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

SECT. I.—CARBO'NIUM.—CARBON.

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:

α. *In the Inorganized Kingdom.*—When pure and crystallized it constitutes the diamond, which Sir Dr. Brewster (*Edinburgh Philosophical Journal*, vol. iii p. 98; and *Philosophical Magazine*, vol. i. p. 147. 1827.) suspects to be of vegetable origin; but a specimen, described by Mr. Heuland, (*Geological Transactions*, 2d 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. Lond. 1834.)

β. *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 this statement has not been confirmed.

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

1. PLUMBA'GO.—GRAPHITE 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, molybdæna,* met with in Pliny, (*Historia Naturalis*, lib. xxxiv. cap. 47, 50, and 53, ed. Valp.) 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. (*London Medical Gazette*, vol. xviii. p. 267.) 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 (belonging to the rhombohedric system,) or in kidney-shaped masses, or disseminated in rocks. Its colour is iron or steel-gray, 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 usually mixed with variable proportions of silica, 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
Plumbago	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. Graphite has been recently analyzed by Dr. R. F. Marchand, (*Proceedings of the Chemical Society*, No. 1, p. xii. 1841.) who states that 1·4580 *gramme* of native graphite left a residue of pure white silica, without a trace of oxide of iron, weighing only 0·0075. On the erroneous 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*, 3er Bd. p. 486. Berlin, 1828.) says it alters, in some way, the lymphatic secretion and the condition of the skin; and after some days' use, causes increased secretion of urine, with difficulty in passing it.

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

2. CAR'BO LIG'NI, *L. E. D.* (U. S.)—WOOD CHARCOAL.

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 charcoal used in the manufacture of gunpowder is prepared by the distillation of wood in cast iron cylinders, set horizontally (or nearly so) in brick-work, over a furnace. The charge is introduced at the front, and the opening is then perfectly secured by an iron door and bar, well luted. The back part of each cylinder is perforated by two pipes, one above the other, which bend downwards into tubs containing water. The tar flows out by the lower pipe, and the pyroligneous acid by the upper one, and condenses in the receiver (the tub.) The smoke and vapours escape into the air. When sufficiently burnt, the charcoal is raked out into iron boxes, which are immediately covered, to exclude the air. (For some farther details consult Mr. Wilkinson's work on the *Engines of War.* Lond. 1841.) At the Waltham Abbey mills, charcoal is prepared from the Dogwood (*Cornus sanguinea,*) the Alder (*Alnus glutinosa,*) and the Willow (*Salix.*) The Dogwood charcoal (which occasions a peculiar ringing sound when it falls on stones) is used for rifle powder; the other kinds for cannon and musket powder. Lieut.-Col. Moody tells me that the Dutch White Willow (*Salix Russelliana?*) is the best kind of Willow for charcoal, but that the Huntingdon Willow is also a good one. (See also *Acetic Acid.*)

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 boxwood charcoal absorbs 1·75 volumes only of hydrogen gas, but 90 volumes of ammoniacal gas. Some of the properties now mentioned (as that of decolourizing) are possessed, in a more eminent degree, by animal charcoal.

Characteristics.—By combustion 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.

COMPOSITION.—The following is the composition of charcoal obtained from different woods, according to the experiments of Berthier:—(*Traité des Essais par la voie sèche,* t. i. p. 286. Paris, 1834.)

	Poplar.	Maple.	Ash.	Fir.	Alder.	Birch.	Oak.	Hazel.
Carbon	85·6	85·2	83·2	90·3	90·2	88·1	88·0	87·7
Calcined Ashes	1·0	1·0	1·8	2·2	1·8	1·9	2·0	2·0
Volatile Matters	13·4	15·8	15·0	7·5	8·0	10·0	10·0	10·3
Charcoal	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

PHYSIOLOGICAL EFFECTS.—Wood charcoal I believe to be an inert substance both with respect to animals and vegetables. Burdin (*Dict. de Mat. Méd.* art. *Carbone,* t. ii., par MM. Mérat 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 the French edition of Hahnemann's Materia Medica, (*Traité de Matière Médicale,* par S. Hahnemann; traduit par A. J. L. Jourdan. Paris, 1834.) no less than thirty-five pages are occupied with the enumeration of the symptoms produced by 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 fetid 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 [hypochlorites] 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; but it is apt to lodge in the space between the gum and tooth, forming an unsightly livid circle (see p. 212.) Brachet (*Considerations sur l'Usage du Carbone en Médecine.* Paris, 1804.) 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, when 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. and Med. Surg. Jour.* vol. x. p. 15.) In this country, however, I believe, it is 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 the 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.

CATAPLASMA CARBONIS LIGNI, D. *Charcoal Poultice.* (Prepared by taking Wood Charcoal red hot from the fire, extinguishing it by sprinkling dry sand over it, reducing it to a very fine powder, and adding it to the simple cataplasm warm.)—The *simple cataplasm* here referred to is made by adding boiling water to a mixture of one part linseed meal and two parts oatmeal, and smearing it over with olive oil. The charcoal poultice is applied to foul, unhealthy, and gangrenous ulcers, to destroy their fetor and improve their appearance. As an antiseptic, however, it is inferior to the chlorides [hypochlorites] of lime and soda.

3. CAR'BO ANIMA'LIS, *L. E.* (U. S.)—ANIMAL CHARCOAL.

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*, p. 318.)

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

Composition.—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. Paris, 1828.)

Phosphate of Lime Carbonate of Lime	88·0
Charcoal	10·0
Carburet of 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 its use, on account of the free acid in the liquids to be decolourized. Hence the necessity of the purification of animal charcoal.

Animal charcoal, when deprived of its saline matters, usually contains traces of nitrogen. Döbereiner, indeed, supposed it to be a kind of sub-nitruret 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 decolourizing agent in various pharmaceutical processes, as in the preparation of sulphate of quinia, hydrochlorate of morphia, veratria, &c. The theory of its efficacy is imperfectly understood. The superior value of animal to vegetable charcoal is usually referred to the minute separation of the carbonaceous particles effected by the presence of other matters, as of phosphate of lime, when bones are employed. Carbonate of potash is better for this purpose than phosphate of lime. The property possessed by minute particles of charcoal, of abstracting colouring matter from liquids, depends, probably, on some chemical affinities existing between carbon and colouring matter. It is stated, in some works, that charcoal which has been once used cannot have its decolourizing 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 decolourizing power.

CARBO ANIMALIS PURIFICATUS, L. E. *Purified Animal Charcoal* (Animal Charcoal, ℔j.; Hydrochloric Acid [commercial, *E.*] and Water, of each, f℥xij. Mix the acid with the water, and pour it gradually upon the water; then digest for two days with a gentle heat, frequently shaking them. Set by, and pour off the supernatant liquor, then wash the charcoal very frequently with water, until nothing acid is perceptible; lastly, dry it. *L.*—The *Edinburgh College* directs the mixture to be boiled, after the digestion for two days; then diluted with two pints of water; the undissolved charcoal collected in a filter of linen and calico, and washed with water till what passes through scarcely precipitates with solution of carbonate of soda. The charcoal is to be heated first moderately, and then to redness in a closely covered crucible.)—In this 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. The carbonate of soda, used by the Edinburgh College, is for the purpose of detecting the presence of a calcareous salt in the washings.

Purified animal charcoal causes no effervescence when mixed with hydrochloric acid, by which the absence of carbonate of lime is shown. Nor is any precipitate produced by the addition of ammonia, or its sesquicarbonate, to the acid which has been digested in the charcoal, by which the absence of any dissolved calcareous matter is shown: caustic ammonia would precipitate any phosphate of lime in solution, while its sesquicarbonate would yield a white precipitate with chloride of calcium. Purified animal charcoal, "when incinerated with its own volume of red oxide of mercury, is dissipated, leaving only a scanty ash."—*Ph. Ed.*

Purified animal charcoal is used as a decolourizing agent in the preparation of the vegetable alkaloids.

SECT. II.—OXYCARBONS.

1. AC′IDUM CARBON′ICUM.—CARBONIC ACID.

History and Synonymes.—Although the ancients were acquainted with the poisonous properties of carbonate acid gas, Dr. Black, in 1757, was the first who explained its nature. 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.

α. *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 600,000 lbs. daily, or 219,000,000 lbs. (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. D'Arcet has applied the carbonic acid gas, evolved from the mineral waters of Vichy, to the preparation of alkaline bicarbonates.[1] 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.)

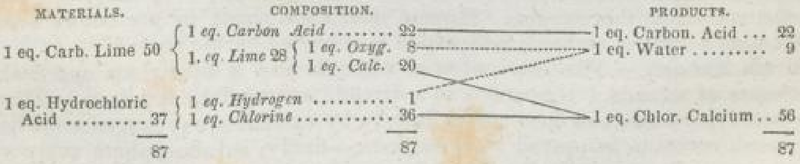
Few mineral waters are without this acid; and in some it exists in such quantity, as to give them a sparkling or effervescent quality (see p. 250.)

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

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

β. *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 the 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 on carbonate of lime. Soda-water makers and the preparers of the alkaline bicarbonates obtain it by the action of sulphuric acid on common whiting. In the laboratory, hydrochloric acid and white marble are generally employed. 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.

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[1] See the description and drawing of the apparatus used in the *Dictionnaire de l'Industrie, Manufacturier, Commerciale et Agricole*, t. iii. p. 60. art. *Carbonates*. Paris, 1835.

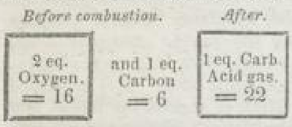
Its specific gravity is 1·5277. It is neither combustible nor a supporter of combustion, except in the case of potassium, which, when heated in this gas, takes fire, the products of the combustion being carbon and carbonate of potash. It extinguishes most burning bodies when introduced into it in the ignited condition. It reddens litmus feebly.

Liquefaction.—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° to 86° F., its bulk increases from 20 to 29 volumes, while the pressure of its vapour augments from 36 to 73 atmospheres.[1]

Solidification.—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, (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 hydrochloric acid. The evolved gas is known to be carbonic acid by the characters before stated. The soluble mono-carbonates form white precipitates in solutions of lime or baryta, soluble in excess of carbonic acid.



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.

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Saussure.*		*Vol.*	*Sp. gr.*		*Vol.*	*Sp. gr.*
Carbon	1	6	27·27	27·04 to 27·38	Carb. vapour	0·5 or	0·4166	Carb. Oxide gas	1	0·9722
Oxygen	2	16	72·73	72·96 to 72·62	Oxygen gas	1	1·1111	Oxygen gas	0·5	0·5555
Carbonic Acid	1	22	100·00	100·00 . 10·000	Carb. Acid gas	1	1·5277	Carb. Acid gas	1	1·5277

Physiological Effects. α. *On Vegetables.*—Carbonic acid gas is injurious to seeds, and diminishes or stops their germination. An aqueous solution of carbonic acid applied to the roots of plants promotes vegetation. An atmosphere containing not more than 1-8th 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. Paris, 1804.) The carbon of plants is derived from carbonic acid, which they take in from the atmosphere, decompose, retain the carbon, and evolve (partially or wholly, according to circumstances) the oxygen. Humus nourishes plants by presenting a slow and lasting source of carbonic acid which is absorbed by the roots.[2]

β. *On Animals.*—The *respiration* of carbonic acid is deleterious and fatal to all classes of animals. It operates as a narcotic or stupefacient poison. That it is a positive poison, and does not act merely by excluding oxygen, as some have supposed, seems to be proved by three facts:—firstly, an atmosphere composed of 79 parts of carbonic acid and 21 of oxygen acts as a poison, although there

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[1] At the Ecole de Pharmacie, in Paris, the apparatus employed in the condensation of the gas burst, and destroyed the *préparateur* (see *Journal de Pharmacie*, t. xxvii; and *London Medical Gazette*, April 16, 1841.)

[2] Liebig's *Organic Chemistry, in its Application to Agriculture and Physiology*, edited by L. Playfair, Ph. D. Lond. 1840.

is as much oxygen present as there is in atmospheric air; secondly, 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, 3d. edit.) and, thirdly, "the cases of insidious poisoning by small doses of carbonic acid scarcely admit of explanation, save on the grounds of the essentially and specifically poisonous action of carbonic acid gas, when sufficiently diluted to become respirable."[1] 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. (Dr. M. Hall *on the Diseases and Derangements of the Nervous System*, p. 66. Lond. 1841.) According to the experiments of Nysten, (*Recherches*, p. 88.) this gas may be *injected into the nervous system* in large quantity, without stopping the circulation, and without acting primitively on the brain; but when more is injected than the blood can dissolve, it produces death by distending the heart, as when air is injected into the veins (see p. 23.) *Applied to the skin of animals*, free access of common air to the lungs being preserved, it produces, if the experiment be continued long enough, death.

γ. *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. It then acts as a narcotic poison. Its specific influence is exercised on the central organs of the cerebro-spinal system, which it probably gains access to, through the medium of the blood. Its action on the nervous system does not depend on its impeding the arterialization of the blood; because death may occur from the respiration of an atmosphere containing sufficient oxygen to support life *per se*, but with which is mixed carbonic acid gas. It is impossible to state the maximum quantity of this gas which may be present in the air without exciting its effects: it probably varies for different individuals, some persons being much more susceptible of its action than others. If the proportion of carbonic acid be large, the effects are almost immediately developed; whereas, if the proportion be small, they are very slowly manifested. Dr. G. Bird has shown that an atmosphere, containing five per cent. of carbonic acid, proved fatal to a bird in thirty minutes; and it is probable that the continued respiration of an atmosphere containing a very considerably smaller proportion of carbonic acid, would be attended with dangerous and even fatal consequences.

The earliest symptom usually experienced by persons exposed to an atmosphere containing carbonic acid gas is throbbing headach, with a feeling of fulness and of tightness across the temples, and in the occipital region. Giddiness, loss of muscular power, a sensation of tightness at the chest, augmented action of the heart, and often palpitation, succeed. The ideas become confused, and the memory partially fails. A buzzing noise in the ears is next experienced; vision is impaired; and a strong tendency to sleep succeeds, or actual syncope ensues. The pulse falls below its natural standard, the respiration becomes slow and laborious, the surface cold and often livid, but the eyes retain their lustre. Convulsions, sometimes accompanied with delirium, foaming at the mouth, and vomiting, come on, and are terminated by death. On post-mortem examination, engorgement of the cerebral vessels, and sometimes serous or even sanguineous effusion, are the usual appearances. (For farther details, I must refer the reader to Dr. Bird's paper before cited.)

Applied to the skin (care being taken that it be not inhaled) it produces a sensation of warmth and prickling or tingling, sometimes accompanied by pain, increased frequency of the pulse, sweating, and excitement of the nervous system.

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[1] Dr. Golding Bird's experiments, in the *Guy's Hospital Reports*, vol. iv. p. 75; also *London Medical Gazette*, N. S. vols. i. and ii. for 1838-9.

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 exhilarating 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, *Méd. Légalé.*) 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. α. *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. But the practice is dangerous. Part of the benefit said to have been derived by consumptive patients from a residence in cow-houses, has been ascribed to the inhalation of carbonic acid gas (see p. 54.)

β. *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 deposite in the urine, carbonic acid water may be taken with advantage; but in this case the common effervescing draught (made of a vegetable acid and a carbonated alkali) must not be substituted for it, on account of the alkaline property communicated by the latter to the urine. From its antiseptic qualities, carbonic acid has been administered internally, in those diseases which are supposed to be connected with a putrescent tendency, as typhoid fevers, &c. (See Dobson's *Medical Commentary on Fixed Air*, 2nd ed. Lond. 1785.)

γ. *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. Mr. Parkin[1] has recommended them in dysentery. The gas may be introduced into the rectum from a bladder, or solutions of tartaric acid and bicarbonate of soda may be injected in the usual way.

δ. *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 (see p. 161.)

ε. *Applied to the skin*, care being taken that the gas be 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

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[1] *On the Efficacy of Carbonic Acid Gas in the Diseases of Tropical Climates; with Directions for the Treatment of Acute and Chronic Stages of Dysentery.* Reviewed in the *London Medical Gazette*, vol. xviii. p. 777. 1836.

in inflammatory cases. In chlorosis, amenorrhœa, dyspepsia, hysteria, scrofula, &c., it has also been found useful.

ζ. 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 carbonic acid water is employed. Or, lastly, we may apply the *yeast poultice* (see *Cataplasma Fermenti.*)

η. *In ophthalmia*, of a chronic kind, a stream of carbonic acid gas, directed on the inflamed part, has appeared to be serviceable. I have seen it used in a case of scrofulous ophthalmia: the patient recovered under its use, after the ordinary plans of treatment had been unsuccessfully tried.

Administration.—Internally, carbonic acid may be administered under the form of *carbonic acid water* or *effervescing draught*. The latter, however, cannot always be employed as a substitute for the former. Where no objection exists to the use of the vegetable salts of potash, the ordinary *effervescing draught* may be administered. 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 to other modes of employing carbonic acid.

Another mode of administering carbonic acid is under the form of the *acidulous* or *carbonated mineral waters* (see p. 250.)

Antidotes.—In accidents arising from the inhalation of carbonic acid gas 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, 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. Apply bottles of hot water to the feet. Stimulants of various kinds may be employed, either internally by the stomach, or in the form of frictions, or inhalations of ammonia, or air impregnated with chlorine gas.

AQUA ACIDI CARBONICI; *Carbonic Acid Water;* (U. S.) *Bottle Soda Water; Soda Water from the Fountain; Artificial Seltzer Water.*—This is prepared by condensing carbonic acid gas (generated by the action of sulphuric acid on whiting) in water. The operation is effected by means of *Tyler's Improved Soda-Water Apparatus.* (See figures in Ure's *Dict. of Arts and Manufactures*, p. 1156. London, 1839.)

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 by the water is doubled, and so on for other degrees of pressure; for Dr. Henry has shown, that the quantity of gas forced into the water is directly as the pressure. In the United States' Pharmacopœia five volumes of gas are directed to be condensed in one volume of water.

The bottle Soda Water of the shops is, in general, carbonic acid water only. Some few manufacturers introduce a small portion of soda (see *Aqua Sodæ Supercarbonatis.*)

Carbonic acid water is a brisk, sparkling liquid. It has a pungent, acidulous taste; reddens litmus; and causes, with lime water, a white precipitate (*carbonate of lime*,) which is re-dissolved by an excess of carbonic acid water.

Carbonic acid water is a refreshing, refrigerant beverage, operating as an anti-emetic, diaphoretic, and diuretic. In febrile disorders it is used to allay thirst, check nausea, and promote secretion. In lithiasis it is employed to check the formation of the phosphates in the urine. It is a convenient vehicle for the exhibition of many medicines, the nauseating qualities of which it diminishes. By the aid of it, extemporaneous imitations of carbonated magnesian and carbonated chalybeate water may be readily made (see *Aqua Magnesiæ Supercarbonatis* and *Aqua Ferri Supercarbonatis.*)

2. AC'IDUM OXAL'ICUM[1].—OXALIC ACID.

History.—This acid was discovered by Scheele, though the credit of its discovery was for a long time given to Bergmann. (See Thomson's *System of Chemistry*, vol. ii. p. 15, 7th ed. Lond. 1831.)

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

α. In the Inorganized Kingdom.—Oxalic acid, in combination with the protoxide of iron, constitutes the mineral denominated by Rivero, *Humboldtine;* by Necker and Beudant, *Humboldtite.*

β. In the Organized Kingdom.—Oxalic acid is found in both plants and animals, but principally in the former.

Oxalic acid, in combination with either lime or potash, is a constituent of a considerable number of plants, especially those belonging to the orders *Polygonaceæ* and *Lichenaceæ.* Oxalate of lime is found in Rhubarb, Bistort, many Lichens, &c. Some Lichens contain nearly half their weight of oxalate of lime. In *Variolaria faginea* [V. communis,] Braconnot found 47·4 per cent. of this salt. Combined with potash, oxalic acid is found in *Oxalis Acetosella, Rumex Acetosa*, Rhubarb, &c. Oxalate of soda is found in *Salsola.* A solution of free oxalic acid is said to exude from the hairs of *Cicer Arietinum*, but the accuracy of the statement is doubtful.

Oxalate of lime constitutes the Mulberry Calculus, and is found in the Liquor Allantoidis of the cow.

Preparation.—Oxalic acid is obtained by the action of nitric acid on sugar or potato starch. Treacle is usually employed in this country as a substitute for solid sugar. The process is generally conducted in open earthenware jars, heated by a warm water bath. The nitrous vapours evolved are usually allowed to escape into the air. In France, attempts have been made to economize them by their employment in the manufacture of sulphuric acid (see *Sulphuric Acid.*) To prevent their noxious influence on the workmen and the surrounding neighbourhood, as well as to economize them, a patent has been taken out to conduct the process in closed vessels connected with receivers and condensers, by which the vapours are condensed and collected again to be used.[2]

Oxalic acid is obtained by digesting, by aid of a gentle heat, one part of sugar, or better still, of potato starch, in 5 parts of nitric acid of sp. gr. 1·42, diluted with 10 parts of water, as long as gaseous products are evolved; by evaporation the acid is obtained in crystals, which may be purified by a second crystallization, after being well dried on paper or porous earthenware. From 12 parts of potato starch, 5 of the acid are obtained. The mother liquor should be treated with an additional quantity of acid, and again warmed, when a second crop of crystals will be obtained: this is repeated until the solution is quite exhausted. (Liebig, in Turner's *Elements of Chemistry*, p. 698, 7th ed. Lond. 1840.)

The formation of oxalic acid depends on the oxidation of organic matter, at the expense of part of the oxygen of the nitric acid, while nitrous vapours are given out. Those organic matters, as sugar and starch, which contain oxygen and hydrogen in the same proportion as water, yield it in the greatest quantity. One equivalent of anhydrous sugar ($C^{12}\ H^{9}\ O^{9}$,) and eighteen equivalents of oxygen (O^{18},) contain the elements of six equivalents of anhydrous oxalic acid ($6\ C^{2}\ O^{3}$,) and nine equivalents of water ($9\ HO$.) But the process is not so simple as this calculation would lead us to suppose. Part of the carbon of the sugar escapes in the form of carbonic acid gas. The mother liquor contains, besides some acetic acid, saccharic acid ($C^{12}\ H^{5}\ O^{11}$;) which, when acted on by a

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[1] This acid has been omitted, inadvertently I presume, in the Edinburgh Pharmacopœia, though it is directed to be employed in the preparation of oxalate of ammonia.

[2] *Repertory of Patent Inventions*, N. S. vol. vii. p. 5. Lond. 1837.—A patent has been taken out for preparing this acid in leaden vessels, and for obtaining it from potatoes, (*Ibid.* N. S. vol. xv. p. 363. Lond. 1841.)

farther portion of nitric, is converted into oxalic and carbonic acids. If the nitrous vapours be conveyed into a condenser, nitric and nitrous acids are deposited.

Properties.—The crystals of oxalic acid are colourless, transparent prisms, which belong to the oblique prismatic system. They are usually flattened, six-sided (by the truncation of one pair of the lateral edges,) and have two or four terminal planes.

Crystallized oxalic acid has often been mistaken for Sulphate of Magnesia, and the consequence has been fatal in many instances. Sulphate of Zinc and Bicyanide of Mercury are likewise apt to be confounded with this acid.

The crystals of oxalic acid taste and react on vegetable colours powerfully acid. When pure they have no odour. Exposed to a warm air they effloresce, evolve 28 per cent. (equal to two equivalents) of water, and become a pulverulent residue (*hydrate of oxalic acid.*) When heated rapidly to 350° F. they fuse, evolve water, and the hydrate of acid sublimes, a portion of it at the same time undergoing decomposition, but no residue being left. They dissolve in 8 parts of water at 60° F., in their own weight of boiling water, and in 4 parts of alcohol at 60° F. By the action of oil of vitriol, aided by heat, they are resolved into water, which remains with the sulphuric acid, and equal volumes of carbonic acid and carbonic oxide gases.

Characteristics.—Oxalic acid reddens litmus, and is volatilized by heat. Nitrate of silver added to a solution of it, yields a white precipitate (*oxalate of silver,*) which is soluble in nitric acid, and when dried and heated on the point of a knife, by the flame of a candle or spirit lamp, becomes brown on the edge, very feebly detonates, and is completely dissipated, being converted into water, carbonic acid, and metallic silver. With lime water, or a solution of chloride of calcium, oxalic acid yields a white precipitate (*oxalate of lime,*) insoluble or nearly so, in excess of oxalic acid, readily soluble in nitric acid, and slightly so in hydrochloric acid. If the precipitate be collected, dried, and calcined, it yields quicklime. With sulphate of copper, oxalic acid yields a blueish white precipitate (*oxalate of copper.*) It reduces the sesquichloride of gold.

To detect oxalic acid in oxalate of lime, proceed as follows:—boil the oxalate with a solution of carbonate of potash for two hours, and filter. The liquor contains oxalate and carbonate of potash. Add acetate of lead, collect the precipitate (*oxalate and carbonate of lead,*) suspend it in water, through which sulphuretted hydrogen is to be passed; filter (to get rid of the dark sulphuret of lead,) boil the clear liquor, which is a solution of oxalic acid, and test as above for the free acid.

If the oxalate of lime were mixed with organic matter, the filtered liquor should be feebly acidulated with nitric acid, before adding the acetate of lead. The acidulated liquor should be filtered, rendered faintly alkaline by carbonate of potash, again filtered, then mixed with acetate of lead, and the precipitate treated as above.

Composition.—Hypothetical or anhydrous oxalic acid, as it exists in dry oxalate of lead, has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Carbon	2	12	33·3̇
Oxygen	3	24	66·6̇
Hypothetical Oxalic Acid	1	36	100·0

Or,	*Atoms.*	*Eq. Wt.*	*Per Cent.*
Carbonic Acid	1	22	61·9
Carbonic Oxide	1	14	38·9
	1	36	100·0

Crystallized oxalic acid contains three equivalents of water, of two of which it may be deprived by heat, leaving, what has been termed, *hydrate of oxalic acid.* The composition of these two substances is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent*
Anhydrous Oxalic Acid	1	36	57·14
Water	3	27	42·86
Crystallized Oxalic Acid	1	63	100·00

	Atoms.	*Eq. Wt.*	*Per Cent.*
Anhydrous Oxalic Acid	1	36	80
Water	1	9	20
Hydrate of Oxalic Acid	1	45	100

Some chemists regard the hydrate of oxalic acid as a real hydracid, composed of $C^2 O^4 + H$.

Impurity.—The crystals of oxalic acid of commerce are sometimes contaminated with nitric acid. In this state they have usually a faint odour, and stain the cork of the bottle, in which they are kept, yellow. If they are exposed to a warm atmosphere, the nitric acid escapes along with the water of crystallization.

Physiological Effects. α. *On Vegetables.*—A solution of oxalic acid acts as a poison to plants.[1] The acid (solid?) has been said to promote the germination of old seeds;[2] but I suspect the statement to be inaccurate.

β. *On Animals.*—The best series of experiments on the effects of this acid on animals are those of Christison and Coindet.[3] They found that concentrated solutions of half-ounce doses of this acid introduced into the stomachs of cats and dogs caused exquisite pain, violent attempts to vomit, dulness, languor, great debility, and death in from two to twenty minutes. Post-mortem examination showed corrosion of the inner coat of the stomach. Large doses of a dilute solution caused great depression of the heart's action; and small doses gave rise to tetanus or narcotism. Farthermore, the acid acts with great violence, and produces nearly the same effects, to whatever part of the body it is applied. From these results it has been inferred that the concentrated acid is a corrosive poison, —while the dilute acid ceases to be corrosive, but, becoming absorbed, acts on the brain, spinal cord, and heart.

It appears to me absurd to suppose, as is usually done, that a dilute solution ceases to act chemically. It does not indeed destroy the gastric membrane as a concentrated solution does, but doubtless it must effect some chemical change on the blood when it gains access to it: though the precise alteration may hitherto have evaded notice. We know that a twentieth part of oxalic acid, added to boiling syrup, renders it thin, and incapable of crystallizing; and we may, therefore, imagine that its action on other organic substances may be equally energetic; and thus alterations may be effected in the condition of the blood, which, though not very marked, may nevertheless be sufficient to render this fluid incapable of supporting life.[4]

γ. *On Man.*—The effects of oxalic acid on the human subject vary somewhat with the dose. When this is large, and the solution concentrated, acute pain is experienced; but, after small doses and dilute solutions, this symptom is not well marked. Vomiting is usually present. The circulation is always depressed; the pulse being feeble or failing, and the surface cold and clammy. Nervous symptoms (such as lassitude, weakness of the limbs, numbness, pain in the back extending down the thighs, and, towards the end, convulsions) have sometimes, but by no means invariably, made their appearance. But death follows so speedily after the injection of large doses, ("few of those, who have died, survived above an hour," *Christison,*) that the symptoms have not been fully made out. If life be prolonged for a few hours, symptoms of gastro-enteritis are observed. Post-mortem examination discovers irritation and often corrosion of the stomach.

Some years since I opened the body of a man, who died in twenty minutes after swallowing oxalic acid by mistake for Epsom salts. The post-mortem examination was made a few hours after death, and while the body was quite warm. The stomach presented a diffused redness, like that of a part affected with erysipelas. The epithelium was destroyed; and presented, in patches, the appearance of the scalded cuticle, or of the pellicle which forms on the surface of boiling saline solutions. I have a wax model of the stomach, executed by the late Mr. Miller.

Uses.—Oxalic acid is not at the present time used in medicine. In France, *Tablettes d'Acide Oxalique* are prepared. Either free or combined with ammonia, it is a valuable test for lime. It is employed for removing ink stains and iron moulds from linen; for cleaning the leather of boot-tops; and for certain styles of discharge in calico-printing.

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[1] Marcet, quoted by De Candolle, in his *Physiologie Végétale*, t. iii. p. 1355. Paris, 1832.

[2] *Repertory of Patent Inventions*, vol. xiii. p. 408. 1832.

[3] *Edinburgh Medical and Surgical Journal*, vol. xix.—In Wibmer's work (*Die Wirkung*, &c. Bd. iv. S. 35.) will be found a notice of the experiments of Rave and Klostermann.

[4] I have before noticed some of Drs. Christison and Coindet's experiments with this acid: see pp. 124, and 133.

ANTIDOTES.—Administer as speedily as possible large quantities of chalk, whiting, or magnesia, suspended in water; by which inert earthy oxalates are formed in the stomach. In the absence of these antidotes, large quantities of warm water may be administered, and at the same time vomiting is to be promoted by tickling the throat. Small quantities of water may prove injurious by favouring absorption. Alkalis do not deprive the acid of its poisonous operation. The stomach-pump and emetics may be used; but on account of the rapidity with which this acid acts, it is not advisable to lose time by their application, until after the antidote has been administered. The same treatment is to be adopted in poisoning by the following salts:—

1. **AMMONIÆ OXALAS,** E. *Oxalate of Ammonia.*—(Oxalic Acid, ℥iv.; Carbonate [Sesquicarbonate] of Ammonia, ℥viij.; Distilled Water, Oiv. Dissolve the carbonate in the water, add gradually the acid, boil, and concentrate sufficiently for crystals to form on cooling.) This salt consists of 1 eq. Oxalic Acid 36, 1 eq. Ammonia 17, and 2 eq. Water 18 = 71. By heat it suffers decomposition, and yields *oxamide*, (*oxalamide*,) composed of HN^2, $C^2 O^2$. Oxalate of ammonia was introduced into the Edinburgh Pharmacopœia as a test for calcareous solutions, with which it produces a white precipitate, (*oxalate of lime*,) which is readily soluble in nitric acid, but is only moderately soluble in hydrochloric acid. It does not occasion any precipitate in solutions of the magnesian salts; hence it is a valuable agent for separating lime from magnesia. According to the experiments of Drs. Christison and Coindet, (*Edinburgh Medical and Surgical Journal*, vol. xix. p. 190.) it is but little inferior in the energy of its operation on the body to oxalic acid. Ninety grains, which contain thirty-six grains of oxalic acid, killed a strong cat in nine minutes. The symptoms were tetanus and coma.

