbonate as a desiccative.

Internally, the zincic compounds are administered in large doses to excite vomiting; in smaller doses as tonics and antispasmodics in intermittent diseases and chronic affections of the nervous system.

Zin'ci Ox'ydum.—Ox'ide of Zinc.

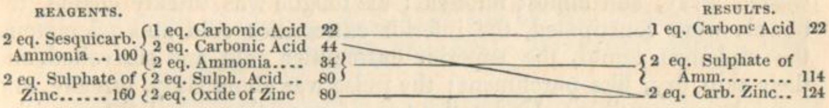
History.—The oxide was first prepared by Hellot in 1735. It has received various names, some of them of a fantastic nature; as *nihil album*, *lana philosophica*, *pompholyx*, *flowers* or *calx of zinc* (*flores* seu *calx zinci*).

Natural History.—Oxide of zinc is found in America, mixed or combined with the sesquioxide of manganese, and constituting the *red oxide of zinc* of the mineralogist. It is also found in various localities, in combination with carbonic, sulphuric, or silicic acid.

Preparation.—In the Dublin Pharmacopœia it is directed to be obtained by throwing zinc into a deep crucible heated to whiteness, and immediately inverting (loosely) a second crucible over the first one, so as not to exclude the air. The metal attracts oxygen from the air, and the oxide thus formed is deposited on the sides of the crucible.

In the London Pharmacopœia it is ordered to be prepared by mixing a pound of sulphate of zinc dissolved in twelve pints of distilled water, with six ounces and a half of sesquicarbonate of ammonia, also dissolved in twelve pints of distilled water. The precipitate is to be frequently washed and ignited during two hours.

In this process double decomposition takes place; sulphate of ammonia is formed in solution, and carbonate of zinc precipitates. A portion of the carbonic acid of the sesquicarbonate of ammonia escapes.



The carbonate of zinc is decomposed by the subsequent ignition, and the carbonic acid expelled, leaving the oxide.

Properties.—The primary form of the crystallized native oxide of zinc (containing the oxides of iron and manganese) is a right rhombic prism.

The artificial oxide met with in the shops is a white, or, when ignited, yellowish-white, tasteless, odourless powder. It is fusible, forming a yellow glass, and at a white heat is volatilized. When heated with charcoal it is readily reduced. It is insoluble in water, but readily dissolves in most acids and in alkalies. It forms two classes of salts: one (the *zincic salts*), in which it is the base; a second (*zincates*), in which it acts acts the part of an acid.

Characteristics.—It dissolves in dilute sulphuric acid. The characteristics of the solution have been already detailed (p. 521).

Composition.—Oxide of zinc has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Proust.	Berzelius.
Zinc	1	32	80	80	80·1
Oxygen	1	8	20	20	19·9
Oxide of Zinc	1	40	100	100	100·0

The oxide of the shops is usually the hydrated oxide of zinc, and consists of 1 eq. oxide of zinc = 40 + 1 eq. water = 9.

Purity.—Pure oxide of zinc is completely and readily soluble in dilute sulphuric acid, without effervescence: the precipitate produced in this solution, by caustic ammonia or caustic potash, should be completely soluble in an excess of the precipitant. Oxide of cadmium has been sometimes found in it, and was once mistaken for arsenious acid (Thomson's *Hist. of Chem.* ii. 219). Iron and manganese (Liebig) are sometimes present in oxide of zinc, and communicate a yellow tinge to it.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—Orfila (*Toxicol. Gén.*) gave from three to six drachms of it to small and weak dogs: they were attacked with vomitings, without suffering much.

(*b.*) *On man.*—Applied to ulcerated or other secreting surfaces, it acts as a desiccating and astringent substance. On account of its insolubility, the absorption of it must be very slow. Taken into the stomach in large doses, it acts as a slight irritant, and provokes vomiting, and sometimes purging. It is said to have also caused occasional giddiness and temporary inebriation. In small doses it may be taken for a considerable period without causing any obvious effects. Sometimes, under its employment, certain affections of the nervous system (as epilepsy, chorea, &c.) subside; from which we infer that it exercises some specific influence over this system; and it is, therefore, termed tonic, antispasmodic, and sedative. But the nature of its influence is not very obvious, and is inferred rather from analogy than observation. By long-continued use it acts as a slow poison, and produces tabes sicca. A gentleman, for the cure of epilepsy, took daily, at an average, twenty grains of oxide till he consumed 3246 grains, which must have taken him about five months. At the end of this time he was found of a pale, earthy hue, wasted away, and almost idiotical: his tongue was thickly coated, the bowels were constipated, the inferior extremities cold and œdematous, the abdomen tumid, the superior extremities cold and shrivelled, and their skin dry, like parchment; the pulse was about sixty, thready, and scarcely perceptible. Under the use of purgatives, a light nutritive diet, with tonic and diuretic medicines, he rapidly recovered, but he remained subject to epileptic attacks (*Brit. and For. Med. Rev.* July 1838, p. 221).

USES.—*Internally* it has been commended in some spasmodic diseases, viz. epilepsy, chorea, hysteria, catalepsy, and hooping-cough; and in some painful affections, as neuralgia and gastrodynia. Though occasionally serviceable in some of these maladies, it has so frequently failed that practitioners have ceased to place much confidence in it.

Externally it is employed in the form of powder, or lotion, or ointment. As a *dusting powder* it is useful, by its mild, absorbent, and desiccative properties, and is applied to impetiginous and other chronic diseases of the skin, attended with profuse secretion. It is also used to allay or prevent excoriation in children and bedridden persons, and to remove chaps and cracks of the nipples. In painful ulcers, with copious discharge, it is not unfrequently beneficial by its desiccative and sedative properties. *Diffused through water* or *a mucilaginous solution* (in the proportion of two drachms of the oxide to six or eight ounces of liquid), it is occasionally useful in chronic ophthalmia, especially *ophthalmi tarsi.* Sommé (*Archiv. Gén. de Méd.* i. 486) employed an injection composed of half an ounce of oxide and two pints of water in gonorrhœa and leucorrhœa, with success.

ADMINISTRATION.—Internally it is administered in the form of pill or powder, in doses of from two or three grains gradually increased to eight, ten, or more.

Unguentum Zinci, Ph. Lond. *Unguentum Zinci Oxydi*, Ph. Dub. and Ed. (Oxide of zinc, ℥j.; lard, ℥vj. M. Ph. Lond. The Edinburgh College substitutes simple liniment for lard; the Dublin College uses eight parts of ointment of white wax to one part of the oxide).—This compound is employed as a mild drying ointment in porrigo, impetigo, and other skin diseases attended with profuse discharges, after extensive burns, blisters, sinapisms, &c.; to painful ulcers with excessive secretion, to chronic inflammation of the eye, &c.

Zinci Oxydum Impurum, Ph. Ed.—This substance is known in the shops under the name of *tutty* (*tutia* seu *tuthia*), or *furnace cadmia* (*cadmia fornacum* seu *factitia*). It is found in the chimney of the furnace in which zinc ores are roasted, or in which zinciferous lead ores are smelted. When prepared by levigation and elutriation it is called *prepared tutty* (*oxidum zinci impurum præparatum*, Ph. Ed.; *tutia præparata*.) It is applied as a dusting powder, or as a cooling ointment (*unguentum oxidi zinci impuri*, Ph. Ed.; composed of simple liniment, 5 parts; prepared impure oxide of zinc, 1 part, M.), to excoriated surfaces.

Zin'ci Chlo'ridum.—Chlo'ride of Zinc.

History.—This compound, which has been long known to chemists, was first introduced into medicine by Papenguth (*Russ. Samml. f. Naturw. u. Heilk.* H. i. S. 79, quoted by Richter, *Ausf. Arzneim.* iv. 526), and subsequently has been recommended by Professor Hancke of Breslau, (Rust's *Magazin*, 1826, Bd. 22, S. 373), and by Dr. Canquoin, of Paris (Dr. Alex. Ure, *Lond. Med. Gaz.* xvii. 391). It is termed *muriate*, *hydrochlorate*, or *butter of zinc*.

Preparation.—The easiest and cheapest method of obtaining it is by dissolving zinc, or its oxide, in hydrochloric acid, evaporating to dryness, and fusing in a glass vessel with a narrow mouth, as a Florence flask.

Properties.—It is a whitish grey semi-transparent mass, having the softness of wax. It is soluble in water, alcohol, and ether. It is fusible, and at a strong heat may be sublimed and crystallized in needles. It is very deliquescent. It unites with both albumen and gelatine to form difficultly soluble compounds, and hence it occasions precipitates with liquids containing these principles in solution.

Characteristics.—Dissolved in water it may be recognised to be a chloride by nitrate of silver (*vide* 105). That zinc is the base of the salt may be shewn by the tests already mentioned for this metal (p. 521).

Composition.—Its composition is as follows:—

	Eq.	Eq.Wt.	Per Cent.	J. Davy.
Zinc	1	32	47	50
Chlorine	1	36	53	50
Chloride of Zinc	1	68	100	100

Physiological Effects.—Its *local* action on living tissues is that of a caustic or escharotic, depending partly on its affinity for albumen and gelatine; so that when placed in contact with living parts into whose composition these organic compounds enter, the chloride exercising its affinity, first destroys the life of the part, and then unites with the albuminous and gelatinous matters present, and forms thus an eschar. Other chemical changes of a comparatively unimportant nature are also effected: thus, various salts found in the solids or liquids of the part may be decomposed. For example, when the chloride is applied to a cancerous sore, it decomposes the carbonate and hydrosulphuret of ammonia found in the secretion of the sore. The effects produced by the application of chloride of zinc are the following:—Soon after it has been applied, a sensation of warmth is felt in the part, quickly followed by violent burning pain, which continues for seven or eight hours; that is, until the parts in contact with the chloride are dead. A white eschar is now observed, which usually separates in from eight to twelve days. Unless used in the neighbourhood of loose cellular tissue, there is rarely much swelling.

As a caustic, chloride of zinc is not inferior in power to chloride of antimony; nay, Vogt (*Pharmakodynamik.* i. 363, 2^{te} Aufl.) says, it appears to him to be more powerful, and to penetrate deeper. It decomposes the organic tissues as quickly as the nitrate of silver, but excites more burning, and for a longer time, owing to its action extending to parts placed more deeply, for it is well known that the operation of the nitrate is confined to superficial parts. Both Vogt and Canquoin agree that chloride of zinc, besides corroding the parts with which it is in contact, exercises an influence over the vital actions of neighbouring parts. To this circumstance is owing, in great part, the efficacy of the chloride in various diseases in which it has been applied, and the healthy appearance of the sore after the separation of the eschar. There is no danger of any constitutional disorder arising from the absorption of the poison, as is the case with the arsenical and mercurial caustics.

Taken *internally*, in *large doses*, it acts as an irritant or caustic poison, and affects the nervous system. Thus it produces a burning sensation in the stomach, nausea, vomiting, anxiety, short breathing, small quick pulse, cold sweats, fainting, and convulsions. Taken in *very small doses*, no obvious effects are produced, except sometimes the amelioration of certain diseases. It is supposed in these cases to influence the nervous system.

USES.—*Internally* chloride of zinc has been given in small but gradually increased doses in scrofula, epilepsy, chorea, and (in combination with hydrocyanic acid) in neuralgia of the face.

Commonly, however, it is employed *externally:* thus Papenguth used a dilute solution of it as a lotion in fistulous ulcers of a scrofulous nature. As a *caustic* it has been applied by Professor Hanke and Dr. Canquoin to produce an issue, to destroy nævi materni, and as an application to parts affected with malignant diseases, such as fungus hæmatodes and cancer, or to other intractable forms of disease, such as old syphilitic or scrofulous ulcers. The benefit is supposed not to depend merely on the escharotic effect, but on the chloride inducing a new action in the surrounding parts.

ADMINISTRATION.—*Internally*, it may be given in doses of one or two grains. Hufeland recommends it to be taken dissolved in ether; his formula for the *æther zinci*, as it is called, is the following:—℞. Zinci Chlor. ʒss.; Alcoholis, ℥j.; Ætheris Sulph. ʒij. Post aliquot dies decanta. The dose of this solution is from four to eight drops, taken twice daily.

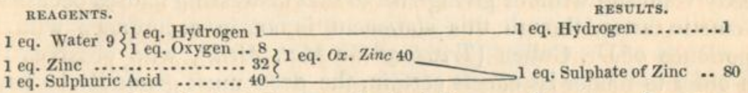
Externally it has been used as a *lotion*, composed of two grains of the chloride and an ounce of water; or in the form of *paste:* this may be composed of one part of chloride of zinc, and from two to four parts of wheaten flour.

Zin'ci Sul'phas.—Sul'phate of Zinc.

History.—This salt is said by Schwartze (*Pharm. Tabell.* 2te Ausg. 779), to have been known towards the end of the 13th, or at the commencement of the 14th century; but Beckmann affirms it was not known before the middle of the 16th century (*Hist. of Invent.* iii. 85). It has had various names, as *sal vitrioli*, *white vitriol*, and *Gilla Theophrasti*.

Natural History.—It occurs native at Rammelsberg, near Goslar, in the Harz; at Holywell, in Flintshire; and other places.

Preparation.—It is readily prepared by dissolving zinc in diluted sulphuric acid. The proportions, directed to be used in the London Pharmacopœia, are five ounces of zinc and two pints of diluted sulphuric acid. The solution is to be filtered, evaporated, and crystallized. In this process 1 equivalent or 9 parts of water are decomposed, an equivalent or 1 part of hydrogen escapes, while an equivalent or 8 parts of oxygen unite with 1 equivalent or 32 parts of zinc, to form 1 equivalent or 40 parts of the oxide, which, with 1 equivalent or 40 parts of sulphuric acid, form 1 equivalent or 80 parts of the sulphate. The zinc and the oxide thus formed combines with some sulphuric acid to form the sulphate.



