inflammatory symptoms are to be combated by the usual antiphlogistic means. Magnesia has been employed, but is said by Devergie to be altogether useless.

1. ALUMEN EXSICCATUM, L. E. (U. S.) *Alumen siccatum*, D.; *Dried Alum; Alumen ustum; Burnt Alum.* (Let Alum liquefy in an earthen vessel over the fire: then let the fire be increased, until the ebullition has ceased, *L.*—The directions of the *Edinburgh* and *Dublin Colleges* are essentially the same; except that they order the dried alum to be reduced to powder.)—In the preparation of this substance care must be taken not to apply too great a heat, lest a portion of the acid be driven off as well as the water. On this account a shallow earthen vessel is preferable to a crucible. Dried alum has a more astringent taste and does not dissolve so readily in water as the crystallized salt. It is employed as a mild escharotic to destroy exuberant spongy granulations; as those commonly known under the name of proud flesh.

2. LIQUOR ALUMINIS COMPOSITUS, L.; *Compound Solution of Alum; Aqua Aluminosa Bateana*, or *Bates's Alum Water.* (Alum, Sulphate of Zinc, each ʒj.; Boiling Water, Oiij. Dissolve the Alum and Sulphate of Zinc together in the Water; afterwards strain.)—This solution 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.

3. PULVIS ALUMINIS COMPOSITUS, E.: *Compound Powder of Alum.* (Alum, ʒiv.; Kino, ʒj. Mix them, and reduce them to fine powder.)—Astringent. Employed in hemorrhages from the stomach, bowels, and uterus; in old diarrhœas; and as an application to flabby indolent ulcers.

4. CATAPLASMA ALUMINIS, D.; *Cataplasm of Alum; Alum Poultice; Albumen Aluminosum.* (Whites of two Eggs; Alum, ʒj. Shake them together to make a coagulum.)—"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." (Montgomery's *Observations on the Dublin Pharmacopœia.*) "Another kind of alum poultice in use is made by coagulating milk with alum, and using the curd as a poultice."

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### OTHER COMPOUNDS OF ALUMINUM.

RED ARMENIAN BOLE; *Bolus Armena rubra.*—This is found in Armenia (whence its name,) as well as in various parts of Europe. Bergmann found it to consist of *silica* 47, *alumina* 19, *magnesia* 6·2, *lime* 5·4, *iron* 5·4, *water*, 7·5.

The substance sold by druggists as Red Armenian Bole is prepared by grinding together, in a mill, Pipe Clay and Red Oxide of Iron, and afterwards levigating. It is principally used in the preparation of tooth powder. (see p. 212.)

The *Lemnian Earth* (*Terra Lemnia*) is very similar to Armenian Bole. It is not, however, always red. It is dug up at Lemnos, formed into flat cylindrical pieces, which are stamped and sold under the name of *Terræ Sigillatæ.*

## ORDER XVII.—COMPOUNDS OF ARSENICUM.

### ACIDUM ARSENIOSUM, *L.* (*U. S.*)—ARSENIOUS ACID.

(Arsenicum album, *E.*—Arsenici Oxydum album, *D.*)

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. chap. ii.) Hippocrates (*De Ulceribus.*) employed Ἀρρενικον (*Orpiment*) and Σανδαρακη (*Realgar*) as topical remedies. Dioscorides (Lib. v. chap. xxi.) is the first author who uses the word Ἀρσενικον (*Orpiment.*)

Natural History.—Arsenious acid is found at Andreasberg in the Hartz, at Joachimsthal in Bohemia, and at some few other places. It is a rare mineral.

Metallic arsenic (*Arsenicum*) is found native either alone or associated with other metals, or their sulphurets. It forms two native sulphurets, viz. *Orpiment* and (*Realgar.*) There are two native compounds of it with oxygen, namely, *Arsenious* and *Arsenic acids*: the latter is found in combination with bases forming native *Arseniates.*

Orfila[1] asserts that arsenic exists in the bones of man and of several other animals. But the experiments of Dr. G. O. Rees, (*Guy's Hospital Reports*, No. xii.) of MM. Danger and Flandin, and of the commissioners appointed by the French Academy of Sciences (*Journal de Pharmacie*, t. xxvii. p. 428. Juillet 1841.) to report on Marsh's apparatus, have failed to corroborate his statements.

Preparation.—Arsenious acid is prepared in Silesia, Bohemia, Saxony, and Cromwall.

At Altenberg, in Silesia, it is obtained from arsenical iron (*Mispickel,*) composed of sulphur 20·65, iron 35·62, and arsenicum 43·73. (Dumas, *Traité de Chimie*, t. iv. p. 120.) After being reduced to powder, the ore is roasted in a muffle furnace by which the arsenicum is converted into arsenious acid, which is conveyed, in the state of vapour called *Flowers of Arsenic* or *Smelting-house Smoke* (*Hüttenrauch,*) into a condensing chamber, where it is deposited in a pulverulent form, and in this state is called *Rough Arsenious Acid* or *Poison-flour* (*Giftmehl.*)

The rough acid is refined by sublimation. This is effected in cast-iron pots, to which cylindrical iron heads are attached, which at the tops are contracted into cones, each terminating in a pipe made of sheet iron, and communicating with the condensing chamber. 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 a 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 an arseniuret of iron, composed of iron 32·35, arsenic 65·88, and sulphur 1·77.