2. **POTASSÆ QUADROXALAS;** *Quadroxalate of Potash.*—This salt is sold in commerce as *Binoxalate of Potash*, *Sal Acetosellæ*, *Salt of Woodsorrel*, or *Essential Salt of Lemons.* It is made by neutralizing one part of oxalic acid with carbonate of potash, and adding to the solution three parts more of acid. It crystallizes in colourless transparent prisms of the doubly oblique prismatic system; and which consist of 4 eq. Oxalic Acid 144, 1 eq. Potash 48, and 7 eq. Water 63 = 255. If three parts of the salt be converted into carbonate by heat, and added to a solution of one part, the neutral oxalate of potash is formed (Liebig.) The commercial quadroxalate is not pure; for I find that it yields, by ignition in a covered crucible, carbonate of potash, contaminated with carbonaceous matter; whereas the pure quadroxalate yields the carbonate only. It is employed for removing ink stains and iron moulds from linen, and for decolourizing straw used for bonnet-making. This salt was formerly used in medicine as a refrigerant. In France, *Tablettes ou Pastilles la Soif* are prepared with it. It possesses poisonous properties similar to, but less energetic than, oxalic acid. A case of poisoning by about an ounce of this salt has been published by my friend and former pupil, Mr. John Jackson.[1] The accident was not known for an hour and a half after it occurred. The symptoms were those of great depression of the heart's action, but without either tetanus or coma. The eyes were sore, the vision dim, the conjunctiva a good deal injured, and the pupils dilated. The patient ultimately recovered.

III.—OXYHYDROCARBONS.

1. AL'COHOL, *L. E. D.* (U. S.)—ALCOHOL.

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, (*Odyssey*, ix. and xxi.) the most ancient of all the profane writers whose works have reached us, and who lived more than 900 years before the Christian era, also frequently mentions wine, and notices its effects on the body, mind, &c. 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. Lond. 1824.) 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

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[1] *London Medical Gazette*, Dec. 18, 1840. In the same journal for March 5th, 1841, is a case of poisoning by about two scruples of oxalic acid swallowed in combination with carbonate of soda (*superoxalate of soda?*)

have lived in the 12th century, taught the mode of procuring spirit from wine. (Gmelin, *Handbuch d. Chimie*, Bd. ii. p. 274.) But as the process of distillation was certainly known long before his time,[1] it is highly probably that his predecessors had submitted fermented liquors to this operation. Raymond Lully,[2] in the 13th century, was acquainted with spirit of wine, (which he called *aqua ardens*,) as well as of 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 liquor; 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 nitrogenous matter, (*ferment*,) is converted into carbonic acid and alcohol; and to this process the name of *vinous* fermentation is applied. Under some circumstances, mannite, lactic acid, and a syrupy mucilage, are formed by the action of the nitrogenous or albuminous principles of vegetable juices on the sugar: this change has been denominated the *viscous* or *mucilaginous* fermentation. (Liebig, in Turner's *Elements of Chemistry*, 7th ed. p. 947. Lond. 1840.) 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 termed 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 requisite.

Both grape and cane sugar yield alcohol by fermentation. It is highly probable, however, "that cane sugar, before it undergoes vinous fermentation, is converted into grape sugar by contact with the ferment; and that, consequently it is grape sugar alone which yields alcohol and carbonic acid." (*Ibid.* p. 946.) On this view, the one equivalent or 171 parts of crystallized cane sugar unite with one equivalent or 9 parts of water, to form one equivalent or 180 parts of grape sugar, which, in the process of fermentation, are converted into four equivalents or 88 parts of carbonic acid, and four equivalents or 92 parts of alcohol.

Vinous fermentation, then, is the metamorphosis of sugar into alcohol and carbonic acid. But as the elements of the yeast or other ferment take no part in the transformation, (that is, do not enter into combination with the elements of the sugar) some difficulty has been experienced in accounting for its agency in exciting fermentation. Two opinions are entertained respecting it: by some it is regarded as a putrefying substance, whose atoms are in continual motion, which they communicate to the constituents of the sugar, and thereby destroy its

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[1] Dr. Royle's *Essay on the Antiquity of Hindoo Medicine*, p. 46. London, 1837.

[2] Thomson's *History of Chemistry*, vol. i. p. 41, Lond. 1830. *Testamentum Novissimum*, p. 2. Edit. Basil, p. 2. 1600.

equilibrium;[1] by others, yeast[2] is considered to consist essentially of seeds or sporules, whose vegetation is the immediate cause of the metamorphosis of the sugar.

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 a mixture of 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 vinous fermentation consists of *water*, *alcohol*, *colouring* and *extractive matters*, *œnanthic ether*, *volatile oil* (*e. g.* oil of potatoes, oil of grain, &c.,) *various acids* and *salts*.

Stage 2. Production of Ardent Spirits.—By the distillation of a vinous liquid we obtain *Ardent Spirit* (*Spiritus Ardens.*) When grape wine is employed, the spirit is called *Brandy* (*Spiritus Vini Gallici*, Ph. Lond.;) 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 denominatod *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 *Whisky*, 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 and 1813.) the average quantities of alcohol (sp. gr. 0·825 at 60° F.) in some kinds of ardent spirit:—

100 *parts* (*by measure*) *of*	*Alcohol* (*by measure.*)	100 *parts* (*by measure*) *of*	*Alcohol* (*by measure.*)
Brandy contain	55·39	Whisky (Scotch) contain	54·32
Rum	53·68	Whisky (Irish)	53·90
Gin	51·60		

Each variety of ardent spirit has an aroma peculiar to itself, and which is characteristic of the substance from which it is produced. This depends on volatile oil.

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 Sikes's 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 pearl ash (carbonate of potash,) which, by its powerful affinity for water, checks the rise of this fluid in distillation. In this way is procured the liquid called *Rectified Spirit* (*Spiritus rectificatus*, L. E. D.,) which is sold by the rectifier to the chemist or apothecary.

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[1] The view above referred to is that entertained by Liebig; for full details of it I must refer to his work, entitled *Organic Chemistry, in its Application to Agriculture and Physiology*, edited by L. Playfair, Ph. D., Lond. 1840; and Turner's *Elements of Chemistry*, 7th ed. p. 944, 1840. Berzelius (*Journ. de Chimie Médicale*, t. iii. p. 425, 2nde Série, 1837) ascribes decompositions of this kind, which are effected by the mere contact of one body with another, to a new force which he supposes to be called into action, and which he denominates *catalytic force* (from καταλυω, I loosen or dissolve.)

[2] The Yeast Plant will be described and figured in a subsequent part of this work, to which the reader is referred. For farther details, consult the Memoirs of Schwann (Poggendorf's *Annalen der Physik*, Bd. XLI, p. 184; "*Pharmaceutisches Central-Blätt* für 1837, S. 547; and Meyen's *Report on the Progress of Vegetable Physiology during the year* 1837. Lond. 1839,) Cagniard-Latour and Turpin, (*Biblioth. Univ. de Genève*, Nov. 1838; and Jameson's *Edinb. New Phil. Journ.*, vol. XXV.,) Kützing, (*Répertoire de Chimie*, t. iii., Paris, 1838,) Quevenne, (*Journ. de Pharm.* t. xxiv.;) and Turpin, (*Mémoires de l'Académie Royale des Sciences de l'Institut*, t. xvii., Paris, 1840.)

1. **Corn Spirit Oil**; *Oil of Grain; Potato Spirit Oil; Fuselöl; Hydrate of Amule; Amilic Alcohol; Bihydrate of Amiline.*—All ardent spirits contain a volatile oil which the Germans (L. Gmelin, *Handb. d. Chemie*, Bd. ii. S. 367.) call *Fuselöl.* In 1825, Pelletan (*Ann. de Chim. et de Physiq.* t. xxx. p. 221; and *Journ. de Chim. Méd.* t. i. p. 76.) described that obtained from Potato Spirit, and which has been subsequently examined, in 1834, by Dumas, (*Ann. de Chim. et de Physiq.* t. lvi. p. 314.) and in 1839, by Cahours. (Ibid. t. lxx. p. 81.) The oil from corn spirit was described several years ago by Buchner. (*Repertorium*, xxiv. 270.) It has been long known to Messrs. Bowerbank, rectifiers, of London, who obtain it in the rectification of corn spirit. From them I procured it several years ago, under the name of *oil of grain;* and, in 1836, noticed it in my lectures. (*London Medical Gazette*, vol. xviii. p. 963.) In 1839, I gave a short description of its properties in the first edition of this work. It has since been more completely examined by Dr. Apjohn. (*Lond. Edin. and Dubl. Phil. Mag.* vol. xvii. p. 86. 1840.) Under the name of *Oleum siticum*, Mulder[1] has described a peculiar oil, which he obtained from corn spirit.

Oil of grain, as I received it from Messrs. Bowerbank, is a limpid, transparent liquid, of a pale yellow colour, and having a very nauseous odour and an acid taste. The inhalation of its vapour produces an unpleasant and persistent sensation in the throat. When washed with water (to remove the alcohol,) and subsequently distilled from chloride of calcium (to deprive it of water,) it is quite colourless, and had, according to my experiments, a sp. gr. of 0·833 at 56° F. [0·813 at 60°, *Apjohn.*] It boils at about 268° F. Dr. Apjohn failed to congeal it at — 6° F.; but Cahours congealed the oil from potato spirit at — 4° F. It burns in the atmosphere with a flame like that of light carburetted hydrogen gas [with a bluish white flame, *Cahours.*] It dissolves iodine; and, according to Dr. Apjohn, is a good solvent for fats, resins, and camphor. It is not miscible with water, which, however, sparingly dissolves it. Neither is it miscible with liquor ammoniæ, nor with liquor potassæ. It dissolves in 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 driven out with considerable violence. When mixed with oil of vitriol, a violet- or blood-red-coloured thick liquid, with the evolution of a mint-like odour, is produced, and, according to Cahours, *sulpho-amulic acid* (bisulphate of oxide of amule $C^{10} H^{11} + O + 2\,SO^{3} + Aq.$) is formed. When distilled with dry phosphoric acid it yields, according to the same authority, a carbo-hydrogen, called *amilene* ($C^{10} H^{10}$.) Potassium rapidly decomposes it with the evolution of hydrogen. If it be heated with fused potash, hydrogen is disengaged, and a compound of potash and *valerianic acid* ($C^{10} H_9 O_3 + Aq.$) is formed.

This oil is composed of carbon, hydrogen, and oxygen. Cahours regards it as the hydrated oxide of a hypothetical base, called *amule* or *amyle* ($C^{10} H^{11}$.) and Liebig has adopted his views.

	Atoms.	Eq. Wt.	Per Ct.	Apjohn.	Dumas.	Cahours.	Or,	Atom.	Eq. Wt.
Carbon	10	60	68·18	68·13	68·6	68·90	Amule	1	71
Hydrogen	12	12	13·64	13·33	13·6	13·58	Oxygen	1	8
Oxygen	2	16	18·18	18·54	17·8	17·52	Water	1	9
Corn Spirit Oil	1	88	100·00	100·00	100·0	100·00	Hydrate of Oxide of Amule	1	88

I am informed by Messrs. Bowerbank, that they obtain from 500 gallons of corn spirit about one gallon of oil, which they employ as a substitute for lamp oil.

2. **Œnanthic Acid and Œnanthic Ether.**—The oily liquid obtained in the distillation of wine is a mixture of Œnanthic acid and Œnanthic ether. (See *Vinum.*)

Properties of Rectified Spirit.—The liquid sold by rectifiers as rectified spirit (*Spiritus rectificatus*, L. E. D.) varies from 54 to 60, or even 64 *per cent. over proof*, in the language of Sikes's hydrometer. Hatters employ that at 54 or 56; varnish-makers that at 58 per cent. over proof. The London College fixes the sp. gr. at 0·838 at 62° F.; the Edinburgh College at 0·838[2], or under, at 60° F.; the Dublin College at 0·844 at 51° F., or 0·840 at 60° F.

Purity.—Rectified spirit, besides having the sp. gr. above mentioned, should be colourless, transparent, and not rendered turbid on the addition of water. "In taste and smell it resembles wine," (*Ph. L.*) Its freedom from other substances than alcohol and water is to be determined partly by the purity of its odour, by the absence of any acid or alkaline reaction, and by its easy and complete volatility. It is frequently contaminated with the *oil of corn spirit;* of the presence

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[1] *Pharmaceutisches Central-Blätt* für 1837, S. 807.—*Siticus*, from σιτικος, of or pertaining to corn.

([2] The alcohol of U. S. P. has a sp. gr. 0·385.)

of which there are two tests, sulphuric acid and nitrate of silver. If colourless oil of vitriol be added to rectified spirit, it causes a red tinge (see p. 312) if the oil be present. According to Vogel, nitrate of silver is a more delicate test for the oil; if it be 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. The following are the directions of the Edinburgh College for the application of this test:—

> "Four fluid ounces [of rectified spirit] treated with 25 minims of solution of nitrate of silver [*Ph. Ed.*,] exposed to bright light for twenty-four hours, and then passed through a filter purified by weak nitric acid, so as to separate the black powder which forms,—undergo no farther change when again exposed to light with more of the test."

The peculiar odour which spirit obtained from brandy or whisky possesses, depends on a volatile oil, which "is best removed, on the small scale, by rectification with a little caustic potash (Göbel, Liebig,) or by digesting the spirits with freshly-ignited pine charcoal." (Turner's *Elements of Chemistry*, p. 829, 7th edit. Lond. 1840.)

PREPARATION OF PROOF SPIRIT.—The sp. gr. of proof spirit (*Spiritus tenuior*, L. E. D.) is fixed by the laws of the kingdom at 0·920 at 60° F. The Dublin College fixes it at 0·923 at 51° F., or 0·919 at 60° F. Proof spirit is usually prepared, by chemists and apothecaries, by mixing rectified spirit with water. The proportions are, Rectified Spirit [sp. gr. 0·838] Ov. [f℥xxj. *E.;* 5¼ parts, *D.;*] and Distilled Water, Oiij. [f℥xij. or a sufficiency, *E.;* 3 parts, *D.*] The tests of its goodness are the same as for rectified spirit.

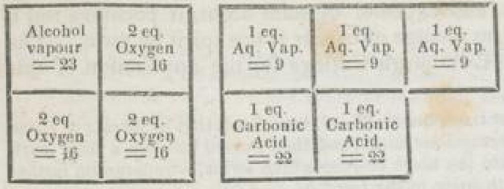
PREPARATION OF ALCOHOL. *Alcohol* (L. E. D.) is prepared by the chemist from the rectified spirit purchased of the rectifier. It is obtained by adding chloride of calcium, carbonate of potash, or well-burnt lime, to the spirit, which is then submitted to distillation. The salts or lime retain the water, while the alcohol distils over. The following are the directions of the British colleges:—

> The *London College* orders Rectified Spirit, *Cong.* j.; Chloride of Calcium, lbj. Put the chloride of calcium into the spirit, and when it is dissolved, let seven pints and five fluid ounces distil.
>
> The *Edinburgh College* directs "Rectified Spirit, Oj.; Lime well burnt, ℥xviij. Break down the lime into small fragments: expose the spirit and lime together to a gentle heat in a glass matrass till the lime begins to slake: withdraw the heat till the slaking is finished, preserving the upper part of the matrass cool with damp cloths. Then attach a proper refrigeratory, and, with a gradually increasing heat, distil off seventeen fluid ounces. The density of this alcohol should not exceed 0·796: if higher, the distillation must have been begun before the slaking of the lime was finished."
>
> The *Dublin College* takes of Rectified Spirit, *Cong.* j. [*wine measure;*] Pearl ashes, dried, and still hot, lbiijss.; Muriate of Lime, dried, lbj. Add the pearl-ashes in powder to the spirit, and let the mixture digest in a covered vessel for seven days, shaking it frequently. Draw off the supernatant spirit, and mix it with the muriate of lime; lastly, distil, with a moderate heat, until the mixture in the retort begins to thicken. The sp. gr. of this liquor should be 0·810.

PROPERTIES OF ALCOHOL.—Alcohol is a limpid, colourless, inflammable liquid, having a peculiar and penetrating odour, and a burning taste. Its sp. gr., at 60° F., is 0·7947; at 68° F. it is 0·792—0·791. It is obvious, therefore, that the *alcohol* of the British colleges is a mixture of alcohol, properly so called, and water.

No means of solidifying it are at present known. It boils at 172° F.: every volume of the boiling liquid gives 488·3 volumes of vapour, calculated at 212° F.

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, unless the supply of oxygen be deficient. The colour of the flame may be variously tinted—as yellow by chloride of sodium, whitish 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.



Before Combustion. *After Combustion.*

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.

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

				Rudberg.	
	Eq.	*Eq. Wt.*	*Per Cent. Wt.*	*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 [condensation 3·77]	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 alkalis, 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 abstracts water from the tissue which, in consequence, shrivels up, 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 water will, however, preserve specimens of the last-mentioned disease in a transparent condition.

Characteristics.—Alcohol and ardent spirits are recognised by their inflammability, odour, taste, and miscibility with water. They dissolve camphor, resin, &c. 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 recognised by the characters above mentioned.

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

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Boullay & Dumas.*	*Saussure.*		*Vol.*
Carbon	2	12	52·18	52·37	51·98	Carbon vapour	1
Hydrogen	3	3	13·04	13·31	13·70	Hydrogen gas	3
Oxygen	1	8	34·78	34·61	34·32	Oxygen gas	0·5
Alcohol	1	23	100·00	100·29	100·00	Alcohol vapour	1

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 (*etherine; tetrato-carbo-hydrogen; quadri-hydrocarburet,*) and two equivalents of water; while some view this liquid as a hydrated oxide of a $\frac{4}{5}$ carbo-hydrogen (*ethule;*[1] *ethereum,*) or as the hydrate of the oxide of ethule. The latter opinions involve the necessity of assuming the equivalent of alcohol to be 46; that is, double the amount stated above. The following table illustrates these views:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Olefiant gas	1	14	60·7
Water	1	9	39·3
Alcohol	1	23	100·0

	Atoms.	*Eq. Wt.*	*Per Cent.*
Etherine	1	28	60·7
Water	2	18	39·3
Alcohol	1	46	100·0

	Atoms.	*Eq. Wt.*	*Per Cent.*
Ethule	1	29	63·04
Oxygen	1	8	17·39
Water	1	9	19·56
Alcohol	1	46	99·99

	Atoms.	*Eq. Wt.*	*Per Cent.*
Ether	1	37	80·43
Water	1	9	19·56
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* (from *υδωρ, water;* and *μετρεω, I measure.*) That employed in this country, in the collection of the duties on spirits, is called *Sikes's hydrometer* (fig. 49.) 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 spirits 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

FIG. 49.

Hydrometer, with one of its ballast weights (a.)
b, Another weight.

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

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[1] *Ethyle,* or *ethule* (from *ether,* and υλη, the material or stuff from which any thing is made,) is the hypothetical radical of the ethers.

Spirit, which is of the strength of 43 *per cent. over proof* at the least, is recognised by the legislature (6 Geo. 4. cap. 80, Sects. 101 and 114.) as *spirits of wine*. All spirit under this strength is known in trade as *plain spirit*. Distillers are not permitted (Ibid. Sect. 81.) to send out spirits at any other strengths than 25 or 11 *per cent. above* or 10 *per cent below proof*. Raw corn spirit, therefore, is sold at 25 or 11 per cent. above proof. *Compounded spirits* (as *Gin*) are not allowed (Ibid. Sect. 124.) to be kept or sent out stronger than 17 *per cent. under proof*; but Gin, as sold by the rectifier, is usually 22 *per cent. under proof*. *Foreign or Colonial spirits* (not being compounded colonial spirits) must not be kept or sent out of less strength than 17 *per cent. under proof*. (Ibid. Sect. 130.) Rum and Brandy, as commonly sold, are 10 *per cent. under proof*.

A series of carefully drawn up tables, showing the relation which exists between the sp. gr. of spirit of different strengths, and the indications of Sikes's hydrometer, is a great desideratum. Mr. Gutteridge[1] has published some tables; but several of his statements do not coincide with experiments which I have made on the subject. The following are extracts from his work:—

	SIKES'S HYDROMETER.	*Sp. Gr. at* 60° F.
Over proof.	70 per centum	0·8095
	64	0·8221
	63.1	0·8238
	62	0·8259
	61·1	0·8277
	60	0·8298
	59·1	0·8315
	58	0·8336
	57·1	0·8354
	56	0·8376
	55·9	0·8379
	55·7	0·8383
	55·0	0·8396
	54·1	0·8413
	50·1	0·8482
	43·1	0·8597
	25	0·8869
	11·1	0·9060

	SIKES'S HYDROMETER.	*Sp. Gr. at* 60° F.
	Proof	0·9200
Under proof.	5 per centum	0·9259
	10	0·9318
	11	0·9329
	15·3	0·9376
	17·1	0·9396
	20	0·9426
	22·3	0·9448
	23·1	0·9456
	25·1	0·9476
	30·1	0·9522
	40·1	0·9603
	50·3	0·9673
	60·4	0·9734
	70·1	0·9790
	80·4	0·9854
	90·2	0·9922
	100 (water)	1·0000

The sp. gr. of spirit may be readily ascertained by *Lovi's beads*, or by the *specific gravity bottle*.

Table[2] *of the Specific Gravities of Mixtures of Spirit* (0·825 *at* 60° F.) *and Water at* 60° F.

Temperature 60° F.	*Sp. gr.*	*Temperature* 60° F.	*Sp. gr.*
Spirit 100 + Water 0	0·82500	Water 100 + Spirit 95	0·93247
" 100 + " 5	0·83599	" 100 + " 90	0·93493
" 100 + " 10	0·84568	" 100 + " 85	0·93749
" 100 + " 15	0.85430	" 100 + " 80	0·94018
" 100 + " 20	0·86208	" 100 + " 75	0·94296
" 100 + " 25	0·86918	" 100 + " 70	0·94579
" 100 + " 30	0·87568	" 100 + " 65	0·94876
" 100 + " 35	0·88169	" 100 + " 60	0·95181
" 100 + " 40	0·88720	" 100 + " 55	0·95493
" 100 + " 45	0·89322	" 100 + " 50	0·95804
" 100 + " 50	0·89707	" 100 + " 45	0·96122
" 100 + " 55	0·90144	" 100 + " 40	0·96437
" 100 + " 60	0·90549	" 100 + " 35	0·96752
" 100 + " 65	0·90927	" 100 + " 30	0·97074
" 100 + " 70	0·91287	" 100 + " 25	0·97409
" 100 + " 75	0·91622	" 100 + " 20	0·97771
" 100 + " 80	0·91933	" 100 + " 15	0·98176
" 100 + " 85	0·92225	" 100 + " 10	0·98654
" 100 + " 90	0·92499	" 100 + " 5	0·99244
" 100 + " 95	0·92758	" 100 + " 0	1·00000
" 100 + " 100	0·93002		

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[1] *The Ne Plus Ultra of Assaying, Weighing, Measuring, and Valuing of Spirituous Liquors*, vol. ii. By W. Gutteridge. London, 1828

[2] Drawn up from Gilpin's Tables in the *Philosophical Transactions* for 1792.—The spirit, which Mr. Gilpin called alcohol, was composed of 89 alcohol (sp. gr. 0·796 at 60° F.) and 11 water.

Another mode of judging of the strength of spirits 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.

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

β. *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 (*Treatise on the Venom of the Viper*, translated by J. Skinner, vol. ii. p. 371, *et seq.*) found, that when half the body of a leech was plunged in spirit, this part lost all motion, whilst the other half continued in action. The same experimentalist observed, that spirit killed frogs, when administered by the stomach (in doses of 40 drops,) injected beneath the skin, or when applied to the brain or spinal marrow. Plunging the heart of this animal into 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. 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.[1] 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. I have given alcohol to birds, but have hitherto been unable to discover the physical changes here stated. 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. Farthermore, 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, (*Philosophical Transactions* for 1712.) Fontana, (*Op. supra cit.*) Viborg, (*Ab-*

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[1] *Recherches sur les fonctions et les propriétés du système nerveux dans les animaux vertébrés.* Paris, 1824.

handl. für Thierärzte, Theil II. quoted by Wibmer, *Die Wirkung*, &c.) Brodie, (*Philosophical Transactions* 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.

γ. *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.

αα. *The local effects of alcohol* or *rectified spirit* are those of a powerfully irritant and caustic poison. To whatever part of the body this agent is applied, it causes contraction and condensation of the tissue, and gives 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* p. 121,) 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 on the chemical influence of the poison.

ββ. *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]

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 (*In vino veritas.*) 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 character of this stage is a disordered condition of the intellectual functions and volition; manifested by delirium, varying in its characters in different individuals, and by an incapability of governing the

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[1] The newspaper reports of the proceedings at the Metropolitan Police Offices furnish examples of the employment, by the lower classes, of certain terms to designate the different degrees of the effects of fermented and spirituous liquors. When an individual is merely excited, he is described as *fresh;* but neither tipsy nor drunk. When the disordered intellect is just commencing, he is said to be *half seas over.* When he is beginning to be unsteady in his gait, he is described as being *tipsy.* When he reels, falls about, is incapable of standing, but is yet sensible, he is said to be *drunk.* And, lastly, when he is insensible or nearly so, he is described as *dead drunk.*—Sir Walter Scott (*Waverly*) distinguishes *fuddled* or *half seas over* (*ebriolus*) from *drunken* (*ebrius.*)

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 headach, loathing of food, great thirst, and lassitude: the tongue is furred and the mouth clammy.

During a paroxysm of drunkenness, certain peculiarities are observed in the character of the delirium in different individuals. These appear to depend on what is commonly denominated temperament. (See p. 148.) Mr. Macnish (*The Anatomy of Drunkenness*, p. 43, 2nd ed. Glasgow, 1828.) has offered a classification of drunkards, founded on these peculiarities. He describes the *sanguineous drunkard*, *the melancholy drunkard*, *the surly drunkard*, *the phlegmatic drunkard*, *the nervous drunkard*, and *the choleric drunkard*.

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, 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. 180 and 181.)

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. The delirium is of a peculiar kind. It usually consists in the imagined presence of objects which the patient is anxious to seize or avoid. 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. Sometimes it is more allied to nervous fever. Opium has been found an important agent in relieving it.

Insanity is another disease produced by the immoderate and habitual use of spirituous liquors. In 110 cases of this disease, occurring in male patients admitted into the Hanwell Asylum in 1840, no less than 31 are ascribed to intemperance, while 34 are referred to combined causes, of which intemperance is stated as one. It is remarkable, however, that of 70 female patients, admitted during the same year, only four cases are ascribed to intemperance.[1]

Disease of the liver is frequently met with in drunkards, who use ardent spirits. It is generally of the kind termed, by Baillie, *common tubercle of the liver;* by Dr. Elliotson, (*London Medical Gazette*, vol. xii. p. 484.) the *gin liver;* by others, *granulated*, *lobulated*, *mamellated*, or *scirrhous liver*. Laennec calls it *cirrhosis*, (from κιρρος, *yellowish*,) in reference to its usual tawny, yellow colour. A beautiful representation of it is given by Cruveilhier. (*Anatom. Patholog.* liv. 12^e, pl. 1.) Dr. Carswell (*Pathological Anatomy*, 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 the late Dr. Hope. (*Principles and Illustrations of Morbid Anatomy*. Lond. 1834.)

Stomach affections are common results of dram-drinking. Persons addicted to the use of ardent spirits suffer with loss of appetite, and are usually dyspeptic; and chronic inflammation of the stomach, or even a scirrhous state of the pylorus, has been said to be occasionally produced by hard drinking.

Dram-drinkers are sometimes affected with *granular disease of the kidneys*,

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[1] *Report of the Resident Physician* [Dr. Conolly] *of the Hanwell Lunatic Asylum, presented to the Court of Quarter Sessions at the Middlesex Sessions*, 1840.

first described by Dr. Bright, and which is generally attended by albuminous urine. Dr. Hope regards this state as corresponding to the granular liver just described.[1]

Peculiarities of Intoxication from Spirit.—Different kinds of ardent spirits present some peculiarities in their operation on the system, which will be noticed hereafter (see *Brandy*, *Rum*, *Gin*, *Whisky*, and *Arrack*.)

The effects of spirit agree, in a considerable number of circumstances, with those of wine, but present some peculiarities. Spirit more speedily induces excitement, which, however, is of shorter duration, being more rapidly followed by collapse, relaxation, or debility. Death is by no means an infrequent consequence of deep intoxication from spirit. Dram-drinkers suffer usually with loss of appetite, especially in the morning, when they are troubled with vomiting. Moreover they are usually thin, wasted, and emaciated. Wine-bibbers, on the other hand, often enjoy an unimpaired appetite, and are frequently plump or corpulent, plethoric individuals. Liver disease, from intemperance, is said to be peculiar to those who take ardent spirits. Organic disease of the stomach is also a consequence of spirit drinking.

A somewhat similar distinction holds good between the effects of spirit and those of malt liquors. The latter possess nutritive properties in addition to narcotic powers: hence we frequently observe that the beer toper is a plethoric, corpulent individual.[2]

The effects of opium are readily distinguished from those of spirit when insensibility has not come on. The sleep which both these agents commonly induce is not usually preceded, in the case of opium, by delirium, thickness of voice, and peculiar difficulty of articulation. When delirium is produced by this drug (opium) it is rather of the ecstatic kind. "There is more poety in its visions—more mental aggrandizement—more range of imagination." (*The Anatomy of Drunkenness*, by Robert Macnish; p. 63, 2d ed. Glasgow, 1828.) But when insensibility is present the diagnosis is not always easy. The odour of the breath is in these cases an important diagnostic. Moreover, the pupil is usually (though not invariably) dilated by spirit, whereas it is contracted by opium.

Modus Operandi.—That alcohol becomes absorbed is proved by the fact, that it has been found in the blood, in the urine, the breath, the bile, the fluid of the serous membranes, the brain, and the liver.

Tiedemann and Gmelin (*Uber die Wege auf welchen Substanzen aus den Magen ins Blut gelangen.* Heidelberg, 1820.) recognised the odour of it in the blood of the splenic vein, though they were unable to detect it in the chyle. A similar observation is reported by Magendie. (*Element. Compend. of Physiology*, by Dr. Milligan, p. 248. 1823.) Dr. Percy[3] also found it in the blood of the animals to whom he had administered it. He likewise detected it in the urine and the bile. 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. Lond. 1820,) 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. Dr. Christison (*Treatise on Poisons*, p. 853. 3rd ed.) has questioned the correctness of this observation, on the ground that gin of sufficient strength to take fire could not enter the blood-vessels without coagulating the blood. But the objection appears to me to be groundless; for I find that a small quantity of undiluted commercial gin may be added to white of egg without causing either

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[1] See also Dr. Christison *On Granular Degeneration of the Kidneys*, p. 110. Edinb. 1839.

[2] Hogarth, in his *Beer Alley* and *Gin Lane*, has well represented the differences between drunkards devoted to malt liquors, and those given to the use of spirit. The first are plump, rubicund, and bloated; the latter are pale, tottering, emaciated, and miserable.