By roasting blende (sulphuret of zinc) in reverboratory furnaces an impure sulphate is obtained, which is lixiviated, and the solution concentrated by evaporation, so that on cooling it forms a crystalline mass resembling lump sugar. This is distinguished among druggists by the name of *white vitriol*, a term which they confine to this commoner kind of sulphate. This impure salt contains iron, and usually copper and lead.

Properties.—The primary form of the crystals of sulphate of zinc is the right rhombic prism: they are transparent and colourless, and have a metallic astringent taste. They are soluble in $2\frac{28}{100}$ times their weight of cold water, and less than their own weight of boiling water. They are insoluble in alcohol. In dry and warm air they effloresce. When heated they undergo the watery fusion; and if the liquid be rapidly cooled, it congeals into a granular, crystalline, white mass: if the heat be continued the salt becomes anhydrous, and, at an intense heat, is decomposed, leaving a residue of zinc.

Characteristics.—That this salt is a sulphate, is proved by the action of chloride of barium on it; a white precipitate is produced, insoluble in nitric acid. Acetate of lead also occasions a white precipitate. The presence of oxide of zinc in the solution is recognized by the tests already mentioned (p. 999.)

Composition.—This salt has the following composition:—

	Eq.	Eq. Wt.	Per Cent.	Berzelius	Mitscherlich.
Oxide of Zinc	1	40	28	32·585	55·24
Sulphuric Acid	1	40	28	30·965	
Water	7	63	44	36·450	44·76
Crystallized Sulphate of Zinc	1	143	100	100·000	100·00

Purity.—Ammonia added to a solution of sulphate of zinc throws down the hydrated oxide of zinc; excess of ammonia re-dissolves the oxide, and forms a colourless solution. If any oxide of iron or magnesia be present it remains undissolved; while any oxide of copper would form an azure blue solution. Arsenic or cadmium may be detected by adding excess of sulphuric acid to the solution of the sulphate, and then passing a stream of hydrosulphuric acid through it: the arsenicum and cadmium are thrown down in the form of sulphurets. The impure sulphate called *white vitriol* is in irregular masses, here and there stained yellow with the iron.

Physiological Effects.—In *small and repeated doses* it acts as an astringent on the alimentary canal, checks secretion, and promotes a constipated condition of bowels. It exercises a specific influence over the nervous system, manifested by its power of removing certain spasmodic affections: hence it is reputed antispasmodic. To the same influence is to be referred its power of preventing the recurrence of intermittent maladies, from which it has principally derived its denomination of a tonic. Its astringent effect is not confined to the bowels, but is manifested in the pulmonary and urethral mucous membranes, the secretions from which it diminishes: hence the advantage of its use in catarrhal affections of these parts. It does not appear to possess any power of checking cutaneous exhalation.

In *full medicinal doses* it is a powerful but safe emetic; it excites speedy vomiting without giving rise to that distressing nausea occasioned by emetic tartar, though this statement is not in accordance with the experience of Dr. Cullen (*Treat. of the Mat. Med.*), who observes that "in order to render its effects certain, the dose must generally be large; and if this is not thrown out again immediately it is apt to continue a disagreeable nausea, or even a vomiting, longer than is necessary." But this observation does not agree with the experience of other practitioners.

In *excessive doses* it acts as an irritant poison, causing vomiting, purging, coldness of the extremities, and fluttering pulse.

The *local action* of it is that of an astringent and desiccant, and in a concentrated form it is a powerful irritant and caustic. Its external use is said to have been found fatal in one case, by causing vomiting, purging, and convulsions (Christison, *op. cit.* p. 468).

Uses.—As an *emetic* it is almost exclusively employed in poisoning, especially by narcotics. In these cases it is the best evacuant we can administer, on account of its prompt action. As an *internal astringent* it is administered in chronic dysentery (Impey, *Lond. Med. and Phys. Journ.* ix. 55, 1803) and diarrhœa, in chronic bronchial affections attended with profuse secretion, and in gleet and leucorrhœa. In the latter cases it is usually associated with terebinthinate medicines, and is sometimes decidedly beneficial. As an *antispasmodic* it has been employed with occasional success in epilepsy, chorea, hysteria, spasmodic asthma, and hooping-cough. I have little faith in its efficacy in any of these cases. As a *tonic* it has been sometimes serviceable in agues, but it is far inferior to sulphate of quinia or arsenious acid.

As a *topical astringent* sulphate of zinc is most extensively employed. We use its aqueous solution as a collyrium in chronic ophthalmia, as a wash for ulcers attended with profuse discharge, or with loose flabby granulations; as a gargle in ulcerations of the mouth, though I have found it for this purpose much inferior to a solution of sulphate of copper; as a lotion for chronic skin diseases; and as an injection in gleet and leucorrhœa.

ADMINISTRATION.—As an *emetic* the dose should be from ten to twenty grains; as a *tonic*, *antispasmodic*, or *expectorant*, from one to five grains. For external use, solutions are made of various strengths. Half a grain of the sulphate to an ounce of water is the weakest. The strongest I ever knew employed consisted of a drachm of sulphate dissolved in an ounce of water: it was used with success as an injection in gleet. But solutions of this strength must be applied with great caution, as they are dangerous.

SOLUTIO SULPHATIS ZINCI, Ph. Ed. (Sulphate of zinc, gr. xvj.; water, ℥viij.; diluted sulphuric acid, gtt. xvj. M.)—This formula might be very properly omitted.

ANTIDOTES.—Promote the evacuation of the poison by demulcents. Afterwards allay hyperemesis by opium, blood-letting, and the usual antiphlogistic regimen. Vegetable astringents have been advised.

Zin'ci Ace'tas.—Ac'etate of Zinc.

HISTORY.—This salt was discovered by Glauber.

PREPARATION.—It may be procured by dissolving oxide of zinc in acetic acid, and crystallizing the saturated solution; or it may be readily obtained by double decomposition: 143 grains of crystallized sulphate of zinc, dissolved in water, and mixed with 190 grains of the acetate of lead, in solution, will produce 152 grains of sulphate of lead, which, being insoluble, precipitates, while 91 grains of the anhydrous acetate of zinc (equal to 154 grains of the crystallized acetate) are left in solution: or it may be procured by immersing a piece of zinc in a solution of acetate of lead until the liquid forms a white precipitate with hydrosulphuric acid. In this process the lead is reduced to the metallic state (forming the *arbor Saturni* or *lead tree*), while the zinc replaces it in solution.

PROPERTIES.—It usually crystallizes in rhomboidal plates, having a pearly or silky lustre, closely resembling talc. The primary form of the crystals is the oblique rhombic prism. The salt is odourless, but has a bitter metallic taste. It dissolves readily in water, and is slightly efflorescent.

CHARACTERISTICS.—When heated it fuses, and gives out an inflammable vapour, having the odour of acetic acid. When sulphuric acid is added to the salt, the vapour of acetic acid is evolved: this is easily recognized by its odour. These characters show it to be an acetate. That it is a zincic salt is proved by the tests before mentioned for a solution of this salt (p. 522).

COMPOSITION.—Its composition is, according to Dr. Thomson, as follows:—

	Eq.	Eq. Wt.	Per Cent.
Oxide of Zinc	1	40	25·97
Acetic Acid	1	51	33·11
Water	7	63	40·90
Crystallized Acetate of Zinc	1	154	99·98

PHYSIOLOGICAL EFFECTS.—Its effects are analogous to, though milder than, the sulphate of zinc, but more energetic than the oxide. Its local action is astringent. Taken internally, in small doses, it acts as a tonic and antispasmodic; large doses occasion vomiting and purging. Devaux and Dejaer (Orfila, *Toxicol. Gén.*) deny that it is a poison, even in large doses.

Uses.—It is rarely administered *internally*; but is applicable as an emetic, tonic, and antispasmodic, in the same cases in which the oxide or sulphate of zinc is employed.

As a *topical* remedy, it is used on account of its astringent qualities in chronic ophthalmia, gleet, and leucorrhœa. In the latter stages of gonorrhœa I have found it far more successful than the sulphate. Its beneficial effects were first described by the late Dr. Wm. Henry, of Manchester (*Lond. Med. and Phys. Jour.* ix. 53, 1803). Sir A. Cooper (*Lancet*, iii. 199) recommends, as the best injection which can be used in the third week of gonorrhœa, a mixture of six grains of sulphate of zinc and four ounces of liquor plumbi subacetatis dilutus. Of course double decomposition takes place, and the active ingredient is the acetate of zinc.

Administration.—When exhibited internally, as a tonic or antispasmodic, the dose is one or two grains gradually increased. As an emetic the dose is five to ten grains: its operation is very safe. As a lotion or injection it is employed in the form of aqueous solution, containing two or three or more grains of the salt to an ounce of water.

Solutio Acetatis Zinci, Ph. Edinb. (Sulphate of zinc, ʒj.; acetate of lead, ℈iv.; distilled water, ℥xx. [by weight]. Dissolve the salts separately, each in ten ounces of the water. Mix the solutions, and when the precipitate has subsided, filter the liquor.)—Double decomposition is effected, sulphate of lead falls down, and acetate of zinc remains in solution. Each fluidounce contains three grains of the acetate. Used as an injection in gonorrhœa.

Zinci Acetatis Tinctura, Ph. Dubl. (Sulphate of zinc; acetate of potash, āā one part. Triturate them together, and add sixteen parts of rectified spirit; macerate for a week, with occasional agitation, and filter through paper.)—Here also we have double decomposition: sulphate of potash and acetate of zinc are formed. The first is precipitated, being insoluble in spirit, the second remains in solution. One drachm contains a quantity of acetate of zinc equal to about four grains of the crystallized acetate. When diluted with water, it is used as a collyrium and injection.

Zin'ci Car'bonas.—Car'bonate of Zinc.

History.—The native carbonate of zinc was perhaps known to the ancients, though they were unacquainted with its nature. The term *calamine* is applied both to the native carbonate and native silicate of zinc: the latter is termed by way of distinction *electric calamine*.

Natural History.—Native carbonate of zinc (*calamine*) is found in great abundance in several parts of England (in the counties of Somerset, Derby, Durham, &c.), as well as in various parts of the continent of Europe (in Carinthia, Hungary, Silesia, &c.) It occurs crystallized or in compact or earthy masses. Its colour varies, being more or less grey, yellow, or brown. Its sp. gr. is 4·2 to 4·5.

Preparation.—Calamine (*calamina*), or the impure carbonate of zinc (*carbonas zinci impura*, Ph. Lond.) is directed to be calcined, in order to make it pulverizable. But in this process water and more or less of the carbonic acid is expelled. It is then reduced to a very fine powder (usually in mills), and is afterwards submitted to the process of elutriation. By this means we obtain *prepared calamine* (*calamina præparata*, Ph. Lond.; *Zinci carbonas impurum præparatum*, Ph. Dubl.)

Properties.—Prepared calamine is met with in the shops in the form of a heavy pinkish or flesh-coloured powder, or made up into little masses. When pure, it dissolves in nitric, hydrochloric, or sulphuric acid, with effervescence. Various impurities mixed with calamine are insoluble in these acids.

Characteristics.—The effervescence with the mineral acids shews calamine to be a carbonate. The presence of zinc in the solution is determined by the tests before mentioned for this metal (p. 522). The action of these tests, however, is more or less impeded by the presence of foreign matters in calamine.

Composition.—Carbonate of zinc has the following composition:—

	Eq.	Eq. Wt.	Per Cent.	Smithson.		
				(*Mendip Ore.*)		(*Derbyshire Ore.*)
Oxide of Zinc	1	40	64·5	64·8	to	65·2
Carbonic Acid	1	22	35·5	35·2	to	34·8
Carbonate of Zinc	1	62	100·0	100·0	to	100·0

Impurities.—The substance sold in the shops as prepared calamine frequently contains only traces of zinc. If hydrochloric acid be poured on it, effervescence (owing to the escape of carbonic and hydrosulphuric acids) takes place, and a portion is dissolved; but the greater part remains undissolved. Mr. Brett (*Lond. Med. Gaz.* xx. 72) found from 78 to 87·5 per cent. of sulphate of baryta. The remainder of the powder consisted of oxide of iron, carbonate of lime, lead (sulphuret of ?), and mere traces of zinc.

Physiological Effects.—Pure carbonate of zinc is probably similar in its action to the oxide.

Uses.—Calamine is employed as a dusting powder for children, and as a mild desiccant and astringent in excoriations, superficial ulceration, &c.

Ceratum Calaminæ, Ph. Lond.; *Unguentum calaminæ*, Ph. Dubl.; *Ceratum Carbonatis Zinci Impuri*, Ph. Ed. (Calamine; wax, āā lb. ss.; olive oil, f℥xvj. Add the calamine to the melted wax and oil when they begin to thicken, *Ph. Lond.* The *Edinburgh College* uses one part of carbonate to five of lard. The *Dublin College* uses one pound of carbonate and five pounds of ointment of yellow wax.) This is commonly called *Turner's Cerate*, or the *Ceratum epuloticum*. It is an excellent desiccative and astringent application (when prepared with good calamine) to burns, scalds, excoriations, superficial ulcerations, &c.

Zin'ci Cyan'idum.—Cy'anide of Zinc.

History.—This salt, sometimes called *hydrocyanate* or *cyanuret of zinc*, has been introduced, by the German physicians, as a substitute for hydrocyanic acid.

Preparation.—It is prepared by adding recently-made oxide of zinc to hydrocyanic acid; or by adding a solution of sulphate of zinc to a solution of cyanide of potassium.

Properties.—Cyanide of zinc is a white powder, insoluble in water or alcohol.

Characters.—If a strong mineral acid be added to it, hydrocyanic acid is developed, and a soluble salt of zinc obtained. The latter is recognized by the tests before mentioned for a solution of zinc (p. 522).

