alum, it is to be recollected that the vegetable astringents decompose it; by which the astringent property of the mixture is probably diminished.

For topical uses, alum is used in the form of powder, solution, and poultice. The powder of burnt alum is sprinkled over ulcers, to destroy spongy granulations. Powder of crystallized alum is applied to the mouth and throat as before mentioned. Solutions of alum are made, for topical purposes, of various strengths, according to the object in view.

The CATAPLASMA ALUMINIS, Ph. Dub. (*Alum curd of Riverius, Albumen Aluminosum*) is prepared by shaking the whites of two eggs with a drachm of alum. "In cases of chronic and purulent ophthalmia, it is applied to the eye between two folds of old linen. It has been praised as a good application to chilblains which are not broken" (Barker and Montgomery's *Observations on the Dub. Pharm.*)

The LIQUOR ALUMINIS COMPOSITUS, Ph. L. (*Aqua aluminosa Bateana*, or *Bates's alum water*) consists of alum, sulphate of zinc—each an ounce; boiling water, three pints: dissolve and strain. It is used as a detergent and astringent wash in old ulcers; when diluted, as a collyrium in mild conjunctival inflammation, as an injection in gleet and leucorrhœa, and as an application to chilblains and slight excoriations.

ANTIDOTE.—In a case of poisoning by alum, let the contents of the stomach be immediately evacuated. Promote vomiting by the use of tepid diluents. The inflammatory symptoms are to be combated by the usual antiphlogistic means. Magnesia has been employed, but is said by Devergie to be altogether useless.

ORDER 16. COMPOUNDS OF ARSENICUM.

Ac'idum Arsenio'sum.—Arse'nious Ac'id.

HISTORY.—Arsenious acid, commonly termed *white arsenic* (*arsenicum album*) or *oxide of arsenic*, is first distinctly mentioned by Geber (*Invent. of Verity*, ch. vii.), who seems to have been also acquainted with metallic arsenic (*Sum of Perfection*, book i. part iv. ch. ii.) Hippocrates (*De Ulceribus*) employed ἀῤῥενικὸν (*orpiment* or *sesquisulphuret of arsenicum*) and σανδαράκη (*realgar* or *sulphuret of arsenicum*) as topical remedies. Dioscorides (lib. v., cap. xxi.) is the first author who uses the word ἀρσενικὸν (*orpiment*).

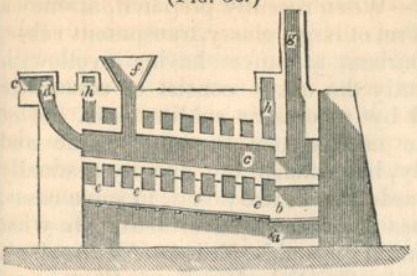
NATURAL HISTORY.—Arsenious acid occurs only in the mineral kingdom. It is rather a rare mineral, and is found at Andreasberg, in the Hartz; at Joachimsthal, in Bohemia; and at some few other places.

PREPARATION.—It is prepared in Silesia, Bohemia, Saxony, and Cornwall.

At Altenberg it is obtained from arsenical iron (*Mispickel*), a compound of arsenicum, iron, and sulphur. After being reduced to powder the ore is roasted in a muffle furnace (fig. 56), by which the arsenicum is converted into arsenious acid. This is conveyed in the state of vapour, called *flowers of arsenic* or *smeltinghouse-smoke* (*Hüttenrauch*), into the condensing chamber (fig. 57), where it is deposited in a pulverent form, and in this state is called *rough arsenious acid*, or *poison-flour* (*Giftmehl*).

The rough arsenious acid is refined by sublimation. This is effected in cast-iron pots, as shewn in fig. 58, p. 376, to which cylindrical iron

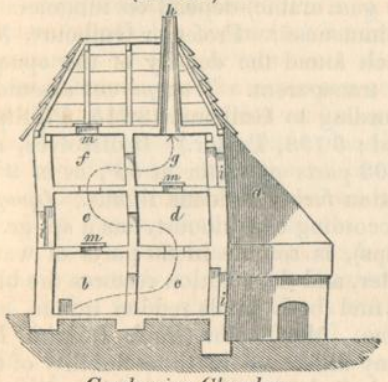
(Fig. 56.)



Section of the Roasting Furnace.

(*a*) Ash-pit. (*b*) Fire-place.
(*eee*) Brick arches for supporting the muffle.
(*c*) Earthen muffle for receiving the ore.
(*f*) Hopper for introducing the ore.
(*d*) Passage for the fumes into the condens-
(*hh*) Flue. [ing chamber.
(*g*) Vent for protecting the workmen from the arsenical fumes.

(Fig. 57.)



Condensing Chamber.

(*b c d e f g h*) Course of the vapour.
(*i i i*) Doors into the chamber.
(*mmm*) Communications between the floors.

zontal flues of the tin burning houses (Mr. J. Taylor, *Ann. Phil.* N.S. iii. 452); from which it is taken for the use of refiners, its value being about ten shillings per ton (*Quart. Min. Rev.* vol. ii. p. 88; and Mr. Davies Gilbert, *Paroch. Hist. of Cornwall*, iii. 305). In this condition it has a grey colour, and is either pulverent or in soft crystalline masses. Mr. Ferris, of Truro, (to whom I am indebted for samples of this impure acid obtained from Wheal Vor tin-mine), tells me that it is conveyed in open waggons to the arsenic-works, of which there are two in the neighbourhood of Truro; one in the parish of Perran Arworthall, the other at Bissow, in the parish of Kea; the former about half a mile, the latter more than a mile, from the Devoron and Carnon stream-works. Here it is purified by sublimation. The fumes from these works are most injurious to neighbouring vegetables and animals. In the human subject, eruptions, principally about the lips and nose, are produced by them. In 1826, eighty-three tons of manufactured arsenic were shipped at Penryn (*Trans. Royal Geol. Soc. of Cornwall*, iii. 360).

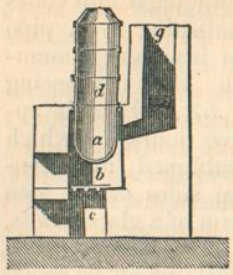
heads (*d*) are attached, which at the tops are contracted into cones (*e*), each terminating in a pipe made of sheet iron, and communicating with the condensing chamber (fig. 57). Heat is applied for twelve hours, by which the acid is sublimed and condensed on the sides of the iron head in the form of a glassy mass, called *glacial white arsenic* (*weissen Arsenikglas*), which is sometimes purified by a second, or even third sublimation. If it contain any sulphuret of arsenicum, a little potash is mixed with it, to prevent the sublimation of the sulphur.

At Reichenstein, arsenious acid is procured from the mineral called arsenical pyrites (a compound of arsenicum and iron, with a small portion of sulphur).

Arsenious acid is procured in some parts of Saxony as a secondary product in the roasting of cobalt ores (the arseniets of cobalt). It is deposited in long horizontal flues (*poison-flues*, or *Giftfängen*), and is purified by sublimation. (For other particulars consult the paper of J. H. Vivian, *Trans. Royal Geol. Society of Cornwall*, i. 60).

Arsenious acid is manufactured in Cornwall. In the impure state it is deposited in the long hori-

(Fig. 58.)



Refining Furnace.
(*c*) Ash-pit. (*b*) Fire-place.
(*a*) Cast-iron pot.
(*d*) Cylindrical head.
(*g*) The chimney.

Properties.—When recently prepared, arsenious acid is in the form of large, glassy, transparent cakes, sometimes colourless, at others having a yellowish tinge. Frequently the cakes consist of concentric laminæ, formed by successive sublimations. Most curiously, these masses soon become opaque and white externally, like enamel, the opacity gradually extending towards the centre; and, in some cases, the acid becomes friable and pulverulent. On what does this alteration depend? Krüger (*Kastn. Arch.* ii. 473, quoted in Gmelin's *Handb. d. Chem.*), ascribes the change to the absorption of water from the atmosphere, for he says it only takes place in moist air, and is attended with an increase of weight, but only to the extent of $\frac{1}{163}$ of the whole mass. Mr. Phillips (*Transl. of the Pharm.* 3d. ed. 1838) has taken the same view of the subject. But, as Berzelius has observed, the augmentation of weight is too trivial to admit of this explanation. Moreover, I find the opacity takes place in an air-tight vessel. Does not the opacity (as in opaque gum arabic) depend on innumerable cracks, imperceptible from their minuteness? Professor Guibourt, Mr. Phillips, and Mr. Taylor, have each found the density of the opaque variety to be less than that of the transparent. *Transparent* arsenious acid has a sp. gr. of 3·7391, according to Guibourt (3·715, Phillips; 3·208 to 3·333, Mitchell and Durand; 3·798, Taylor.) It dissolves, according to the same authority, in 103 parts of water at 59°, or in 9·33 parts of boiling water, and the solution feebly reddens litmus. *Opaque* arsenious acid, on the other hand, according to Guibourt, has a sp. gr. of 3·695 (3·529, Taylor; 3·620, Phillips), is soluble in 80 parts of water at 59°, or in 7·72 parts of boiling water, and the solution restores the blue colour of reddened litmus. But I find both kinds redden litmus, and Dr. Christison has observed the same. Mr. Taylor (*Guy's Hospital Reports*, vol. ii. p. 83), did not find any difference in the solubility of the two varieties. He found that water boiled for an hour on this substance dissolved $\frac{1}{24}$ of its weight; that this water on perfect cooling did not retain more than $\frac{1}{40}$ of its weight; and that water at ordinary temperatures will dissolve from about $\frac{1}{1000}$ to $\frac{1}{500}$ of its weight. It appears, then, that water perfectly cooled from a boiling saturated solution will retain from ten to twenty or more times the quantity of acid in solution than it will take up at common temperatures without heat,—a fact which is as curious as it is inexplicable (*op. cit.* p. 96.) Arsenious acid is soluble in alcohol and oils. It is of importance to know that the presence of organic matters very much impairs the solvent power of water for this acid—a circumstance which readily explains why arsenious acid has not, in some cases, been found in the liquid contents of the stomach of persons poisoned by it. Arsenious acid has little or no taste, as Plenck (*Toxicologia*, ed. 2nda. 26), Addison, and Christison, have remarked: and neither in the solid nor vaporous form has it odour. The acid may be readily obtained in a crystalline condition by sublimation or by cooling a boiling saturated solution: the crystals are transparent, usually regular octahedra, sometimes tetrahedra or acicular. At a temperature of 380° F. it volatilizes: when heated under pressure it liquefies, and is converted into a transparent glass.

