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

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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$^{\text{er}}$. 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.

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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

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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*).

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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

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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.

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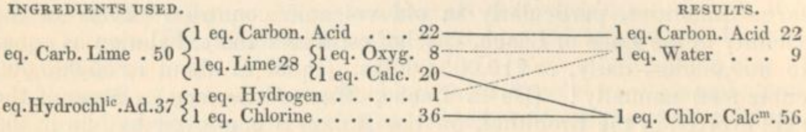
It is produced in the burning of limestone (carbonate of lime) at lime kilns, and by the combustion of charcoal, coal, wood, coal gas, the fire-damp of coal mines, and other combustibles containing carbon.

(*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 stopcock 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

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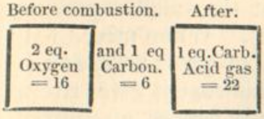
(except in the case above mentioned), and by its forming, with a solution of lime or of baryta, a white precipitate, soluble in acetic acid.

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	0·4166̇	Carb. Oxide gas	1	0·9722̇
Oxygen	2	16	72·73	72·96 to 72·62	Oxygen gas	1	1·1111̇	Oxygen gas	0·5	0·5555̇
Carbonic Acid	1	22	100·00	100·00 . 100·00	Carb. Acid gas	1	1.5277̇	Carb. Acid gas.	1	1·5277̇

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

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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

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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*.

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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.

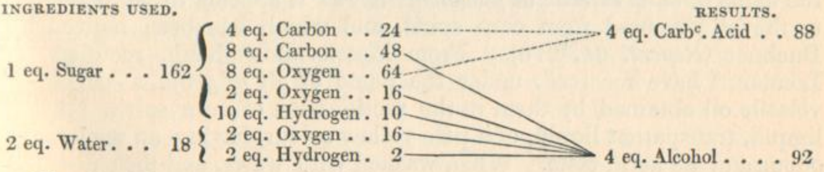
STAGE 1. *PRODUCTION OF A VINOUS LIQUOR.*—When vegetable substances are placed in contact with air and moisture, they undergo that kind of decomposition which is denominated *fermentation*. The products of this process vary at different periods or stages; and on this depends the distinction into kinds 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).
Brandy contain	53·39
Rum	53·68
Gin	51·60
Whiskey (Scotch) contain	54·32
Whiskey (Irish)	53·90

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.

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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 $C^4 H^4 O^2$.

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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	0·833$\dot{3}$
Hydrogen gas	3	0·208$\dot{3}$
Oxygen gas	0·5	0·555$\dot{5}$
Alcohol vapour	1	1·597$\dot{2}$

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

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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

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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

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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.

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(*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.

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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. 12e. 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

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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 blood-vessels 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

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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

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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,

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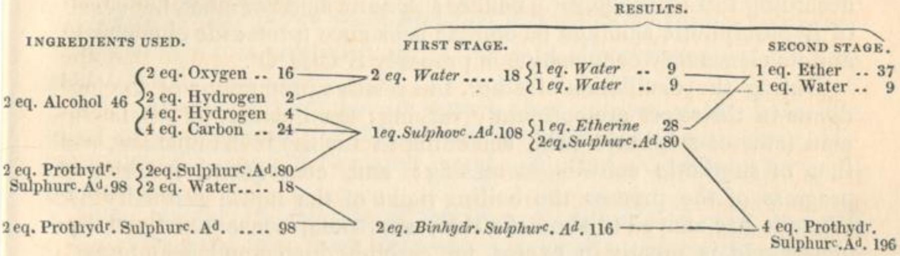
by which ether and sulphuric acid are obtained. Mr. Hennell explains the process in the following way:—Four equivalents or 196 parts of the protohydrated sulphuric acid re-act on two equivalents or 46 parts of alcohol, and produce two equivalents or 18 parts of water, one equivalent, or 108 parts of 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:—

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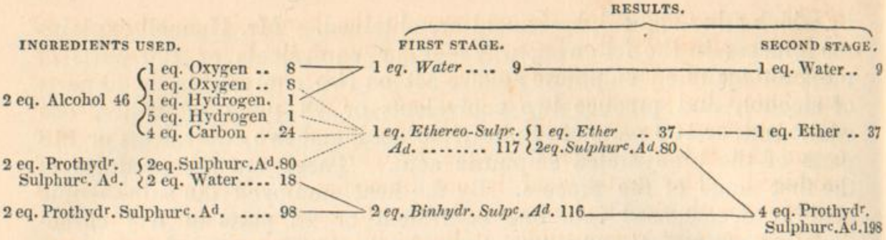

The ethereo-sulphuric acid of Liebig may be viewed as the *hydrate of sulpho-vinic acid* (Hennell),—as a *bisulphate of ether*,—as the *hydrated bisulphate of etherine*,—or, lastly, as the *bisulphate of the oxide of ethereum* (*ethule*).

