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MATERIA MEDICA, PHARMACOLOGY

AND

THERAPEUTICS

MATERIA MEDICA, PHARMACOLOGY

AND

THERAPEUTICS

INORGANIC SUBSTANCES

BY

CHARLES D. F. PHILLIPS, M.D., LL.D., F.R.S. (EDIN.)

LATE LECTURER ON MATERIA MEDICA AND THERAPEUTICS AT THE WESTMINSTER HOSPITAL MEDICAL SCHOOL; LATE EXAMINER IN THE UNIVERSITY OF EDINBURGH, ETC., ETC.

SECOND EDITION

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TO

THOMAS R. FRASER, M.D., LL.D., F.R.S.,

PROFESSOR OF MATERIA MEDICA AND CLINICAL MEDICINE IN THE UNIVERSITY OF EDINBURGH,

THIS BOOK IS DEDICATED

AS AN

EXPRESSION OF ESTEEM FOR HIS PROFESSIONAL ABILITY

AND OF

GRATITUDE FOR MUCH PERSONAL KINDNESS.

PREFACE.

THE present work is a new edition of one which was published under the same title in 1882, and has been out of print for some years. It is based upon the same plan, but with many emendations and additions called for by the lapse of time and the progress of knowledge, notably in such subjects as oxygen, nitrogen monoxide, and hydrogen sulphide, iodoform and allied compounds, mineral waters, chromic, hydrobromic and lactic acids, and the physiological action of arsenic, iron, lead, etc. Space has, however, been economised by alterations in type.

A natural classification has not been attempted, and however interesting be the relation between chemical constitution and physiological action, it is not clear enough for practical purposes. Alphabetical order has been the main principle followed, but in different divisions—the gases and non-metallic elements first, then the halogens (iodine first), then water in its various modes of use, and afterwards the acids before the metals: of these last, the order is that of their Latin names, though the heading of the pages is in English.

A companion volume on the Vegetable, Animal, and Organic Compounds, published in 1886, is nearly out of print, but is well advanced towards another edition, and will supplement the present one.

Both are written under the constant pressure of active

practice, which must be my apology for the defects that may be found, but I trust that as more than usual space is devoted to the Pharmacy, as well as to the Physiological and Therapeutical actions of remedies, the work may occupy a practically useful place of its own amongst the numerous other treatises on the same subjects.

References to original memoirs are given as fully as possible in the text; and I am indebted to my friends, Dr. Ralph Stockman, Dr. Mackey, Professor W. D. Halliburton, and Dr. Sidney Martin, for the verification of these and for various suggestions, as well as for some revision and correction for the press.

10 Henrietta Street, Cavendish Square, W.,
May, 1894.

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MATERIA MEDICA

AND

THERAPEUTICS.

INORGANIC SUBSTANCES.

OXYGEN (O = 16). *Not Officinal.*

Oxygen is the most universally diffused element, forming part of the air, the water, the earth, and of the tissues of plants and animals. Of the air it constitutes 23·01 per cent. by weight, 20·81 per cent. by measure, being about one-fifth part. By Priestley (who discovered it in 1774), it was named "dephlogisticated or vital air." The name oxygen (acid producer) was given to the gas by Lavoisier, 1778.

Preparation.—Oxygen may be obtained pure from many of its combinations, but is conveniently and usually prepared by heating the peroxide of manganese, or the chlorate of potash, or preferably both together. The former yields about one-ninth of its weight of oxygen. $3MnO_2 = MnO, Mn_2O_3 + 2O$; or $2KClO_3 = 2KCl + 3O_2$. By the Brin process oxygen is separated from the atmosphere by a baryta method, the product containing 95 p.c. mixed with 5 p.c. of other constituents of the air.

Characters and Tests.—The principal characteristic of oxygen is its energetic power of combination with organic principles, and with minerals, to form oxides, acids, and bases—for instance, with hydrogen to form water. It is a gas devoid of colour, odour, or taste, of sp. gr. 1·1057 (atmospheric air being taken as 1). Under a pressure of 320 atmospheres, and at a

temperature of – 220° F., it has been liquefied by Pictet (1877), and in this form is colourless and transparent.

Professor Dewar, at a Royal Institution lecture in June, 1892, produced liquid oxygen in pints, and showed it boiling in air at 182° C. below zero; its chemical reactions disappear in the liquid form, for instance, phosphorus may be added to it without change, but its magnetic properties are intensified; it leaps up to the poles of a magnet and remains there till it disappears as gas: it is almost a non-conductor of electricity.

PHYSIOLOGICAL ACTION.—*External.*—The external and local action of oxygen in contact with mucous membrane or denuded skin is moderately stimulating.

PHYSIOLOGICAL ACTION.—*Internal.*—To describe fully the physiological action of oxygen would involve a description of the processes of respiration, blood-formation, nutrition, and tissue-change, for to all these, and to life itself, it is essential. If it be deficient in the respired air, or if it be insufficiently absorbed, all the functions become disordered, assimilation is impeded, circulation diminished, and temperature lowered, and if its access to the lungs be prevented for a few minutes, life ceases. But we are concerned, at present, only with the results of certain experiments in which animals or men have been made to respire either pure oxygen, or an atmosphere artificially charged with a definite proportion of the gas, and the first question that arises is whether more than a normal amount of oxygen can be taken into the blood under such circumstances.

It was early proved that animals kept under a bell-jar filled with oxygen lived longer than in ordinary air; and also that animals made to breathe oxygen could resist asphyxia longer than similar animals that had breathed only air (Priestley, Beddoes), but Regnault and Reiset, whilst corroborating the former observation, concluded from a series of experiments that breathing an atmosphere rich in oxygen, or even one of the pure gas, did *not* make the blood take up more oxygen than it would from ordinary air, nor was more carbonic acid excreted in consequence (Annales de Chimie, 1844): their conclusions, however, which had much influence on professional opinion at the time, have been disproved. Preyer showed that a greater saturation from oxygen-inhalation is, *à priori*, probable, and that ordinary arterial blood is not fully

saturated with oxygen—that it can take up more by being shaken with the gas. Demarquay proved it by showing that suppurating, indolent, or unhealthy wounds on the extremities of animals became quickly florid and hyperæmic when pure oxygen was inhaled —an extra amount of the stimulating gas must clearly have been carried by the circulation to the wound. Allen and Pepys, and later, Limousin, showed, by inhaling an equal quantity of atmospheric air at one time, and of oxygen at another, that after the latter, double the amount of carbonic acid was expired, and this increase continued fifteen minutes after the inhalation had finished. Other observers have reported that the elimination of uric acid during a course of oxygen-inhalation is markedly lessened, *i.e.*, that more complete combustion occurs within the system (Schmidt's Jahrb., 1865, 1, 28); thus Kollmann found that whilst 300 grammes of the ordinary secretion of urine contained 236 milligrammes of acid, the same quantity of urine contained only 122 milligrammes after inhalation of 12 litres of oxygen. On another occasion the amount of acid came down from 134 milligrammes to 25 milligrammes.

A clinical illustration, pointing in the same direction, is given by Gubler. After several copious draughts of the pure gas in an active nascent condition, the respiratory movements and the pulse became slower, a general sense of comfort was felt, and without any dyspnœa, the pause between expiration and inspiration could be much prolonged. Thus, taking 30 seconds as a maximum time during which the breath may be "held" after breathing atmospheric air, it rises to 90 to 100 seconds after breathing oxygen (apnœa); Rosenthal proved the same in animals. From these and other observations, Gubler concludes that the blood receives the gas in proportion to its physical capacity for it, rather than in proportion merely to the vital necessity of hæmatosis: the globules absorb what they need, whilst any excess circulates free, and enters into combination only as the hæmoglobin loses oxygen in passing through the capillaries. Hence the amount of oxygen absorbed by an individual is proportionate to the number of his corpuscles (we should now say to the amount of his hæmoglobin), and a plethoric man using up quickly his reserve air, breathes faster than a healthy one. On the other hand, an anæmic patient also breathes more rapidly than normal, since his corpuscles are

either too few in number or poor in hæmoglobin, so that they cannot take up enough oxygen.[1] Buchheim states an opposite view, viz., that oxygen is not absorbed proportionally to the amount of it brought to the lungs, but to the requirements for tissue-change—yet even he admits that the amount taken in can be increased to some extent by continued deep inspirations, and by breathing air rich in oxygen or under high pressure; he only denies that such adventitious oxygen affects the tissue-change (Archiv f. exper. Pathol., Bd. iv., 1875)—he admits also that improvement in symptoms may result from breathing compressed air or pure oxygen, but thinks we cannot hope to influence the course of illness by increasing the amount of oxygen contained in the blood.

The appeal for therapeutical purposes must always be to clinical results, and Dr. G. Hayem, after many observations, concludes that it stimulates energetically the nutritive functions, the appetite, temperature, circulation, etc., and increases the formation of corpuscles and their amount of hæmoglobin (Comptes Rend., 1881); still we may now be sure that it never causes the lung inflammation, etc., predicted by Beddoes.

Granting, then, the possibility of taking into the blood more than the normal amount of the gas, yet it remains true that in many *healthy* persons no marked effect is to be noted from inhalations of 15 to 30 litres of oxygen, unless it be a sense of warmth in the mouth and at the epigastrium (Husemann).

Naoumoff and Beliaieff, breathing it for 7 to 17 minutes, found no appreciable change in pulse or temperature, whilst in dogs made to breathe alternately air and oxygen, the temperature rose sometimes with the latter a few tenths of a degree, and there seemed some dilatation of capillaries (Abstract, Lancet, i., 1875). Filipow, also, could detect no influence of oxygen on pulse, respiration, or temperature in man or frog (Revue des Sci. Méd. To., 25).

[1] "Quinquaud, availing himself of the reducing properties of sodic hydrosulphite, was enabled to calculate the maximum quantity of oxygen capable of being absorbed by a given amount of blood. The mean capacity in health, he found, was 240 cubic centimètres of oxygen to every 1000 grammes of blood = 128 grammes hæmoglobin." He assumes that this absorption capacity is invariable, but in reality it varies according to illness, especially in forms of anæmia (Coupland, Gulstonian Lectures, March, 1881).

Mr. Savory, partly following Regnault and Reiset, and partly relying upon observations with animals which showed no increase of temperature under oxygen-inhalations, has also argued that these can exert no effect on the system; but Dr. Edward Smith has pointed out that such experiments, to be conclusive, should extend over long periods, and take account of changes in diet, etc. —he himself found evidence of increased chemical change under oxygen.

Dr. Gilman Thompson of New York, in an able paper based on many experiments, concludes that very little additional oxygen can be made to enter the blood under conditions of healthy circulation, by any degree of pressure short of that which mechanically interferes with functions; still he found that pure oxygen under slightly increased pressure often proves beneficial, mixing readily with carbonic acid already in the lungs, a little more than usual being taken up by the plasma: in a case of acute lung congestion (traumatic) marked relief was given (Pract., ii., 1889).

In some persons, inhalation of the gas causes temporary nervous symptoms, such as exhilaration, sense of vigour, heat of skin, tingling of fingers, and even pain referred to the fifth nerve (Husemann). I have myself observed all these symptoms, except the last, immediately after the inhalation; also some giddiness, and some rise of pulse, probably from extra effort in breathing; in the delicate, improved appetite, improved motor power, and sleep have followed. Dr. Carter (Liverpool) says that if inhaled suddenly in large quantities "it is very stimulating, and may produce a tetanic condition of muscles." Oxygen, then, is not without effects, though these vary with different individuals, and we cannot yet reduce them to precise scientific expression.

Sir W. B. Richardson, judging partly from a case in which the blood passed from the lungs back to the right heart, and so circulated "surcharged with oxygen," states that such excess leads to great exhaustion of muscular and nervous power and constant perspiration (Lancet, ii., 1878), but the conditions are not simple enough to support the assertion that these symptoms are solely due to the gas. It was held, not many years ago, that animals cannot live in pure oxygen, because of greatly increased metabolism leading

to convulsions and death (Broughton). Bert found that excess of oxygen, under a pressure of three atmospheres, produced tetanic symptoms and death, not due to simple increase of pressure, as air at a similar pressure had no such effect. Richardson (1860) and Demarquay, who reported a similar conclusion (although they endeavoured to purify the re-breathed gas), described the blood, post mortem, as in a condition of "hyperinosis"; but Dr. Seegen concluded that death in such cases is due to poisoning by products of tissue waste. These give an unpleasant odour, and may be removed by passing the gas through a red-hot tube, and then on re-introducing it at the other end of the chamber the animal can be kept in it almost any length of time without injury. Dr. A. H. Smith has clearly proved that so long as exhaled waste products are removed, animals live many hours in the pure gas under ordinary pressure without special symptoms or change.

Direct Influence of Oxygen on the Heart.—Some observations by Cyon on this subject deserve notice. Separating the heart of a frog, he connected it with a system of glass tubes and a manometer, and then passed through its cavities first serum saturated with carbonic acid gas, and afterwards serum saturated with oxygen. The former caused sudden arrest in diastole, whilst the latter restored the movements of the heart. Mr. Erichsen found, in experiments on asphyxiated animals, that ventricular contraction could be re-excited by oxygen when ordinary air had no effect. According to Hermann oxygen is not indispensable for the cardiac contractions—they may occur without it, but irregularly; and if the gas be absent, or supplied in insufficient quantity, regular and synchronous contractions are impossible (Journ. d'Anat. et de Physiol., 1868-70).

Musculo-Nervous System.—Many observers have localised in the muscular system the special action of oxygen, and Spallanzani, finding that a chrysalis absorbed much less of the gas than a butterfly, argued that the difference was determined by the less movement of the former. Brown-Séquard has shown, by interesting experiments, that when the muscular and the nervous tissues have lost their vital properties, they may recover them under the influence of freshly oxygenated blood. Thus, having injected some of his own blood (defibrinated and charged with

oxygen) into the radial artery of a man executed thirteen hours previously, and whose limbs were quite rigid, muscular irritability returned to the hand. In animals the vital qualities could not be restored so long after death ; but in one curious experiment, the head of a dog being cut off, was injected through the carotid and vertebral arteries, and movements of the eyes and the face-muscles continued for a quarter of an hour. Other observations have proved that oxygen augments the vital functions of the spinal cord, and motor and sensory nerves, and that, by the continued injection of blood charged with it, a dead body resists decomposition for upwards of fifty hours.

Compressed Air.—Physiological Action.—This varies somewhat according as the patient is wholly immersed in an atmosphere of air compressed $\frac{1}{2}$ to 1 atmosphere in a closed chamber for one or two hours, or whether he simply breathes it from a reservoir through a tube with closely-fitting mouthpiece for 20 to 60 inspirations.

The former and older method, as carried out at Reichenhall, Tölz, etc., often caused oppression of head, tinnitus and acute pain in ears, and other disagreeable sensations, but had a sedative and equalising effect on the circulation, slowing the heart's action, raising arterial tension and altering the distribution of blood, lessening its amount in the veins and increasing it in the arteries. It increased also expectoration and excretion (Burdon Sanderson, Pract., i.). The physiological effects are described by Von Vivenot more fully as follows :—Pallor of skin and mucous membrane, sense of pressure in eyes, more ease with less frequency of respiration, increase of "vital capacity" and volume of lungs with depression of cardiac force and, consequently, of strength of pulse, rise of body-temperature with increase of muscular vigour, of secretion and nutrition, compression of intestines, and probably some increased absorption of oxygen and excretion of carbonic acid. Under excessive pressure, dangerous, even fatal effects may be caused. Frequent exposure, *i.e.*, for two hours daily during several weeks, afterwards less frequently, to an atmosphere compressed $\frac{1}{5}$ to $\frac{1}{2}$ above normal, can permanently increase the "vital capacity," and the other effects described are fairly persistent. Further evidence in favour of these facts has been recorded by Dr. C. T. Williams (B. M. J., i., 1885).

In the more recent method employed by Waldenburg and Biedert, the extra compression amounts to only $\frac{1}{100}$ to $\frac{1}{45}$ atmosphere, and the good results obtained are more clearly traceable to the extra amount of oxygen. Nutrition and blood-formation are improved, the "lesser circulation" is rendered freer and less congested, and at the same time the vital capacity of the lungs is increased. Inspiration of air *condensed* by $\frac{1}{60}$ to $\frac{1}{40}$ of an atmosphere causes a sensation of extreme distension of the chest as well as a real expansion of it and of the lungs, and increased taking in of air, with relief of inspiratory dyspnœa if present. The thoracic contents are naturally compressed and become comparatively anæmic, whilst arterial pressure is increased, the jugulars become distended and the systemic vessels full. The alternate use of *rarefied* air, which induces rather opposite conditions, is employed in this method (Med. Times, ii., 1877). Expiration *into* air rarefied by $\frac{1}{60}$ of an atmosphere causes a sense of compression of the thorax, and partial retraction of lung occurs with increase in amount of air expired, and relief to respiratory dyspnœa if present; the ultimate result being to somewhat lessen circumference of chest, but to increase vital capacity and respiratory power. Certainly theory favours further trials of "pneumatic medicine," but we require more extensive experience before judging of its merits. Ducrocq, indeed, reports almost opposite conclusions to those of Burdon Sanderson (Archives Gén., 1876). A third method of employing compressed air is an air bath, with arrangements by means of which the air upon the exterior of the body may be either compressed or rarefied, while the patient breathes air at normal pressure either saturated or not with medicinal vapours. It was Hawke who first applied this method to bring about increased thoracic movements in atelectasis, and other lung affections in children (Von Ziemssen's Handbook, vol. iii.).

Mosso describes various anomalous results in the distribution of blood in the extremities under a pressure of 2 atmospheres, and explains them by changes in the innervation of the heart, or with Paul Bert by chemical, rather than by mechanical effects (Med. Record, 1879).

Divers who work in making bridges, etc., under a pressure of 2 to 3 atmospheres, suffer from pains in the ears and joints,

apparently due to "dilatation of superficial vessels" after leaving work, but amongst a large number of men no hæmorrhage, heart disease, or serious disorder occurred (Med. Times, ii., 1877; *cf.* Moxon, B. M. J., i., 1881). Danger seems to lie in too sudden changes of pressure.

OZONE.—Ozone is an allotropic form of oxygen. Its discoverer, Schönbein, did not arrive at a knowledge of its real nature, but Odling (in 1860), by a "splendid hypothesis," concluded it to be a *condensed* condition of oxygen, and this was afterwards verified, amongst other observers, by Brodie, who adopted the symbol O_3, implying that three atoms of oxygen are condensed in each molecule of ozone. A minute proportion of it is found in the atmosphere—more in that of the open country and of the sea than in that of towns, but its precise distribution and variation are not yet ascertained. Richardson calculated its amount as 1 in 10,000 of air (Brit. Assoc. Rep., 1865).

Ozone is produced in small quantities during the slow oxidation of phosphorus and some other substances. Lender recommends for its evolution in sick chambers a mixture of peroxide of manganese, permanganate of potash, and oxalic acid, to be dissolved in water. In the laboratory it is prepared by passing a succession of electric shocks through a closed chamber filled with air.

Ozone is much denser than oxygen, and in most chemical and physical, though not in all vital effects, it is more active; it is further distinguished by a peculiar odour: it is a powerful oxidising agent, and changes many protosalts into persalts; it displaces iodine from some of its combinations, hence iodised starch paper is used as a test for the gas—the paper turns bluish as iodine is set free and combines with the starch, but the test is not very dependable.

According to Paul Bert, it possesses marked antiseptic properties, and animal substances keep long unputrefied in an atmosphere to which a minute proportion of ozone has been added (Med. Record, 1876; Comptes Rendus, t. 80).

PHYSIOLOGICAL ACTION.—Drs. Dewar and McKendrick pointed out the remarkable fact that, instead of the blood becoming more highly oxygenated under ozone-inhalations, it assumes venous characters in all the vessels, a fact which is explained by

the greater density of this gas interfering with the due excretion of carbonic acid from the blood ; it causes also some local irritation of the lining of the air-passages, and it induces slowing of the heart's action and respiration (Proc. Roy. Soc., 1873-74). After exposure to ozone, albumen undergoes an extraordinary change, becoming uncoagulable by boiling and by acids, except in large quantities, and by the other reagents usually employed to precipitate it with the exception of basic lead acetate, and of alcohol (Brunton). The change probably occurs also in the mucous membrane of the air-passages when the gas is breathed.

Dr. Ireland had previously stated that ozone *quickened* respiration and circulation, excited the nervous system, and promoted coagulation of blood (Edin. Med. Journ., 1862-63), but it is probable that his animals respired mainly oxygen. Dr. Day also had found that oxygen, "ozonised in proportion of one-twelfth, caused rapid respiration and heart-action, and much local irritation" ; but quite recently, Dr. John Barlow has confirmed and added to the observations of Drs. Dewar and McKendrick. He reports that ozonised air depresses the nervous system, probably through leading to accumulation of carbonic acid in the blood ; it lessens the frequency of respiration, and hence also of the heart's action, together with the excretion of carbonic acid and the absorption of oxygen. It irritates the pulmonary and nasal mucous membrane, and may cause inflammation of the latter or bronchitis or lung-congestion (Redfern), or even asphyxia (Journ. Anat., Oct., 1879). Any such irritant effects may, however, be entirely obviated by dilution, thus Dr. A. Ransome reports that pure oxygen ozonised to 9 or 11 p.c. may be freely inhaled without causing any inflammation (B. M. J., i., 1890).

It is exceedingly poisonous to low organisms such as bacteria, and is thus a powerful antiseptic. It decolorises the red corpuscles, and causes a granular appearance, probably from uniting with hæmoglobin ; it stops the amœboid movements of the white corpuscles, and renders the nucleus apparent; there is no evidence of its entering the circulation in a free state. It is a physiological impossibility to take ozone into the blood through the lungs, and even were it possible, its presence there is incompatible with the continuance of the circulation (Dr. G. Thompson, *loc. cit.*).

THERAPEUTICAL ACTION.—*External.*—**Ulceration—Gangrene.**—Oxygen has been applied in jet to atonic scrofulous ulcers by M. Demarquay, without much advantage, but in cases of severe and extensive burn, it has been of service (Record, 1884).

Gangrene has been attributed by M. Raynaud to deficient oxygenation of tissue, and Langier and other French surgeons have recorded good results from its local treatment by oxygen (Bulletin de Thérap., 1863-66). The destruction of tissue has been checked and limited, the swelling subdued, and the neighbouring threatened livid tissue restored to its natural colour. Dr. Goolden has recorded severe cases of phagedænic ulceration, especially one affecting the throat, which yielded to local application of oxygen, and has written to renew his advocacy of this remedy (Lancet, i., 1866, ii., 1879).

THERAPEUTICAL ACTION.—*Internal.*—**Inhalation.**—Remedially, oxygen may be considered as it exists diluted in the atmosphere, or as prepared artificially for inhalation with a definite proportion of air.

Pure fresh air of the elevated country or the coast is of well-known efficacy in all conditions of debility, of chronic catarrh and chronic dyspepsia; sea air especially contains more ozone than the air of land, and is of value to those who have lived in towns and followed sedentary occupations. On the other hand, patients with weak chests and readily congested lungs are better in a less rare and less ozonised atmosphere, since a large proportion of ozone may excite in them irritation of mucous membrane (Cornelius Fox). During epidemics of influenza an unusual amount of ozone has been verified in the air, whilst in cholera epidemics it has been almost absent. The choice of a climate for any given case is, however, generally influenced by other considerations than the mere amount of oxygen to be obtained; the subject need not, therefore, be fully considered in this place. The chief cases in which theory indicates, and experience justifies, the use of oxygen-inhalation, are those of asphyxia and of venous congestion occurring in the course of phthisis, pneumonia, asthma, emphysema, and other forms of lung or heart disease, and in these its use has become much more frequent since the last edition of this work.

Asphyxia.—When this condition is induced by breathing

noxious gases, the best results are obtained from oxygen. Sometimes a free current of fresh air is sufficient to restore persons rendered unconscious by an escape of gas or by the products of combustion retained within a room ; but in extreme cases, pure oxygen would seem the only means of saving life. Limousin has reported a case of asphyxia from carbonic acid inhalation, with intense cyanosis, which recovered under the use of oxygen, and in which he was able to verify a steadily increased elimination of carbonic acid by the lung, in proportion to the oxygen taken (Compt. Rend. Soc. de Thérap., 1868). M. Constantin Paul has recorded many cases, including cyanosis from obstructed respiration, coma from opium-poisoning (when the respirations were only seven per minute), and asphyxia from carbonic oxide, all quickly and markedly relieved by oxygen (Bulletin de Thérap., Aug., 1868). Rabuteau refers to an instance of its good effect in asphyxia from sewer-gas, when ordinary means, employed by M. Grisolle, had failed to relieve ; and a striking case has been reported by Dr. Charles B. Ball. A man, wife, and daughter were found unconscious in a small room where there had been, through the night, a large fire, though the chimney was blocked. The two adults recovered with fresh air and ordinary means, but the daughter, aged sixteen (phthisical), remained unconscious and convulsed. After many hours of stimulating treatment she seemed to be dying—respiration was feeble and slow, the pulse imperceptible—then she was made to inhale pure oxygen, afterwards oxygen and air. "The effects were rapid and marked," respiration, colour, and pulse improved, and though at first convulsed, she ultimately recovered. Dr. Ball, impressed by this case, and remembering Reynault's proof that man can live in an atmosphere strong in carbonic acid, provided that the proportion of oxygen is also increased, has contrived an apparatus with a reservoir of oxygen and a mask for safe use in dangerous mines. He has himself safely respired an atmosphere containing 18 per cent. carbonic acid with 30 per cent. oxygen added (B. M. J., i., 1878), and the combination of oxygen with nitrous oxide has been found to make its action both safer and pleasanter, cyanosis being often altogether absent during the anæsthesia. If we compare the result in Dr. Ball's case with the fatal course of such cases of gas-asphyxia as, *e.g.*, may be found in the Edinburgh Journal,

1874, we shall better realise the importance of using oxygen in preference to other measures.

In various forms of poisoning whenever death threatens from asphyxia, as under prussic acid, chloroform, morphine, etc., artificial respiration, *i.e.*, supplying more oxygen, offers the best means of saving life. Colonel Esdaile has recently drawn public attention to this by a sensational case of oxygen-inhalation in coal-gas poisoning (Lancet, i., 1891), but the results are not always so favourable. Dr. G. Thompson could trace no satisfactory result in blood-poisoning from diphtheria, or coal-gas, or in endocarditis, but much in bronchitis, pneumonia, etc., and wherever there was lessened surface for aeration of blood, especially in neurotic and uræmic dyspnœa (*loc. cit.*). Dr. Catlin also points out that if, with a limited lung-capacity, we can secure absorption of the same quantity of oxygen as in health, the result must be good, and describes it as a sure and satisfactory stimulant in cases of shock (Record, 1891).