Arsenious acid is procured in some parts of Saxony as a secondary product in the roasting of cobalt ores (the arseniurets of cobalt.) It is deposited in long horizontal flues. (*Poison-flues*, or *Giftfängen,*) and is purified by sublimation.[2]

Arsenious acid is manufactured in Cornwall, from the White Mundic or Mispickel found with the tin ore. In the impure state it is deposited in the long horizontal flues of the 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.[3] In this condition it has a gray colour, and is either pulverulent or in soft crystalline masses. There are two arsenic works in the neighbourhood of Truro; one in the parish of Perran Arworthall, the other belonging to Mr. Conn, near Bissow Bridge, in the parish of Kea; the former about half a mile, the latter more than a mile, from the Devoran and Carnon steam-works. More recently a third manufactory has been set at work in the parish of Illogan, near Redruth.

The rough arsenious acid is brought to these works from the burning-houses in all parts of Cornwall. It is first separated from sulphur in a common reverberatory furnace, having a flue several hundred yards in length. The heat is low at first, and is gradually increased. By this means the sulphur is dissipated before the arsenic is volatilized. The process is carried on for several weeks, or even months. The fire is then extinguished, and the arsenic removed from the flue. The waste rubbish is used for destroying weeds, &c., in garden walks.

[1] *Journal de Chimie Médicale*, t. v. 11e Série, p. 632. Dec. 1839.—Also, the *Lond. and Edinb. Phil. Mag.* for April 1840.

[2] For farther particulars consult the paper of J. H. Vivian, *Trans. Royal Geol. Society of Cornwall*, i. 60.

[3] *Quart. Min. Rev.* vol. ii. p. 88; and Mr. Davies Gilbert, *Parock. Hist. of Cornwall*, iii. 305.

The arsenious acid thus obtained is then sublimed in conical cast-iron *kettles*, about $2\frac{1}{2}$ feet high, and from 15 to 18 inches in diameter at the base. These kettles are hollow truncated cones, closed at the top by an iron plate perforated for an iron stopper; but open at the bottom. Ten or twelve of these kettles are placed in a circular form on an iron plate, to which they are clamped by a flanch. This plate forms the bottom to all the kettles, and is heated by a fire beneath. The rough arsenic is then introduced through the top aperture, and, heat being applied, is sublimed. Several charges are in this way introduced, until a sufficiently thick crust has been deposited within: the clamps are then taken off, and the kettle conveyed into the open air, where the crust is removed.[1] 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.[2]

In 1826, eighty-three tons of manufactured arsenic were shipped at Penryn.[3] At present, says Mr. Henwood, I believe not less than from 600 to 800 tons are prepared annually.

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. 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 pulverulent. 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.* 4th ed.) has taken the same view of the subject. I have some arsenious acid which has remained transparent for more than two years, in a glass tube hermetically sealed. This fact is confirmatory of the opinion just stated.[4]

Professor Guibourt, (*Journal de Chimie Méd.* t. ii. p. 57. Paris, 1826.) 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 $\frac{1}{2\,5}$ of its weight; that this water, on perfect cooling, did not retain more than $\frac{1}{4\,0}$ of its weight; and that water at ordinary temperatures will dissolve from about $\frac{1}{1\,0\,0}$ to $\frac{1}{3\,0\,0}$ 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 by which he readily explains why arsenious acid has not, in some cases, been found in the liquid contents of

[1] Henwood, in *the Seventh Annual Report of the Royal Cornwall Polytechnic Society*. Falmouth, 1839. Part of the above information was obligingly communicated to me, *viva voce*, by Mr. Henwood.

[2] For this and some other information, as well as for samples of the rough arsenious acid from Wheal Vor tin mine, I am indebted to Mr. Ferris, surgeon, of Truro.

[3] *Transactions of the Royal Geological Society of Cornwall*, iii. 360.

[4] In the first edition of this work I stated that arsenious acid became opaque in an air-tight vessel. I have since had reason to believe that the bottle referred to was not completely air-tight, though covered by a varnished bladder.

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 octohedra, 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:—*α*. The characteristics of solid arsenious acid;—*β*. the characteristics of a pure solution of arsenious acid;—*γ*. The characteristics of arsenious acid in organic mixtures.

*α*. **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 or cinder, 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 are sparkling, and, when examined by a magnifying glass, are found to be regular octohedra.

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 piece of red-hot cinder or charcoal, (placed for convenience in a saucer,) it evolves a scarcely visible vapour, (*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 shown 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. 81) 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 grayish-white colour of its inner surface; its volatility; its conversion, by sublimation, up and down the tube, into octohedral crystals of arsenious acid, which may be dissolved in distilled water, and tested by the

FIG. 81.

*Berzelius's reduction tube.*

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 metallic character of the crust is sometimes rendered more evident by applying to it, for a few seconds, the flame of the spirit-lamp, which drives off a black powder (*black oxide of arsenic*) and leaves the brilliant metal. If the heat be continued too long the metal itself sublimes.

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, iron-gray 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 two parts of ignited carbonate of soda and one of charcoal should be employed. The alkali is here essential, in order to combine with the sulphur. Black flux (see p. 442 and 449) 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, (*Hand. d. Reag. u. Zerlegungslehre*, ii. 268. Lemgo, 1836.) and oxalate of soda by Dr. M'Gregor. (*Lond. Med. Gaz.* xxii. 613.) I find that quadroxalate of potash (see p. 309) 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 or feather,) while their comparative scarcity and greater cost are objections to their employment. (For farther details concerning the reduction process, consult Dr. Christison's *Treatise*, so frequently referred to.)