[3] *An Experimental Inquiry concerning the presence of Alcohol in the Ventricles of the Brain, after Poisoning with that liquid, together with Experiments illustrative of the Physiological Action of Alcohol.* Lond. 1839.

coagulation or the slightest opacity. Dr. Ogston (*Edinburgh Medical and Surgical Journal*, vol. xl.) has confirmed the testimony of Carlisle, and states, that in one case he found about four ounces of fluid in the ventricles, having all the physical qualities of alcohol. Dr. Percy (*Op. supra cit.*) has recently set the question at rest, and satisfactorily proved the accuracy of the above statements, by his experiments on animals. He appears to think that some peculiar affinity exists between the substance of the brain and the spirit; more especially as, after analyzing a much larger quantity of blood than can possibly exist in the cranium, he could generally obtain much more alcohol from the brain than from this quantity of blood. He was unable to determine whether or not the fluid of the ventricles contained any alcohol. Dr. Percy also detected alcohol in the liver, and has endeavoured to connect this fact with the frequent occurrence of hepatic disease in drunkards.

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 spirit may or may not be found in the stomach, according to the rapidity with which death has been produced. The odour of spirit may perhaps be recognised in various parts of the body, especially in the brain and the serous cavities.

USES.—Spirit of wine is employed both for medicinal and pharmaceutical purposes.

1. **Medicinal Uses.**—Spirit is used both internally and externally:—

α. **Internally.**—Spirit of Wine is rarely administered internally; for when ardent spirit is indicated, Brandy, Gin, or Whisky, is generally employed. The separate uses of each of these will be noticed presently: at present, therefore, I shall confine myself to some general remarks on the internal employment of spirit. I may observe, however, that Brandy is the ardent spirit usually administered for medicinal purposes; and, unless otherwise stated, is the spirit referred to in the following observations.

As a *stomachic stimulant*, spirit is employed to relieve spasmodic pains and flatulency, 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*, it is given with considerable advantage in the latter stages of fever. As a *powerful excitant*, it is used to support the vital powers, to prevent fainting during a tedious operation, to relieve syncope and languor, and to assist the restoration of 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 such cases it is advisable to allow, temporarily, the patient the moderate use of the particular kind of spirit which he has been in the habit of employing. In *poisoning by foxglove and tobacco*, spirit and ammonia are used to rouse the action of the heart. In *mild cases of diarrhœa*, attended with griping pain, but unaccompanied by any inflammatory symptoms, a small quantity of spirit and water, taken warm, with nutmeg, is often a most efficacious remedy.

β. **Externally.**—Spirit of wine is used externally for several purposes, of which the following are the principal:—*As a styptic*, to restrain hemorrhage from weak and relaxed parts. It proves efficacious in two ways:—it coagulates the blood by its chemical influence on the liquid albumen and fibrin, and it causes the contraction of the mouths of the bleeding vessels by its stimulant and astringent qualities. Sponge or soft linen, soaked in spirit and water, has been applied to the mouth of the uterus in uterine hemorrhage. (Richter, *Ausführliche Arzneimit-*

tellehre, 3er Bd. S. 256. Berlin, 1828.) *Spirit is used to harden the cuticle over the tender and delicate parts.* Thus, brandy is sometimes applied to the nipples, several weeks before delivery, in order to prevent the production of sore nipple from suckling in individuals predisposed to it. Spirit is also applied to the feet, when the skin is readily blistered by walking. 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. (*An Essay on Burns.* Lond. 1798.—*A Second Essay on Burns.* Newcastle, 1800.) 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; on the hypogastric region, to stimulate the bladder, when retention of urine depends on inertia, or a paralytic condition of this viscus; on 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 (see p. 64.) 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 inflammations, &c.

ANTIDOTES.—The first object in the treatment of poisoning by spirituous liquors is to evacuate the contents of the stomach. This is best effected by the stomach-pump; emetics being frequently unsuccessful. Stimulants are then to be employed: the most effectual are the injection of cold water into the ears, cold affusion to the head and neck, warmth to the extremities, when these are cold, and the internal use either of ammonia, or of the solution of the acetate of ammonia, both of which agents have been found useful in relieving stupor. The cerebral congestion often requires the cautious employment of local blood-letting, and the application of cold to the head. If the patient appear to be dying from paralysis of the respiratory muscles, artificial respiration should be effected: if from closure of the larynx, tracheotomy may be performed (see pp. 180 and 181.)

1. **SPIRITUS VINI GALLICI**, L.; *Brandy*;[1] *Eau-de-vie.*—This is an ardent spirit obtained by the distillation of wine. Its properties are subject to some variation, arising from different growths of the vine: "The brandies of Languedoc, Bordeaux, Armagnac, Cognac, Aunis, Saintonge, Rochelle, Orleans, Barcelona, Naples, &c. being each recognisable by an experienced dealer." (Ure's *Dictionary of Arts and Manufactures*, p. 164. Lond. 1839.) The most celebrated of the French brandies are those of Cognac and Armagnac. Genuine brandy has an agreeable, vinous, aromatic odour. Both its flavour and odour, however, are peculiar. *Pale brandy* has a very slight brownish yellow tint, derived from the cask in which it has been kept. The *high coloured brandy*, usually found in the shops of this country, is artificially coloured (before its arrival in this country) by burnt sugar (caramel;) which is said to render the spirit mellow and

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[1] *Brandy* is a contraction for *Brandy-wine* (*Branntwein*, Germ.,) which literally signifies *Burnt-wine* (*Vinum adustum.*)

more palatable. (M'Culloch's *Dictionary of Commerce.*) Saunders wood is also stated, by the same authority, to be frequently used as a colouring ingredient.

The constituents of brandy are *alcohol*, *water*, *volatile oil*, a minute portion of *acetic acid*, a little *acetic ether*, *œnanthic ether*, *colouring matter*, and *tannin*. The latter is said to be derived from the cask in which the spirit has been preserved: but I find that the high coloured brandies react more powerfully on the salts of iron than pale brandy: whence I conclude that some astringent matter has been added to them.

Brandy when just imported is usually above proof. I found a sample of pale brandy, in bond, supplied me by my friend, Mr. Gassiot, to be 1·5 *over proof;* and a coloured brandy, 2·2 *over proof*, as indicated by Sikes's hydrometer. By keeping in the cask its alcoholic strength is diminished. I am informed that brandy, as usually sold, is 10 *per cent. under proof*. This would give, according to Gutteridge's table, a sp. gr. of 0·9318. But Soubeiran (*Nouveau Traité de Pharmacie*, t. i. p. 142, 2^nde^ éd.) states, that the sp. gr. of eau-de-vie varies from about 0·902 to 0·941. Now according to Gilpin's tables a spirit having the sp. gr. of 0·93002 is composed of equal parts of alcohol (sp. gr. 0·825) and water. But Mr. Brande states that 100 parts by measure of brandy, contain 53·39 parts of alcohol, sp. gr. 0·825. The relative quantities of spirit contained in this and other ardent spirits, in wine, and in beer, have been already mentioned. (See p. 95 and 311.)

British Brandy is extensively manufactured, and sold as foreign brandy. Dr. Ure (*Dictionary of Arts and Manufactures*, p. 165.) gives the following formula for it:—"Dilute the pure alcohol to the proof pitch; add to every hundred pounds weight of it from half a pound to a pound of argol (crude winestone) dissolved in water, a little acetic ether, and French-wine vinegar, some bruised French plums, and flavour-stuff from Cognac; then distil the mixture, with a gentle fire, in an alembic furnished with an agitator. The spirit which comes over may be coloured with nicely burned sugar (caramel) to the desired tint, and roughened in taste with a few drops of tincture of catechu or oak-bark."

Acrid matters (as Grains of Paradise) are sometimes added to brandy to give it an artificial strength. They may be readily detected by evaporation. Sugar, also, may be discovered in the same way. The residue of the evaporation of genuine brandy yields a green colour with the salts of iron, indicating the presence of tannin: and imitation brandy may be readily made to produce the same effect, by the addition of catechu, or some other astringent.

The general effects and uses of brandy are those of alcohol already described. From the ardent spirits in ordinary use it is distinguished by its cordial and stomachic properties; and it is, in consequence, the stimulant usually preferred for medicinal purposes.

Burnt Brandy is a popular remedy for diarrhœa.

2. MISTURA SPIRITUS VINI GALLICI, L. (Brandy, Cinnamon Water, of each, f℥iv.: the yelks of two Eggs; Purified Sugar, ʒss.; Oil of Cinnamon, ♏ij. Mix.)—This mixture is an imitation of a well-known compound, termed *Egg-Flip.*[1] It is an exceedingly valuable stimulant and restorative; and is employed in the latter stages of low fever, and in extreme exhaustion from uterine and other hemorrhages. The dose of it is from f℥ss. to f℥iss.

3. SPIRITUS SACCHARI; *Rum.*—This is an ardent spirit obtained both in the West and East Indies, by distillation from the fermented skimmings of the sugar boilers, the drainings (called *molasses*) of the pots and hogsheads of sugar, the washings of the boilers,[2] and the lees or spent wash of former distillations, called

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[1] The terms *Egg-flip*, *Egg-hot*, or simply *Flip*, are applied to a preparation of ale with egg and ardent spirit (see Dr. Kitchener's *Cook's Oracle.*)

[2] *The Civil and Natural History of Jamaica*, by P. Browne, M. D., p. 132. Lond. 1789.

dunder. (Dunder from the Spanish *redundar*, to overflow.) It is imported into this country in puncheons. In some parts of the West India islands it is customary to put slices of pine-apples in the puncheons of rum: hence the designation *pine-apple rum*.

The term *Tafia*, or *Taffia*, is applied to a spirit obtained, by distillation, from the fermented juice of the sugar-cane. (Merat and De Lens, *Dict. de Mat. Méd.* t. vi. p. 150.) It is, therefore, *Cane Spirit* (*Spiritus Succi Sacchari.*)

Good rum is transparent and of a brownish tint. Its depth of colour, however, varies considerably. The peculiar flavour of rum depends on *volatile oil*. The quantity of *alcohol* (sp. gr. 0·825) in 100 vols. of rum is, according to Mr. Brande, about 53·68 vols. As sent out, its strength is 10 *per cent. under proof*, in the language of Sikes's hydrometer. *Jamaica rum* is more highly esteemed than the *Leeward Islands rum.*

The general effects and uses of rum are similar to those of alcohol already described.[1] It is considered more heating and sudorific than the other kinds of ardent spirit, to which it has been popularly thought preferable in coughs, catarrhs, and rheumatism.

4. **SPIRITUS FRUMENTI COMPOSITUS**; *Compound Corn Spirit*.—The spirit manufactured in British islands is usually obtained by distillation from fermented infusions of corn. The ardent spirits known as *Gin*, *Whisky*, and the various *Compounds*,[2] are corn spirit differently flavoured.

Gin owes its peculiar flavour to the Juniper, whence it is frequently denominated *Spiritus Juniperi*. It is not allowed to be sent out stronger than 17 *per cent. under proof;* but it is usually sold to the trade at 22 *per cent. under proof.* The retail dealer always reduces its strength, and flavours it with sugar. Frequently also other additions are made to it. Gin possesses the general properties of alcohol. On account of the oil of juniper which it holds in solution, it is more powerfully diuretic than brandy and rum; and hence it is a popular remedy in dropsical and other affections, where an augmentation of the renal secretions is considered desirable. Moreover, it is frequently used to promote menstruation. It is the ordinary intoxicating spirit of the lower classes in this metropolis. At the London Hospital, gin is frequently administered medicinally, as a substitute for brandy, to patients who have been accustomed to its use.

Whisky agrees in most of its properties with gin; from which it differs in its peculiar smoky flavour and odour: these it acquires from the malt, which is dried by turf fires. It is the national spirit of Ireland and Scotland.

5. **ARRACK**, or **RACK**.—This is a spirit obtained in various parts of the East. In Batavia, it is procured by distillation from fermented infusions of rice, whence it has been termed *Rice Spirit* (*Spiritus Oryzæ*.) In Ceylon,[3] it is obtained by distillation from fermented cocoa-nut toddy (by some called *Palm wine*.)

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[1] "They talk of a common experiment here, [Jamaica,] that any Animal's Liver put into Rum grows soft, and not so in Brandy, whence they argue this last less wholesome than that, but their Experiment, if true, proves no such thing. I think it may be said to have all good and bad qualities of Brandy, or any fermented or vinous spirit."—(Sloane's *Jamaica*, vol. i. p. xxx. Lond. 1707.)

[2] By spirit dealers, British compounded spirits are denominated *Compounds*, while Foreign compounded spirits are called *Liqueurs*. Both class of liquors are sweetened spirits.

The following list of Compounds, usually kept at the gin-shops of this metropolis, has been supplied me by the proprietor of one of these establishments:—

Compounds.	*Under Proof.*	*Compounds.*	*Under Proof.*
Gin	17	Tent	"
Gin	22	Aniseed	"
Mint (*Peppermint*)	64	Caraway	"
Cloves	"	Lovage	"
Bitters	"	Usquebaugh (X)	"
Raspberry	"	Rum Shrub	"
Noyeau	"	Orange Cordial (X)	"
Cinnamon	"	Citron ditto (X)	

"The above are permitted to us at the strengths named; but, in point of fact, are much nearer approaching 80 U. P.—Those marked thus (X) are seldom asked for."

[3] *The Cocoa Nut Palm, its Uses and Cultivation.* By J. W. Bennett, Esq. Lond. 1836.

"Pine apples, steeped in it, impart a most exquisite flavour to the spirit; and, by age, it becomes a delicious liqueur, which is unrivalled in the world for making nectarial punch." In England, arrack is never employed for medicinal purposes. In its general properties it agrees with the other ardent spirits; but is said to be distinguished by its stimulating and narcotic properties. It is sometimes used in this country to impart an agreeable flavour to *punch.* A mock arrack is made by dissolving twenty grains of benzoic acid in two pounds of rum.

2. Pharmaceutical Uses of Alcohol.—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 alkalis, castor oil, &c. Rectified and proof spirits are most extensively employed in officinal pharmacy: as in the formation of *Tinctures*, *Spirits*, *Ethers*, *Etherial, Oil*, and *Resinous Extracts*, and in the manufacture of the *Vegetable Alkalis.* Lastly, spirit is added to various preparations to assist in preserving them.

1. TINCTURÆ, L. D.; (U. S.) *Tinctures*, E.; *Alcoolés.*—These are solutions of vegetable, animal, or mineral substances, in proof or rectified spirit. They are preparations of substances whose active principles are imperfectly or not at all soluble in water, or whose aqueous solutions readily undergo decomposition.

Some are prepared by *solution* merely; as the *Tinctura Iodinii composita*, Ph. L.; *Tinctura Camphoræ*, Ph. Ed.; and *Tinctura Ferri Sesquichloridi.*

Some of the vegetable tinctures are prepared by adding rectified spirit to the expressed juices of plants. These preparations are frequently denominated *preserved vegetable juices.* They have been long in use on the continent. In 1835, Mr. Squire (*Pharmaceutical Transactions*, No. iii. p. 94. Sept. 1841.) commenced their manufacture. More recently, Mr. Bently (*On the Best Method of obtaining the more powerful Vegetable Preparations for Medical Use.*) has directed the attention of the profession to them.

Mr. Squire states, that on an average the juice of the young plant just coming into flower, will yield only two-thirds of the amount of extract which is obtained from the same quantity of juice from the matured plant ("when more than half the flowers are fully blown,") and the strength of the product is also inferior. He also asserts (*Op. supra cit.*) that the leaves only should be used: and in the case of biennial plants, those of the second year's growth should exclusively be employed.[1]

The mode of obtaining these preparations is as follows:—The leaves being bruised in a marble mortar, are placed in a powerful press. The expressed juice is allowed to stand for twenty-four hours, by which a considerable quantity of feculent matter is deposited. Rectified spirit [56 over proof] is then added, in the proportion of four fluid ounces to every sixteen fluid ounces of the juice, which is quite sufficient to render the preservation complete, and throw down any mucilage which may be mechanically suspended. After standing for twenty-four hours the liquor is to be filtered. (Bentley, *op. supra cit.*)

Mr. Squire employs one measure of spirit to two measures of juice.

These preserved expressed juices are superior preparations to the tinctures prepared by digestion from the same parts of either fresh or dried plants. In some cases (*e. g.* Aconite,) tinctures prepared with rectified spirit from the dried roots, by digestion, are greatly superior in activity to the preserved juices of the leaves.

The ordinary method of preparing tinctures is by *maceration* or *digestion.*

"Tinctures are usually made by reducing the solid ingredients to small fragments, coarse powder, or fine powder, macerating them for seven days or upwards in proof spirit or rectified spirit, straining the solution through linen or calico, and finally expressing the residuum strongly to obtain what fluid is still retained in the mass."—*Ph. E.*

All Tinctures should be prepared in stoppered glass vessels, and frequently shaken during maceration.—*Ph. Lond.*

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[1] See the article *Hyoscyamus*, for an account of the relative quantities of juice and extract yielded by the leaves and stalks.

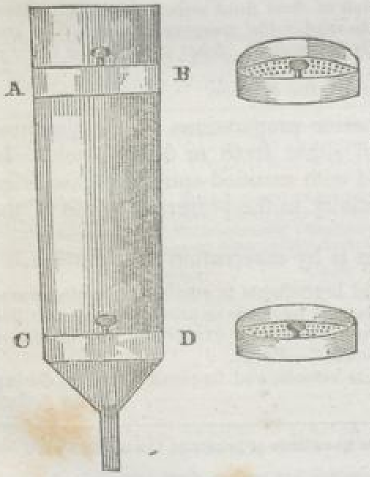
The tinctures which are made with resinous substances cannot in general be well prepared in any other way than by digestion. This remark applies to *Tinctura Aloes*, *Tinctura Asafœtidæ*, *Tinctura Benzoini composita*, *Tinctura Guaiaci*, and *Tinctura Balsami Tolutani*.

Another and more expeditious method of preparing tinctures is by *percolation* or *lixiviation* (*procédé* on *méthode de déplacement*;) and which is also applicable to the preparation of etherial, as well as alcoholic, tinctures, and of infusions. The principle of this method has been adopted by the Scotch brewers; the process being called by them *sparging*. It has also been used in the preparation of coffee. It was first employed for pharmaceutical purposes by Boullay. (*Journal de Pharmacie*, t. xix. p. 393.) In the preparation of tinctures its professed advantages are expedition, economy, and uniformity of strength. But it is more troublesome, requires more skill and attention; and is not equally applicable to all substances. It answers best for those tinctures made with woody and fibrous parts, as roots, barks, woods, leaves, fruits, seeds, and insects. The Tinctures of Catechu and Myrrh may also be prepared in this way. The *Edinburgh College* offers the following remarks on this mode of preparation:—

> "A much superior method, however, has been lately introduced, which answers well for most tinctures, namely, the method of displacement by percolation. According to this process, the solid materials, usually in coarse or moderately fine powder, are moistened with a sufficiency of the solvent to form a thick pulp. In twelve hours, or frequently without any delay, the mass is put into a cylinder of glass, porcelain, or tinned iron, open at both ends, but obstructed at the lower end by a piece of calico or linen, tied tightly over it as a filter; and the pulp being packed by pressure, varying as to degree with various articles, the remainder of the solvent is poured into the upper part of the cylinder, and allowed gradually to percolate. In order to obtain the portion of the fluid which is kept in the residuum, an additional quantity of the solvent is poured into the cylinder, until the tincture, which has passed through, equals in amount the spirit originally prescribed: and the spirit employed for this purpose is then recovered for the most part by pouring over the residuum as much water as there is of spirit retained in it, which may be easily known by an obvious calculation in each case. The method by percolation, where applicable, will be found much more convenient and expeditious than the mode hitherto commonly followed, and it exhausts the solid materials in general much more completely. As considerable practice, however, is required for managing the details in different cases, more especially in regard to the degree of firmness with which they are to be packed in the cylinder, we have thought it right to direct that the method of maceration, may be followed as an alternative. But the method of percolation is now preferred by all who have made sufficient trial of it to apply it correctly."

The percolator is best made of tin plate or zinc. A simple tube (of glass, porcelain, or tinned iron,) as stated by the Edinburgh College, answers for an extemporaneous percolator. It is fitted into the mouth of a wide-mouthed bottle by means of a cork, in which is a small aperture to allow of the escape of air. One of the most convenient percolators is that proposed by Boullay. It is a simple cylinder of equal diameter, and terminating inferiorly in a cone or funnel. (Fig 50.) Mr. Deane's percolator (*Pharmaceutical Transactions*, part ii.) is a modification of this: its lower end has a smaller circumference than its upper one, is flat, and communicates with a tube, to which a stop-cock is fitted. Soubeiran (*Nouveau Traité de Pharmacie*, t. i. p. iii. 2^{nde} éd.) has adapted to Boullay's percolator a tin receiver, to which is fitted, at the most depending part, a stop-cock, by which the tincture may be drawn off.

Fig. 50.



The size of the percolator must, of course, vary according to circumstances. The smallest may be half an inch in diameter and four inches long. Large ones are six inches in diameter and eighteen inches long. They should be furnished with two diaphragms (perforated metallic disks,) between which the ingredients are placed. When small percolators are used, a little cotton-wool, or even tow, may be substituted for the lower diaphragm,—or a piece of calico or linen may be tied over the end of the tube, as directed by the Edinburgh College. The lower extremity of the percolator should be furnished with a stop-cock, for regulating the discharge of the fluid.

Considerable skill and experience are required in packing the ingredients. Indeed, the principal art of percolating has reference to this part of the process. Substances, as Rhubarb and Gentian, which yield a large quantity of mucilage, and are to be acted on by water, must be employed in the form of a very coarse powder, and should be placed loosely in the percolator, in order to allow them to swell. With alcohol or ether, however, the tissues swell less, the mucilaginous matter is not dissolved, and the percolation is readily effected even with a finer powder and closer packing.

Boullay imagined that one liquid may be employed to displace another liquid, without the two liquids becoming mixed: hence he called the process the *displacement method*. The Edinburgh College, I presume, has adopted his opinion, since it directs the tincture to be displaced by spirit, and the spirit by water. But Guilliermond (*Journal de Pharmacie*, t. xxi. p. 349.) has shown that this displacement cannot be effected without a certain degree of mixture.[1]

2. SPIRITUS, L. D. (U. S.) *Spiritus*, E. *Alcoolats.*—These are alcoholic solutions of volatile substances (usually of a vegetable nature) obtained by distillation. Some of them are prepared with rectified spirit (e. g. *Spiritus Rosmarini,*) but most of them with proof spirit. Several of the spirits which owe their peculiar flavour and odour to volatile oil may be, and usually are, imitated by dissolving the oil in the spirit without the aid of distillation; and, for all therapeutical purposes, they are equally effective.

2. Æ'THER SULPHU'RICUS, *L. E. D.*—SULPHURIC ETHER.

History and Synonymes.—This liquid is said to have been known to Raymond Lully,[2] who lived in the 13th century; and to Basil Valentine,[3] in the 15th century. In 1540, Valerius Cordus[4] 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.—All the British Colleges give directions for the preparation of sulphuric ether.

The *London College* orders of Rectified Spirit, lbiij.; Sulphuric Acid, lbij; Carbonate of Potash, previously ignited, ℥j.: 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.

The directions of the *Edinburgh College* are as follows:—"Take of Rectified Spirit, f℥l.; Sulphuric Acid, f℥x. Pour twelve fluid ounces of the spirit gently over the acid contained in an open vessel, and then stir them together briskly and thoroughly. Transfer the mixture

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[1] For farther details respecting percolation, consult, besides the memoirs already quoted, Dausse, *Mémoire sur la preparation de tous les extraits pharmaceutiques, par la méthode de déplacement*. Paris, 1836.

[2] Dulk, *Die Preussische Pharmakopöe übers und erläutert*, 2er Th. S. 201. 2te Aufl. Leipz. 1830.

[3] Ibid.

[4] Thomson, *System of Chemistry*, vol. ii. p. 296. 7th ed. 1831.

immediately into a glass matrass connected with a refrigeratory, and raise the heat quickly to about 280°. As soon as the etherial fluid begins to distil over, supply fresh spirit through a tube into the matrass in a continuous stream, and in such quantity as to equal that of the fluid which distils over. This is best accomplished by connecting one end of the tube with a graduated vessel containing the spirit, passing the other end through a cork fitted into the matrass,—and having a stop cock on the tube to regulate the discharge. When forty-two ounces have distilled over, and the whole spirit has been added, the process may be stopped. Agitate the impure ether with sixteen fluid ounces of a saturated solution of muriate of lime, containing about half an ounce of lime recently slaked. When all odour of sulphurous acid has been thus removed, pour off the supernatant liquor, and distil it with a very gentle heat, so long as the liquid which passes over has a density not above 0·735. More ether of the same strength is then to be obtained from the solution of muriate of lime. From the residuum of both distillations, a weaker ether may be obtained in small quantity, which must be rectified by distilling it gently again."

The *Dublin College* directs Sulphuric Ether to be prepared from the *Liquor Æthereus Sulphuricus*, which is ordered to be made thus:—Take of Rectified Spirit, Sulphuric Acid, of each ℥xxxij. *by weight.* Pour the spirit into a glass retort adapted to bearing a sudden heat, and then pour on the acid in an unbroken stream; mix them gradually, and let twenty ounces *by measure* of the liquor be distilled with a sudden and sufficiently strong heat, into a receiver kept cold. If sixteen ounces of rectified spirit be poured upon the acid remaining in the retort, sulphuric ethereal liquor will again come over by distillation.

Take of this Sulphuric Etherial Liquor, f℥xx.; Carbonate of Potash, dried and powdered, ʒij. Mix them, and, from a very high retort, distil, by a very gentle heat, twelve ounces *by measure* into a receiver kept cold. The sp. gr. of the liquor should be to that of distilled water as 0·765 to 1·000.

(The *U. S. Pharmocopœia* directs Alcohol, four pints; Sulphuric Acid, a pint; Potassa, six drachms; Distilled Water, three fluid ounces. To two pints of the Alcohol, in an open vessel, add gradually fourteen fluid ounces of the acid, stirring them frequently. Pour the mixture, while still hot, into a tubulated glass retort, placed upon a sand bath and connected by a long adapter with a receiver kept cold by ice or water, then raise the heat quickly until the liquid begins to boil. When about half a pint of ethereal liquid shall have passed over, introduce gradually into the retort, the remainder of the alcohol, previously mixed with two fluid ounces of the acid, taking care that the mixture shall enter in a continuous stream, and in such quantity as shall supply the place, as nearly as possible, of the liquid which distils over. This may be accomplished by connecting a vessel containing the alcoholic liquid within the retort, by means of a tube, provided with a stop cock, to regulate the discharge, and passing nearly to the bottom of the retort, through a cock accurately fitted into the tubulure. When all the alcohol has been thus added, continue the distillation until about three pints shall have passed over, or until white vapours shall appear in the retort.

To the product thus obtained, add the potassa previously dissolved in the distilled water, and shake them frequently. At the end of twenty-four hours, pour off from the alkaline solution the supernatant ether, introduce it into a retort, and with a gentle heat, distil until two pints shall have passed over, or until the distilled liquor shall have the specific gravity of 0·750.)

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 9 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 change thus far appears very simple, there are some accessory reactions which make the theory of etherification exceedingly complicated, and about the precise nature of which chemists are not quite agreed.

That the sole or efficient cause of the conversion of alcohol into ether is not the mere abstraction of the water, by the affinity of the sulphuric acid for that liquid, is proved by various circumstances, of which the following are some:—(Brande, *Manual of Chemistry*, p. 1284, 5th ed. 1841.)

α. Water may be abstracted from alcohol by alkalis and chloride of calcium, yet nothing like ether is the result.

β. Water passes over, during the whole process, along with the ether, with which the acid ought to combine in preference to dehydrating the alcohol.

γ. Ether is not produced by the action of anhydrous sulphuric acid on alcohol.

δ. Ether is never produced except by the aid of heat.

ε. When the oil of vitriol is mixed with rectified spirit, the saturating power of the acid is diminished.

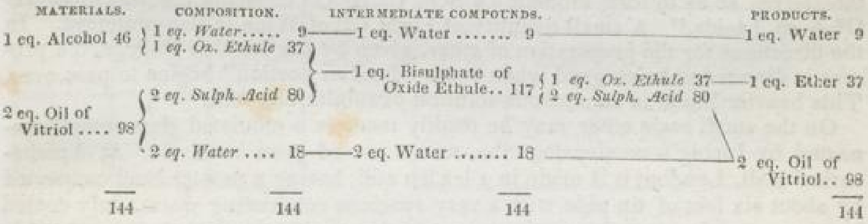
When oil of vitriol is added to rectified spirit, a new compound is formed, which contains, besides the elements of sulphuric acid, carbon, hydrogen, and oxygen.

As this new compound reddens litmus, and forms salts with bases, it has been regarded as an acid (*sulpho-vinic acid;*) (Hennell, *Philosoph. Trans.* 1826 and 1828.) (*ethereo-sulphuric acid.*[1]) But as the sulphuric acid, by its union with the elements of the alcohol, has lost half its saturating power, the new compound is rather to be regarded as a supersalt (*bisulphate of the oxide of ethule,*) (Liebig, in Turner's *Elements of Chemistry*, p. 837, et seq. 7th ed. 1840.) combined with water; or as a double salt composed of sulphate of the oxide of ethule and sulphate of water. Carbo-hydrogen is the basic constituent of this salt, which, by the action of heat, is resolved into ether, sulphuric acid, and water.

On the ethule hypothesis, so ably advocated by Liebig, the following is an explanation of the changes attending the formation of ether:—

Alcohol is regarded as the hydrate of the oxide of ethule, and its equivalent is assumed to be 46. On the addition of oil of vitriol, two equivalents or 80 parts of anhydrous sulphuric acid combine with one equivalent or 37 parts of oxide of ethule (*ether,*) contained in the alcohol, and form one equivalent or 117 parts of bisulphate of oxide of ethule (*bisulphate of ether.*) The water of the alcohol and of the oil of vitriol unites with the bisulphate. By the heat, which is subsequently applied to the mixture, the hydrated bisulphate is resolved into ether, water, and sulphuric acid.

In the following diagram, the oil of vitriol ($SO^3 + HO$) is assumed to be the strongest procurable, and the alcohol to be uncombined with water:—



"If we consider each particle of the [hydrated] bisulphate of oxide of ethule as composed of ether, [oxide of ethule,] anhydrous sulphuric acid, and water, it is clear that the anhydrous acid, at the moment of its separation from the ether, must seize on all water, free or combined, in the vicinity of the ether. Thus, at the moment the ether becomes free, the anhydrous acid, also set free, prevents it from uniting with water to form alcohol. But when the gaseous ether passes through the undecomposed hydrated bisulphate of oxide of ethule, a certain proportion of the water of that compound must evaporate in the dry gas; and in these circumstances the ether and water do not combine together. The surface of the effervescing liquid has the temperature at which [hydrated] bisulphate of oxide of ethule is decomposed; but at this temperature, 284°, the water of that compound is gaseous. There are thus produced, simultaneously, water in the gaseous form by evaporation, and ether, also gaseous, by decomposition; which, as both are in the nascent state, unite to form alcohol. Thus the alcohol, always observed to distil over with the ether, is derived from the surface; and the ether and water, which distil over, proceed from the decomposition in the interior of the liquid. This explains why no ether is obtained when the liquid is not in brisk ebullition, no matter how high the temperature may be; it explains farther, why more alcohol is obtained when a current of dry air passes through the liquid, since in that case the same decomposition goes on in the interior of the liquid as generally occurs at the surface." (Liebig, in Turner's *Elements of Chemistry*, p. 841, 7th ed.)

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[1] Liebig, in the *Handwörterbuch der reinen und angewandten Chemie*, von Dr. J. Liebig and Dr. T. C. Poggendorf, Bd. i. S. 114. Braunschweig, 1837.