Rosenthal and Leube found that the symptoms of strychnine-poisoning might be deferred or prevented by artificial respiration (Reichert's Archiv, 1867). H. Ebner thought the same result could be obtained by rhythmical movements of the limbs without supplying more air to the lungs, but Ananoff has since proved that pure oxygen is distinctly antagonistic to strychnine, and that when supplied to animals poisoned by this alkaloid, it relieves them more than free access of ordinary air, or any movements (Cbl. f. med. Wiss., 1874).

Asthma — Emphysema, etc. — The main suffering, the "besoin de respirer," common to these maladies, is clearly traceable to deficient access of oxygen to the blood in the lung-capillaries, and I am satisfied that in the majority of instances relief to this suffering may be given by supplying a larger proportion of the gas. If it be objected that permanent good results are not obtained from it, the same objection may be made to many other remedies—it is still something to have a means at hand for temporary relief. Dr. John Hooper thus describes its effects in a man of fifty-five, "for many years a martyr to asthma." During a very severe paroxysm he was thought to be dying; it seemed impossible that he could rally. As a *dernier ressort*, oxygen was tried, the end of a glass retort containing it being applied to his mouth, though he had not power to enclose it with

his lips. "The effect was wonderful and quickly manifest in increased mobility of the ribs, fuller inspiration, disappearance of lividity, and lastly in his seizing the end of the retort, and in the avidity with which he inhaled when possessing the voluntary power" (B. M. J., i., 1862). Details of diagnosis are not given in this instance, but paroxysms of true nervous asthma and of bronchial asthma may sometimes (not always) be shortened by similar inhalation. Beddoes related twenty-two cases, of which he claimed to have cured ten and relieved nine; and it seems worth while to refer to his case of "Mr. Hare, of Conduit Street, who, in 1796, after having been subject for eleven years to asthmatic attacks accompanied by indescribable suffering, and only relieved after many hours by blisters and expectorants," recovered average health under the use of the gas, continued for some months (*op. cit.*, 4th part). M. Demarquay also witnessed excellent results, *e.g.*, in a man aged nineteen, subject from childhood to asthmatic attacks —"they ceased, as if by magic, as soon as he began to inhale oxygen" (Essai de Pneumatologie). Of three cases reported by Dr. Blakiston, two were much benefited, the third less (B. M. J., i., 1892).

Dr. Mackey has reported (Pract., ii., 1869) the case of a lady, aged fifty-five, subject to constant dyspnœa, increased by movement, and amounting at times to partial asphyxia. She had advanced emphysema with dilated weak heart, embarrassed circulation, and œdema of the face and extremities; was subject to attacks of bronchitis, but at the time of treatment the main complaint was the difficulty of breathing. She inhaled a mixture of from three to twelve pints of oxygen, with sixty of air, at intervals of three or four days for a period of six weeks. After each dose "marked relief was experienced, which she expressed as being able to take a deep breath and get sufficient air (a feeling not known for years), as being able to move with comparative ease, feeling more buoyant and more like healthy persons should feel than she ever remembered." Expectoration was rendered more copious and easy for a day or two after the inhalation; there was no other definite effect on secretion, nor any on circulation, unless it were some palpitation during the night after a large dose. The nervous irritable states to which such patients are liable were also soothed under the treatment, which certainly effected more than

ordinary medicinal agents. These illustrations seem sufficient to prove that oxygen might be used more often than it commonly is in such cases; on the other hand, later experience both in asthma and emphysema has given varying results, showing that benefit is not to be always depended upon.

According to Biedert's method, emphysema is treated by a few short sittings of respiration in *compressed air*, and then by expirations into an atmosphere of *rarefied air*, "in order to counteract anæmia by attracting blood towards the lung-tissue."

In **Bronchitis**, bronchial catarrh, and bronchial asthma, *compressed air* is used to stimulate the lung, improve its circulation, and facilitate expectoration—it seems to be useless during actual asthmatic attacks. In mitral disease it is said to be valuable, and in dyspnœa dependent on dilatation of right heart.

Pleuritic Effusion—Empyema.—I have used oxygen in several of these cases with good results. During inhalation, relief to breathing was experienced, which lasted for some time afterwards: compressed air has also been employed for these disorders. Biedert reports two cases of pleuritic adhesion in which vital capacity was much increased by it, and Kelemen one of empyema in which the effusion disappeared as diuresis set in (Med. Record, Aug., 1879). Williams' results in pleuritic cases are not so favourable (B. M. J., i., 1885).

Whooping-Cough.—Moutard-Martin says that compressed air baths are efficient in this complaint (Union Méd., 1879). Of 100 cases (children) recorded by Sandahl in Sweden, 88 are reported cured by this treatment, the exceptions being phthisical. Oertel confirms this experience.

Phthisis.—The value of oxygen-inhalations in this disease has been the subject of much discussion. So early as 1783 it was tried with apparent good result, and Fourcroy was appointed by the French government to report on the subject. After examining into twenty cases he concluded that almost all patients benefited, for a time at least, by the treatment, but relapsed and got worse more rapidly and with more inflammatory complication than if oxygen had not been used (Sur les Proprietés Médicinales de l'Air Vital, 1789). It is evident that to establish such a conclusion very careful observation is required, and more precision than the then art of diagnosis could attain, but the opinion

exercised considerable influence at the time, was adopted by Dr. Beddoes and some other observers, and was one reason why this method of treatment fell into a disuse which was not altogether deserved.

Amongst modern writers, Drs. Birch, Constantin Paul, and Demarquay have reported relief in cases of phthisis. In the same disorders, also specially in *broncho-pneumonia*, of which an unusual amount has followed the late epidemic of influenza, oxygen has again been largely used. A paper by Drs. Lauder Brunton and Prichett (B. M. J., i., 1892) described a severe case with cyanosis, etc., in which, after failure of venesection and strychnine, much improvement followed the use of this gas, which did not, however, prevent a fatal issue. Similar cases with like results were reported by Drs. Allen, Gilchrist, M. Skerritt, Mr. Langston, and others, with more fortunate terminations by Beverley Robinson, Mr. Maughan, Dr. Collier, etc. My own experience has not been so favourable—no effect was produced in one case by a free stream for 15 or 20 minutes, and the greatest objection was shown by the half-conscious patient to the ori-nasal inhaler. If this remedy be adopted it should be given a fair trial, and continued more or less for several hours or even days.

In *cardiac asthma* connected with mitral disease, especially recurrent in the early morning, I have known oxygen-inhalation give much relief. Mr. Blair and others have reported *the same* in the cyanosis of such conditions. A large number of cases are given by Dr. A. H. Smith (New York Prize Essay), and his general results are so far favourable as to warrant still further trials with this agent. I would except from its use cases of very acute character, and of hæmoptysis, in which, indeed, the mere exertion of inhaling would contra-indicate it. In other cases benefit may be hoped for, not so much through any local action on the lung-tissue as through improvement of the blood-condition, the appetite, and the power of assimilation ; nor, speaking from experience, do I believe that oxygen, used with ordinary care, and in such dilution as has been mentioned, can at all irritate or inflame the lung-tissue.

Dr. Reid (Long Island) has reported a series of twenty cases treated by inhalations of oxygen in *conjunction* with cod-liver oil. The majority did well, and he reports it an " admirable adjuvant to the usual routine treatment of phthisis, especially when the

patients were unable to go out of doors." He gave the gas also in acute pneumonia, and apparently with advantage. Albrecht has more recently reported good effects in cases of phthisis, the patients gaining weight, etc., under oxygen-inhalation; of inoculated animals also, those subjected to inhalations continued to live long after those not inhaling had died (Record, 1883). Drs. Thorowgood, Neumann, and others have also reported relief to the dyspnœa, etc., of advanced phthisis, and Dr. A. Ransome, at the Manchester Hospital for consumption, administered the ozonised oxygen already referred to "to fifteen patients in all stages of the complaint, and results were very marked in procuring improvement in general health, better appetite, sounder sleep, freedom from fever, and consequent gain in weight" (Medical Chron., 1889). It had no obvious germicidal action in many of the cases, though the amount of expectoration was lessened.

The use of compressed and rarefied air seems rather to alleviate symptoms than to cure phthisis. In pretubercular stages it may serve to strengthen the respiratory muscles and open out the chest, but it is not suitable for acute or hæmorrhagic cases, or those with a large area of congestion.

Scarlet Fever.—In a scientific paper on the value of oxygen in scarlet fever, Dr. Astley Gresswell has analysed nearly 600 cases, and gives reason for judging it of service in many, especially in the lessening of renal and removal of pulmonary complications, and in collapse. It was given freely from Brin's cylinders, and in highly-oxygenated water (Practitioner, ii., 1888).

Hepatic Congestion.—Dr. Birch has advocated the use of the gas in this condition, and states that it will relieve the constipation and other symptoms connected with it. The remedy no doubt may be of service, especially in cases with headache, depression, loss of appetite, and sense of pain and constriction about the shoulder and chest, with palpitation and dyspnœa. In some chronic cases in which it was tried I have not seen benefit, and, as a general rule, medicinal and dietetic treatment, with such oxygen as is obtained by increased *exercise*, will give at least more rapid results.

Chlorosis—Anæmia.—Beddoes relates many instances of chlorosis benefited by inhalations, but other observers have not met with equal success from its use in this malady. I have,

however, known it relieve chlorotic headache. In leukæmia it has proved serviceable (Record, 1884); but in some extreme cases of anæmia, the gas is not always well borne—it has seemed sometimes to increase depression for the time, and cause faintness and palpitation. Neumann, on the other hand, reports favourably; also Hayem. At an establishment at St. Raphael (Riviera), a specialty is made of the treatment of anæmia, debility, etc., by inhalation of ozonised air, as well as baths, etc., and some good results are reported. The inspiration of condensed air has been found a useful adjuvant to other remedies.

Diabetes.—Pettenkofer and Voit determined that diabetics absorbed less oxygen than healthy persons, and that hence we might hope, by introducing more into their system, to obviate some conditions of their malady.

Bouchardat, and also Demarquay, have recorded cases relieved by this treatment, but no extensive trial of it has been made. Peroxide of hydrogen has been given internally with the same object—of oxygenation—and with some partial success. I have tried oxygen-inhalation in several cases of diabetes in which prostration, dyspnœa, and tendency to cyanosis were prominent symptoms—one case was at the very unusual age of seventeen months, another at thirteen years, and three others at adult age. The gas certainly relieved for a time the symptoms mentioned, although it did not in any instance reduce the sugar in the urine. Dr. E. Morin reports very favourably of daily oxygen-inhalations for diabetes (in a prize essay before the Medical Society of Antwerp).

Albuminuria.—In a few cases of Bright's disease narrated by Dr. C. Paul, albumen disappeared from the urine during treatment by oxygen. This occurred also in the often-quoted case observed by Kollmann and Eckart (Schmidt, Jahrb., 1865). More recently, Dujardin-Beaumetz reports a case "in the last stage," and in which every diuretic had proved useless, and yet, twenty-four hours after inhaling oxygen, the albumen disappeared, and was still absent twelve days afterwards when the case was reported (Med. Record, 1879). Other physicians, whilst recording similar cases in their own experience, have stated that the good result was not of long duration. Jaccoud observes that if albuminuric cases do not show marked improvement under his ordinary treat-

ment of milk diet and cold douches, his next resource is always inhalation of oxygen—thirty litres daily, at three or four sittings (Med. Times, i., 1885).

Nerve-Disorders.—A few cases of severe neuralgia relieved by oxygen are on record (Birch, Hooper), and it has been praised in spinal palsy, nerve-debility, and hysteria, but I think without sufficient reason. What little trial I have made of it in such cases has not given me any good result. Binz has shown that ozonised air is soporific to some persons (Record, 1883).

Dr. Ramskill has reported a case of epilepsy apparently relieved by the gas, which he gave by inhalation from peroxide of hydrogen (Med. Times, i., 1863). The compressed air bath has been used with advantage in Menière's disease (B. M. J., i., 1886).

Hydrophobia.—Drs. Paul and Josias used oxygen in this malady, and although the patients died, some relief was given to the symptoms of asphyxia. Dr. Schmidt has recorded the case of a girl, aged twelve, who, when recovering from diphtheria, was bitten by a mad dog; seventeen days afterwards she had difficulty of breathing and of swallowing, and oxygen-inhalation relieved her: she relapsed next day with convulsions, spasms of respiratory muscles, and unconsciousness; oxygen again relieved her, and after some complications traceable to the diphtheria, she ultimately recovered (Med. Record, 1878). Other cases have been relieved (*Ibid.*, 1885).

Tetanus—Strychnine-Poisoning.—Richardson refers to some cases of tetanus, under Sir J. Paget, much relieved by oxygen-inhalation: the patients became bathed in perspiration, and the muscles relaxed. He insists also on its importance in strychnine-poisoning in conjunction with amyl nitrite: as unless elimination be promoted by oxygen the spasm, even if relieved, soon returns. "Oxygen is a remedy for all excess of nerve-action leading to spasm" (*cf.* p. 13). It has proved valuable in eclampsia, and is said to lessen reflex excitability (Record, 1885).

Paralysis of Divers.—When divers are submerged at a considerable depth, the high pressure causes both the nitrogen and oxygen of the air to be absorbed into the blood. On coming to the surface, the nitrogen being set free, gaseous emboli may be formed. Bert found in animals in this condition that the normal state of the blood was restored by the inhalation of oxygen, as nitrogen

diffuses as rapidly into an atmosphere of oxygen as into a vacuum : he therefore strongly recommends it in this form of paralysis.

Cholera.—Its use has been recommended in this disease ; but sufficient observations have not yet been made to warrant any positive opinion as to its value. It is said that during the late cholera epidemic at Marseilles, ozone disappeared for a time from the atmosphere, and when it reappeared with a change in the wind, the mortality fell (B. M. J., ii., 1884). Oxygen was used in the hospital wards during the same epidemic, and some highly favourable results are recorded in official reports, but it was employed in conjunction with other treatment.

Dose and Mode of Administration. — M. Demarquay obtained his oxygen from chlorate of potash and made use of caoutchouc bags, which were filled with the washed gas, and could be carried to the patient's bedside. M. Limousin introduced a small portable apparatus with brass retort, wash-bottle, and caoutchouc bag, so that the gas can be prepared and used on the spot. Mr. Barth supplies a small gasometer, with the gas condensed under high pressure into iron bottles, from which a measured quantity can be introduced, mixed in definite proportion with air. The Brin Oxygen Co. supply iron cylinders of various sizes containing the compressed gas which in urgent cases may be administered through the mouth or nose from a tube directly connected, but the intervention of a caoutchouc bag and mouthpiece is generally advisable—sometimes a valved ori-nasal facepiece, as for nitrous oxide, is better. The gas being heavier than air, it is well to suspend the bag above the patient, so that the contents readily pass out with slight pressure. The dose may be varied according to effect, but from half to one gallon every half-hour continued for three to four days has been used (Chambers, Lancet, i., 1890). In chronic maladies an inhalation of the gas, preferably diluted with half or two-thirds of air or one-third of nitrogen, should be practised for about half-an-hour once or twice with slow deep inspirations, about one minute between each. As this requires an effort for some patients, they should be quiet for a time before and after, not over-fatigued, and the stomach should not be full nor quite empty ; the feet should be warm and the circulation equable. Dr. Valenzuela (Madrid) has given the gas readily

per rectum, as much as five litres being absorbed four times in an hour, and states that dyspnœa may be relieved in this manner when attempts at inhalation fail. Under the skin, also, from half to one litre may be introduced at a time, with marked stimulating effect on the heart (Lancet, 1891). Laudi has passed it directly into the stomach through water previously injected; Laborde has given it by intravenous injection (Comptes Rendus, 1885), Kollogg and Humphrey by enemata (Med. Age, April, 1888).

Other modes have been devised for introducing oxygen into the system, as by oxygenated water, which may have a limited sphere of usefulness: Bert has stated that it destroys the bacilli of anthrax. A method still open to investigation is the administration of peroxides, especially those of hydrogen and iron, and of chlorate or permanganate of potash (*v.* p. 29, also Potash); and some experiments of C. Bernard warrant the conclusion that these compounds give up to the blood a proportion of their oxygen, and are eliminated in a less oxidised condition.

Contra-Indications.—I have not met with any case in which oxygen, more or less diluted, could not be safely used if it were indicated. If organic heart-disease be present, care should be taken to regulate the force and the effort of inhaling, which sometimes gives rise to giddiness or palpitation independent of the remedy. Some soreness of the throat and temporary discomfort about the mouth may occur if the apparatus be not quite free from dust, but from the gas I have seen no bad results whatever. The contra-indications to the use of compressed air are degeneration of vessels and an apoplectic tendency: to that of rarefied air, pulmonary hæmorrhage.

NITROGEN (N = 14). *Not Officinal.*

This gas is very widely diffused, constituting 76·99 per cent. by weight of the atmosphere, 79·19 per cent. by measure. It forms several combinations with oxygen, some of which act as acids, and give rise to both animal and vegetable nitrates and nitrites; it also enters into the composition of albuminous tissues, and of the alkaloids.

PREPARATION.—Nitrogen may be obtained by burning either phosphorus or a mixture of iron filings and sulphur, or certain other substances,

in a limited quantity of air, as under a bell-jar: the oxygen oxidises the other body; the oxide so formed is removed in some way (as by absorption by water), and the nitrogen is left.

CHARACTERS.—A colourless, odourless gas, sp. gr. ·975, soluble in water to some extent.

PHYSIOLOGICAL ACTION.—This is negative in character; the gas will not support respiration nor combustion, and it seems in the atmosphere to serve the purpose of a diluting agent for oxygen. M. Demarquay injected nitrogen into the peritoneum and cellular tissue of animals, and came to the conclusion that more or less exhalation from the lungs of the normal gases of the blood was caused by it (Archives Gén., 1859). Sir George Johnson found that pure nitrogen, with 5 per cent. oxygen, produced anæsthesia in a most satisfactory manner, in an average time of eighty-seven seconds (Lancet, i., 1891).

THERAPEUTICAL ACTION.—*External.*—On the hypothesis that the stimulation of ordinary air caused irritation and suppuration in wounds, stumps, etc., Demarquay was led to try the effect of enclosing them in caoutchouc bags full of nitrogen; but the practice was not successful.

Inhalation.—It has been proposed to utilise nitrogen by adding a larger than normal proportion of it to ordinary air, for inhalation in irritable and inflammatory lung-condition, but no definite results have been obtained in this country. Steinbrück (Vienna) has, however, lately recommended nitrogen-inhalations in the first and second stages of phthisis in young persons, stating that "they lower the circulation and allay nervous irritability, give great relief, and sometimes cure"; in the third stage they are injurious (Dobell's Reports, 1876). I have not seen any confirmation of these results.

NITROUS OXIDE—LAUGHING GAS ($N_2O = 44$).

Not Officinal.

NITROGEN MONOXIDE.

PREPARATION.—On heating nitrate of ammonium in a retort, the gas is given off: $NO_3\,NH_4 = 2H_2O + N_2O$. It requires to be carefully washed and purified before use. (The heat should be applied gradually, first to melt the ammonium nitrate at about 226° F., then to keep it boiling and giving off gas at about 460° F.)

CHARACTERS.—A colourless gas, with a slight odour and sweetish taste. The presence of any red fumes in the vapour shows contamination with the irritant nitric peroxide (NO_2). It accelerates combustion just as oxygen does, but is much heavier than the latter, and much more soluble in water. At 45° F. it is liquefied by a pressure of forty atmospheres, and is now supplied for anæsthetic purposes in a liquid form in iron cylinders.

PHYSIOLOGICAL ACTION.—This is at first slightly stimulant to the circulation, producing some sense of warmth, with a feeling of pressure and fulness in the head and ears. If a certain proportion of air be admitted with the gas, these stimulant effects may be very marked as shown by laughing, excited talking, etc. Hysterical symptoms, with screaming and crying rather than laughter, sometimes develop, and headache and sickness occasionally follow, but as a rule, with due care, the gas may be inhaled to complete anæsthesia without unpleasant effects. As the gas enters the circulation the skin becomes livid, and in thirty to sixty seconds the conjunctivæ are insensible, the muscles, which at first may be contracted, relax, the pulse is generally *quickened* and weakened,[1] and when anæsthesia is complete the breathing is commonly stertorous, and convulsive twitchings of the muscles occur.

Short operations may be performed painlessly at this stage, and if only a little air be admitted, fresh gas may be given and anæsthesia safely prolonged for several minutes.

The mode in which nitrous oxide produces its effects has been much discussed. The purple coloration, along with some other symptoms, and the post mortem appearance of dilated right heart and congested lungs (in some cases) resemble the effects of asphyxia, *i.e.*, deficient aeration of blood, but this alone would not account for the early stimulation and for the general absence of headache, malaise, etc., after an inhalation. Gases which act simply by deprivation of oxygen, such as carbonic acid, commonly cause a good deal of these latter symptoms, with weariness, anorexia, and nausea, as shown by Dr. Evans of Paris.

We may attribute its effects, partially at least, to impairment

[1] This is probably the usual effect in practice, but though Thomas asserts it, Turnbull says "the pulse always *decreases* when the patient has begun to inhale" (Anæsthesia, 2nd ed., p. 179). Wood and Cerna state that under the pure gas the pulse rate is *slowed*, and the blood pressure greatly raised.

of due oxygenation in the lungs, and to retention of the constituents exhaled in normal respiration (for exhalation of carbonic acid, though diminished *during*, is increased *after* nitrous oxide administration); but, besides, we presume a special effect on the nerve centres, and, according to Flourens, the spinal axis is first affected, and then the cerebellum and the medulla oblongata. Van Arsdale concludes that its special effect is to shut off oxygen from the blood, and this is to be distinguished from a mechanical asphyxia, because, in the latter case, carbonic acid is formed in the blood: under the gas this is not so, unless air is admitted with it. In asphyxia under the pure gas there is simply want of oxygen, for Rothman, using diluted solutions, showed the hæmoglobin spectrum unimpaired, *i.e.*, there was no chemical effect on the blood (International Jour. Med. Sci., 1891). Turnbull has shown that the corpuscles are not altered.

After death in animals poisoned by nitrous oxide, the lungs are found moderately crepitant, of pink or rose colour, and generally with small circular ecchymoses on their posterior surfaces. These have been considered peculiar to gas-asphyxia, as distinguished from that of drowning or hanging. The blood from an incision in the lungs contains gas bubbles, which may be found also mixed with the bronchial mucus, and in a few instances this has been found of rusty, frothy character, as it often is in cases of drowning.

There are on record a few cases of death attributed to the administration of nitrous oxide, but of these, most, I think, may be explained by nerve shock.[1]

THERAPEUTICAL USE—**Mode of Administration.**—Nitrous oxide is used mainly for the production of anæsthesia for short operations, and especially in dentistry. It is important in administering it to secure a good and fresh gas (that which is two or three weeks old is not nearly so effective), and to get this quickly into the circulation without admixture of air. The clothing should be loosened, a suitable closely-fitting inhaler be adapted to mouth and nose, and slow, full inspiration directed, until the symptoms

[1] In a recent case, where "the venous system was engorged with dark fluid blood," it was probable that only a small quantity of gas was inhaled, and that death resulted from mechanical asphyxia by pressure of facepiece, possibly accidental (B. M. J., i., 1893).

previously described appear. This may be in thirty to sixty seconds, but when the gas is not delivered under much pressure, or when respiration is shallow and feeble, a longer time—it may be one, or nearly two minutes, or more—is required for the production of anæsthesia. There is no special contra-indication to its use : it has been safely given in many forms of cardiac and pulmonary disorder, but I have found it desirable sometimes to give ether or brandy before the inhalation, and attach more importance to the injection of such remedies than to artificial respiration, though that, of course, with drawing forward of the tongue, should also be at once resorted to in the presence of danger : the ordinary treatment of syncope by posture, air, cold water, frictions, etc., should not be omitted. During recovery from the anæsthesia, quiet for some minutes is very desirable.

In the careful paper by Van Arsdale already cited, it is stated that the average time for the pure gas to produce anæsthesia and unconsciousness is two minutes eight seconds (which seems more than usual with us), and total cessation of respiration about three minutes, but the heart continues to beat after respiration has ceased—one cause of the comparative safety of this gas.

Dr. Silk, analysing 1000 cases of nitrous oxide anæsthesia, reports that 12 per cent. had much surface itching, 2 per cent. had asphyxial symptoms, several were hysterical, but 70 per cent. had no trouble. The average quantity given was four to five gallons ; the average time of facepiece on, sixty-seven and a half seconds. Sexual illusions occurred in six cases. In epileptics there was no danger ; of pregnant cases there were nine, which did well but showed a tendency to vomit, and one of valvular heart-disease had a tendency to syncope (Internat. Journ., 1890).

Mr. Percy Edgelow, in some practical observations, recommends that stertor and jactitation should be waited for before commencing an operation : he notes that if air be admitted there is likely to be more feeling of tension in the head and sense of suffocation : he objects to a supplemental bag (Lancet, i., 1891).

In the hope of avoiding asphyxial symptoms, Herman, and after him Paul Bert, mixed oxygen with nitrogen, about one vol. of the former to four of the latter, increasing tension of the mixture by one-fifth of atmospheric air. Bert constructed a glass room that could be hermetically closed, and in this were surgeon, patients,

and assistants. Many operations under nitrous oxide were performed in it, with satisfactory anæsthesia, which was almost instantly induced, continued for any reasonable time, and followed by recovery from the anæsthetic without any bad symptoms whatever (Comptes Rendus, 1879-87).

Hewitt reported many cases in which oxygen, 12½ parts, and nitrogen, 87½ parts, were given in mixture from a gasometer: respiration was soon slowed, but neither cyanosis nor stertorous breathing occurred: the pulse was strong at 80 to 90. An administration of two minutes was generally sufficient for satisfactory extraction, but sometimes failed completely (Lancet, i., 1889). This admixture prevents the increase of blood pressure. After many experiments, Van Arsdale found the best proportion to be 10 of oxygen to 90 of nitrous oxide: if any failure occurred with this it was generally due to insufficient inspiration, which he obviated by increasing pressure. His cases went off as in quiet deep sleep, and were submitted to various operations, but were found to recover consciousness more quickly than convenient for dentistry: a few excitable cases he explains by chronic alcoholism.

The gas has also been administered with some good effect in *neuralgia*, *hysterical aphonia*, *local paralysis of muscles*, on which it has a stimulating effect, and in *spasmodic asthma*. In *epilepsy*, when independent of organic changes, it has been recommended for use three or four times a week, and Ziegler has described advantage in various pulmonary and renal disorders from drinking an aqueous solution of the gas.

Childbirth.—Perhaps a more important, though, as yet, scarcely practicable, application of nitrous oxide with oxygen is to safely relieve the pains of childbirth. Zweifel at Erlangen, and several physicians in Russia, have had constructed chambers (after Bert's model), in which 20 per cent. of oxygen has been mixed with 80 per cent. of nitrous oxide, and in which parturient women have been placed. In sixty cases all has gone well; the process has not been retarded, and the women have been free from pain and yet not unconscious (B. M. J., ii., 1885) (*cf.* Van Arsdale, *loc. cit.*).