CHARACTERISTICS.—These may be conveniently and usefully discussed under three heads:—(*a.*) The characteristics of solid arsenious acid; (*b.*) the characteristics of a pure solution of arsenious acid; (*c.*) the characteristics of arsenious acid in organic mixtures.

(*a.*) *OF SOLID ARSENIOUS ACID.*—The characteristics of solid arsenious acid are (besides its physical properties before mentioned) principally three—its volatility, the garlic odour evolved by throwing it on ignited charcoal, and the qualities of the metallic crust obtained by reducing the acid.

1. *Its volatility.*—Heated on the point of a penknife in the flame of a spirit lamp arsenious acid produces a white smoke, and speedily disappears. If the acid be heated in a test tube, a crystalline sublimate is obtained: the crystals when examined by a magnifying glass are found to be regular octahedra. The *impediments* to the operation of this test are alkaline or earthy bases which retain a portion of the arsenious acid, and prevent its rising in vapour: boracic acid may be used to counteract their influence. The *fallacy* of this test is, that other white solids (as hydrochlorate of ammonia, oxalic acid, &c.) are volatile, and produce a white smoke when heated.

2. *Garlic odour.*—If arsenious acid or an arsenite be put on a red-hot cinder (placed for convenience in a saucer), it evolves a scarcely visible vapour (of metallic arsenicum) having a garlic odour, and which, at the distance of an inch or two from the cinder, is converted into a dense, white, odourless smoke (arsenious acid.) The deoxidation of the acid is essential to the production of the garlic odour: hence no odour is perceived when arsenious acid is placed on a heated metallic or glass plate. The *impediment* to the action of this test is the presence of organic matter (as flour): this, by burning, developes a strong odour, which masks the smell of the vapour of arsenicum. The *fallacy* attending it is, that some other bodies (as phosphorus, with certain of its compounds and some organic matters) evolve when heated a garlic odour. Vauquelin, Barruel, and Orfila, have shewn that a compound of albumen and fat, which exhaled this odour when heated, did not contain a particle of arsenious acid. "It is true," say these experimenters, "that arsenicum does evolve a garlic odour when volatilized; but even when this is well characterized, it is insufficient to establish the existence of the oxide of arsenic, since it belongs to some other substances; and it is not impossible that there may be developed in the stomach, during digestion, substances which exhale an analogous odour, when heated."

3. *Formation of a metallic crust. Reduction test.*—If arsenious acid be intimately mixed with freshly-ignited but cold charcoal, and heated in a glass tube, the acid is deoxidized, and yields arsenicum, which is sublimed into a cooler portion of the tube, where it condenses, and forms a metallic crust. A common cylindrical test tube answers very well, but the reduction tube of Berzelius (fig. 59) is to be preferred. The characters of the arsenical crust are—the brilliancy of its outer surface, which is frequently equal to polished steel or looking-glass; the crystalline appearance and greyish white colour of its inner surface; its volatility; its conversion, by sublimation, up and down the

FIG. 59.

Berzelius's Redn. tube.

tube, into octahedral crystals of arsenious acid, which may be dissolved in distilled water, and tested by the liquid re-agents presently to be mentioned; and its yielding arsenic acid by dissolving it in nitro-hydrochloric acid, and carefully evaporating the solution to dryness. The arsenic acid is known by the red precipitate (arseniate of silver) produced on the addition of nitrate of silver: but if the evaporation has not been carried on sufficiently far, some hydrochloric acid or chlorine will be left, which will form a white precipitate (chloride of silver) with nitrate of silver. The arseniate of silver may be reduced, if necessary, by mixing it with charcoal and boracic acid, and heating it in a glass tube.

In some cases the metallic crust is imperfectly formed, or is masked by some decomposed organic matter. Whenever any doubt respecting its nature is entertained, proceed as follows:—Cut off with a file the portion of the tube which contains the suspected crust, roughly powder it, introduce it into another glass tube, and apply heat.

The *fallacies* to which this test is liable are principally two—a charcoal crust may, by an inexperienced experimenter, be mistaken for the arsenical crust; and I have seen students confound a stratum of globules of mercury (obtained by reducing calomel) with the arsenical crust. Careful examination, especially by a magnifying glass, will, however, easily enable the experimenter to distinguish them: the inner surface of the charcoal crust is brown, powdery, and dull, whereas that of the arsenical crust has a crystalline texture, grey colour, and shiny appearance: the sublimate obtained by reducing calomel or mercurial compounds has all the brilliancy of arsenicum, but by a glass is found to consist of minute globules which may be made to coalesce by the point of a knife. Lastly, the arsenical may be distinguished from all other crusts by oxidating it, as before directed, and converting it into arsenious or arsenic acid which can be readily recognised by the tests already mentioned:—*a proceeding which ought never to be omitted.*

As a deoxidizing agent I have directed freshly ignited charcoal to be employed to convert arsenious acid into arsenicum. If carbonate of soda or of potash be mixed with the charcoal, a part only of the arsenicum is disengaged, an arseniuret of sodium or of potassium being formed: hence when the quantity of acid to be reduced is small, charcoal only should be employed. "Where the quantity of material, however, is considerable, it is preferable to employ the black flux, or still better, as not being deliquescent, a mixture of charcoal and carbonate of soda, deprived of water of crystallization by heat." (Christison's *Treatise on Poisons*, 3d ed. 237.) If the substance to be reduced be an arsenite (as of silver, copper, or lime), or an arseniate (as of silver), a mixture of charcoal and boracic acid should be used. For the reduction of the arsenical sulphurets (as the precipitate obtained by passing hydrosulphuric acid gas through a solution of arsenious acid) a mixture of 2 parts of ignited carbonate of soda and 1 of charcoal should be employed. The alkali is here essential in order to combine with the sulphur. Black flux (prepared by deflagrating 1 part of nitre and 2½ of bitartrate of potash) is objectionable on account of its deliquescent property. Various other deoxidizing agents have been recommended, as formate of soda by Goebel (Griffin's *Chem. Recreat.* 8th ed. 140), oxalate of lime by Du Menil (*Handb. d. Reag. u. Zerlegungslehre*, ii. 268), and oxalate of soda by Dr. M'Gregor (*London Med. Gaz.* xxii. 613.) I find that binoxalate of potash answers very

well. None of these, however, present any advantage over charcoal save that of not soiling the tube (an occurrence easily avoided by using a glass funnel, as recommended by Dr. Christison, or which may be obviated by wiping the tube, after the introduction of the mixture, with a wisp of paper), while their comparative scarcity and greater cost are objections to their employment. (For further details concerning the reduction process, consult Dr. Christison's *Treatise*, so frequently referred to.)

(*b.*) *Characters of a pure aqueous solution of Arsenious Acid.*—A clear watery solution of white arsenic may be recognized by certain liquid reagents which give rise to peculiar precipitates, as well as by nascent hydrogen, which causes the formation of a gas (arseniuretted hydrogen) possessed of remarkable and peculiar properties. The liquid reagents which deserve notice are four only—namely, *lime water*, *ammoniaco-sulphate of copper*, *ammoniaco-nitrate of silver*, and *hydrosulphuric acid*. Their relative delicacy, as stated by Devergie, (*Méd. Lég.* ii. 718), and the delicacy of the nascent hydrogen test, as ascertained by Mohr (*Journ. de Pharm.* xxiii. 566), are as follows:—

	Dilution of arsenious solution.
Lime water ceases to act at	2·000
Ammoniaco-sulphate of copper, ditto at	5·200
Hydrosulphuric acid, ditto at	200·000
Ammoniaco-nitrate of silver, ditto at	400·000
Marsh's nascent hydrogen test, ditto at	500·000

1. *Lime Water.*—Lime water occasions a white precipitate (arsenite of lime), with a solution of arsenious acid. The precipitate is soluble in most acids. The *impediments* to the operation of this test are, a large quantity of water and free acids, which hold it in solution, and gelatinous and oleaginous liquids, which keep it suspended. The *fallacies* of this test are, carbonates, oxalates, tartrates, &c. which also throw down white precipitates with lime water. On the whole, it is a test of very little value.

2. *Ammoniaco-sulphate of Copper.*—If a dilute solution of ammoniaco-sulphate of copper be added to a solution of arsenious acid, a pale green precipitate (arsenite of copper, or Scheele's green) is obtained, and sulphate of ammonia remains in solution. This test is prepared as follows:—Add (cautiously) liquor ammoniæ to a solution of the sulphate of copper, so as to re-dissove the oxide of copper, which it at first throws down. Care must be taken not to employ too much alkali, otherwise the test will not act. Moreover, the solution must not be concentrated, or no precipitate will be obtained. The *impediments* to the action of this test are astringents, as tea, infusion of galls, &c. which prevent its acting characteristically. The *fallacies* to be guarded against, are, yellow-coloured and other organic fluids, which give a green colour, and slight precipitate, even though no arsenic be present.