During the distillation of ether the relative proportions of the ingredients are constantly varying; for the absolute quantity of hydrated bisulphate of ethule is continually diminishing, and thereby the relative quantity of oil of vitriol is increasing. In consequence of this, the boiling point of the liquid gradually rises. When it arrives at about 320°, new reactions take place between the oxide of ethule and the sulphuric acid. The principal products of these reactions are sulphurous acid, olefiant gas, water, and carbon. The subjoined diagram will explain how these are produced from the bisulphate of oxide of ethule:—

MATERIAL.	COMPOSITION.			RESULTS.
		2 eq. Sulphurous Acid	64	3 eq. Sulphurous Acid 64
1 eq. Bisulphate of Oxide Ethule 117	*2 eq. Sulphuric Acid* 80	*2 eq. Oxygen*	16	3 eq. Water 27
	1 eq. Oxygen		8	
	1 eq. Ethule 29	*3 eq. Hydrogen*	3	
		2 eq. Hydrogen	2	1 eq. Olefiant gas 14
		2 eq. Carbon	12	
		2 eq. Carbon	12	2 eq. Carbon 12
117			117	117

These are not the only products of the reaction above referred to. In certain proportions of the ingredients, acetic acid [$C^4 H^3 O^3$] is formed. "With a great excess of [sulphuric] acid, traces of formic acid [$C^2 H^1 O^3$] and carbonic oxide are produced. As long as olefiant gas comes off, carbonic acid cannot be detected. During this decomposition, sulphurous acid and olefiant gas are given off in equal volume." "Carbon and water are the elements of acetic acid, the formation of which must diminish the quantity of carbon in the residue. By the action of the sulphuric acid in excess on acetic acid, formic acid and sulphurous acid are formed; and by the action of the sulphuric acid in excess of formic acid, carbonic oxide gas is produced." (Liebig, *op. supra cit.*) "It is probable that in this decomposition, the elements of sulphuric acid and of ether first arrange themselves so as to form ethionic [$4 SO^3, C^4 H^5 O$] or isethionic [$S^2 O^5, C^4 H^5 O^2 + aq.$] acids." A small quantity of Light Oil of Wine is also produced. In the directions for the preparation of ether, given by the London College, the process is directed to be stopped when some "heavier portion" begins to pass over. This heavier liquid is an aqueous solution of sulphurous acid.

On the small scale ether may be readily made in a tubulated glass retort, connected by Liebig's condensing tube, with a cooled glass receiver. At Apothecaries' Hall, London, it is made in a leaden still, having a pewter head connected by about six feet of tin pipe with a very spacious condensing worm, duly cooled by a current of water; the receivers are of pewter with glass lids, and have a side tube to connect them with the delivering end of the worm-pipe. The still is heated by high-pressure steam carried through it in a contorted leaden pipe. A tube enters the upper part of the still for the purpose of suffering alcohol gradually to run into the acid. (Brande's *Manual of Chemistry*, p. 1275, 5th ed. 1841.)

Mitscherlich (*Lehrbuch der Chemie*, 1er Band, S. 98, 2te Aufl. Berlin, 1833.) has shown how a given quantity of oil of vitriol may be made to convert an unlimited quantity of alcohol into ether; the whole of the alcohol which enters the retort passing off as ether and water. As, however, ether is usually prepared from hydrated alcohol (rectified spirit) the superfluous water gradually dilutes the acid until ultimately it becomes too dilute to effect the conversion of alcohol into ether. The process of the Edinburgh Pharmacopœia is an imitation of Mitscherlich's principle.

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. (Thenard and Bussy.) I have submitted it to the action of solid carbonic acid (whose temperature was probably 148° below the zero of Fahrenheit,) without freezing it. But Fourcroy and Vauquelin, and more recently Liebig, state that it may be frozen at 46° below zero. The sp. gr. of pure ether at 68° F. is, according to Dumas and Boullay, 0·713. The ether of the shops contains a little alcohol, and its sp. gr. varies from 0·733 to 0·765: in the London Pharmacopœia its sp. gr. at 62° F. is fixed at 0·750. Ether is extremely volatile: when of sp. gr. 0·720, its boiling point (the mercury in the barometer standing at 30 inches,) is about 98° F. In a vacuum, it boils at 40° F. below zero. The evaporation of ether causes intense cold. The sp. gr. of ether-vapour was found, by Gay-Lussac, to be 2·586. Pure and recently prepared ether possesses neither acid nor alkaline properties; but, by exposure to air and light, it absorbs oxygen, by which acetic acid and water are produced. The acetic acid is not immediately observed, because it combines with some undecomposed ether to form acetic ether.

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 either 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, acetic, formic, and lampic [aldehydric] acids are produced.

Before Combustion.

1 eq. Ether Vap = 37	2 eq. Oxygen = 16	2 eq. Oxygen = 16	2 eq. Oxygen = 16
2 eq. Oxygen = 16	2 eq. Oxygen = 16	2 eq. Oxygen = 16	

After Combustion.

1 eq. Carb. Acid = 22	1 eq. Carb. Acid = 22	1 eq. Aq. Vap. = 9	1 eq. Aq. Vap. = 9	1 eq. Aq. Vap. = 9
1 eq. Carb. Acid = 22	1 eq. Carb. Acid = 22	1 eq. Aq. Vap. = 9	1 eq. Aq. Vap. = 9	

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 alkalis, urea, and osmazome.

Characteristics.—Sulphuric ether may be recognised 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 a phial, the mixture speedily separates, on standing, into two layers. It dissolves most resins; the solutions, evaporated on the surface of water, leave a resinous film.

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

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Dumas & Boullay.*
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 *oxide of ethule* (ethereum.)

2 eq. Olefiant gas	28	1 eq. etherine	28	1 eq. 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. Oxide of Ethule	37

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

Purity.—The ether of commerce is usually contaminated with small quantities of either spirit or water, or both. These augment its sp. gr. but do not much affect its medicinal properties. The London College states that its sp. gr. should be 0·750; but this is too high. The Edinburgh College fixes it at 0·735, or under. I think 0·740 would be sufficiently low. 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, either from being imperfectly prepared or being too long kept. Ten fluid ounces of water should not dissolve more than one fluid ounce of ether, and the solution should be quite transparent. It should speedily and totally evaporate in the air. It should not become milky when mixed with water. "When agitated in a minim measure, with half its volume of concentrated solution of muriate of lime, its volume is not lessened," *Ph. Ed.*

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

β. 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 osœphagus 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 (Wibmer, in *Die Wirkung*, &c.) found that a half an ounce of ether acted as a fatal poison to a crane: at the end of forty-eight 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 twenty-four hours.

γ. 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. (Mérat 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 effects analogous to those caused by the protoxide of nitrogen (*vide* p. 264;) moreover, persons peculiarly susceptible of the action of the one are also powerfully affected by the other. (*Journal of Science*, vol. iv. p. 158.) If the air be too strongly impregnated with ether, stupefaction ensues. In one case this state continued with occasional periods of intermission for more than thirty 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.) In the case of a man poisoned by laudanum, and to whom before death half an ounce of spirit of sulphuric ether was given, the ether was detected by its odour in the brain. (*Lancet* for 1836-7, vol. i. p. 271.)

Uses.—Ether is employed both medicinally and for pharmaceutical purposes.

1. Medicinal Uses. α. *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 attacks. In cramp of the stomach, singultus, and flatulent colic, its happy effects are well established.[1] 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 (*Cours Elém. de Matière Médicale.* Paris, 1789.) 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.

Headach 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 show 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[2] recommends a mixture of three parts ether and two oil of turpentine, as a solvent for biliary calculi. Bourdier (*Méd. 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

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[1] On the Effects of Ether in Spasmodic Affections of the Stomach, and in Intermittents. See *Medical Facts and Observations*, vol. v. Lond.

[2] *Observ. sur l'Efficacité du Mélange d'Ether sulphuriq. et d'Huile volatils du Téréb. dans Colliques hépatiq. produites par des Pierres Biliaires.* Strasburg, 1790.

lowness of spirits, it is a popular remedy. In poisoning by hemlock and mushrooms, it has been employed. (J. Frank, *Toxicologie*, s. 70, 108.) In asphyxia it has been used with benefit.

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

β. *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 headach 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 USES.—Ether is employed in the preparation of the Compound Spirit of Sulphuric Ether. Ether, or its alcoholic solution, is also used to extract the active principles of certain drugs, as of Lobelia, Aloes, Musk, &c. The solutions are called Ethereal Tinctures, (*Tincturæ Ethereæ*,) or by the French pharmacologists *Ethéroles*. These may be conveniently prepared by percolation (see p. 326.) 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 fʒss. to fʒij.:—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 up with spermaceti employed in the proportion of two grains for each fluiddrachm of the ether." (*United States Dispensatory*, p. 727, 3 edit. Philadelphia, 1836.)

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

1. **SPIRITUS ÆTHERIS SULPHURICI**, E. *Spirit of Sulphuric Ether*. (Sulphuric Ether, Oj.; Rectified Spirit, Oij. Mix them. The density of this preparation ought to be 0·809. "It does not affect litmus paper, or render water muddy: when agitated with twice its volume of a concentrated solution of muriate of lime, 28 per cent. of ether separates by rest.")—Its medicinal properties are similar to, though somewhat less powerful than, those of ether, over which it has the advantage of being miscible with water in all proportions. The dose of it is fʒj. to fʒiij. mixed with some diluent. It is used in the preparation of the *Tinctura Lobeliæ ætherea*, E.

2. **SPIRITUS ÆTHERIS SULPHURICI COMPOSITUS**, L. (U. S.) *Compound Spirit of Sulphuric Ether*. (Sulphuric Ether, f℥viij.; Rectified Spirit, f℥xvj.; Etherial Oil, fʒiij. Mix.)—This preparation is commonly called *Hoffmann's Mineral Anodyne Liquor* (*Liquor anodynus mineralis Hoffmanni;*) being made in imitation of a preparation described by Hoffmann,[1] and which it is said he was

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[1] *De Acido Vitrioli Vinoso*, 1732.—Fr. Hoffmanni, *Operum omnium Supplementum*, p. 855. Genevæ, 1754

taught by an apothecary of the name of Martmeier.[1] This preparation is sometimes employed as an adjunct to laudanum, to prevent the nausea which the latter excites in certain habits. Its dose is from fʒss. to fʒij. in any proper vehicle.

3. O'LEUM ÆTHE'REUM, *L.*—(U. S.) ETHEREAL OIL.

(Liquor Æthereus Oleosus, *D.*)

History and Synonymes.—This liquid is commonly termed *heavy oil of wine*, or simply *oil of wine*. Dumas (*Traité de Chimie*, t. 5me, 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 (*Philosophical Transactions*, 1826.) it is a *sulphate of hydrocarbon*,—Dumas (*Op. supra cit.*) calls it *sulphatic ether*,—others a *double sulphate of ether* and *hydrocarbon*,—while Liebig (Turner's *Elements of Chemistry*, p. 844 and 861, 7th ed. 1841.) terms it *sulphate of oxide of ethule and etherole*. (The term *etherole* is applied to a $\frac{4}{4}$ carbo-hydrogen, better known as *Light Oil of Wine*.)

Preparation.—The following directions for procuring it are given in the *London Pharmacopœia:*—

> "Take of Rectified Spirit, lb. ij.; Sulphuric Acid, lb. iv.; Solution or Potash, Distilled Water, of each f℥j.; or as much as may be sufficient. Mix the acid cautiously with the spirit. Let the liquor distil until a black froth arises; then immediately remove the retort from the fire. Separate the lighter supernatant liquor from the heavier one, and expose the former to the air for a day. Add to it the solution of potash first mixed with water, and shake them together. Lastly, when sufficiently washed, separate the ethereal oil which subsides."
>
> The *Dublin College* gives the following directions for its preparation:—"Take what remains in the retort after the distillation of sulphuric ether. Distil down to one half, with a moderate heat."
>
> [The U. S. Pharmacopœia directs Alcohol, two pints; Sulphuric Acid, three pints; Solution of Potassa, half a fluid ounce; Distilled water, a fluid ounce. Mix the acid cautiously with the Alcohol; allow the mixture to stand twelve hours, then pour it into a large glass retort, to which a receiver kept cool by ice or water is adapted, and distil by means of a sand-bath until a black froth arises, when the retort is to be removed immediately from the sand-bath. Separate the lighter supernatant liquid in the receiver from the heavier, and expose it to the air for a day; then add to it the Solution of Potassa previously mixed with the Distilled Water, and shake them together. Lastly, separate the Ethereal oil as soon as it shall have subsided.]

The process of the London Parmacopœia is that followed at Apothecaries' Hall, London. Mr. Hennell informs me that 33lbs. avoird. of Rectified Spirit, and 64lbs. avoird. of Oil of Vitriol, yielded in one operation 17 ounces avoird. of ethereal oil. There is, therefore, an immense loss in the operation.

Theory of the Process.—When oil of vitriol and alcohol are mixed, bisulphate of oxide of ethule ($C^4 H^5 O, 2SO^3$) and water are formed (see p. 329.) Under the influence of heat the bisulphate suffers decomposition; but the reactions vary with the temperature. When the sulphuric acid is greatly in excess, and the boiling point of the liquid has attained 320° F., the principal products of the decomposition are sulphurous acid, olefiant gas (carbo-hydrogen,) water, and carbon (see p. 330.) At this period of the process heavy oil of wine is also produced in small quantity. Its formation may be accounted for by supposing that two equivalents of the bisulphate of oxide of ethule and water react on one another, and that the carbo-hydrogen ($C^4 H^4 = 1$ eq. Etherole) of the one is substituted for the water of the other; the products being heavy oil of wine (*oleum æthereum*, Ph. L.) sulphuric acid, and water.

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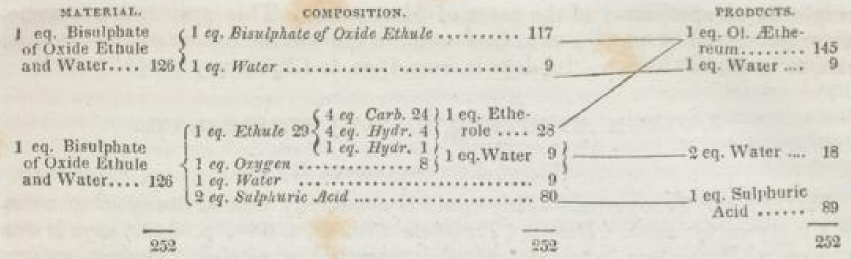
[1] Voigtels, *Vollstandiges System der Arzneymittellehre*, Bd. ii. 3tte Abt. S. 38. Leipzig, 1817



The substance termed by Liebig, ETHEROLE ($C^4 H^4$) is commonly denominated *Light Oil of Wine*. It was discovered by Hennell, who calls it *Hydrocarbon from Oil of Wine*, because it is obtained by boiling the heavy oil of wine with water. It is a colourless, oily liquid, of sp. gr. 0·917 to 0·920. When kept for some time at a low temperature it deposites a crystalline matter called ETHERINE or *Camphor of Oil of Wine* ($C^4 H^4$;) which is isomeric with etherole.

PROPERTIES.—Ethereal oil is an oily liquid, usually having a yellowish tint, though when quite pure it is said to be colourless. It has a peculiar aromatic odour, and a bitter taste. Its sp. gr., according to Mr. Hennell, is 1·05; but according to Serullas it is 1·13. It boils at 540° F. It is insoluble in water, but dissolves readily in alcohol and ether. It neither reddens litmus nor precipitates a solution of chloride of barium, so that the sulphuric acid contained in it seems to be completely neutralized. According to Mr. Hennell ethereal oil dissolves a variable quantity of a $\frac{4}{4}$ carbo-hydrogen, part of which separates in a crystalline form (*etherine*) when the oil is kept for some time, or when exposed to cold.

When ethereal oil is slightly heated with water it yields a light yellow oil (*etherole*,) which floats on water, and bisulphate of oxide of ethule, which is dissolved by the water.

Characteristics.—Ethereal oil is recognised 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 of 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 analyzed 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.		
	Atoms.	*Eq. Wt.*	*Theory.*	*Liebig.*	*Serullas.*	*Eq.*	*Eq. Wt.*	*Per Cent.*
Sulphuric Acid	2	80	55·172	55·614	55·02	1	40	38·0
Carbon	8	48	33·103	33·180	33·05	9	54	53·7
Hydrogen	9	9	6·207	5·788	6·11	9	9	8.3
Oxygen	1	8	5·517	5·418	5·49	0	0	0·0
Oleum Æthereum (Ph. L.	1	145	99·999	100·000	99·67	1	103	100·0

It would appear, from this table, that Hennell (*Philosophical Transactions*, 1826, p. 247 and 248.) must have analyzed ethereal oil holding in solution carbohydrogen (*etherine*,) and that he omitted to take into calculation the elements of water which this oil contains.

According to Serullas (*Ann. de Chim. et de Phys.* t. xxxix. p. 153.) and Liebig (Turner's *Elements of Chemistry*, 7th ed. pp. 844 and 861.) this oil is a double sulphate of oxide of ethule (ether) and etherole (carbohydrogen.)

	Atoms.	*Eq. Wt.*	*Or,*	*Atoms.*	*Eq. Wt.*
2 eq. Sulphuric Acid	2	80	Sulphate of Oxide of Ethule (Ether)	1	77
1 eq. Oxide of Ethule (Ether)	1	37	Sulphate of Etherole (Carbohydrogen)	1	68
1 eq. Etherole (Carbohydrogen)	1	21			
1 Sulphate of Oxide of Ethule and Etherole	1	145		1	145

Dumas, (*Traité de Chimie appliqué aux Arts*, t. v. p. 545. Paris, 1835.) however, regards it as true sulphatic ether, (SO^3, $C^4 H^5 O$,) holding in solution variable quantities of carbohydrogen.

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

Uses.—Ethereal oil is used in the manufacture of the *Spiritus Ætheris Sulphurici Compositus* of the Pharmacopœia (see p. 334.)

"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*.)

4. SPIR'ITUS Æ'THERIS NI'TRICI, *L. E.* (U. S.)—SPIRIT OF NITRIC ETHER, OR SWEET SPIRIT OF NITRE.

(Spiritus Æthereus Nitrosus, *D.*—Hyponitrous Ether, with four volumes of Rectified Spirit. *E.*)

History.—The first traces of this preparation are to be found in the writings of Raymond Lully, in the 13th century.[1] Basil Valentine, in the 15th century, taught a much improved method of preparing it.[2] Nitric ether was first mentioned by Kunkel, in 1681.[3]

Spirit of nitric ether has been known by various names, such as *Dulcified Acid of Nitre* (*Acidum Nitri dulcificatum*,) *Sweet Spirit of Nitre* (*Spiritus Nitri dulcis*,) *Spirit of Nitrous Ether* (*Spiritus Ætheris Nitrosi*) and *Nitre Drops*.

Preparation.—It is usually prepared by the action of nitric acid on rectified spirit at one operation, as in the process of the *London College*, which is that employed at Apothecaries' Hall, London. Or it may be procured by first preparing nitric [hyponitrous] ether, and subsequently diluting this with rectified spirit, as in the process of the *Edinburgh College*.

1. Preparation of Hyponitrous Ether.—Liebig (Turner's *Elements of Chemistry*, 7th edit. p. 848.) has lately given the following method of obtaining this compound in a state of purity:—"One part of starch, and ten parts of nitric acid, sp. gr. 1·3, are introduced into a capacious retort, which is connected by means of a wide tube, bent at right angles, with a two-necked bottle, so that the farther end of the tube reaches to the bottom of the bottle. Into this bottle is introduced a mixture of two parts of alcohol at 85 p. c. and one part of water, and it is surrounded by cold water. The second aperture of the bottle is connected, by means of a long wide tube, with a good cooling apparatus or condenser. The starch and nitric acid are heated in the water-bath; pure hyponitrous acid is disengaged, which, passing through the alcohol, instantly combines with the ether, forming hyponitrite of oxide of ethule, which distils in a continuous stream. This process is very productive. By means of water, the new ether is purified from alcohol, and by standing over chloride of calcium it is freed from water. The tube which connects the retort with the two-necked bottle must have a length of two or three feet, and must be surrounded with moist paper during the operation. If the alcohol be not carefully cooled, it becomes spontaneously hot, and boils violently. From this moment the hyponitrite of ethule is no longer pure."

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[1] Dulk, *Die Preussische Pharmakopöe übers und erlautert*, 2er Th. S. 704, 2te Aufl. Leipzig, 1830.

[2] Ibid.

[3] Thomson, *System of Chemistry of Inorganic Bodies*, vol. ii. p. 317, 7th edit. 1831.

The process of the *Edinburgh College* for the preparation of hyponitrous ether is as follows:—Take of Rectified Spirit, Oij. and f℥vj.; Pure Nitric Acid (Density 1·500) f℥vij. Put fifteen fluid ounces of the spirit, with a little clean sand, into a two-pint matrass, fitted with a cork, through which are passed a safety tube, terminating an inch above the spirit, and another tube leading to a refrigeratory. The safety-tube being filled with pure nitric acid, add through it gradually three fluid ounces and a-half of the acid. When the ebullition which slowly arises is nearly over, add the rest of the acid gradually, half a fluid ounce at a time, waiting till the ebullition caused by each portion is nearly over before adding more, and cooling the refrigeratory with a stream of water, iced in the summer. The ether thus distilled over being received in a bottle, is to be agitated first with a little milk of lime, till it ceases to redden litmus paper, and then with half its volume of concentrated solution of muriate of lime. The pure hyponitrous ether thus obtained should have a density of 0·899.

The process of the *Dublin College* is as follows:—Take of Nitrate of Potash, purified, dried, and coarsely powdered, lb. iss.; Sulphuric Acid, lb. j.; Rectified Spirit, f℥xix. Put the nitrate of potash into a tubulated retort placed in a bath of cold water, and pour on it by degrees and at intervals, the sulphuric acid and the spirit, previously mixed and cooled after their mixture. Without almost any external heat, or at most a very gentle one (as of warm water added to the bath,) the ethereal liquor will begin to distil without the application of fire; in a short time the heat in the retort will increase spontaneously, and a considerable ebullition will take place, which must be moderated by reducing the temperature of the bath with cold water. The receiver must also be kept cold with water or snow, and furnished with a proper apparatus for transmitting the highly elastic vapour (bursting from the mixture with great violence if the heat be too much increased) through a pound of rectified spirit contained in a cool phial. The ethereal liquor thus spontaneously distilled, is to be received into a phial with a ground-glass stopper, and there must be added by degrees (closing the phial after each addition) as much very dry and powdered carbonate of potash as will suffice to saturate the excess of acid, using litmus as a test: this is effected by the addition of about a drachm of the salt. In a short time the nitrous ether will rise to the surface, and is to be separated by means of a funnel.

If the ether be required very pure, distil it again to one half, from a water-bath at a temperature of 140°. Its specific gravity is, to that of distilled water, as 0·900 to 1·000.

The *theory* of Leibig's process for making hyponitrous ether is simple. Starch deoxidizes nitric acid and evolves hyponitrous acid [the nitrous acid of Graham and continental chemists.] This being conveyed into alcohol, combines with the oxide of ethule of the latter, and disengages the water.

MATERIALS.				PRODUCTS.	
1 eq. Hyponitrous Acid....	38			1 eq. Hyponitrous Ether........	75
2 eq. Alcohol..............	46	1 *eq. Oxide Ethule*	37		
		1 *eq. Water*.......	9	1 eq. Water	9
	84				84

Hyponitrous ether is, however, usually prepared by the action of nitric acid on alcohol; as in the Edinburgh and Dublin processes. The reactions are then more complicated, but vary with the strength of the acid and the temperature. They essentially depend on the deoxidation of the nitric acid by the hydrogen and carbon of the ethule of part of the alcohol. As hydrogen has more affinity than carbon for oxygen, it follows that in the earlier stages, and when reaction is moderate, it is the hydrogen of the ethule which is oxidized by the oxygen of the nitric acid. Thus, when we employ a dilute acid, or moderate the reaction by cold, the products are aldehyd (hydrated oxide of acetule,[1]) water, and hyponitrous ether.

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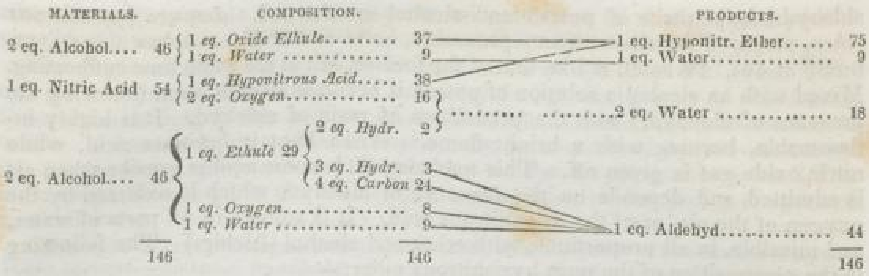
[1] *Acetule*, and the *oxide of acetule*, are hypothetical substances Aldehyd is regarded as the hydrate of the hypothetical oxide of acetule.



When, however, the reaction is more energetic, as when strong nitric acid is employed, and the temperature is not moderated, the carbon as well as the hydrogen of the ethule is oxidized by the oxygen of the acid, and several products, besides those above mentioned, are then obtained. Carbonic ($C\,O^2$) and oxalic ($C^2\,O^3$) acids are formed by the oxidation of the carbon. Acetic ($C^4\,H^3\,O^3$) and formic ($C^2\,H\,O^3$) acids are also generated; "besides acetate and formiate of ethule" (Liebig.) By the deoxidation of nitric acid there are obtained, besides hyponitrous acid already mentioned, nitrous acid, binoxide of nitrogen, protoxide of nitrogen and nitrogen (Thenard.)

2. Preparation of Spiritus Ætheris Nitrici.—The processes of all the British Colleges differ from each other.

The *London College* orders of Rectified Spirit, lbiij.; Nitric Acid, ℥iv. Add the Acid gradually to the Spirit, and mix; then let 32 fluid ounces distil.

The *Edinburgh College* directs the pure hyponitrous ether (obtained by the process above detailed) to be mixed with the remainder (*i. e.* f℥xxxj.) of the rectified spirit, or exactly four times its volume. Spirit of nitric ether ought not to be kept long, as it always undergoes decomposition, and becomes at length strongly acid. Its density, by this process, is 0·847.

The directions of the *Dublin College* are as follows:—Add to the matter which remains after the distillation of nitrous ether, the rectified spirit employed in that operation for condensing the elastic vapour, and distil till the residuum be dry, with the greater heat of a warm bath. Mix the distilled liquor with the alkaline liquor which remains after the separation of the nitrous ether, and add, moreover, as much well-dried carbonate of potash as shall be sufficient to saturate the predominant acid. This is made evident by the test of litmus. Lastly, distil as long as any drops come over by the medium heat of a warm bath. The sp. gr. of this liquor is to that of distilled water as 0·850 to 1000. Nitrous ethereal spirit may also be prepared by adding two ounces of nitric acid to a pound, *by measure*, of rectified spirit, and distilling twelve ounces with a proper apparatus and the application of a gentle heat.

[The U. S. Pharmacopœia directs to take Nitrate of Potassa in coarse powder two pounds; Sulphuric Acid a pound and a-half, Alcohol nine pints and a-half, Diluted Alcohol a pint; Carbonate of Potassa an ounce. Mix the Nitrate of Potassa and the Alcohol in a large glass retort, and having gradually poured in the acid, digest with a gentle heat for two hours; then raise the heat and distil a gallon. To the Distilled Liquor add the Diluted Alcohol and Carbonate of Potassa, and again distil a gallon.]

At Apothecaries' Hall, London, this preparation is made in an earthenware still, with a condensing worm of the same material. The still is heated by the slow application of steam to its outer surface. (Brande, *Manual of Pharmacy*, p. 461, 3rd edit. Lond.)

The *theory*[1] of the process is essentially the same as that for preparing pure hyponitrous ether. The latter, when formed, distils over along with rectified spirit, and constitutes the spiritus ætheris nitrici, *Ph. L.*

Properties. α. **Of Hyponitrous Ether.**—*Pure hyponitrous ether*, prepared by Liebig's process, is pale yellow, has a most fragrant smell of apples and Hungary wines, boils at 62°, and has the sp. gr. of 0·947 at 60°. It may be mixed with an alcoholic solution of potash without becoming brown (showing the absence of

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[1] Dr. Golding Bird (*Lond. and Edinb. Phil. Mag.* 1839, vol. xiv. p. 324) says, that while the ether distils, mixed with alcohol only, oxalhydric [saccharic] acid, ($C^{12}\,H^{10}\,O^{16}$.) but no oxalic acid is formed. He also states, that aldehyd is generated, but does not appear in the distilled liquid until the formation of ether has nearly or entirely ceased; the aldehyd and oxalic acid being nearly of simultaneous origin.

aldehyd:) hyponitrite of potash and alcohol are formed. *Impure hyponitrous ether*, prepared by the ordinary processes, boils at 70° F., and has the sp. gr. 0·886 at 40°. Its smell is like that of the former, but at the same time suffocating. Mixed with an alcoholic solution of potash it becomes dark brown, (showing the presence of aldehyd,) with the production of resin of aldehyd. It is highly inflammable, burning with a bright flame. When kept it becomes acid, while nitric oxide gas is given off. This tendency to become acid is greater when air is admitted, and depends on the presence of aldehyd, which is oxidized by the oxygen of the air, or of the hyponitrous acid. It is soluble in 48 parts of water, and miscible, in all proportions, with ether and alcohol (Liebig.) The following is the composition of the pure hyponitrous ether:—

	Atoms.	*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
Hyponitrous Ether	1	75	100·00	100·00

Or,	*Atoms.*	*Eq. Wt.*	*Per Cent.*
Hyponitrous Acid	1	38	50·66
Oxide of Ethule (Ether)	1	37	49·34
Hyponitrite of Oxide of Ethule	1	75	100·00

β. **Of Spiritus Ætheris Nitrici.**—Spirit of nitric ether is a colourless, limpid liquor, having a fragrant ethereal odour, somewhat analogous to that of ripe apples, and a pungent, aromatic, sweetish acidulous taste. Prepared according to the London Pharmacopœia its sp. gr. should not exceed 0·834; but the preparation of the Edinburgh Pharmacopœia has a sp. gr. of 0·847. It is very volatile, producing much cold by its evaporation. It is very inflammable, and burns with a whitish flame. By keeping it usually becomes strongly acid, though I have had some kept for several years which possessed only slight acidity. It dissolves in alcohol and water in all proportions. "Hyponitrous ether may be separated from the alcohol, water, and uncombined acid, which the preparation of the pharmacopœia contains, by digesting lime reduced to powder in it, and subjecting the mixture to distillation. (Mr. R. Phillips, *Translation of the Pharmacopœia*, 4th ed. Lond. 1841.)

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 or an acid of nitrogen; and produces, with tincture of guaiacum, a blue tint, which passes through various shades of green: this last effect depends on the presence of an acid of nitrogen. These effects are not invariably produced; for in some spirit of nitric ether which I have had for several years they do not take place.

COMPOSITION.—Spirit of nitric ether is a mixture of [impure] *hyponitrous ether* and *rectified spirit*. Prepared according to the Edinburgh Pharmacopœia, its composition is as follows:—

	Vols.	*Sp gr.*	*Weight.*
Hyponitrous Ether	1	0·886	20·9
Rectified Spirit	4	0·838	79·1
Spiritus Ætheris Nitrici, *Ph. Ed.*	5	0·847	100·0

PURITY.—Few articles of the pharmacopœia are more extensively adulterated than spirit of nitric ether. To prove how great a fraud must be practised with it, I may mention that, in July, 1840, Mr. Hennell informed me, that it was then selling in the trade at a price which was but just above that of the duty on the spirit used in manufacturing the genuine article. Wholesale dealers usually keep two, or even three, qualities of this preparation: the inferior ones being obtained by diluting the best with different quantities of water, or spirit of wine and water. Some years since large quantities of spirit of wine, flavoured with hyponitrous ether, were imported from Ireland into London, under the name of spirit of nitric ether, in order to evade the duty payable on it as spirit of wine. Aldehyd and an acid of nitrogen are accidental impurities frequently present.