β. **Characters of a pure Aqueous Solution of Arsenious Acid.**—A clear watery solution of white arsenic may be recognised by certain liquid re-agents 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 re-agents, 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.) and by the commissioners (MM. Thénard, Dumas, Boussingault, and Regnalt.) of the French Academy of Sciences, 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 according to Mohr. |
| Ditto ditto ditto at..... | 1000·000 according to the Commissioners. |

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-dissolve 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, solution of ammonia, 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, re-dissolved (see *Solutio Argenti Ammoniati*, E.) 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.

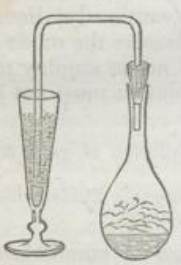
Ammoniaco-nitrate of silver, when properly prepared, does not occasion a yellow precipitate with any substance save arsenious acid; and hence is not subject to any *fallacy* of that kind. If, however, it be not properly prepared, it may occasion a yellow precipitate (*subsesquiphosphate of silver*) with 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 (*sesquisulphuret of arsenicum* or *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; 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 gas should, if possible, be passed through water contained in a double-necked bottle, before it is conveyed into the arsenical liquor, as a portion of iron is apt to be carried over. The ingredients for developing the gas are a metallic sulphuret (as of iron or 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 flux, or a mixture of ignited carbonate of soda and charcoal. When the quantity of sesquisulphuret is small, some difficulty may be 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.

FIG. 82.



*Mode of passing Hydrosulphuric acid through an arsenical solution.*

The *fallacies* of the hydrosulphuric acid test are, the *salts of cadmium*, the *per-salts 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, but it is not soluble in alkaline solutions. This metal (cadmium) has been detected in some of the preparations of zinc. (*Vide* Thomson's *History 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 (*hydrated 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. 413) 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 thus be 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:—

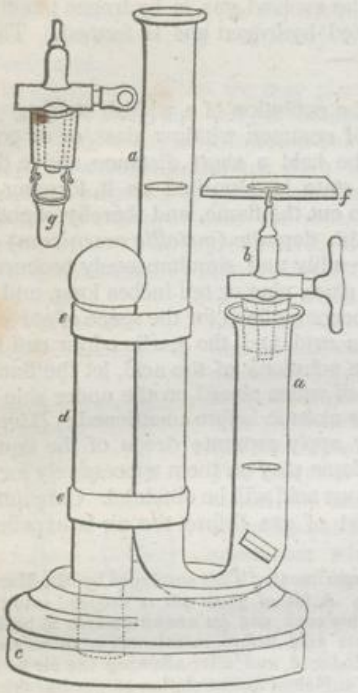
*α.* It has an alliaceous odour.

*β.* It burns with a bluish white flame and the evolution of a whitish smoke. If a plate of mica (commonly termed talc) or of common window glass, or of porcelain (as a white saucer or dinner plate,) be held a short distance above the flame, arsenious acid in a finely pulverulent state is deposited on it, forming a white crust: if the plate be depressed so as to cut the flame, and thereby slightly to impede the combustion of the gas, a blackish deposite (*metallic arsenicum*) is obtained. Or both these deposites may be readily and simultaneously procured by holding vertically over the flame a tube of glass, nine or ten 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, *Lond. Med. Gaz.* vol. xviii. p. 889.) Or apply separate drops of the liquid tests themselves to the plate, and then let the flame play on them successively for a few minutes, the characteristic effects of arsenious acid will be obtained. Care must be taken not to apply a lighted taper to the jet of gas before the air is expelled, or an explosion may be the result.

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. 83.) 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 then 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. 84,) 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.

When the quantity of arsenical liquor to be tested is large, an inverted bell-glass with a stop-cock attached may be used. The zinc is suspended within. The bell-glass is immersed in the diluted acid to which the suspected liquor is added. This apparatus is similar to that used for obtaining fire by the aid of a stream of hydrogen gas thrown on spongy platinum.

Fig. 84. Fig. 83. Fig. 85.



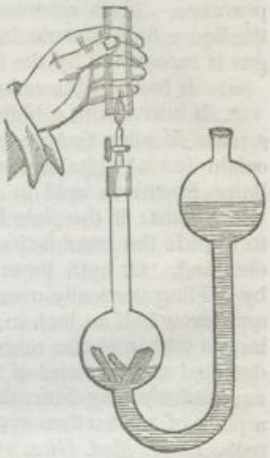

*Marsh's Apparatus.*

Fig. 83.

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

Fig. 84.

*g*. Small glass bucket.



*Modification of Marsh's Apparatus.*

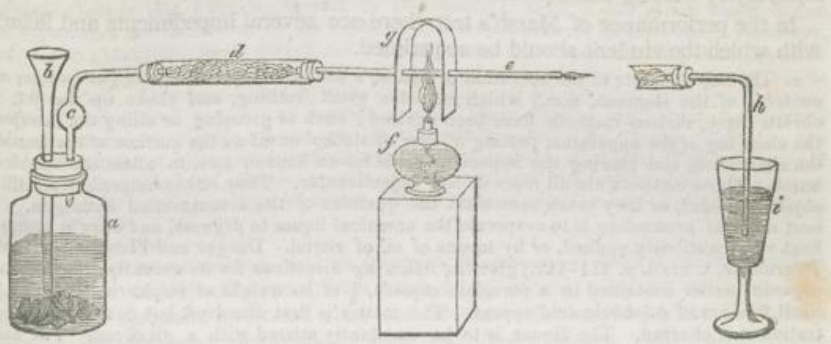
Fig. 86.