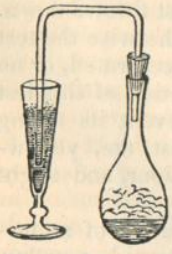
3. *Ammoniaco-nitrate of silver: Hume's test.*—If a solution of ammoniaco-nitrate of silver be added to a solution of arsenious acid, a yellow precipitate (arsenite of silver) takes place, and nitrate of ammonia remains in solution. The precipitate is soluble in liquid nitric acid, ammonia water, and a solution of nitrate of ammonia. The mode of preparing this test is as follows:—Add a few drops of liquor ammoniæ to a solution of nitrate of silver, so that the oxide of silver which the alkali at first throws down may be nearly, but not entirely, redissolved. Great care is requisite to add neither too much nor too little; for if too much be employed, the solution will not occasion any precipitate with arsenious acid; and if too

little, it will produce a precipitate with phosphate of soda similar in colour to that produced with arsenious acid. The only certain way of knowing when the proper quantity has been employed is to test it. Arsenious acid, but not phosphate of soda, ought to occasion a precipitate with it. The *impediments* to the operation of this test, are, free acids (as hydrochloric nitric, acetic, citric, or tartaric), chlorides, and organic matters. The acids may be readily neutralized by an alkali. If common salt, or other metallic chloride be present, ammoniaco-nitrate of silver throws down a white precipitate (chloride of silver), even though a considerable quantity of arsenic be present. To obviate this, add a few drops of nitric acid, then an excess of a solution of nitrate of silver. Filter to get rid of the precipitated chloride of silver, and apply the ammoniaco-nitrate of silver. The presence of much organic matter impedes the action of this test. Ammoniaco-nitrate of silver, when properly prepared, does not occasion a yellow precipitate with any substance save arsenious acid; and hence is not subject to any *fallacy* of that kind. If, however, it be not properly prepared, it may occasion a yellow precipitate (subphosphate of silver) with phosphate of soda. There is an optical fallacy, against which the student should be put on his guard: if ammoniaco-nitrate of silver be added to certain yellow liquids containing common salt, a white precipitate (chloride of silver) is produced, which, seen through a yellow medium, might, by a careless observer, be mistaken for a yellow precipitate.

4. *Hydrosulphuric Acid* (*Sulphuretted Hydrogen*).—If this gas be passed through a solution of arsenious acid, a yellow precipitate of sesquisulphuret of arsenicum (orpiment) is produced, while the oxygen of the arsenious acid, and the hydrogen of the hydrosulphuric acid, unite to form water. In order, however, for this effect to be produced, it is necessary that the liquid be slightly acidified by some acid (as the hydrochloric). If the liquid be already acid, we must neutralize it by cautiously adding an alkali, and then acidify by hydrochloric acid.

In applying this test we may place the suspected liquid in a test-tube, or conical wine or ale-glass (fig. 60); the gas being developed in a common Florence flask (or two-necked bottle, as recommended by Dr. Christison): the mouth of the flask is closed by a cork, perforated by a tube curved twice at right angles. The ingredients for developing the gas are a metallic sulphuret (as of iron or of antimony) and sulphuric or hydrochloric acid. I prefer the sulphuret of iron with sulphuric acid diluted with water. These are to be introduced into the flask previous to the adaptation of the cork. After the gas has passed through the arsenical liquid for a few minutes, portions of the yellow sesquisulphuret of arsenicum (orpiment) begin to fall down. The separation of the precipitate is promoted by ebullition, and the exposure of the solution for a few hours to the air. The essential characters of the precipitate are, its yellow colour, its rapid solution in liquor ammoniæ, forming a colourless and very limpid liquid, and its yielding metallic arsenicum when dried and heated with black flax, or a mixture of ignited carbonate of soda and charcoal. When the quantity of sesquisulphuret is small, some difficulty may be

FIG. 60.



Mode of passing Hydrosulphuric Acid through an arsenical solution.

experienced in removing it from the filter for reduction. The readiest way is that recommended by Devergie:—Collect it on the filter in as small a space as possible, then wash it with liquor ammoniæ, which dissolves it. The filtered liquid may then be evaporated in a capsule or watch-glass: the ammonia flies off, and leaves the sesquisulphuret.

The *fallacies* of the hydrosulphuric acid test are, the *salts of cadmium*, the *persalts of tin*, the *antimonial compounds*, and *selenic acid*, which occasion precipitates with hydrosulphuric acid, more or less analogous in colour to that produced by arsenious acid. The precipitate with cadmium closely resembles that with arsenic. This metal (cadmium) has been detected in some of the preparations of zinc (*vide* Thomson's *Hist. of Chemistry*, ii. 220). The perchloride of tin, sold for the use of dyers under the name of *spirit of tin*, occasions a yellow precipitate (bisulphuret of tin) somewhat resembling sesquisulphuret of arsenicum. Very weak solutions of emetic tartar form a reddish yellow liquid, or throw down a reddish precipitate (sesquisulphuret of antimony) somewhat analogous in appearance to that formed by an arsenical liquid. If hydrosulphuric acid be transmitted through a liquid in which *pulvis antimonialis* has been boiled, the solution acquires a yellowish red colour, from the formation of some sesqui- or bisulphuret of antimony. From all the above precipitates sesquisulphuret of arsenicum is readily distinguished by the reduction test already mentioned.

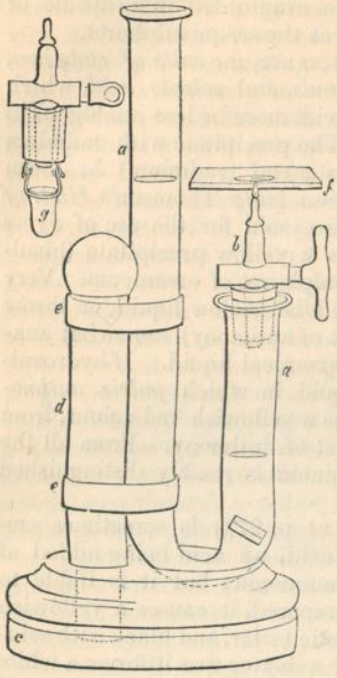
Hydrosulphate of ammonia (described at p. 271) is sometimes employed as a substitute for hydrosulphuric acid, an acid being added at the time of applying it, to neutralize the ammonia; but it is liable to several serious objections. When fresh prepared, it causes a yellowish precipitate with arsenious acid, red with emetic tartar, and black with solutions of lead; but by exposure to the air for a day or two it forms a white precipitate with arsenious acid, yellow with emetic tartar, and red with lead!

5. *Nascent Hydrogen: Marsh's test.*—If arsenious acid be submitted to the action of nascent hydrogen, it is deoxidized, and the metallic arsenicum thereby obtained, combining with hydrogen, forms arseniuretted hydrogen gas.

This test, which is the discovery of Mr. Marsh, of Woolwich (*Trans. of the Soc. of Arts*, li. 66; also *Lond. Med. Gaz.* xviii. 650), may be thus applied:—Mix a small portion of the suspected liquid with some diluted sulphuric acid (1 oil of vitriol and 7 water), and pour the mixture over some pieces of zinc previously introduced into a proper apparatus: bubbles of gas immediately make their appearance. If no arsenious acid be present, the evolved gas is hydrogen; but if the liquor hold arsenic in solution, arseniuretted hydrogen gas is formed. This gas is recognised by the following characters: it has an alliaceous odour, and burns in the air with a bluish white flame, and the deposition of black metallic arsenicum and white arsenious acid. If a plate of mica, or of common window-glass, or of porcelain (as a white saucer), be held a short distance above the flame, arsenious acid, in a finely pulverent state, is deposited on it: if the plate be depressed so as to touch the flame, and thereby slightly to impede the combustion of the gas, a blackish deposit of metallic arsenicum is obtained. Or both these deposits may be readily procured by holding vertically over the flame a tube of glass, 9 or 10 inches long, and a quarter or half an inch in diameter: the tube becomes lined for the space of several inches with metallic arsenicum and

arsenious acid, and the garlic odour can be detected at either end of the tube. To obtain solutions of the acid, let the flame successively play beneath three or four drops of water placed on the under side of a plate of mica; then apply the liquid tests for arsenic before mentioned (Herapath, *Med. Gaz.* xviii. 889).

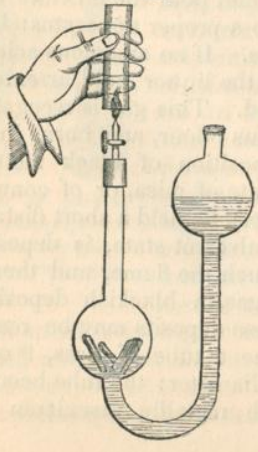
Fig. 62. & Fig. 61.



(*a*) A syphon tube.
(*b*) Stop-cock.
(*c*) Wooden block.
(*d*) The pillar.
(*ee*) Caoutchouc slips, to fasten the tube to the pillar.
(*f*) Place of mica or glass.

Fig. 62.—(*g*) Small glass bucket.

Fig. 63.