The goodness of Spirit of Nitric Ether is to be estimated in part by an attentive examination of the flavour, and by taking the specific gravity of this liquid. Prepared according to the process of the London Pharmacopœia, its density is 0·834. A free acid (an acid of nitrogen) may be recognised by litmus, and by the effervescence produced on the addition of the alkaline carbonates. The *Edinburgh College* gives the following characteristics of the purity of spirit of nitric ether:—

> "Density, 0·847: it effervesces feebly, or not at all, with a solution of bicarbonate of potash. When agitated with twice its volume of muriate of lime, 12 per cent. of ether slowly separates."

Two samples of spirit of nitric ether, prepared by Messrs. Howard and Co., of Stratford, I found to be 47·8 *over proof*, according to Sikes's hydrometer; indicating the sp. gr. to be about 0·85. But I failed to separate the hyponitrous ether by the use of a solution of muriate of lime, as directed by the Edinburgh College.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Its effects on plants have not been ascertained.

β. *On Animals.*—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.)

γ. *On Man.*—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 operates as a volatile stimulant and diuretic. According to the experiments of Alexander (See p. 197.) it acts mildly on the kidneys. It is believed to possess diaphoretic properties. By some pharmacologists it is described as being refrigerant,—a quality which it owes perhaps 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*, S. 484. Göttingen, 1831.) 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 emetic tartar. As a carminative it is frequently useful in relieving flatulence and allaying nausea. On account of its volatility it may be applied to produce cold by its evaporation. Spirit dealers employ it as a flavouring ingredient.

ADMINISTRATION.—The usual dose of this liquid in febrile cases is f ʒss. to f ʒij or f ʒiij. When we wish it to act as a diuretic, it should be given in large doses, as two or three tea-spoonsful.

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.

5. ÆʹTHER HYDROCHLOʹRICUS.—HYDROCHLORIC ETHER.

History and Synonymes.—In the Edinburgh Pharmacopœia for 1735, was a preparation called *Spiritus Salis dulcis*. It was a solution of Hydrochloric Ether in rectified spirit. Very little, however, was known of the properties of this ether till Gehlen published a dissertation on the subject, in 1804. (Thomson's *System of Chemistry of Inorganic Bodies*, vol. ii. p. 310, 7th ed. Lond. 1831.) This ether has had various appellations, such as *Chlorhydric Ether*, *Muriatic Ether*, *Marine Ether*, and, hypothetically, *Chloride of Ethule*.

Preparation.—It is best obtained by saturating alcohol with hydrochloric acid gas (see p. 256,) and distilling, by means of a water-bath, into a carefully cooled receiver.

By the reaction of one equivalent or 37 parts of hydrochloric acid (Chl. H) on two equivalents or 46 parts of alcohol ($C^4 H^5 O + HO$,) we obtain one equivalent or 65 parts of hydrochloric ether ($C^4 H^5$ Chl.) and two equivalents or 18 parts of water (2 HO.)

Properties.—Hydrochloric ether is a colourless liquid, having a penetrating odour, and a taste somewhat sweetish. Its sp. gr. is 0·874 at 40° F. It boils at 51° F. This great volatility prevents its being kept in the shops. When pure it is quite neutral, dissolves in about 24 parts of water, does not precipitate nitrate of silver, and burns with a flame edged with green, producing vapours of hydrochloric acid. By the slow action of hydrate of potash on it, chloride of potassium and alcohol are formed.

Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Carbon	4	24	36·92
Hydrogen	5	5	7·69
Chlorine	1	36	55·38
Hydrochloric Ether	1	65	99·99

Or,	*Atoms.*	*Eq. Wt.*	*Per Cent.*
Ethule	1	29	44·61
Chlorine	1	36	55·38
Chloride Ethule	1	65	99·99

Physiological Effects and Uses.—It is a highly diffusible stimulant, like the other ethers, but is rarely employed alone; though it has been used as an antispasmodic.

SPIRITUS ÆTHERIS HYDROCHLORICI; *Æther Muriaticus Alcoholicus; Spiritus Muriatico-Æthereus; Spiritus Salis dulcis; Spirit of Hydrochloric Ether; Spirit of Muriatic Ether; Dulcified Marine Acid.*—In the Edinburgh Pharmacopœia for 1735, this was ordered to be prepared by adding one part of muriatic acid to three parts of rectified spirit, digesting for some days, and then distilling by a sand heat. Or it may be prepared by dissolving hydrochloric ether in an equal volume of rectified spirit. Liebig says, that the spiritus muriatico-ethereus, used on the continent, contains *heavy muriatic ether*, the composition of which is not known. The action of spirit of muriatic ether seems to be similar to that of spirit of nitric ether. A scruple of it thrown into the veins of a buck augmented the renal secretion. (Lanzoni, quoted by Wibmer, *Die Wirkung*, &c. Bd. i. S. 56.) An ounce and a half injected into the jugular vein of a dog, coagulated the blood, caused difficulty of breathing, and death. (Freind, quoted by Wibmer.) It has been used in dyspeptic affections, connected with hepatic obstructions. In hectic fever, Berends (Sundelin, *Handbuch der speciellen Heilmittellehre*, Bd. ii. S. 71. 3tte Aufl. Berlin, 1833.) found its continued use beneficial. The dose of it is fʒi. to fʒiij.

6. ÆʹTHER ACEʹTICUS.—ACETIC ETHER.

History.—It was discovered by Count de Lauraguais, in 1759. (Thomson, *op. supra cit.*)

Preparation.—It is prepared by submitting to distillation a mixture of 16 parts of dry acetate of lead, 4½ of alcohol, and 6 of oil of vitriol; or 10 parts of crystallized acetate of soda, 15 of oil of vitriol, and 6 of alcohol, at 80 or 85 per cent. The product is rectified with slaked lime and chloride of calcium, to remove acid and water; and a quantity of acetic ether, equal in weight to the alcohol, is obtained. (Liebig.)

PROPERTIES.—Acetic ether is colourless, and has an agreeable odour of acetic acid and ether. Its sp. gr. is 0·89 at 60°. It boils at 165°. It is soluble in 7 parts of water, and mixes with alcohol and ether in every proportion. Oil of vitriol resolves it into ether and acetic acid.

COMPOSITION.—The composition of this ether is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Or,*	*Atoms.*	*Eq. Wt.*	*Per Cent.*
Carbon	8	48	51·54	Ethule	1	29	32·95
Hydrogen	8	8	9·1	Oxygen	1	8	9·1
Oxygen	4	32	36·36	Acetic Acid	1	51	57·95
Acetic Ether	1	88	100·00	Acetate of the Oxide of Ethule	1	88	100·00

PHYSIOLOGICAL EFFECTS AND USES.—Acetic ether is not used in medicine in this country. On the continent, however, it is occasionally employed. It is somewhat similar in its operation to the other ethers; but is milder, more agreeable, and more diaphoretic. It is used in nervous and putrid fevers, in cardialgia, spasmodic vomiting, and asthenic affections of the stomach and alimentary canal. (Sundelin, *op. supra cit.*) Dose, fʒss. to fʒij.

7. AC'IDUM ACE'TICUM.—*L. E. D.* (U. S.) ACETIC ACID.

HISTORY.—Vinegar must have been known from the most remote periods of antiquity. It is mentioned, by Moses, (*Numbers*, ch. vi. ver. 3.) 1490 years before Christ. Hippocrates (*De Natura Muliebri*) employed it (ὀξυς) medicinally. Hannibal, in his passage over the Alps, is said to have softened the rocks by fire and vinegar[1]. 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. (Dulk, *Die Preussiche Pharmakopöe übers und erläutert*, 2^{ter} Th. S. 123, 2^{te} Aufl. Leipzig, 1830.

NATURAL HISTORY.—Acetic acid is peculiar to the organized kingdom.

Acetic acid, free, or combined with potash, lime or ammonia, 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 Areca Catechu. Many vegetable substances yield it by decomposition.

Acetic acid is said to have been detected in the gastric juice, the perspiration, the urine, the milk, and the blood. It is propable, however, that in most, if not all, of these cases, lactic acid was mistaken for acetic acid.

Gmelin (*Handb. d. Chem.* Bd. ii. S. 126.) 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. Geiger (*Handb. d. Pharm.* Bd. i. S. 601, 3^{te} Aufl.) states that acetate of potash is found in some mineral waters.

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. Acetous Fermentation.—All liquids which are susceptible of vinous fermentation may be made to yield vinegar. A solution of saccharine matter (or some substance capable of producing sugar) is the essential ingredient. It is converted, by fermentation, first into alcohol, and subsequently into acetic acid.

The liquids employed in the manufacture of vinegar vary according to circumstances. In this country the vinegar of commerce is obtained from an infusion

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[1] Livy, c. 37.—Polybius, however, from whom Livy has borrowed the greater part of his narrative, does not mention the use of vinegar. See some remarks on this subject in *A Dissertation on the Passage of Hannibal over the Alps*, p. 107. Oxford, 1820.

of malt, or of a mixture of malt and raw barley. In wine countries it is procured from inferior wines. Dilute spirit, beer, a solution of sugar, and other liquids, are also susceptible of the acetous fermentation.

1. *Malt Vinegar* (*Acetum*, L.; *Acetum Britannicum* or *British Vinegar*, E.)—This 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 standing endways, tied over with a coarse cloth, and placed close together in darkened chambers, artificially heated by a stove.[1] Here the liquor remains until the acetous fermentation is complete. This process usually occupies several weeks, or even months. The product is not yet fit for sale. It is introduced into large tuns furnished with false bottoms, on which is placed *rape* (the residuary fruit which has served for making domestic wines.) These rape-tuns are worked by pairs; one of them is quite filled with the vinegar from the barrels, and the other only three-quarters full, so that the fermentation is excited more easily in the latter than the former, and every day a portion of the vinegar is conveyed from one to the other, till the whole is completely finished, and fit for sale.[2] 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. These barrels were then exposed to the sun and air for several months, until the acetification was perfect. But the introduction of stoved chambers has nearly superseded this method.

Malt vinegar has a yellowish red colour, an agreeable acid taste, which it owes to acetic and partly to sulphuric acid, and a peculiar, refreshing, pleasant odour, which it derives from acetic acid and acetic ether. Vinegar of four different degrees of strength are sold by the makers, and are distinguished as Nos. 18, 20, 22, and 24: the latter, which is the strongest, is also called *proof vinegar*, and is estimated to contain 5 per cent. of real acetic acid: but, according to Mr. Phillips, it does not usually contain more than 4·6 per cent. One fluid ounce (= 446 grs.) of the latter strength should saturate very nearly 58 grs. of crystallized carbonate of soda. In the London Pharmacopœia it is stated that one fluid ounce should saturate 60 grs. of crystallized carbonate of soda: the two grains extra being "allowed for saturating the sulphuric acid permitted to be mixed with vinegar, and for decomposing the sulphates of the water used in vinegar making." (Mr. R. Phillips, *Translation of the Pharmacopœia*, 4th ed. p. 51. Lond. 1841.) The Edinburgh College fixes the density of British vinegar at from 1·006 to 1·012; but it is usually higher than this. Mr. Phillips (*Lond. Medical Gazette*, N.S., vol. ii. for 1838–39, p. 687.) found it, in one sample obtained from a respectable source, to be 1·019. Dr. T. Thomson found it to vary from 1·0135 to 1·0251. Vinegar is very liable to undergo decomposition: it becomes turbid, loses its acidity, acquires an unpleasant odour, and deposites a slippery gelatiniform substance. The mucilaginous coat or skin which forms on the surface of vinegar, and is called the *mother of vinegar*, appears to consist of myriads of exceedingly minute vegetables, having a globular form. (See Keïtzing, in the *Répertoire de Chimie*, t. iii. p. 263. Paris, 1838.) The surface of vinegar is frequently covered by Mouldiness (*Mucor Mucedo*.) The microscopic animals, called Vinegar Eels[3] (*Anguillula Aceti*,) are generated and

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[1] The proper temperature is usually stated to be about 80° F; but I suspect a much higher temperature is employed. I found the heat of one of these chambers so great that I was unable to support it beyond a few minutes. The proprietor of the establishment (one of the largest vinegar works in the metropolis) refused to allow me to inspect the thermometer hanging up in the chamber.

[2] For farther information on this subject, consult Aikins' *Dictionary of Chemistry*, vol. ii. p. 468, Lond. 1807; and Donovan's *Domestic Economy*, vol. i. 1830, in Lardner's *Cabinet Cyclopædia*.

[3] See some remarks on these animalcules by Professor Owen, in the *Cyclopædia of Anatomy and Physiology*, vol. ii. p. 113. Lond. 1839.

nourished in vinegar. They may be destroyed by submitting the liquid in which they are contained to heat. Vinegar is also infested by a small fly (*Musca cellaris.*)

Malt vinegar consists of *water, acetic acid, acetic ether, colouring matter, a peculiar organic matter,* commonly denominated mucilage, a small portion of *alcohol* and *sulphuric acid.* Vinegar makers are allowed to add one-thousandth part by weight of sulphuric acid. This may be detected by a solution of chloride of barium, which forms a white precipitate (*sulphate of baryta,*) insoluble in nitric acid. The quantity of sulphate of baryta thrown down from a fluid ounce of vinegar, by the addition of solution of chloride of barium, should not exceed 1·14 grains,[1] (*Ph. L.*) If the vinegar be free from copper, lead, tin, and other metallic matter, it yields no precipitate on the addition of hydrosulphuric acid (sulphuretted hydrogen.) The presence of hydrochloric acid may be recognised by nitrate of silver, which produces a white precipitate (*chloride of silver*) with it, insoluble in nitric acid. The presence of nitric acid in vinegar may be recognised by boiling this liquid with indigo, which is rendered yellow by nitric acid. Or it may be detected by saturating the suspected acid with potash or soda, and evaporating to dryness: the residue deflagrates, when thrown on red-hot coals, if nitric acid be present. In the London Pharmacopœia the detection of nitric acid is directed to be effected by immersing a plate of silver in the suspected acid: if nitric acid be present, a solution of nitrate of silver will be obtained, which is recognised by the white precipitate (*chloride of silver*) caused by the subsequent addition of hydrochloric acid. Pepper, or other acrid substances, may be detected by neutralizing the vinegar with carbonate of soda, when their acrid taste becomes very obvious.

2. *Wine Vinegar* (*Acetum Gallicum,* or *French Vinegar,* E.; *Acetum Vini,* D.)—In wine countries, vinegar is obtained from inferior wines. In France, wine vinegar is prepared in casks, which are placed in a stoved chamber, heated to between 68° and 77° F. Each vat communicates with the air by two apertures. Every eight or ten days the liquor in the vats must be changed. Either red or white wine may be used, but the latter is generally employed.[2]

Wine Vinegar is of two kinds, *white* and *red,* according as it is prepared from white or red wine. *White wine vinegar* is usually preferred, as it keeps better. That which is made at Orleans is regarded as the best. According to the Edinburgh Pharmacopœia its density varies from 1·014 to 1·022. A sample of it, examined by Mr. Phillips, had a density of 1·016; and 100 minims of it saturated nearly 14 grains of crystallized carbonate of soda, while an equal quantity of English vinegar, exclusive of the sulphuric acid which it contains, saturated little more than 12 grains; consequently, the French is stronger than the English vinegar by nearly one-sixth. (*London Medical Gazette,* Aug. 3, 1839.)

The constituents of wine vinegar are very similar to those of malt vinegar. It contains a small quantity of bitartrate and sulphate of potash. Both these salts occasion precipitates with barytic solutions: but that produced by the bitartrate is soluble in nitric acid. The Edinburgh College states that "Ammonia, in slight excess, causes a purplish muddiness, and slowly a purplish precipitate. In four fluid ounces, complete precipitation takes place with 30 minims of Solution of Nitrate of Baryta," *Ph. Ed.* But Mr. Phillips (*Op. supra cit.*) has shown that this quantity of nitrate is more than twice as much as is requisite.

3. *Improved, German, or Quick Method of Vinegar-making.*—As acetification is essentially the oxidation of alcohol, the German chemists have contrived an improved method of effecting it, by which the time necessary to the produc-

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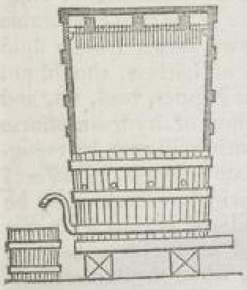
[1] The Edinburgh College states, that "In four fluid ounces [of British vinegar] complete precipitation takes place with thirty minims of Solution of Nitrate of Baryta," *Ph. Ed.* But Mr. Phillips (*Lond. Med. Gaz.* Aug. 3, 1839) has shown, that more than three times this quantity of nitrate is required.

[2] See Guibourt, *Hist ire Abrégée des Drogues Simples,* 3rd. ed. t. ii. p. 630, Paris, 1836; Ure's *Dictionary of Arts,* p. 3, Lond. 1839; and Donovan, *op. supra cit.* p. 328.

tion of vinegar is greatly curtailed. It consists in greatly enlarging the surface of the liquid exposed to the air.

This is effected by causing a mixture of one part of alcohol at 80 per cent., four to six parts water, $\frac{1}{1000}$ of ferment, honey, or extract of malt, to trickle down through a mass of beech shavings steeped in vinegar, and contained in a vessel called a *Vinegar Generator* (*Essigbilder*,) or *Graduation Vessel.* It is an oaken tub, narrower at the bottom than at the top, furnished with a loose lid or cover, below which is a perforated shelf (colender or false bottom,) having a number of small holes loosely filled with packthread about six inches long, and prevented from falling through by a knot at the upper end. The shelf is also perforated with four open glass tubes, as air vents, each having their ends projecting above and below the shelf. The tub, at its lower part, is pierced with a horizontal row of eight equidistant round holes, to admit atmospheric air. One inch above the bottom is a syphon-formed discharge pipe, whose upper curvature stands one inch below the level of the air-holes in the side of the tub. The body of the tub being filled with beech chips, the alcoholic liquor (first heated to between 75° F. and 83° F.) is placed on the shelf. It trickles slowly through the holes by means of the packthreads, diffuses itself over the chips, slowly collects at the bottom of the tub, and then runs off by the syphon pipe. The air enters by the circumferential holes, circulates freely through the tub, and escapes by the glass tubes. As the oxygen is absorbed, the temperature of the liquid rises to 100° or 104° F., and remains stationary at that point while the action goes on favourably. The liquid requires to be passed three or four times through the cask before acetification is complete, which is in general effected in from twenty-four to thirty-six hours.[1]

Fig 51.

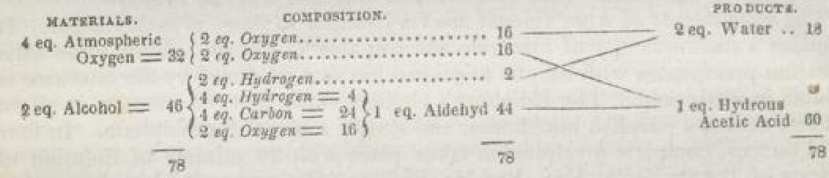


Vinegar Generator.

(The upper part of the figure represents a vertical section of the tub.)

Theory of Acetification.—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. During the acetous fermentation the alcohol is converted into acetic acid, by the absorption of atmospheric oxygen. 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 anhydrous acetic acid, and of three equivalents or 27 parts of water; or one equivalent or 60 parts of hydrous acetic acid, and two equivalents or 18 parts of water.

According to Liebig, however, the transformation of alcohol into acetic acid is not immediate and direct. The atmospheric oxygen first oxidizes part of its hydrogen, forming water and aldehyd; and the latter absorbing oxygen, is converted into acetic acid.



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

2. By the Destructive Distillation of Wood.—By the destructive distillation of the hard woods (oak, beech, hornbeam, ash, and birch,) in iron cylinders, an impure acid, called Pyroligneous Acid, is obtained. The woods should be dried

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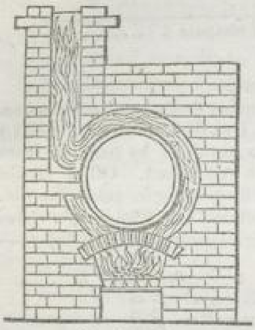
[1] For farther details consult Ure's *Dictionary of Arts*, pp. 4 and 617; Mitscherlich, *Lehrbuch der Chemie*, Bd. 1er, S. 549, 2te Aufl. Berlin, 1834; and Liebig, in Turner's *Elements of Chemistry*, p. 876, 7th ed.

during several months. The lighter woods, as fir, and old ship timber, do not pay to distil, as the acid product is too weak.

Sometimes the still is a cast-iron cylinder, placed horizontally in a furnace, the fire of which plays around the cylinder, as in fig. 52. Another form of still is used at a large manufactory in the neighbourhood of London. It is a short cylinder of large diameter, placed upright in the furnace. The wood, cut up into convenient lengths, is introduced into wrought-iron canisters, in each of which is a hole, to allow of the escape of volatile matters. By the aid of a crane, these canisters are raised and deposited in the cylindrical still, the top of which is then carefully closed and made air-tight by luting. The still communicates with a large iron pipe which passes successively through two tanks of cold water, in which it is variously convoluted, and terminates in an underground reservoir, where tar and an acid liquor are deposited. The incondensible products are carbonic acid and some inflammable gases, (carbonic oxide, light carburetted hydrogen, and olefiant gas,) which escape. When no more volatile matter comes over, the still is opened, and the canisters being removed while still hot, the apertures in them are carefully closed by damp sand, to exclude air.

Fig. 52.



Section of a Pyroligneous Acid Still.

The *tar* obtained by the above process yields, on distillation, *oil of tar*, and a residuum called *English asphalt*, or *pitch*.

The *acid liquor*, which rests on the tar in the reservoir, consists of *acetic acid, water, tar*, and *pyroxilic spirit*. A light tarry matter usually floats on the top of it. By means of a pump, the acid liquor is raised and introduced into a copper still, where it is subjected to distillation. The first runnings contain pyroxilic spirit. After this has come over, an impure dilute acetic acid, called pyroligneous acid, distils over. The residue in the retort is English asphalt, or pitch.

The pyroligneous acid thus obtained is mixed with cream of lime, and the mixture evaporated to dryness in shallow wrought-iron pans, when it forms a grayish mass, called *pyrolignite of lime*. If this be submitted to distillation with sulphuric acid, it yields an impure acetic acid, which is used in the manufacture of acetate of lead, and for making carbonate of lead by the Dutch process.

If pyrolignite of lime be mixed with a solution of sulphate of soda, double decomposition is effected, and sulphate of lime and acetate of soda are the products. The latter is repeatedly crystallized until it is colourless, and is then in a fit state for the manufacture of pure concentrated acetic acid.

1. PYROXILIC SPIRIT; *Pyroligneous Ether; Hydrate of Oxide of Methule; Bihydrate of Methylene.* Sometimes, but improperly, termed *Naphtha*. The first runnings of the distillation of the acid liquor above referred to, are redistilled once or twice, and the product is sold under the name of *pyroligneous ether*. It is an impure liquor, containing, besides hydrate of the oxide of methule, acetone and other inflammable liquors. It is employed by chemists as a substitute for spirit of wine for burning in lamps, and by hatters and varnish-makers for dissolving resinous substances. Drs. Babington and Rees (*Guy's Hospital Reports*, Oct. 1839; and *London Medical Gazette*, N. S. vol. i. for 1839–40.) have suggested its use for the preservation of subjects for anatomical purposes. The spirit is to be injected into the aorta, the rectum, and the peritoneum. It was tried at the London Hospital, but the smell arising from the spirit was so intolerable, that, even if there were no other objections to its use, this alone would be fatal to it.

Pure pyroxilic spirit is obtained by introducing it into a retort with excess of chloride of calcium, and distilling the mixture by a water-bath, as long as volatile matter passes off. A quantity of water, equal to the spirit employed, is then added, and the distillation continued. The product is now pure pyroxilic spirit, carrying along with it a little water, which is removed by a second distillation with quicklime (Liebig.)

Pure pyroxilic spirit is a very mobile, colourless, inflammable liquid, which has a peculiar odour, somewhat resembling that of alcohol and acetic ether. It boils at 150° F. It dissolves many resins, mixes with most essential oils, and forms crystalline compounds with baryta, lime, and chloride of calcium. Its composition is as follows:—

	Atoms.	*Eq. Wt*	*Or,*	*Atoms.*	*Eq. Wt.*
Carbon	2	12	Oxide of Methule	1	23
Hydrogen	4	4	Water	1	9
Oxygen	2	16			
Pyroxilic Spirit	1	32	Hydrate of Oxide of Methule	1	32

Methule ($C^2 H^3$) is the hypothetical radical of pyroxilic spirit.

Oxide of Methule, or *Methylic Ether* ($C^2 H^3 O$) is a colourless gas.

The repeated use of small quantities of pyroxilic spirit caused colicy pains, and acted as an anthelmintic. (Dierbach, *Neuesten Entdeck. in d. Mat. Med.*, Bd. i. S. 314, 2te Ausg. 1837.)

2. Eblanin; *Pyroxanthine; Pyroxilene.*—This substance was obtained by Scanlan from raw pyroxilic spirit. It is a crystalline substance, of an orange red colour. Oil of vitriol dissolves it, and assumes a reddish blue colour. Concentrated hydrochloric acid also dissolves it, and acquires an intense purple colour. (For farther details, see Thomson's *Chemistry of Organic Bodies*, p. 751. Lond. 1838.) Eblanin has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Carbon	21	126	75·45
Hydrogen	9	9	5·39
Oxygen	4	32	19·16
Eblanin	1	167	100·00

Preparation of Acetic acid.—All the British colleges give directions for the preparation of a concentrated solution of acetic acid, which they simply term acetic acid.

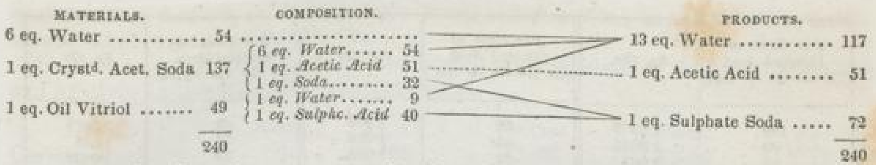
The *London College* orders Acetate of Soda, lb. ij.; Sulphuric Acid, ℥ix.; Distilled Water, f℥ix. Add the sulphuric acid, first mixed with the water, to the acetate of soda put into a glass retort, then let the acid distil in a sand-bath. Care is to be taken that the heat, towards the end, be not too much increased.

The *Edinburgh College* gives the following directions:—"Take of Acetate of Lead any convenient quantity; heat it gradually in a porcelain basin, by means of a bath of oil, or fusible metal (8 tin, 4 lead, 3 bismuth) to 320° F.; and stir till the fused mass concretes again: pulverize this when cold, and heat the powder again to 320°, with frequent stirring, till the particles cease to accrete. Add six ounces of the powder to nine fluid-drachms and a-half of pure sulphuric acid, contained in a glass matrass: attach a proper tube and refrigeratory, and distil from a fusible-metal-bath, with a heat of 320°, to complete dryness. Agitate the distilled liquid with a grain or two of red oxide of lead to remove a little sulphurous acid; allow the vessel to rest a few minutes, pour off the clear liquor, and redistil it. The density should be not above 1·065."

The directions of the *Dublin College* are as follows:—Take of Acetate of Potash, 100 parts, Sulphuric Acid, 52 parts. Put the acid into a tubulated retort, then gradually, and at different intervals of time, add the Acetate of Potash, waiting, after each addition, until the mixture becomes cool. Lastly, with a moderate heat, distil the acid until the residuum is dry. The specific gravity of this acid is to that of distilled water as 1·074 to 1·000.

[The U. S. Pharmacopœia directs, Acetate of Soda in powder a pound; Sulphuric Acid half a pound; Red Oxide of Lead a drachm. Pour the Sulphuric Acid into a glass retort, and gradually add the Acetate of Soda; then by means of a sand-bath distil at a moderate heat into a glass receiver till the residuum becomes dry. Mix the resulting liquid with the Red Oxide of Lead, and again distil at a moderate heat to dryness.]

The proportions of acetate of soda, sulphuric acid, and water, used by the London College, are nearly equal to one equivalent or 137 parts of crystallized acetate of soda, one equivalent or 49 parts of the strongest oil of vitriol (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, and thirteen equivalents or 117 parts of water.



The calculated results agree very closely with the actual products. The resulting acid consists of 51 real acetic acid and 114·58 water; so that 117—114·58 = 2·42 of water must remain in the retort with the sulphate of soda.

The Edinburgh College substitutes acetate of lead for acetate of soda. The salt is first dried to expel the water of crystallization, and the anhydrous salt thus obtained is subjected to distillation along with pure oil of vitriol, with the view, I presume, of obtaining glacial acetic acid. Hydrated acetic acid distils over, and sulphate of lead is left in the retort. To remove any sulphurous acid which may be formed, red oxide of lead is ordered to be added to the acetic acid, by which sulphate and sulphite of lead are formed, and the acetic acid is then to be redistilled.[1]

The *Dublin College* employs acetate of potash to yield acetic acid. The reactions are similar to those of the London process.

The distillation of acetic acid is usually effected in glass or earthenware stills. On the large scale, silver condensers are sometimes used.

Properties.—*Glacial Acetic Acid* is the strongest acetic acid procurable. It crystallizes at 45° F. when we throw into it any particle of solid matter (a crystal of acetic acid answers best,) and the thermometer plunged into it rises at the same time from 45° to 51°. These crystals are brilliant, broad flat plates, of a pearly lustre. They melt at a temperature somewhat below 60° F. The sp. gr. of the liquid at 60° is 1·06296.

When crystals of glacial acetic acid are dissolved in water we obtain a solution which by way of distinction, we may denominate *liquid acetic acid*. The following table, drawn up by Dr. Thomson, (*First Principles of Chemistry* vol. ii. p. 135.) shows the specific gravity of various atomic compounds of this acid and water:—

Acid.		*Water.*	*Sp. gr. at 60°.*
1 atom	+	1 atom	1·06296
1	+	2	1·07060
1	+	3	1·07084
1	+	4	1·07132
1	+	5	1·06820
1	+	6	1·06708
1	+	7	1·06349
1	+	8	1·05974
1	+	9	1·05794
1	+	10	1·05439

More recently Mohr (*Pharmaceutisches Central-Blatt* für 1839, S. 840–41.) has published the following table, exhibiting the sp. gr. of acetic acid of different strengths:—

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[1] The process of the Edinburgh Pharmacopœia has been critically examined by Mr. R. Phillips (*London Medical Gazette*, N. S. vol. ii. for 1839-40, p. 271.) It cannot be denied that several unnecessary refinements have been introduced into it, which render the operation troublesome, wasteful, and expensive. Such are the use of a bath of oil or fusible metal,—the addition of red lead, and subsequent redistillation of the acid to get rid of a quantity of sulphurous acid, which, judging from the quantity of red oxide to be used, cannot exceed the $\frac{1}{2000}$ part of the product. Moreover, the whole process is objectionable on the ground that acid of this strength is not required for medicinal or pharmaceutical purposes.