*Simple mode of applying Marsh's Test.*

A modification (fig. 85) 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 with a glass tube or tobacco-pipe (as in fig. 86.) 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.

γ. If arseniuretted hydrogen be subjected to a red heat it is decomposed into arsenicum, which is deposited, and hydrogen gas, which escapes. The gas may be generated in a double-necked bottle, or in a wide-mouthed bottle, closed by a cork bored with two holes; and may be allowed to escape by a horizontal tube (made of difficultly fusible glass,) which may be heated by a large-wicked spirit lamp. The gas is decomposed by the heat; and the arsenicum is deposited in the form of a metallic ring, beyond the flame and nearer the aperture.

FIG. 87.




*Apparatus for subjecting Arseniuretted Hydrogen to the action of Heat or Nitrate of Silver.*

*a*. Bottle for generating the arseniuretted hydrogen.
*b*. Funnel, or tube, by which the sulphuric acid and arsenical liquor are introduced into the bottle.
*c*. Escape tube, supplied with a bulb to condense any liquid which may arise from the bottle.
*d*. Wider tube loosely filled with asbestos, to impede the passage of any water. This is not essential.
*e*. Narrow tube of difficultly fusible glass, drawn out to a fine point at the extremity.
*f*. Spirit lamp.
*g*. Curved and perforated metallic plate (copper, zinc, or tinned iron,) to support the glass tube in the event of its softening by the heat.
*h*. Curved glass tube, which may be substituted for the tube *e*, when the gas is to be passed through a solution of nitrate of silver.
*i*. Test-glass, containing a solution of nitrate of silver.

The detection of arseniuretted hydrogen by heat was suggested by Liebig, (*Journal de Pharmacie*, t. xxiii. p. 568.) Berzelius, (*Ibid*, t. xxiv. p. 180.) and Chevallier. (*Journ. de Chim. Méd.* t. v. IIe Sér. p. 383.) Some useful and practical improvements in the mode of applying this test were suggested by MM. Kœppelin and Kampmann. (*Journ. de Pharmacie*, t. xxvii. p. 480; *Lond. Med. Gaz.* Aug. 20, 1841.) The Commissioners appointed by the French Academy introduced some additional modifications of the experiment. (*Ibid*, t. xxvii. p. 425.) The latter recommend that the tube *e* should be coated with gold or silver leaf, and subjected to the heat of a coal fire, which is preferred to the spirit lamp flame, as it more effectually decomposes the gas. But it complicates the operation, and renders it much more difficult of performance.

The arsenicum deposited in the tube may be recognised by its physical and chemical properties before described (see p. 523.)

If the arseniuretted hydrogen by completely decomposed, hydrogen only will be evolved by the extremity of the tube *e*. But as a portion of the gas may escape decomposition, the jet should be set fire to, and attempts made to obtain arsenical spots on a plate of porcelain.

δ. If the arseniuretted hydrogen be passed through a solution of nitrate of silver, a mutual re-action between these substances is effected, Black metallic flocculi are deposited, and a solution of arsenious acid is obtained, mixed with free nitric acid. Hydrochloric acid is then to be cautiously added to the decanted liquor, to convert the excess of nitrate of silver into the insoluble white chloride of silver. The filtered liquor may then be tested for arsenious acid. Or it may be evaporated to dryness, during which operation the nitric acid oxidizes the arsenious acid, and converts it into arsenic acid, which constitutes the dry residuum. This yields a brick-red precipitate, with a solution of nitrate of silver. Or the concentrated solution may be transferred to a very small Marsh's apparatus.

This test was suggested by Lassaigne. (*Journal de Chimie Méd.* t. vii. IIe Sér, p. 638.) It has been adopted by the Commissioners appointed by the French Academy. (*Journal de Pharmacie*, t. xxvii. p. 425.—Also, *Lond. Med. Gaz.* Aug. 20, 1841. It is a very valuable mode of using Marsh's test, and prevents the loss of the first portions of gas.

The apparatus fitted for performing Lassaigne's test has been already described and figured.

The black flocculi produced in a solution of nitrate of silver by arseniuretted hydrogen are regarded by Lassaigne as metallic silver, by Graham (*Elements of Chemistry*, p. 635.) as

arseniuret of silver. It appears to me to be metallic silver contaminated by some intimately adherent arsenious acid, which can be removed by repeated washing and boiling in water, and especially by washing with an alkaline solution.

In the performance of Marsh's test there are several impediments and fallacies, with which the student should be acquainted.