Composition.—Its composition is as follows:—

	Eq.	Eq. Wt.	Per Cent.
Zinc	1	32	55·2
Cyanogen	1	26	44·8
Cyanide of Zinc	1	58	100·0

Physiological Effects.—Its effects have not been carefully ascertained, but they are supposed to be similar to those of hydrocyanic acid.

Uses.—It has been used principally in affections of the nervous system, as epilepsy, hysteria, and chorea. It has also been employed in cardialgia and cramps of the stomach, and as an anthelmintic in children.

Administration.—We may give it in doses of from a quarter of a grain to a grain and a half three times a day. It may be taken in the form of powder mixed with calcined magnesia.

Order 26.—Iron and its Compounds.

Fer'rum.—I'ron.

History.—This metal (called by the alchymists *Mars*) was known in the most ancient times. It was employed medicinally at a very early period, namely, above 3200 years ago. Indeed, it appears to have been the first mineral used internally; and a curious anecdote is given of its introduction into medicine. Melampus (a shepherd supposed to possess supernatural powers) being applied to by Iphicles, son of Philacus, for a remedy against impotence, slaughtered two bulls, the intestines of which he cut to pieces, in order to attract birds to an augury. Among the animals which came to the feast was a vulture, from whom Melampus pretended to learn that his patient, when a boy, had stuck a knife wet with the blood of some rams into a consecrated chestnut-tree, and that the bark had subsequently enveloped it. The vulture also indicated the remedy, namely, to procure the knife, scrape off the rust, and drink it in wine, for the space of ten days, by which time Iphicles would be lusty, and capable of begetting children. The advice thus given by Melampus is said to have been followed by the young prince with the most perfect success! (Le Clerc, *Hist. de la Médecine.*)

Natural History.—Iron is met with in both kingdoms of nature.

(*a.*) *In the inorganic kingdom.*—Few minerals are free from iron. It is found in the metallic state (*native iron*), in combination with oxygen (*hæmatite*, *micaceous iron*, *brown iron stone*, and *magnetic iron ore*), with sulphur (*iron pyrites*, and *magnetic pyrites*), with chlorine (*pyrosmalite*), with oxygen and an acid (*carbonate*, *phosphate*, *sulphate*, *arseniate*, *tungstate*, *tantalate*, *titaniate*, *chromate*, *oxalate*, and *silicate*.)

(*b.*) *In the organic kingdom.*—It occurs in the ashes of most plants, and in the blood and some other parts of animals.

Extraction.—In Sweden, iron is extracted from magnetic iron ore and micaceous iron: in England, principally from clay iron ore (carbonate of iron.)

Clay iron ore (technically called *mine*) is burned with coal in large heaps, by which it loses carbonic acid, water, and sulphur. It is then smelted with a flux (in South Wales this is limestone; in the forest of Dean, clay;) and coke. The smelted iron is run into moulds, and is then called *cast iron* (*ferrum fusum*), or *pig iron*. This contains carbon, oxygen, silicon, and often sulphur and phosphorus. To separate these, it is submitted to several processes (called refining, puddling, and welding,) by which it is converted into *wrought iron* (*ferrum cusum*), (*Manufacture of Iron*, in the *Library of Useful Knowledge;* also, *Treatise on Iron and Steel*, in *Lardner's Cyclopædia*).

PROPERTIES.—The primary form of the crystals of native iron is the regular octahedron. Pure iron has a whitish grey colour, or, according to Berzelius, is almost silver white. When polished it has much brilliancy: its taste is peculiar and styptic; when rubbed it becomes odorous. Its ductility and tenacity are great; its malleability comparatively small. Its sp. gr. is 7·788, but diminishes by rolling or drawing. It is attracted by the magnet, and several of its compounds are capable of becoming permanent magnets; but pure iron retains its magnetic property for a short time only. It requires a very intense heat to fuse it; and it is not volatile at any known temperature; while in the softened state, previous to melting, it is capable of being welded. Its equivalent or atomic weight is 28.

CHARACTERISTICS.—Iron readily dissolves in diluted sulphuric acid, with the evolution of hydrogen gas. The solution contains the protosulphate of iron, and produces, on the addition of caustic potash or soda, a greenish-white precipitate (the hydrated protoxide): this precipitate, by exposure to the air, attracts oxygen, and is converted into the red or sesquioxide. Auro-chloride of sodium forms a purple precipitate with the protosalts of iron. By boiling the solution with a little nitric acid, we obtain a persulphate of iron, recognized by ferrocyanide of potassium causing a blue precipitate; sulphocyanic or meconic acid, a red colour; gallic or tannic acid, or infusion of galls, a purple or bluish black; and succinate, or benzoate of ammonia, a yellowish precipitate.

PHYSIOLOGICAL EFFECTS. (*a.*) *Of the metallic iron.*—Iron is probably inert so long as it retains its metallic form, but it readily oxidizes in the alimentary canal, and thereby acquires medicinal power. As acids promote this chemical change, acid wines and fruits assist in rendering the metal active, while alkalies and their carbonates have an opposite effect. The oxidizement of the iron is attended with the evolution of hydrogen gas, which gives rise to unpleasant eructations. If sulphur be taken along with iron, hydrosulphuric acid is developed. Like the ferruginous preparations generally, the internal employment of iron causes blackening of the stools. The nature of the effects produced by oxide of iron formed in the alimentary canal will be best examined hereafter, under the head of ferruginous preparations. I may, however, remark here, that it is one of the few metals which by oxidizement is not rendered more or less poisonous.

(*b.*) *Of the ferruginous compounds.* α. *On vegetables.*—Most of the compounds of iron do not appear to be hurtful to plants: at least this is the case with the oxides (Decandolle, *Phys. Vég.* 1337.) The sulphate, however, is said to be injurious (*vide* p. 551.)

β. *On animals.*—The effects of the ferruginous compounds on animals generally are similar to those on man. It is stated that in animals to whom iron has been given for a considerable time, the spleen has been found smaller, harder, and denser—an effect which is supposed to be owing to the increased contractile power experienced by the veins of the abdomen. The liver is also said to have been affected in a similar manner, though in a somewhat slighter degree.

γ. *On man.* — The *local* effects of the sulphate and chloride of iron are those of irritants, and these preparations accordingly rank among poisons; but they are not equal in power to the mercurial or cupreous salts. Most of the ferruginous preparations are astringent; that is, they constringe the parts with which they are in contact, and thereby diminish secretions and check sanguineous discharges. Thus, when swallowed, they repress the secretions and exhalation of the gastro-intestinal membrane, and thereby render the alvine evacuations more solid, and even occasion costiveness. The sulphate and chloride of iron are the most powerful of the ferruginous astringents. Administered in large quantities, or when the alimentary canal is in an irritable condition, all the compounds of iron are capable of exciting heat, weight, and uneasiness at the præcordia, nausea, and even vomiting, and sometimes purging.

The constitutional or *remote* effects of the chalybeates are principally observed in the alteration induced in the actions of the vascular and muscular systems, and are best seen in that state of the system denominated *anæmia*, or more properly *hypæmia*, in which both the quantity and quality of the blood appear defective. We have a good illustration of this state in chlorotic patients. The skin appears pale and almost exsanguineous, the cellular tissue is œdematous, and, after death, the larger vessels as well as the capillaries are found to be imperfectly supplied with blood. Patients with this condition of system are affected with great feebleness, loss of appetite, and palpitation; and in females the catamenial secretion is frequently, but not invariably, defective. That the want of uterine action is not the cause, but in some cases is, perhaps, the effect of this condition of system, seems tolerably clear from the circumstance of the same constitutional symptoms of anæmia sometimes occurring with a perfect regularity of the uterine functions; moreover, we occasionally meet with anæmia in men. It is sometimes the consequence of hæmorrhages—at other times it occurs spontaneously, and without any known cause (Andral, *Pathol. Anat.* by Townsend and West, i. 97).

If in this condition of system we administer iron, the appetite increases, digestion is promoted, the pulse becomes fuller and stronger, the skin assumes its natural tint, the lips and cheeks become more florid, the temperature of the body is increased, the œdema disappears, and the muscular strength is greatly augmented. The alvine evacuations assume a black colour, as they always do under the use of the ferruginous preparations. After continuing the use of iron for a few weeks, we frequently find excitement of the vascular system (particularly of the brain); thus we have throbbing of the cerebral vessels, and sometimes pain in the head, a febrile condition of system, with a tendency to hæmorrhage. Mr. Carmichael (*Essay on the Effects of Carbonate of Iron on Cancer*, Dubl. 1806, p. 396) considers the *sanguine* temperament (marked by a high complexion, celerity of thought, remarkable irritability of fibre, and a quick pulse) as depending on an excess of iron in the system; whereas the *leucophlegmatic*, or *relaxed*, temperament (characterized by a pale bloated countenance, dull eyes, mind heavy and slow in receiving and forming ideas, little irritability of fibre, and pulse small and feeble) as depending on a deficiency of iron.

When by the use of iron the state of the general system improves, the secretions resume their natural condition, and thus at one time we observe this metal promoting the uterine discharge, at another checking it, according as chlorosis or menorrhagia had been previously present; we cannot, therefore, regard the preparations of this metal as having any direct emmenagogue effect, as some have supposed.

Some refer all the other symptoms of anæmia to the abnormal state of the blood, and ascribe the beneficial influence of iron to the improvement in the quality of this liquid. It is certain that, under the use of the preparations of this metal, the blood frequently acquires a more scarlet colour, owing, as it has been fancied, to an increase in the quantity of its colouring particles; and it is said that the crassamentum becomes firmer and more solid, and even increased in quantity. This alteration of the physical and chemical properties of the blood is supposed to render it more stimulating, and thus the different organs, receiving a fluid of a more healthy character, resume their normal condition, and perform their functions in a proper manner. Tiedemann and Gmelin (*Vers. üb. d. Wege auf. welch. Subst. aus d. Magen u. Darmk.*) have detected it in the serum of the blood of the portal and mesenteric veins of horses and dogs, to whom they administered either the sulphate or chloride; occasionally, too, the urine has been found to contain it. Moreover, Menghini (*De ferrearum particul. progressu ad sanguinem.* In *Com. Acad. Bonon.* t. ii. pt. iii. p. 475) asserts the quantity of iron in the blood of dogs is increased by feeding them on substances mixed with this metal. Furthermore, it is not to be forgotten, that iron exists in no inconsiderable quantity in healthy blood, and is supposed to contribute to its colour, and probably to its stimulant properties; so that it is not unlikely any variation in the quantity of this metal would be attended with an alteration in the action of every organ.

Iron is a substance not readily absorbed, for it remains in the stomach and intestines many days after it is swallowed: in order, therefore, that the ferruginous preparations should have much effect on the general system, it is necessary that they be employed for some considerable time. It does not, like most other metals, act as a poison when it gets into the blood. Another circumstance connected with the operation of iron is likewise deserving of notice; namely, that it has no primary or specific effect on the nervous system, as arsenic, mercury, copper, zinc, bismuth, silver, and many other metals. It must not, however, be imagined from these remarks, that the preparations of iron never operate injuriously. On the contrary, we see them sometimes acting as local irritants on the alimentary canal, as already noticed; and by the use of them in too large quantities, or for too long a period of time, they bring on a hypersthenic or phlogistic diathesis.

USES. (*a.*) *Of metallic iron.*—Iron filings have been used in those cases where the chalybeate preparations generally have been administered, and which will be presently noticed. In some instances, however, the efficacy of iron depends on its being employed in the uncombined state. Thus, when used as an antidote to poisoning by the salts of copper, it is necessary that the iron be administered in the metallic state, in order to reduce the cupreous salts (*vide* p. 494). Iron filings have been regarded as anthelmintic, especially in the small thread-worm (the *Ascaris vermicularis*); they have been used also as an astringent application, to repress fœtid secretion of the feet.

(*b.*) *Of the ferruginous compounds.*—By a careful attention to the known physiological effects of the ferruginous compounds, the indications and contra-indications for their employment may be in great part learned. Thus, the impropriety of administering them where there is irritation or inflammation of the alimentary canal, in plethoric habits, and in persons disposed to inflammatory diseases, or to apoplexy, will be obvious from the foregoing remarks. On the other hand, in all cases characterized by feebleness and inertia of the different organs of the body, by a soft lax condition of the solids, and by a leucophlegmatic state of the system — where the patient appears to be suffering from a state of general anæmia, already described—the preparations of iron are indicated. It is hardly within the scope of my present object to instance particular diseases where this metal may be used, but rather to point out those conditions of system which affect the employment of iron in diseases generally. I may notice a few cases by way of illustration.

As *external* or *local* agents we rarely employ the preparations of iron, since we have other more efficacious and powerful remedies. Occasionally, however, they have been used as astringents, styptics, and caustics. Thus solutions of the sulphate and chloride have been used in the form of injection, in discharges from the urethra and vagina: and the tincture of the chloride is now and then applied as a styptic, or to repress the growth of spongy granulations.

The ferruginous preparations are principally resorted to with the view of affecting the general system. The are frequently given *to promote the uterine functions,* as in chlorosis, amenorrhœa, dysmenorrhœa, and menorrhagia, and often with success. When chlorosis depends on, or at least is accompanied by, that condition of the system before described under the name of anæmia, the ferruginous preparations are frequently useful; but if it occur in patients of a full habit, or if it arise from inflammation of some organ (as the lungs, stomach, or bowels), chalybeates will do harm. In cases of impotence, connected with or arising from general feebleness, it may be now and then useful; but in nine out of ten cases which we are called on to treat, this condition arises from indulgence in bad habits, which no medicine can affect. Sometimes iron is resorted to in sterility (though Dioscorides says the rust of iron hinders women from conceiving), but the conditions under which it is likely to be useful are precisely those before mentioned for other diseases. In discharges from the genital organs, as gleet and leucorrhœa, the internal employment of the tincture of the chloride of iron, sometimes conjoined with the tincture of cantharides, has been found useful.