Per Cent. of Glacial Acid ($C^4 H^3 O^3$ + Aq.)	*Sp. Gr.*	*Per Cent. of Glacial Acid* ($C^4 H^3 O^3$ + Aq.)	*Sp. Gr.*	*Per Cent. of Glacial Acid.* ($C^4 H^3 O^3$ + Aq.)	*Sp. Gr.*
100	1·0635	66	1·069	32	1·0424
99	1·0655	65	1·068	31	1·041
98	1·067	64	1·068	30	1·040
97	1·0680	63	1·068	29	1·039
96	1·069	62	1·067	28	1·038
95	1·070	61	10·67	27	1·036
94	1·0706	60	1·067	26	1·035
93	1·0708	59	1·066	25	1·034
92	1·0716	58	1·066	24	1·033
91	1·0721	57	1·065	23	1·032
90	1·0730	56	1·064	22	1·031
89	1·0730	55	1·064	21	1·029
88	1·0730	54	1·063	20	1·027
87	1·0730	53	1·063	19	1·026
86	1·0730	52	1·062	18	1·025
85	1·0730	51	1·061	17	1·024
84	1·0730	50	1.060	16	1·023
83	1·0730	49	1·059	15	1·022
82	1·0730	48	1·058	14	1·020
81	1·0732	47	1·056	13	1·018
80	1·0735	46	1·055	12	1·017
79	1·0735	45	1·055	11	1·016
78	1·0732	44	1·054	10	1·015
77	1·0732	43	1·053	9	1·013
76	1·073	42	1·052	8	1·012
75	1·072	41	1·0515	7	1·010
74	1·072	40	1·0513	6	1·008
73	1·072	39	1·050	5	1·0067
72	1·071	38	1·049	4	1·0055
71	1·071	37	1·048	3	1·004
70	1·070	36	1·047	2	1·002
69	1·070	35	1·046	1	1·001
68	1·070	34	1·045	0	1·000
67	1·069	33	1·044		

From these tables it is obvious that density is no criterion of the strength of liquid acetic acid.

The *Acidum Aceticum* of the Edinburgh Pharmacopœia is stated in one part of that work (p. 44) to have a sp. gr. of not above 1·065, in another (p. 2) to have a sp. gr. of not above 1·0685: moreover, in the same work, the density of the acid is said to be increased by [the addition of] 20 per cent. of water. There are, however, some obvious mistakes in these statements. (See Mr. R. Phillips, in the *London Medical Gazette*, N. S. for 1838--9, vol. ii. p. 688.)

The *Acidum Aceticum* of the London Pharmacopœia has a sp. gr. of 1·048. One hundred grains of it are saturated by eighty-seven grains of crystals of carbonate of soda. Hence it contains 30·8 per cent. of real or anhydrous acetic acid. It is a limpid, colourless liquid, having a pungent but agreeable odour, and an acrid taste. 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.

Characteristics.—Free acetic acid is known by it peculiar odour and by its volatility. Its vapour reddens litmus, and fumes with ammonia. It does not occasion any precipitate with lime water, solutions of the barytic salts, or a solution of nitrate of silver. It forms with potash a very deliquescent salt. Concentrated acetic acid does not cause effervescence when marble is dropped into it, unless water be added.

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 the nitrate of silver and the protonitrate of mercury. They redden solutions of the sesquisalts of iron (forming *sesquiacetate of iron.*) 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^9, H^3, O^9.

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

	Atoms.	*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 *Acidum Aceticum* of the pharmacopœias is a compound of Anhydrous or Real Acetic Acid and Water. Prepared according to the London Pharmacopœia, 100 grs. of it contain 30·8 grs. of real acetic acid; or very nearly one equivalent of real acetic acid, and 13 equivalents of water.

	Atoms.	*Eq. Wt.*	*Theory.*	*Experiment.*
Anhydrous Acetic Acid	1	51	30·35	30·8
Water	13	117	69·65	69·2
Acidum Aceticum, *Ph. L.*	1	168	100·00	100·0

Owing to the errors before alluded to in the statements of the Edinburgh College, it is impossible to estimate, correctly, the strength of the acid intended to be obtained by the process given in the Edinburgh Pharmacopœia. If, however, the acid had a sp. gr. of 1·068, and 100 minims of it required 216 grs. of crystallized carbonate of soda to saturate it, as stated by the College, its per-centage quantity of real acetic acid would be 78·65.

Acetometry.—The strength of acetic acid is best determined by ascertaining the quantity of alkaline carbonate which is required to saturate a given quantity of acid. Crystallized carbonate of soda, or crystallized bicarbonate of potash, are salts of uniform constitution, and may be employed for this purpose. Every 144 grs. of the crystallized carbonate of soda, or 101 grs. of crystallized bicarbonate of potash, are equal to 51 grs. of real acetic acid, or 60 grs. of glacial acetic acid. Marble or carbonate of lime is objectionable, since concentrated acetic acid will not decompose it without the addition of water.

I have already shown that specific gravity is no criterion of the strength of the hydrated acid; since two acids of very unequal strength may have the same density. Moreover, the foreign matters (*i. e.* mucilage and alcohol) contained in vinegar, alter the density of this fluid, though they do not affect its acetometrical strength. The acetometrical method employed by the Excise is that recommended by Messrs. J. and P. Taylor, (*Quarterly Journal of Science*, vol. vi. p. 255.) and consists in estimating the strength of the acid by the sp. gr. which it acquires when saturated by hydrate of lime. Acid, which contains 5 per cent. of real acetic acid, is equal in strength to the best malt vinegar, called by the makers No. 24, and is assumed as the standard of vinegar strength, under the denomination of *proof vinegar.* (58 Geo. 3. c. 65.) Acid, which contains 40 per cent. of real acetic acid, is, therefore, in the language of the revenue, 35 *per cent. over proof:* it is the strongest acid on which duty is charged by the Acetometer. Vinegars, which have not been distilled, contain mucilage, and require an allowance for the increase of weight from this cause. Hence in the Acetometer sold by Bate, a weight marked M is provided, and is used in trying such vinegars.[1] As the hydrate of lime employed causes the precipitation of part of the mucilaginous matter in the vinegar, it serves to get rid of part of the difficulty above referred to.

Impurities.—The presence of sulphuric, hydrochloric, or nitric acid,—of

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[1] See *Description of the Acetometer for determining the Strengths of Acetic Acid made for the Revenue of the United Kingdom*, by R. B. Bate, 21, Poultry, London.

metallic matter,—and of acrid substances in acetic acid, may be detected by the same methods as have already been pointed out for vinegar (see p. 345.) Sulphurous acid is recognised by the white precipitate (*sulphate of lead*) produced on the addition of peroxide of lead. The presence of lead in acetic acid is known by the yellow precipitate (*iodide of lead*) occasioned by the addition of iodide of potassium.

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 its influence 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 creasote which it contains. Secondly, the action of acetic acid on albumen, fibrin, and blood-disks, deserves especial notice. Liquid albumen (as serum of blood and 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.)

α. On Vegetables.—Distilled vinegar is ranked, by Achard, among vegetable poisons. (De Candolle, *Phys. Végét.*)

β. On Animals generally.—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. (Orfila, *Journ. de Chim. Méd.* t. vii. p. 449.) Four or five ounces of common vinegar proved fatal to dogs in ten or fifteen hours, when vomiting was prevented by tying the œsophagus. (*Ibid.*) Injected into the veins, vinegar does not appear to act 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, *Die Wirkung der Arzneimittel. und Gifte*, Bd. i. S. 11.) Analogous results have been obtained by Courten and Hertwich (quoted by Wibmer) and by Pommer. (Christison, *Treatise on Poisons.*)

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 of it was an affection of the windpipe and lungs. The acid was detected by its odour, in the blood and secretions. (Wibmer, *op. supra cit.*)

γ. On Man.—In the concentrated state acetic acid is an irritant and corrosive poison (see p. 208.) Its chemical influence depends principally on its power of dissolving fibrin, albumen, and gelatine, as before mentioned, by which it is enabled to dissolve many of the animal tissues. Applied to the skin it acts as a rubefacient and vesicant (see p. 209.) Only one fatal 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. (Orfila, *Journ. Chim. Méd.* t. ii.)

Swallowed in a very dilute form, and in moderate doses, it proves refreshing, allays thirst, diminishes preternatural heat, lowers the pulse, and augments the urine. In its general effects, therefore, it appears to lower the powers of life and to prove antiphlogistic. It agrees in its operation with the diluted mineral acids (see pp. 189, 192, 198, and 207.) 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. "Every one knows," says Giacomini, (*Lond. Med. Gaz.*, N. S. vol. ii. for 1838–9, p. 175.) "that when habitually taken, it produces leanness, from a sort of languor of the digestive process." The following is a case, quoted by this author, from Portal:—

> "A few years ago, a young lady, in easy circumstances, enjoyed good health; she was very plump, had a good appetite, and a complexion blooming with roses and lilies. She began to look upon her plumpness with suspicion; for her mother was very fat, and she was afraid of becoming like her. Accordingly, she consulted a woman, who advised her to drink a small glass of vinegar daily: the young lady followed her advice, and her plumpness diminished. She was delighted with the success of the remedy, and continued it for more than a month. She began to have a cough; but it was dry at its commencement, and was considered as a slight cold, which would go off. Meantime, from dry it became moist; a slow fever came on, and a difficulty of breathing; her body became lean, and wasted away; night sweats, swelling of the feet and of the legs, succeeded, and a diarrhœa terminated her life. On examination, all the lobes of the lungs were found filled wtth tubercles, and somewhat resembled a bunch of grapes."

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 (Christison, *Treatise on Poisons.*) 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 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. On inquiry among the workmen of a large vinegar-manufactory, I find the notion of the injurious influence of the vapour generally repudiated. Both at these works, and at a pyroligneous acid manufactory, the workmen appeared in excellent health.

USES.—The uses of acetic acid and vinegar, to the medical practitioner, are of two kinds,—medicinal and pharmaceutical.

1. **Medicinal.**—Taken internally, common vinegar, or acetic acid properly diluted, is used for various purposes: the most important of these 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 *hemorrhages*, as from the nose, lungs, stomach, or uterus, it is particularly beneficial by its refrigerant, sedative, and astringent qualities. It diminishes excessive vascular action, and promotes contraction of the bleeding vessels. As a local astringent, it is injected into the nose in epistaxis, and is used as a wash in profuse hemorrhoidal discharges. The benefit obtained by the application of vinegar and water to the abdomen, vulva, and thighs, in uterine hemorrhages, arises principally 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 hemorrhage, and prevents diarrhœa. In *mania*, it has been recommended as a means of allaying cerebral excitement. In *poisoning by opium*, it is used as a counter-poison; but as acetic acid forms very soluble, and, therefore, powerful compounds with morphia, it ought not to be exhibited until the contents of the stomach have been evacuated. In poisoning by the alkalis,

and their carbonates, and by lime, vinegar is the safest and most efficacious acidulous substance that can be administered. In diseases attended with *phosphatic deposites* 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 is more apt to produce lead colic than the acetate. In *scurvy*, acetic acid 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 hemorrhage; and of relieving inflammation or congestive conditions of the brain.

As a stimulant, disinfectant, and antiseptic, diluted acetic acid is 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 in cynanche, gargles containing acetic acid or vinegar are sometimes used with good effect. Acetic collyria are useful, as mild astringents, 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, usually proves refreshing and grateful in febrile disorders with a hot skin. 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, known in the shops as Beaufoy's, 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 around 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.

ADMINISTRATION.—Vinegar is used as a condiment *ad libitum*. Medicinally it is given in doses of from fʒj. or fʒij. to f℥ss. As an enema f℥j. or f℥ij. have been used. A refrigerant drink in fevers is made by adding f℥j. or f℥ij. of vinegar to a quart of water. A vinegar wash is prepared by mixing f℥iij. of vinegar and f℥v. of water.

ANTIDOTES.—In poisoning by strong acetic acid, the treatment is the same as that for poisoning by other acids. (See p. 262. Also *Acidum Sulphuricum*.)

1. ACETUM DESTILLATUM, L. E. D. (U. S.) *Distilled Vinegar*.—All the British colleges give directions for the preparation of this liquid.

The *London College* directs us to take of Vinegar a gallon. Let the Vinegar distil in a sand-bath, from a glass retort into a glass receiver. Keep the seven pints first distilled for use. [This process has been adopted by the U. S. Pharmacopœia.]

The *Edinburgh College* says, "Take of Vinegar (French, by preference) eight parts: distil over with a gentle heat six parts: dilute the product, if necessary, with distilled water till the density is 1·005."

The *Dublin College* takes of Wine vinegar, *by measure*, ten parts. Distil with a slow fire eight parts by measure. In the distillation, glass vessels should be employed, and the first portion which comes over, in quantity amounting to one part, rejected.

The first portions which distil over are alcohol, acetic ether, water, and a little acetic acid. Hence the Dublin College directs the first tenth part to be rejected. Prepared according to the pharmacopœias, distilled vinegar has a yellowish tint, and contains, besides acetic acid and water, a little alcohol, acetic ether, and an organic substance called mucilage. Hence, when it is saturated with alkalis, the solution becomes brown by heat, and deposites a dark-coloured substance, probably arising from the decomposition of the mucilage.

One hundred grains of *acetum destillatum*, Ph. Lond. saturate thirteen grains of crystals of carbonate of soda. This indicates the per-centage quantity of real acetic acid in it to be 4·6. But the *acetum destillatum*, Ph. Ed. is not so strong, in consequence of the College directing only $\frac{5}{8}$ths of the vinegar to be distilled. Its density is stated to be 1·005; and one hundred minims of it neutralize eight grains of crystallized carbonate of soda, indicating the per-centage quantity of real acid to be 3·07.[1]

In order to prevent the distilled vinegar from acquiring a metallic impregnation, the head of the still and the worm or condensing pipe should be of glass or earthenware. I was informed at one vinegar works that a silver worm was employed.

A mixture of acetic acid and water may be advantageously substituted for distilled vinegar. If the acetic acid be of the strength directed in the London Pharmacopœia, the proportions will be, of acetic acid 15 parts, of water 85 parts, to form a dilute acid equal in strength to that of distilled vinegar.

The effects and uses of distilled vinegar have been noticed under the head of Acetic Acid.

[2. **ACIDUM ACETICUM DILUTUM**, U. S.—Take of Acetic Acid half a pint; Distilled Water five pints. Mix them. One fluid ounce is saturated by 36 grains of crystallized Bicarbonate of Potassa. This preparation is used as a substitute for distilled vinegar where nicety is requisite, as it is free from mucilage, and therefore does not change colour, from the action of an alkali that may be used to saturate the acid.]

3. **ACIDUM ACETICUM AROMATICUM**, *E.*—(Rosemary, and Origanum, of each ℥j., dried; Lavender, dried, ℥ss.; Cloves, bruised, ℥ss.; Acetic Acid, Oiss. Macerate for seven days, strain and express strongly, and filter the liquor.) In the former Edinburgh Pharmacopœia there was contained, under the same name, a somewhat similar but weaker preparation, made with *diluted* acetic acid, (*i. e.* distilled vinegar,) in imitation of the celebrated *Marseilles Vinegar*, or *Vinegar of the Four Thieves*[2] (*Vinaigre des Quatre-Voleurs; Acetum quatuor Furum*,) once supposed to be a prophylactic against the plague and other contagious diseases. It was a very useless preparation. In the present Edinburgh Pharmacopœia, concentrated acetic acid has been substituted for distilled vinegar, and Origanum for Sage. It is now a pungent perfume, and may be used as a substitute for *Henry's Aromatic Vinegar*. But it appears to me to be a very unnecessary preparation.

The *Acetum aromaticum*, or *Aromatic Vinegar* of the shops, is made in imitation of Henry's Aromatic Vinegar. At Apothecaries' Hall it is prepared by dissolving the Oils of Cloves, Lavender, Rosemary, and Acorus Calamus, in crystallizable Acetic Acid. It is a very volatile and corrosive preparation, and requires to be kept in carefully-stoppered bottles. Some manufacturers add camphor. The addition of water to it causes the precipitation of the greater part of the camphor. It is a much perfumed pungent perfume, whose vapour is snuffed up the nostrils, to produce a powerful excitant impression, in fainting, languor, headach, and nervous debility. For this purpose it is dropped on sponge, which

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[1] See Mr. R. Phillips, in *London Medical Gazette*, N. S. vol. ii. for 1838–39, p. 688; and vol. ii. for 1839–40 p. 271.

[2] "The repute of this preparation as a prophylactic in contagious fevers, is said to have arisen from the confession of four thieves, who, during the plague of Marseilles, plundered the dead bodies with perfect security, and, upon being arrested, stated, on condition of their lives being spared, that the use of aromatic vinegar had preserved them from the influence of contagion. It is on this account sometimes called "Le Vinaigre des quatre Voleurs." It was, however, long used before the plague of Marseilles, for it was the constant custom of Cardinal Wolsey to carry in his hand an orange, deprived of its contents, and filled with a sponge which had been soaked in vinegar impregnated with various spices, in order to preserve himself from infection, when passing through the crowds which his splendour or office attracted. The first plague raged in 1649, whereas Wolsey died in 1531." (Paris, *Pharmacologia*, vol. ii. p. 18, 6th ed. Lond. 1825.)

is preserved in smelling-bottles or *vinaigrettes*. It is also used for the purpose of correcting unpleasant odours, which it does, not by destroying, but by disguising them (see p. 210.) *An extemporaneous aromatic vinegar* may be prepared by putting into a stoppered bottle f℥j. of acetate of potash, three drops of some essential oil, (as Lavender or Lemon) and twenty drops of oil of vitriol.

4. **ACIDUM ACETICUM CAMPHORATUM**, E. D.—(Camphor, ℥ss.; Acetic Acid, f℥viss. [f℥vj. *D.*] Pulverize the camphor with the aid of a little rectified spirit, and dissolve it in the acid.)—This preparation is an officinal substitute for *Henry's Aromatic Vinegar*. The spirit is used merely to assist in reducing the camphor to powder. Camphorated acetic acid is exceedingly pungent and corrosive. Its vapour is snuffed up the nostrils as a powerful stimulant in syncope. It is never used internally.

5. **OXYMEL**, L. D. *Syrupus Aceti*, E.; *Oxymel Simplex* or *Simple Oxymel*. (The *London College* directs of Honey [clarified,] lb. x.; Acetic Acid, Oiss. Mix the acid with the honey made hot.[1]—The *Dublin College* orders of Honey, by weight, lb. ij.; Distilled Vinegar, Oj. [*wine measure.*] Boil them in a glass vessel, with a slow fire, to the thickness of syrup, removing the scum.—The *Edinburgh College* substitutes sugar for honey:—Take of Vinegar, French in preference, f℥xj.; Pure Sugar, ℥xiv. Boil them together.)—It is employed as a detergent and pectoral. It is frequently added to gargles; but is more commonly used as an expectorant in slight colds and coughs. Diffused through barley-water, it forms an agreeable refrigerant drink in febrile and inflammatory complaints. It is sometimes used as a vehicle for other medicines. Dose from ʒj. to ℥ss. or ℥j.

2. **Pharmaceutical Uses.**—Vinegar or acetic acid is employed for extracting the virtues of various medicinal substances, as Squills, Opium, Colchicum, and Cantharides: the solutions are called *Medicated Vinegars*, (*Acetica*,) or, by the French pharmacologists, *Oxéolés* (from ὄξος, vinegar.) 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. They are usually prepared by marceration. The preparations into the composition of which acetic acid and honey enter, are called *Oxymels*, (*Oxymellites*,) or the *Acid Mellites*. Acetic acid is employed also in the manufacture of the salts called *Acetates*. It is a powerful solvent of the gum-resins, and is used, on this account, in the preparation of the *Emplastrum Ammoniaci*. Lastly, distilled vinegar is used in the preparation of Cataplasma Sinapis, Ceratum, Saponis, Linimentum Æruginis, and Unguentum Plumbi compositum.

8. AC'IDUM CI'TRICUM, *L. E. D.* (U. S.)—CITRIC ACID.

History.—This acid was first procured in the solid state by Scheele in 1781. It is sometimes termed the *Concrete Acid of Lemons*.

Natural History.—Citric acid is peculiar to the vegetable kingdom.

It is found in many acid juices of fruits usually free, but sometimes in combination with either potash or lime. Besides the fruits of the genus *Citrus*, it is found, with little or no malic acid, in the fruits of Dulcamara, Dog-rose, Cranberry, Bird-cherry, and Whortleberry. Mixed with an equal quantity of malic acid, it is found in the Gooseberry, Red Currant, Strawberry, Raspberry, Cherry, &c. In the Tamarind it exists with both malic and tartaric acids.

Preparation.—All the British colleges give directions for the preparation of this acid.

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[1] There is a mistake in the formula of the London College; the quantity of acetic acid directed to be used being much too large. Prepared according to the London Pharmacopœia, oxymel is an acrid preparation. The quantity of acetic acid employed should be sufficient to give the preparation an agreeable flavour. When the honey is very thick, a little water should be employed. A very fine oxymel, which I examined, was prepared with 132 lbs. 12 oz. of honey, and 8 lbs. 2 oz. (*Avoirdupois*) of acetic acid.

The *London College* orders of Lemon Juice, Oiv.; Prepared Chalk, ℥ivss.; Diluted Sulphuric Acid, f℥xxviiss.; Distilled Water, Oij. Add the Chalk gradually to the Lemon Juice made hot, and mix. Set by, that the powder may subside: afterwards pour off the supernatant liquor. Wash the Citrate of Lime frequently with warm water. Then pour upon it the diluted Sulphuric Acid and the distilled Water, and boil for a quarter of an hour. Press the liquor strongly through linen, and strain it; evaporate the strained liquor with a gentle heat, and set it by, that crystals may be formed. Dissolve the crystals, that they may be pure, again and a third time in water, and as often strain the solution, boil down and set it aside.

The *Edinburgh College* employs the same quantity of Lemon Juice and Chalk (or of the latter a sufficiency,) and "Diluted Sulphuric Acid, f℥xxvii., or in the same proportion to the chalk required."[1] The lemon juice is to be boiled twice, and allowed to rest once before the chalk is added. After the sulphuric acid has been added, the filtered liquor is to be tested with a solution of nitrate of baryta, and if the precipitate thereby obtained be not "almost entirely soluble in nitric acid," more citrate of lime is to be added [to saturate the great excess of sulphuric acid.]

The process of the *Dublin College* is essentially similar to that of the London College.

The juice of lemons and limes is imported for citric acid manufacturers, in pipes and hogsheads. It is saturated with chalk or whiting in a large vat. By this means a citrate of lime is formed. This is precipitated, while the carbonic acid of the chalk escapes, and the mucilage of the juice for the most part remains in solution.

MATERIALS.	COMPOSITION.	PRODUCTS.
Chalk	*Carbonic Acid*	Carbonic Acid Gas.
	Lime	
Lemon Juice	*Water, Mucilage, &c.*	Water, Mucilage, &c.
	Citric Acid	Citrate of Lime.

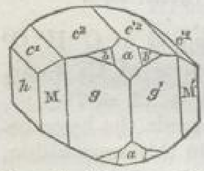
The supernatant liquor is then drawn off, and the citrate of lime is passed through a sieve and frequently washed with warm water, until the mucilage and other soluble impurities are for the most part got rid of. Sulphuric acid, diluted with water, is afterwards added: sulphate of lime separates, and citric acid is left in solution.

MATERIALS.	COMPOSITION.	PRODUCTS.
Citrate of Lime	*Citric Acid*	Citric Acid.
	Lime	
Sulphuric Acid		Sulphate of Lime.

The clear solution is then evaporated in leaden boilers, and the concentrated solution set aside to crystallize. The crystals are afterwards purified by re-solution and re-crystallization. (For farther details, consult Parkes's *Chemical Essays*, vol. i. p. 539, 2d ed. 1823.)

PROPERTIES.—Citric acid crystallizes in colourless, odourless, very sour, transparent, short, rhomboidal prisms, whose extremities are terminated by four trapezoidal faces, and which belong to the right prismatic system. (Brooke, *Annals of Philosophy*, N. S. vol. vi. p. 119.) Crystallized citric acid becomes damp by exposure to a moist atmosphere, though Dumas, and other French chemists, state it to be unalterable by the air. According to Vauquelin, it is soluble in 75 parts of cold and 50 of boiling water. The solution is strongly acid, and becomes mouldy by keeping. Crystallized citric acid is much less soluble in alcohol than in water. Its sp. gr. is 1·617. Heated with potash, it is converted into oxalic and acetic acids and water. Treated with oil of vitriol it evolves sulphurous acid, carbonic acid, carbonic oxide, acetic acid, and water. Heated with nitric acid, it becomes oxalic acid.

FIG. 53.



Crystal of Citric Acid.

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[1] The Edinburgh College employs half an ounce of diluted sulphuric acid less than the London College; whereas, it ought to have been increased by eight ounces, in consequence of the diluted sulphuric acid of the Edinburgh Pharmacopœia being weaker than that of the London Pharmacopœia (Mr. R. Phillips, *London Medical Gazette*, N. S. vol. ii. 1838-9, p. 690.)

According to Crasso, crystallized citric acid, when exposed to heat, exhibits four stages of decomposition. During the first, the water of crystallization alone is given off, and the residue contains unaltered citric acid. The second stage is characterized by white vapours, and the production of acetone, carbonic oxide, and carbonic acid, while the residue consists of hydrated aconitic acid ($C^4 H O^3 + Aq.$,) which is the true pyrocitric acid. In the third stage, the aconitic acid, not being volatile, is itself decomposed, yielding carbonic acid and an oily liquid which soon crystallizes. This is the pyroaconitic acid, the citricic of Baup, for which Crasso proposes the name of itaconic acid ($C^5 H^2 O^3 + H O$.) This acid, when heated, yields citraconic acid ($C^5 H^2 O^3 + H O$,) the citribic acid of Baup. In the fourth period empyreumatic oil is produced, and a voluminous coal remains behind. (Crasso, quoted by Liebig, in Turner's *Elements of Chemistry*, 7th ed.)

Characteristics.—When added in excess to lime water, no precipitate is produced. "When a few drops of a solution of citric acid are added to lime water, a clear liquid results, which, when heated, deposites a white powder, soluble in acids without effervescence," (Liebig.) It does not yield a crystalline precipitate when added in excess to a solution of carbonate of potash. It forms, with barytic water, a white precipitate (*citrate of baryta.*) With a solution of acetate of lead it also furnishes a white precipitate (*citrate of lead,*) soluble in ammonia, which forms with it a double salt (*ammoniacal citrate of lead.*) Added to a solution of nitrate of silver it produces a white precipitate (*citrate of silver,*) which, when heated, becomes brown, froths up, deflagrates, discharges white fumes, and leaves an abundant, ash-gray, coarsely fibrous, crumbly residue, which by heat becomes pure silver.

COMPOSITION.—The following is the composition of crystallized citric acid:—

	Atoms	*Eq. Wt.*	*Per Cent.*	*Dumas.*	*Prout.*	*Ure.*
Carbon	4	24	35·8	36·28	34·28	33·00
Hydrogen	3	3	4·5	4·45	4·76	4·63
Oxygen	5	40	59·7	59·27	60·96	62·37
Citric Acid crystallized by cooling a solution saturated at 212°	1	67	100·0	100·00	100·00	100·00

Crystallized citric acid of commerce contains, however, somewhat more oxygen and hydrogen (elements of water) than the above:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Dumas.*
Carbon	4	24	34·29	34·75
Hydrogen	$3\frac{1}{3}$	$3{\cdot}3\dot{3}$	4·76	4·72
Oxygen	$5\frac{1}{3}$	$42{\cdot}6\dot{6}$	60·95	60·53
Commercial Citric Acid, or Acid formed at 61°.	1	70·00	100·00	100·00

According to Berzelius, hypothetical dry citric acid is composed of $C^4 H^2 O^4$ (=58;) and, therefore, the acid, crystallized by cooling, consists of $\overline{Ci} + Aq.$ ($58 + 9 = 67$,) and the commercial acid of $\overline{Ci} + 1\frac{1}{3}$ Aq. ($58 + 12 = 70$.)

But Liebig (Turner's *Elements of Chemistry*, 7th edit.) regards the hypothetical dry citric acid as composed of $C^{12} H^5 O^{11}$ (= 165.) On this supposition, the acid, crystallized by cooling, is composed of $\overline{Ci} + 3 HO + Aq.$ ($165 + 36 = 201$;) and the commercial crystals of $\overline{Ci} + 3 HO + 2 Aq.$ ($165 + 45 = 210$.) On this view of its constitution citric acid is a tribasic acid; that is, it combines with three equivalents of base: its equivalent weight being three times the amount assumed in the above tables.

PURITY.—Powdered citric acid is sometimes adulterated with powdered tartaric acid. The fraud may be readily detected by dissolving the suspected acid in a small quantity of water, and adding cautiously to it a solution of carbonate of potash, taking care that the acid be in excess. If any tartaric acid be present, a white crystalline precipitate (*bitartrate of potash*) is formed. The directions of the London and Edinburgh Colleges for ascertaining the purity of the acid are as follows:—

> This acid is soluble in water; what is precipitated from the solution by acetate of lead is dissolved by nitric acid. No salt of potash, except the tartrate, is precipitated by solution of citric acid. It is totally dissipated in the fire (*Ph. Lond.*)

The solubility of the plumbeous precipitate in nitric acid shows the absence of sulphuric acid or a sulphate.

> A solution, in four parts of water, is not precipitated by carbonate of potash: when incinerated with the aid of the red oxide of mercury, no ash is left, or a mere trace (*Ph. Ed.*)

The elements of citric acid (viz. oxygen, hydrogen, and carbon) are dissipated by a red heat. But this dissipation is promoted by agents (*ex.* red oxide of mercury) capable of supplying oxygen without leaving any fixed residuum.

PHYSIOLOGICAL EFFECTS.—Orfila (*Toxicologie Générale.*) ranks citric acid among the irritant poisons: but Drs. Christison (Christison, *On Poisons*, p. 208, 3rd edit.) and Coindet gave drachm doses of it to cats without observing that the animals suffered any inconvenience therefrom. The effects of large doses of this acid on man I am not acquainted with. Small quantities of it, dissolved in water, form an agreeable beverage, which allays thirst, diminishes preternatural heat, checks profuse sweating, and promotes the secretion of urine. (See pp. 192, 198, and 207.) Vogt (*Pharmakodyn*, Bd. ii. S. 72. 2te Aufl.) considers it to act more powerfully on the skin, and less so on the alimentary canal and urinary organs, than tartaric acid. In its action on the skin it agrees with acetic acid. The continued employment of it, as well as of other acids, disturbs the functions of the digestive organs.[1]

USES.—Citric acid is employed in medicine, as a substitute for lemon juice, in the preparation of refrigerant drinks and effervescing draughts, and as antiscorbutic, anti-narcotic, and anti-alkaline. (See *Lemon Juice.*)

1. **ARTIFICIAL LEMON JUICE.**—This is prepared by dissolving Citric Acid ʒviijss., in Water f℥xvj., and flavouring with a few drops of Essence of Lemons. This is less apt to undergo decomposition than the genuine juice, for which the artificial juice may be employed in the preparation of cooling beverages.

2. **EFFERVESCING CITRATES.**—Citric acid, with the alkaline carbonates, is frequently employed in the preparation of effervescing draughts. The following are the relative proportions of acid and base required to form a neutral compound.

20 *grs. of Commercial Crystals of Citric Acid are saturated by about—*

Crystallized Bicarbonate of Potash	29 grs.
Carbonate of Potash of Commerce	24 "
Hydrated Sesquicarbonate of Ammonia	17 "
Crystallized Carbonate of Soda	41 "
Sesquicarbonate of Soda of Commerce	24 "

The most agreeable effervescing citrate is that prepared with bicarbonate of potash, flavoured with tincture of orange peel and syrup (see *Potassæ Citras.*) Sometimes an effervescing citrate is prepared with the hydrated sesquicarbonate of ammonia (see *Ammoniæ Citras*, p. 295.) The carbonates of soda are rarely employed with citric acid.

9. AC'IDUM TARTAR'ICUM, *L. E. D.* (U.S.)—TARTARIC ACID.

HISTORY.—Tartaric acid was first procured in a separate state by Scheele, in 1770. It is sometimes termed the *crystallized acid of tartar*.

NATURAL HISTORY.—It is peculiar to the vegetable kingdom.

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[1] For some farther observations on its effects, see the article *Lemon Juice*, in a subsequent part of this work.