α. 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. To obviate these, various methods have been advised; such as 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. These methods are all more or less objectionable. They either imperfectly fulfil the object intended, or they mask somewhat the qualities of the arseniuretted hydrogen. The best mode of proceeding is to evaporate the arsenical liquor to dryness, and char it either by heat very cautiously applied, or by means of oil of vitriol. Danger and Flandin (*Journal de Pharmacie*, t. xxvii. p. 411–412.) give the following directions for its execution:—Add to the organic matter contained in a porcelain capsule, $\frac{1}{5}$ of its weight of sulphuric acid, and heat until vapours of sulphuric acid appear. The matter is first dissolved, but during the concentration it is charred. The liquor is to be constantly stirred with a glass rod. The carbonization is effected without any swelling or frothing, and is to be continued until the charcoal is friable and almost dry. A small quantity of concentrated nitric acid or nitromuriatic acid is to be added, by means of a pipette, when the capsule is cold. This converts the arsenious acid into the more soluble arsenic acid. The mixture is then to be evaporated to dryness, treated with boiling water, and the limpid liquor introduced into Marsh's apparatus, in which it never froths.

Nitric acid or nitrate of potash is sometimes used to char organic matter; but it is less manageable than sulphuric acid; for towards the end of the experiment it is difficult to prevent deflagration, by which part of the arsenic is lost.

β. The *fallacies* of this test arise from the presence of either antimony or imperfectly charred organic matter in the suspected liquid, or from the employment of either zinc or sulphuric acid contaminated with arsenic. A solution of Emetic Tartar, placed in Marsh's apparatus (with zinc and dilute sulphuric acid) evolves *antimoniuretted hydrogen gas*, which agrees in several of its characters with arseniuretted hydrogen.[1] Thus it has a marked odour (dependent probably on the hydrogen,) and which might be confounded with that of arseniuretted hydrogen. It burns in the air with a yellowish flame, and the deposition of a black crust of metallic antimony surrounded by a white one of oxide (on mica or glass held over it,) resembling arsenicum and arsenious acid deposited by arseniuretted hydrogen: moreover, the action of hydrosulphuric acid and of ammoniaco-sulphate of copper on the oxide of antimony, produces colours similar to those generated by the action of these tests on arsenious acid. Furthermore, when heated during its passage through a glass tube, antimoniuretted hydrogen is decomposed, and forms a dark metallic crust. It also occasions a black deposite in a solution of nitrate of silver. The antimonial, may be distinguished from the arsenical, crust by adding a drop of nitric acid, 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 octohedral 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. If antimoniuretted hydrogen be conveyed into a solution of nitrate of silver, no arsenious or arsenic acid can be detected by the tests before directed to be used for arseniuretted hydrogen. Lastly, the metallic crust obtained by submitting a current of the gas to heat presents some distinguishing characters: the arsenical crust is always deposited in the more distant or anterior part of the tube, whereas the antimonial one is first deposited on the heated part of the tube, and by continuing the heat we obtain two rings, one in the anterior or more distant, the other in the posterior or less distant part of the tube.

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. It has been already stated (p. 406) that sulphuric acid frequently contains arsenious acid. The experimenter should also be fully alive to the possibility of the 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.*

[1] Mr. L. Thompson, *Lond. and Edinb. Phil. Mag.* May, 1837.—Also Pfaff, *Pharmaceutisches Central Blatt für* 1838, S. 65.

*de Pharm.* xxiii. p. 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.

Messrs. Danger and Flandin (*Journal de Pharmacie*, t. xxvii. p. 410.) have asserted, and their statements are confirmed by the report of the commissioners of the French Academy, (*Ibid.* p. 428.) that imperfectly carbonized organic matter introduced into Marsh's apparatus may deposite on glass or porcelain crusts which strongly simulate those obtained from arsenical substances. These non-arsenical spots are composed of sulphite and phosphite of ammonia mixed with a small quantity of organic matter. They dissolve with difficulty in nitric acid, and the residue, obtained by evaporating the nitric solution to dryness, yields, on the addition of nitrate of silver, a yellow precipitate of phosphate of silver. The true arsenical spots, on the other hand, dissolve readily in nitric acid, and the residue obtained by evaporating the nitric solution to dryness forms, with nitrate of silver, a brick-red precipitate of arseniate of silver.

γ. **Detection of Arsenious Acid in Organic Mixtures.**—I shall confine myself to a brief notice of detecting arsenious acid when mixed with the contents and tissues of the stomach, and must refer the reader to the works of Dr. Christison (*Treatise on Poisons;* also *Edinb. Med. and Surg. Journ.* xxii. 60.) and Devergie (*Medécine Légale*, ii. 718.) for farther 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 (p. 523.)

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 (pp. 523 and 526.)

Arsenious acid in organic liquids may sometimes be readily detected by the development of arseniuretted hydrogen when zinc and sulphuric acid are added to the suspected liquor (*vide* p. 526,) but the frothing produced by the organic matter creates considerable difficulty. I have already pointed out the best method of obviating this (see p. 630.)

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

| | *Atoms.* | *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.

It is entirely sublimed when heated. Mixed with charcoal and exposed to heat, it emits an alliaceous smell. It is dissolved by boiling water; and hydrosulphuric, when added, throws down a yellow precipitate, and lime-water yields a white one. *Ph. L.*

The *Edinburgh College* merely observes, that arsenious acid "is entirely sublimed by heat."

Physiological Effects. *α. 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. 98.) 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 of the leaves and petals, and the appearance of brownish patches on the leaves, the veins and midribs of which are discoloured. If the stem of the Common Barberry (*Barberis vulgaris*) be placed in a solution of arsenious acid, the plant dies, but the stamens according to Macaire, become stiff, hard, and retracted, and on any attempts being made to alter their position, they readily break. On repeating the experiment, however, I did not observe this condition of the stamens. I found them not at all brittle, but quite flexible, and difficult to break by the point of a knife. The leaves when burnt evolved a garlic odour. Jäger has seen a small plant, supposed by De Candolle (*Phys. Vég.* p. 1329.) to be *Mucor imperceptibilis*, growing in water which contained $\frac{1}{312}$ 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 farther examination, Jäger has shown that arsenic is absorbed by plants; for he found that, on burning vegetables destroyed by this poison, he obtained a garlic odour, as I have also done.