Various forms of apparatus may be used for this experiment. That employed by Mr. Marsh is a simple glass tube, bent like a syphon (fig. 61). A bit of glass rod is dropped into the shorter leg, then a piece of clean sheet zinc: the stop-cock and jet are afterwards to be inserted. The suspected liquid, mixed with the dilute acid before mentioned, is to be then poured into the long leg. Effervescence is produced, and after allowing the air to be expelled, the stop-cock is to be closed, and when a sufficient accumulation of gas has taken place, it is again to be opened, and the gas ignited. Where the matter to be examined is very small in quantity, Mr. Marsh puts the suspected liquid, the acid, and the zinc, in a little glass bucket (fig. 62), attached to the stop-cock by a platinum wire, and then introduces it into the short leg of the syphon, previously filled with common water. A modification (fig. 63) of Mr. Marsh's apparatus is supplied with two bulbs, one in each leg of the instrument, and presents some advantages over the simple syphon tube: thus it enables us to collect a larger quantity of gas, while the bulb assists in checking the frothing by breaking the bubbles. But the simplest, cheapest, and often the most useful form of apparatus, is a two-ounce wide-mouthed phial, with a cork perforated by a glass tube or tobacco-pipe, as in fig. 64, p. 383, annexed. It presents this great advantage, that we can employ a fresh apparatus for every experiment, and thus avoid all possibility of contamination from arsenical liquids used in previous experiments.

The *impediments* to the operation of Marsh's test are, organic liquids (as porter, soup, contents of the stomach, &c.), which occasion great frothing, and choke up the jet. The means of obviating this are, greasing or oiling the interior of the short leg of the apparatus, putting a layer of

alcohol or oil on the surface of the liquid in the short limb, and placing the apparatus aside for an hour or two, to allow the bubbles to burst.

The *fallacy* of the test is, that if a solution of emetic tartar be employed instead of an arsenical liquid, we obtain antimoniuretted hydrogen gas, which coincides in many of its properties with arseniuretted hydrogen (Mr. L. Thompson, *Lond. & Edinb. Phil. Mag.*, May 1837). Thus it has a peculiar odour, not very unlike that of arseniuretted hydrogen, and burns in the air with a pale bluish flame, and the deposition of metallic antimony and the white oxide (on mica or glass held over it), which resemble, in their general appearance, arsenicum and arsenious acid: moreover, the action of hydrosulphuric acid and of ammoniaco-sulphate of copper on the oxide of antimony, produces colours resembling those generated by the action of these tests on arsenious acid. The two metals may, however, be distinguished by adding a drop of nitric acid to the crusts, and evaporating to dryness: a white powder is left in each instance. A few drops of a dilute solution of the nitrate of silver being now added, and the whole exposed to the fumes arising from a stopper moistened with ammonia, the arsenical crust will give the well known canary-yellow flocculi (Mr. L. Thompson, *op. cit.*) Moreover, the greater volatility of arsenicum, and its conversion into octahedral crystals of arsenious acid (Dr. E. Turner's *Chemistry*, by W. Turner) may serve, in some cases, to distinguish it from antimony. Furthermore, the solubility of the arsenious acid, and the reaction of the before-mentioned liquid tests on the solution, will distinguish it from oxide of antimony, which is insoluble.

Fig. 64.

In performing Marsh's test great care must be taken that the apparatus be perfectly clean, and that fresh zinc and acid liquor be used for every experiment. The experimenter should be fully alive to the possibility of the acid, zinc, or even the brasswork of the apparatus, containing minute traces of arsenic; hence the necessity of examining the qualities of the hydrogen flame before adding the suspected arsenical liquid. It has been shown by Mohr (*Journ. de Pharm.* xxiii. 563) that zinc which had been once used, but afterwards carefully washed both in water and acid, retained sufficient arsenic to produce the usual effects on the hydrogen flame.

3. *Of Arsenious Acid in Organic Mixtures.*—I shall confine myself to a brief notice of the modes of detecting arsenious acid when mixed with the contents and tissues of the stomach, and must refer the reader to Dr. Christison *On Poisons*, and to his paper in the *Edinb. Med. & Surg. Journ.* xxii. 60, as well as to Devergie's *Méd. Lég.* ii. 718, for further details, especially in reference to other organic mixtures.

When the stomach is laid open we sometimes observe in it a white powder or white particles; these are, of course, to be carefully removed; and if they be arsenious acid, no difficulty will be experienced in recognising them by the tests already mentioned.

If no solid arsenious acid be observed, cut the stomach into small pieces, and boil it with the contents of this viscus for half an hour in distilled water, to which a small quantity of liquor potassæ has been added: then filter, first through muslin, and afterwards through paper. Fibrin is insoluble in water, and, by boiling, albumen is coagulated, so

that (with the exception of small portions of these principles held in solution by the alkali) the filtered liquor is free from both fibrin and albumen. A little acetic acid is now to be added, and the liquid boiled, by which any caseum present will be coagulated, and got rid of by filtering a second time. Sometimes the liquor is now found sufficiently free from organic matters to enable us to detect the arsenious acid very readily by the ammoniaco-nitrate of silver. Dr. Christison says, that if this test act characteristically, that is, gives a copious yellow precipitate, the liquid is sufficiently free from foreign matter. If, however, it give no indication, or at least only imperfect ones of arsenious acid, evaporate to dryness by a gentle heat (as a water-bath), and boil the residue in repeated portions of distilled water. We thus obtain a solution of arsenious acid, which, after being acidulated with acetic or hydrochloric acid, is to be decomposed by passing a current of hydrosulphuric acid through it. The precipitated orpiment (sesquisulphuret of arsenicum) is to be collected, and reduced in the way already described (p. 378).

Arsenious acid in organic liquids may sometimes be readily detected by the developement of arseniuretted hydrogen when zinc and sulphuric acid are added to the suspected liquor (*vide* p. 381). But the frothing produced by the organic matter creates considerable difficulty. I have already pointed out the best methods of obviating it.

Composition.—The following is the composition of arsenious acid:—

	Eq.	Eq.Wt.	Per Cent.	Berzelius.	Mitscherlich.
Arsenicum	1	38	76	75·782	75·73
Oxygen	1½	12	24	24·218	24·27
Arsenious Acid	1	50	100	100·000	100·00

Purity.—Powdered arsenious acid is sometimes adulterated with chalk or sulphate of lime. The fraud is readily detected by heat, which volatilizes the acid, but leaves the impurities.

Physiological Effects. (*a.*) *On vegetables.*—The effects of arsenious acid on plants have been studied by Jäger (*Diss. Inaug.* Tubingæ, 1808, quoted by Marx in his *Die Lehre von den Giften*, ii. 99); Marcet; Macaire, *Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève* t. iii.), and by others; and from their observations we learn that it is poisonous to all the higher and most of the lower families of plants. It appears that seeds which have been soaked in a solution of arsenious acid are incapable of germinating, and that buds which have been plunged in it are no longer capable of expanding. If roots or stems be immersed in this solution the plants perish; death being preceded by drooping and alteration of the colour of the leaves and petals. If the stem of the common barberry (*Berberis vulgaris*) be placed in dilute hydrocyanic acid, or in an aqueous solution of opium, the stamens lose their remarkable contractile power, but remain flexible. If, however, we employ a solution of arsenious acid, the plant equally dies, but the stamens become stiff, hard, and retracted, and on any attempts being made to alter their position, they readily break. These curious facts appear to prove that the effects produced by this acid on vegetables are very different from those caused by hydrocyanic acid and opium; for the latter seem to exhaust the irritability, while the former appear to give rise to a condition very analogous to the spasm of animals. Jäger has seen a small plant (supposed by Decandolle, in his *Phys. Vég.* p. 1329, to be *Mucor imperceptibilis*) grow in

water which contained $\frac{1}{3}\frac{1}{2}$ of its weight of arsenic. And, more recently, Gilgenkrantz (*Journ. de Pharm.* xxiii. 38) says he has seen an algaceous plant, of the genus either *Leptomitus* or *Hygrocrocis*, develope itself in a solution of arsenic. These are most remarkable exceptions to the general effects of this poison on vegetables, and deserve further examination. Jäger has shewn that arsenic is absorbed by plants: for he found that on burning vegetables destroyed by this poison he obtained a garlic odour.

(*b.*) *On animals generally.*—Arsenious acid is poisonous to all classes of animals. No exceptions, I believe, are known to exist to this statement. The most extensive series of experiments on this subject are those performed by Jäger (*op. cit.*) From them we learn that in all animals, from the infusoria up to man, death from arsenic is invariably preceded by inordinate actions and increased evacuations, especially from the mucous membranes. In most animals the stools were frequent and fluid; and in those in which mucus is secreted on the surface, it was remarkably increased. The power of voluntary motion and susceptibility of external stimuli were decreased; and after death the muscles soon ceased to be influenced by the galvanic agency. In animals which breathe by lungs, respiration became difficult and laborious; and in warm-blooded animals great thirst was experienced. In birds and mammals convulsions came on, preceded by vomiting, except in those animals (as the rabbit) which cannot vomit. Enormous quantities of arsenious acid have been sometimes administered to horses with impunity. Berthe (*Recueil de Méd. Vét.* Oct. 1825) gave 2 and afterwards 3 drachms to a mare, for the cure of an obstinate skin disease, without any injurious effects. Beissenhirz (quoted by Wibmer, *die Wirkung*, &c. i. 317) gave successively, on different days, 1, 4, 3, 2, and 8 drachms of arsenious acid to a horse: the animal did not die until the ninth day after taking the last-mentioned dose. Yet notwithstanding these and some other analogous facts, which seem to prove that arsenic has comparatively little effect on horses, the best informed veterinarians agree in considering it an energetic poison to these animals. (See the evidence of Mr. Bowles, in the *Ed. Med. and Surg. Journ.* viii. 351.)