1 eq.Sulpho-vinicA^{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 $S^{2}C^{4}H^{4}O^{6}$.

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.

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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 $C^4 H^3 O^2 + \dot{H}$ (*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

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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,

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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 contra-indicate 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

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the vapour of the etherial tincture of hemlock is occasionally useful in relieving spasmodic affections of the respiratory organs, and has been 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. $5^{\text{me.}}$ 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 imme-

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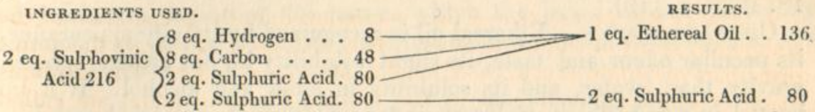
diately remove the retort from the fire. Separate the lighter supernatant liquor from the heavier one, and expose the former to the air for a day. Add to it the solution of potash first mixed with water, and shake them together. Lastly, when sufficiently washed, separate the ethereal oil which subsides." 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.

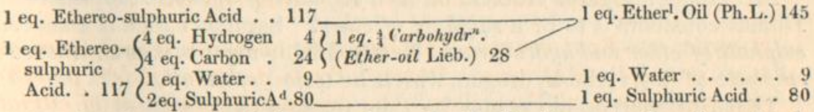
THEORY OF THE PROCESS.—In the first part of the process the changes are the same as those which occur in the process for making sulphuric ether. When the sulphuric acid and rectified spirit are mixed, sulphovinic acid (ethereo-sulphuric acid, according to Liebig) is formed, and by distillation water 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 sulphovinic 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 $\frac{4}{4}$ carbohydrogen, 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 $\frac{4}{4}$ carbohydrogen (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 $\frac{4}{4}$ carbohydrogen (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

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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	2 eq. Sulphuric Acid 80 1 eq. Ether........ 37	1 eq. Sulphuric Acid.. 40	1 eq. Sulph^{c}. Acid . 40
		1 eq. Ether 37	9 eq. Hydrocarbon . 63
1 eq. Ether-oil 28	4 eq. Hydrocarbon .. 28		
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

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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.

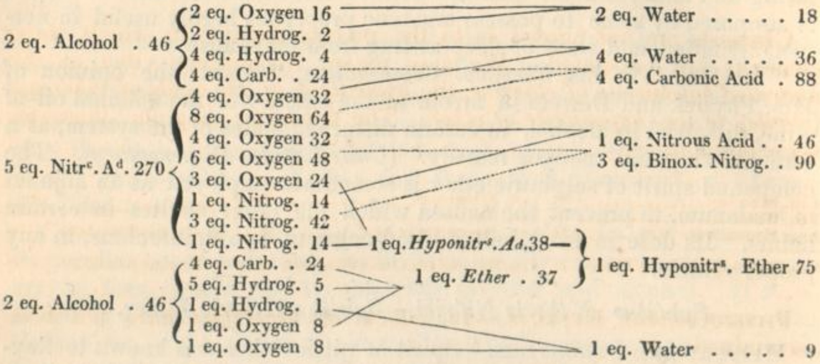
PREPARATION.—The following directions for its preparation are given in the London Pharmacopœia:—"Take of rectified spirit three pounds, nitric acid four ounces: add the acid gradually to the spirit, and mix: then let thirty-two fluid ounces distil." At Apothecaries' Hall it is prepared in an earthenware 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.

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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
Hyponitr^{s}. Ether	1	75	100·00	100·00

	Vols.	Sp. Gr.
Carbon vapour	2 or 4	$1·666\dot{6}$
Hydrogen gas	5	$0·347\dot{2}$
Oxygen gas	2	$2·222\dot{2}$
Nitrogen gas	1	$0·972\dot{2}$
Vapour of Hyponitr^{s}. 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. Hydr^{d}. Hyponitrite Ethere^{e}.	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

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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

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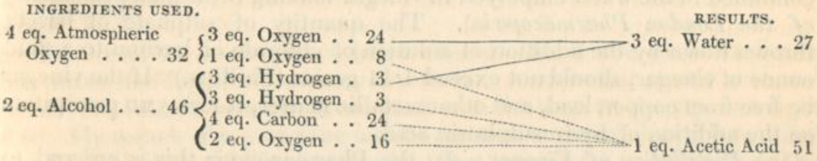
for sale.—(For further information on this subject, consult Aikins' *Dict. of Chem.*, and Donovan's *Domestic Economy*, in Lardner's *Cabinet Cyclopædia*). Green twigs, or fresh cuttings of the vine, recommended by Boerhaave, are sometimes employed, instead of rape, to flavour vinegar.

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,

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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.