*β. 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 (see p. 118.) Enormous quantities of arsenious acid have been sometimes administered to horses with impunity. Berthe (*Recueil de Med. Vét.* Oct. 1825.) gave two, and afterwards three, 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, one, four, three, two, and eight drachms of arsenious acid to a horse: the animal did not die until the ninth day 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.)

*γ. On Man.* *αα. Of very small* or *therapeutical doses.*—In very small quantities (as one-sixteenth or one-twelfth 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 (Vogt, *Pharmakodynamik.*) 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. 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 the 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. 96, quoted from Wibmer.) In farther 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 poison.

Dr. Fowler (*Med. Reports of the Effects of Arsenic*, p. 98. Lond. 1786.) gives the following summary of the effects of the arsenical solution in more than 320 cases:—In about one-third no operation: "somewhat more than one-third were attended with nausea; and nearly one-third with an open body; and about one-third with griping. Vomiting, purgings, swellings, and anorexia, were but rare in comparison with the preceding effects, and their less frequent occurrence was generally found in the order in which they are here enumerated, swellings and anorexia being the seldomest. About one-fifth of the cases attended with nausea, and one-quarter 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.*)—Small doses of arsenious acid continued for a long period, act 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 shows symptoms of the poisonous operation of this agent.

Hahnemann (quoted by Dr. Christison) has graphically described the condi-

tion 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 the 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 Therap.* ii. 148.) also mention this symptom as produced by the long-continued use of feeble doses of arsenic. Another instance of this effect has been published by Mr. Jones. (*Lond. Med. Gaz.* vol. xxvi. p. 266.) 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. Quick, small, and sometimes irregular, pulse; oppressed respiration, with a dry cough. The body wastes; the stomach being frequently so irritable that no food can be retained in it. Headach, 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 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, 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*.[1] 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 $\frac{1}{6}$, $\frac{1}{4}$, 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 druggist's 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 distention 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.[2]

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:—

*α. 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.

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[1] See some remarks on this subject by Mr. A. S. Taylor, in the *Guy's Hospital Reports*, No. xii.

[2] *Lond. Med. Gaz.* xix. 238, from *Amer. Journ. of Med. Sciences*, Aug. 1836.

*β. 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,[1] which penetrate a line in depth into the substance of the heart. The pericardium usually contains serum.

*γ. 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.

*δ.* 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, Hünefield, and others;[2] 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.[3]

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 on Poisons*. 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 the quantity of arsenic in the body diminishes, probably by exhalation,—a circum-

[1] White spots are frequently met with on the surface of the heart when no arsenic has been taken (*Guy's Hospital Reports*, vol. iii.)

[2] Quoted by Wibmer, in his *Wirkung d. Arzneim. u. Gifte;* and by Dr. Christison, in his *Treatise on Poisons.*

[3] In the dissecting-room of the London Hospital I have often witnessed the powerful and valuable antiseptic properties of arsenious acid. Subjects injected with this substance are but little changed at the expiration of one or two months, even during the summer season.

stance very probable, when we bear in mind the garlic odour emitted by the body, and which has been observed by several writers. The dimunition, 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 recognise: 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. Lassaigne (*Lond. Med. and Phys. Journ.* vol. xlvi. p. 259, Aug. 1821.) 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 recognise it. 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. More recently, and by the aid of Marsh's apparatus, it has been detected in the liver and urine of dogs poisoned by it. (Report of the French Commissioners in the *Journ. de Pharm.* t. xxvii. p. 415.)

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 headach, giddiness, wandering pains, impaired sensibility of the extremities, and delirium or coma, are indications of the cerebral affection; while the feebleness, lassitude, trembling of the limbs, and 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 farther supported by the fact of the remarkable influence it exercises in some cutaneous diseases, especially lepra. The salivation noticed by Marcus, Ferrier, Mr. Furley, Cazenave, and others, shows that the *salivary glands* are 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 has failed. Dr. Brown, (*Cyclopædia of Practical Medicine*, ii. 228.) who has used it in many hundreds of cases, never saw any permanently ill effect arise from it: he considers it superior to crude bark, but inferior to quinia: over both it has the advantages of cheapness and tastelessness. It should be given three times a-day. It is not necessary to intermit its use during the febrile paroxysm, for I have repeatedly seen it given with the best effects during the attack. In agues, accompanied with inflammatory conditions, in which cinchona and sulphate of quinia are apt to disagree, arsenic may, according to Dr. Brown, be sometimes administered with the best effects. It is also very successful in relapses after the use of the above remedies. Dr. Macculloch (*An Essay on the Remitt. and Intermitt. Diseases*, 1828.) states that $\frac{1}{16}$ of a grain of white arsenic given three or four times a-day, will sometimes cure ague when the *liquor potassæ arsenitis* fails. A combination of arsenic and cinchona, or arsenic and sulphate of quinia, sometimes succeeds, where these agents used separately fail. When the stomach is very irritable, opium is occasionally advantageously conjoined with arsenic. If the bowels be confined during the use of the remedy, gentle laxatives should be employed. Arsenic has been beneficially employed

in various other periodical diseases; as periodical headachs, 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 are 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 eye-lids, the use of the medicine ought to be immediately suspended. Ichthyosis and elephantiasis are said to have been benefited by the use of it.[1]

*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 great advantage attend its use. It has also relieved angina pectoris. It is said to possess the power of controlling determinations of blood to the head. (*Edinb. Med. and Surg. Journ.* April, 1839.)