(*c.*) *On man.* α. *Of very small* or *therapeutical doses.*—In very small quantities (as $\frac{1}{1}\frac{1}{6}$ or $\frac{1}{1}\frac{1}{2}$ of a grain) no obvious effects are usually produced by the use of arsenic, unless it be continued for a long period. Indeed some writers (*e. g.* Vogt, *Pharmakodyn.*) go so far as to assert that it is a strengthening remedy, and that it improves the appetite, invigorates digestion, promotes assimilation and secretion, excites the muscular and nervous functions,—in a word, acts as a *tonic*. I cannot, however, subscribe to this doctrine, because I have never been able to see the effects here asserted. It is, indeed, true that patients sometimes experience a temporary increase of appetite from the use of small doses of arsenic; and it is also certain that this remedy is frequently beneficial in agues and other diseases in which tonics have been found efficacious. But the analogy between the action of arsenious acid and that of the vegetable tonics (as cinchona, to which Vogt compares it) stops here. I have sought in vain for other evidences of a tonic operation. I have seen very minute doses of arsenic given to patients affected with lepra, and continued for many days, without being able to detect the least indication of its action on the system, except the amelioration of the disease. When

the dose was slightly increased, the appetite in some cases appeared to be increased; but this effect was neither universal nor continued. Very shortly afterwards, a sensation of heat in the throat, œsophagus, and stomach, came on, occasionally with nausea, but seldom with vomiting; in a few cases with gastrodynia; a febrile condition of the body was set up; there were dryness of the skin, increased secretion of urine, relaxed bowels, sometimes with griping; the patients usually complained of great languor, inaptitude for employment, and want of sleep; and sometimes these symptoms were accompanied with, or followed by, redness of the eyes and certain swellings especially of the face, (*œdema arsenicalis*)—effects which are so different from those produced by the remedies called strengthening, that I cannot regard arsenic as a tonic. In proof of the beneficial effects of this substance, we are gravely told that the country people of Upper Styria, in Austria, use arsenic as a stomachic, and condiment for many kinds of food—for example, cheese; and a healthy peasant himself tells us that he was accustomed to take two grains of arsenic daily, without which, he assures us, he could not live! (*Med. Jahrb. d. österr. Staates.* 1822, i. 99, quoted from Wibmer.) In further proof of this strengthening action of arsenic, Vogt says that it promotes the appetite, the activity, and the power of old enfeebled horses, and mentions that Jäger noticed the same effects on a pigeon. To the first of these statements, namely, the beneficial effects from the use of arsenic as a condiment, I confess I do not give credence; and with respect to the action of arsenic on horses, every well-informed veterinarian knows that it operates on these animals as a virulent poison.

Dr. Fowler (*Med. Reports of the Effects of Arsenic*, p. 98) gives the following summary of the effects of the arsenical solution in more than 320 cases:—In about $\frac{1}{3}$ no operation: "somewhat more than $\frac{1}{3}$ were attended with nausea; and nearly $\frac{1}{3}$ with an open body; and about $\frac{1}{3}$ with griping. Vomiting, purgings, swellings, and anorexia, were but rare in comparison with the preceding effects, and their less frequent occurrence were generally found in the order in which they are here enumerated, swellings and anorexia being the seldomest. About $\frac{1}{5}$ of the cases attended with nausea, and $\frac{1}{4}$ of those attended with an open body, were unconnected with any other effects. Griping did not often occur alone; purging and anorexia seldom or never; and vomiting was always accompanied with more or less nausea." In some cases salivation has been produced by the medicinal use of arsenic, as will be noticed presently.

β. *Of long-continued small doses, or of large medicinal doses* (*slow or chronic poisoning.*)—If the use of small doses of arsenious acid be continued for a long period, it acts as a slow poison; and if persevered in, will ultimately occasion death. The same effects take place, in a shorter period, from the administration of large medicinal doses. Sometimes the digestive apparatus, at other times the nervous system, first shews symptoms of the poisonous operation of this agent.

Hahnemann (quoted by Dr. Christison) has graphically described the condition of slow poisoning by arsenic as "a gradual sinking of the powers of life, without any violent symptom; a nameless feeling of illness, failure of the strength, an aversion to food and drink, and all the other enjoyments of life."

On some occasions the first symptoms which I have observed of its poisonous operation have been thirst, redness of the conjunctiva and

eyelids, followed by a cutaneous eruption. At other times irritation of stomach is the leading symptom. In some cases ptyalism is brought on. Marcus (*Ephemeriden*, 1809) noticed this effect: as also Dr. Ferriar (*Med. Hist. and Refl.* iii. 306.) Mr. Furley (*Lond. Med. Gaz.* xvi.) has published five illustrative cases of it. Trousseau and Pidoux (*Traité de Thérap.* ii. 148) also mention this symptom as produced by the long-continued use of feeble doses of arsenic. This effect acquired some importance in the celebrated Bristol case of poisoning. (*Lond. Med. Gaz.* xv. 519, and *Trans. Prov. Assoc.* iii. 432.)

The following is an abstract of the symptoms produced by the long-continued employment of small doses of arsenious acid, but which are more or less modified in different cases:—Disorder of the digestive functions, characterized by flatulence, sensation of warmth, or actual pain, in the stomach and bowels; loss of appetite; thirst, nausea, and vomiting; purging, or at least a relaxed condition of the bowels, and griping; furred tongue, with dryness and tightness of the mouth and throat, or with salivation. The pulse is quick, small, and sometimes irregular; the respiration oppressed, and accompanied with a dry cough. The body wastes; the stomach being frequently so irritable that no food can be retained in it. Headache, giddiness, and want of sleep, are frequently observed. The limbs become painful, feeble, trembling, subject to convulsions; occasionally benumbed, and ultimately paralyzed. The cutaneous system is, in some cases, affected, an eruption makes its appearance, and now and then the hair and nails fall off. Swelling of the feet and of the face is not unfrequently observed; and under these symptoms the patient gradually sinks, in some cases retaining his consciousness to the last, but at other times delirium or stupor supervening.

γ. Of excessive or poisonous doses (*acute poisoning.*)—The symptoms produced by the ingestion of a large dose of arsenious acid are not invariably alike, but put on three forms. In some cases the principal or leading ones are those indicating gastro-enteritis; the nervous system being not obviously, or at least only slightly, affected. In others, the gastro-enteritic symptoms are absent, and the principal operation of the poison is on the vascular and nervous systems. Lastly, there are other cases in which we have both gastro-enteritic symptoms with an affection of the nervous and vascular systems.

Form 1st: Acute poisoning with symptoms of gastro-enteritis.—In this form of arsenical poisoning, nausea and vomiting come on soon after the poison has been swallowed, and are attended with burning pain in the throat and stomach, and which soon extends over the whole abdomen. Pain and vomiting, however, are not invariably present. The matters vomited vary in their nature and appearance; sometimes being bilious, at other times tinged with blood. Frequently there is a sense of heat, dryness, tightness, and constriction of the throat, accompanied with incessant thirst, and occasionally with an almost hydrophobic difficulty of swallowing. The lower part of the alimentary canal soon becomes affected, indicated by the burning pain, which is increased on pressure—by the hard and tense condition of the abdomen—by the diarrhœa (the stools occasionally being bloody)—by the tenesmus—and by the occasional heat and excoriation of the anus. When the lower part of the alimentary canal is powerfully irritated, the urino-genital apparatus becomes affected; and thus there may be difficulty in passing the water, with burning pain in the genital organs. The constitutional symptoms

are, in part, such as might be expected from this violent local disorder: thus the pulse is quick, but at the same time small, feeble, and irregular: there are cold clammy sweats; the action of the heart is irregular, giving rise to palpitation; the breathing is short, laborious, and often painful; the tongue is dry and furred; and the membrane lining the air-passages feels hot, and oftentimes painful.

Although, in this form of acute arsenical poisoning, the gastro-enteritis is the principal, and in some cases almost the only affection, yet there are generally observed some symptoms indicative of disorder of the cerebro-spinal system: sometimes in the form of tremblings or cramps of the limbs, or delirium, and even, in the last stage, insensibility. Occasionally, also, eruptions take place.

In this form of poisoning, death usually occurs in from twenty-four hours to three days after the administration of arsenic; but Dr. Christison says that Pyl has recorded a case where death occurred in three hours after swallowing the poison.

Form 2d: Acute poisoning with narcotism, without any remarkable symptoms of gastro-enteritis.—In some cases of poisoning, in both man and animals, the symptoms are those indicating disorder of the cerebro-spinal and vascular systems: abdominal pain, vomiting, and purging, being either altogether absent or very slight. The symptoms are usually faintness, or perhaps actual syncope, convulsions, or paralysis; and, sometimes, insensibility; at other times, delirium. These symptoms constitute the state called *narcotism*. Of this form of arsenical poisoning (which is somewhat rare) Dr. Christison has given an abstract of twelve recorded cases. In most of them the quantity of arsenious acid taken was very large; for example, half an ounce, or even an ounce.

Form 3d: Acute poisoning with symptoms of gastro-enteritis, followed by an affection of the cerebro-spinal system.—In this form of poisoning we have at first the usual gastro-enteritic symptoms, and which I have already described under the first form of poisoning. When, from the smallness of the dose, or from other circumstances, the patient recovers from the gastro-enteritis, symptoms of a cerebro-spinal affection sometimes make their appearance. The kind of disorder, however, varies considerably in different individuals. "The most formidable," says Dr. Christison, "is coma; the slightest, a peculiar imperfect palsy of the arms or legs, resembling what is occasioned by the poison of lead; and between these extremes have been observed epileptic fits, or tetanus, or an affection resembling hysteria, or madness."