HYDROGEN (H = 1). *Not Officinal.*

Hydrogen, being the lightest of known elements, is commonly

taken as a standard of specific gravity and combining proportion. It has been found free in small proportions in certain volcanic gases, and occurs extensively in combination, *e.g.*, in water, in many acids and gases, in hydrocarbons, and all substances used for artificial light—tallow, oils, coal gas, etc.—and throughout the vegetable kingdom. It was formerly known as "inflammable air," and, when lighted, burns with a bluish flame.

PREPARATION.—By acting on granulated zinc with dilute sulphuric or hydrochloric acid—$Zn + H_2SO_4 = ZnSO_4 + H_2$.

CHARACTERS.—A colourless, inodorous gas, of sp. gr. 0·0692. It combines readily with arsenic, sulphur, etc.

PHYSIOLOGICAL ACTION.—This is negative in character. Hydrogen does not support respiration or combustion, and animals immersed in it die as soon as in carbonic acid. Attempts to inhale it cause cyanosis of the lips and face, quickness and smallness of pulse, vertigo, impaired vision, and in some persons, drowsiness, slight insensibility, and when pushed, asphyxia in greater or less degree. A mixture with oxygen, when inhaled, causes the voice to become shrill.

THERAPEUTICAL ACTION.—Dr. Beddoes used hydrogen gas as an inhalation in phthisis, both by itself and in mixture with oxygen. He reported some cases as relieved and others cured, but his results have not been corroborated. The most constant effect seems to have been the production of sleep.

HYDROGENII PEROXIDUM—PEROXIDE OF HYDROGEN

($H_2O_2 = 34$). Not Officinal.

PREPARATION.—By acting on barium dioxide with hydrochloric acid. $BaO_2 + 2HCl = H_2O_2 + BaCl_2$.

CHARACTERS.—It is a liquid of syrupy consistence, of strong, disagreeable, metallic taste, very unstable, and readily parting with its oxygen; hence it is a powerful oxidiser. It blanches litmus, and a solution, of sp. gr. 1006, is in common use abroad for bleaching purposes. Its solution in ether is more stable, and is known as ozonic ether.

PHYSIOLOGICAL ACTION.—*External.*—This liquid, applied locally, whitens the skin and mucous membranes, and acts as a moderate caustic; it has also marked antiseptic power.

Urine mixed with one-tenth of peroxide remained nine months without putrefying (Guttmann).

PHYSIOLOGICAL ACTION.—*Internal.*—It produces, when given internally, stimulating and in full doses irritant, effects. The bleaching solution, of sp. gr. 1006, has been used by Assmuth, Schmidt, and Guttmann for hypodermic injection in animals, and was found to cause dyspnœa, clonic convulsions, and death in a few minutes from asphyxia. The last-named observer traces this to the development of bubbles of gas in the right cavities of the heart, the blood frothing up as if air entered by the veins. The result is partially antagonised by injection of ferrous sulphate, implying the combination of this with part of the oxygen liberated (Virchow's Archiv., 73, 1878).

THERAPEUTICAL ACTION.—*External.*—**Ulcerations.**—Lotions containing peroxide have been used with advantage in soft chancre, and in cases of fœtid ulcerations of the mouth, otorrhœa, etc. Owing to its oxidising powers it is a good antiseptic and germicide: in contact with pus or blood it decomposes with effervescence (Pract., v., 32).

THERAPEUTICAL ACTION.—*Internal.*—**Chronic Dyspepsia.**—Richardson, Guttmann, and others have reported improvement of the digestion under this remedy, but it is not much used.

Diabetes.—Cases of this disorder treated successfully by peroxide of hydrogen have been recorded (B. M. J. and Lancet, 1868), and much good was at one time expected from it as an oxidising agent; but Sir B. W. Richardson, who introduced the remedy, and used it in more than two hundred cases, came to the conclusion that although it could reduce the sp. gr. of the urine, it, at the same time, increased its quantity, and had no really good effect (Med. Times, ii., 1868). In a recent paper he attributes much more value to it, especially in combination with codeine, also in phthisis, syphilis, and pertussis (Lancet, i., 1891). Dr. Pavy tried it in a few cases without any result (On Diabetes, last ed.).

Cyanosis—Pulmonary Conjestion (Passive).—In these conditions, where oxygenation of the blood is defective, and which are generally connected with heart-disease, I have sometimes seen advantage from the internal use of peroxide of hydrogen—it is worth trial, but further observations are needed for estimating its

true powers. Sir Walter Foster has reported two cases of congenital cyanosis relieved by it (Clinical Medicine, 1874).

Inflammation of Mucous Membranes.—Its use has been suggested in many inflammatory and purulent affections of mucous membrane, such as ophthalmia, otorrhœa, gonorrhœa, ozœna, and diphtheria ; also as a wash for the stomach and bladder. Dr. W. A. Dayton finds that a 4 per cent. solution is a good cleanser in cases of otitis ; it renders easy examination of such cases with the speculum, and cocaine acts better after its use (Practitioner, ii., 1885). Dr. Sexton also speaks highly of the same remedy in such cases (Record, 1885). M. Landolt of Paris uses it largely in ophthalmic practice, with great success (Arch. d'Ophthal., to. ii.).

Pertussis.—Much power has been claimed for peroxide of hydrogen in the relief of paroxysms of whooping-cough, but I have no experience of it. In a severe case, complicated with cyanosis, in a child with patent foramen ovale, Dr. Mackey used the remedy with apparently good result for the time : the degree of cyanosis was less whilst the remedy was taken, and the attack of pertussis ran a mild course.

PREPARATIONS AND DOSE.—A solution containing 10 volumes of oxygen is the one recommended by Sir B. W. Richardson ; the ethereal solution is preferred by others. Dose : of the former 1 to 4 dr. freely diluted ; of the ethereal solution ½ to 2 dr. For local use, a 4 p.c. solution, which may be diluted.

SULPHURETTED HYDROGEN—HYDROGEN SULPHIDE

(H_2S = 34). Not Officinal.

PREPARATION.—By decomposing any sulphide with an acid, ferrous sulphide and dilute sulphuric acid being generally employed. $FeS + H_2SO_4 = H_2S + FeSO_4$.

CHARACTERS.—A transparent, colourless gas of offensive odour (like bad eggs), about $\frac{1}{5}$ heavier than air. It is inflammable, burning with a pale-bluish flame, and is readily decomposed, sulphur being deposited. It is found free in nature in many mineral waters, in the emanations from volcanoes, as a product of the decay of albuminous substances, and of the decomposition of metallic sulphides. It precipitates metals from acid solutions, and hence is in frequent use as a test. Water absorbs about three times its volume of the gas, the solution being feebly acid.

PHYSIOLOGICAL ACTION.—This gas has antiseptic and germicide powers; it is highly poisonous to animal life when concentrated, and even when diluted with 600 to 1200 times its volume of air, it is fatal to the lower animals and to plants. Brouardel and Loye gave proportions of 2 per cent. and ½ per cent. with air to tracheotomised dogs, death occurring in three minutes under the stronger, and in seventeen to fifty minutes under the weaker mixture. The former was presumed to kill by paralysis of nerve centres, the latter partly by asphyxia; the pupils dilated and the conjunctivæ became insensible, the respiratory movements ceased for a time, but recommenced before death.

The gas has a destructive effect on the blood corpuscles, but the blood coagulates readily, and is found still to contain oxygen; its colour seen in thin layers is violet (Abst. Amer. Journ. (International), 1886).

The physiological action of sulphuretted hydrogen has a resemblance to that of hydrocyanic acid, but in fatal cases, which are most likely to occur from exposure to the confined gases of decaying animal matter, there are generally muscular tremors and frequently convulsion.

Extreme general depression, as well as local distension, has been connected with absorption of an unusual amount of the gas formed in the intestine. Dr. Schulz describes a soporific effect in animals confined under a bell-jar with definite proportions of the gas, and it is suggested that sulphonal, trional, etc., give off this gas in the body.

THERAPEUTICAL ACTION.—**Phthisis, etc.**—Mineral waters containing sulphides and sulphuretted hydrogen have long been used by inhalation and vapour, as well as by the stomach, in diseases of the respiratory tract. Dr. Bergeon of Lyons some years ago introduced a method of treating pulmonary tuberculosis by injection into the rectum of gaseous sulphuretted hydrogen diluted with carbonic acid. The gas is absorbed into the blood and excreted through the pulmonary mucous membrane. About 4 litres of carbonic acid mixed with 100 cubic centimètres of sulphuretted hydrogen, or an equivalent of natural sulphur water, were injected once or twice daily. Although good effects were reported from this treatment, and it attracted a good deal of attention, yet further trials showed that it was not

of much real value. Dr. Coghill spoke of it as "the greatest advance ever made in the therapeutics of pulmonary disease" (B. M. J., ii., 1886), and Dr. Burney Yeo and others reported some good results.

Chronic Bronchitis.—Chronic Rheumatism.—The waters already referred to, as Barèges, Aix, Harrogate, etc., are of well-known value in these diseases, applied locally in spray or bath, as well as taken internally.

ANTIDOTES.—Chlorine cautiously inhaled—artificial respiration (Brunton).

CARBO, CHARCOAL (C = 12).

Carbon is very widely distributed throughout all the kingdoms of nature. The *diamond* represents its purest condition, and is a crystallised form derived by a symmetrical geometric operation from a regular octahedron. *Plumbago*, or *graphite*, the "black lead" of our pencils, is another form which is nearly pure, and is sometimes crystalline, the crystals belonging to the hexagonal system. *Charcoal* is a third allotropic modification, and is non-crystalline. In the form of carbonic acid gas (CO_2) it occurs in the air and in many mineral waters, while as carbonates, such as limestone, it is very widely distributed over the earth's surface. Another compound with oxygen, carbon monoxide (CO), is a highly poisonous gas, and is formed to a certain extent during the combustion of charcoal; it does not form salts. Two varieties of carbon are now officinal, in the form of charcoal prepared from wood and from bones.

CARBO LIGNI—WOOD CHARCOAL.

PREPARATION.—Wood charcoal is prepared by burning wood in covered heaps or in closed vessels, in such a manner as to almost entirely prevents the access of air. The oxygen, hydrogen, and nitrogen of the vegetable substance are driven off, and about 20 per cent. of carbon remains with a small proportion of earthy salts—carbonates of potash and lime, etc. A pure charcoal may be obtained from the combustion of oils or resins with insufficient oxygen, and is known as lampblack. For medicinal use, either kind may be further purified by ignition in a closed vessel to a red heat.

CHARACTERS.—Wood charcoal occurs as a black powder, or in black brittle pieces, very light and porous, and retaining the

shape and texture of the original wood. It is distinguished from purified animal charcoal by leaving 1 or 2 per cent. of mineral ash, and by not sinking so readily in water.

CARBO ANIMALIS—ANIMAL CHARCOAL—BONE BLACK.

PREPARATION.—By exposing the bones of animals to a red heat without access of air. Thus prepared, it contains 10 to 20 per cent. of charcoal, the remainder being mostly phosphate and carbonate of lime, with the other mineral substances found in bone. It may be obtained from any animal substance, a good quality being procured from dried blood.

CARBO ANIMALIS PURIFICATUS—PURIFIED ANIMAL CHARCOAL.

PREPARATION.—By digesting bone black with dilute hydrochloric acid for two days in a warm place; filtering, washing, drying the residue, and igniting in a closed crucible. By these processes the salts are decomposed and rendered soluble, being removed as superphosphates and soluble chlorides, whilst carbonic acid and sulphuretted hydrogen gases are driven off.

CHARACTERS.—It occurs as a smooth, black powder, which has no odour and scarcely any taste, but possesses certain chemical and mechanical properties which are very useful in pharmacy. Wood charcoal is used as a deoxidising agent, as in the preparation of sulphurous from sulphuric acid (by distilling the latter with it), and the reduction of iodate to iodide of potassium. Animal charcoal is used as a decoloriser in the preparation of alkaloids, etc.; its power in this respect is such that diluted tincture of litmus will filter through it colourless. Warrington ascertained that it would remove the bitterness of hops and other vegetable infusions, and Dr. Garrod soon afterwards pointed out that it would destroy the activity of many organic poisons, as opium, aconite, and nux vomica, by absorbing them (Lancet, ii., 1845). Animal charcoal is much more powerful as an antidote in this way than that prepared from wood.

Both varieties possess great absorptive power, taking up many times their volume of gases (the amount varies with different gases), and may be used for purifying water by filtration, for the absorption of sewer emanations, and the deodorising of sick rooms, dissecting rooms, etc. A respirator containing a layer of charcoal has been recommended as a protective against poisonous gases (Stenhouse, Marcet).

THERAPEUTICAL ACTION. — *External.* — **Fœtid Discharges.**—Charcoal is used in surgery to cleanse and alter the condition of old and sloughing ulcers, suppurating sores and wounds, and is sometimes applied directly to them in the form of powder, or poultice with bread : to relieve offensive odours it is better enclosed dry in muslin bags and placed over the wounds. In open cancer a paste of soot with glycerine is a useful application. For offensive perspiration of the feet or axillæ, charcoal may be mixed with alum or zinc oxide and used as a dusting powder, but although an efficient, it is not a very elegant application. Alone or mixed with chalk it forms a cleansing dentrifice : it removes offensive odours if present, and is said to preserve the teeth by absorbing acids. Charcoal "pegs," made up with nitrate of potash, have been used as a cautery (Lancet, ii., 1866).

THERAPEUTICAL ACTION. — *Internal.* — For ordinary medicinal use, wood charcoal is commonly preferred.

Dyspepsia, Flatulence, etc.—It is very useful for patients suffering from pain, weight, and sense of fulness at the epigastrium, with flatulent distension, acidity, sour or bitter eructations, nausea or vomiting, furred tongue, foul breath, and with a tendency to loose, ill-formed motions. These stomach-symptoms are usually accompanied with palpitation.

The charcoal powder acts by causing oxidation and decomposition of the offensive products of fermentation and putrefaction. It should be perfectly fresh and taken dry, preferably at the commencement of a meal. The dose need not be so large as a teaspoonful, which is commonly given ; in many cases I have found 5 gr. sufficient. The tincture of nux vomica, in 5 m. doses, or subnitrate of bismuth and magnesia, of each about 10 gr., are sometimes advisable at the same time.

Diarrhœa.—Charcoal acts well in the diarrhœa of scrofulous children when the stools are small, slimy, and light-coloured, with intermediate troublesome discharge of flatus and itching of the anus ; also when the attacks have depended on irritation of the mucous membrane from undigested food, etc. : it may be well given with milk (Record, March, 1881). Rhubarb is often usefully combined with it.

Charcoal is also serviceable in the atonic irritative diarrhœa of old people, but intestinal hæmorrhage may occur after its use.

If large quantities be given, some may be retained, and act as a mechanical irritant, so that the remedy is not so innocent as commonly thought.

Dysentery.—Charcoal has been recommended in dysentery, and its antiseptic powers may be serviceable in chronic cases. The putrid smell of the discharges may be relieved by a few doses of 30 to 60 gr., but it returns on discontinuance of the remedy—the effect being a temporary chemical one. Dr. Farre has reported cases in which it has acted well when given in enema (Ranking, ii., 1862).

In **Enteric Fever** charcoal lessens the distension of stomach and intestines, and mixed with magnesia sometimes proves more beneficial; here also there is some risk of its causing hæmorrhage.

Cancer of Stomach—Gastric Ulcer.—In these organic diseases many of the distressing symptoms, such as flatulence, vomiting, and pain, may be relieved by charcoal.

Ascarides.—A daily dose of a mixture of charcoal and salt (a teaspoonful), given early in the morning, has been found useful in destroying, and preventing the development of these parasites.

PREPARATIONS AND DOSE.—*Of wood charcoal* many varieties are in use, some practitioners giving the preference to that made from heavy woods (box, acacia, etc.), others to the light woods (poplar or willow). Dr. A. Leared recommended that made from "vegetable ivory." Charcoal from the hæmatoxylon campechianum is good, but has been over-praised. Biscuits and lozenges of charcoal are used, but are not so effective as the powder; they sometimes irritate the stomach. *Carbo ligni:* dose, as antacid, antiseptic, or absorbent, 10 to 60 gr. or more. *Cataplasma carbonis* (charcoal poultice) is made with 2 oz. of crumb of bread and 1½ oz. linseed meal, and 10 oz. boiling water. *Carbo animalis purificatus* is to be preferred as an antidote to poisons: dose, from ½ to 2 oz. or more, according to the amount of poison swallowed: in ordinary cases, 20 to 60 grains or more: it is best taken suspended in water.

Gelatine capsules, each containing 4 gr. charcoal, and compressed tabloids, are also in use.

SULPHUR (S = 32).

This element occurs in the animal kingdom as a constituent of the albuminous (proteid) tissues, of bile, of cystin, etc., in vegetable proteids, in many essential oils and in resins, such as those of mustard, horse-radish, garlic, and asafœtida. In volcanic districts it is found native, and in many places it is met in com-

bination with metals as sulphides (copper and iron pyrites). United with hydrogen, as sulphuretted hydrogen (H_2S), or in the form of sulphides of the alkalies, it is found in many organic substances, especially during putrefaction, and in many mineral waters. With oxygen it forms sulphur dioxide (SO_2), the salts of which are called sulphites, and sulphur trioxide (SO_3), the salts of which are called sulphates.

CHARACTERS AND TESTS.—Sulphur occurs in commerce either as a gritty powder, or in round sticks (roll sulphur—brimstone), or in crystals; it is opaque and brittle, pale yellow in colour, of insipid taste, and emitting a peculiar odour if it be rubbed; it is inflammable, burning with a bluish flame and evolution of sulphur dioxide. It melts at 115° F.; at greater heat becomes amber-coloured, then brown, and gradually thickens until the containing vessel may be inverted without spilling it; is insoluble in water, slightly soluble in alcohol (absolute alcohol dissolves nearly 1 per cent.), in fixed and volatile oils, and bisulphide of carbon. Hydrochloric acid added to sulphur or its compounds causes evolution of sulphuretted hydrogen.

Officinal Forms.—Two varieties of sulphur are placed in the Pharmacopœia—the sublimed and the precipitated.

SULPHUR SUBLIMATUM—SUBLIMED SULPHUR—FLOWERS OF SULPHUR.

PREPARATION.—By heating native sulphur-earth, or any metallic sulphide, and condensing the volatilised sulphur in large chambers.

CHARACTERS.—Sublimed sulphur is a gritty powder, canary-yellow in colour, and possessing the characters of the element as already described. It may be acid in reaction from the presence of small quantities of sulphurous and sulphuric acids formed by slow oxidation, and should be freed from these by washing with distilled water, when it is known as "sulphur lotum."

SULPHUR PRÆCIPITATUM—PRECIPITATED SULPHUR.

Called also lac sulphuris (milk of sulphur), though this name was originally given to an old preparation containing calcium sulphate.

PREPARATION.—It is prepared from sublimed sulphur by boiling with slaked lime, until calcium sulphide and hyposulphite are formed: these

are soluble in water, and are separated from excess of lime by filtration; on adding hydrochloric acid to the filtrate, sulphur is precipitated as a fine powder, and should be dried at a heat of 120° F.

CHARACTERS.—A pure specimen is of pale yellow colour, without odour or taste, very smooth to the touch, not readily diffused in water; under the microscope it presents opaque rounded granules, separate or in clusters.

POTASSA SULPHURATA—SULPHURATED POTASH—HEPAR SULPHURIS.

PREPARATION.—By fusing together sublimed sulphur and carbonate of potassium.

CHARACTERS AND TESTS.—From its liver colour it was formerly called "liver of sulphur," but it rapidly absorbs oxygen from the air and becomes green and then dull white, sulphate of potassium being formed: it has an acid taste but alkaline reaction. It evolves sulphuretted hydrogen on the addition of any acid.

CALX SULPHURATA—SULPHURATED LIME—CALCII SULPHIDUM.

PREPARATION.—By heating together sulphate of calcium and wood charcoal.

CHARACTERS AND TESTS.—A nearly white powder, smelling of sulphuretted hydrogen. It should contain not less than 50 per cent. calcium sulphide (CaS), the remainder being unreduced calcium sulphate.

ABSORPTION AND ELIMINATION.—It has been stated, though not satisfactorily proved, that finely-divided sulphur may pass as such into the blood. Eberhard states further that he has seen it in the lymphatics, and Griffith that he has found it excreted in the urine, but these statements lack confirmation, and are not easy of credence.

It is more probable that, before absorption, under the influence of alkaline saliva and mucus, and the secretion of intestinal glands, alkaline sulphides are formed, part of which becomes decomposed in the intestine into sulphuretted hydrogen, and part oxidised, since the administration of sulphur increases the urinary sulphates (Regensburger, Cbl. f. med. Wiss., 1877). Of any ordinary

dose of sulphur a certain proportion passes out unchanged and unabsorbed in the fæces. Fatty substances are said to promote absorption of sulphur, though the experiments of A. Krause (1853) scarcely support this view. He found that when equal doses of sulphur were given either with or without fat, the amount of sulphates excreted by the urine was the same.

The sulphuretted hydrogen after absorption is eliminated by the skin, the bronchial mucous membrane, and by the various glands, giving indication of its presence by its odour and by staining silver articles worn about the person. Orfila detected it in the urine. In exceptional cases the gas may be absorbed from the intestine with production of marked but temporary nervous depression. In aged persons, and in some cases of hepatic and intestinal disorder, I have noticed attacks of depression coincident with flatulence and foul breath, and relieved by a stimulating purge; and Senator has recorded the case of an adult suffering from gastric catarrh, in whose breath and urine sulphuretted hydrogen had been detected, and who had more than one attack of collapse lasting for a few minutes and accompanied with pallor, giddiness, and small, quick pulse; he recovered after purgation (Berlin. klin. Woch., 1868).

PHYSIOLOGICAL ACTION.—*External.*—Simply dusted on the sound skin, sulphur has no irritant effect, but applied with friction, and especially if in the form of ointment or lotion, it causes a moderate degree of irritation; much more if the surface be excoriated. The alkaline sulphides, such as those of potash and of lime, irritate severely if used in strong and warm solution to a delicate skin. Sulphur and some of its compounds have the power of destroying the lower forms of vegetable and animal life; whence their practical value as "anti-zymotic and anti-parasitic" remedies. Binz attributes this power to the formation of *sulphurous acid* under the influence of exposure to the air, and to heat, and to contact with protoplasmic organisms (*e.g.*, the oïdium Tuckeri of the grape). The subject of disinfection is more fully considered under the heading of Sulphurous Acid.

PHYSIOLOGICAL ACTION.—*Internal.*—Given to animals, it produces at first some stimulant effect. Benk states that its after-effect is of reverse character, and that this is accompanied by, and is probably due to, intestinal irritation. Hertwig found also that

animals were readily brought under the influence of the drug with production of diarrhœa. After two 1 oz. doses of sulphur, a man got rigors, headache, T. 104 P. 120, fetid breath, contracted pupils, and sweating, with tympanitic abdomen and much pain vomiting and purging with blood—in brief, the symptoms of a strong irritant poison, but he gradually recovered (B. M. J., ii., 1888).

Circulatory System.—Sulphur and the sulphides, in moderate doses, stimulate the circulation, especially in the arterioles of the skin and mucous membranes, and the venous circulation within the pelvis. Congestive headache, vertigo, and sometimes hæmorrhage have been traced to the use of the drug and of mineral waters containing it. Gubler, Mitscherlich, and many older authorities are agreed upon these points, and assert further that a rise in temperature and distinct pyrexia may be caused by sulphur, especially in plethoric persons.

Secretion and Excretion.—Buchheim and some modern writers express doubts as to whether sulphur really increases secretion from the bronchial mucous membrane and the skin; but I cannot agree with them, for I have frequently seen an augmentation of these secretions under the use of this remedy. According to Boecker, the urinary water and solids are increased in amount under the action of sulphur, but this requires confirmation (Husemann).

Cutaneous System.—Some dark coloration and much irritation of the skin may occur from the internal use of sulphur. I have seen a red papular eruption from it, and also occasionally boils and carbuncles. The waters of Harrogate, Barèges, Aix-la-Chapelle, etc., have been known to produce such effects.

Digestive System.—The *sulphides*, in small doses, excite a sensation of warmth at the epigastrium; in excessive doses, they may cause gastro-enteritis, and even "insensibility and speedy death" (Ringer). Sulphur itself passes through the stomach unchanged, but in the duodenum a small portion is converted into alkaline sulphides, which act as irritants, and are the cause of the laxative action. Sulphurous waters in the quantity of several ounces often cause pain and oppression in delicate subjects. Doses of 20 to 40 gr. and upwards of sulphur in powder cause moderate stools, semi-solid in character, and passed with perceptibly increased peristaltic action;

hence it has been presumed that the muscular coat is mainly acted upon. Sundelin maintained that sulphur had a "specific" action on the mucous coat, but we cannot speak positively about this. The too prolonged use of sulphur as an aperient may induce intestinal catarrh.

Husemann holds the view that the unaltered and unabsorbed sulphur mechanically protects the intestinal mucous membrane like bismuth, and this would explain the fact that large doses relax without colic, whilst moderate doses relax equally but with some colic, and small doses cause pain without the relaxation.

SYNERGISTS.—As a stimulant, sulphur is aided in effect by the volatile oils; as an alterative, it has analogies with arsenic, phosphorus, and possibly iodine (Gubler); as an aperient, magnesia and the acid tartrate of potash assist its action.

Antagonists.—Sedatives, refrigerants, astringents, and cold oppose the ordinary action of sulphur; quinine and bromides have a specially antagonistic effect.

THERAPEUTICAL ACTION.—*External.*—**Parasitic Skin-Diseases—Scabies.**—Sulphur is one of the substances which are fatal to acari, and it still remains one of the best, as it is the commonest remedy for scabies, though Dr. McCall Anderson and others have objected to it as too irritant.

It is nearly certain that sulphur, when used by itself or mixed with lard, has simply a mechanical effect on the epidermis, but when carbonate of potash is added to the ointment, *sulphurated potash* is formed, and this compound quickly destroys the acari. We know, from clinical observation, that these insects often live in the plain sulphur ointment for several days, without much apparent detriment, whilst, as Kuchenmeister says, "the acari, kept in a solution of sulphurated potash, die in a quarter of an hour." When applied to the skin, therefore, sulphur probably acts only after combination with the secretions.