In some *periodical diseases*—namely, ague, asthma, and tic douloureux—the ferruginous preparations have gained considerable repute. In the first of these diseases (that is, ague), the sulphate has been used by Marc (*Recherches sur l'Emploi du Sulf. de Fer dans le Traitement des Fièvres Interm.* Paris, 1810) and others, the subcarbonate by Buchwald, the ammoniacal chloride by Hartmann; but it has been almost wholly superseded, of late years, by the sulphate of quinine and by arsenic. In asthma, Dr. Bree (*On Asthma*), who was himself a sufferer from the disease, regards iron as preferable to all other remedies. However, the experience of others has not confirmed his favourable opinion of it. The sesquioxide of iron has latterly been extensively employed, at the recommendation of Mr. B. Hutchinson (*Cases of Tic Doulour. successfully treated*), in tic douloureux, and with variable success; in some cases acting in a most extraordinarily beneficial manner, in others being of no avail.

In *diseases of the spleen and liver*, the ferruginous compounds are occasionally found useful. I have already alluded to the influence which they are supposed to possess over these organs; a supposition the more probable from the occasional remarkable effects produced by them in diseases of these organs. "I regard iron as a *specific*," says Cruveilhier, (*Dict. de Méd. et de Chir. Prat.* t. viii. p. 62), "in *hypertrophy of the spleen*, or *chronic splenitis;* whether primitive or consecutive to intermittent fevers." After noticing the symptoms attending this condition (such as paleness of the lips, &c. great lassitude, abdominal and cephalic pulsations, brought on by the slightest exertion; pain at the left side, disordered state of the digestive organs, accelerated pulse, and heart easily excited), he goes on to remark, "By the aid of iron I have obtained the complete resolution of enlargements of the spleen, which have occupied half, or even two-thirds, of the abdomen." In hypertrophy of the liver, iron has not been equally serviceable.

Some years ago the preparations of iron were strongly recommended in *cancer* by Mr. Carmichael (*op. cit.*) The grounds on which he was led to the use of them were the probability that cancer had an independent life—in other words, that it was a kind of parasite, as some preceding writers, more particularly Dr. Adams, had presumed; and secondly, the efficacy of iron in destroying intestinal worms, which led him to hope that it would be equally destructive to other parasites. With these views he employed (externally and internally) various ferruginous compounds—namely, the ferrotartrate of potash, the subcarbonate (sesquioxide) of iron, and the phosphates. Whatever hopes may have at one time been entertained of these remedies as curative agents, in this most intractable disease, they are now completely destroyed. That these medicines are occasionally useful as palliatives may perhaps be admitted; but they have no curative powers. Indeed this might have been suspected, from the hypothetical grounds on which they were introduced into use. The proofs of the parasitical nature of cancer must be much stronger than any yet offered, ere we can admit this hypothesis. Moreover, the preparations of iron, though useful, are not so "very effectual" in worms as Mr. Carmichael's remarks would lead us to imagine.

In certain affections of the digestive organs, the preparations of iron are occasionally used with benefit; as in some forms of dyspepsia, but only in the conditions of system already noticed. In some *affections of the nervous system* which occur in weak debilitated subjects, it is also useful; for example, in epilepsy, chorea, hysteria, and the shaking palsy produced by the vapour of mercury.

These are the most important diseases for which we employ the ferruginous compounds. There are many other diseases for which chalybeates are occasionally beneficial; but the general principles regulating their use will be readily comprehended from the foregoing remarks, and I have only to add, in all diseases attended by debility and marked by atony and inertia of organs, more especially in those indicating a disordered state of the hæmatose functions, the preparations of iron will be found in most instances more or less serviceable. Furthermore, I may enumerate scrofula, rickets, dropsy, and gout, as diseases in which iron has been at times used with advantage.

Fer'ri Sesquiox'ydum.—Sesquiox'ide of I'ron.

HISTORY.—Gebert (*Invent. of Verity*, 280) was acquainted with this substance, which he calls *crocus martis*. It was probably known long before his time It is the *red* or *peroxide of iron* of some chemists.

NATURAL HISTORY. — It is found native in the crystallized state (*specular iron* or *iron glance*) and in globular and stalactitic masses (*red hæmatite*): the finest specimen of the first occur in the Isle of Elba; the second is found near Ulverstone in Lancashire, and in Saxony. The hydrated sesquioxide of iron (*brown iron stone*) is met with in Scotland and at Shotover Hill, Oxfordshire. *Yellow ochre* is a hydrated sesquioxide of iron.

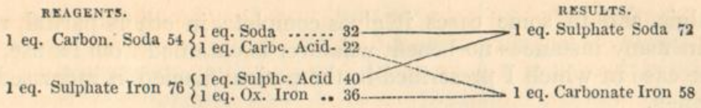
PREPARATION.—There are several modes of preparing this compound.

One method is to calcine crystallized sulphate of iron, by which, first the water and afterwards the sulphuric acid are expelled: the protoxide of iron of the sulphate is peroxidized at the expense of the oxygen of part of the sulphuric acid, and a portion of sulphurous acid gas is developed. The sesquioxide thus procured constitutes the *ferri oxidum rubrum* of the Dublin and Edinburgh Pharmacopœias: in commerce it is called *colcothar*, *caput mortuum vitrioli*, *trip*, *brown-red*, or *rouge*.

Rust of iron (*rubigo ferri*, Ph. Dubl.; *ferri subcarbonas*, Ph. Ed.) is the hydrated sesquioxide sometimes mixed with a little carbonate of the protoxide. It is directed to be prepared by exposing moistened iron (cuttings of wire or filings) to the air, whereby it attracts oxygen both from the air and water. It is then to be reduced to an impalpable powder, by levigation and elutriation. In the shops it is found in little conical masses.

Another mode of preparing sesquioxide of iron is by precipitation. In the London Pharmacopœia it is directed to be procured by mixing a solution of four pounds of sulphate of iron in three gallons of water, with a solution of four pounds and two ounces of carbonate of soda, also in three gallons of water. The precipitated powder, when washed and dried is a hydrated sesquioxide of iron, mixed with a portion of the protocarbonate. It is the *ferri sesquioxydum* of the London Pharmacopœia, (*ferri carbonas*, Ph. Dubl.; *carbonas ferri præcipitatus*, Ph. Ed.) When procured according to the above directions, its colour is reddish chocolate brown; but the greater part of that met with in the shops has been calcined, and is of a brownish red colour.

The *theory* of the last mentioned process is as follows:—One equivalent or 76 parts of sulphate of iron are decomposed by one equivalent or 54 parts of carbonate of soda; one equivalent or 58 parts of carbonate of the protoxide of iron precipitate, while one equivalent or 72 parts of sulphate of soda remain in solution.



By exposure to the air during the washing and drying, the carbonate of the protoxide of iron is decomposed, the oxygen of the air combines with the protoxide, and thereby converts it into sesquioxide, while carbonic acid is disengaged. A portion of protocarbonate usually escapes decomposition.

Properties.—The primary form of the crystals of native sesquioxide of iron is the rhombohedron; that of the native hydrated sesquioxide is the cube.

The artificial sesquioxide of the shops is a brownish red powder: when it has been exposed to an intense heat it sometimes has a purplish tint; the hydrated sesquioxide has a chocolate brown tint. It is odourless, insoluble in water, and not magnetic. Prepared according to the London Pharmacopœia it has a styptic taste; when calcined it is tasteless. When free from carbonate of iron, it dissolves in hydrochloric acid without effervescence.

Characteristics.—Its hydrochloric solution affords a deep blue precipitate with the ferrocyanide of potassium; a purplish black precipitate with tincture of nutgalls; a brownish red precipitate with the alkalies; and a red colour with sulphocyanic or meconic acid.

Composition.—Sesquioxide of iron has the following composition:—

	Eq.	Eq. Wt.	Per Cent.	Gay-Lussac.	Berzelius.
Iron	1	28	70	70·27	69·22
Oxygen	1½	12	30	29·73	30·78
Sesquioxide of Iron	1	40	100	100·00	100·00

When prepared by precipitation, it usually contains some carbonate of the protoxide; and, when digested in hydrochloric acid, some carbonic acid evolves. According to Mr. Phillips, the quantity of carbonate in the preparation of the shops is only 4 per cent.

Purity.—Adulteration is hardly to be apprehended. If it should contain copper, its hydrochloric solution will deposit this metal on a bright rod of iron. After the sesquioxide has been thrown down by ammonia from the hydrochloric solution, the supernatant liquor should give no indications of containing any other metal in solution; and chloride of barium ought not to occasion any precipitate.

Physiological Effects.—It is termed alterative, tonic, and emmenagogue. Its obvious effects on the body are very slight. It produces blackness of the stools; and in large doses occasions nausea, a sensation of weight at the pit of the stomach, and sometimes dyspeptic symptoms. It possesses little or no astringency. The constitutional effects, arising from the continued use of it, are those produced by the ferruginous compounds generally, and which have been before described (p. 534).

Uses.—It may be employed in any of the before mentioned cases (p. 536) in which the ferruginous tonics are indicated.

It has been strongly recommended by Mr. Benjamin Hutchinson (*Cases of Tic Douloureux successfully treated*, 1820) as a remedy for neuralgia, and in some cases it gives complete, in others partial, relief. But in many instances no benefit whatever is obtained from its use, and in one case in which I prescribed it, the patient fancied it increased her sufferings.

Mr. Carmichael, as I have before mentioned (p. 537), has recommended it as a remedy for cancerous diseases.

The use of the hydrated sesquioxide of iron, as an antidote for arsenious acid, has been before noticed (p. 396).

Administration.—The usual dose of this preparation, as a tonic and emmenagogue, is from ten grains to half a drachm, combined with aromatics, to enable it to sit more easily on the stomach. In tic douloureux it is given in much larger doses, as from half a drachm to two, three, or four drachms.

Emplastrum Oxidi Ferri Rubri, Ph. Ed.; *Emplastrum Thuris*, Ph. Dub. (Litharge plaster, ℔ij.; frankincense [concrete juice of Pinus Abies] ℔ss.; red oxide of iron, ℥iij. M. Ph. Dub. In the Edinburgh Pharmacopœia, resin, wax, and oil, are substituted for the frankincense, and the quantity of oxide is nearly three times as much).—This is the old *emplastrum roborans* or *strengthening plaster*, and is employed, spread on a leather, as a mechanical support and slight stimulant, in muscular relaxation, lumbago, weakness of the joints, &c.

Fer'ri Ox'ydum Ni'grum.—Black Ox'ide of I'ron.

History.—It was first employed as a medicine by Lemery in 1735. It is the *martial Ethiops* (*Æthiops martialis*) of some writers, and the *oxydum ferroso-ferricum* of Berzelius. It is sometimes termed the *magnetic oxide*.

Natural History.—It occurs in the mineral kingdom under the name of *magnetic iron ore*, the massive form of which is called *native loadstone*. It is found in Cornwall, Devonshire, Sweden, &c.

Preparation.—In the Dublin Pharmacopœia it is directed to be procured by washing and drying the scales of the oxide of iron (*ferri oxydi squamæ*), and then separating them from impurities by means of a magnet. They are afterwards to be reduced to a very fine powder by levigation and elutriation.

Other modes of preparing this compound are described in chemical works. The above is a cheap method, and yields a product sufficiently pure for the purposes of medicine. The process of the Paris Codex is regarded as a superior one. It consists in covering filings of iron with water, and exposing the mixture to the air; then, by elutriation, separating the black powder.

Properties.—It is a velvet-black powder, soluble in hydrochloric acid without effervescence, and magnetic.

Characteristics.—Its hydrochloric solution affords a green or greenish-brown precipitate with a caustic alkali, and a greenish or blue precipitate with ferrocyanide of potassium. Its other characteristics are the same as those of the ferruginous compounds generally.

Composition.—It is a mixture or compound of protoxide and sesquioxide of iron. According to Mosander (Turner's *Elemetns of Chemistry*), scales of iron have the following composition:—

	Outer layer.		*Inner layer.*	
	Eq.	Eq.Wt.	Eq.	Eq.Wt.
Protoxide of Iron	2	72	3	108
Sesquioxide of Iron	1	40	1	40
Scales of Iron	1	112	1	148

Purity.—It should be readily soluble in hydrochloric acid, without effervescence, by which the absence of metallic iron is shown.

Physiological Effects.—Its general effects are the same as the ferruginous compounds already described (p. 534). It is a more valuable preparation than the sesquioxide, in consequence of being more readily soluble in the fluids of the stomach. When it contains metallic iron it causes eructations of hydrogen gas.

Uses.—It is employed in the same cases as other chalybeates (*vide* p. 536).

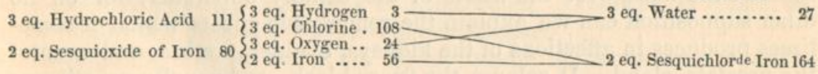
Administration.—The dose of it is from five grains to a scruple twice or thrice daily.

Tinc tura Fer'ri Sesquichlo'ridi.—Tinc'ture of Sesquichlo'ride of Iron.

History.—This compound has been long in use, and is commonly termed the *tincture of the muriate of iron.* It is the *liquor of muriate of iron* (*muriatis ferri liquor*) of the Dublin Pharmacopœia.