In a medico-legal point of view it is important to determine *what is the smallest fatal dose of arsenious acid.* It is not easy, however, to give a positive answer to this question. Dr. Christison says, "the smallest actually fatal dose I have hitherto found recorded is $4\frac{1}{2}$ grains. The subject was a child four years old, and death occurred in six hours. In this instance, however, the poison was taken in solution." The powerful effects sometimes produced by $\frac{1}{8}$, $\frac{1}{4}$, or $\frac{1}{2}$ a grain, lead us to suspect that 1 grain *might* produce death; but we have no recorded case of this. Hahnemann says, 1 or 2 grains may prove fatal in a few days; and Dr. Christison remarks, that this statement cannot be very wide of the truth. Of course a *repetition* of much smaller quantities might cause death. However, under certain circumstances, enormous quantities have been swallowed with very trivial effects. Some years ago I opened the body of a man who destroyed himself by taking arsenic, and I was informed

by the friends that about a fortnight previous to his death, he made an attempt to destroy himself by swallowing a quantity of powdered arsenic, which they found, on inquiry at the druggists of whom it was purchased, to have weighed half an ounce. It was taken immediately after dinner, and the only effect produced was violent vomiting. Here it is evident that the distension of the stomach with food saved the patient's life. This unfortunate individual repeated the attempt, and death was the result. Another remarkable case of recovery, after the ingestion of half an ounce, has been recorded by Dr. Skillman (*Lond. Med. Gaz.* xix. 238, from *Amer. Journ. of Med. Sciences*, Aug. 1836).

MORBID APPEARANCES PRODUCED BY ARSENIOUS ACID.—When arsenious acid kills by its narcotic operation (constituting the second form of arsenical poisoning), no morbid condition is observable after death. In other cases, however, various alterations are observed, which may be most conveniently arranged under the following heads :—

(*a.*) *Morbid appearances of the alimentary canal.*—The alterations observed in the condition of the intestinal canal vary with the quantity of the poison taken, and probably with other circumstances, but they are all indicative of inflammation: thus we have redness as one symptom, sometimes accompanied with extravasations of blood into the tissue of the canal; ulceration is also frequently observed, sometimes softening of the mucous coat, effusion (of lymph or blood), and occasionally even gangrenous spots.

(*b.*) *Morbid appearances of the vascular system.*—The blood is sometimes, though not invariably, fluid after death, and dark coloured. The heart is mostly flabby, and it is asserted that on its inner surface (especially the carneæ columnæ and valves, particularly of the left side), is observed redness, sometimes diffused, sometimes in the form of spots, and which penetrates a line in depth into the substance of the heart. The pericardium usually contains serum.

(*c.*) *Morbid appearances of the respiratory system.*—These are neither very remarkable nor constant, and principally consist in redness of the pleura, effusion of lymph or serum into the cavity of the pleura, red spots, and occasional congestion of the lungs, and redness of the membrane lining the air tubes.

(*d.*) The *morbid appearances of other parts* deserve little attention. In some cases inflammation, and even gangrene, of the *genital* organs have been observed; the *conjunctiva* is sometimes very vascular, and alterations are occasionally observed in the condition of the *skin*. Redness, extravasation of blood, and effusion of serum, are said to have been seen in the *brain*.

In connexion with the morbid appearances produced by arsenic, the following remarks, made by Orfila (*Dict. de Méd.* ed. 2, art. *Arsenic*) deserve notice. " Under certain circumstances the mucous membrane of the stomach and intestines is lined with a multitude of brilliant points, composed of fat and albumen: placed on burning coals these grains decrepitate on drying, and produce a noise which has been improperly denominated *detonation:* they inflame as a fatty body when they contain a notable quantity of fat, and exhale an odour of burned animal matter. These *fatty* and *albuminous* globules may be met with in the bodies of individuals who have not been poisoned, and require attentive examination in order to distinguish them from arsenious acid. The best method of

avoiding this error is to digest these granular parts with water, and to apply the tests proper for demonstrating the existence of arsenious acid."

Influence of Arsenious Acid on the Putrefactive Process.—Until the commencement of the present century it was supposed that the bodies of animals poisoned by arsenious acid were unusually prone to putrefaction. This, however, has been satisfactorily disproved by the experiments and observations of Klank, Kelch, Hünefeld, and others (quoted by Wibmer, in his *Wirkung d. Arzneim. u. Gifte*; and by Dr. Christison, in his *Treatise on Poisons*); and it appears, that when placed in contact with animal textures, it acts as an antiseptic. "I have kept a bit of ox's stomach four years in a solution of arsenic," says Dr. Christison, "and, except slight shrivelling and whitening, I could not observe any change produced in it." This antiseptic property of arsenious acid, which has been, in my opinion, fully and satisfactorily proved, sufficiently accounts for the good state of preservation in which the alimentary canal has been frequently found some months after death in those poisoned by this acid, where it was not evacuated by vomiting or purging.

But there is another effect said to be produced on the bodies of animals, which is not so easily accounted for: I mean their conversion into a kind of mummy-like or adipocirous matter. The following is an abstract of the phenomena, as deduced from numerous experiments and observations, several of which are recorded in Dr. Christison's invaluable *Treatise*. After death putrefaction commences, and is attended with the usual odour; but, instead of increasing in the customary manner, it seems for a time to be at a stand-still, and then a series of changes commences of a peculiar character: the soft parts become firmer and drier, at the same time retaining their structure; the putrid odour is frequently succeeded by one resembling garlic; the skin becomes brown and parchment-like; the muscular fibres and cellular tissue (especially of the abdominal parietes) are changed into a tallowy cheesy-like mass; the liver, spleen, and heart, become dry, while the bowels, lungs, and brain, form a greasy mass. During these processes it is said that the quantity of arsenic diminishes, probably by exhalation,—a circumstance very probable, when we bear in mind the garlic odour emitted by the body, and which has been observed by several writers. The diminution, however, must be exceedingly small. After some time the cheesy smell disappears, and the body becomes dry and hard. In some cases the alimentary tube has been found little changed or decomposed, although other parts of the body had been completely mummified.

I ought, however, to remark, that some writers do not ascribe these phenomena to the influence of arsenious acid, but to other causes. Jäger (quoted by Wibmer, *op. cit.* i. 305) tells us that in his experiments the putrefaction of the bodies of animals poisoned by arsenic seemed neither to be retarded nor hastened, whether they were buried or not; but he admits that parts in contact with an arsenical solution seem preserved from putrefaction. Seemann (quoted by Dr. Christison, *op. cit.* p. 322; also Wibmer, *op. cit.* i. 322) likewise states, that the bodies of three dogs underwent the usual kind of putrefaction after death. However, that in many cases arsenic modifies the putrefactive process, can hardly, I think, be doubted by those who carefully examine the evidence adduced in favour of this opinion.

Does this mummifying process depend on the chemical influence of the

arsenic, or ought we to refer it to a change effected by arsenic on the body, during life, causing " a different disposition and affinity among the ultimate elements of organized matter, and so altering the operation of physical laws in it?" The latter hypothesis, though advocated by Dr. Christison, appears to me untenable; for, in the first place, there is no evidence of any peculiar change of this kind during life; secondly, that this does not take place appears probable, from the putrefactive process commencing after death as usual; and it would appear that the peculiar influence of the arsenic does not commence, or at least is not evident, until this process has existed for some time, and when a garlic odour is evolved by the body. It is, indeed, true that the quantity of arsenic which has been detected in the body after death, is, as Dr. Christison remarks, " almost inappreciably small;" but it is probable that the quantity is much larger than chemists have yet been able to recognize; and it is not at all unlikely that the arsenious acid may enter into new combinations while within the dead body, and in this way become diffused, probably in a gaseous state: the garlic odour which is evolved favours this notion, as well as the statement made by some, that the quantity of arsenic in the body diminishes during the progress of the mummifying process.

Modus Operandi.—When we consider that arsenious acid operates as a poison to whatever part of the body it be applied, the nerves and muscular fibres excepted; that the quickness with which it acts is in proportion to the absorbing powers of the part, and that the most soluble are the most energetic preparations, we can have little difficulty in admitting that absorption into the blood-vessels is necessary to the action of this potent agent. But the detection of arsenic in the solids and fluids of the body has hitherto not been effected in a satisfactory manner. Lassaigne (quoted by Wibmer, *op. cit.* i. 321) states, that he detected it in the infiltrated pleura of a horse; and Fodéré (quoted by Dr. Christison) twice got indications of its presence in the urine: but Hardegg and Schubarth, on the other hand, failed to recognize it, and therefore further evidence of its existence in the body is necessary, to enable us to place confidence in the results of Lassaigne and Fodéré. An acquaintance of Beissenhirz (quoted by Wibmer, *op. cit.* i. 318) obtained nearly three grains of metallic arsenic from the stomach, cœcum, lungs, liver, heart, and brain of a horse poisoned by six drachms of arsenious acid, taken at divided doses: but the extraction of this substance from the stomach and cœcum is no evidence of its absorption.