In the *free* state it exists in tamarinds, grapes, the pine-apple, and pepper. It is also found native in combination with bases: thus, *bitartrate of potash* exists in tamarinds, grapes, mulberries, &c., and *tartrate of lime* in the fruit of *Rhus typhinum*.

Preparation.—All the British colleges give formulæ for its preparation.

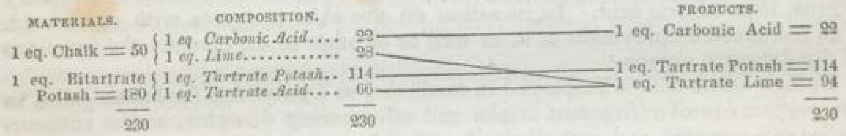
The *London College* directs us to take of Bitartrate of Potash, lb. iv.: Boiling Distilled Water, *Cong.* iiss.; Prepared Chalk, ℥xxv. and ʒvj. Diluted Sulphuric Acid, Ovij. and f℥xvij.; Hydrochloric Acid, f℥xxviss., or as much as may be sufficient. Boil the Bitartrate of Potash with two gallons of Distilled Water, and add, gradually, half the prepared Chalk; then, the effervescence having ceased, add the remainder of the Chalk, previously dissolved in the Hydrochloric Acid with four pints of the Distilled Water. Lastly, set aside, that the Tartrate of Lime may subside; pour off the liquor, and wash frequently the Tartrate of Lime, with Distilled Water, until it be void of taste; then pour on it the diluted Sulphuric Acid, and boil for a quarter of an hour. Evaporate the strained liquor by a gentle heat, that crystals may be formed.

Dissolve the crystals, that they may be pure, again, and a third time, in water, and, as often, strain the liquor, boil down, and set it aside.

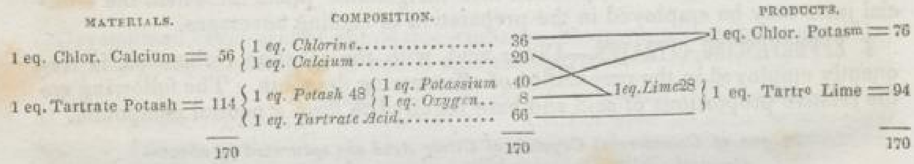
The process of the *Edinburgh Pharmacopœia* is essentially the same.[1]

The *Dublin College* uses of Bitartrate of Potash, reduced to powder, ten parts; Prepared Chalk, four parts; Sulphuric Acid, seven parts; Water, one hundred and twenty parts. The process is otherwise similar to that of the London Pharmacopœia.

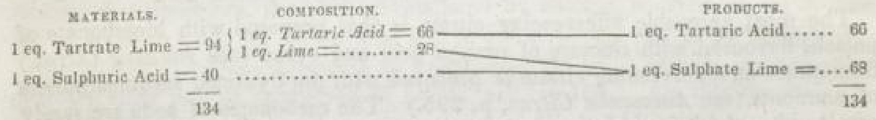
The following is the *theory* of the process for making tartaric acid:—By the mutual action of bitartrate of potash and carbonate of lime (chalk,) we obtain tartrate of potash in solution and tartrate of lime precipitated, while carbonic acid escapes.—The following diagram explains these changes:—



If to the solution of tartrate of potash we add chloride of calcium (obtained by dissolving chalk in hydrochloric acid,) double decomposition ensues; tartrate of lime is precipitated, and chloride of potassium remains in solution.



The tartrate of lime obtained in the above two operations is then decomposed by sulphuric acid, which forms the almost insoluble sulphate of lime, and sets tartaric acid free.



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[1] The Edinburgh College employs the same quantity (Ovii. and f℥xvii.) of diluted Sulphuric Acid as is used by the London College; but, as its strength is weaker, the quantity ought to have been greater. The "Edinburgh College should have directed more than ten pints of diluted Sulphuric Acid, instead of less than eight." (Mr. R. Phillips, *London Medical Gazette*, N. S. vol. ii. 1838-39, p. 689.)

Properties.—Tartaric Acid crystallizes in elongated, colourless, inodorous, very sour, imperfectly transparent prisms, which belong to the oblique prismatic system. (Brooke, *Annals of Philosophy*, N. S. vol. vi. p. 118.)

Fig. 54.

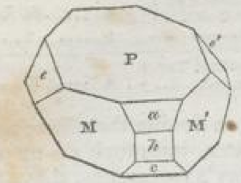
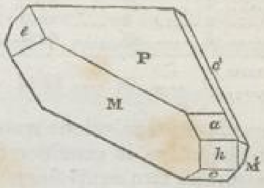


Fig. 55.



Crystals of Tartaric Acid.

Fig. 54. The crystals as usually modified.

Fig. 55. The same modified form, with the planes irregularly disposed, as they appear in most of the crystals.

(The corresponding planes in both figures are marked with the same letters.)

They are permanent in the air. When heated they fuse, and undergo chemical changes varying with the degree and continuance of the heat. When they have lost by heat a fourth of their water, they become *tartralic acid*, which has, in its salts, the same composition as tartaric acid, but neutralizes one-fourth less base. It differs from tartaric acid, therefore, as pyrophosphoric acid differs from phosphoric acid. When tartralic acid is farther heated it loses as much more water, and becomes *tartrelic acid*, which also has, in its salts, the composition of tartaric acid, but only half the neutralizing power. It corresponds, therefore, to metaphosphoric acid. By a higher degree of heat all the water of this acid is driven off, and we have *anhydrous tartaric acid*, which, however, has lost its acid properties, and is quite insoluble in water. (See Fremy, *Ann. de Chim. et de Phys.* Aûot, 1838.) "This is a powerful argument in favour of the view, according to which all acids are compounds of hydrogen" (Liebig.) When subjected to distillation, tartaric acid yields carbonic acid, water, and two pyrogenous acids,—one of which is crystalline, and is called *pyrotartaric acid* ($C^5H^3O^3 + Aq.$;) the other is oily, and is termed *pyruvic acid* ($C^6 H^3 O^5 + Aq.$) Strongly heated in the air it evolves the odour of caramel, and furnishes a carbonaceous mass, which eventually disappears by combustion. Cold water dissolves crystallized tartaric acid: boiling water takes up twice its own weight of the acid. A soft, mucilaginous, flexible mass, forms in a solution of tartaric acid, as well as of emetic tartar, when long kept.[1] Alcohol sparingly dissolves the acid. Heated with either nitric acid or potash it yields oxalic acid. By the action of sulphuric acid on it acetic acid is formed.

Characteristics.—A solution of tartaric acid is very sour, and causes with solutions of caustic, lime, baryta, and strontia, white precipitates (*earthy tartrates*,) soluble in excess of acid. Sal ammoniac dissolves the precipitate (*tartrate of lime*) produced by lime water. With acetate of lead the solution of tartaric acid also forms a white precipitate (*tartrate of lead*) soluble in excess of acid. Dropped into a solution of sulphate of lime it furnishes no precipitate. Heated with a solution of chloride of platinum, tartrate of potash occasions a black precipitate (*metallic platinum*.) If excess of acid be added to a concentrated solution of a potash salt, small granular crystals (*bitartrate of potash*) are deposited. With nitrate of silver, tartrate of potash furnishes a white precipitate (*tartrate of silver*,) which, when heated, does not deflagrate, but becomes brown, froths up, evolves white fumes, and leaves pure silver.

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[1] This formation is probably owing to the development in the solution of a vegetable organized being. Keïtzing (*Repertoire de Chimie*, t. iii. p. 278. Paris, 1838) has described and figured the plant which forms in a solution of emetic tartar.

Composition.—The composition of tartaric acid is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*
Carbon	4	24	36·36	35·980
Hydrogen	2	2	3·03	3·807
Oxygen	5	40	60·61	60·213
Anhydrous Tartaric Acid	1	66	100·00	100·000

	Atoms.	*Eq. Wt.*	*Per Cent.*
Anhydrous Tartaric Acid	1	66	88
Water	1	9	12
Crystallized Tartaric Acid	1	75	100

Liebig regards the equivalent weight of the acid as double that above assumed; and the acid, therefore, is considered as a bibasic one, inasmuch as, on that hypothesis, it saturates two equivalents of base. Fremy's researches, above referred to, tend to support this view.

Impurity.—The only adulteration practised on this acid is the mixture of its powder with bitartrate of potash. This fraud may be detected by the difficult solubility in water of the bitartrate, and its yielding, on incineration, carbonate of potash (known by the tests hereafter to be described.) The tests of the purity of the acid, given by the London and Edinburgh Colleges, are as follows:—

"Totally soluble in water. The solution throws down bitartrate of potash from any neutral salt of potash. Whatever is precipitated from this solution by acetate of lead is dissolved in diluted nitric acid."—*Ph. L.*

A precipitate insoluble in nitric acid would indicate the presence of sulphuric acid or a sulphate.

"When incinerated with the aid of the red oxide of mercury, it leaves no residuum, or a mere trace only."—*Ph. Ed.*

This test is devised to detect any fixed substance, and might be used to recognise the potash, if bitartrate of this alkali had been present.

Physiological Effects.—The effects of tartaric acid, *in small doses* properly diluted, are those of a refrigerant (see p. 192.) It reduces febrile heat, diminishes excessive vascular action, allays thirst, checks excessive perspiration, and perhaps also a too copious secretion of bile. It appears to promote the action of the absorbents, to increase the secretion of urine (see p. 198,) and to act gently on the bowels. It possesses the tonic properties of the mineral acids (see p. 207) in a very slight degree only, if at all. Its continued use very readily disturbs the digestive process. Some doubt exists as to the effects of *large doses* of the acid. According to Dr. Christison (*Treat. on Poisons*, p. 208, 3d. ed.) it may be taken in very considerable quantities without injury. Six drachms have been taken in twenty-four hours without inconvenience. Pommer, however, asserts that when it is injected into the veins, it is scarcely less poisonous than oxalic acid (*Ibid.*)

Uses.—Tartaric acid may be used as a cheap substitute for citric acid or lemon juice, in the formation of acidulous refrigerant drinks, for febrile and inflammatory disorders. It is, however, rarely employed for this purpose. Its common medicinal use is in the preparation of effervescing compounds, with the alkaline carbonates, especially with bicarbonate of soda.

EFFERVESCING TARTRATES.—The following are the relative proportions of tartaric acid and alkaline carbonates for preparing effervescing draughts:—

20 grs. of the Crystals of Tartaric Acid are saturated by—

Crystallized Bicarbonate of Potash	27	grains.
Carbonate of Potash of Commerce	22	„
Hydrated Sesquicarbonate of Ammonia	15½	„
Crystallized Carbonate of Soda	38½	„
Sesquicarbonate of Soda of Commerce	22	„

The most commonly used effervescing tartrate is that made with sesquicarbonate of soda (see *Sodæ Sesquicarbonas* and *Sodæ Tartras.*)

10. AC'IDUM BENZO'ICUM, *L. E. D.* (U. S.)—BENZOIC ACID.

History.—This acid was described in 1608 by Blaise de Vigenere; but it seems to have been known to Alexander Pedemontanus in 1560. The acid obtained by sublimation is frequently denominated *Flowers of Benjamin* (*Flores Benzoini.*)

Natural History.—Benzoic acid is peculiar to the organized kingdom.

It exists ready formed in certain vegetable substances (as the balsams,) and is readily produced in some others by the action of exterior agents (as heat, air, acids, and alkalis.) "It is formed by the oxidation of hydruret of benzule in the air, and by the decomposition of many compounds of benzule, and of hippuric acid and amygdaline by oxidizing reagents" (Liebig.) It is also produced by the action of potash on cinnamon and some other oils (Mulder.) It is readily obtained from, and was formerly supposed to exist in, certain animal substances, (as the urine of herbivorous animals,) which are now known not to contain it, but yield it only by the decomposition of some of their proximate principles. The benzoic acid procured from the urine of horses is not originally contained in that liquid, but is produced by the decomposition of hippuric acid, which is readily converted into benzoic acid. Thus, if the urine of the horse or cow be left to itself for a long time, or evaporated at a boiling temperature, it yields not a trace of hippuric acid, but only benzoic acid.

Preparation.—All the British colleges give directions for the preparation of this acid.

The *London College* orders of Benzoin, lb.j. Put the benzoin in a proper vessel placed on sand, and the heat being gradually raised, sublime until nothing more rises; press that which is sublimed, wrapped in bibulous paper, and separate it from the oily part. Afterwards again sublime it.

The directions of the *Edinburgh College* agree with these, except that they order "any convenient quantity" of benzoin to be used, and "a glass-matrass" to be employed in the manufacture.

The process of the *Dublin College* is as follows:—Benzoin, five parts; Lime, fresh burnt; Muriatic Acid, of each, one part; Water, two hundred parts. Triturate the Benzoin with the Lime, then boil the mixture in one hundred parts of Water; suffer the vessel to rest, and pour off the liquor when cold. Boil the remainder in seventy parts of water, and again pour off the cold liquor. Evaporate the mixed liquors to one-half, filter them through paper, and to the liquors, when cold, gradually add the Muriatic Acid. Lastly, having decanted off the supernatant fluid, dry with a gentle heat the residual powder, previously washed with a small quantity of cold water; pass it into a proper vessel, and with a slow fire sublime the benzoic acid.

[The U. S. Pharmacopœia directs the admixture with sand before sublimation, and the process is that of the L. and E. Ps.]

The process of the *London* and *Edinburgh Colleges* is the simplest, and, I believe, the most economical. The following is the method practised at Apothecaries' Hall, London:—"The better kind of benzoin is most economically employed: it may be put into an iron pot, set in brickwork over a proper fire-place: the sublimate is most conveniently received into a large wooden box, lined with paper, communicating with a conical iron or tin-plate neck with the subliming pot. The first product may be sublimed a second time in the same apparatus: and, by conducting the process rather rapidly, the acid condenses in beautiful prismatic crystals, somewhat elastic. If slowly sublimed it is more scaly. By this process of sublimation good benzoin yields 10 to 12 per cent. of acid contaminated by empyreumatic oil; and which, when pressed between folds of blotting-paper, and again sublimed, is reduced to the proportion of 8 or 9 per cent. of the purified acid." (Brande, *Manual of Chemistry*, p. 1153, 5th edit.) The simplest method of procuring it is by putting coarsely-powdered benzoin into an earthen pot, over which is placed a cone of thick brown paper or pasteboard, and applying a moderate heat: the acid sublimes into the cone, and there condenses. Some employ, as a substitute for the cone, *a house*, as it is termed, made of pasteboard and laths, and lined with loose sheets of blotting-paper, which are renewed every time of use. The oil produced in sublimation is, for the most part, formed during the process.

Mohr[1] gives the following directions for preparing it:—Benzoin, in the form of a coarse powder, either alone or mixed with an equal weight of sand, is spread upon the bottom of a round vessel, of cast plate iron, eight or nine inches in diameter, with the sides about two inches high. A sheet of dry bibulous paper is stretched tightly over the opening, and fastened to the sides of the vessel by a little paste. A hat made of thick paper, and of the common form of a man's hat, is made to cover the whole, and tightly tied to the sides of the vessel by a strong string. The vessel is now placed upon sand spread upon an iron plate, below which a fire is kept for three or four hours. The vapours of the sublimed benzoic acid pass readily through the pores of the bibulous paper, and are deposited in crystals upon the hat; the crystals are prevented from falling back into the iron vessel by the paper which closes its opening.[2] Moreover, the paper absorbs the oil which sublimes with the acid.

Scheele's process, adopted by the *Dublin College*, is, I believe, seldom followed. By boiling benzoin and lime with water, a soluble *benzoate of lime* is formed. Muriatic acid is then added to the concentrated solution, by which *benzoic acid* is precipitated, while *chloride of calcium* (in solution) and *water* are formed. The precipitated benzoic acid is then sublimed. The acid, obtained by this process, is said to be whiter and purer (being free of empyreumatic oil) than that procured by sublimation only. Carbonate of soda is sometimes substituted for lime in the above process, by which a soluble benzoate of soda is obtained.

PROPERTIES.—As met with in the shops benzoic acid occurs in the form of soft, light, feathery white crystals, or scales, which are flexible, transparent, and of a mother-of-pearl lustre, having a sour, warm taste, but no odour when pure. It readily fuses and volatilizes, its vapour being exceedingly irritating to the air-passages. It is combustible, burning with a bright yellow flame. It is very soluble in about two hundred parts of cold water, dissolves in about twenty-five parts of warm water, and is very soluble in alcohol.

Characteristics.—Benzoic acid is readily distinguished from other acids by its light and feathery crystals, its fusibility, volatility, odour of its vapour, and by the characters of its soluble salts. Thus the benzoate of ammonia produces, with the sesquisalts of iron, a pale red precipitate (*benzoate of iron,*) and with the nitrate of silver, acetate of lead, nitrate mercury, and supernitrate of bismuth, white precipitates of (*benzoates* of the respective metals.)

COMPOSITION.—The following is the composition of this acid.

Ultimate constituents.					*Hypothetical constitution.*		
	Atoms.	*Eq. Wt.*	*Per Cent.*	*Dumas.*		*Atoms.*	*Eq. Wt.*
Carbon	14	84	74·3	74·7	Benzule	1	105
Hydrogen	5	5	4·4	4·3	Oxygen	1	8
Oxygen	3	24	21·3	21·0			
Anhydrous Benzoic Acid	1	113	100·0	100·0	Anhydrous Benzoic Acid	1	113

The crystallized acid contains one equivalent or 9 parts of water $(\overline{Bz} + aq.) = 122$.

Benzule or *Benzoyle* is the hypothetical radical of benzoic acid. It consists of $C^{14} H^{5} O^{2}$. Laurent discovered a crystallizable substance, which he termed *benzule*, but which Liebig calls *benzile*. It has the composition of the hypothetical radical benzule. Oil of bitter almonds is the *hydruret of benzule*. $(C^{14} H^{6} O^{2}.)$

PURITY.—Good benzoic acid has the following properties:—It is colourless, and is sublimed entirely by heat (*Edinb. Pharm.*) When cautiously heated it totally evaporates with a peculiar odour. It is sparingly soluble in water, but plentifully in rectified spirit. It is entirely dissolved by solution of potash or

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[1] *Ann. d r Pharm.* xix. p. 178; also, *Pharmaceutisches Central-Blatt für* 1839, p. 233; and Liebig, in Turner's *Elements of Chemistry*, 7th edit. p. 781.

[2] For some practical remarks on the preparation of this acid, see Euler and Herberger, in *Pharmaceutisches Central-Blatt für* 1840, p. 166.

lime-water, and is precipitated from its solution by hydrochloric acid (*Pharm. Lond.*)

Physiological Effects.—The local action of benzoic acid is that of an acrid. When swallowed it occasions a sensation of heat and acridity in the back part of the mouth and throat, and heat at the stomach. The inhalation of its vapour causes violent coughing.

When taken into the stomach benzoic acid becomes absorbed, and operates on the general system as a stimulant, whose influence is, however, principally directed to the mucous surfaces, especially the aërian membrane. According to Dr. Alexander Ure[1], hippuric acid ($C^{18}\ NH^{8}\ O^{5} + Aq.$) is found in the urine two hours after taking benzoic acid, while not a trace of uric acid is recognizable. This effect does not always take place. I have found it produced readily in a rheumatic subject.

Uses.—Benzoic acid is a constituent of the *Tinctura Camphoræ Composita;* otherwise is but little employed in medicine. It is sometimes employed in chronic bronchial affections. I have repeatedly tried it, but have seldom seen benefit result from its use. I have more frequently seen it augment than relieve the cough. Dr. A. Ure has suggested the employment of benzoic acid, or a benzoate, in the gouty diathesis, to prevent the formation of the tophaceous concretions commonly called *chalk stones*, and which consist of urate of soda.—Dose, grs. v. to ℈j.

11. CREASO'TON, *L.*—CREASOTE.

Creazotum, *E.* (U. S.)

(An Oxy-hydro-carburet; prepared from pyroxillic oil, *L.*)

History.—This substance was discovered a few years since by Reichenbach, who termed it *Creasote* (from κρεας, *flesh*, and σωζω, *I preserve*, or the *flesh-preserver*, on account of its antiseptic property. Its name is sometimes written *Creosote*, or *Kreosote.*

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 *Elements of 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.[2] The oil from which creasote is prepared, is that obtained by the distillation of wood-tar, and is either imported from Stockholm, Archangel, and America, or is made in the manufacture of pyroligneous acid.

Properties.—Pure creasote is colourless and transparent; and 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 evo-

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[1] Proceedings of the Royal Medical and Surgical Society, in the *London Medical Gazette*, N. S. vol. 184-041, p. 735; also, *Pharmaceutical Transactions*, No. 1, p. 24. Lond. 1841.

[2] For farther details I must refer to Dumas' *Traité de Chimie;* the *Ann. de Chim. et Physiq.* t. 57, 1834; and Cozzi, in the *Journal de Pharmacie*, t. xxviii. p 629.

lution 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, naptha, 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 reaction 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; diluted 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 Creasote*. Edinburgh, 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.

A patent has been taken out by Mr. Flockton, for the preservation of wood, &c. by creasote. The liquid actually used under this patent is the impure oily liquor obtained by distillation from tar, and in which old iron has been digested, so that it is a mixture of various volatile oils and acetate of iron.

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.

Impurity.—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 a substance like almond oil, are substances which have been mixed 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. Capnomor is similar to creasote in many of its physical and chemical properties, and is frequently associated with the creasote of the shops.

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:—

	Atoms.	*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. α. *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.

β. *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 *Brit. & For. Med. Rev.* vol. i. p. 265.) and Miguet have observed inflammation of the gastro-intestinal mucous membrane of dogs poisoned by creasote, but which survived some time after its administration.

γ. 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, like nitrate of silver. Swallowed in large doses it causes vomiting and purging. The caustic effect of creasote depends on its union with albumen.

Unless largely diluted, it occasions, when swallowed, heat in the 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, headach, 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 headach 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 (*Lond. 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 recognised, 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 farther evidence to establish them. In the dose of two drachms creasote proved fatal in thirty-six hours. It caused acute pain. (See *The Times* of June 17, 1839. I presume the mental faculties were unaffected.)

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, (Tar will be described hereafter.) Soot,[1], Crude Pyroligne-

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[1] WOOD SOOT (*Fuligo Ligni*) was formerly contained in the list of the materia medica of the British Pharmacopœias. It is still in use on the continent, and statements of its efficacy are occasionally met with in the periodicals. It is a mixture of distilled products from the imperfectly burnt wood and of ashes, or other fixed matters, carried up the chimney by the current of air. It consists of a pyrogenous or empyreumatic resin called *pyretin*, combined with *acetic acid*, which also saturates the bases (*potash*, *lime*, and *magnesia*) of the ashes which are carried up the chimney. Besides these, there are small quantities of *sesquioxide of iron*, *silica*, and *carbon*. *Acetate of ammonia*, *chloride of calcium*, and *sulphate of lime*, are also contained in soot. Moreover, there is *extractive matter*, part of which is insoluble in alcohol. Lastly, to these constituents must be added *creasote*. Braconnot (*Ann. Chim. et Phys.* t. xxxi. p. 37) mentions a bitter principle, which he calls *asbolin*, (from ασβολη, soot) in soot; but Berzelius (*Traité de Chimie*, t. vi. p. 725) considers it to be a mixture of different matters with the acid pyretine. The matters insoluble in water constitute about 0·44 of soot. Formerly soot was esteemed tonic, antispasmodic, and emmenagogue. It is now principally employed, as an external remedy, chiefly in ringworm and other analogous eruptions, and obstinate ulcers. It is employed in the form of *decoction* (prepared by boiling two handfuls of soot in a pint of water for half an hour) and of *ointment* (composed of a drachm of soot to an ounce of lard.) The decoction has been used as an injection in chronic cystitis, (*Lond. Med. Gaz.* 1839–40, vol. i. p. 864.) The *Tincture of Soot*, formerly in the London Pharmacopœia, consists of Wood Soot, ℥ij.; Asafœtida, ℥j; and proof Spirit, f℥xxxij. It is sometimes called *Soot Drops* or *Hysteric Mixture*, and is prescribed in doses of one or two tea-spoonsful in hysteria.

ous Acid, *Aqua Binelli*,[1] the Empyreumatic Water of Runge and Hanke, Pyrothonide,[2] 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. Trans.* 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 (*London Medical Gazette*, 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.) Dr. Burne, (*London Medical Gazette*, August 18th, 1838.) however, found it efficacious in gastro-enteritic irritation. I have found it much more frequently fail than succeed in alleviating irritable stomach. It sometimes relieves the chronic vomiting connected with granular disease of the kidneys when other means fail. (See Christison, *On Granular Degeneration of the Kidneys*. Edinb. 1839.)

In gastrodynia or flatulence it occasionally succeeds, but is admissible in those cases only in which local stimulants are usually found beneficial. Where both hydrocyanic acid 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-Chirurg. Trans.*, and Professor Berndt, *Lancet*, July 18, 1835.) I have tried it at the London Hospital, but without obtaining benefit from its use.

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 toothach. After carefully cleaning out the cavity of the tooth, a drop of creasote, or an *alcoholic solution* of this principle, 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, impetigo, eczema) 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. Lupus is said to have healed under the employment of an ointment of creasote. (Mr. Browne, in the *London Medical Gazette*, for April 7, 1838.) In hemorrhages creasote 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

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[1] AQUA BINELLI, or *Aqua arterialis balsamica Doctoris Benelli*, a once-celebrated styptic, discovered by a physician (Dr. Binelli) of Turin, in 1797 (Dierbach, *Neuesten Entdeck. in d. Mat. Med.* 2te Ausg. 1837. See also Dr. J. Davy, *Edinb. Med. and Surg. Journ.* July, 1833.)

[2] PYROTHONIDE, from πυρ, *fire*; and ὀθονη, *linen*.) or *liquor pyro-oleosus e linteo paratus*, is a very popular remedy for toothach 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 farther particulars concerning it, consult Merat and De Lens, *Dict. Mat. Med.*; Dierbach, *op. cit.*; Schwartz, *Pharmac. Tabell.* 2te Aus.; L. Richter, *Ausführl. Arzneim.* Supplem. Bd.

causing contraction of the bleeding vessels. *Creasote water* (prepared by mixing one part of creasote with eighty parts of water) may be applied either to bleeding wounds and leech-bites, or introduced into the vagina in uterine hemorrhage, 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 farther 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. (See also *Lancet*, vol. ii. for 1834–5, p. 398.)

ADMINISTRATION.—Creasote may be given, at the commencement of its use, in doses of one or two drops diffused through an ounce of some aromatic 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.

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. 159.)

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 distention, and thereby to excite the contractions, of the heart. 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.

1. **MISTURA CREASOTI.** *Mistura Creazotæ*, E. ("Take of Creazote and Acetic Acid, of each, ♏xvj.; Compound Spirit of Juniper, and Syrup, of each, f℥j.; Water, f℥xiv.; mix the creazote with the acid, then gradually [add] the water, and lastly the syrup and spirit.) Dose f℥j. to f℥ij. or more.

2. **UNGUENTUM CREASOTI**, L. (U. S.) *Unguentum Creasoti*, E. (Creasote, fʒss.; Lard, ℥j. rub and mix them, *L.* (U. S.)—Axunge, ℥iij.; Creazote, ʒj. Melt the axunge, add the creazote, stir them briskly, and continue to do so as the mixture concretes on cooling, *E.*)—It is used principally in skin diseases, as ring-worm. The quantity of creasote may be augmented or lessened according to circumstances.

12. PETRO'LEUM, *L. E. D.*—PETROLEUM OR ROCK OIL.

Petroleum (Barbadense.) *L.*
(Bitumen Petroleum. Petroleum Barbadense, *D.*)

History.—Herodotus (*Melpomene*, cxcv.) mentions the petroleum springs of Zacynthus (now called Zante) more than 400 years before Christ. Plutarch, in his Life of Alexander, speaks of a lake of naphtha at Ecbatana (now Hamedan,) in Media. The substance known to mineralogists as petroleum is the *black naphtha* (ναφθα μελαινα) of Dioscorides (lib. i.,) the *bitumen liquidum* of Pliny (lib. xxxv.)

Natural History.—There are two varieties of liquid bitumen or mineral oil: one is transparent and nearly colourless, or only slightly yellow, and when burnt leaves no residuum; the other is thick, of a reddish brown colour or blackish, and leaves, after combustion, a black coal. The first is called *naphtha* (a Chaldæan word;) the second *petroleum* (from *petra*, a rock; and *oleum*, oil) or *rock oil*, because it is frequently found exuding in the form of an oily liquid from rocks. Both kinds are supposed to be produced by the decomposition of organic (vegetable) matter, for they are always found in Neptunian rocks, and they appear sometimes to be one of the products of the decomposition of coal. (Berzelius, *Traité de Chim.* t. 6me.) From the investigation of Drs. Christison and Gregory, (*Trans. of the 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, and at St. Catherine's Well, near Edinburgh. In France it is produced at the village of Gabian in Languedoc, and hence it was termed *Oleum Gabianum*. It is also found in various other parts of Europe, especially in Italy. In the United States of America it is met with in various places: that from the shore of Seneka Lake in New York is called *Seneka oil*. Several of the West India Islands, especially Barbadoes and Trinidad, yield it. The Barbadoes petroleum (*Petroleum Barbadense*, L. D.; *Pisselæum Indicum*, Dale) is commonly termed *Barbadoes Tar*, or *Barbadoes Naphtha*. Mr. Hughes (*The Natural History of Barbadoes*, p. 50. Lond. 1750.) speaks of two kinds of it; one of a dirty black, inclining to a green, issuing from some hills in St. Andrew's and St. Joseph's parishes; and one of a blacker colour, in St. Joseph's parish. 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.

Extraction.—Mr. Hughes says that the mode of procuring the green tar of Barbadoes is to dig a hole or trench in, or very near, the place where it oozes out of the earth. This by degrees becomes filled with water, having a thick film or cream of this liquid bitumen swimming upon the surface; from whence it is skimmed off, and preserved in earthen jars or other vessels. The most convenient season for gathering it is in the months of January, February, and March.

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*. The latter probably are accidental.

By distillation, five parts by measure yield rather more than four parts of *a yellow oily fluid*, somewhat similar in appearance to the liquid carbo-hydrogen obtained in the manufacture of oil-gas, but dissimilar to naphtha. 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 becomes absorbed, and in this way probably acts topically on the secreting organs; for Mr. Hughes observes, that when a horse "that has been dosed with it begins to be warm upon his journey, the rider will smell the tar strongly." 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. Mr. Hughes says it is used in paralytic and nervous disorders.

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 tea-spoonful given in any convenient vehicle (as some aromatic water, tea, or spirit.) The quantity should be gradually increased. An ounce has been taken in the day without any inconvenience.

13. SUC'CINUM, *L. D.* (U. S.)—AMBER.

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 ηλεκτρον, *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 Konigsberg and Memel. It is supposed to be disengaged, by the action of the sea, from beds of lignite.

The vegetable origin of amber is shown 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 enclosed in it are insects and parts of plants (as the wood, leaves, flowers, and fruit.) According to Sir David Brewster, (*Edinburgh Philosophical Journal*, 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.[1] On chemical grounds, however, Liebig (Turner's *Elements of Chemistry*, 7th edit. p. 1050.) suggests that it is a product of wax, or of some other substance allied to the fats or fixed oils; since succinic acid is formed by the oxidation of stearic and margaric acids.[2]

Properties.—It occurs in irregular shaped pieces, usually flat and somewhat rounded at the sides. Its colour is yellowish white (*succinum album*,) yellow (*succinum citrinum*,) or reddish (*succinum rubrum*.) It is usually translucent, sometimes opaque or transparent: it is tasteless and odourless. Its sp. gr. is

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[1] Hope, *On Succinic Insects*, in *Trans. Entom. Soc.*, vols. i. and ii. See also Sendelius, *Historia Succinorum*. Lips. 1742.