Preparation.—In the *London Pharmacopœia* it is prepared by pouring a pint of hydrochloric acid upon six ounces of sesquioxide of iron in a glass vessel, and digesting for three days, frequently shaking; then adding three pints of rectified spirit, and straining. In the *Dublin Pharmacopœia*, one part of rust of iron, six parts of hydrochloric acid, and six parts of rectified spirit, are used; the hydrochloric solution is evaporated to one-third before the spirit is added, by which the excess of hydrochloric acid is driven off. In the *Edinburgh Pharmacopœia*, three ounces of the black oxide of iron, ten ounces(or as much as may be sufficient) of hydrochloric acid, and sufficient alcohol to make the whole amount two pounds and a half: this solution is more apt to decompose, owing to the presence of a larger quantity of protochloride, and the subsequent formation of sesquioxide.

By digestion in hydrochloric acid the sesquioxide becomes the sesquichloride of iron, and some water is formed.



As the sesquioxide of iron employed in the London and Dublin Pharmacopœias contains a small portion of protocarbonate of iron, a little protochloride of iron is formed, and slight effervescence, owing to the escape of carbonic acid, takes place. Both the chlorides of iron are soluble in water as well as in spirit.

Properties.—This tincture is of a reddish brown colour, and stains white paper yellow. It has a sour styptic taste, and an odour of hydrochloric ether, so that it would appear that a mutual reaction takes place between the hydrochloric acid and the alcohol. It reacts on vegetable colours as an acid. " Its sp. gr. is about 0·992, and a fluidounce yields, when decomposed by potash, nearly 30 grains of sesquioxide of iron," (Mr. R. Phillips, *Transl. of the Lond. Pharm.*)

CHARACTERISTICS.—Its reaction on vegetable colours, its inflammability, its remarkable odour, its affording chloride of silver when treated by nitrate of silver, and its reaction, like the other ferruginous compounds (p. 533), are properties sufficient to characterize it. It forms a brown semitransparent jelly with mucilage of gum arabic.

COMPOSITION.—This tincture consists of *rectified spirit*, a small portion of *hydrochloric ether*, *hydrochloric acid*, *sesquichloride of iron*, and a little *proto-chloride of iron*. Unless excess of hydrochloric acid be present, sesquioxide of iron is thrown down when the tincture is exposed to the air, owing to the iron of the chloride attracting oxygen, and becoming sesquioxide.

Sesquichloride of iron has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	J. Davy.
Iron	1	28	34·15	35·1
Chlorine	1½	54	65·85	64·9
Sesquichloride of Iron	1	92	100·00	100·0

PURITY AND STRENGTH.—The commercial tincture of sesquichloride of iron varies in its strength, owing to the varying strength of the hydrochloric acid employed. Moreover, a diluted spirit is frequently substituted for rectified spirit. These differences can only be discovered by examining the colour and specific gravity of the tincture, as well as the quantity of oxide which it yields.

PHYSIOLOGICAL EFFECTS.—This is, in its local action, one of the most powerful of the preparations of iron. It acts as an energetic astringent and styptic, and in large doses as an irritant. The large quantity of free hydrochloric acid which the tincture of the shops frequently contains, contributes to increase its irritant properties; and in Dr. Christison's *Treatise on Poisons* is a brief notice of a case in which an ounce and a half of this tincture was swallowed, and death occurred in about six weeks—the symptoms during life, and the appearances after death, being those indicative of inflammation of the alimentary canal. When swallowed in large medicinal doses it readily disorders the stomach. The general or constitutional effects of this preparation agree with those of other ferruginous compounds. It appears to possess, in addition, powerfully diuretic properties. Indeed it would seem to exercise some specific influence over the whole of the urinary apparatus; for on no other supposition can we explain the remarkable effects which it sometimes produces in affections of the kidneys, bladder, urethra, and even of the prostate gland. It colours the fæces black, and usually constipates the bowels.

USES.—It is sometimes, though not frequently, used as a topical agent. Thus it is applied as a *caustic* to venereal warts, and to spongy granulations. As an *astringent* it is sometimes employed as a local application to ulcers attended with a copious discharge; or as a *styptic* to stop hæmorrhage from numerous small vessels.

Internally it may be employed as a *tonic* in any of the cases in which the other ferruginous compounds are administered, and which I have already mentioned. It has been especially commended in scrofula.

In various affections of the urino-genital organs it is frequently used with great success. Thus, in retention of urine, arising from spasmodic stricture, its effects are sometimes beneficial. It should be given in doses of ten minims every ten minutes until benefit is obtained, which frequently does not take place until nausea is excited. It has been used with success by Mr. Cline (*Med. Records and Researches*, Lond. 1798); by Mr. Collins (*Med. and Phys. Journ.* xvi. 250); by Drs. Thomas, Eberle, and Francis (*Eberle's Treat. on Mat. Med.* ii. 270, 2d ed.); and by Dr. Davy (Paris's *Pharmacologia*, ii. 478, 6th ed.) However, Mr. Lawrence (*Lond. Med. Gaz.* vi. 845), alluding to Mr. Cline's recommendation of it, observes, " I believe general experience has not led others to place any very great confidence in the use of this remedy." In gleet and leucorrhœa it is sometimes serviceable. I have found it occasionally successful, when given in conjunction with the tincture of cantharides, in the latter stage of gonorrhœa, after a variety of other remedies had failed. In passive hæmorrhage from the kidneys, uterus, and bladder, it is likewise employed with benefit.

ADMINISTRATION.—The dose of it is from ten to thirty minims gradually increased to one or two drachms, and taken in some mild diluent.

ANTIDOTES.—In a case of poisoning by it the treatment should be the same as for the mineral acids (*vide* pp. 154 and 208.)

Fer'ri Ammo'nio-Chlo'ridum.—Ammo'nio-Chlo'ride of I'ron.

HISTORY.—This compound, which was known to Basil Valentine, has had various appellations, such as *flores salis ammoniaci martiales*, *ferrum ammoniacale*, or *ferrum ammoniatum*.

PREPARATION.—In the London Pharmacopœia it is directed to be prepared by digesting three ounces of sesquioxide of iron with half a pint of hydrochloric acid in a sandbath for two hours; afterwards adding two pounds and a half of hydrochlorate of ammonia dissolved in three pints of distilled water. The liquor is to be strained and evaporated, and the residue rubbed to powder.

By the mutual reaction of sesquioxide of iron and hydrochloric acid we obtain sesquichloride of iron and water, as explained at p. 541. A small portion of protochloride of iron must also be produced by the action of hydrochloric acid on the carbonate of the protoxide of iron usually contained in the sesquioxide of the Pharmacopœia. By evaporating the solution of the two chlorides with a solution of hydrochlorate of ammonia, we obtain a mixture of these bodies. There is no reason to believe that any chemical combination takes place.

PROPERTIES.—It is met with in the shops in the form of reddish orange-coloured crystalline grains, having a feeble odour and a styptic saline taste. It is deliquescent, and is soluble in both water and alcohol.

CHARACTERS.—Rubbed with quicklime or caustic potash, ammonia is evolved. Its solution affords chloride of silver when mixed with the nitrate of silver. It reacts as a ferruginous salt (p. 533).

COMPOSITION.—It is a mechanical mixture of hydrochlorate of ammonia and sesquichloride of iron, in the following proportions:—

Sesquichloride of Iron	15
Hydrochlorate of Ammonia	85
Ferri Ammonio-Chloridum	100

It yields about 7 per cent. of sesquioxide of iron when decomposed by an alkali (Phillips).

The yellow bands sometimes found in cakes of hydrochlorate of ammonia are probably a true chemical compound of sesquichloride of iron and hydrochlorate of ammonia (*vide* p 180; also Mr. Jackson, *Lond. Med. Gaz.* Aug. 4, 1837).

Physiological Effects.—It produces the general effects of the ferruginous preparations; but, on account of the small and variable quantity of iron present, it is a compound which is of little value. The hydrochlorate of ammonia, which it contains, renders it alterative, and in large doses aperient.

Uses.—It has been employed as a deobstruent in glandular swellings, in amenorrhœa, and other cases where the preparations of iron are usually employed.

Administration.—It may be given in substance in doses of from four to twelve grains.

Tinctura Ferri Ammonio-Chloridi, Ph. Lond. (Ammonio-chloride of iron, ℥iv.; proof spirit, Oj. M.)—" A fluidounce yields by decomposition 5·8 grains of sesquioxide of iron," (Phillips, *op. cit.*) It should be expunged from the Pharmacopœia.

Fer'ri Io'didum.—I'odide of I'ron.

History.—We are indebted to Dr. A. T. Thomson for the introduction of this substance into medicine (*Observat. on the Preparation and Medicinal Employment of Ioduret and Hydriodate of Iron*, 1834).

Preparation.—In the London Pharmacopœia it is directed to be prepared as follows:—Mix six ounces of iodine with four pints of water, and to these add two ounces of iron filings. Heat them in a sand-bath and when it has acquired a greenish colour, pour off the liquor. Wash the residue with half a pint of boiling water. Evaporate the mixed and strained liquors at a heat not exceeding 212° in an iron vessel, that the salt may be dried. Keep it in a well-stoppered vessel, the access of light being prevented. In this process one equivalent or 126 parts of iodine combine with one equivalent or 28 parts of iron to form one equivalent or 154 parts of iodide of iron. Dr. Thomson has " found the soft iron wire used for stringing pianofortes preferable to the filings."

Properties.—It is an opaque iron grey crystalline mass, with a faint metallic lustre and a styptic taste. It may be obtained in acicular crystals. It is fusible, volatile, very deliquescent, and very soluble in both water and alcohol. It readily attracts oxygen from the air, and forms sesquioxide and sesquiodide of iron.

Characteristics.—By the application of heat the violet vapour of iodine is evolved, and sesquioxide of iron is left. If this be dissolved in an acid (hydrochloric, nitric, or sulphuric), the liquid reacts as a solution of a ferruginous salt (*vide* p. 533). Thus, ferrocyanide of potassium strikes a blue, tincture of galls a bluish black, meconic or sulphocyanic acid a red, colour. Furthermore, the alkalies throw down from it the reddish brown sesquioxide of iron.

Composition.—The composition of crystallized iodide of iron, according to Mr. Phillips (*Transl. of the Pharm.*), is as follows:—

	Eq.	Eq.Wt.	Per Cent.
Iron	1	28	14
Iodine	1	126	63·3
Water	5	45	22·7
Hydrated Iodide of Iron	1	199	100·0

Purity.—It should be perfectly soluble in water. By exposure to the air it forms sesquioxide and sesquiodide of iron: the latter is soluble, the former is insoluble, in water. To preserve a solution of this salt, a coil of soft iron wire is to be kept immersed in it: this prevents the formation of sesquioxdide of iron, though it does not that of sesquioxide.

Physiological Effects. (*a.*) *On animals.*—Three drachms of iodide of iron were administered to a dog: vomiting and purging were produced, but in three days the animal was well. One drachm dissolved in a drachm of water killed a rabbit in three hours and a half, with the appearance of gradually-increasing debility: the stomach was found congested, and its lining membrane decomposed. Forty grains injected into the jugular vein of a dog killed the animal within twelve hours: the symptoms were dilatation of the pupils, staggering, vomiting, and bloody stools, (Cogswell, *Essay on Iodine and its Compounds*, p. 128, et seq.)

(*b.*) *On man.*—In *small and repeated doses* its effects are not very obvious, save that of blackening the stools. It passes out of the system in the urine, and both of its constituents may be detected in this fluid. When it does not purge, it frequently acts as a diuretic. In *full doses*, as ten grains, it on one occasion caused uneasy sensation at the epigastrium, nausea, slight headache, copious black stool, and, in two hours, a larger quantity of urine, containing both iron and iodine (Dr. A. T. Thomson, *op. cit.*) Its medicinal influence on the body seems to be stimulant, tonic, and alterative or deobstruent. Dr. Thomson regards it as possessing the combined properties of iron and iodine.

Uses.—In scrofulous affections the united influence of iodine and iron is sometimes beneficial. In chlorosis, and in atonic amenorrhœa, Dr. Thomson found it serviceable; and his testimony of its good effects has been supported by that of others. Its operation must be promoted by exercise and an invigorating diet. In a case of anæmia, without any disturbance of the uterine function, I found it useless; while the compound iron mixture was of essential service. In secondary syphilis occurring in debilitated and scrofulous subjects, it is in some cases, according to the testimony of both Dr. Thomson and Ricord (*Journ. de Pharm.* xxiii. 303), a valuable remedy. The last-mentioned writer employed it in the form of injection (composed of from a half drachm to a drachm of iodide dissolved in eight ounces of water) in blenorrhœas, and in that of lotion in venereal and carious ulcers. Dr. Pierquin (quoted by Dierbach, *Neueste Entd. in d. Mat. Med.* 2te Ausg.) employed it internally and externally in leucorrhœa and amenorrhœa. It has also been used in incipient cancer and in atonic dyspepsia (Thomson).

Administration.—The dose of it is three grains gradually increased to eight or ten. Ricord has given forty grains per day. It may be exhibited in the form of tincture or of aqueous solution, flavoured with a little tincture of orange-peel. It must be remembered that acids, alkalies, and their carbonates, most metallic salts, all vegetable astringents, and many organic solutions, decompose it. Pierquin gave it in chocolate, Bourdeaux wine, distilled water, diluted spirit, or made into lozenges with saffron and sugar. In leucorrhœa and amenorrhœa he employed an ointment (composed of a drachm of iodide to an ounce of lard), by way of friction in the upper part of the thighs.

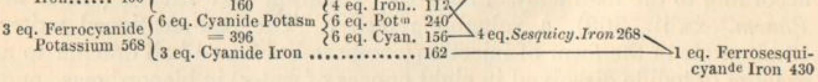
Fer'ri Fer'ro-sesquicyan'idum.—Fer'ro-sesquicy'anide of I'ron.