The strength and the frequency of the application should be varied according to the delicacy of the patient's skin and the amount of the eruption; the more active the preparation, and the more thorough its use, the quicker will be the cure. Thus, painting the body with a solution of chloride of sulphur in bi-sulphide of carbon (12 parts in 100) is said to cure in five minutes (Med. Times, i., 1856); whilst Bourguignon's formula with lime

and sulphur is allowed half-an-hour. This is prepared by boiling 1 part of quicklime with 2 parts of sublimed sulphur in 20 parts of water, boil to 10 parts and filter, it is rubbed into the skin for half-an-hour, and one pint is sufficient for each time. M. Hardy's method with soft soap frictions, warm bath, and anointing with 2 parts of sulphur to 8 of lard and 1 of potash carbonate, effects its purpose in four hours (Brit. and For. Rev., ii., 1852); but such results are liable to be accompanied with unnecessary irritation and pain to the patient. Dr. Tilbury Fox, having seen eczematous eruptions and chronic irritation often induced by the excessive use of too strong an ointment, and founding his advice on observation of the parts usually affected, advocates the use of a mild ointment (1 part in 16, *i.e.*, ½ dr. to the ounce of lard) *to the wrists and between the fingers only*, in acute cases accompanied with general irritation (Lancet, ii., 1871); but, as Hebra and Dr. R. Liveing observe, the restriction of the application to a *few portions* needs very exact diagnosis, and, as a rule, the ointment of the selected strength should be applied to every part. A prolonged warm bath, lasting half-an-hour, and thorough cleansing with soap and friction, should precede the inunction; then, after drying, either the mild ointment of Fox, or the simple ointment of the Pharmacopœia (1 part in 5), or one of intermediate strength (1 part in 8, with ½ part of potash carbonate) should be plentifully rubbed over the trunk and the limbs, especially the flexor side of the limbs and between the fingers and toes; and then socks, gloves, drawers, and jersey should be used to keep the ointment in contact with the skin (Liveing). An ointment I commonly prescribe is made with sublimed sulphur, 2 dr.; sulphide of calcium, ½ dr.; and simple ointment, 2 oz. After a night's application, a warm bath in the morning may be used to remove the odour of sulphur, but then a second or third inunction may be required; if the first one can be left undisturbed for twenty-four hours, it will often suffice to cure. In some cases a lotion of sulphuret of calcium (liquor calcis c. sulphure) acts better, because it is more thoroughly applied than an ointment; its use should also be preceded by a warm bath, and it need only be *gently* applied with a sponge or brush; if used with friction it may cause very severe irritation. Dr. Dolan speaks highly of this application (B. M. J., i., 1884).

A sulphur-*bath* is not so efficacious as these remedies, but may sometimes be required, and may be made with half a pound of sulphurated potash to thirty gallons of water—or with sulphur, hyposulphite of soda, and acid (*v.* Preparations). Wooden or porcelain vessels should be used for the baths, of which several will be required. Sulphur in vapour may also be employed (*ib.*). Friction with dry precipitated sulphur, the same being sprinkled on the bed-clothes is said to be effective, in conjunction with ordinary warm baths (N. Y. Record, 1890).

It is important to remember that irritation of skin may remain even after the scabies itself is cured, and this irritation is to be treated by soothing remedies; sulphur is not to be continued longer than is absolutely necessary for the destruction of the parasite. Sometimes it may be altogether contra-indicated, or may be inconvenient, and then recourse may be had to styrax, tolu, petroleum, or iodide of potassium; but in most cases the preceding method will give satisfactory results.

Tinea Tonsurans—Tinea Versicolor.—The parasites in these maladies are curable by sulphur applications, but a compound ointment containing ammoniated mercury acts better than simple sulphur ointment (Ung. hydrarg. ammon., with an equal part of Ung. sulphuris, is a good formula).

Sycosis Mentagra ("Barber's Itch").—In this disease, Hebra advises that the affected hairs should be pulled out, the chin well shaved every day, and a paste containing sulphur, glycerine, and alcohol, in equal parts, rubbed over the diseased skin every night and morning; by this means a cure is rapidly effected, but it is rather severe treatment. It is specially adapted for the parasitic form, but is useful also in the more common one, because sulphur lessens pus-formation.

Prurigo.—In chronic prurigo—especially when connected with phtheiriasis, but also in independent forms—an ointment containing sulphur with a preparation of tar is often of much service. Dr. McCall Anderson recommends 6 dr. of pix liquida in 4 oz. of ordinary sulphur ointment (Lancet, ii., 1869). Sulphur vapour baths are useful. In ordinary pruritus I find a lotion of sulphurated potash very effective.

Eczema—Psoriasis.—When eczema occurs as a complication of scabies, Hebra joins with the sulphur an equal quantity of tar

and half the quantity of chalk; and there are some stages of idiopathic eczema when sulphur acts as a useful stimulant, viz., when the eruption is on the *decline*, but remains in obstinate chronic patches, especially about the legs. It acts best in lymphatic constitutions; but, as a rule, I prefer potash or tar applications to sulphur. I may say the same as to my own experience in chronic psoriasis, but compound sulphur ointments have been found useful in this malady. Dr. Wetzler states that ordinary psoriasis, when not much developed, can be cured by Aix-la-Chapelle waters alone, if prolonged baths can be borne. In very extensive and obstinate cases, however, he adds iodide of potassium to the water, and prescribes in addition sulphurous vapour baths, tar-frictions, etc., and it is stated with the best results.

Acne.—With the exception of scabies, acne is the skin-disease in which sulphur is most frequently used and gives the best results; the degree of stimulus or irritation supplied by it seems more appropriate than that of any other application, unless it be sometimes mercury. In the *simple acne* of young people, occurring in the sebaceous glands about the face and shoulders, accompanied by comedo and without much general congestion, a fairly strong preparation may be used, such as the sulphur ointment of the Pharmacopœia; or potash may be added to it, or a lotion containing 6 dr. of precipitated sulphur and 1 dr. of glycerine, with 6 oz. of rectified spirit (Anderson); such preparations no doubt kill the demodex folliculorum, a parasite, the presence of which sometimes complicates acne. When a moderate degree of irritation is present the proportions may be altered; thus, 1 dr. of sublimed sulphur may be rubbed up with a little alcohol, and then 2 dr. of the smoother variety may be added, with water to dilute sufficiently (Morris, Lancet, i., 1855); or a lotion that I commonly use with advantage is made with 2 to 4 dr. of precipitated sulphur, with the same quantity of spirit and glycerine, in 6 oz. of rose water. Spirit of camphor or ether may be added to relieve itching or heat, and special indications for internal treatment must be considered. Sometimes *dusting* with the pure dry precipitated sulphur answers better than anything (Parsons, B. M. J., i., 1879). The local remedies should be lightly or firmly applied, according as they can be borne, left in contact all night, and washed off with mucilaginous decoctions, or water in the morning.

For *acne rosacea*, one of the best applications is an ointment containing 2 dr. of the hypochlorite of sulphur in the ounce of rumex ointment (Wilson), or a lotion of ½ oz. of sublimed sulphur in 4 oz. of elderflower water. The officinal ointment of *iodide of sulphur*, which is still stronger, may be carefully used to chronic cases of any form of acne. A certain amount of temporary irritation must be expected from these remedies, and may require their occasional intermission, and the use of sedatives; but some compound of sulphur, judiciously employed, will be found the most effective cure. The internal use of calcium sulphide should be conjoined with this treatment.

The old-fashioned "balsam of sulphur," made by boiling with oil, is also an effective remedy in many of the skin affections mentioned; it should be diluted with 4 to 8 of simple ointment, and the odour masked with lavender.

Rheumatism.—The friction of rheumatic limbs with sulphur is as ancient at least as Pliny (Lib. xxxv.), and attention was specially directed to it again some years ago by Dr. Fuller, Dr. O'Connor, and others (Med. Times, i., 1858). They found it useful also in sciatica and lumbago, adding to the frictions close and constant covering with flannel. Rénard found it very serviceable in rheumatism affecting tendinous parts, in his own person, after an acute attack; it produced some degree of heat and increase of perspiration when it acted well. It should certainly be tried in all obstinate forms of rheumatism, and especially that form which attacks the soles of the feet in those who are exposed to damp and cold.

It is in the different forms of chronic rheumatism and chronic skin-disease that baths of sulphurous waters, as at Barèges and Aix-la-Chapelle, are found most valuable.

THERAPEUTICAL ACTION.—*Internal.*—The therapeutical action of sulphur and the sulphides is somewhat similar, but the former is commonly used in small doses to produce an "alterative," and in large doses a laxative effect, and the latter to modify some acute conditions, especially when they are connected with suppuration in various stages.

Skin-Disease.—The *internal* use of sulphur for many skin-diseases rests on an old tradition, but is not much adopted in modern practice. I have tried it extensively, and although the

alkaline sulphurous waters are useful sometimes, and in *acne rosacea* the calcium sulphide in $\frac{1}{4}$ to $\frac{1}{2}$ gr. doses thrice daily, seems to help absorption of the tubercles and abate venous hyperæmia, yet with these exceptions, I have not seen much advantage. Dr. Cane refers to sixteen cases of acne in which the last-named remedy was useful (Lancet, ii., 1878).

Scrofula—Swollen Lips, Glands, etc.—Scrofulous children are often disfigured by a chronic swelling of the upper lip and alæ nasi, which may be connected with a crack or fissure on the inner surface of the mucous membrane. Accompanying this condition, there often exists a tendency to dyspepsia, and indolent swelling of the mesenteric, cervical, or other glands.

Although we cannot wholly cure the constitutional tendency in such cases by sulphide of calcium, yet I have seen their general condition greatly improved by $\frac{1}{4}$ gr. doses given night and morning for a few weeks—the fissure has healed and the lip-swelling subsided, and the glands have grown less.

In cases where pus has actually formed in some of the glands, the effects of this remedy may readily be traced in the subsidence and disappearance of some of the swellings, whilst others progress quickly, maturate and discharge, and others that have been open and discharging unhealthily for some time, take on healthy action and ultimately contract and heal. For permanent good results this treatment should be followed up by cod-liver oil and generous diet, and if possible change to the seaside. As a rule frequent doses of the sulphide are not desirable, as they are apt to derange the stomach and cause eructation of sulphuretted hydrogen.

Scrofulous Ophthalmia, etc.—In this affection I can recommend sulphide of calcium, and especially when ulceration of the cornea is present; it also acts well in scrofulous otorrhœa, and in almost all purulent discharges occurring in children, even if fœtid and obstinate in character.

Suppuration.—Calcium sulphide exerts a marked influence on the formation of pus. If given early it controls the inflammatory process, *e.g.*, in tonsillitis, either aborting it so that it does not go on to suppuration, or if this takes place, controlling and limiting its extent, promoting a more healthy formation, quicker evacuation, and more rapid subsequent healing: this observation

is much more generally accepted now than when first published some years ago.

In the treatment of simple *abscess* I have frequently used it with much advantage; in tonsillar abscess (quinsy) it is particularly valuable, and may save recourse to incision; and in mammary abscess, if the time for belladonna or antimony is past, the sulphide is the best remedy. It has seemed to me to check the spread of the inflammation, and to help to evacuate matter quickly, and so shorten the tedious course common in this malady. Should hardness and pain continue after an opening has formed, and should the discharge come away incompletely, the remedy must still be continued, as it is likely to exert a favourable influence.

In *bubo*, especially if indolent, and with scanty, unhealthy pus-formation, the sulphide will often determine a more healthy action; $\frac{1}{4}$ to $\frac{1}{2}$ gr. in pill every three or four hours is a suitable dose.

In ordinary *boils*, and in *carbuncles*, a compress moistened with sulphide of calcium lotion—(4 to 6 gr. to the pint of water)—should be applied. When eruptions of boils recur at intervals, I commonly advise a course of the precipitated sulphur—5 to 10 gr. night and morning—for several weeks during the intervals, but at the time of actual maturation, recommend the sulphide as acting more quickly: $\frac{1}{4}$ grain taken every two hours for six or seven doses often arrests the formation of a commencing boil. This is best given as a powder triturated with sugar of milk, and the powders must always be freshly made. Even in *pneumonia*, in those exceptional cases when the exudation in later stages degenerates into pus, I have seen benefit from the same remedy: it has also seemed to assist evacuation of matter already formed, and to check any tendency to its further formation.

Syphilis.—In most of the later manifestations of this disorder, sulphurous waters have a good reputation, but in my opinion without sufficient reason. At Aix-la-Chapelle, for instance, the treatment is conducted mainly by mercurial inunction, and the sulphur waters used locally and internally can only be considered adjuvants to this more powerful remedy. I think they serve mainly to cleanse and stimulate the skin, to regulate the action of the bowels and viscera, and to counteract any injurious effects that might arise from the mercury (*v.* Baths).

I must say also that I have seen advantage from the use of sulphide of calcium in *syphilitic laryngitis*, notably when mercury had been previously taken to saturation.

Diphtheria.—During certain stages of this malady, preparations of aconite, iron, iodine, bromine, etc., are indicated, as described under those medicines, but at the time when pus is commencing to form, and the false membrane is becoming somewhat loosened from the mucous surface, the sulphide of calcium is often useful, for it exerts the action already referred to, of assisting the healthy completion, and at the same time limiting the extent of the suppurative process. We know that this formation of pus-cells occurs as part of the diphtheritic inflammation before the return of healthy conditions, and as remarked by Mackenzie (who does not, however, mention this remedy), "when it is found impossible to check the formation of lymph it is rational treatment to convert, as far as we can, the inflammatory into a suppurative process" (On Diphtheria, 1879). If commenced early in this stage in doses of $\frac{1}{10}$ to $\frac{1}{4}$ gr. every one or two hours it produces the best effects, but it is useful also even if begun after pus-formation is fully developed, and I believe it has some influence in lessening blood-poisoning. The value of steam-inhalation in helping on the natural changes of diphtheria and the formation of muco-pus and loosening of the membranes has been often proved, and is now well known. I find it still more efficacious if the sulphide of calcium be added to the boiling water in the proportion of about 4 gr. to the pint, so that a certain amount of sulphurous vapour is locally applied.

The local insufflation of finely-powdered sulphur has been credited with arresting the development of diphtheritic exudation (Pract., Nov., 1868), but has disappointed expectation. Experience teaches that it acts only as a "scouring powder," wearing off the membranes by friction; it has no influence at the onset of the malady, but has seemed to answer when purulent infiltration and fibrinous exudation have already ceased; then it has an antizymotic power, but only in so far as it forms alkaline compounds and becomes dissolved in the secretions, while it is liable to cause irritation (B. M. J., i., 1879). Mr. Stuart has, however, written in favour of local applications of precipitated sulphur. "It is best applied, after being rubbed up with a little water, on a

swab to the affected part, and is more safe in this manner than by insufflation" (Pract., Oct., 1879). He states that six cases treated with sulphur made a rapid recovery, but this is too small a number from which to draw reliable conclusions.

The sulphide of calcium solution is said to be very effective in spray frequently used to the throat—for children it may be diluted (*ib.*, i., 1889).

In **Laryngo-tracheal Diphtheria (Croup),** where we cannot always see the false membrane, I find the sulphide of calcium treatment indicated if wheezing, rattling sounds accompany the breathing, *i.e.*, when the membrane begins to be loosened, rather than in the first stage when the breath-sounds are of a dry and sawing character.

Chronic Sore Throat.—Dr. Guéneau de Mussy has specially pointed out the value of sulphur waters in glandular angina, which under ordinary treatment is an obstinate malady. The waters of Eaux Bonnes are of remarkable efficacy in such cases; the sulphurous acid spray is also useful if not too irritating.

Scarlet Fever.—Mr. Pigeon believes that in sulphur he has found the true remedy for this fever; he anoints the patient twice daily with sulphur ointment, gives 5 gr. of sulphur by the mouth twice daily, and fumigates frequently with sulphur vapour (Lancet, ii., 1876). More extended observations have shown, however, that it is not a true specific for scarlet fever, and this method of treatment, though it may sometimes be followed by good results, is now seldom employed. In *variola*, sulphide of calcium, I believe, often moderates excessive suppuration.

Asthma—Chronic Bronchitis.—In cases with much cough and profuse secretion, sulphur will often relieve, lessening and modifying the expectoration: I have seen this in many instances. The old physicians described it as "balsamum pectoris," and it still forms part of some quack "nostrums." Dr. Graves records his experience in its favour. Binz suggests that sulphuretted hydrogen being excreted by the bronchial mucous membrane may partially narcotise the terminals of irritated bronchial nerves, and advocates for the continued use of small doses of sulphur in asthma are not wanting (Duclos, Bull. Thérap., 1861). I have seen cases marked by loud wheezing, profuse but difficult expec-

toration, troublesome palpitation, and nocturnal spasms of severe dyspnœa, improve quickly with 5 to 10 gr. of sulphur taken thrice daily. The sulphur springs of Weilbach are celebrated for relieving cases of chronic bronchitis, especially when complicated with hæmorrhoids.

Phthisis.—Sulphur was well known to the ancients as a remedy in consumption, and Galen ordered to phthisical patients inhalation of the vapour from the crater of Etna. It is not much used internally in modern practice, but for chronic phthisis the springs of Weilbach have a favourable reputation.

Sutro finds sulphur of good service in some cases of phthisis, and the presence of hæmorrhoids is one indication for it; he suggests that it combines with the iron of effete blood-corpuscles, quickens the elimination of this and other residua, and thus relieves the portal system and indirectly the lungs (Med. Times, i., 1862), and, although I do not accept this theory of its action, I agree with those observers who have noted much advantage from the use of sulphur both internally and by inhalation in this disease. Dr. Dewar relates instances where sulphurous acid and steam acted unexpectedly well on phthisical subjects exposed to them (Med. Times, i., 1867). A spray containing sulphurous acid facilitates expectoration, and also disinfects and lessens purulent secretion, and so far relieves certain symptoms, but has no specific power over the disease.

Chronic Rheumatism.—Sulphur frictions for rheumatism have been already mentioned, and the drug was formerly considered a good internal remedy for chronic muscular and articular pain, and no doubt it is often of value when given in doses of from 5 to 20 gr. twice daily for some time—I think the smaller doses give the better results. Remedies calculated to produce diaphoresis, such as vapour baths, should be generally combined with its use. In acute articular rheumatism it has little or no power, but Sir A. Garrod has recently spoken well of it in chronic rheumatic arthritis (Lancet, i., 1889).

Mercurial Tremor—Mercurialism.—In cases of palsy and tremor connected with the action of mercury, sulphur is useful (Lettsom) and deserves trial; it is said also to neutralise acute mercurialism accompanied with salivation, etc., and may be given in 5 to 10 gr. doses at the same time as chlorate of potash.

On the other hand, in patients who have taken mercury at some previous period, sulphur, like iodides and other powerful alteratives, has sometimes produced a fresh salivation.

Lead Colic—Lead Palsy.—In these conditions sulphur has been found available, as it lessens reabsorption of the lead from the intestine, but iodide of potassium is now proved to be a better remedy. In an epidemic of lead-poisoning at Havre, M. Marguerette found sulphur give much relief; it required to be exhibited at first in very large doses (50 grammes the first day), these being afterwards gradually diminished as the symptoms improved (Bull. Thérap., 1867).

Hepatic Disease.—Chronic enlargement of the liver, with obstruction to the portal circulation, accompanied as it usually is by hæmorrhoids, is often much benefited by a course of sulphur, or of calcium or potassium sulphide.

Constipation—Hæmorrhoids.—The mild action of sulphur renders it a useful aperient for children and delicate persons, especially if there be congestion about the rectum or pelvic viscera. In cases of hæmorrhoids it is one of the best laxatives, and if not powerful enough may be combined with bitartrate of potash, or with confection of senna. In cases of fissure of the anus, active purgatives not being admissible, sulphur is exceedingly useful. It may also be used as a remedy for constipation in cases of stricture or prolapse of the anus. The compound lozenge or compound liquorice powder of the B.P. is probably the best form for administering it. In the treatment of piles sulphur need not be given in quantity sufficient to produce a laxative effect, unless this is otherwise required, for it can relieve by virtue of its stimulant and tonic action on the venous and capillary circulation of the rectum and pelvic viscera without any direct aperient action. The ordinary dose should be 5 or 10 gr. morning and night. Weak sulphur ointments locally applied increase the good result. The remedy may also be used in the form of vapour, and if the fumes from burning sulphur can, by means of apparatus, be applied directly, they often relieve congested, painful, and bleeding piles—this is a popular domestic "cure" in some parts of the country. Dr. Thorowgood attributes to sulphur a special value in torpor of the colon, which often causes or complicates dyspepsia; he recommends 10 to 20 gr.

to be taken in the early morning with nux vomica; the lozenges of Holsverck contain the same ingredients (Lancet, i., 1869; Times, i., 1858); and Sir A. Garrod speaks highly of trochiscus sulphuris, which he considers to form a soluble sulphide in the duodenum rather than in the stomach (Lancet, i., 1889).

Diarrhœa—Dysentery—Cholera.—Dr. Blacklock, of the Madras army, and Dr. Graves quote an extensive experience in favour of the efficacy of sulphur in these maladies; the latter observer combines it with soda and spirit of lavender, and in severe cases with opium (On Cholera, 1865). Mr. Prosser also finds drachm doses given with mucilage to be "one of the best remedies in epidemic diarrhœa and cholera" (Lancet, ii., 1866). This is not a general experience, nor is it mine, although I have found sulphur in 2 and 3 gr. doses useful in the fœtid, watery diarrhœa of scrofulous children; also in some cases of chronic dysenteric diarrhœa with tenesmus.

Disorders of Generative Organs.—Sulphur has been useful in cases of sexual irritation arising from hæmorrhoidal congestion, and when the menses are delayed in weakly and phlegmatic persons, it has, when used as an habitual laxative, some influence in bringing on the flow. On the other hand, it has been recommended for relieving uterine congestion and its consequences at the climacteric period (Tilt).

Ascaris Vermicularis.—Precipitated sulphur is often a simple and efficient remedy for these parasites; 5 to 10 or 15 gr. should be given daily, morning and night, for some weeks.

PREPARATIONS AND DOSE.—*Precipitated sulphur* is more finely divided, and is thought to be more active, than the sublimed form; the dose of either is, however, the same—5 to 10 gr. as a stimulant, 20 to 60 gr. as a laxative; it is well given in milk, honey, or treacle. From precipitated sulphur a *trochiscus sulphuris* is made containing 5 gr. with 1 gr. acid tartrate of potash. The other officinal preparations are made from sublimed sulphur, and are *unguentum sulphuris* (1 to 4 benzoated lard): *Confectio sulphuris*—dose, 60 to 120 gr. as laxative, 5 to 20 gr. as alterative; *pulvis glycyrrhizæ compositus* (sulphur, liquorice, fennel, senna, and sugar)—dose, 30 to 60 gr. (calcium sulphide) *calx sulphurata*—dose, $\frac{1}{10}$ to 1 gr. in pill. *Potassa sulphurata* is not given internally. The *unguentum potassæ sulphuratæ* (30 gr. to 1 oz. hard and soft paraffin) is the only officinal preparation. An apparatus for vaporising sulphur for inhalation is described by Adams (Lancet, ii., 1891).

A solution of lime with sulphur (liquor calcis c̄ sulphure) may be prepared

by boiling together 1 oz. quicklime and 5 oz. sublimed sulphur in 1 pint water for half-an-hour. Filter and make it measure half a pint.

Sulphurated potash may be used as a lotion, 1 dr. to half a pint of water; and as a bath, ½ lb. to 30 gallons of water in a porcelain or wooden vessel.

The *balneum sulphuris compositum* (Startin) is—Precipitated sulphur 2 oz., hyposulphite of sodium 1 oz., dilute sulphuric acid ½ oz., water 1 pint; to be added to 30 gallons of water. A sulphur vapour bath may be prepared by evaporating ½ to 2 oz. of the solution of lime and sulphur by means of a spirit-lamp placed under a suitable arrangement of chairs and coverings; the face should be protected from the vapour.

A disinfecting preparation called "Thiocamf" owes its properties mainly to sulphur dioxide gas which forms a liquid when brought in contact with camphor. If exposed to the air in thin layers, very large volumes of the gas (impregnated with other disinfectants) are given off, and diffuse through every part of a well-closed room (Dr. E. Reynolds, B. M. J., ii., 1889). Liquid sulphur dioxide has recently been introduced in sealed tin canisters of which each one evolves on opening about 28 cubic feet of gas, being sufficient for fumigation of an ordinary room (B. M. J., i., 1893).

ADULTERATIONS.—The precipitated sulphur commonly sold, especially before the passing of the Adulteration Act, contained a large proportion of sulphate of lime; this was due to the employment of sulphuric acid instead of the hydrochloric acid ordered in the Pharmacopœia, but, as some excuse, it may be mentioned that a former London Pharmacopœia contained a preparation made with sulphuric acid, and known as "milk of sulphur." This name has now been transferred as a synonym to the modern "precipitated sulphur," and hence has arisen much confusion and litigation. Druggists have been prosecuted for supplying the lime compound when asked for "milk of sulphur," and although convicted by some magistrates of offences against the Act, the convictions have mostly been quashed on appeal to a higher court, on the ground that "milk of sulphur" is known by trade custom to be a distinct thing from the pure precipitated form. It is desirable that this should be particularly understood (B. M. J., i., 1877; Lancet, i., 1876). As a rule, a pure preparation may be obtained by asking for that of the B.P. An adulterated specimen is whiter, with only slight yellowish tinge, and when pressed looks silky and glistening: under the microscope, crystals may be seen in thin tables or elongated prisms, and on exposure to a red heat, lime is left as a white ash (Med. Times, i., 1853). Washed Sicilian sulphur is nearly always pure,

but that prepared from pyrites often contains arsenic. Water, after agitation with sulphur lotum, should not redden blue litmus paper, showing that no free acid is present.

PHOSPHORUS (P = 31).

This non-metallic element was obtained in the seventeenth century from the urinary phosphates by Brandt of Hamburg, and by Dr. Boyle in this country. London was, for some time, the principal place of its manufacture, so that it became known as "phosphorus anglicanus." It does not occur free in nature, but may be obtained from its compounds in two allotropic modifications, namely, as yellow and red phosphorus. It forms with oxygen two compounds, phosphorus trioxide (P_2O_3), and phosphorus pentoxide (P_2O_5). The latter combines with water in different proportions to form two distinct acids known as metaphosphoric (HPO_3) and orthophosphoric (H_3PO_4). A third acid, pyrophosphoric ($H_4P_2O_7$), is prepared from orthophosphoric acid by the action of heat. All these acids form salts, the ordinary phosphates being compounds of orthophosphoric acid.

Phosphorus occurs in the bodies of animals, especially in the bones and in nervous tissue; phosphates are also found in the blood and urine. It occurs in bone chiefly as calcium phosphate, which constituent is most abundant in the bones of young animals.

Animals obtain the phosphates necessary for the formation of their tissues from plants, especially from their seeds. Plants again draw their supply from the soil, whilst soils derive their phosphates from manure, also from small quantities existing in the oldest granite rocks, by the disintegration of which the fertile soils have been produced.

Phosphorus oxide has been obtained as a white wax-like solid, which is slowly soluble in water, and the action of the drug has been attributed to this (Lancet, ii., 1890).

Phosphorus trioxide combines with water to form phosphorous acid (H_3PO_3), the salts being known as phosphites.

Hypophosphorous acid (H_3PO_2) combines with bases to form hypophosphites. The anhydride has not been isolated.