*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. There is, however, no valid reason for supposing that it possesses any remedial power in these cases. 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. and iv.) *in syphilis; in passive dropsies;* in the last stage of *typhus*, &c. (Ferriar *Med. Hist.* i. 84.)

Arsenious acid has long been employed as an *external application*. It has been applied and recommended by Sir A. Cooper, Dupuytren, and other high authorities, but its use is always attended with some danger. M. Roux, a celebrated surgeon at Paris states, (*Nouv. Elem. 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. Générale.*) shows 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

[1] For farther information on the use of arsenic in skin diseases, consult Rayer, *Treatise on Diseases of the Skin*, by Dr. Willis, p. 80.

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 the nature of its chemical influence on the animal tissues is unknown. Hence it is termed by some a *dynamical* caustic, in opposition to those caustics acting by known chemical agencies. Mr. Blackadder (*Observations on Phagedena Gangrenosa.* Edinb. 1818.) 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[1] 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 shown 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 of calomel and 1 part arsenious acid) in lupus, not as an escharotic, but rather as a specific. Mixed with gum-water or with fatty matters, it has been sometimes used as a paste or ointment. These applications are to be allowed to fall off spontaneously, and to be repeated five or six times. Sir A. Cooper (*Lancet*, i. 264.) recommends an arsenical ointment (arsenious acid; sublimed sulphur, āā. ʒj.: spermaceti cerate, ʒj.) to be applied, on lint, for twenty-four 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.

In *onychia maligna*, my friend, Mr. Luke regards an arsenical ointment (composed of arsenious acid, gr. ij., and spermaceti ointment, ʒj.) as almost a specific.

Arsenious acid is a constituent of some of the preparations sold as depilatories.

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

[1] *An Account of the Methods pursued in the Treatment of Cancerous and Scirrhous Disorders, and other Indurations.* Lond. 1780.

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 eye-lids, dryness of throat, ptyalism, headach, 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.

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. Administer as speedily as possible moist hydrated sesquioxide of iron (the preparation of which will be hereafter described.)[1] The quantity necessary to be given to render the arsenic inert, is large. Dr. Maclagan (*Edinb. Med. and Surg. Journ.* No. 144,) observes that "as far as chemical evidence goes, at least twelve parts of oxide, prepared by ammonia, and moist, are required for each part of arsenic." As, however, we cannot ascertain, in many instances, how much arsenic has been taken, we should administer to an adult a table-spoonful, at least, and to children, a dessert spoonful, every five or ten minutes, until relief from the urgent symptom is obtained. (Dr. T. R. Beck, *Lond. Med. Gaz.* Oct. 15, 1841.) The hydrated sesquioxide forms, with the arsenious acid, an arsenite of iron. This becomes a protarseniate of iron. (Graham's *Elements of Chemistry.*) "The arsenious acid derives oxygen from the peroxide [sesquioxide] of iron, and becomes arsenic acid, while the peroxide of iron becomes protoxide; a protarseniate of iron being the result, which is insoluble and inert."

Charcoal, magnesia, and any inert powder, 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.

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 counter-poison. However, on this point he has probably taken a too exaggerated view

[1] [For some remarks upon the necessity of the *recent* preparation of the antidote, by William Procter, Jr. See Hydrated Sesquioxide of Iron.]

of its efficacy; but it is undeniable that on most 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.

1. LIQUOR POTASSÆ ARSENITIS, L. (U. S.) *Liquor Arsenicalis*, E. D. *Fowler's Solution; Mineral Solution.*—(Arsenious Acid [broken in small pieces, *L.*; in powder, *E.*;] Carbonate of Potash, each grs. lxxx.; Compound Tincture of Lavender, f3v.; Distilled Water, Oj. Boil the Arsenious Acid and Carbonate of Potash with half a pint of the Water in a glass vessel until they are dissolved. Add the Compound Tincture of Lavender to the cooled liquor. Lastly, add besides, of distilled water, as much as may be sufficient, that it may accurately fill a pint measure, *L. E.*—The preparation of the *Dublin College* is one-ninth weaker: the proportions of materials used are of Arsenious Acid, in powder; Carbonate of Potash, from Tartar, of each sixty grains; Compound Spirit of Lavender, f3iv.; Distilled Water, Oss. [*wine measure.*])—[The U. S. Pharmacopœia directs, Arsenious Acid in small fragments; Pure Carbonate of Potassa, each sixty-four grains; Distilled Water a sufficient quantity; Compound Spirit of Lavender half a fluid ounce. Boil the Arsenious Acid and Carbonate of Potassa with twelve fluid ounces of Distilled Water in a glass vessel till the acid is entirely dissolved. To the solution when cold, add the Spirit of Lavender, and afterwards sufficient Distilled Water to make it fill exactly the measure of a pint.] In this preparation the arsenious acid combines with the potash of the carbonate, and disengages the carbonic acid. A slight excess of carbonate is used. The compound tincture of lavender is used as a colouring and flavouring ingredient. 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. and Phys. Sc.* xiv. 187.) administered it successfully to a child only six weeks old, affected with a severe tertian ague. Dr. Fowler 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.