History.—This compound was accidentally discovered at the commencement of the last century by Diesbach and Dippel. It was termed *Prussian* or *Berlin blue* (*cæruleum Borussicum* seu *Berolinense*). In the London Pharmacopœia it is called *percyanide of iron* (*ferri percyanidum*); in the Dublin Pharmacopœia, *cyanuret of iron* (*ferri cyanuretum*); in the United States Pharmacopœia, *ferrocyanate of iron* (*ferri ferrocyanas*). It is sometimes termed *ferroprussiate of iron*.

Preparation.—It may be prepared by mixing a solution of persulphate or perchloride of iron with a solution of ferrocyanide of potassium.

In commerce it is procured by adding a mixture of two parts of alum and one of sulphate of iron to an impure solution of ferrocyanide of potassium (called *lixivium sanguinis*). A dingy-green precipitate falls, which, by repeated washing with very dilute hydrochloric acid, and exposure to the air, becomes gradually of a deep blue. It is then collected and drained in a cloth, and afterwards dried. By the reaction of ferrocyanide of potassium on sulphate of the protoxide of iron, sulphate of potash is formed in solution, and a white precipitate (cyanide of iron) subsides, which, by exposure to the air, becomes blue (ferrosesquicyanide of iron), in consequence of part of its iron combining with oxygen to form sesquioxide of iron. Ferrocyanide of potassium, with sulphate of the sesquioxide of iron, forms sulphate of potash and ferrosesquicyanide of iron. The green colour of the precipitate above alluded to depends on the presence of sesquioxide (thrown down by the carbonate of potash of the lixivium sanguinis), which is removed by hydrochloric acid. Commercial Prussian blue contains alumina (derived from the alum), and usually some sesquioxide of iron.

The following diagram illustrates the reaction of ferrocyanide of potassium on sulphate of the sesquioxide of iron:—



Properties.—Prussian blue occurs in masses of a rich dark blue colour. It is tasteless and inodorous. When broken it has a copper or bronze tint, somewhat like that of indigo, but which is distinguished from that of the latter by its being removed by rubbing with the nail. It is insoluble in water, alcohol, and the diluted mineral acids. Strong sulphuric acid forms with it a white pasty mass, from which water again separates Prussian blue. Both nitric acid and chlorine decompose it. Hydrochloric acid abstracts part of its iron.

Characteristics.—Its colour and copper tint above described form part of its characteristics. Boiled with water and binoxide of mercury it yields bicyanide of mercury (*vide* p. 487). Boiled with solution of potash it forms ferrocyanide of potassium (*vide* p. 547). Heated in a retort it yields water, hydrocyanate of ammonia, then carbonate of ammonia, and leaves a black, carbonaceous, and ferruginous mass.

COMPOSITION.—The following is the composition of pure and anhydrous Prussian blue:—

	Eq.	Eq.Wt.	Per Cent.			Eq.	Eq.Wt.	Per Cent.
Iron	7	196	45·5	or	Protocyanide of Iron	3	162	37·8
Cyanogen	9	234	54·5		Sesquicyanide of Iron	4	268	62·2
Ferrosesquicyanide of Iron	1	430	100·0			1	430	100·0

PURITY.—Prussian blue of commerce usually contains alumina and sesquioxide of iron. These may be detected by boiling the suspected compound with diluted hydrochloric acid, which dissolves both the impurities. Caustic ammonia added to the filtered solution will throw down the impurities; excess of the alkali will redissolve the alumina.

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.*—Coullon gave it to dogs and sparrows without killing them; and Schubarth states that the only effect produced on a dog by two drachms was dejection (Wibmer, *Wirk. d. Arzneim*, ii. 356).

(*b.*) *On man.*—Its effects on man are not very obvious. It is reputed alterative, tonic, and febrifuge. Sachs (*Handwört d. prakt. Arzneim*, ii. 557) calls it a resolvent tonic.

USES.—It has been recommended by Dr. Zollickoffer (*Treatise on the Use of Prussian Blue in Intermitting and Remitting Fevers*, Maryland, 1822) as a more certain, prompt, and efficacious remedy for intermitting and remitting fevers than cinchona; and particularly adapted for children, on account of its insipidity and smallness of dose. It may be administered during the paroxysm as well as in the intermission, and does not disagree with the most irritable stomach. Hosack (*New York Medical and Physiological Journal*, 1823, quoted by Richter, *Ausf. Arzneim*), Eberle (*Mat. Med.* i. 233), and others, have borne testimony to its good effects. Subsequently, Zollickoffer found it useful in dysentery. Kirkhoff (*Froriep's Notizen*, Bd. xvij. 340) used it for many years in epilepsy, with the best results, having cured some cases of several years' standing. It has also been employed by Dr. Bridges, of Philadelphia, (*United States Dispens.*) in a case of severe and protracted facial neuralgia, with very considerable relief. Lastly, it has been used in the form of ointment, as an application to foul ulcers.

In pharmacy it is employed in the manufacture of bicyanide of murcury.

ADMINISTRATION.—The dose of commercial Prussian blue is from four to six or more grains every four hours. The *ointment* above referred to may be prepared with a drachm of Prussian blue and an ounce of lard.

Potas'sii Fer'ro-cyan'idum.—Fer'ro-cy'anide of Potas'sium.

HISTORY.—This salt was accidentally discovered at the commencement of the last century. It has had a variety of appellations, such as *prussiate of potash*, *ferro-prussiate of potash*, and *ferrocyanate of potash*.

PREPARATION. — The usual method of obtaining it is the following:—"Into an egg-shaped iron pot, brought to moderate ignition, project a mixture of good pearl-ash and dry animal matters, of which hoofs and horns are the best, in the proportion of two parts of the former to five of the latter. Stir them well with a flat iron paddle. The mixture, as it calcines, will gradually assume a pasty form, during which transition it must be tossed about with much manual labour and dexterity. When the conversion into a chemical compound is seen to be completed by the cessation of the fœtid animal vapours, remove the pasty mass with an iron ladle. If this be thrown, while hot, into water, some of the prussic acid will be converted into ammonia, and of course the usual product diminished. Allow it to cool, dissolve it in water, clarify the solution by filtration or subsidence, evaporate, and on cooling, yellow crystals of the ferroprussiate of potash will form. Separate these, re-dissolve them in hot water, and by allowing the solution to cool very slowly, larger and very regular crystals may be had," (Ure's *Dictionary of Chemistry*.)

Properties.—This salt crystallizes in large, beautiful, lemon-yellow, transparent, permanent, inodorous crystals, whose primary form is an octahedron with a square base. They have a peculiar toughness or flexibility somewhat analogous to selenite. Their sp. gr. is 1·832. They have a sweetish, yet somewhat bitter, saline taste. They are insoluble in alcohol, but dissolve readily in both hot and cold water. When moderately heated they evolve about 13 per cent. of water of crystallization, and are converted into a white friable powder (anhydrous ferrocyanide of potassium.) When heated to redness in contact with air, the cyanide of iron of the salt is decomposed and the residuum consists of cyanide of potassium, oxide of iron, and carbon: by a more continued heat hydrocyanic acid and ammonia are evolved, while the residue consists of sesquioxide of iron and carbonate of potash.

Characteristics.—A solution of this salt throws down, with the protosalts of iron, a white precipitate, which by exposure to the air becomes blue. With the persalts of iron it forms a deep blue; with the salts of copper a deep brown; and with those of lead a white precipitate: the precipitates are ferrocyanides of the respective metals. Heated with dilute sulphuric acid, hydrocyanic acid is evolved, and a white precipitate formed, which, by exposure to the air, becomes blue (*vide* p. 236.) Hydrosulphuric acid, the sulphurets, alkalies, or tincture of galls, give no precipitate with a solution of this salt; shewing that the iron which it contains is in some remarkable state of combination. If a solution of the ferrocyanide of potassium be boiled with binoxide of mercury, bicyanide of mercury is formed in solution, and sesquioxide of iron precipitated. The presence of potassium is best shown by calcining the salt, and detecting potash by the usual tests in the residuum. If chlorine be passed through a solution of ferrocyanide of potassium, it abstracts one equivalent of potassium from every two equivalents of the ferrocyanide, by which one equivalent of the ferrosesquicyanide of potassium is formed in solution, and by evaporation this salt may be obtained in the form of red crystals, which throw down a blue precipitate with the protosalts of iron, but occasion no change with the persalts of iron.

Composition.—Crystallized ferrocyanide of potassium has the following composition:—

	Eq.	Eq.Wt.	Per Cent.
Cyanide of Iron	1	54	25·35
Cyanide of Potassium	2	132	61·97
Water	3	27	12·67
Cryst^{d}. Ferrocyanide Potassium	1	213	99·99

PHYSIOLOGICAL EFFECTS. (*a.*) *On animals.* — Schubarth (Wibmer, *Wirk. d. Arzneim.*) gave two drachms to one dog, and half an ounce to another, without observing any injurious consequences. Callies (Wibmer, *op. cit.*, also Christison's *Treat. on Poisons*) found the commercial ferrocyanide of potassium slightly poisonous, but when prepared with care he remarked that several ounces might be given with impunity. These and other experiments show that this salt possesses very little activity. The rapidity with which it is absorbed and gets into the secretions, as the urine, is most remarkable. Westrumb (*Müller's Physiology*, by Baly, i. 247) recognised it in the urine, in from two to ten minutes after it was taken into the stomach. Hering (*Lond. Med. Gaz.* iv. 250) has shown the amazing rapidity with which it traverses the body when it once gets into the blood. Thus, when it was placed in one jugular vein of a horse, he recognised it in the opposite one in from twenty to thirty seconds.

(*b.*) *On man.*—It has no great influence on man. D'Arcet swallowed half a pound of a solution of this salt, prepared as a test, without any ill effects (Merat and De Lens, *Dict. Mat. Méd.* ii. 532). "Similar results," observes Dr. Christison (*Treatise*, p. 699), "were obtained previously with smaller doses by Wollaston, Marcet, Emmert, as well as afterwards by Dr. Macneven and Schubarth, who found that a drachm or even two drachms might be taken with impunity by man and the lower animals."

Dr. Smart (*Amer. Journ. of Med. Sciences*, xv. 362), however, regards it as possessed of some activity. He asserts that its primary action is that of a sedative, softening and diminishing the fulness and frequency of the pulse, and allaying pain and irritation. In a healthy person, he says, a full dose will often reduce the number of pulsations ten beats in a minute, in a few minutes after being taken; and in a diseased state of the system, accompanied with increased arterial action, the sedative effects are much more striking. Occasionally also it acts as a diaphoretic (in cases accompanied with excessive vascular action and increased heat of skin) and astringent, as seen in its power of diminishing excessive discharges. In some cases, he says, it caused ptyalism, with redness, swelling, and tenderness of the gums, but unaccompanied with swelling of the salivary glands or fœtor. An over-dose, he tells us, occasions vertigo, coldness, and numbness, with a sense of gastric sinking; sometimes universal tremors, as in an ague fit. Further evidence, however, is required to confirm these statements, which do not accord with the observations before reported.

USES. — Hitherto it has rarely been employed in medicine. Dr. Smart employed it as a sedative in diseases of increased action of the vascular system and morbid sensibility of the nerves, as in erysipelas, to allay pain, in cephalalgia, in inflammation of the brain, in chronic bronchitis, &c. In the last-mentioned disease it lessened the frequency of pulse, the sweating, the cough, and the dyspnœa. As an anodyne, he gave it in neuralgia. In hooping-cough he speaks highly of it. As an astringent, he administered it to check colliquative sweating in chronic bronchitis and phthisis, to diminish leucorrhœal discharge and to allay diarrhœa. Rau (Dierbach, *Neueste Entd. in d. Mat. Med.* i. 371, 1837) employed it in calculous complaints.

ADMINISTRATION.—The dose, according to Dr. Smart, is from ten to fifteen grains, given in the form of solution every four or six hours. Rau gave as much as forty grains at a dose, and I have no doubt that very much larger doses may be given with safety.

Fer'ri Sul'phas.—Sul'phate of I'ron.

History.—Sulphate of iron is one of the substances which Pliny (*Hist. Nat.* xxxiv. 32) termed *chalcanthum.* This is evident from the circumstance of his statement that the Romans called it *atramentum sutorium*, or *shoe-maker's black.* It is frequently termed *copperas*, and in consequence has been sometimes confounded with the salts of copper (Dr. Cummin, *Lond. Med. Gaz.* xix. 40): *green vitriol* (*vitriolum viride*), *vitriol of Mars* (*vitriolum martis*), *salt of Mars* (*sal martis*), *vitriolated iron* (*ferrum vitriolatum*), are other names by which it has been known.

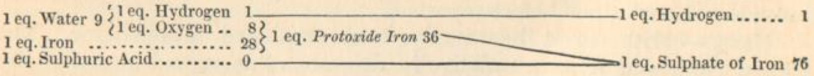
Natural History.—It is found dissolved in some mineral waters (*sulphated chalybeates*, vide p. 145), as those of the Hartfell Spa, Scotland. In the *aluminous chalybeate* waters it is associated with sulphate of alumina; as in the water of Sand Rock, Isle of Wight. The strong Moffatt chalybeate, and Vicar's Brig chalybeate, contain the sulphate of the sesquioxide of iron. Sulphate of iron is also found in the waters of several copper mines.

Sulphate of the protoxide of iron is rarely met native in the crystallized state. It occurs, however, in Rammelsberg mine, near Goslar; at Schwartzenburg, in Saxony; at Hurlet, near Paisley; and in New England (Phillips's *Mineralogy*, by Allan).

Dr. Thomson (*Mineralogy*) has described two native sulphates of the sesquioxide of iron, and an aluminous protosulphate.

Preparation.—Sulphate of the protoxide of iron is prepared by dissolving clean unoxidized iron in diluted sulphuric acid. The proportions employed in the London Pharmacopœia are eight ounces of iron filings, fourteen ounces of sulphuric acid, and four pints of water. The Dublin Pharmacopœia employs two pints more water.