Three compounds of phosphorus and hydrogen are known, of

which the symbols are PH_3, P_2H_4, P_4H_2. The first of these is a poisonous gas called phosphuretted hydrogen, which has the odour of putrid fish. None of these have any therapeutical interest.

PREPARATION.—It is now procured from bone ash (os ustum), by digesting it with dilute sulphuric acid. By this means a white precipitate of calcium sulphate is formed, whilst the greater part of the phosphorus in the bones enters into solution as calcium hydrogen phosphate (superphosphate of lime). This liquid is drawn off, mixed with charcoal, thoroughly dried, and then distilled in an earthenware retort; during the drying the calcium superphosphate is converted into metaphosphate, and this is decomposed by the carbon as shown in the equation $3Ca(PO_3)_2 + 10C = P_4 + Ca_3(PO_4)_2 + 10CO$. Two-thirds of the phosphorus distils over and is collected under water; the remaining third is got by adding sand (silicic acid), which combines with the lime and sets free the phosphoric acid to be decomposed by the charcoal. Phosphorus may be purified by redistillation, and is then cast into cakes, sticks or pencils.

CHARACTERS.—The cakes or pencils are colourless, white and translucent when fresh, but on exposure become coated with an opaque layer of crystals, which may be white, yellowish, or sometimes red from the formation of an allotropic variety of phosphorus. Phosphorus oxidises so easily that it needs to be kept under cold water, in which it is practically insoluble; in ether, turpentine, and oils, it is soluble to a great extent; in rectified spirit it is but slightly so (1 part in 320); in chloroform, 1 part in 100; but in bisulphide of carbon it is wholly soluble. ("Fenian Fire" is the term given to a very inflammable solution in this liquid, containing 70 per cent. phosphorus.) Naunyn states that phosphorus is very slightly soluble in water at 96° to 104° F.; it is more soluble in organic fluids. The element is soft and flexible at ordinary temperatures, melts at 110°, and takes fire at a little over that point; it is luminous in the dark, and, when exposed to air, gives off white vapours of phosphorous acid, exhaling an odour *sui generis*, which has been compared to that of garlic.

On exposure to sunlight or to heat without access of oxygen, it is converted into red or "amorphous" phosphorus—a brittle powder which is not acted on by the air, and is insoluble; when volatilised, this reverts to the ordinary form.

Amorphous phosphorus has been, by some observers, credited with physiological activity. Thus, Bednar used it for a long period in small doses, and observed symptoms of excitation,

trembling and clonic convulsions; but as much as 1 oz. has been given to dogs without perceptible effect. Thompson, in twelve carefully-observed cases, found its action *nil*, and plausibly attributes its supposed powers to a slight admixture of ordinary phosphorus (Pharm. Journ., 1875). I believe it to be practically inert, and the following observations will refer only to the ordinary form.

Zinci Phosphidum—Phosphide of Zinc, PZn_3 (not officinal). A greyish friable substance, having a lustrous crystalline fracture, stable at ordinary temperatures, readily decomposed by weak acids, almost tasteless, but possessing active properties like those of phosphorus.

COMPOUNDS OF PHOSPHORUS.

CALCII HYPOPHOSPHIS—HYPOPHOSPHITE OF CALCIUM.

$Ca(PH_2O_2)_2 = 170.$

PREPARATION.—By heating phosphorus and nearly twice its weight of calcium hydrate with water until phosphuretted hydrogen gas ceases to be evolved, filter, precipitate excess of lime with carbonic acid gas, evaporate, and crystallise.

CHARACTERS AND TESTS.—A white crystalline salt with a pearly lustre and a bitter nauseous taste. Soluble in six parts of cold water, insoluble in cold rectified spirit. Heated to redness, the crystals ignite, evolving spontaneously inflammable phosphuretted hydrogen. Its aqueous solution gives a white precipitate with oxalate of ammonium, and also with perchloride of mercury.

SODII HYPOPHOSPHIS—HYPOPHOSPHITE OF SODIUM.

$NaPH_2O_2 = 88.$

PREPARATION.—By adding carbonate of sodium to solution of hypophosphite of calcium, filter, and evaporate filtrate with aid of heat.

CHARACTERS AND TESTS.—A white granular salt with a bitter nauseous taste, deliquescent, very soluble in water and in spirit. It ignites at a red heat, emitting spontaneously inflammable fumes of phosphuretted hydrogen. Its solution gives a white precipitate with nitrate of silver.

ABSORPTION AND ELIMINATION.—Phosphorus taken by the mouth, and especially when finely divided or dissolved, is absorbed into the blood under the influence of alkaline, albuminous, or

oleaginous materials which it meets in the stomach and intestine: the amount and the rapidity of its absorption are proportionate to the amount of such materials, and especially of fats, which are its *best* solvents. The exact condition in which it circulates is still a subject for discussion; according to varying circumstances some portion may pass into the blood *unaltered* (Orfila, etc.), another oxidised, as hypophosphorous, phosphorous, or phosphoric acid (Frerichs, Munk, and Leyden, etc.), and a third portion as phosphuretted hydrogen (Lecorché, Archives de Physiologie, 1-2). It has been found in each of these forms in certain cases of poisoning, though in other cases none at all has been detected.

Portions of unabsorbed phosphorus pass sometimes with the fæces, rendering them phosphorescent, and the urine has presented a similar appearance: the element has also been found in a free state in the liver, ten hours after death (Dybkowsky)—it is eliminated by it, and by the other glandular organs, by the skin, and by the lungs. In one case of fatal poisoning, phosphorus paste seems to have been applied on the hands and face only (Lancet, i., 1890).

PHYSIOLOGICAL ACTION.—*External.*—When applied in the solid form phosphorus has been known to catch fire on the skin, and, indeed, has been used as a moxa; it is liable to cause very troublesome sores and even gangrene, and the same results may follow its use in ointment. In certain experiments on *dogs*, however, when pieces of the element were placed in the cellular tissue they remained unaltered, and no inflammation was excited, yet the animals died in a few weeks from phosphorus poisoning; whilst, on the other hand, rabbits and some other animals treated in the same way did not show either local or general symptoms; also a dog swallowed a stick of phosphorus, which was afterwards found in an abscess, without other symptoms of local irritation. Hence it is clear that pure phosphorus does not necessarily act as a local irritant. The fumes cause irritation, catarrh, and even inflammation of mucous membranes, especially those of the conjunctiva and bronchi; they have also a special effect in causing inflammation of the *periosteum* and *bone* with necrosis of exposed parts such as the maxilla and decayed teeth. It is only when the phosphorus fumes *directly* reach the periosteum or some raw vascular surface in immediate connection with the nutrition of

bone, and when their application is prolonged under particular circumstances of temperature, and probably of oxidation, that its injurious effects are witnessed. The necrosis is, therefore, entirely due to the local action of the phosphorus fumes, and occurs when there are carious teeth in the jaw; it is noteworthy that not until eleven years after the opening of the match factory in Vienna was the first case of this kind seen, and only those engaged in "dipping and drying" the matches were affected. The substitution of the amorphous for the yellow variety of phosphorus in match factories prevents the occurrence of such cases.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—After taking, in ethereal solution, $\frac{1}{50}$ gr. each morning for ten days, and then $\frac{1}{100}$ gr. for nearly four weeks, I experienced increased thirst and dryness of mouth, with coated tongue, flatulent distension and eructations, and an uneasy feeling in the region of the gall-bladder, without nausea or vomiting; the motions were dark but healthy, the urine natural. There was slight headache and sense of fulness along the vertex and over the left temple, with some restlessness and sleeplessness. On discontinuing the medicine, these symptoms disappeared in about three days, and on resuming it at the end of a month I felt them return in about ten days' time. Other persons may take the quantity just mentioned without so much inconvenience, but larger doses ($\frac{1}{30}$ to $\frac{1}{15}$ gr. and upwards) are very liable to disorder the stomach, causing nausea and a sense of warmth or irritation. The appetite may be at first increased, but in many patients dyspepsia quickly occurs, and nausea, flatulency, colic, or diarrhœa hinders the employment of at least the ordinary preparations of phosphorus. A silvery-white condition of the tongue may be caused, and the gums may become inflamed.

Zinc phosphide in any quantity above $\frac{1}{4}$ gr. readily induces vomiting. Professor Gubler, examining the effects of this phosphide upon artificial digestion, found that the phosphuretted hydrogen which was developed arrested the process, and he concluded that the same thing occurred with other preparations of phosphorus taken by the stomach; whilst Dr. G. A. Thompson attributes gastric irritation to the formation of hypophosphorous acid, and states that he has only seen these symptoms occur after the use of mixtures prepared with a *vegetable* oil.

Whatever the precise explanation may be, the limit of medicinal and the commencement of toxic doses is marked by more evident irritation of the digestive organs—the mouth becomes tender and sore, the nausea is accompanied with retching, vomiting, and diarrhœa; tenderness and enlargement of the liver may be detected, and there is an icteric tint of the skin and conjunctivæ. In the irritant form of phosphorus-poisoning (to be described separately), these symptoms become very severe.

Cutaneous System—Mucous Membranes.—A good deal of irritation with hyperæsthesia may be produced in the skin and the conjunctivæ, as well as in the buccal mucous membrane, by the use of phosphorus. It is not easy to say whether this is caused by the elimination of the drug, or by the presence of biliary compounds from interference with the functions of the liver, or from the impaired condition of the blood: the icteric tint has been already mentioned. In cases of poisoning, erythematous and hæmorrhagic patches occur in the skin: and increased perspiration has been traced to the medicinal use of the drug.

Genito-urinary System.—There is but little evidence of any stimulation to the generative functions or organs exerted by phosphorus given to healthy subjects, whatever may be its power in certain forms of disease. The stimulation that has been noted in some cases, both in men and animals, was not *special*, but merely a result of the *general* stimulus to the whole nervous system. Leroy, indeed, and some other French authors, have reported some temporary genital stimulation from large doses, and in a few cases of poisoning, irritation and excitement of the genitalia have been recorded, but they are to be explained as above. Thompson gave to two healthy adults 1 to $1\frac{1}{2}$ gr. of zinc phosphide daily for eight or nine days, and to another $\frac{1}{8}$ to $\frac{1}{6}$ gr. of free phosphorus until symptoms of incipient poisoning arose, but without any trace of aphrodisiac effect. Dr. Eames has reported similar negative results from observations with phosphuretted oil, and Mr. Bradley's experience is to the same effect.

With special reference to this point, I have myself carefully experimented upon twenty healthy men. Ten of them took $\frac{1}{10}$ gr. daily for a fortnight; five took $\frac{1}{5}$ gr. each day for a similar

period; and the other five took $\frac{1}{2}$ gr. every third day for five successive doses. Slight toxic symptoms occurred in some of the subjects, but, except possibly in one of the last set, no sign of increased sexual excitement was observed. I have, however, seen men from forty to sixty years of age, apparently in good health, but suffering from complete loss of generative power (in consequence either of previous sexual abuse, or of overtaxed brain and nervous system), in whom very small doses—$\frac{1}{200}$ gr. thrice daily—caused weak erections and involuntary emissions, but mental depression was developed to such an extent as to compel the suspension of the drug; this implies a state of irritation of the generative organs, but certainly not one of increased tone or strength.

With regard to its influence upon the *uterus*, we have evidence that long-suppressed menstruation may reappear under its continued use in small doses, but this may reasonably be supposed to be connected with improvement in the condition of the blood rather than with specific stimulation: in cases of poisoning, however, uterine hæmorrhage and abortion occur.

The urine under the influence of phosphorus becomes high-coloured; it may be phosphorescent, and have a smell of violets or sulphur: and urea is present in excess. Husemann reports the nitrogenous constituents increased in amount, and more recently in dogs poisoned by phosphorus Bauer found the excretion of urea 20 to 90 per cent. above normal (Zeitsch. f. Biol., Bd. xiv., 1878); the phosphates are unaltered in quantity (Derlon). Leucin, tyrosin, and sarcolactic acid have been found in cases of poisoning; lecithin is said to be diminished (Heffter, Rev. des. Sc., t. 37).

Osseous System.—Wegner has furnished definite proof that phosphorus stimulates the growth of bone, for after giving minute doses continuously to animals he found the epiphyseal cartilages ossify more quickly and more completely than usual, and the cancellous and compact bone become more dense, even to the extent of obliterating the medullary canal (Virchow's Archiv, 1872; *cf.* p. 77).

Nervous System.—The fact just recorded of phosphorus stimulating the growth of bone—a tissue of which it forms a component part—has led to the inference that it can stimulate the

nutrition of nerve-tissue, of which also it forms a normal constituent; but the evidence on this subject is not very definite. Gubler describes the effect of $\frac{1}{30}$ to $\frac{1}{15}$ gr. to be a "general sense of stimulation more complete than that caused by coffee, more active than that produced by opium." G. A. Thompson speaks of it as producing "exhilaration, and increased capacity for exertion, both mental and physical, and an effect like that of alcohol without the subsequent depression." He states also that if $\frac{1}{2}$ to 1 gr. be taken in the course of twenty-four hours, the feelings described are more sustained, and transient giddiness or quasi-intoxication occurs. There seems to me some exaggeration in these accounts, but it is within my own experience that a general tonic effect may be obtained from these and smaller quantities of the drug. In cases where poisonous symptoms are developed, marked excitement, tremor, and spasmodic muscular twitching occur, and in severe cases, cramp or partial paralysis, delirium, convulsion, collapse, or coma.

Circulatory System.—In accordance with the general excitation already described, the pulse and temperature are slightly raised about an hour after taking doses of $\frac{1}{30}$ gr.; and after such doses, given daily for some weeks, the circulation has been found more equable and more steady than before (Dr. Ford on fifteen patients, Amer. Jour. Insan., 1874). Thompson has noted dilatation of the small vessels of the skin. In toxic cases the pulse rises to 120 or more per minute, and the temperature to 102° to 103° F., though this condition is only temporary.

Dr. Gowers has proved that under the influence of small continued doses the proportion of red blood-corpuscles is increased (B. M. J., i., 1878), at least in lymphoma, and this interesting observation may throw light on the tonic power of the drug. On the other hand, toxic doses markedly diminish the number of red corpuscles as shown in fowls (Lancet, i., 1881). Hypophosphites in full doses dispose to hæmorrhage.

Toxic Action.—The poisonous symptoms produced are essentially of an irritant and destructive character, but vary in degree, and are often obscure and insidious—probably in proportion to the varying amount absorbed, or the chemical changes which the drug undergoes under different circumstances. Lecorché makes three forms of "acute phosphorismus": 1, that produced by

phosphuretted hydrogen; 2, that by phosphoric acid; 3, a mixed form; but the clinical varieties described by Trousseau, or better by Dr. Guy, are of more practical importance—he names them as 1, the irritant; 2, the nervous; and 3, the hæmorrhagic form.

1. *The irritant form* is the most common: it is induced (on the Continent, not infrequently) by swallowing match-heads, or a certain rat-poison paste, and is accompanied by pain, vomiting, and purging, sometimes with blood and with phosphorescence.

In the early stages there is pyrexia with nervous excitement, delirium and delusion sometimes erotic, though priapism is rare. Twitchings, cramps, and convulsions may occur, but later on follow prostration and collapse, loss of sensation, retention of urine, and partial paralysis, affecting mostly the extensor muscles.

2. *In the nervous form*, these latter symptoms become much more marked, but there is little pyrexia; erythematous spots occur in the skin, which is dry and yellow, and later, becomes cold: dilatation of pupil and strabismus are described, and the fatal termination comes on with somnolence and coma.

3. *The hæmorrhagic form* is less quickly fatal than the others. In it, the ejecta are almost wholly sanguineous; bleeding occurs in and from the skin and mucous membranes, and many parts of the body. It is due partly to the altered state of the blood, and partly to general softening of the tissues, including fatty degeneration of vessels (Lebert). In women there is uterine hæmorrhage, miscarriage, or abortion—but these may be due to the irritant effects on the intestinal canal.

In all cases of phosphorus-poisoning the liver becomes enlarged, and about the third or fourth day pain is felt over the hepatic region, followed shortly afterwards by jaundice, headache, and sleeplessness: the urine is found to contain bile, and generally albumen, leucin, tyrosin, and sarcolactic acid. The presence of bile is an argument that the jaundice depends not on suppression, but on occlusion of the biliary passages, which is probably catarrhal in character. In exceptional cases (in which, probably, only a small amount of the poison has been absorbed) there has been neither gastro-enteritis, nervous excitement, nor quick pulse, but the prominent symptoms have been jaundice and hepatic congestion. The time that elapses from the taking of the phosphorus to the appearance of symptoms varies from a few minutes to two

days. Death, when it occurs, is usually from asthenia, but the course of the illness is not always steadily progressive: sometimes the severe symptoms subside for a few hours or days, and death takes place *suddenly*, from failure of the cardiac muscle (Habershon, Med.-Chir. Trans., v., 50). A remarkable instance of subsidence of all irritant symptoms for four days when death occurred from hæmorrhage and collapse is recorded (Lancet, ii., 1891). A fatal dose may be stated as about 1 to 2 gr. for adults, but much less for children, in whom vomiting and convulsions are usually the prominent symptoms.

Tolerance.—The system may become habituated to the use of phosphorus to some extent, and a gradual increase of dose may be borne up to an amount which would not at first be tolerated. Any "cumulative action," so called, may be explained by the mechanical accumulation of the drug in the stomach and intestines.

Pathological Changes induced by Phosphorus.—Ecchymoses and gangrenous spots have been found in the intestinal tract, together with swelling and softening of the mucous membrane and mesenteric glands; rarely perforation. The viscera are hyperæmic, and œdema and hæmorrhagic infiltration affect the skin, serous membranes, and other tissues, especially the mediastinum; hæmorrhage has also occurred between the spinal membranes, thus accounting for paralysis. According to the observations of Dr. Danillo, in cases of phosphorus-poisoning, there are deposits of pigment of hæmatic origin in the central nervous system, while the cord shows evidence of either inflammatory irritation or diffused or central myelitis, according to the amount taken (Gaz. méd. de Paris, 1882). The blood itself is black and viscid, and in many cases, even during life, the corpuscles are destroyed and the hæmoglobin altered, so that it will not show the usual spectrum (Lecorché, Voit); in others, the corpuscles have been found normal after death, and the blood-crystals (of hæmoglobin and hæmin) found unchanged (Lebert, Gubler); but in all cases the blood and the solid organs contain an increased proportion of waste products, such as urea, creatin, leucin, tyrosin, etc., and fatty degeneration affects every tissue. The muscles, including the cardiac muscle, are discoloured, soft, and fatty, the vascular walls are degenerated in a similar manner,

the gastric glands and renal tubules are choked with fatty epithelium, and the liver especially is enlarged, yellow in colour, and its cells filled with fat globules, for, in protracted cases, degeneration of the cells occurs. That this is a true degeneration, and not simply deposit of fat, is corroborated by finding, in hardened sections of liver and kidney, that the structure is entirely obliterated by ether (Lancet, i., 1890).

The condition described resembles closely that found in "acute yellow atrophy" of the liver, and the question of diagnosis has been raised in medico-legal cases (Annales d'Hygiène, 1869). An illustration of this is recorded by Surgeon-Major Martin, in a man admitted to Netley Hospital without any history of poison, and whose case was diagnosed as acute yellow atrophy—it was only after death that the real fact of phosphorus-poisoning was disclosed by examination (B. M. J., i., 1878). An instructive case arising from the external application of phosphorus paste is recorded (Lancet, i., 1890).

Theory of Action.—The direct irritant effects on the intestinal canal depend rather upon the oxygen or hydrogen compounds formed, than upon phosphorus itself; the pain, vomiting, and prostration follow from the local irritation produced.

To explain the other constitutional symptoms, the subsequent arrest of nutrition and the fatty degeneration, several modern writers have argued that the strong affinity of phosphorus for oxygen leads it to abstract that gas from the blood, and so induce a condition of *asphyxia* (Eulenburg, Lecorché), but as oxygen would be continually renewed by inspiration, and the amount that can be absorbed by the metalloid is only limited, I cannot see that such serious consequences would result; neither would asphyxia produce preliminary excitement nor subsequent waste, nor is the black colour of the blood of poisoned animals due to simple venosity of the blood; moreover, it is sometimes bright red, a condition incompatible with asphyxia (Vigier, Bull. Thérap., 1868). Others have argued that phosphorus indeed removes oxygen from the blood and the tissues, but with the main result of forming phosphorous and phosphoric acids, which act as *local* corrosive agents, and which, after absorption, destroy blood-corpuscles. That phosphoric acid is formed in the system seems proved by its

excretion from the lungs, and further, it is pointed out that this acid, *when injected into the veins*, will destroy the corpuscles, and lead to fatty degeneration (Personne); and although it will not act thus when given by the mouth, yet it may do so when directly generated within the system by the oxidation of free phosphorus. Whilst allowing this to some extent, I cannot believe it possible that sufficient to account for such results could be formed in this manner. Again, oxygen has proved an antidote to phosphorus-poisoning (Crocq), and turpentine acts as an antidote by a process of oxidation, whilst free ventilation is the best means of preventing necrosis of the maxilla, etc., in phosphorus factories (Savory, Sieveking), so that it seems at least unlikely that *oxidation* of phosphorus is the cause of its ill effects.

Binz is of opinion that in contact with the tissues it gives rise to nascent oxygen, and that this body is the destructive agent. Gubler also suggests that it acts chiefly by the strong *ozonising* power which we know burning phosphorus to possess. Although through this combustion a minimum quantity of oxygen gets lost for respiration, the remainder would shortly acquire from its admixture with the ozonised portion so great an increase in combining power as to be very likely to induce general stimulation of the system. But increased activity is accompanied by an increased waste, particularly of the blood-cells; anæmia follows this irregular activity, and fatty degeneration of the tissues and impairment in the function of the different organs take place. On the other hand, amorphous phosphorus, which has no ozonising power, would fail to produce any such symptoms, as is really the case; but more accurate analyses of the secretions are required in order to support the hypothesis. The excretion of carbonic acid is moreover lessened, not increased (Rabuteau), and this seems to me to be a fatal objection; and the explanation of the action of the drug given by Voit and Bauer (Journ. Chem. Society, xxiv.) seems more satisfactory; viz., that the fatty degeneration produced by phosphorus depends on a more rapid splitting up of albuminous tissues along with deficient oxidation. They gave phosphorus to dogs absolutely deprived of food, when the fat found after death could neither have come from the food, nor from fat deposited in other parts of the body, as that had all been absorbed before the administration of the

drug had been commenced; it must, therefore, have been formed *in situ* from the decomposition of albuminous substances. These were shown to have split up more quickly than usual by the amount of urea in the urine being increased, while oxidation in the body was shown to have diminished by the amount of oxygen absorbed and carbonic acid given off being lessened. In man, the products of albuminous waste are often not converted into urea, but appear in the urine as leucin and tyrosin (Lauder Brunton).

I have still to refer to the effects of *Phosphuretted Hydrogen*, which would readily be formed from phosphides, or from the very unstable hypophosphorous acid. We have seen that this gas interferes with the digestive process, and we know that if it be passed into defibrinated blood, it turns it black and destroys its hæmoglobin (Dybkowsky); also that it possesses, equally with phosphoric acid, and other acids and substances which act destructively on the blood, the power of inducing fatty degeneration from impaired nutrition (Med. Times, ii., 1865). The formation of phosphuretted hydrogen in the system would equally well explain the production of the principal toxic effects of free phosphorus, and I incline to attribute them largely to it. Lecorché states that this compound has been found in the tissues in fatal cases, and he connects its presence specially with the second or neurotic form of poisoning, in which the course is rapid and nervous symptoms are prominent.

Fatty degeneration was found by Munk and Leyden in the tissues of frogs and rabbits within two or three days after giving phosphorus (Med. Times, ii., 1865), and since these researches its occurrence in phosphorus-poisoning has been amply demonstrated, especially by German observers (Ziemssen's Cyclopædia). In Tamassia's experiments it was very rapidly produced. He injected 3, 4, 5, 6 gr. respectively into the rectum of four animals (dogs and rabbits); toxic symptoms occurred in about fifteen minutes, death in eight hours (the temperature falling 8° F.). In all four of the animals the kidneys, and in two of them the liver also, were in a state of fatty degeneration (Med. Record, Jan., 1878).

SYNERGISTS.—Arsenic is allied to phosphorus in its power of acting upon the blood (with advantage in small doses, in large

doses with destructive effect), also in its action upon nutrition. Cantharides, oxygen, and stimulants have somewhat analogous stimulating powers.

Adjuvants are found in phosphoric acid, and in fatty and fleshy foods. Phosphoric acid has especially been shown to develop or augment the powers of phosphorus, probably from aiding in its solution and circulation (Personne). The brains of animals and the flesh of hogs are said to be rich in phosphorus, and *roast* food to retain more than *boiled*.

ANTAGONISTS — ANTIDOTES. — Magnesium or calcium hydrates will neutralise the acid compounds of phosphorus, and charcoal will absorb phosphorus fumes. Bi-sulphide of carbon antagonises the excitant action of the drug, as also do sulphuretted hydrogen, anæsthetics generally, and cyanides (Gubler). Nitrate of silver was recommended as antidotal by Bellini (Med.-Chir. Rev., ii., 1875). Solution of potassic permanganate, one-third per cent., also converts it into phosphoric acid (Pharm. Journ., 1892); and a one-tenth per cent. solution has been used by the stomach pump successfully (Lancet, i., 1892).

In an important experiment by Crocq, oxygen was used as an antidote, defibrinated blood charged with the gas being injected into the veins, with the effect of restoring to its normal condition the dark, pitch-like blood of poisoned animals (*ib.*).

But the two antidotes which claim special attention are sulphate of copper and ozonised oil of turpentine. With any soluble salt of copper, phosphorus forms a black phosphide, which is not poisonous; and as copper sulphate is also a good emetic, it is specially available for cases when the poison has been taken by the stomach, and when the remedy can be given soon afterwards. Five grains should be given every two or three minutes until free vomiting is induced, and then either continued in small doses with opium, or turpentine may be substituted.

If oil of turpentine be brought into contact with phosphorus at a suitable temperature, a crystalline white solid is formed—terebinthino-phosphoric acid—which is not poisonous. Kohler and Schimpf obtained it by adding gradually 2 lbs. of the oil to $\frac{3}{4}$ oz. of the element at 40° C., and the same substance has been obtained in the distillate from urine in cases of poisoning (Pharm. Journ., 1873). To produce the desired result, the oil

must come into *direct* contact with phosphorus in the stomach, and in the proportion of about 100 parts to each one of the latter. It should be given in 40 m. doses in mucilage every fifteen minutes for an hour. Eleven hours is the longest time that has elapsed before the administration of the remedy in successful cases. Moreover, it is not every kind that will act well; the pure rectified oil, and much of that imported as German and American, do not form the crystalline acid, and hence a difference in the results of some observers. It is the crude, acid, French oil, or that which has been ozonised by long exposure, which gives reliable results. It is said that milk lessens its good effect, and other fats and oils must be withheld, as they dissolve any phosphorus which may be in the alimentary canal and facilitate its absorption.