Arsenious acid appears to exercise a specific influence over several parts of the body, especially the alimentary canal, the heart, and the nervous system. That the *alimentary canal* is specifically affected is shown by the inflammation of the stomach, induced by the application of arsenic to wounds, and which, according to Sir B. Brodie (*Phil. Trans.* for 1812, 205), is more violent, and more immediate, than when this poison is taken into the stomach itself. That the *heart* is also specifically acted on by arsenious acid is proved by the symptoms (the anxiety at the præcordia, the quick irregular pulse, &c.), and by the post-mortem appearances (red spots in the substance of this viscus), and by the diminished susceptibility to the galvanic influence. The specific affection of the *nervous system* is inferred from the symptoms: thus, the headache, giddiness, wandering pains, impaired sensibility of the extre-

mities, and delirium or coma, are indications of the cerebral affection; while the feebleness, lassitude, trembling of the limbs, and the paralysis or tetanic symptoms, are evidences of the disordered condition of the true spinal or excito-motory system of Dr. Hall.

The alimentary canal, heart, and nervous system, are not the only parts on which this acid appears to exercise a specific influence: the lungs, the skin, the salivary glands, &c. are also specifically affected. The disorder of the *lungs* is inferred from the local pain, cough, and occasional inflammatory appearances after death. The eruptions and other altered appearances of the *skin*, and the falling off of the hair and nails (sometimes noticed), have led to the idea of the specific influence of arsenious acid on the cutaneous system,—an opinion which seems further supported by the fact of the remarkable influence it exercises in some cutaneous diseases, especially lepra. The salivation noticed by Marcus, Ferriar, Mr. Furley, Cazenave, and others, seems to shew that the *salivary* glands are sometimes specifically influenced. The swelling of the face, and the irritation and redness of the eyelids, also deserve notice in connexion with the specific effects of this poison.

Uses.—So powerful a poison as arsenic necessarily requires to be employed with great caution, and to have its effects carefully and attentively watched; for it has on more than one occasion proved fatal when used as a medicinal agent.

In *intermittent fevers and other periodical diseases*, arsenic has been employed with great success. For its introduction into practice in these cases in this country, we are indebted to the late Dr. Fowler, of Stafford (*Med. Rep. of the Effects of Arsenic*, 1786); but Lemery and Wepfer appear to have first mentioned its febrifuge property. Dr. Fowler was led to its use from the beneficial effects obtained by the use of the "*Tasteless Ague Drop*," and from the information of Mr. Hughes, that this patent medicine was a preparation of arsenic. The reports published by Dr. Fowler, of the good effects of arsenic in periodical diseases, as observed by himself, by Dr. Arnold, and by Dr. Withering, have been amply confirmed by the subsequent experience of the profession generally. No remedy has been more successful in the treatment of ague. It will not unfrequently put a stop to the disease, even when cinchona or the sulphate of quinia have failed. Dr. Brown (*Cyclopædia of Practical Medicine*, ii. 228) who has used it in many hundreds of cases, never saw any permanently ill effect arise from it: he considers it superior to crude bark, but inferior to quinia: over both it has the advantages of cheapness and tastelessness. It should be given three times a day. It is not necessary to intermit its use during the febrile paroxysm, for I have repeatedly seen it given with the best effects during the attack. In agues, accompanied with inflammatory conditions, in which cinchona and sulphate of quinia are apt to disagree, arsenic may, according to Dr. Brown, be sometimes administered with the best effects. It is also very successful in relapses after the use of the above remedies. Dr. Macculloch (*An Essay on the Remitt. and Intermitt. Diseases*, 1828) states that $\frac{1}{16}$ of a grain of white arsenic given three or four times a day will sometimes cure ague when the liquor potassæ arsenitis fails. A combination of arsenic and cinchona, or arsenic and sulphate of quinia, sometimes succeeds, where these agents used separately fail. When the stomach is very irritable, opium is occasionally advan-

tageously conjoined with arsenic. If the bowels be confined during the use of the remedy, gentle laxatives should be employed. Arsenic has been beneficially employed in various other periodical diseases, as periodical headaches, intermittent neuralgias, &c.

In various *chronic affections of the skin*, particularly the scaly diseases (lepra and psoriasis), eczema, and impetigo, arsenic is one of our most valuable agents. I can confidently recommend it in lepra, having seen a large number of cases treated by it without a single failure. Frequently the disease is relieved without any obvious constitutional effect: sometimes a febrile condition of the body is brought on, with a slight feeling of heat in the throat, and thirst; occasionally with an augmentation of appetite: the urine and cutaneous secretion often promoted; the bowels may be constipated or relaxed, and occasionally, as I have already noticed, salivation takes place. If the patient complain of swelling and stiffness about the face, or itching of the eyelids, the use of the medicine ought to be immediately suspended. Ichthyosis and elephantiasis are said to have been benefited by the use of it. (For further information on the use of arsenic in skin diseases, consult Rayer, *Treatise on Diseases of the Skin*, by Dr. Willis, p. 80.)

Various chronic affections of the nervous system have been treated by the arsenious acid, and with occasional benefit: for example, neuralgia, epilepsy, chorea (Dr. Gregory, *Med. Chirurg. Trans. of London*, xi. 299), and even tetanus. I have seen arsenic used in a considerable number of epileptic cases, and in none was the disease cured. In some the fits occurred less frequently, but I am not sure that this was the effect of the medicine. In chorea, I have seen advantage now and then accrue from the use of this agent. It has also relieved angina pectoris.

In bites of venomous snakes and of rabid animals, arsenious acid has been recommended. In India, the Tanjore pill (the basis of which is arsenious acid) has long been celebrated for the cure of the bite of the Cobra di Capello, and other venomous serpents. Arsenic has been employed as an internal agent in various other diseases—as *chronic rheumatism*, especially when attended with pains in the bones; *in diseases of the bones*, particularly venereal nodes (Colhoun and Baer, *Amer. Med. Record.* iii. & iv.); *in syphilis; in passive dropsies;* in the last stage of *typhus* (Ferriar, *Med. Hist.* i. 84).

Arsenious acid has long been employed as an *external application.* Notwithstanding that it has been applied and recommended by Sir A. Cooper, Dupuytren, and other high authorities, some doubt may be fairly entertained as to the propriety of its use, especially as in most, if not in all instances, we may derive equal advantage by the employment of other less dangerous applications. M. Roux, a celebrated surgeon at Paris, states (*Nouv. Elém. de Méd.*) that he amputated the breast of a girl 18 years of age, on account of a scirrhus of considerable magnitude. After the cicatrix had been several days completed, ulceration commenced, accompanied with darting pains. To avoid frightening the girl by the use of the actual cautery, he applied an arsenical paste over a surface of about an inch in diameter. Colic, vomiting, and alteration of countenance, came on the next day, and in two days afterwards she died in violent convulsions. "I am convinced," says M. Roux, "that this girl died poisoned by arsenic." I could quote several other cases illustrative of the same fact, but shall content myself with referring to Wibmer's

work (*Die Wirkung.* &c.) for an account of them. The following case, related by Desgranges (Orfila's *Toxicol. Gén.*) shews the danger of applying arsenic externally, even when the skin is sound:—A chamber-maid rubbed her head with an arsenical ointment, to destroy vermin. Though the skin was perfectly sound, the head began to swell in six or seven days after; the ears became twice their natural size, and covered with scabs, as were also several parts of the head; the glands of the jaw and face enlarged; the face was tumefied, and almost erysipelatous. Her pulse was hard, tense, and febrile; the tongue parched, and the skin dry. To these were added excruciating pain, and a sensation of great heat. Vertigo, fainting, cardialgia, occasional vomiting, ardor urinæ, constipation, trembling of the limbs, and delirium, were also present. In a day or two after, the body, and especially the hands and feet, were covered with a considerable eruption of small pimples, with white heads. She finally recovered, but during her convalescence the hair fell off.

Though employed as a caustic, yet it produces no known chemical change in the animal tissues. Hence it is termed by some a *dynamical* caustic, in opposition to those acting obviously by chemical agencies. Mr. Blackadder (*Observ. on Phaged. Gangren.*) asserts that the danger of employing arsenic consists in not applying a sufficient quantity. A small quantity, he says, becomes absorbed, whereas a large quantity quickly destroys the organization of the part, and stops absorption.

Arsenic has been extolled as a remedy for *cancer*. Justamond esteemed it a specific. Various empirical compounds, which gained temporary notoriety in the treatment of this affection, owe their activity to either arsenious acid or the sesquisulphuret of arsenicum. But by the best surgeons of the present day it is never employed, because experience has fully shewn that it is incapable of curing genuine cancer, while it endangers the lives of the unfortunate patients. It cannot, however, be denied that diseases resembling cancer have been much relieved, if not cured, by it, and that the progress of cancer itself has occasionally been somewhat checked by its use.

In some forms of severe and unmanageable ulceration, especially *lupus* or *noli me tangere*, arsenical applications are employed with occasional benefit, where all other local remedies fail. In such cases arsenic is not to be regarded as a mere caustic, for other, and far more powerful agents of this kind, are generally useless. It must act by substitution: that is, it sets up a new action in the part incompatible with that of the disease. The late Baron Dupuytren employed an arsenical dusting powder (composed of 99 parts calomel and 1 part arsenious acid) in lupus, not as an escharotic, but rather as a specific. Mixed with gum-water or with fatty matters, it has been sometimes used as a paste or ointment. These applications are to be allowed to fall off spontaneously, and to be repeated five or six times. Sir A. Cooper (*Lancet*, i. 264) recommends an arsenical ointment (arsenious acid; sublimed sulphur, $\overline{aa}$ ʒj.; spermaceti cerate, ℥j.) to be applied, on lint, for 24 hours, and then to be removed. When the slough comes away, the ulcer is to be dressed with simple ointment, and will generally heal in a short time. Cazenave says he has seen arsenical applications used by Biett, and has himself employed them many times, without having met with one instance of injurious consequences. The arsenical paste (arsenious acid, cinnabar, and burnt leather, made into a paste with saliva or gum-water) is used where a powerful action is

required: but, besides the danger of causing constitutional symptoms, to which all arsenical compounds are liable, it is apt to occasion erysipelas.