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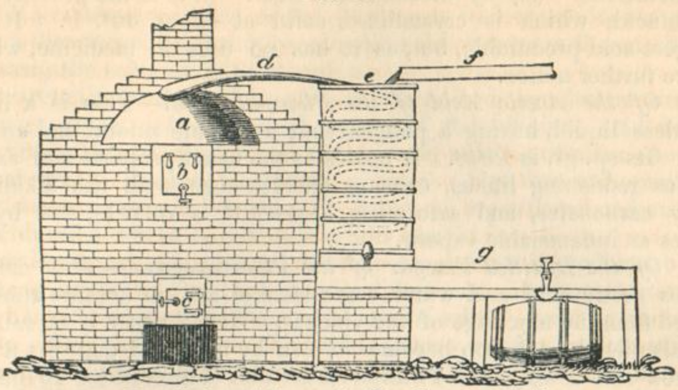
FIG. 46.



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,

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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 4½ 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.*)

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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

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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

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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

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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.

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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,

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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.

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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

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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. 6^{me}.) 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

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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.	Drassier.	Ure.	Proximate Constituents. (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

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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

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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.

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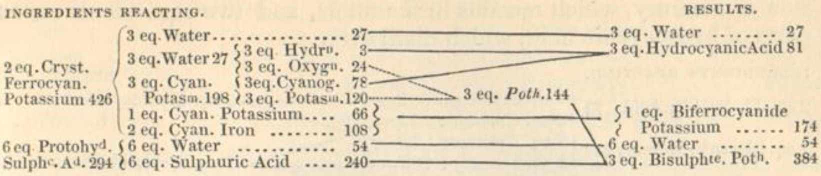
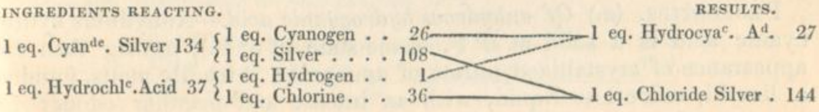


The salt here called biferrocyanide of potassium, is termed, by Mr Everitt, *yellow salt*. I have prepared it with the greatest care, but have always found it to be white. Gay-Lussac also says it is white (*Ann. Chim. et Phys.* t. 46, p. 77). By exposure to the air it becomes blue.

(*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 48½ 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 bichlo-

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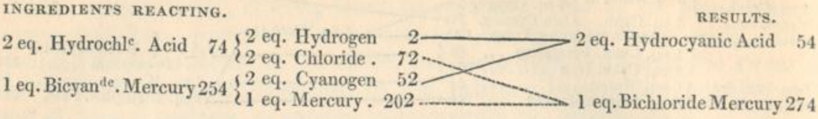
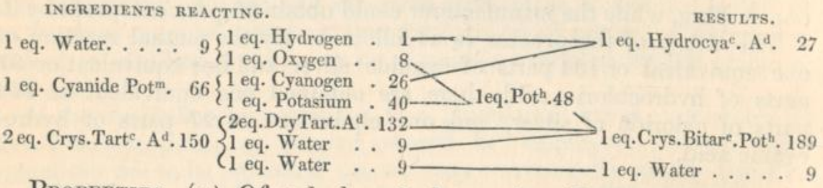
ride of mercury, which remains in the retort, and two equivalents or 54 parts of hydrocyanic acid, which distil over.



(*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

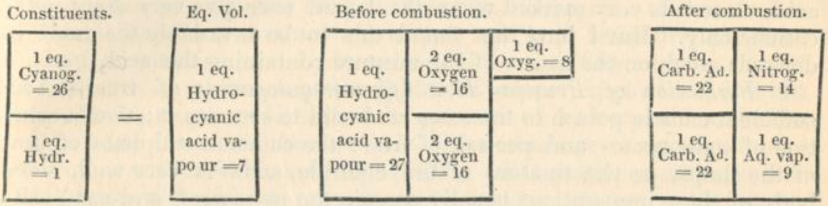
	Vols.	Sp. Gr.
Carbon vapour	1 or 2	$0{\cdot}833\dot{3}$
Nitrogen gas	1	$0{\cdot}972\dot{2}$
Hydrogen gas	1	$0{\cdot}069\dot{4}$
Hydrocyanic vapour	2	$0{\cdot}937\dot{4}$

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	0·9374

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

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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.

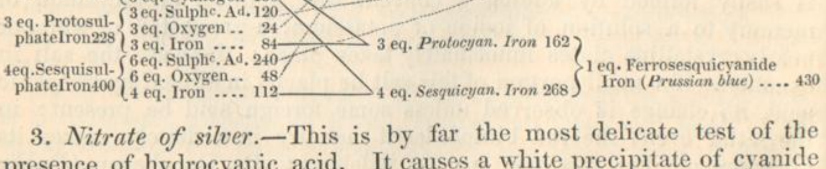
CHARACTERISTICS.—The following are the best tests for hydrocyanic acid.

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.*—*a. 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

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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 sup-

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posed 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

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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,

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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

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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

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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

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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

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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

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