A case illustrating the value of both the antidotes recommended occurred in my practice some years ago. A young man (insane from over-study for examination) swallowed some pieces of solid phosphorus, and, whilst his friends were gone for assistance, gashed his throat and body with a razor. When I saw him, the most pressing need was to stay hæmorrhage, and while copper sulphate and turpentine were being procured, mustard and water was administered. This and the copper produced free emesis, with rejection of a piece of phosphorus 2 in. long. I then gave turpentine in milk (also in water), and still encouraged vomiting, because from the small pieces left in the patient's bottle of phosphorus more was thought to have been taken. Eventually two other pieces, $1\frac{1}{2}$ in. and $\frac{1}{2}$ in. long, were rejected, after having been in the stomach at least three hours. Several more doses of turpentine were given, and the patient eventually made a good recovery. The case may be considered another illustration of the fact that large pieces of phosphorus are less dangerous than the finely-divided substance, but I think real benefit resulted from the antidotes used.

A case is reported of a man who swallowed 120 match-heads, and then took turpentine to increase the effect: he did not vomit, but recovered (Med.-Chir. Rev., ii., 1869). The subject has been again investigated by Dr. Bush (Dorpat), who gave to various animals poisoned by phosphorus, emulsion of turpentine about an hour afterwards, and confirmed the above statements (Lancet, ii., 1892).

THERAPEUTICAL ACTION.—*Internal.*—From what has preceded, it will be recognised that the value of phosphorus lies in its power of strengthening and giving tone to the nervous centres when their activity is impaired; also, since debility of the nervous system is associated with other than purely *nervous diseases*, a nerve tonic of this kind has a wide field of usefulness, and is applicable, not only in nervous exhaustion and pain, but in many conditions of adynamia. Rabuteau, however, states an opposite view when he says: "I do not hesitate to assert that this poison has never cured anything up to the present time, and I would never prescribe it; it has always been useless" (Traité de Thérap.); whilst Dujardin-Beaumetz, A. Thompson, and others have recorded wonderful results from it. The truth probably lies between the two extremes, and we must not forget that some failures may be accounted for by inactive preparations of a drug always difficult to dispense.

Neuralgia.—Eighty years ago, Von Lobel, a physician, related his cure from an inveterate cranial neuralgia, which was accompanied with debility and failure of mental and sensory power, by an ethereal solution of the drug. He took $\frac{1}{4}$ gr. every two hours, and (with one relapse) was restored to health in a short time, and after only a few doses. This experience was corroborated to some extent, and the remedy came into great repute, but was soon found to be a dangerous one and difficult to manage, and it gradually fell into disuse, no doubt owing to the largeness of the doses. A few years ago Mr. M. Bradley published a case of neuralgia of the chest-walls, rapidly cured by "tincture of phosphorus," after failure of all recognised remedies, and later he recorded other successful results (B. M. J., ii., 1872). In the following year Dr. Slade King added testimony to its value in doses of $\frac{1}{30}$ to $\frac{1}{20}$ gr., and Dr. Ashburton Thompson recorded forty consecutive cases either cured or relieved (Pract., 1873); Mr. Sanger referred to an equal number, and Dr. Hammond praised it in America (Pract., i., 1877).

Drs. Radcliffe and Broadbent may be cited also amongst those who early employed it with good results, the latter especially in "anginoid pain"—a *cardiac* neuralgia (Pract., 1875). It was found useful in cases connected with extreme general debility—whether from over-lactation, hæmorrhage, or simple asthenia—

in cases due to pregnancy, to cold, and to local irritation, such as carious teeth, and even to rectal cancer (Thompson). Anstie's experience was not so favourable.

I have myself seen much benefit from it in many of the above cases, also in *uterine neuralgia* occurring in sensitive patients, and induced either by protracted lactation, sexual excess, or by mental or local causes. The severe pain is apt to come on just before or during the monthly period, and then $\frac{1}{100}$ to $\frac{1}{50}$ gr. should be given three or four times daily; during the interval the smaller dose should be given, and less frequently.

For upwards of twenty years I have been accustomed to use phosphorus in intercostal neuralgia, and can speak favourably of its power. I have notes of fifty-six cases wherein the pain quickly subsided under this treatment, and did not, so far as I know, subsequently return. In some instances phosphorus succeeded where arsenic had failed; the dose was $\frac{1}{100}$ to $\frac{1}{50}$ gr. three times daily. In herpes zoster also phosphorus has in some instances relieved the severe pain.

Twitching of the facial muscles, especially about the orbit, often occurs in cases of neuralgia, and I have known it improved by phosphorus.

With regard to the dose in neuralgia and nervous disorders generally, I may say that in my experience the comparatively large doses recommended by Thompson cannot be tolerated for any length of time by the system. They may seem at first to stimulate, or rather over-stimulate, the nerve-centres, but after a short time they depress in a disastrous manner; whilst the small doses of $\frac{1}{200}$ to $\frac{1}{50}$ gr., continued for a length of time, nourish and strengthen nervous tissue, without any evidence of undue excitement; a gradual alterative action is what is desired.

Nervous Exhaustion. — Neurasthenia. — Gubler found phosphide of zinc remove the sensation of fatigue after hard work, improve the appetite and digestion, and conduce to sleep. He gave a $\frac{1}{2}$ gr. dose with an ordinary digestive pill at dinner-time, but such a dose is too large, and is very liable to nauseate. When the nervous system is jaded and below par, so that slight impressions are too deeply felt, and the nerve-controlling power is impaired, phosphorus has been found to supply what is wanting for a time; also, it has been said to improve intellectual tone in

those subjected to either monotonous brain-work or to an unusual mental effort (Thompson). Dr. Broadbent recorded some striking cases of this kind—one of "nervous break-down" in a city merchant, with insomnia, and extreme depression and incapacity for work, and another in which "epileptiform vertigo" was present in addition; both got well "quickly and completely" under phosphorus (Pract., 1873). Travignot has reported good results from phosphorated oil in *diabetes*—without restriction in diet (Progrès Médical, 1884).

In cases of **Chronic Exhaustion of Brain Power**, or of general nervous exhaustion consequent on chronic disease, small doses continued for some months are advisable, and have been plausibly held to supply to the nerve-tissue a vital element in which it is deficient, and to improve its nutrition, just as Wegner showed that the drug improved the nutrition of bone; and certainly its supply, in some form, to nerve-tissue is as necessary as that of iron to blood-corpuscles.

I have reason to believe that benefit may be obtained from phosphorus even when there exists evidence of atrophic change in the brain, of the nature of white softening or chronic fatty degeneration, with such symptoms as failure of memory and of self-control, loss of proper sensation and cerebral power generally. These are commonly associated with feeble action of the heart, and with arterial degeneration, and may occur not only in advanced life, but as a consequence of wasting disease, chronic alcoholism, etc. I remember well a case of this kind in which *epistaxis* was a frequent symptom, and had proved rebellious to iron, acids, and other ordinary treatment in the hands of experienced men: small doses of ethereal tincture of phosphorus improved the patient both as to brain and muscular power, but the symptoms always tended to recur on the omission of the remedy, and the patient continued it with good results. Dr. Mackey has noted a similar case—a woman of eighty-two, who found memory so impaired that she could not be sure, *e.g.*, as to which of her two sons had gone away from home, but found marked improvement in brain power from the hypophosphites. A suitable dose is $\frac{1}{50}$ gr. thrice daily for about a fortnight, and then it should be reduced to $\frac{1}{100}$ gr. or less, and should be taken for twelve to eighteen months, omission being made for about ten days in each month.

Although I do not find this experience to be general, yet it is not wholly singular, for Dr. Hammond also speaks of the value of the remedy in conditions of softening; he recommends similar doses given with cod-liver oil, or zinc phosphide in $\frac{1}{10}$ gr. doses.

Fatty Degeneration.—That a different action may be obtained from a different dose of the same medicine is an elementary therapeutical axiom in constant application, and it is, I believe, a clinical fact that phosphorus can relieve the symptoms which are usually associated with fatty degeneration, not only of the brain, but of other organs. I have notes of more than thirty cases in which fatty degeneration of the heart might fairly be diagnosed—the cardiac sounds were feeble, the impulse weak, the pulse slow, sometimes excited, irregular, soft, and compressible; with dyspnœa on exertion, and a sense of anxiety and tendency to syncope to a greater or less degree; the arcus senilis was present in some cases. After taking phosphorus for a few months most of the patients were much relieved, and were able to move about without fear, and with comparative comfort. No doubt somewhat similar cardiac symptoms may be caused by nervous exhaustion or by gout; the absolute diagnosis of fatty degeneration cannot always be insisted on, and I do not wish to maintain that phosphorus reconstructs degenerated cells, but its acknowledged power over nutrition makes it reasonable to suppose that it can hinder or stop commencing degeneration, and especially improve the condition of the nervous system.

It is highly important to proportion carefully the dose to the necessities of each individual case, as some patients will take with advantage more than others. Where the action of the heart has been very irregular, or the dyspnœa and syncopal feelings more than ordinarily troublesome, I have given $\frac{1}{30}$ to $\frac{1}{20}$ gr. occasionally, but these doses should not be given frequently for fear of aggravating the symptoms; I prefer to give $\frac{1}{200}$ to $\frac{1}{100}$ or $\frac{1}{50}$ gr. twice or thrice daily. Not only in heart-disease of the kind described, but in fatty degeneration of other organs, and in the form which threatens during typhus and some other acute diseases, phosphorus is worthy of attention.

For many years I have been accustomed to use it in such cases, and the improvement traceable to it is often remarkable. The smaller doses mentioned are to be preferred, in order to

avoid irritant effects, and to get the system slowly but more fully under the influence of the remedy; when this is done the effect is more thorough and lasting.

Exhaustion of Fevers, etc.—The value of phosphorus in conditions of extreme exhaustion in advanced disease is one of the earliest recorded experiences of Kramer, Mentz, Leroy, and others (1733-1798). They used it in the muttering delirium and incipient coma of typhus, the collapse of malignant "bilious fevers," and the profound depression of extensive pneumonia. Bayle says: "In every disease where death is imminent from failure of vital force without much structural alteration, phosphorus is indicated. We see this in severe continuous fevers during their last stage, whether they be caused by some miasm, typhus, plague, etc., or by 'spontaneous alteration of the blood,' and in adynamic or putrid fevers (so called); in such cases phosphorus reanimates vitality, furnishes nature the means of effectually resisting the disease, and eliminating its material cause by natural excretory outlets. It is indicated, secondly, in all acute exanthemata when eruption has disappeared suddenly, with aggravation of symptoms, measles, variola, erysipelas, low fever with exanthem; thirdly, in malignant pustule, where the disease has reached its acme and the vital power is almost extinct." Bayle adds that it is useful in chronic gout and rheumatism (which are relieved through profuse excretion of sweat or urine), and in "all morbid conditions wherein it is proper to excite these secretions, and at the same time to stimulate vitality in a speedy and energetic manner" (Bibliot. de Thérap., vol. ii.).

Phosphorus is recommended in intermittent fevers as often superior to arsenic, and as a good substitute for quinine (Record, 1886).

Powers so extensive as these have not been accorded to phosphorus by more modern writers, but Mr. Clay has illustrated its value in the collapse of variola (Lancet, ii., 1858), and Dr. John Brunton in the adynamia of typhus and typhoid fevers; rapid improvement taking place under drachm doses of the following solution:—Tinct. Phosph. Æth. (gr. $\frac{1}{3}$ ad ʒj.) ʒiij. Spt. Rectif. ʒss., Glycerini ad ʒiss. About two grains were taken in the course of two days.

I have frequently prescribed phosphorus in the exhaustion of typhus and typhoid, and have sometimes seen remarkably good results from it; but, on the other hand, have been often disappointed, and cannot but consider it an uncertain remedy in such cases. I would place more dependence upon ammonia, camphor, and other stimulants of that class, but if they failed, should then have recourse to phosphorus. Another use of the drug in fevers is to assist development of the specific eruption, *e.g.*, in enteric, scarlet fever, and measles, and within my own experience it has proved of service when the eruption has disappeared suddenly with the onset of serious symptoms.

Exhaustion of Generative System—Impotence.—In such conditions phosphorus has long had a reputation, and was much valued by early authorities; but modern experience has shown its power to be more limited than was supposed. If the special exhaustion referred to be only part of a generally enfeebled state, it will doubtless improve as the general tone and vigour improve, but this system is not stimulated apart from the others; indeed, if it were so, this might be a serious drawback to the ordinary use of the remedy. I may say, however, that in some of my own cases an irritable weakly condition of the sexual organs, traceable to previous early abuses or subsequent excesses, has been much benefited by continued doses of $\frac{1}{200}$ to $\frac{1}{100}$ gr. thrice daily.

Spinal Irritation.—I consider phosphorus of greater value when this condition is connected with onanism than when arising from over-fatigue or other causes. The irritation is marked by local discomfort, a burning pain in the lumbar region, sense of fatigue and impaired walking power, mental distress, etc. In such cases it is essential that the patient exert moral control over himself, and that treatment be continued judiciously for some months. The remedy relieves the spinal pain and the mental depression, and thus indirectly tends to lessen abnormal sexual desire.

Disorders of Menstruation.—Patients with scanty, watery, and irregular catamenia, sometimes suffer, about the time of the periods, from sick headache, and when this is the case a continued course of phosphorus increases the quantity and improves the quality and regularity of the menses, while the headaches frequently disappear. Phosphorus, like aconite, restores the discharge when suddenly interrupted by cold or fright.

When the discharge is not only watery but too profuse in character, and somewhat delayed beyond the natural time, phosphorus is of considerable use, as it checks the overflow, relieves the backache, improves the mental depression, removes the nausea and vomiting so frequently attendant, and strengthens the general condition. It is also useful in profuse menstruation attended with excessive sexual excitement. The dose should rarely exceed $\frac{1}{100}$ gr. every two to four hours during the menstrual period, and morning and night during the interval. Bromide usually acts better.

Paralysis.—Cases of hemiplegia relieved by phosphorus are on record, but not from very reliable sources. It is contra-indicated in acute irritative conditions, but may be tried in the chronic stages, particularly if exhaustion be a prominent symptom. I agree, generally, with Lemaire, who has summarised the modern use of it for paralysis, and finds that in local palsies after severe illness, or from anæmia or hæmorrhage, it has a general tonic stimulant power, but not a specific curative effect, and is always uncertain. It is commonly useless in old paraplegia, in sclerosis, and in lead palsy; and Mr. Sanger is almost alone in reporting paraplegia and paralysis agitans cured by the drug. I have, however, known it relieve formication in paralysed parts, and also, specially, *functional derangement with adynamia* (*cf.* Bulletin Gén. de Thérap., 1875). For intra-ocular paralysis it was used by Tavignot externally and internally, and De Mussy used it in alcoholic and mercurial tremor, and in partial paralysis caused by arsenic (Lancet, i., 1876).

Locomotor Ataxy.—Dujardin-Beaumetz has advocated the use of phosphorus in ataxia, upon the strength of four partially successful cases, of which, however, the after-history is not given. His favourable observations have not been generally confirmed, though a patient said to be suffering from "progressive locomotor ataxy," unrelieved by bromides, strychnine, quinine, and iron, was able to stand and to walk after two months' treatment by phosphorated oil (Hartley, Lancet, i., 1877). Some other scattered observations of the same kind may be found. The malady exhibits, in its natural course, remission and improvements, partial and lasting for a variable time, but sufficient to throw uncertainty on the action of any medicine, unless very carefully and frequently verified. This was instanced in one of eighteen cases of ataxy

reported by Mr. Bradley (B. M. J., ii., 1878)—the improvement observed might have been credited to the remedy, had not the patient relapsed afterwards, whilst under the same treatment. The others remained *in statu quo.* It is possible that in these and similar instances, the dose was too large, or not continued long enough, and further observations should be made. Certainly, in some few cases I have seen much improvement during a prolonged use of phosphorus ($\frac{1}{100}$ gr.), or zinc phosphide, though I am not satisfied that it was really due to the drug.

Hysteria.—Nervous power is impaired in this affection, the emotions not being under normal control; more or less neuralgia is often concomitant, and altogether it is a condition in which we should expect phosphorus to be useful, and instances of its value are on record. The cases benefited by it have been acute or chronic, dependent on sudden shock, or gradually coming on with increasing weakness and despondency; in either form a period of debility is liable to be followed by convulsive attacks. I do not undervalue moral and hygienic treatment, but amongst medicines, phosphorus in doses of $\frac{1}{100}$ to $\frac{1}{20}$ gr. has proved efficient in my hands. When hysterical attacks are connected with delayed or suppressed menses, pain in the iliac and lumbar regions, neurotic vomiting, palpitation, and general excitement alternating with depression, I have found this remedy help to regulate the periods and cure the hysterical symptoms.

Epilepsy.—In true epilepsy it has, like most other nerve-tonics, been used and commended, but evidence of its really preventing the attacks is contradictory. Broadbent found it useful in epileptiform vertigo (Pract., viii.-x.), and Anstie observed it relieve the depression of epileptics and improve their temper and power of control (Med. Times, i., 1862). In the early period of the disease when dependent upon sexual abuse, I have known phosphorus prove very beneficial. I remember, especially, the cases of two men, aged nineteen and twenty-three, whose attacks began soon after puberty, and who had taken large doses of potassium bromide without evident relief, and who became quite freed from their attacks during a course of phosphorus, and have continued free from them during the years that have since elapsed. The dose was only $\frac{1}{100}$ gr. three times daily, which was continued (irregularly) for twelve or fifteen months.

Melancholia — Dementia. — Dr. S. W. Williams in this country, and Dr. Ford in America, have recorded a moderately favourable experience of phosphorus in these conditions (Journ. Ment. Sci., 1874, and Amer. Journ. Insan., 1874). Dr. Judson Andrews also has written in favour of *phosphoric acid* in different forms of insanity, but especially those tending to melancholia (*ib.*, 1869).

I have notes of thirteen cases of recovery from this distressing affection in patients between the ages of thirty-two and forty-five years, most of whom showed well-marked symptoms, such as despondency and depression, suicidal impulse, fear of solitude, loss of sleep, etc.: they looked haggard, the face was flushed, and they complained of cold clammy skin, vertigo, and various disturbances of the digestive system. In addition to general treatment by exercise and different forms of bath and the occasional use of nux vomica or aperients, I gave phosphorus, at first $\frac{1}{30}$ gr., afterwards $\frac{1}{100}$ gr., thrice daily, with the result that all recovered in the course of two to three months. My experience of fourteen other cases between the ages of thirty-five and fifty shows, however, that it is an uncertain remedy, and although quickly beneficial in some cases, in others it is disappointing.

Pneumonia.—Phosphorus is good in ordinary cases with difficult muco-sanguineous expectoration, with very marked lowering of strength and evening exacerbations; also in later stages when either pyrexia has subsided and the patient is left very feeble, and does not progress towards convalescence; or again, when red hepatisation is complete, fever and prostration increase and suppuration is imminent—although when pus has actually formed, the drug is contra-indicated.

Dr. Thompson, speaking highly of its value in pneumonia, remarks that success depends greatly on the dose given, and in his opinion the better results of older practitioners were traceable to their use of full doses, toxic effects being less known and consequently less feared by them. He says that "no caution need limit the quantity of such a preparation as the tincture, the only limit to be recognised being improvement in the patient." He commonly orders $\frac{1}{12}$ gr. dose in the cases referred to, but I cannot agree either with this theory or practice; my best results have been obtained with $\frac{1}{200}$ to $\frac{1}{100}$ or $\frac{1}{50}$ gr. given every two to four hours.

I have also had good results from phosphorus in *chronic* pneumonia; but when this condition occurs in tuberculous subjects with a tendency to hæmorrhage, this drug should be avoided. In acute or chronic cases, complicated with *bronchitis*, phosphorus is less appropriate than some other remedies, such as ammonia.

Tubercular Meningitis.—A number of cases have been recorded in which recovery took place under the free administration of phosphorus (Greenway, B. M. J., i., 1884; Green., Pract. ii., 1884). Betz used it locally, rubbing into the scalp a weak solution in oil (Med. Times, 1885). It has been suggested that it acts by causing fatty degeneration and consequent disappearance of effused lymph (B. M. J., i., 1884).

Phthisis.—The action of phosphorus in this affection can only be considered palliative; but it can, at least, moderate some troublesome and irritating symptoms. I have used it in various doses in upwards of 800 cases, of which I have a record, and am satisfied that it does not cure advanced tuberclosis, but appears in many cases to arrest its progress, at least for a time, also to improve the condition of the throat and the voice, and to relieve the dry, harassing cough, the pain after food, and even the colliquative diarrhœa and night-sweats. It has also removed pleuritic stitches, and seemed to strengthen the general condition; on the other hand, its use is not free from danger, and requires caution, since it may induce obstinate hæmoptysis. These remarks apply also to hypophosphites.

Chronic Diarrhœa in children, with frequent watery evacuations, abdominal pains, depression, and emaciation, or the colliquative form, occurring, *e.g.*, in phthisical adults, has often in my hands yielded to phosphorus. Sometimes it is well to give a few small doses of Fowler's solution of arsenic in conjunction with phosphorus.

Cutaneous Diseases.—The value of phosphorus in these maladies was mentioned by Cazenave, and in 1850 Burgess recommended it in psoriasis and in lupus. More recently Dr. Broadbent, inquiring how far the chemical analogies of drugs would act as a guide to their therapeutical effect, was led to use phosphorus in the same class of cases as arsenic, and he recorded six cases of eczema and six of psoriasis treated by the former drug; the majority of these were relieved or cured (Clin. Soc.

Trans., vol. iv.). Dr. Eames has also reported successful cases under the same treatment (Dub. Journ., Jan., 1872).

In a case of Dr. Whipham's, whatever good was obtained in the first month of treatment was lost in the second, and in several cases within my knowledge—severe and chronic cases, it is true—phosphorus was given without benefit. It would seem, then, that it is *uncertain* as a remedy, and without denying its occasional power of relieving, I think, with the late Sir Erasmus Wilson, that it is indicated rather for the impaired nerve-condition accompanying many skin-disorders than for any direct influence upon the nutrition of the skin.

Bone-Disease—Rachitis—Fracture.—In cases of fracture, resection, and transplanting of periosteum, Wegner found that small continued doses of phosphorus stimulated the growth of new bone, especially in young animals; also that ossification in the fœtus was promoted by giving phosphorus to the mother. It is noteworthy that he obtained similar results, though less in degree, from phosphoric acid and oxy-compounds of phosphorus, but not from the amorphous element, nor from lime phosphate.

I have myself seen good results from phosphorus in ordinary *caries* of bone, and again in cases of *abscess* connected with necrosed bone, it lessens suppuration and hastens the separation of the sequestrum; given during pregnancy it relieves the dental caries and neuralgia often incidental to that state, and I have given the hypophosphites successfully in such cases. It may be presumed that phosphorus, and such preparations of it, would also improve the nutrition of the fœtus in weakly subjects, and I think they might often be used with advantage in chronic rachitis.

Kassowitz has reported an exceptionally favourable experience in rickets, founded on the treatment of 500 cases. Cranio-tabes disappeared, and good effects were produced on thoracic and spinal deformities and other symptoms after a few weeks' treatment by small doses of free phosphorus, generally given as phosphorated oil. Experimenting on animals he found such doses increase the growth of *compact* bone, but larger quantities increased rather the *cancellous* tissue (Berl. klin. Woch., 1884).

These observations attracted much attention, and whilst they were supported by Genser, Boas, and others, the experience of

Henoch and, I think, of a majority of German physicians, was not confirmatory (Revue Génerale, 1885).

Leucocythæmia — Pernicious Anæmia — Lymphadenoma.—It is in such blood—and gland—disorders, which are essentially of serious, if not fatal import, that phosphorus has been recently employed, and Dr. Broadbent, one of the first to recommend it, offered evidence in its favour. A boy with "essential anæmia," prostration, diarrhœa, yellow waxy face, etc., recovered very quickly under phosphorus, and remained well for some time. In another case of "leucocythæmia," treated in the same manner, inflammation of the spleen was produced (Practitioner, i., 1875). In a woman with lymphadenoma, having symmetrical enlargement of cervical glands, anæmia, dyspnœa, etc., and who had been steadily getting worse for some time, "complete recovery took place" after taking phosphorus (B. M. J., ii., 1876). In two other cases—one very far advanced, the other chronic—the same remedy was successful. Some support was given to Dr. Broadbent's conclusions by a case, under Dr. Wilson Fox, of "leukæmia splenica" occurring in a man, aged thirty-seven, in University College Hospital, for when extremely enfeebled he began to take $\frac{1}{50}$ to $\frac{1}{30}$ gr. doses, and after three months' treatment had greatly improved; he died, however, in the following year (Lancet, ii., 1875). Mr. T. J. Verrall has reported a marked case of subsidence of splenic enlargement and improvement in the blood-condition of an infant, after the addition of one minim of phosphorated oil to other remedies which had previously been taken without good effect (B. M. J., i., 1885).

If we add to these cases one of leukæmia (Dr. Gowers), in which the use of phosphorus was followed by diminution in size of the glands, and lessened anæmia (though albuminuria and death afterwards occurred), it will be seen that the evidence in favour of phosphorus is not strong, whilst many cases of its failure are on record. Dr. Moxon objects even to receive Dr. Fox's successful case as one of leukæmia, because the white corpuscles in the field were "only twenty to thirty," and refers to about thirty cases of his own ("pernicious anæmia," apparently), all unsuccessfully treated by phosphorus (B. M. J., ii., 1876).

At the meetings of the Clinical Society at which this subject

was discussed (November, 1876), Dr. Greenfield and Dr. Goodhart related unsuccessful cases, and Sir William Jenner referred to three of "splenic leucocythæmia," in which the remedy seems to have had a really fair trial without any good result. The question was even raised, whether it might not be responsible for some fatty degeneration found post mortem; but without laying stress upon that point the general conclusion of competent authorities, both at that time and since, has been adverse to the value of phosphorus in such cases.

It would seem, perhaps, to offer a better prospect in cases of *lymphadenoma* than of *leukæmia*, and especially in early cases, and more evidence must be collected before we can rightly estimate the true power of the drug. I have already referred to the increase of red blood-corpuscles, reported by Dr. Gowers, under the use of phosphorus; this was in a case of "lymphoma," and the increase in one month was from 52 to 66 per cent., and in another month to 74 per cent.; $\frac{1}{30}$ gr. was taken three times and then six times daily—no other drug was given, nor were the circumstances of the patient altered. The pathology of these maladies is, however, still very obscure, and they are not well defined one from the other. Greater clearness in their diagnosis and prognosis must be expected to precede therapeutic advance; but we may say this, that much more benefit has been already recorded from *arsenic*, both in pernicious anæmia and in lymphadenoma, than from phosphorus. The two remedies are, doubtless, allied, but the former is more trustworthy.