Arsenious acid, or sesquisulphuret of arsenicum, is a constituent of most of the preparations sold as depilatories; as *Delcroix's Poudre Subtile*, which, according to Dr. Paris, consists of quicklime, sulphuret of arsenic, and some vegetable powder. Such applications are exceedingly dangerous.

ADMINISTRATION.—Arsenious acid may be administered, in substance, in doses of from one-sixteenth to one-eighth of a grain, made into pills, with crumb of bread. In making a mass of pills, great care should be taken that the arsenic be equally divided; for this purpose it should be well rubbed in a mortar with some fine powder (as sugar) before adding the bread crumb. A much safer mode of exhibition is to give this potent remedy, in the form of solution, with potash (as the *liquor potassæ arsenitis*). But I have already mentioned, that Dr. Macculloch found solid arsenic more efficacious than this solution: and Dr. Physick, of the United States, thinks "that they act differently, and cannot be substituted for one another" (*United States Dispensatory*). Whether given in the solid or liquid form, it is best to exhibit it immediately after a meal, when the stomach is filled with food; for when given on an empty stomach (as in the morning fasting), it is much more apt to occasion gastric disorder. It is sometimes advisable to conjoin opium, either to enable the stomach to retain it, or to check purging. In debilitated constitutions, tonics may be usefully combined with it. An emetic (as ipecacuanha), or a laxative (as rhubarb), may be employed where the stomach is overloaded, or the bowels confined. Its effects are to be carefully watched, and whenever any unpleasant symptoms (as vomiting, griping, purging, swelling or redness of the eyelids, dryness of throat, ptyalism, headache, or tremors) make their appearance, it will of course be advisable to diminish the dose, or suspend for a few days the use of the remedy. Indeed, when none of these symptoms occur, it is not proper to continue its use more than two weeks without intermitting its employment for a day or two, in order to guard against the occasional ill consequences resulting from the accumulation of the poison in the system.

1. *LIQUOR POTASSÆ ARSENITIS*, Ph. Lon. & U. S.; *solutio arsenicalis*, Ph. Ed.; *Fowler's* or the *mineral solution* (arsenious acid, carbonate of potash, āā gr. lxxx.; compound tincture of lavender, ʒv.; water, ʒxx.) The arsenious acid and carbonate of potash are to be boiled, with the water, in a glass vessel: arsenite of potash is formed, and carbonic acid evolved; but the quantity of carbonate of potash is not sufficient to saturate the acid. The compound tincture of lavender, which is used as a colouring and flavouring ingredient, is to be added to the solution when cold, and afterwards more distilled water, to make the whole amount exactly to a pint; (*i. e.* twenty ounces). The dose of this solution is four or five minims, gradually and cautiously increased. I have known 15 minims taken three times a day for a week, without any ill effects. Dr. Mitchell, of Ohio, has given from 15 to 20 drops, three times a day, in intermittents (*United States Dispensatory*). But as some persons are peculiarly susceptible of the influence of arsenic, we ought always to commence with small doses. It has been given to children, and even pregnant women. Dr. Dewees (*Philadelphia Journ. of Med. & Phys. Sc.* xiv. 187) adminis-

tered it successfully to a child only six weeks old, affected with a severe tertian ague. Dr. Fowler (*Med. Rep. of the Effects of Arsenic*) drew up the following table of doses for patients of different ages:—

Ages.	Doses.
From 2 to 4 years	from 2 or 3 to 5 drops.
5 — 7 „	„ 5 — 7 „
8 — 12 „	„ 7 — 10 „
13 — 18 „	„ 10 — 12 „
18, and upwards	12 „

But it may be remarked, that the quantities here indicated are larger than it will be safe, in most cases, to commence with.

The *liquor arsenicalis* of the Dublin Pharmacopœia is one-sixteenth weaker than the corresponding preparation of the London and Edinburgh Pharmacopœia.

2. *Ceratum Arsenici*, Ph. U. S. (arsenious acid, ℈j.; simple cerate, ℥j. M.) This preparation, which is used as a dressing to cancerous ulcers, should be employed with great circumspection.

Antidotes.—In cases of poisoning by arsenic, the first object is to expel the poison from the stomach. For this purpose the stomach-pump should be immediately applied. If this be not in readiness, and vomiting have not commenced, tickle the throat with a feather or the finger, and administer an emetic of sulphate of copper or sulphate of zinc. Promote vomiting by diluent and demulcent liquids; as milk, white of egg and water, flour and water, gruel, sugared water, and broths. Charcoal, magnesia, and other inert powders, when swallowed in large quantities, may be occasionally of service, by enveloping the particles of arsenic, and preventing their contact with the gastric surface. Olive oil, on which, according to Dr. Paris (*Pharmacologia*), the Cornish miners rely with confidence, can only act mechanically in the way just mentioned.

Hydrated sesquioxide of iron was proposed, in 1834, by MM. Bunsen and Berthold, as an effectual chemical antidote (*Journ. de Pharm.* xx. 567). Its efficacy was confirmed by the experiments of Souberain and Miquel (*Journ. de Chim. Méd.* i. 2e. Ser. p. 3); of Orfila and Lesueur (*ibid.* p. 45); of Bouley, jun. (*ibid.* 46); and of Borelli and Demaria (*ibid.* p. 393), as well as by some cases of arsenical poisoning in the human subject, in which this remedy was employed (*Journ. de Pharm.* xxi. 98 & 681; *Lond. Med. Gaz.* xv. 447; xvi. 832; and xix. 177). To be efficacious it must be given in very large doses; and when the poison has been swallowed in a solid form, 15 or 20 drops of liquor ammoniæ should be conjoined with each dose of the antidote, to transform the acid into a soluble arsenite, on which the oxide may act. It may also be exhibited in the form of enema. Hydrated sesquioxide of iron may be procured by adding ammonia or potash, or their carbonates, to a solution either of pernitrate of iron (obtained by dissolving iron in nitric acid over the fire in a pipkin), or of persulphate of iron (prepared by boiling a solution of the common sulphate of iron with nitric acid): the precipitate is to be washed with water, and swallowed undried. Mr. Brett (*Lond. Med. Gaz.* xv. 220) denies the efficacy of the antidote, and states, moreover, that carefully prepared arsenite of iron is poisonous.

The subsequent part of the treatment of poisoning by arsenic consists in neutralizing or counteracting its effects, and which is to be effected on general principles, as we have no counter-poison. When the gastro-

enteritis is marked, our principal reliance must be on the usual antiphlogistic measures, particularly blood-letting, both general and local, and blisters to the abdomen. One drawback to the success of this treatment is the great depression of the vascular system, so that the patient cannot support large evacuations of blood. Opium is a very valuable agent. Indeed Jäger seems to regard it in the light of a counterpoison. However, on this point he has probably taken a too exaggerated view of its efficacy; but it is undeniable that on many occasions it is of great service. If the stomach reject it, we may employ it in the form of clysters. If constipation and tenesmus be troublesome, mild laxatives, especially castor oil, should be exhibited.

Arsen'ici Io'didum.—Iodide of Arsen'icum.

This compound is prepared by gently heating, in a tubulated retort placed in a sand-bath, a mixture of one part finely pulverized metallic arsenicum and three parts of iodine: the iodide is afterwards to be sublimed, to separate the excess of arsenicum. The compound thus obtained is an orange-red solid, volatile, and soluble in water. If the solution be rapidly evaporated to dryness, we reprocure the iodide; but if we concentrate, and then place the solution aside, white pearly plates are obtained, which by Plisson are regarded as a periodide of arsenicum, but by Serullas as a compound of oxide and iodide of arsenicum (Souberain, *Nouv. Traité de Pharm.* ii. 613; and Serullas, *Journ. de Chim. Méd.* iii. 601). Iodide of arsenicum is probably composed of $1\frac{1}{2}$ eq. iodine = 187·5, and 1 eq. arsenicum = 38. It has been employed by Biett in the form of ointment (composed of iodide of arsenicum, gr. iij.; lard, ℥j.) as an application to corroding tubercular skin diseases (Magendie, *Formulaire*).

Order 17. Compounds of Antimony.

Antimo'nii Sesquisulphure'tum.—Sesquisul'phuret of An'timony.

History.—Black sulphuret of antimony was known in the most ancient times, being used by the Asiatic and Greek ladies as a pigment for the eyebrows (2 *Kings*, ix. 30; *Ezekiel*, xxiii. 40; Pliny, *Hist. Nat.* xxxiii.) It was formerly called *stimmi* (στίμμι vel στίμμις, *stibium* (στίβι), or *platyophthalmon* (πλατυόφθαλμον), Dioscorides, v. 99.) In the native state it is technically termed *antimony ore*, and when fused out of its gangue, *crude antimony*, or *sulphuret of antimony*.

Natural History.—Sesquisulphuret of antimony is found native in various parts of the world, especially in Hungary, in the Hartz, in France, in Cornwall, and in Borneo. From the latter place it is imported into this country by way of Singapore, being brought over as ballast to the vessels. In the years 1835-36, and 37, the quantities of ore imported were respectively 645, 825, and 659 tons (*Trade List*, Jan. 10, 1837, and Jan. 9, 1838).

Preparation.—The old method of separating the sesquisulphuret from its siliceous gangue was to melt it in a covered crucible or pot, in the bottom of which there are several holes, through which the fused sulphuret passes into an inferior or receiving pot. According to Gensenne's method, the melting pots are placed in a circular reverberatory furnace,