In this process an equivalent or 28 parts of iron decompose one equivalent or 9 parts of water, combine with an equivalent or 8 parts of oxygen, and set free an equivalent or 1 part of hydrogen, which escapes in the gaseous form. The equivalent or 36 parts of protoxide iron, thus formed, combines with an equivalent or 40 parts of sulphuric acid, to form an equivalent or 76 parts of sulphate of iron.



The *common green vitriol*, or *copperas* of the shops, is prepared by exposing heaps of moistened iron pyrites (bisulphuret of iron) to the air for several months. In some places the ore is previously roasted. The moistening is effected by rain or by manual labour. The pyrites attracts oxygen, and is converted into a supersulphate of iron, which is dissolved out by lixiviation; and to the solution thus obtained old iron is added to saturate the free acid. It is then concentrated in leaden boilers, and run off into large vessels (lined with lead) to crystallize.

Properties. — Sulphate of the protoxide of iron crystallizes in transparent pale bluish green crystals, the primary form of which is the oblique rhombic prism. Their sp. gr. is 1·82. They have an acid, styptic taste, and redden litmus. By exposure to the air oxygen is absorbed, and they acquire, first, a yellowish and darker green tint (sulphate of the black oxide), then slightly effloresce, and become covered with a yellow crust, which subsequently becomes a brownish (sulphate of the sesquioxide of iron). When heated the crystals undergo the watery fusion, give out water, and become white and pulverent: at an intense heat they are deprived of their acid. They are soluble in water, but insoluble in alcohol. They require two parts of cold, and three-fourths of their weight of boiling water, to dissolve them. The solution has a bluish green colour, but by exposure to the air it attracts oxygen, becomes reddish yellow, and deposits a tetrasulphate of the sesquioxide of iron.

Characteristics.—It is known to be a sulphate by chloride of barium (*vide* p. 265). Binoxide of nitrogen communicates a deep olive colour to a solution of this salt (*vide* p. 160). Ferrocyanide of potassium causes a white precipitate, which, by exposure to the air, becomes blue with a solution of the sulphate of the protoxide: if any sesquioxide be present, a bluish precipitate is obtained. Alkalies throw down the greenish white hydrated protoxide of iron (*vide* p. 533).

Composition.—The composition of this salt is as follows:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.	Thomson
Protoxide of Iron	1	36	25·9	25·7	26·7
Sulphuric Acid	1	40	28·8	28·9	28·3
Water	7	63	45·3	45·4	45·0
Crystallized Sulphate of the Protoxide of Iron	1	139	100·0	100·0	100·0

Purity.—This salt is frequently mixed with sulphate of the sesquioxide: this may be known by the yellowish green colour of the crystals, and by the blue colour produced on the addition of ferrocyanide of potassium.

The *common green vitriol*, or *copperas* of the shops, is a mixture of the sulphates of the protoxide and sesquioxide of iron. It sometimes contains copper, which may be recognized by immersing a clean iron spatula in a solution of it; the iron becomes incrusted with copper: or it may be detected by adding excess of caustic ammonia, and filtering the liquor. If copper be present, the liquor will have an azure blue tint. The ammoniacal liquid should yield, by evaporation, no fixed residuum.

Physiological Effects. (*a.*) *On vegetables.*—Sir H. Davy (*Agricult. Chem.* 4th ed. 186) ascribes the sterility of a soil to the presence of sulphate of iron.

(*b.*) *On animals.*—C. G. Gmelin (*Vers. ü. d. Wirk.* &c. 84) found that two drachms given to a dog caused vomiting only; that forty grains had no effect on a rabbit; and that twenty grains, thrown into the jugular vein of a dog, produced no effect. Dr. Smith (quoted by Wibmer and by Christison), however, found that two drachms proved fatal to a dog when taken into the stomach or applied to a wound. Orfila (*Toxicol. Gén.*) obtained similar results. The effects were local inflammation and a specific affection of the stomach and rectum. According to Weinhold (quoted by Richter, *Ausf. Arzneim.* v. 55), the spleen of animals fed with it becomes remarkable small and compact.

(*c.*) *On man.*—This salt acts locally as a powerful astringent, and, when employed in a concentrated form, as an irritant. The latter effect depends on its chemical action on the organic constituents (albumen, &c.) of the tissues. The remote effects of sulphate of iron are analogous to those of other ferruginous compounds, and which have been already described.

Swallowed *in small doses* it has an astringent operation on the gastro-intestinal mucous membrane, and thereby diminishes the quantity of fluids secreted or exhaled; hence its continued use causes constipation. It blackens the stools like other compounds of iron. It becomes absorbed, and operates on the system as a tonic, stimulant, emmenagogue, and astringent. *In large medicinal doses* it readily excites pain, heat, or other uneasiness at the pit of the stomach, and not unfrequently nausea and vomiting: this is especially the case in irritable conditions of this viscus. *In excessive doses* it operates as an irritant poison. A girl took, as an emmenagogue, an ounce of it in beer, and was seized, in consequence, with colic pains, constant vomiting and purging for seven hours. Mucilaginous and oily drinks soon cured her (Christison, from *Rust's Magazin*, xxi. 247).

USES.—Sulphate of iron is to be preferred to other ferruginous compounds where there is great relaxation of the solid parts with immoderate discharges. Where the long-continued use of ferruginous compounds is required, it is less adapted for administration than some other preparations of iron, on account of its local action on the alimentary canal.

It is employed in lump, powder, or solution, as a styptic, to check hæmorrhage from numerous small vessels. A solution of it is applied to ulcerated surfaces, and to mucous membranes, to diminish profuse discharges; as in chronic ophthalmia, leucorrhœa, and gleet.

Internally it is administered in passive hæmorrhages, on account of its supposed astringent influence over the system generally: also in immoderate secretion and exhalation; as in humid asthma, chronic mucous catarrh, old dysenteric affections, colliquative sweating, diabetes, leucorrhœa, gleet, &c. In intermittents it has been employed as a tonic. It has also been found serviceable against tape-worm. Its other uses are the same as the ferruginous compounds generally (*vide* p. 536).

ADMINISTRATION.—The dose of it is from one to five grains, in the form of pill. If given in solution the water should be recently boiled, to expel the atmospheric air dissolved in it; the oxygen of which converts this salt into a persulphate. For local purposes, solutions of it are employed of various strengths, according to circumstances. In chronic ophthalmia we may use one or two grains to an ounce of water: as an injection in gleet, from four to ten grains.

Fer'ri Car'bonas.—Car'bonate of I'ron.

HISTORY.—This compound must not be confounded with the sesquioxide of iron, which is frequently termed carbonate of iron.

NATURAL HISTORY.—It occurs native in the crystallized state, constituting the mineral called *spathose iron.* It is also found in most chalybeate waters (*vide* p. 145.)

PREPARATION.—It is prepared by adding a solution of an alkaline carbonate to a solution of a protosalt (as the sulphate) of iron, the atmospheric air being carefully excluded. The carbonate of the protoxide of iron is precipitated. When we attempt to collect and dry it, decomposition takes place; oxygen of the air is absorbed, carbonic acid escapes, and sesquioxide of iron remains (*ferri sesquioxydum*, Ph. L. *vide* p. 538). Hence when employed in medicine it must be prepared extemporaneously.

PROPERTIES.—Native protocarbonate of iron is yellow: the primary form of its crystals is the obtuse rhombohedron. Carbonate of iron prepared as above directed is a white precipitate, which by exposure to the air becomes at first greenish, then brown (sesquioxide). It is insoluble in water, but dissolves in sulphuric or hydrochloric acid with effervescence. It also readily dissolves in carbonic acid water: the acidulo-chalybeate waters are natural solutions of this kind (*vide* p 145.)

CHARACTERISTICS.—It dissolves in diluted sulphuric acid with effervescence. The solution possesses the before-mentioned properties of the ferruginous solutions (*vide* p. 533).

COMPOSITION.—Carbonate of the protoxide of iron is thus composed:—

	Eq.	Eq.Wt.	Per Cent.	Stromeyer. (Native.)
Protoxide of Iron	1	36	62	59·6276
Carbonic Acid	1	22	38	38·0352
Carbonate of Iron	1	58	100	97·6628

PHYSIOLOGICAL EFFECTS.—It is one of the most valuable of the ferruginous compounds, on account of the facility with which it dissolves in the fluids of the stomach and becomes absorbed. Its local effects are very mild.

MISTURA FERRI COMPOSITA, Ph. Lond. and Dubl. (Myrrh, powdered, ʒij.; carbonate of potash, ʒj.; rose-water, f℥xviij.; sulphate of iron, powdered, ℈iiss.; spirit of nutmeg, fʒij.; sugar, ʒij. Rub together the myrrh with the spirit of nutmeg and the carbonate of potash, and to these, while rubbing, add first the rose-water with the sugar, then the sulphate of iron. Put the mixture immediately into a proper glass vessel, and stop it).—This is a professed imitation of Dr. Griffith's celebrated antihectic or tonic mixture (Dr. M. Griffith, *Observ. on the Cure of Hectic and Slow Fevers, and the Pulm. Consump.* 1776): hence it is frequently termed *Griffith's Mixture* (*mistura Griffithii*).

In the preparation of it, double decomposition takes place: by the mutual reaction of carbonate of potash and sulphate of iron we obtain sulphate of potash, which remains in solution, and carbonate of protoxide of iron, which precipitates. To prevent the latter attracting more oxygen, it is to be preserved in a well-stoppered bottle. As more carbonate of potash is used than undergoes decomposition, the excess combines with the myrrh, and forms a kind of saponaceous compound, which assists in suspending the carbonate of iron in the liquid.

When first made, this mixture has a greenish colour, owing to the ferruginous carbonate; but by exposure to the air it becomes reddish, owing to the absorption of oxygen, by which sesquioxide of iron is formed, and carbonic acid evolves: hence it should only be prepared when required for use.

It is one of the most useful and efficacious ferruginous preparations, and which is supposed to be owing to its being readily soluble, and consequently easy of digestion and absorption. Its constitutional effects are analogous to those of the ferruginous compounds in general, and which have been already described. Its tonic and stimulant operation is promoted by the myrrh: the excess of alkaline carbonate must not be forgotten in estimating the sources of activity of this medicine.

It is admissible in most of the cases in which ferruginous remedies are indicated; but it is especially serviceable in anæmia, chlorosis, atonic amenorrhœa, and hysterical affections. It is also employed with benefit in the hectic fever of phthisis and chronic mucous catarrhs. It is contra-indicated in inflammatory conditions of the gastro-intestinal membrane.

The dose of it is one or two fluidounces three or four times a day. Of course acids and acidulous salts, as well as all vegetable astringents which contain gallic or tannic acid, are incompatible with it.

Pilulæ Ferri Compositæ, Ph. Lond. and Dubl. (Myrrh, powdered, ℥ij.; carbonate of soda; sulphate of iron; treacle, a̅a̅ ʒj. Rub the myrrh with the carbonate of soda; then, having added the sulphate of iron, rub them again; afterwards beat the whole in a vessel previously warmed, until incorporated).—This preparation is analogous in its composition, effects, and uses, to the preceding one. Double decomposition takes place between the two salts employed, aad the products are sulphate of soda and carbonate of iron. The carbonate of soda is preferred to the carbonate of potash, on account of the deliquescence of the latter. These pills, like the mixture, should only be made when required for use.

Twenty grains of this compound contain about one grain of protoxide of iron, or $1\frac{7}{10}$ grs. of protocarbonate. The effects and uses are precisely the same as the *mistura ferri composita*. The dose is from ten to twenty grains.

Carbonated Chalybeate Waters. — A most agreeable and efficacious mode of administering carbonate of the protoxide of iron is in the form of the carbonated chalybeate waters, as those of the Islington Spa, near London, of Tunbridge Wells, of Oddy's saline chalybeate at Harrowgate, and of the Spa in Belgium. The last-mentioned water contains a considerable excess of carbonic acid (*vide* p. 145). A convenient extemporaneous mode of administering carbonate of iron in imitation of these waters, is by intimately mixing equal parts (as 10 or 12 grains) of sulphate of iron and sesquicarbonate of soda, and dissolving in a tumblerful of carbonic acid water (soda water of the shops): the solution is to be taken in a state of effervescence.

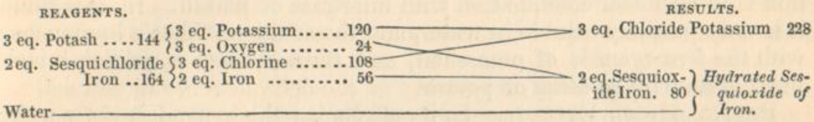
Potas'sæ Fer'ro-Tar'tras.—Fer'ro-Tar'trate of Pot'ash.

History.—This preparation was first described by Angelus Sala at the commencement of the seventeenth century. It is sometimes termed *chalybeated tartar* (*tartarus chalybeatus* seu *ferratus*), *tartarized iron* (*ferrum tartarizatum*); *ferri tartarum*, Ph. Ed.; *tartras potassæ et ferri*, Ph. Dub.; *ferri potassio-tartras*, Ph. Lond.

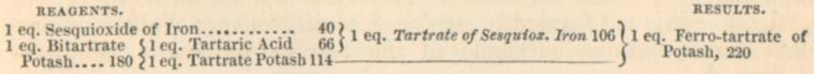
Preparation.—Soubeiran (*Nouv. Traité de Pharm.* ii. 486) directs it to be prepared thus:—Boil together one part of powdered bitartrate of potash, six parts of water, and as much moist hydrated sesquioxide of iron as the liquid will dissolve. Filter and evaporate to dryness by a gentle heat.