PREPARATIONS AND DOSE.—*Phosphorus:* dose, $\frac{1}{100}$ to $\frac{1}{10}$ gr., less or more. *Oleum phosphoratum* (made with oil of almonds, 4 gr. dissolved in 1 oz. at 180° F., the oil being previously heated to 300° F. to destroy organic impurities): dose, 3 to 10 min. *Pilula phosphori* (made with balsam of tolu, yellow wax, and curd soap); 5 gr. of the pill contain $\frac{1}{18}$ grain. *Zinci phosphidum:* dose, $\frac{1}{20}$ to $\frac{1}{2}$ gr. in pill; *calcii hypophosphis*, 5 to 10 gr.; *sodii hypophosphis*, 5 to 10 gr. These may be given in solution in syrup, in cod-liver oil, or in mixtures.

Exception has been taken to these officinal preparations—to the *oil* as disagreeing with the stomach, to the *pill* as being too concentrated, or not soluble enough: and many other formulæ for the medicine have been published (B. M. J., i., 1879, Martindale, etc.). It is commonly agreed that the free unoxidised element will produce effects which none of its chemical compounds

can do, and it is desirable, therefore, to give it in its pure unaltered state. There is also a good French syrup (Fauconnet).

An *alcoholic tincture* may be prepared by adding phosphorus in excess to boiling alcohol quite free from water; this will take up 1 gr. in 6 dr. 20 min. (Thompson), and, if carefully kept from light and air, will remain unchanged for some weeks: 3 dr. 10 min. of this tincture (= ½ gr. phosphorus) added to 1 oz. 40 min. of anhydrous glycerine, with 5 min. of spirit of peppermint, is a stable and not disagreeable form.

I myself prefer an *ethereal tincture*, in which 1 gr. phosphorus is first dissolved in 1 dr. of pure ether; and this solution, after standing some days, is mixed with pure alcohol, so that a proportion of 1 gr. in 500 min. is preserved. From 2½ to 5 or 10 min. of this ($\frac{1}{250}$ to $\frac{1}{100}$ or $\frac{1}{50}$ gr.) are readily taken, mixed with water, and the preparation is stable enough for all practical purposes, though it should not be kept long.

What has been stated of the action of phosphorus may be applied to the hypophosphites, only that they are less active and less irritant; they are frequently given in combination.

IODUM—IODINE (I = 127).

Iodine occurs as the iodide of magnesium, sodium, and other alkalis, in sea-water, and in many mineral waters, such as those of Kreuznach, Woodhall, and Cauterets; also in sponges and sea-weeds, in water-cress, beans, potatoes, etc. Molluscs, and the liver of the cod and other fish, contain iodine, and in the human organism minute quantities are commonly found. It was discovered in 1811 by Courtois.

PREPARATION.—Iodine is prepared from kelp, the residue of burnt sea-weed, the soluble iodides being extracted by water, treated with sulphuric acid, and distilled with manganese binoxide. Free iodine volatilises, and is condensed in receivers—$2NaI + MnO_2 + 2H_2SO_4 = I_2 + Na_2SO_4 + MnSO_4 + 2H_2O$.

CHARACTERS AND TESTS.—Iodine forms heavy, bluish-black, glistening scales, which stain the skin yellow or brown, and have a peculiar irritating odour. It is volatile, rising in violet-purple vapour at 400°. The sp. gr. of this vapour is 8·7 compared with air, that of the crystals 4·9 compared with water. It is soluble in alcohol, ether, and chloroform, and in water containing salt or

iodide of potassium, but very slightly soluble in pure water (1 part in 7000). The best test for free iodine is starch solution, which forms with it a dark-blue iodide of starch. In testing an alkaline iodide, nitric acid or solution of chlorine must be added before the starch, which should be cold, as the iodide loses its colour on heating. The addition of caustic alkali also decolorises the solution, iodide and iodate of the alkali being formed—$6I + 6KHO = 5KI + KIO_3 + 3H_2O$. Iodine is closely related, chemically, to bromine and chlorine; it has a stronger affinity for oxygen than these latter, but, for all elements except oxygen, a weaker affinity. Like the other halogens, it is a powerful antiseptic agent.

COMPOUNDS OF IODINE.

POTASSII IODIDUM—IODIDE OF POTASSIUM

(KI = 166).

PREPARATION.—(1) Iodine is added to liquor potassæ in slight excess, as indicated by a pale-brown colour of the solution. (2) The resulting mixture of iodide and iodate of potassium is then heated with finely-powdered charcoal, which deoxidises the latter salt, so that iodide only remains: it is dissolved out and crystallised.

(1) $6KHO + 6I = 5KI + KIO_3 + 3H_2O$.
(2) $KIO_3 + C_3 = KI + 3CO$.

CHARACTERS AND TESTS.—It occurs in white crystals, usually cubical and opaque, but sometimes octahedral and transparent. When pure, these are odourless, but they commonly have a slight smell of free iodine, and if this be present they are tinged more or less yellow: the taste is saline and disagreeable. They are very soluble in water and in six parts of rectified spirit. Nitrate of silver precipitates a pale-yellow iodide of silver, insoluble in ammonia. If the solution be first acidified with nitric acid, no precipitate should occur; if it does occur, chlorides are present. The most important adulteration—not, however, a very frequent one—is the iodate of potash, and this is detected by its insolubility in rectified spirit, and also by the blue colour developed on adding prepared starch and a little tartaric or other acid.

SODII IODIDUM—IODIDE OF SODIUM

(NaI = 150).

PREPARATION.—Same as that of potassium iodide, solution of soda being used in place of solution of potash.

CHARACTERS AND TESTS.—A dry, white, crystalline, deliquescent powder, having a saline and somewhat bitter taste, readily soluble in water and spirit: gives the chemical reactions for iodine and sodium.

Ammonii iodidum—iodide of ammonium (not officinal) is prepared in a similar way. It is a crystalline body, and being less stable than the preceding salts, is usually stained yellow from free iodine. *Iodide of Strontium* has been lately much commended by Laborde and others.

ABSORPTION AND ELIMINATION.—Iodine may be absorbed to some extent by the unbroken skin, if the local inflammation excited be not too severe: a dilute solution is therefore better absorbed than a strong irritant tincture. If a limb be painted with tincture of iodine, and covered with oiled silk, drops of colourless liquid may be found upon it after a few hours; this liquid contains the drug altered in some way by the perspiration, and a similar alteration possibly occurs before its absorption. The drug may also be absorbed by the skin in a bath containing iodine and iodide of potassium, and from serous and mucous membranes. Iodide of potassium and other alkaline iodides are not absorbed as such, even when applied to the skin continuously in lotion or ointment, but after being decomposed by the acids of the perspiration, or of lard, etc., they evolve free iodine, which may be absorbed, as proved by its appearance in the urine (Rabuteau). Iodide of ammonium is the alkaline salt most readily decomposed. Baehrach applied compresses of 2½ per cent. iodate of potassium solution to the limbs, and in healthy subjects found iodine in the urine after fifteen minutes—in fever patients only after an hour or more (Cbl. f. med. Wiss., ii., 1879). By *mucous* surfaces these compounds are easily absorbed; thus, when a suppository containing 20 gr. of iodide of potassium was placed in the vagina, 18 gr. were absorbed in twelve hours; glycerine diminished the rate of absorption, whilst a little free iodine increased it (B. M. J., i., 1878). *Serous* membranes absorb iodides still more rapidly.

Taken into the stomach in small or moderate doses, iodine coagulates and combines with albuminous material, and is probably taken up in part as an albuminate, though a larger proportion combines with the soda of the stomach contents, and

becomes iodide of sodium before being absorbed. Rabuteau thinks this combination with sodium occurs, to some extent, in the blood.

Alkaline iodides are either absorbed unchanged, or as iodide of sodium. Metallic iodides, such as those of iron, lead, or mercury, are decomposed in the alimentary canal, forming iodide of sodium, which appears in the urine, whilst the metal passes by the bowel or is deposited in the tissues. Absorption of iodides seems to be markedly promoted by ozonic ether, by ammonia, and some other stimulants. Both iodine and the alkaline iodides are readily and rapidly eliminated by the different secretions, and may be detected in the saliva, the buccal and bronchial mucus, the tears, the milk, the perspiration, the urine, the serum of joints, etc. R. W. Taylor has reported evidence of elimination of iodine by the skin in the case of a man with pityriasis, who took large doses of the potassium salt whilst wearing a starched shirt; he had profuse perspirations, and a dark coloration, due to the formation of iodide of starch, appeared on his back. In another case of a man taking 10 gr. doses for syphilis, not only the linen but the hair became coloured brown (B. M. J., ii., 1891).

It would seem that almost all the iodine taken is excreted in the urine, for Scharlau recovered from that excretion 345 centigrammes out of 350, and according to Melsens, very little can be traced in the fæces; the iodine that is excreted into the intestine being absorbed again by the lining membrane before it reaches the rectum. Rabuteau found a small quantity in the fæces, so long as it was present in the other secretions; if diarrhœa occurred the quantity was notably increased. Ehlers concluded that doses above 20 gr. are not completely absorbed; of that quantity he found 75 per cent. eliminated (Annales de Derm. et Syph., 1890).

The *rapidity* of elimination varies with the quantity taken, a large dose giving evidence of its passage very quickly. Ranke found traces in the urine three and a half minutes after administration, and even sooner in the saliva. Nothnagel also found it early—in ten minutes in the latter secretion. Dr. Richardson found it in the urine within one minute of injecting tincture of iodine into an enlarged bursa, and three minutes after breathing iodide of ethyl, iodine could be detected in the urine. It is an important practical point that the elimination of this drug is com-

pleted sooner than that of many others. Dr. Balfour noted that even if large doses of iodide of potassium had been taken for many weeks, their elimination was complete within three or four days after ceasing to take them (Edin. Med. Journ., 1868). Sir Dyce Duckworth, after a dose of 4 gr., found iodine in the saliva in five minutes, in the urine in twenty-five minutes; after twelve hours' interval it was still to be detected in both secretions, but after thirty-six hours in neither (Barth. Hosp. Rep., vol. iii.). Rabuteau, after 15 gr., found traces in the urine for three days; after 150 gr. for ten days; not afterwards. The greater part was eliminated during the first day, little passed on the second, and scarcely a trace on the third; in the dog, elimination was somewhat slower. Claude Bernard, giving iodide of potassium, ceased to find it in the urine twenty-four hours afterwards; that he detected it in the saliva for three weeks must be considered exceptional. Speck has stated that in Bright's disease the kidneys do not eliminate iodine, and Sir Dyce Duckworth could not detect it in one case after giving 10 min. of the compound tincture, but 3 gr. of the iodide of potassium gave evidence of its presence, much later, however, than usual, namely, one, two, or three hours after administration.[1] Desprez gave iodide of potassium subcutaneously, and succeeded in recovering two-thirds of it subsequently from the urine, its earliest appearance in that secretion occurring twenty minutes after the injection. He found that febrile conditions and disease of the kidney delayed the appearance of the salt in the urine, prolonged the period during which elimination occurred, and in the case of Bright's disease, instead of finding two-thirds of the drug in the urine, he found only a quarter, a sixth, and even an eighth (Lancet, ii., 1884). Baehrach, giving moderate doses of iodate of potassium by the mouth to healthy subjects and to fever patients, traced the drug in the urine of both within fifteen minutes, but on injecting it under the skin, elimination in the former occurred in five minutes, and in the latter forty minutes later (*loc. cit.*). If tincture of iodine be injected into serous cavities, it passes out of the system as iodide of sodium, never as free iodine or iodate (Anfuso. Rev. Sc. Méd., 1891).

[1] Iodine may be detected in any secretions by white starched paper, which should be moistened with the liquid and then touched with nitric acid containing some nitrous acid: blue iodide of starch will be developed.

As will be noticed again under therapeutical action, iodides have a remarkable power of eliminating with themselves various metals and possibly organic poisons previously circulating in the blood or deposited in the tissues.

PHYSIOLOGICAL ACTION.—*External.*—Locally applied, iodine in tincture, or strong solution, acts as an irritant or caustic. It stains the skin yellowish-brown, permeates and destroys the epidermis, and if it reaches the true skin, causes severe heat and prickling, sometimes vesication, followed by desquamation or superficial scarring.

Volkmann and Schede found that a few hours after the application of iodine the white blood-corpuscles had escaped from the neighbouring vessels to such an extent as to give, under the microscope, an appearance of suppuration; disintegration and fatty degeneration of tissue-elements also occurred, and prolonged applications to the limbs of rabbits caused periostitis.

Iodine has marked antiseptic and antizymotic power, and is fatal to the lower forms of life, both animal and vegetable.

Its vapour, when inhaled undiluted and in sufficient quantity, causes heat, irritation and cough, and sometimes has occasioned bronchitis and hæmoptysis: it is also very irritating to the conjunctivæ.

Frictions with iodide of potassium sometimes produce local irritation and an acneiform eruption.

PHYSIOLOGICAL ACTION.—*Internal.*—**Mucous Membranes.**—The earliest and most marked evidence of the constitutional action of iodine, whether taken by the mouth or injected hypodermically, is furnished by irritation and catarrh of the mucous membranes. If iodine itself be used, as in the form of tincture, there is more liability to *local* irritation of the mouth and stomach than with the alkaline iodides, but the *distal* mucous irritation is the same with all forms of the drug. It is shown mostly in the throat and bronchi, the nose and eyes—parts that are all exposed to contact with carbonic acid gas, which it is supposed decomposes the iodide as it is eliminated, so that free iodine exerts its local irritant effect. Others trace a similar decomposition to contact with ozone in the blood or in the air (Virchow's Archiv, lix.). The irritation shows itself by pain and sense of pressure over the frontal sinuses, œdema, prickling, and heat about the

nose and eyes, with sense of stuffiness and serous discharge like that of ordinary coryza. The dose that will produce these symptoms varies a good deal with different persons, some being acutely affected by 1 or 2 gr. of potassium iodide, others not by 10 or even 20 gr. continued daily for a long time.

Circulatory System.—Iodine and iodides, especially the former, stimulate this system, raising the blood-pressure, rendering the pulse fuller and more frequent, dilating the capillaries, and increasing heat in the extremities; the after-effects, however, of continued doses may be the reverse of these.

Germain Sée discriminates between the action of the potassic and sodic iodides, finding that the former at first quickens and strengthens the action of the heart and raises the blood-pressure and constricts the capillaries, whilst the latter slows the heart—he distinguishes two phases of the action, that of the alkali and of the iodine—and the *final* effect of continued doses of either salt is to *lower* blood-pressure (Lancet, ii., 1889). Prévost and Binet state analogous conclusions as to pressure, but find the sodium acts quite like the potassium salt, if given in much larger doses (Rev. Sc. Méd., 1891).

After toxic doses, first palpitation and flushings, afterwards faintness, pallor, and collapse occur, and Benedict concluded, from observations on batrachia, that both cardiac action and respiration were paralysed (Schmidt's Jahrb., Bd. cxv.). A case of this kind is reported by Heller (Wien. Med. Presse, 1887), besides the extravasation of blood, most of the typical symptoms of iodism being present; and a fatal case is reported, from less than 4 gr. every six hours for four days, in a woman of forty-nine (Internat. Journ., 1891).

The blood itself does not seem to be affected unless it be rendered more fluid, and disposed to exude, for a form of purpura—"iodic purpura"—has sometimes occurred under the use of iodide of potassium, but, probably, it is better accounted for by the action of the drug on the walls of the vessels.

Dr. T. C. Fox records an illustration in an adult with syphilide, and convalescent from rheumatic fever. After the second dose of 5 gr., a copious eruption of purpura came out on the arms and legs; this gradually faded and again recurred whilst the medicine was continued. The eruption came again under each of

the alkaline iodides, especially the ammonium salt; iodism occurred at the same time, but the syphilide got well: there was no evidence of renal or other organic disease (B. M. J., i., 1879). Dr. Stephen Mackenzie attributed fatal purpura in an infant to one dose of 2½ gr. of the same medicine, but, in this case, the sequence is not so clear as in some others alluded to by him (B. M. J., i., 1878). Dr. G. Thin, after microscopic examination of eruptions caused by iodide, asserts that the neighbouring capillaries are blocked, and their walls altered, but the patient from whom the specimens were taken was syphilitic (Med.-Chir. Trans., 1879). I have myself noticed in several cases that a purpuric eruption has followed the use of iodide of potassium. Dr. J. A. Lindsay has recorded a case where, after two doses of 3¾ gr., this salt caused an eruption scattered over the whole of the cutaneous surface excepting the legs, and consisting of blisters about the size of half-a-crown, which were surrounded by two concentric red rings; a considerable amount of itching was also present (B. M. J., i., 1884). M. Besnier affirms that pure iodine never causes purpura, only iodides (Annales de Derm. et Syph., t. x.).

Whatever the pathological processes may be, I am satisfied that tincture of iodine is liable to cause hæmorrhage from various organs, especially in phthisical subjects, and in those with uterine congestion. Kness has observed hæmorrhage from the lungs and uterus in poisoning by iodide of potassium (B. M. J., i., 1879), and extravasations of blood have been found post mortem in animals poisoned by iodoform (Med. Record, 1879).

Nervous System.—Much disturbance of the nervous system sometimes follows the full action of iodine. It is marked at first by excitement with restlessness, tremor, anxiety, and insomnia, but this state is liable to be succeeded by feebleness and depression. Toxic doses have caused violent headache, and sometimes convulsion (*cf.* Iodoform). Rilliet described neuralgia, tinnitus, disturbed intellect, and convulsions, as prominent symptoms in some cases of iodism. Trigeminal neuralgia has also been reported by others, but lasting for a time only (Lancet, i., 1891). Altered vision and paralysis were noted by Brodie. "Occasional hyperæsthesia and temporary palsy of lower extremities" occurred in a man who was taking very large doses (90 gr. thrice daily) of

iodide of potassium (S. A. Lane, Lancet, ii., 1873). Such symptoms, however, must be considered rare. H. Wood states that he has only seen the nervous system affected once in his experience, even "with enormous doses," and then the patient, who had been taking 270 gr. daily, became "intensely sleepy and stupid," as if under the influence of *bromide*. Extreme depression is not an uncommon effect of even small doses in sensitive subjects, and sometimes compels the disuse of the drug.

Binz experimented with the *iodate of sodium*, and found that in rather large doses this salt caused narcosis in animals. It proved especially poisonous to the respiratory and cardiac centres, and he suggests that both this salt and iodoform are decomposed, and liberate iodine in the brain and cord.

Digestive System.—Iodine has a pungent taste, and in small doses causes heat and stimulation of the stomach, with some increase of appetite. A dose of more than 1 gr. usually causes sickness, and 5 gr. give rise to salivation, pain in the abdomen, and diarrhœa, though even 15 grains may be tolerated; large doses may cause glossitis, local inflammation, and ulceration. Vomiting, burning pain, spasm, choking sensation, and impairment of the special senses were symptoms noted by Mr. Bainbridge, after the taking of 1 oz. tinct. iodine B.P.; oil was given, and recovery occurred gradually (Lancet, ii., 1875).

The alkaline iodides readily disorder the stomach in many persons, and though at first they may increase appetite, they afterwards impair it. Small quantities are apt to constipate, but if continued they produce diarrhœa with liquid, slimy stools. At times, gastric irritation and catarrh are the only marked symptoms of iodism (Rilliet); large doses seem often better borne than small ones. Leroy (Brussels) has adduced evidence to show that when gastric pain is caused by iodide of potassium, it is really due to adulteration with iodate (Med.-Chir. Rev., ii., 1857). Mialhe endorses this, and Melsens considers such adulteration dangerous; five dogs were poisoned by it (Mémoire, Brussels, 1865).

Rabuteau points out that either of the salts separately is unacted upon by weak hydrochloric acid, whilst their mixture is quickly decomposed by it with liberation of free iodine; also, if fresh gastric juice be mixed with starch in test tubes containing the one iodide, and the other iodate, no blue reaction occurs till

the contents of the two tubes are mixed, implying that free iodine is the irritant agent in the impure salt, and that a pure alkaline iodide is non-irritant. Practically, however, I am satisfied that as pure an iodide as is obtainable will produce gastric irritation in some subjects. In the case of all iodine compounds, such irritation may be avoided or lessened by giving them freely diluted, and shortly after food; though some say that the mucus of the fasting stomach is a better protection.

Lymphatic System.—The drug increases the activity of the lymphatic system. This increased absorption is, no doubt, however, very largely due to the fact that certain kinds of tissue are broken down and rendered more susceptible of absorption. The iodine set free from the iodide is taken up by albuminous substances, and the entrance of the iodine molecule into their composition causes them to undergo more rapid metamorphosis. This explains the action of the drug in causing absorption of gummata and inflammatory deposits; and gives a reason for its usefulness in scrofulous conditions, associated with enlargement of lymphatic glands, thyroid, and spleen.

Schleich and also Heinz have found, independently, that iodide of potassium both increases the formation of leucocytes and their determination to any wounded or ulcerated place, thus stimulating granulations: at the same time they corroborated the observation of Binz, that iodoform, *i.e.*, free iodine, lessened the migration of leucocytes (Rev. Sc. Méd., 1891).

The secretion of the salivary glands, of the pancreas, and, possibly, of the lachrymal glands and of mucous membranes and the testes, is increased by it. Rutherford concluded that the bile was not affected in quantity (B. M. J., i., 1879).

The secretion of milk is lessened under the influence of iodides, and may be almost wholly prevented by small doses commenced soon after delivery. If already established it may be suppressed by the same treatment if the infant be not placed to the breast (Morris, Lancet, ii., 1864). There are, however, some observations to the contrary, *e.g.*, those of Lazansky (Med. Record, 1878), who states that iodine does not affect the secretion, and certainly it may be given to syphilitic nursing mothers without stopping the flow of milk when this has been established for several months. Dr. Dolan also concluded that iodide of potas-

sium failed to stop the secretion, but the balance of recorded evidence is that 5 or 10 gr. doses will do so. Drs. Braxton Hicks and Playfair teach the same.

Whether iodine can cause atrophy of true glandular structure is an important question which is not yet decided in the affirmative, though Rilliet accepts its truth in the case of the testes and mammæ. Moisisovitz states that iodine has this effect, but not the iodides; he refers to 800 patients (Canstatt, Jahresb., 1866): certainly large quantities have been given without any such occurrence. Rabuteau gave to a woman, in the course of six years, 3 *kilogrammes* of iodide of potassium, yet the breasts were not at all affected by it, and Velpeau never observed wasting in 15,000 cases treated by him (Med.-Chir. Rev., ii., 1860). On the other hand, one case of wasting of the testes is recorded, but is not convincing (Philad. Med. Times, iv.). An enlarged and hard gland will grow less under these remedies from absorption of hyperplastic material, and even a healthy gland may grow smaller from absorption of fat or epithelial products, but so far as I have seen, the breasts, etc., recover their natural appearance on omission of the remedy, which they would not do if the gland-structure were actually destroyed.

Cutaneous System.—Besides the purpura already mentioned, various forms of skin-eruption may follow the internal use of iodine or the iodides, the most usual being allied to acne in appearance, and (according to T. Fox) in pathology also, that is to say, connected with irritation of the sebaceous glands. Sir Dyce Duckworth did not find the sweat- or hair-glands affected, and speaks of the rash as a "vesiculating dermatitis" (B. M. J., i., 1879); but I have seen the rash differ greatly in appearance.

The ordinary rash is at first papular and then becomes pustular, and affects especially the face, head, and back; sometimes an erysipelatous blush is produced, sometimes bullæ, ecthyma, or anomalous pustules (Hutchinson). An interesting case of "dermatitis tuberosa" affecting the nose is recorded by Dr. Walker, from Unna's clinique; he adds also, urticarial, pemphigoid, anthracoid, and nodular, to the various forms described above as occasionally due to iodides (Lancet, i., 1892; *cf.* N. Y. Med. Journ., Nov., 1888—Dr. Taylor's case). Œdema of the eyelids sometimes occurs. The irritant effect upon the skin may be much

controlled by small doses of arsenic, and by scrupulous cleanliness: it cannot be taken as an index of the physiological or therapeutical action of the drug.

Genito-urinary System.—The genital system is said to be stimulated by iodine (Jörg); an increased flow of blood to the uterus is sometimes produced by it. If the iodide of potassium has a similar effect it is much less in degree; in fact, this drug is usually regarded as anaphrodisiac.

The effect of either preparation upon the urine is variable. Begbie speaks of iodide of potassium as one of the best diuretics (Lancet, ii., 1875), whilst Dr. Handfield Jones, out of six cases observed, found the secretion increased in three, but diminished in two (Beale's Archives, No. 3): similar variation has occurred in the uric acid and urea. Rabuteau observed no diuresis from 15 gr. doses. Wöhler, giving iodine to a dog, noted increase of urination, but only in proportion to increased quantity of water drunk. Bassefreund, from observations on himself, concluded that the urine in healthy persons was not augmented under iodides; at first, it was rather lessened in quantity (Canstatt, Jahresb., 1859). Very large doses may irritate and congest the kidney, and induce albuminuria, in which case the amount secreted would naturally be lessened (Gubler). Mr. Hutchinson "suspects that iodides may cause Bright's disease" (Lancet, ii., 1876). Dr. Simon found that albuminuria occurred in the majority of children who had tincture of iodine externally applied, whether to the scalp, the chest, or the knee (B. M. J., ii., 1876), although from the analyses of Dr. Ord in a case of iodine-poisoning, the urinary precipitate in such cases would seem to be mucin rather than albumen. As remarked by Sir Spencer Wells, the alkaline iodides have some power of dissolving uric acid, but this is due probably to the alkali rather than the iodine. In Dr. Ord's case, urea and uric acid were largely *increased*. In diabetics taking iodide, the same thing occurred (Bouchardat).

On the other hand, Rabuteau, taking daily, for five days, 15 gr. of iodide of potassium, reported marked *diminution* in his excretion of urea to the extent, some days, of 40 per cent. during the period of experiment, and for nearly a fortnight afterwards.

Influence on Nutrition.—From the above discrepant results, it becomes difficult to theorise concerning the action of iodine on nutrition, and further reliable analyses of the excretions under its

use are desirable. The French physiologists concluded that its influence resembled that of arsenic, *i.e.*, had more of an alterative and modifying than of an absorbent and eliminant character. My own observations lead me to place more stress upon the latter. Although the medicinal use of iodides in certain disorders may bring about an improved state of the nutrition (Wallace found, for instance, that his syphilitic patients gained flesh under its use), yet, when given continuously to persons of average health, these medicines usually impair nutrition, and induce more or less emaciation. Dr. Mitchell Bruce states that it accelerates tissue change without increase of urea, or bodily wasting, and suggests metabolism of plasma rather than of tissues themselves. Samoilow has shown, by numerous observations on animals, that iodide of potassium given in small doses promotes assimilation, whilst large doses have an opposite effect (Internat. Journ., 1887).