2. PILULÆ ASIATICÆ: *Asiatic Pills.*[1]—(Arsenious Acid, gr. lv.; Powdered Black Pepper, 3ix.; Gum Arabic, a sufficient quantity to make 800 pills; each of which contain about $\frac{1}{15}$ of a grain of arsenious acid.)—These pills are employed in the East for the cure of syphilis and elephantiasis.

3. UNGUENTUM ARSENICI; *Arsenical Ointment.*—An ointment containing arsenious acid is used of different strengths by surgeons. For onychia maligna I have already mentioned one containing two grains of arsenic to an ounce of lard or spermaceti ointment. The *Ceratum Arsenici* of the United States Pharmacopœia consists of arsenious acid, in very fine powder, ℈j.; Simple Cerate, 3j. This is used as a dressing for cancerous sores, but must be applied with great circumspection (see another formula at p. 540.)

[1] *Asiatic Researches*, vol. ii. p. 153. The formula for these pills, given in the text, is that usually followed (Rayer, *Treatise on Skin Diseases*, by Willis, p. 1215.) The original recipe is very indefinite: one tola [105 grs.] of arsenic and six times as much black pepper are to be made into pills "as large as tares or small pulse."

4. PASTA ARSENICALIS; *Arsenical Paste.*—Various formulæ for this are given. The *Pulvis Escharotica Arsenicalis* (*Poudre caustique du frère Cosme ou de Rousselot*) of the French Codex is composed of finely levigated Cinnabar, 16 *parts;* powdered Dragon's Blood, 16 *parts;* fine levigated Arsenious Acid, 8 *parts.* Mix intimately. At the time of employing it, it is made into a paste, by means of a little saliva, or mucilage. This preparation is employed to cauterize cancerous wounds. It must be used very cautiously, and applied to limited portions only of the ulcerated surface. I have already referred to its occasional dangerous or fatal effects. (See p. 540.) It deserves especial notice, that this officinal preparation of the French Codex is very considerably stronger than was used either by Rousselot or Come, notwithstanding that it is named after them.[1]

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## OTHER COMPOUNDS OF ARSENICUM.

1. ARSENICI IODIDUM; *Iodide of Arsenic.*—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 five 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 periodide of arsenicum, but by Serullas as a compound of oxide and iodide of arsenicum.[2] Iodide of arsenicum is probably composed of 1½ 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.*)

Dr. A. T. Thomson (*Lancet* for 1838–39, vol. i. p. 176.) has administered it internally in doses of from one-eighth to one-third of a grain, in lepra, impetigo, and diseases resembling carcinoma. Its general effects appear to be similar to those of arsenious acid.

2. REALGAR; *Red Sulphuret of Arsenic; Red Arsenic; Protosulphuret of Arsenic; Bisulphuret of Arsenic*, Graham; *Sandarach*[3] (σανδαρακη.) Though this substance occurs native, the commercial article is prepared artificially. It is met with in the form of red vitreous masses or as red powder. It consists of 1 eq. *Arsenicum* 38 + 1 eq. *Sulphur* 16 = 54. It is an energetic poison. It was the agent employed by Mrs. Burdock to destroy Mrs. Smith.[4] The body of the victim was exhumed after having been buried for fourteen months. It was then discovered that the realgar had been transformed into orpiment, which was found in the stomach. Mr. Herapath (*Ibid.* vol. xviii. p. 888.) has shown that ammonia and sulphuretted hydrogen (gases evolved during putrid decomposition) are each capable of converting realgar into orpiment. Realgar is not used in medicine, but is employed by pyrotechnists, and as a pigment. Heated with black flux it yields arsenicum (see p. 524.)

3. ORPIMENT; *Yellow Sulphuret of Arsenic; Yellow Arsenic; Sesquisulphuret of Arsenic; Sulphoarsenious Acid; King's Yellow.*—This is both found native and prepared artificially. Native orpiment is the *Auripigmentum* of the ancients. Orpiment consists of 1 eq. Arsenicum 38, + 1½ eq. Sulphur 24 = 62. It is soluble in alkalis (by which it is readily distinguished from sulphuret of cadmium, which is insoluble in alkalis,) and is precipitated from its alkaline solutions by acids. Heated with black flux it yields metallic arsenicum (see p. 524.) As met with in the shops it is a powerful poison. It is a constituent of some depilatories (see p. 211.) According to Dr. Paris, Delcroix's depilatory, called *Poudre Subtile*, consists of quicklime, orpiment, and some vegetable powder. Orpiment is used by pyrotechnists, and as a pigment.

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[1] For farther information respecting Arsenical Paste, see Patrix, *L'Art. d'appliquer la Pate Arsenicale*, 8vo. Paris, 1816.

[2] Souberain, *Nouv. Traité de Pharm.* ii. 2nde ed. 580; also Serullas, *Journ. de Chim. Méd.* iii. 601.

[3] The term *Sandarach* is also applied to the resinous substance commonly called *Gum Juniper.*

[4] See the account of the celebrated Bristol case of poisoning, in the *Lond. Med. Gaz.* vol. xv. p. 519; and xvi. p. 120.