[2] For farther details respecting the Natural History of Amber, consult John's *Naturgeschichte d. Suciens*, Coln. 1816; and Graftenhauer's *Histoire Naturelle, chimique, et technique, du Succin*. Paris, 1824.

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 550° 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 acid and acetic acids,) then some succinic deposites in the neck of the retort, and an empyreumatic oil (*oleum succini*) comes over, at first thin and yellowish, afterwards brown and thick: towards the end of the operation a yellow light sublimate is observed in the neck of the retort; this is called, by Berzelius, *crystallized pyrétine;* by Vogel, *volatile resin of amber;* by Gmelin, *amber-camphor*. An inflammable gas is evolved during the whole time of the operation.

Composition.—The *ultimate* constituents of amber are *Carbon*, *Hydrogen*, and *Oxygen*. The *proximate* principles are, a *Volatile Oil*, *two Resins*, *Succinic Acid*, and a *Bituminous substance*.

Ultimate Constituents.			*Proximate Constituents.*
	Drassier.	*Ure.*	*(Berzelius.)*
Carbon	80·59	70·68	Volatile Oil.
Hydrogen	7·31	11·62	Two Resins.
Oxygen	6·73	7·77	Succinic Acid.
Ashes (silica, lime, and alumina)	3·27	——	Bitumen.
Amber	97·90	90·07	Amber.

According to Hünefeldt, hydrochloric acid extracts from amber, besides succinic acid, another acid, very similar to *mellitic acid*.

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 deposites. The *bituminous matter* constitutes the principal part of amber: it is insoluble in alcohol, ether, the oils both volatile and fixed, and alkaline solutions.

Characteristics and Purity.—The resins copal and animi are sometimes substituted for amber. They may be distinguished by the difference in their colour and fracture, and by their not emitting the peculiar odour of amber when thrown upon hot iron. (*United States' Dispensatory.*) They do not yield succinic acid when submitted to distillation. Copal, during its combustion is constantly falling in drops; and by this character may be distinguished from amber. (Kidd's *Outlines of Mineralogy*, vol. ii. p. 38. Oxford, 1809.)

Physiological Effects.—Amber was formerly celebrated as a stimulant and antispasmodic. It probably possesses little or no medicinal power.

Uses.—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.

1. **OLEUM SUCCINI,** L. D. (U. S.) *Oil of Amber.*—The following are the directions for the preparation of this oil:—

The *London College* orders Amber to be put into an alembic, so that an acid liquor, an oil, and a salt, contaminated with the oil, may distil in a sand-bath, with a heat gradually increased. Afterwards let the oil distil again, and a third time.

The *Dublin College* directs, of Amber reduced to a coarse powder, Pure Sand, of each one part. On the application of heat gradually increased, an acid liquor, oil and an acid in the crystallized form, will distil over. The latter should be received on bibulous paper, and exposed to strong pressure to expel the oil, and again sublimed. By filtration through bibulous paper, the oil may be obtained separate from the acid liquor.

[The U. S. P. directs to take of Amber in powder any quantity. Put the Amber, previously mixed with an equal weight of sand, into a glass retort, which is to be only half filled, then distil by means of a sand-bath, with a gradually increasing heat, an acid liquor, an oil and a concrete acid impregnated with oil. Separate the oil from the other matters and keep it in well stopped bottles.

To obtain OLEUM SUCCINI RECTIFICATUM, *Rectified Oil of Amber*, the same authority directs Oil of Amber, a pint; Water, six pints. Mix them in a glass retort and distil until four pints of the water shall have passed with the oil into the receiver; then separate the oil from the water, and keep it in well-stopped bottles.]

The following mode of preparing this oil I have seen practised by an experienced manufacturer:—The amber is distilled in a large iron still or retort, set in brickwork over a proper fire, and connected with an earthen globe, which opens into an old oil jar for a receiver. Three distilled products are obtained: impure succinic acid, called *volatile salt of amber;* an aqueous liquor, termed *volatile spirit of amber*, consisting of water, acetic and succinic acid, and pyrogenous oil; and *volatile oil of amber.* The residue in the retort is a kind of pitch; and is called *English asphalt.* The oil is afterwards rectified by distillation in an iron pot, to which an earthen head is adapted. A very gentle heat suffices for re-distillation.

Scrapings of Copal and the resin Dammar are frequently substituted for amber. They yield no succinic acid, but a volatile oil scarcely distinguishable from genuine oil of amber.

Volatile oil of amber, when fresh drawn, has a pale yellowish colour, which deepens by age, and a strong and remarkable, but agreeable odour. It is a powerful local irritant. When rubbed on the skin it acts as a rubefacient, and is sometimes employed in liniments in rheumatism and paralysis. Taken internally it operates, like most other empyreumatic oils, on the nervous system, and is used as a stimulant, antispasmodic, and emmenagogue, in hysteria and amenorrhœa. The dose is from ten to fifteen drops. It is a constituent of the *Tinctura Ammoniæ composita* (see p. 280.) which is made in imitation of *Eau de Luce*, the history of which has been fully detailed by Beckmann. (*History of Inventions and Discoveries*, vol. iv. p. 595, 2d. edit. Lond. 1814.)

ARTIFICIAL MUSK (*Moschus artificialis; Moschus factitius*) is prepared by adding gradually f℥iiss. of concentrated nitric acid to f℥j. of oil of amber, in a large glass tumbler. When the acid is not of sufficient strength, its action must be assisted by heat. The oil is gradually resinified at the expense of the oxygen of the acid, nitrous fumes being evolved. An orange yellow resin, having a peculiar musky odour, is obtained; which is to be well washed with water to remove all traces of acid. Artificial musk is reputed antispasmodic and nervine, and has been employed in hooping cough and low nervous fevers. A tincture of it (*Tinctura Moschi artificialis*) is prepared by dissolving ℥j. of artificial musk in f℥x. of rectified spirit. The dose is f℥j.

2. ACIDUM SUCCINICUM, D. *Succinic Acid* or *the Acid of Amber; Sal Succini.*—This acid is obtained in the distillation of amber. The mode of purifying it has been already stated. It may also be procured by the oxidation of stearic and margaric acids. It crystallizes in colourless white scales or prisms, which are quite volatile. Anhydrous succinic acid is composed of $C^4 H^2 O^3 = 50$. The sublimed acid is composed of $2\,\overline{S} + \text{aq.} = 109$. It is soluble in water; scarcely so in cold, but more so in boiling alcohol. It is almost insoluble in oil of turpentine, by which it is distinguished from benzoic acid. Succinate of ammonia produces, with the salts of the sesquioxide of iron, a brownish red, flaky precipitate (*persuccinate of iron,*) and, with the salts of lead, a white precipitate (*succinate of lead.*) Succinic acid is said to possess stimulant and antispasmodic properties, and to promote perspiration and urine. It was formerly employed in rheumatism, gout, suppressed or repressed eruptions, cramps, &c. It is now never used in medicine. The dose in which it was formerly given was grs. v. to grs. xv.

IV. COMPOUNDS CONTAINING CARBON AND NITROGEN.

1. OLE'UM ANIMA'LE EMPYREUMAT'ICUM.—EMPYREUMATIC ANIMAL OIL.

When animal substances (as bone or hartshorn) are subjected to destructive distillation, a fetid volatile oil is obtained, which is commonly called *Animal* or *Dippel's Oil.* That which is found in commerce is obtained in the manufacture of bone black (see p. 290.) 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.* It contains ammonia, and therefore has an alkaline re-action. 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 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.* Paris, 1824.) 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.

2. AC'IDUM HYDROCYAN'ICUM DILU'TUM, *L.*—DILUTED HYDROCYANIC OR PRUSSIC ACID.

(Acidum Hydrocyanicum, *E.* (U. S.)—Acidum Prussicum, *D.*)

History.—The substance called *Prussian* or *Berlin blue* (*Cæruleum Borussicum* seu *Berolinense*) was accidentally discovered by Driesbach 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.* Lond. 1746.) 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.[1]

Synonymes and Etymology.—It has been denominated *Prussic* (*Acidum Borussicum,*) *Zootic* (*Acidum Zooticum,*) *Hydrocyanic* or *Cyanohydric 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,

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[1] 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.

hydrogen and cyanogen (so called from κυανος, *blue;* and γενναω, *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 *Ramnus Frangula* and Ergot of Rye. In some of the vegetables now referred to, hydrocyanic acid does not exist ready formed, but is a product of the process by which it is obtained. This has been fully proved in the case of the bitter almond, and is inferred in other instances.

This acid is rarely, if ever, found in animals. One of its constituents (cyanogen) has, however, been detected, in combination with iron, (forming Prussian blue) in the urine, the menstrual fluid, and the sweat: and with sulphur and potassium in the saliva. The greenish-blue discharge of some ulcers probably depends on the presence of Prussian blue. In one case I detected the presence of iron in this discharge.[1] 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.

α. *By the action of diluted Sulphuric Acid on Ferrocyanide of Potassium.*—This is the process directed by the London and Edinburgh Colleges (and U. S. P.):—

The *London College* orders of "Ferrocyanide of Potassium, ℥ij.; SulphuricA cid, ℥iss.; Distilled Water, Oiss. Mix the acid with four fluid ounces 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 fluid ounces of the water into a cooled receiver; then, having adapted the retort, let six fluid ounces of acid, distilled with a gentle heat in a sand-bath, pass into this water. Lastly, add six more fluid ounces 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." [This process is adopted by the U. S. P.]

The *Edinburgh College* orders of "Ferrocyanide of Potassium, ℥iij.; Sulphuric Acid, f℥vj.: Water, f℥xvj. Dissolve the salt in eleven fluid ounces of the water, and put the solution into a matrass: add the acid, previously diluted with five fluid ounces of the water, and allowed to cool: connect the matrass with a proper refrigeratory: distil with a gentle heat, by means of a sand-bath or naked gas-flame, till fourteen fluid ounces pass over, or till the residuum begins to froth up. Dilute the product with distilled water till it measures sixteen fluid ounces."

On the large scale, the distillation is conducted in a stoneware still, with a worm refrigerator of the same material.

If it be performed in a [tubulated] retort, as directed in the London 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, deposites 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 carefully distilled three times.

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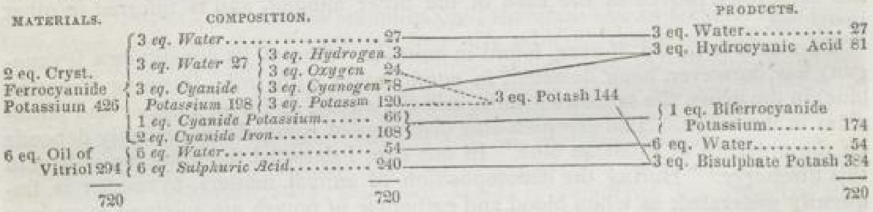
[1] Is the formation of cyanogen dependent on the oxidation of gelatine? Persoy states, that when gelatine is submitted to an oxidizing agent it is susceptible of being transformed into hydroscyanic acid, ammonia, and carbonic acid, and a small quantity of one of the fat, volatile and odoriferous acids, the existence of which was established by Chevreul (*Brit. and For. Med. Rev* vol. xii. p. 532.)

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 oil of vitriol (SO^3 + aq.) 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 with some water distil over. In the London Pharmacopœia an additional quantity of water is employed to assist the condensation of the acid.



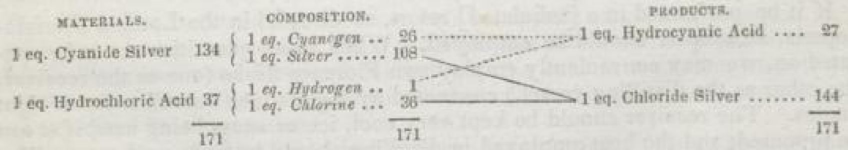
The salt here called biferrocyanide of potassium is termed, by Mr. Everitt, the *yellow salt*. I have prepared it with the greatest care, but have always found it to be white. Gay-Lussac also says it is white. (*Ann. Chim. et Phys.* t. xlvi. p. 77.) By exposure to the air it becomes blue.

β. *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.

In the *London Pharmacopœia* it is stated that diluted Hydrocyanic Acid may be otherwise prepared, when it is to be more quickly used, from forty-eight grains and a half of Cyanide of Silver, added to a fluid ounce of distilled water, mixed with thirty-nine grains and a half 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. [This is also adopted by U. S. P., taking 51 grs. of Cyanide of Silver, and 41 grs. of Hydrochloric Acid.]

The proportions directed by Mr. Everitt are 40 grs. of cyanide, 7 fluid-drachms 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.



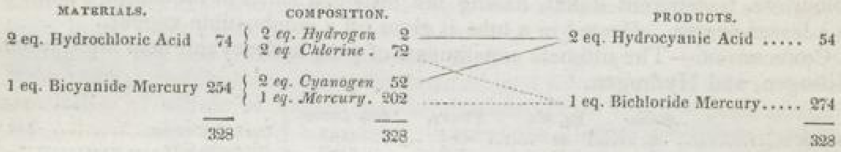
γ. *By the action of Hydrochloric Acid on Bicyanide of Mercury.*—At Apothecaries' Hall hydrocyanic acid was formerly prepared from one part of bicyanide of mercury, one part hydrochloric acid, (sp. gr. 1·15,) and six parts of water. The mixture was distilled until six parts had passed over. The acid thus obtained had a sp. gr. 0·995, and its standard strength was such, that two fluid-drachms 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 *Dublin College* orders Prussic acid to be prepared from Cyanuret of Mercury, ℥j.; Muriatic Acid, *by measure*, ʒvij.; Water, *by measure*, ℥viij. Distil into a refrigerated receiver, eight ounces, *by measure*, to be kept in a well corked bottle, in a cool and dark place.

The specific gravity of this acid is to the specific gravity of distilled water, as 998 to 1000.

The most convenient method of procuring *concentrated* or *anhydrous* hydrocyanic acid, is by the action of strong liquid hydrochloric acid on bicyanide of mercury. The vapour should be passed over carbonate of lime, to deprive it of hydrochloric acid; and over chloride of calcium, to remove the water. The receiver should be immersed in a freezing mixture, consisting of ice and chloride of sodium.

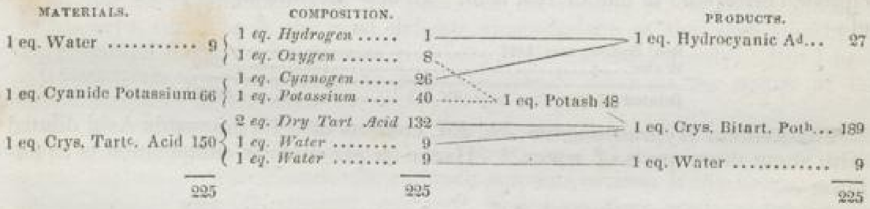
The theory of the process is as follows:—Two equivalents or 74 parts of hydrochloric acid react on one equivalent or 254 parts of the bicyanide of mercury, and form one equivalent or 274 parts of the bichloride of mercury, which remain in the retort, and two equivalents or 54 parts of hydrocyanic acid, which distil over.



δ. *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 fluid-drachms of distilled water, and to this solution are to be added 50 grains of crystallized tartaric acid, dissolved in 3 fluid-drachms of rectified spirit. One fluid-drachm of the decanted liquor contains one grain of pure hydrocyanic acid.

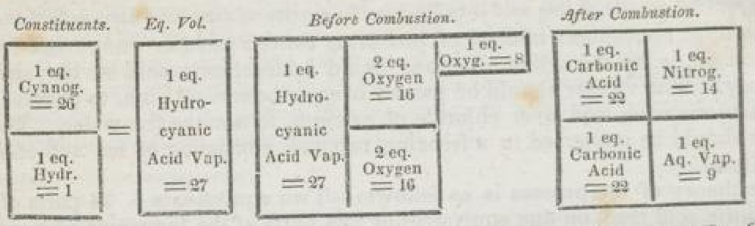
The objections to this process (which, however, has several advantages) are the trouble and expense of procuring pure cyanide of potassium, and the liability of the salt to undergo spontaneous decomposition.

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. α. *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.

The following diagrams illustrate the composition as well as the products of the combustion of the gaseous acid when exploded with oxygen gas:—



Anhydrous hydrocyanic acid undergoes speedy decomposition. Yet Dr. Christison says he has kept it unchanged for a fortnight in ice-cold water.

β. *Of Diluted Hydrocyanic Acid.*—Diluted 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.

	Atoms.	*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
Hydrocyanic Acid	1	27	100·0	100·00

	Vols.
Carbon Vapour	1 or 2
Nitrogen Gas	1
Hydrogen Gas	1
Hydrocyanic Vapour	2

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:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Cyanogen	1	26	96·3
Hydrogen	1	1	3·7
Hydrocyanic Acid	1	27	100·0

	Vols.
Cyanogen Gas	1
Hydrogen Gas	1
Hydrocyanic Vapour	2

STRENGTH OF THE DILUTED ACID.—In the London 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. Five parts of this precipitate correspond to one of real acid. Hence the diluted acid *Ph. L.* consists of—

Real Hydrocyanic Acid	2·0
Water	98·0
Diluted Hydrocyanic Acid (Ph. L.)	100·0

The Acidum Hydrocyanicum *Ph. Ed.* consists of "Hydrocyanic Acid diluted with about thirty parts of water." Hence its per-centage composition is as follows:—

Real Hydrocyanic Acid	3·226
Water	96·774
Acidum Hydrocyanicum (Ph. Ed.)	100·000

The Edinburgh College gives the following directions for ascertaining its strength:—

> "Fifty minims [of the acid] diluted with one fluid ounce of distilled water, agitated with 390 minims of solution of Nitrate of Silver [*Ph. Ed.*,] and allowed to settle, will again give a precipitate with 40 minims more of the test; but a farther addition of the test, after agitation and rest, has no effect. The precipitate entirely disappears in boiling nitric acid."

The Acidum Prussicum *Ph. Dub.* contains only 1·6 per cent. of real acid.[1]

This discrepancy in the strength of the acid ordered in the British pharmacopœias, is greatly to be regretted. Most of the acid met with in the shops of London chemists, is stated by the label to be of "Scheele's strength." But as Scheele's process[2] gave an acid of variable strength, this statement is by no means definite. A manufacturer of large quantities of the acid informs me he sells, under the name of Scheele's acid, a diluted hydrocyanic acid, which contains 4 per cent. real acid.

Purity.—Diluted 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 recognised 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 of this salt is immediately formed. 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 the salts of barium. "Solution of nitrate of baryta occasions no precipitate" in the pure acid (*Ph. Ed.*;) but if sulphuric acid be present, it occasions a white precipitate (*sulphate of baryta*,) insoluble in nitric acid. Hydrochloric acid is recognised by nitrate of silver, which forms therewith white chloride of silver insoluble in boiling nitric acid, whereas the white cyanide of silver is soluble in nitric acid at a boiling temperature. I would observe, that the presence of either of these acids is no farther 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 daylight,) 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 sesqui-salt of iron: the common sulphate of iron of the shops, or the tincture of the chloride, answers very well, since both these preparations usually contain the two (*prot-* and *sesqui-*)salts of iron. A precipitate is thus obtained, which is liable to considerable variation in its colour, depending on the quantity

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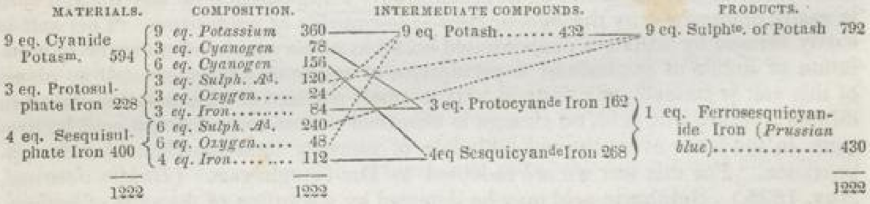
[1] Barker and Montgomery's *Observations on the Dublin Pharmacopœia.* Dubl. 1830.

[2] Scheele prepared this acid by boiling together Prussian blue, Peroxide of Mercury, and Water. Bicyanide of Mercury was obtained in solution. Iron filings and Sulphuric Acid were then added, and the products of the reaction were Hydrocyanic Acid, Metallic Mercury, and Sulphate of Iron. The liquor was then submitted to distillation.—The strength of the acid product varied with the degree of purity of the Prussian blue.

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 proto-cyanide of iron is produced, while with a sesqui-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 in a small glass tube, 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:—Super-saturate 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, leaving the white cyanide of this metal.

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, (*Quarterly Journal of Science*, vol. x. p. 182.) of Berne, 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 recognised 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 instances, 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, occasionally, 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. It is said to have been detected in ergot of rye.

Physiological Effects. α. *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 emersed in the diluted 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 shown that the acid becomes absorbed. (De Candolle, *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.*)

β. *On Animals generally.*—Hydrocyanic acid is an energetic poison to 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. Mr. Gray, however, states that some of the larvæ of the common Musca having been put into hydrocyanic acid, remained uninjured after two or three days exposure. (*Athenæum* for 1837, p. 671.) The cold-blooded animals are more slowly affected by hydrocyanic acid than the hot-blooded ones.

Dr. Christison states that 25 grs. of the strong acid, applied to the mouth, killed a rabbit within ten seconds. I once caused the almost instantaneous death of a rabbit by applying its nose to a receiver filled with the vapour of the pure acid: the animal died 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 using the acid.[1] If the pure acid be applied to the eye of a dog, it causes opacity and whiteness of the cornea, and a copious flow of tears. In a very short time it gives rise to constitutional symptoms.

γ. *On Man.* αα. *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:—a 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, but in others much, affected, though not uniformly; its action being sometimes quickened, at others reduced in frequency. In some instances faint-

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[1] For some remarks on the period of time which intervenes between the application of a poison and the first symptoms of its action, see p. 128.

ness is experienced. Drs. Macleod and Granville (*Lond. Med. and Phys. Journ.* vol. xlvi. pp. 359 and 363.) have noticed salivation and ulceration of the mouth during its medicinal use.

ββ. *In poisonous doses: convulsions and insensibility* (Epilepsy?:) *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 is succeeded by tetanic convulsions and insensibility; the respiration is difficult and spasmodic; the odour of hydrocyanic acid may be recognised 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. Jour.* Nov. 1835.) is an illustration of these effects:—A gentleman, aged 21, having been for some time subject to an uneasiness in the stomach, not actually amounting to gastrodynia, after having tried many remedies in vain, was induced to have recourse to hydrocyanic acid. He commenced with one minim of the Dublin Pharmacopœia, sp. gr. 0·998: this dose he repeated twelve times the first day, without any perceptible effect. On the following day he took half a drachm, with the same result. The third day his dose was a drachm, which he repeated the fourth day. On the fifth day he took a drachm and a half; still no effect of any kind. On the sixth day he increased his dose to two drachms. In about two minutes after taking this quantity, he experienced a sensation of extreme bitterness in the mouth, and having walked a few paces, was affected with great confusion, headach, 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 distention 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.

γγ. *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 a matter of great moment. Some years ago the life of a prisoner almost turned on this point. The following is an outline of the case:[1]—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,

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[1] More fully developed in Dr. Christison's *Treatise on Poisons*, and in the *Medical Gazette*, vol. viii. pp. 577 and 797.

could the deceased, after having drunk the poison, have had time to cork the phial, wrap it up, and adjust the bed-clothes, before insensibility came on? It was supposed that if the death were of that slow description to allow of these acts of volition, convulsions would have occurred, and the bed-clothes would have been found disordered. On the other hand, those cases in which no convulsions occur usually terminate too quickly to allow of the above acts. The medical witnesses in the above case were not agreed in opinion: the majority thought that it was impossible the deceased could have had the power of corking the bottle. The jury very properly found the prisoner not guilty.

There are two points of inquiry connected with the action of this acid, which are interesting, more particularly in a medico-legal point of view—namely, the time at which the poison begins to operate, and the period in which it proves fatal. No absolute answer can be given to either of these questions, since the strength and quantity of the acid exhibited, and peculiarities (not known or understood) affect the result. Very strong acid, in large doses, begins to operate very speedily, especially if its vapour be inhaled. The diluted 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. (*Annales d'Hygiène Publ. et de Méd. Lég.* t. ii.) But I have not found the same quantity of the same acid kill different animals 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; though Dr. Christison 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.

α. *Local action.*—Dr. Christison says that Robiquet's fingers became affected with numbness, which lasted several days, in consequence of their exposure for some time to the vapour of this acid. (*Treatise on Poisons*, 3d ed. p. 698.) This effect would appear to depend on the local action of the poison on the nerves,—a mode of operation which we are constrained likewise to admit in the case of some other narcotics. (See p. 13; also Müller's *Physiology*, by Baly, vol. i. p. 630.) The alleviation of gastrodynia by hydrocyanic acid depends probably on this benumbing effect. 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.

β. *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. The exhalation by the breath of the odour of the acid may sometimes serve to recognise the presence of the poison in the system. (Dr. Lonsdale, in the *Edinb. Med. and Surg. Journ.* for Jan. 1839.)

γ. *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 doubt has been entertained of its action being dependent on its absorption. (See pp. 126, 133, and 137.) 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: *fifthly*, a sufficient time always elapses between its application to the body and the first symptom of its action, to admit of its operation by absorption. (See p. 128.)

δ. *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*, 1^{er} Bd. 2^{de} Abt. S. 154.) mentions the following experiment performed by Wedemeyer (*Virsuche über das Nervensystem*, S. 241, Vers. 7.) and which shows 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 vertebræ, 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 system 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.

ε. *Condition of the brain and spinal marrow induced by this acid.*—The precise pathological condition of the brain and spinal cord of an animal under the influence of hydrocyanic acid, cannot be positively determined, and is, therefore, a matter of conjecture. Whatever it may be, it is probably identical with that which occurs during an epileptic paroxysm, and with that produced by loss of blood: for the essential symptoms (insensibility and convulsions occurring suddenly) are the same in all three states,—and ammonia has been found to relieve them. Now Dr. Hall (*Lect. on the Nerv. Syst.* p. 139.) has shown that the convulsion from hemorrhage is spinal. Dr. Holst, Professor of Materia Medica in the University of Christiana, Norway, told me of a case of epilepsy which had been under his care, and 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 by the vertebral arteries, which derived it, through the basilar artery, from the carotids. Now the cessation of the pulse during the paroxysm proved that the circulation through these vessels was temporarily interrupted. Does any similar interruption occur in poisoning by hydrocyanic acid?

δ. *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.

η. 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 edit. 1820.)

α. Internal.—By the founders of the theory of contra-stimulus this acid was regarded as a powerful asthenic or contra-stimulant, 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 shown 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 painful (neuralgic) and spasmodic 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[1] for a full investigation of its powers in these complaints.

Every practitioner is familiar with a stomach complaint in which pain of a spasmodic character is the leading symptom, but which is not essentially accompanied by pyrexia, as in gastritis—by tendency to faint, as in cardialgia—by indigestion, as in dyspepsia, nor by loss of appetite; though one or more of these conditions may attend it. By some nosologists (as Sauvages and Sagar) it has been regarded as a distinct disease, and has been termed *gastrodynia.* It is not unfrequently accompanied by vomiting and præcordial tenderness, which, however, cannot be regarded as indicative of inflammation, for various reasons; one of which is the alleviation of it often obtained by the use of stimulants and antispasmodics. What may be the precise pathological condition of this malady I know not. Dr. Barlow (*Cyclopædia of Practical Medicine*, art. *Gastrodynia.*) thinks the primary disease to be irritation or excitement of the mucous membrane of the stomach, whereby a redundant, dense, membranous, and opaque mucus is secreted, which accumulates and oppresses the stomach. The pain he supposes to arise from a contractile effort of the stomach to detach and expel the offending matter: but the immediate and permanent relief sometimes obtained by the use of hydrocyanic acid, is, I conceive, almost fatal to this hypothesis. Some time since I prescribed the acid for a lady who had suffered for months with gastrodynia, and who was persuaded, from her sensations, she had some organic disease. The remedy acted in the most surprising manner: in a few hours, to the astonishment of herself and friends, she was apparently quite well, and has since had no return of her complaint. It can hardly be imagined, that irritation of stomach can be rapidly removed by a substance which is itself an irritant. For my own part, I conceive the affection to be, essentially, a disordered condition of the nerves supplying the stomach, or of the nervous centres from whence those nerves are derived; in other words, it is a gastric neuralgia. It is frequently, but not in-

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[1] *Numerous Cases illustrative of the Efficacy of the Hydrocyanic Acid in Affections of the Stomach.* 1820.

variably, accompanied by 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 it, 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 disulphate of quinia) without the least benefit. I advised the employment of the hydrocyanic acid, and accordingly five minims were administered at the commencement of a paroxysm: the remedy acted like a charm: all the unpleasant symptoms immediately disappeared. Several doses of the acid were given before the period 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. I have found it successful in checking the diarrhœa of phthisical subjects, when log-wood, chalk, and opium had failed.

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.[1] 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. Dr. Roe (*A Treatise on the Nature and Treatment of the Hooping-Cough*. Lond. 1838.) ascribes to this acid the power of curing simple hooping-cough, that is, convulsive cough unaccompanied by inflammatory symptoms. He gives it in conjunction with ipecacuanha and tartarized antimony. In two or three days after the use of these remedies, the violence of the paroxysms, he says, is perceptibly diminished, and their duration shortened. To a girl of ten years of age he gave

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[1] See Dr. Granville's *Treatise* before referred to; and also Magendie's *Recherches sur l'emploi de l'Acide Prussique*, 1819.

a minim and a-half of the acid every quarter of an hour for twelve hours. I have not found this practice so successful as Dr. Roe's reports would lead us to expect.

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 first three of these affections, but without any evident relief. It has been repeatedly used in hydrophobia, at the London Hospital, but without success. A most interesting case of its employment in this malady has been published in the *Lancet* (for May 10th, 1839.) Under its use the hydrophobic symptoms subsided, and typhus fever supervened, of which the patient, after some days, died. 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."

β. *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 one drachm and a-half 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 relief. Dr. Elliotson says he has found it efficacious in sores behind the ears, and in scabs of the face; and adds, to an irritable face it is very soothing, if employed before and after shaving. In cancer of the uterus, lotions containing this acid have been employed 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 diluted acid, *Ph. L.*, three or four times a day, in about an ounce of some mild vehicle (simple water answers very well.) Gum or syrup, and some flavouring ingredients (as orange-flower water, which is used on the continent) may be added. Some persons give it in almond emulsion. In some cases of irritable stomach this is objectionable.

As a wash, two fluid-drachms 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 spirit is added, and Dr. A. T. 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*.

α. *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 be at hand, this should be given in doses of one or two teaspoonsful properly diluted with water. In the absence of this, weak solutions of the chloride [hypochlorite] of lime, or the chloride [hypochlorite] 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.

β. *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. 276.) In the absence of ammonia the inhalation of the vapour of burnt feathers might be employed. Ammonia cannot be useful, as an antidote, by its chemical properties merely, since hydrocyanate of ammonia is a powerful poison.

γ. *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 is 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.

δ. *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; also Lonsdale, *op. supra cit.*)

ORDER VIII. COMPOUND OF BORON AND OXYGEN.

AC'IDUM BORA'CICUM.—BORACIC ACID.

HISTORY.—Beccher (Thomson's *History of Chemistry*, vol. i. p. 248. Lond. 1830.) "was undoubtedly the first discoverer of boracic acid, though the credit of the discovery has usually been given to Homberg," who, in 1702, (*Histoire de l'Academie Royale des Sciences*, 1702; *Memoires*, p. 50.) obtained it in small shining plates, which have been called *Sedative* or *Narcotic Salt* (*Sal sedativum Hombergi.*) In the year 1776 it was discovered in the lagoons (*Lagoni*) of