The London Pharmacopœia professes to follow Soubeiran's process, but the formula which is given is much more complex; it is as follows:—Mix three ounces of sesquioxide of iron with half a pint of hydrochloric acid, and digest for two hours in a sand bath. Add to these two gallons of water, and set aside for an hour; then pour off the supernatant liquid. Four pints and a half, or as much as may be sufficient, of solution of potash being added, wash what is precipitated frequently with water, and, while moist, boil it with eleven ounces and a half of bitartrate of potash, previously mixed with a gallon of water. If the liquor should be acid when tried by litmus, drop into it solution of sesquicarbonate of ammonia until it is saturated. Lastly, strain the liquor, and with a gentle heat let it evaporate, so that the salt may remain dry.

The *theory* of this process is as follows:—By the reaction of sesquioxide of iron and hydrochloric acid we obtain water and sesquichloride of iron (*vide* p. 541). On the addition of caustic potash, the sesquichloride is decomposed, hydrated sesquioxide of iron is precipitated, and chloride of potassium is left solution. These changes are illustrated by the following diagram:—



When the hydrated sesquioxide of iron is boiled with bitartrate of potash, one equivalent or 40 parts of sesquioxide combine with one equivalent or 66 parts of tartaric acid of the bitartrate of potash, and form an equivalent or 106 parts of tartrate of sesquioxide of iron, which combine with an equivalent or 114 parts of tartrate of potash, to form one equivalent or 220 parts of ferrotartrate of potash.



The processes of the Dublin and Edinburgh Colleges are much inferior to the above, and need not be minutely described. A mixture of iron, bitartrate of potash, and water, is exposed to the air, by which the iron is converted into sesquioxide, and combines with the bitartrate.

PROPERTIES.—It is an olive-brown inodorous powder, with a styptic inky taste. It reacts on vegetable colours, mildly alkaline. It is slightly deliquescent, probably from the tartrate of potash which it contains. It dissolves in about four times its weight of water, and slightly in alcohol.

CHARACTERISTICS.—Ferrocyanide of potassium does not occasion any blue colour with it, unless a few drops of acid be added. Potash, soda, and their carbonates, do not decompose it at ordinary temperatures, nor does ammonia or its carbonate even by the aid of heat. Tincture of nutgalls causes a dark-coloured precipitate. Sulphuric, nitric, or hydrochloric acid, throws down the sesquioxide of iron from a solution of this salt; an excess of acid redissolves it: the solution has then a very astringent taste. Tartaric acid causes the formation of crystals of tartar. Heated in a covered crucible, ferrotartrate of potash yields charcoal, carbonate of potash, and protoxide of iron.

Composition.—The following table exhibits the composition of this salt, according to Soubeiran (*op. cit.*) and Phillips (*Transl. of Pharmacopœia*).

	Phillips.			Soubeiran.	
Tartrate of Sesquioxide of Iron	1	106	48·18	Sesquitartrate of Sesquioxide	45
Tartrate of Potash	1	114	51·82	Tartrate of Potash	55
Ferro-tartrate of Potash	1	220	100·00	,,	100

Soubeiran says it contains 13 per cent. of sesquioxide of iron; whereas, according to Mr. Phillips, the quantity is 18·18 per cent.

The ferro-tartrate of potash is to be regarded as a double salt, in which tartrate of iron is the acid or electro-negative ingredient, and tartrate of potash the basic or electro-positive constituent. On this view, we comprehend why ferrocyanide of potassium and the alkalies refuse to act on it in the way they do on the ordinary ferruginous salts, until an acid be added. Geiger (*Handb. d. Pharm.*) regards it as a combination of tartrate of iron and ferrate of potash.

Purity. — In commerce we frequently meet with an imperfectly prepared compound, in which none or only part of the sesquioxide of iron is in chemical combination with bitartrate of potash. In this state it is only partially soluble in water, and the solution strikes a blue colour with the ferrocyanide of potassium, and throws down a reddish-brown precipitate with solution of potash.

Physiological Effects.—In its effects on the system it agrees, for the most part, with other ferruginous compounds. Its taste, however, is comparatively slight, its astringency is much less than the sulphate or sesquichloride, and consequently its constipating effects are not so obvious, and its stimulant influence over the vascular system is said to be somewhat milder. These peculiarities in its operation are supposed to depend on the tartaric acid and potash with which it is in combination.

Uses.—It is not frequently employed, yet it is a very eligible preparation of iron, and may be employed wherever the ferruginous tonics are indicated.

Administration.—The dose of it is from ten grains to half a drachm, in the form of solution or bolus, combined with some aromatic.

Ammo'niæ Fer'ro-tar'tras.—Fer'ro-tar'trate of Ammo'nia.

This salt, commonly termed *tartrate of iron and ammonia*, or *ammonio-tartrate of iron*, is occasionally employed in medicine. It was first noticed by Mr. Aikin (*Lond. Med. Gaz.* viii. 438).

It may be prepared by adding caustic ammonia to a solution of tartrate of iron (prepared by digesting together, for two or three days, one part of tartaric acid, dissolved in hot water, with two or three parts of iron filings). The green solution thus obtained is to be evaporated to dryness by a gentle heat (Aikin, *op. cit.*)

It is in the form of shining brittle fragments of a deep red colour, not very unlike pieces of very deep-coloured shell-lac. It is very soluble in water. Its taste is strongly saccharine.

Its general effects are analogous to those of the other ferruginous compounds, except that it has very little of any astringency. Its advantages over other chalybeates are its ready solubility in water, its palatable taste, and the facility with which it may be mixed with various saline substances, without undergoing decomposition. It contains more oxide of iron than the same quantity of sulphate. The dose for an adult is five or six grains in powder, pill, or solution. It may be exhibited in porter without being detected by the taste. It may be added to the compound decoction of aloes without suffering decomposition.

Fer'ri Acé'tas.—Ac'etate of I'ron.

History.—A solution of iron in acetic acid has long been known and used in the arts. It constitutes the *iron liquor* of the dyer.

Preparation. — In the Dublin Pharmacopœia acetate of iron is directed to be prepared by digesting, for three days, one part of carbonate of iron (sesquioxide) in six parts of acetic acid, and then filtering.

Properties.—It is a deep-red liquid, having an acid chalybeate taste. It reddens litmus.

Characteristics.—When heated, it yield acetic acid. Ferrocyanide of potassium strikes a blue colour with it; infusion of galls a purplish black.

Composition.—It consists of the acetate of the protoxide and acetate of the sesquioxide of iron.

The Physiological Effects and Uses are the same as other ferruginous compounds. The Dose is from ten to twenty-five drops, in water.

Ferri Acetatis Tinctura, Ph. Dubl. (Acetate of potash, two parts; sulphate of iron, one part; rectified spirit, 26 parts. Rub together the acetate and sulphate, then dry, and add the spirit. Digest for seven days, then filter.)—In this process sulphate of potash and acetate of iron are formed: the latter, as well as the excess of the acetate of potash, dissolves in the spirit. It is a claret-coloured tincture. It possesses the usual properties of a ferruginous compound. It is said to be an agreeable chalybeate, and was introduced into the Dublin Pharmacopœia by Dr. Perceval. The dose is from half a drachm to a drachm.

Tinctura Acetatis Ferri cum Alcohol, Ph. Dubl. (Sulphate of iron; acetate of potash, āā ℥j.; alcohol, ℥xxxij. Triturate together the sulphate and acetate, then dry, and when cold add the alcohol. Digest for twenty-four hours.)—The dose is twenty drops to a drachm.

Order 27.—Binoxide of Manganese.

Mangane'sii Binox'ydum.—Binox'ide of Man'ganese.

History.—Native binoxide of manganese has been long known and used in the manufacture of glass (*magnesia vitriariorum*); but until Kaim, in 1770, succeeded in extracting a peculiar metal from it, it was usually regarded as an ore of iron. It is commonly termed *native black* or *peroxide of manganese*, or for brevity *manganese.*

Natural History.—The oxide of manganese used in chemistry and pharmacy is the native anhydrous binoxide, called by mineralogists *pyrolusite*. It is found in great abundance in Cornwall, Devonshire, Somersetshire, and Aberdeenshire, from whence most of what is met with in commerce in this country is obtained. The principal mines of it are in the neighbourhood of Launceston, Lifton, and Exeter. The Upton Pyne mine, once celebrated for its oxide of manganese, has yielded scarcely any for several years past, if, indeed, it be not completely worked out. Pyrolusite is also found in Saxony, Hungary, France, and other countries of Europe.

Preparation.—Native binoxide of manganese after being raised from the mine is broken into small pieces, about the size of peas, and then washed to separate the earthy impurities. It is afterwards ground in mills to an impalpable powder.

Properties.—This mineral occurs massive, columnar, crystallized, and pulverent: the primary form of the crystals is the right rhombic prism. The massive variety has sometimes a metallic lustre, but is generally dull and earthy: its colour is iron black or brownish: it soils the fingers in handling it: its sp. gr. varies from 4·6 to 4·9: it is tasteless, odourless, and insoluble in water: it yields a black powder.

Characteristics.—When heated it yields oxygen gas. Mixed with common salt and sulphuric acid it gives out chlorine. Heated with sulphuric acid it evolves oxygen, and forms a sulphate of the protoxide of manganese. It is infusible before the blow-pipe; dissolves in fused borax with effervescence, and colours the globule of an amethystine colour. If it be digested in hydrochloric acid until chlorine cease to be evolved, and the solution slightly supersaturated with ammonia, we get rid of the sesquioxide of iron: the filtered liquid throws down a white precipitate with ferrocyanide of potassium.

Composition.—Pure binoxide of manganese has the following composition:—

	Eq.	Eq.Wt.	Per Cent.	Forchhammer	Berzelius & Arfvedson.
Manganese	1	28	63·5	63·75	64·02
Oxygen	2	16	36·5	36·25	35·98
Binoxide of Manganese	1	44	100·0	100·00	100·00

The native binoxide is, however, never pure: it usually contains oxide of iron, carbonate of lime, sulphate of baryta, and argillaceous matter. Its purity is judged of by the quantity of oxygen or of chlorine which it is capable of yielding. The brown varieties are inferior to the black ones.

Physiological Effects.—The effects of this substance are imperfectly known. Kapp (*Hufeland's Journ.* Bd. xix. St. 1, S. 176) first employed it internally. He regards it as a permanent stimulant, and says it promotes the appetite and digestion. Vogt (*Pharmakodynamik*) places it among the tonics, and considers it to be intermediate between iron and lead, but his views are altogether theoretical, as he does not seem to have employed it. Dr. Coupar (*Brit. Ann. of Med.* Jan. 13, 1837, p. 41) has described several cases of disease which took place among the men engaged in grinding it at the chemical works of Messrs. Tennant and Co. in Glasgow: from these it appears, when slowly introduced into the system, to produce paralysis of the motor nerves. The disease commences with symptoms of paraplegia. It differs from lead in not causing colica pictonum or constipation, and from mercury in first affecting the lower extremities, and in not exciting tremors of the affected part. C. G. Gmelin (*Versuche ü. d. Wirkungen*, &c.) tried the effect of the sulphate of the protoxide of manganese on animals, and found that it caused vomiting, paralysis, without convulsions, and inflammation of the stomach, small intestines, liver, spleen, and heart. Gmelin observes, as remarkable, "the extraordinary secretion of bile produced by it, and which was so considerable that nearly all the intestines were coloured yellow by it, and the large intestines had a wax yellow colour communicated to them," (*op. cit.* 90.) It deserves notice, in connexion with this effect, that the *sel désopilant* of Rouvière, used as a quack remedy to evacuate bile, contains chloride of manganese (*Journ. de Chim. Méd.* v. 534.)

Dr. Thomson has seen an ounce of the sulphate swallowed without any effect, except the free action of the bowels, (Coupar, *op. cit.*) Hünefeld (*Horn's Archiv f. Med.* Erf. 1830, quoted by Wibmer, *Wirk. d. Arzn.*) gave to a rabbit nearly two drachms of manganesic acid, in three days, in doses of ten or fifteen grains. The only obvious effect was increased secretion of urine. The animal being killed, the peritoneum and external coat of the colon was found of a greenish colour [protoxide of manganese is green], the muscles were readily lacerated and pale, the liver was inflamed, the bile increased. Wibmer (*op. cit.*) gave six grains daily of the carbonate of the protoxide of manganese to a rabbit during many weeks. No disturbance of function was observed. The animal was killed, but neither in the blood nor the muscles could the least trace of manganese be detected.

Uses.—It is rarely employed in medicine. Kapp (*op. cit.*) administered it, as well as the salts of manganese, internally as well as externally in the various forms of syphilis. In herpes, scabies, and the scorbutic diathesis, he used it with benefit. Brera (Harless, *Neues Journ. d. Ausl. Med. Lit.* Bd. viii. St. 2, S. 57) used it in chlorosis, scorbutus, hypochondriasis, hysteria, &c. Otto (*Frorieps Notizen*, Bd. xii. No. 22, S. 347) administered it in cachectic complaints with favourable results. Odier (*Handb. d. pr. Arzneiwiss.* quoted by Richter) employed it in cardialgia. It has been applied as an absorbent in the treatment of old ulcers, as a depilatory, and as a remedy for skin diseases, especially itch and porrigo (Rayer, *Treat. on Skin Diseases*, by Willis, p. 58.)

Administration.—Internally it has been given in the form of pills, in doses varying from three grains to a scruple, three or four times in the day. As a local agent it has been used in the form of gargle, composed of two or three drachms of the oxide diffused through five or six ounces of barley water. An ointment, consisting of one or two drachms of oxide to an ounce of lard, has also been used.

In chemistry and pharmacy it is employed in the manufacture of oxygen, chlorine, and iodine. In the arts it is used by the bleacher for the production of chlorine; by the glass-maker to destroy the brown colour communicated to glass by iron; and to give an amethystine tint to plate glass; and by the potter for colouring earthenware.

END OF PART I.

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