Idiosyncrasy—Toleration.—There is much difference in the susceptibility of persons to the action of iodine, and we can explain this in no better way than as "idiosyncrasy." According to Seguin, children are usually more tolerant than adults in proportion, and cerebral and cardiac cases usually less so (Lectures). Speaking generally, it may be said that pale, thin, languid patients often bear it better than the stout and plethoric who have a tendency to active congestion of the head or stasis of circulation. Such subjects, if rheumatic, are often intolerant of even small doses; so are the sufferers from goître or exophthalmos, or nervous palpitation accompanied with irregular flushing and impaired vaso-motor power. In such cases small doses ($\frac{1}{2}$ gr.) often produce as beneficial results as large ones do in persons who are but little affected by the drug.

Climate and soil seem to have some influence, for Coindet's patients, in Geneva, were much more susceptible than those of Ricord, in Paris (Med.-Chir. Rev., ii., 1860). Gerson saw no iodism after giving 21 gr. to a patient suffering from chronic nephritis: no iodine was excreted in the urine, which accounts for the result (München. med. Woch., 1889). Dr. Lisson concluded that people with fair skin were more susceptible to the action of this, and all other drugs affecting the skin, than dark subjects, and this may prove some guide. He himself was able, by commencing with small doses, to induce a state of toleration, so that he could

take 100 gr. of iodide of potassium without marked effect (Lancet, i., 1860). Mr. Arthur Cooper states that the largest amount he has given in the day was 540 gr. of the iodide of ammonium, and he mentions no bad effects from it (Lancet, i., 1885). On the other hand, 3 gr. doses have caused severe inflammatory attacks (Lancet, ii., 1873), and even a less quantity may excite distressing coryza. Bad effects may, however, be often avoided by following Lisson's plan, and inducing tolerance, *e.g.*, I gave a patient with syphilis iodide of potassium in 3 gr. doses thrice daily, but he always suffered from coryza and headache after two or three days; then it was reduced to 1 gr., and the same results followed; then he took $\frac{1}{2}$ gr. thrice daily and had no ill effects, and the dose was gradually increased, and in a few weeks he was able to take 15 gr. three times daily without any bad symptoms. In one case, iodism setting in after the fourth dose of 3 gr. of iodide of potassium affected the larynx so intensely as to require tracheotomy (Lancet, ii., 1875), and Fournier reports two fatal cases of œdema glottidis due to iodide of potassium (Gaz. des. Hôp., 1889), while Rosenberg has also seen œdema of larynx (Deut. med. Woch., 1890). Other cases of œdema glottidis lead to the conclusion that this symptom is due to idiosyncrasy and not to impurity in the drug or to disease in the larynx (B. M. J., i., 1890). *Acute* iodism is generally proportional to the largeness of the dose; but the *chronic* condition is more readily induced by continued small doses. The iodide of sodium is often, although not always, better borne than the potassium salt, while the iodide of ammonium, owing to its instability, is apt to disagree, but iodide of strontium seems to have advantages over all these (although I have seen five cases of iodism from iodide of strontium).

SYNERGISTS.—The stimulant action of iodine is increased by warmth, alcohol, ozonic ether, the essential oils, etc. Ammonia especially has been found to assist its effect and enable it to be borne, either by chemical combination with it, or by bringing about free circulation in the skin.

The absorbent effect is remarkably aided by the simultaneous use of mercury, and *vice versâ*.

ANTAGONISTS AND INCOMPATIBLES.—Cold, quinine, digitalis, the alkaline bromides, and other sedatives to the circulation, moderate or antagonise in part the specific action of iodine;

this fact, however, does not prevent its combination with those drugs for therapeutical purposes. Starch and albuminous substances are the best chemical antidotes to iodine in cases of poisoning.

Carbolic acid and liquor ammoniæ enter into combination with the drug, and remove its brown colour, but are said not to lessen its active properties. I have not, however, obtained as good curative results in absorption of tumours from the ammoniated iodine as from the pure drug. Bismuth subnitrate, which is sometimes prescribed with the iodide of potassium, precipitates an insoluble red iodide of bismuth. The organic alkaloids, strychnine, atropine, etc., are precipitated by iodine—according to Dr. Fuller, 1½ gr. of strychnine by 1 dr. of tincture of iodine; hence he and other observers have thought them mutually antidotal, but the compounds formed are themselves poisonous (Med. Times, i., 1861; Lancet, i., 1868), and require removal from the stomach as much as the original poison (Lancet, i., 1876). With regard to the asserted incompatibility of quinine and iodides, no doubt the direct combination of full doses is apt to disagree and to cause sickness (B. M. J., i.-ii., 1884), but if the quinine be first dissolved in a little hydrochloric acid, or better, in glycerine, ordinary doses are usually well borne. Brunton notes a "persistent bitter taste" from the mixture, not experienced from either drug separately, and thinks it due to the iodide promoting excretion by the saliva. The iodide of starch may be antidotal to sulphides and to caustic alkalies, as stated by Bellini. If calomel be applied to the eye while iodide of potassium is being taken internally, red iodide of mercury is formed locally and may irritate the conjunctiva severely.

THERAPEUTICAL ACTION.—*External.*—Iodine is used (both alone and combined with iodide of potassium or with camphor) in tincture, liniment, and ointment, as a mild stimulant, or strong counter-irritant, or a caustic, according to the strength of the application. It causes pain when applied freely, and in children, and delicate tuberculous subjects, should be used with special caution.

Strumous Glands.—"Iodine paint" is a common and often a useful application to enlarged and hardened glands in the neck, groin, etc.; but sometimes the constant application of iodine lotion (½ oz. of tincture to ½ pint of water) gives a better result, and is

less painful. Mr. F. Jordan recommends painting iodine not *over* but *round* the enlarged glands, and this is sometimes more advantageous.

If suppuration has occurred, the tincture should be painted over the neighbouring thin skin; and if the open sore remain indolent, it should be dressed with iodoform ointment, or with a solution of about 2 dr. of tincture in ½ pint of water, and applied on lint covered with oiled silk. In certain chronic glandular enlargements, the direct injection of iodine tincture acts better and more quickly. Bonalimi (Med. Record, 1876) found it more serviceable when the growth was not scrofulous; but Mr. Bradley recorded a very favourable experience—(1) in true hypertrophy of lymphatic glands; (2) in strumous hypertrophy, before softening has occurred; (3) in hard multiple lymphomata and encapsuled cervical tumour. He used from 5 to 10 min. of the tincture, at intervals of four to five days (Lancet, ii., 1875).

Enlarged Tonsils.—These are often connected with the strumous diathesis, and iodine tincture is one of the best local applications, though it is an unpleasant one, and sometimes excites irritation. After some absorption has occurred, I follow its use with the solution of perchloride of iron. In obstinate cases, a few drops of iodine tincture have been injected into the substance of the tonsil with good result. The internal use of the drug, or of iodides and cod-liver oil, is desirable at the same time.

Bronchocele.—In cases of fibrous and fibro-cystic bronchocele where calcareous degeneration has not occurred, local applications of iodine should be combined with its internal use. If the part be tender or inflamed, soothing fomentations, or even moderate leeching, may be needed before using iodine; then either the liniment may be painted on once or twice daily for several days, according to the degree of irritation produced, or an iodised collar may be worn (made with iodine sprinkled on wool), or iodide of mercury ointment may be rubbed in (*v.* Mercury). I have sometimes been disappointed with the mere external use of iodine in bronchocele, but have had excellent results from its *injection* into fibrous and fibro-cystic cases (25) in which I have used it. In one large fibro-cystic growth, in which there was some difficulty of diagnosis, no fluid being suspected, 30 min. of the tincture were injected, and considerable diminution of the growth

followed: a month afterwards 3 oz. of fluid were drawn off, and the cyst injected with 2 dr. of a solution containing 1 part of tincture to 3 of water. The man was highly scrofulous, and the growth of long duration; but after the inflammatory condition set up by the iodine had subsided, the bronchocele disappeared and gave no further trouble. The only case in which dangerous results occurred was one in which some iodine solution had escaped into the cellular tissue, and sloughing of the part followed. Nineteen out of the twenty-five cases got well, two of them having been injected seven times. Dr. Lücke, of Berne, has reported equally good results in the fibrous form of enlargement. Of sixteen cases treated by him, eleven were cured and four improved; and Sir Morell Mackenzie, who at first considered this method inferior to others, recorded his later experience of it as very favourable. He obtained unexpected cures in fibrous and adenoid cases from the weekly or bi-weekly injection of 30 drops of tincture (Med. Times, i., 1872; B. M. J., ii., 1873). Dr. Luton speaks well of similar injections of iodic acid—1 part to 5 of water,—he uses about ½ dr. at one time (Lancet, ii., 1873). Evidence both for and against parenchymatous injections of iodine in goître has accumulated since my last edition, but the balance is still favourable, though possible danger must be recognised. Whilst Scopari, Tivy, and others have reported excellent results (Med. Record, 1883-85), Drs. Sémon, Wörner, and others have drawn attention to cases where serious and even fatal consequences have followed (B. M. J., i., 1885; Record, 1885). The latter concludes, however, that the operation is feasible, if the innervation of the larynx is unimpaired. The treatment of goître by iodide of potassium, together with local application of cold by Leiter's tubes, has also been advocated (Record, 1884) (*v.* Iodoform; also Internal Use).

Orchitis—Prostatitis—Mammary Growths.—If hardness and swelling of the testicle remain after subsidence of the acute stage of this malady, iodine lotion or ointment, with strapping, will prove effective.

In subacute and chronic enlargement affecting the prostate gland, I have seen much advantage from iodine suppositories, but still more from iodoform ointment, though Sir H. Thompson, in his treatise, does not speak favourably of the former, nor does

he mention the latter. In cases of chronic enlargement, Heine states that he has injected the tincture into the substance of the gland with successful results (Med.-Chir. Rev., i., 1873).

Congestions and localised hardness and obstruction of the mammary ducts are amenable to iodine frictions, but the skin of the breast is very sensitive and easily irritated.

Pleuritis—Phthisis.—The external use of iodine will frequently relieve subacute pleuritic pain and the "flying" chest-pains which are common in phthisis. In chronic pleuritis with effusion, iodine liniment or ointment has some power to promote absorption; and in phthisis and chronic bronchitis, painting it over the front part of the chest serves to impregnate the air which is breathed, and modifies expectoration and the state of the bronchial membrane. Inhalation of iodine may also be practised, and a few grains may be left exposed in the sick room with advantage. Fœtid organic odours from the breath, etc., are lessened by it. Iodine, 10 gr., dissolved in 1 oz. amyl hydride, makes a good inhalation (Med. Times, ii., 1871).

Diphtheria—Croup.—I have found an iodised spray or inhalation often useful in these maladies. A good formula is one containing 4 gr. each of iodine and iodide of potassium in ½ oz. alcohol and 4 oz. water. Of this one to four teaspoonfuls may be added to a pint of boiling vinegar or water, and the vapour inhaled every two hours from five to ten minutes.

Menzel has injected a few drops of tincture of iodine into the soft palate and tonsils in diphtheria, and apparently with success (Med. Times, ii., 1873).

Chronic Peritonitis, etc.—In this malady, especially when occurring in strumous subjects, and accompanied with enlarged mesenteric glands, the external use of iodine in the form of ointment, liniment, or compress, should be conjoined with internal treatment: also in cases of chronic congestion of the liver and spleen the external application of iodine is often useful.

Uterine Congestion, etc.—In congestive enlargement of the uterus, with some induration of the cervix connected with subinvolution or chronic inflammation, benefit may be derived from iodine locally applied. Tepid injections containing 1 to 2 dr. of the tincture in a pint of water, and also iodised hip-baths are useful. Dr. Greenhalgh prepares an "iodised cotton" by satu-

rating 8 oz. of cotton in the same quantity of glycerine, containing 1 oz. of pure iodine and 2 oz. iodide of potassium, and keeps a pledget of this pressed for some hours against the cervix, withdrawing it when necessary by a thread secured to it. Dr. Graily Hewitt applied the tincture directly to the inflamed part, and recommends this treatment especially for patients of sluggish habit and scrofulous diathesis. My own experience of this treatment in similar cases is favourable. Dr. James Bennet recommends direct injection of an iodised solution in chronic cervical metritis (Dub. Med. Journ., Oct., 1878). In cases of granular erosion and ulceration, the iodide of silver, prepared extempore as recommended by Dr. Wright, by adding a few drops of iodine tincture to some nitrate of silver solution, may be used with much advantage. In amenorrhœa dependent upon torpor of the uterine system, local applications of iodine are useful.

Menorrhagia.—In persistent cases Dr. Savage, and also Dr. Routh, have used intra-uterine injections of iodine (Lancet, ii., 1851; Med. Times, i., 1860), but this treatment involves too much risk for ordinary use. In chronic uterine leucorrhœa Dr. G. Murray applied the remedy by means of a sound, which is safer than injection (Lancet, i., 1866).

Injection of Cysts—Hydrocele.—The injection of iodine in cases of hydrocele gives better results than any other remedy. The serous fluid should first be evacuated thoroughly, and then 1 to 4 dr. of iodine tincture injected (according to the size of the cyst). Sometimes inflammatory reaction occurs, and lasts two to six weeks, but the ultimate result is usually good. I have seen one case of fifteen years' duration, where the scrotum hung nearly to the knees, and was supported by a sling round the neck; after puncturing and evacuating, 6 oz. of iodine tincture were injected: the physiological effects were strongly developed, but complete cure followed. I believe that Sir Ranald Martin introduced this method of treatment, but he diluted the tincture with two parts of water.

Mr. Furneaux Jordan has advocated the use of two or three threads soaked in the tincture and drawn through the hydrocele, to act like a seton (Lancet, i., 1876).

Spina Bifida.—I have not myself had much experience recently in the use of iodine in this deformity, and what I had in

former years was not favourable; but the results of Dr. Brainard, Dr. Morton of Glasgow, and others, have placed the operation on a new basis. The cases were not simply those in which connection with the spinal canal was naturally obliterated, and which might fairly be expected to recover, but included some of much more serious nature; and in the majority, not only was the sac obliterated, but improvement as to paralysis and general health occurred. The solution used ("Morton's solution") was—"iodine 10 gr., iodide of potassium 30 gr., glycerine 1 oz.," and of this ½ to 1 dr. was injected after removal of more or less fluid according to the case (Lancet, ii., 1876).

Dr. G. W. Thompson records an instructive illustration, in which the tumour over the sacral region was twelve inches in circumference ten days after birth; it was attached by a pedicle and communicated with the spinal canal. After tapping and removing about 2 oz. of fluid, 25 min. of Morton's solution were injected and the aperture sealed. There was much shock, and brandy was given freely; gradual improvement, however, took place, and six months afterwards only a mass of thickened skin remained (B. M. J., ii., 1878).

Mr. Pearce Gould has recorded an interesting case of recovery under similar treatment. The child, aged eighteen months, had a sessile tumour, as large as a cricket ball, situated over the last lumbar and sacral vertebræ, and communicating with the spinal canal. At the first operation 6 dr. of fluid were drawn off, and ½ dr. of Morton's solution injected; at the second operation 1 oz. was removed and 1 dr. injected; at a third, 2½ oz. removed and 2 dr. injected. There was neither shock nor convulsion; improvement set in on the ninth day after the last operation, and ultimately only a flat mass of dense tissue remained: there was no paralysis (Clin. Soc. Trans., vol. xi.), but in other cases paralysis has occurred (B. M. J., i., 1886).

The committee of the Clinical Society, appointed to investigate Spina Bifida, gave the following report (Trans., 1882), on Morton's treatment. They considered it the best method with which they were acquainted, notwithstanding its many failures, but they recommended a more careful selection of cases than had been made hitherto. Marasmus, hydrocephalus, and intercurrent disease contra-indicate the operation. The best result is to be hoped for

in children who have reached the age of two months, in whom there is no paralysis or hydrocephalus, and when the sac is covered with healthy skin. In cases in which the operation may be legitimately performed, the following were stated to be unfavourable circumstances: (1) evidence of the cord being in the sac; (2) a very thin, membranous, ulcerated, or previously ruptured sac; (3) the occurrence of a distinct impulse between the tumour and the anterior fontanelle, or a sac, the contents of which are easily returned into the spinal canal; and (4) a very early age of the patient.

Hydrarthrosis.—In extensive chronic serous effusion in the knee-joint, injection of iodine has frequently led to cure. One part of iodine, 2 of iodide of potassium, and 8 of water, are injected in about the same quantity as is withdrawn by aspiration; air should be carefully excluded from the wound. Mr. C. Macnamara has injected 1 oz. of the pure tincture with quite satisfactory results (Lectures, 1881).

In less severe cases of effusion, in bursal effusions (housemaid's knee), and in rheumatic and gouty joints, the external application of iodoform, or iodine paint, promotes absorption, and should be tried before puncture. Dr. Fuller recommended a lotion containing $\frac{1}{2}$ oz. of tinct. iod. in 6 oz. each of glycerine and water, and applied on lint covered with flannel; frictions and douches should be combined with this treatment (Lancet, i., 1863).

Pleuritic Effusion.—The external use of iodine, combined with pressure, aids in the absorption of such effusions, and some surgeons have, in chronic cases, injected and retained a weak iodine solution (4 or 5 gr. to the pint) into the pleural cavity, with ultimate success. It seems to be, however, an operation of unusual risk, and one which has been followed, more than once, by death from inflammatory reaction, embolism, or shock (*v.* Empyema).

In **Ascites** of chronic character, M. Boinet injected iodine, in the first instance by mistake, thinking the case ovarian, but after a very serious attack of peritonitis, the patient at length recovered (Iodothérapie, 1855). Leriche, Dieulafoy, and some few other surgeons have recorded similar cases, and remark that the ascitic fluid should not be all evacuated previous to injection, so that moderate dilution of the iodine may be insured. Dr. Ford (U.S.)

has recently reported two cases of ascites cured by iodine injection, so that the operation is by no means obsolete. One of his cases "was connected with renal mischief," the other "followed on cessation of the menses." After tapping, he injected 2 oz. of tinct. iodi with an equal quantity of water (Pract., i., 1877).

The cases here alluded to are not very clearly described by their narrators, but we must recognise that those suited for this method of treatment can only be of certain kinds; for instance, such as are dependent on chronic peritonitis, or simple anomalies of secretion, or perhaps on hepatic disorder, but not cases of ascites connected with cardiac or advanced renal disease, or anæmia.

Empyema.—In chronic cases, provided a free opening is secured, an iodine injection (1 to 2 dr. of tr. in the pint) is sometimes serviceable, both to disinfect and to stimulate healthier secretion and contraction of the cavity; many patients have, doubtless, recovered under its use. Dr. Dickinson speaks of it as better than any other treatment in his experience (B. M. J., 1876). On the other hand, I have myself known it excite much undue irritation, both local and systemic. In some cases, sudden, or nearly sudden, death has followed the injection of iodine solutions into the pleural cavity, but we cannot reasonably attribute the result to iodine, because in the very same cases iodine had been previously used without harm, and besides, sudden death has followed, in a similar manner, the injection of warm water, of carbolic acid lotion, etc. The effect may have been connected rather with mechanical conditions, such as insufficient freedom of exit or too great pressure of fluid, or else with special cardiac conditions of feebleness, dilatation, etc., but, certainly, I am of opinion that injections into the pleural cavity are seldom without some risk, and can rarely be practised safely; they should be discontinued in favour of free drainage with strict antiseptic precautions (and this change in practice has become much more general since my last edition).

A little of the solid iodine, placed in perforated chip-boxes in or near the bed, forms a good disinfectant in cases of foul wounds and discharges.

Pericardial Effusion.—I have treated several severe cases of this condition by iodine injections: for instance—(1) G. H., aged thirty-seven, had in youth two attacks of rheumatic fever, with

endocarditis of aortic valves: when otherwise robust, a third attack came on in August, 1876. In November, when I first saw him, there was extensive pericardial effusion, with visible bulging and fluctuation; cardiac dulness extended beyond the right of the lower sternum, and upwards as high as the second rib; the heart-sounds were feeble and indistinct, and the respiration impeded; there was a short dry cough, and extreme orthopnœa, so that life was in imminent danger. I drew off 3 oz. of fluid, and injected 10 min. of iodine tincture; relief was experienced, and I repeated the operation in forty-eight hours. After this the man gradually recovered, though eight months afterwards he died suddenly from his aortic disease. (2) In another man, aged twenty-three, also suffering from extensive pericardial effusion, with intense dyspnœa and other urgent symptoms, 2 to 3 oz. of fluid were drawn off by aspiration; much relief was experienced, and 10 min. of iodine tincture were then injected. Thirty hours afterwards, 10 min. more were injected; no symptoms of iodism appeared, and the patient made a good recovery. In both cases, 4 to 6 gr. of iodide of potassium were taken with bark thrice daily, before and after the operation.

Abdominal Cysts.—The following case, which occurred in my practice some years ago, will illustrate some of the risks and the possibilities of treating large cysts by strong iodine injections. A gentleman, aged seventy, had an enlargement of the abdomen which was obscure in its nature, and diagnosed as dependent on cystic or a solid growth from the under surface of the liver. Attacked one day with rigors and sudden, violent pain, he became jaundiced and collapsed, and when seen by me was semi-comatose and apparently dying. Some obscure fluctuation being detected in the enlargement, a trocar was inserted, and 21 to 23 pints of thick grumous fluid, with some pus, were drawn off; this was examined without detection of hooklets. Three weeks afterwards, 16 pints of fluid were drawn off, and 16 oz. of pure tincture of iodine (B.P.) injected, allowed to remain for twenty minutes in the sac, and then some of it to escape. Severe effects soon followed the injection—salivation, soreness of the mouth and throat, sickness, eructations, headache, giddiness, tinnitus aurium, muscæ volitantes, accompanied by palpitation and pyrexia: the pulse was 140, weak and irregular, the temperature 101·8° F.

Epistaxis occurred twice during the first thirty-six hours; tightness across the chest and pain at the epigastrium were complained of, and frequent thin watery stools were passed; the general condition was one of extreme nervousness, prostration, and unrest.

On the second and third days the temperature, which was highest in the afternoon, varied from 101° to 104° F., and the pulse from 110 to 140. Pains in the limbs and in the loins set in, and were felt also in the long bones, which were evidently due to periostitis; synovial effusion distended the left knee-joint; the urine, which was at first pale and profuse, became scanty and blood-stained, and both it and the saliva contained large quantities of iodine; the salivary glands were painful and swollen, and the palate and fauces sore and inflamed; there was constant short dry cough with more or less aphonia.

All these symptoms continued to increase until the end of the fourth day, when an eruption, somewhat like measles, appeared, with apparent relief to many of the urgent symptoms. By the fifth day, the periostitis had considerably subsided, and by the ninth, most of the other symptoms had disappeared. Iodine was, however, excreted by the urine for about sixteen days, and albumen for twenty-five days; during the whole time nourishment was taken well. After the severe attack convalescence progressed favourably, and the patient lived for two years afterwards, and died from the effects of a large cholesterin calculus in the gall-bladder.

Ovarian Cysts.—When the cyst is unilocular, and no acute symptoms are present nor active growth going on, then the injection of iodine may in some instances prove useful, although the radical operation of removing the diseased ovary has now such an average success that the less certain method of injection is seldom employed. M. Boinet records forty-five cases, treated by tapping and injecting equal parts of iodine tincture and water, allowing this to remain for a few minutes, whilst the abdomen was gently manipulated, then to escape; thirty-one out of these cases are said to have been successful, whilst nine ended fatally; this is a much higher mortality than after ovariotomy.

Velpeau, Simpson, and Sir Spencer Wells have also obtained, on the whole, favourable results with the same method (Med. Times, ii., 1860), but Dr. Tyler Smith succeeded in only two out of ten cases in which he employed it, and of six patients treated

by Schuh, only one was cured and one relieved. My own experience of injection in ovarian dropsy, though not large, is rather favourable. In one case, now nineteen years ago, I withdrew a pint of fluid from a large cyst, and injected 4 oz. of iodine tincture, and after repeating this three times, absorption ultimately took place, and the lady, now living, has had no further inconvenience. In another similar case in which I drew off a pint of fluid, and injected 2 to 3 oz. of iodine tincture, severe physiological effects followed, and continued for ten days; but the patient soon rallied, and three months afterwards 4 oz. more were injected, and absorption of the cystic fluid rapidly took place: this was in 1864, and at the present time there remains only a growth the size of an orange, which gives rise to no annoyance.

In both cases the cysts were judged to be unilocular, and were of some years' duration, but the operation, though favourable in result, required repetition, and produced for a time troublesome symptoms. It is clearly not one to be adopted without much consideration, and only for cases such as those described, where the patients would not submit to removal of the ovary. Sometimes a fatal issue has followed directly from iodine injection, as in the often-quoted case of Dr. E. Rose. He injected into an ovarian cyst 5 oz. of iodine tincture containing 1 dr. of iodide of potassium, and severe symptoms of iodism and collapse immediately set in, with vomiting and cyanosis; scanty dark urine, containing iodine, was excreted; three days afterwards the cutaneous capillaries dilated, the face flushed, maculæ appeared on the skin, and hæmorrhage occurred from the lungs and uterus. On the eighth day most of the urgent symptoms had disappeared, but the urine still contained iodine and albumen; on the tenth day death occurred suddenly from cardiac failure (Nothnagel).

Ranula.—It has been recommended to inject the sac of a ranula with iodine after emptying its contents; I have made numerous trials of this plan, but have abandoned it as unsatisfactory. I used it three times in one case, but with no other result than to cause much irritation; cure was ultimately obtained by dilating the duct-aperture with laminaria.

Abscess Cavities, etc.—The injection of iodine has been resorted to, and sometimes with success, for the purpose of disinfecting such cavities and controlling the secretion of pus (*v.* p. 132).

Boinet gives the history of a chronic abscess occupying the whole right iliac fossa; it followed a bubo, and discharged profusely by a fistulous tract. After many months of unsuccessful treatment by injections, ointments, nitrate of mercury, potash, compression, etc., he injected a solution of iodine (2 dr. of tincture in 4 oz. of water) to the bottom of the cavity through a catheter; much pain followed and afterwards severe febrile reaction, but in about a fortnight a radical cure was obtained. Such successful results cannot be always depended upon, and, in fact, I have known injury from this mode of treatment in many such cases; for instance, in one case of psoas abscess 1 dr. of tincture in 3 oz. of water was injected three times in a fortnight, but considerable irritation and increase of hectic fever were set up without subsequent improvement; after an interval of four months it was repeated (1 dr. in 4 oz.), but with the same result, and the patient died shortly afterwards, when a slight amount of vertebral caries was found.

In another similar psoas abscess, where the malady was not recognised until an opening in the groin had nearly occurred, iodine was injected, and induced much hectic and aggravation of symptoms; no improvement could be traced to repeated injections, but the patient is still living.

In smaller abscesses I have found the injection of iodine beneficial; it offers less risk than in large psoas abscess, and is more likely to succeed. Mr. Stirton found it answer well in a chronic scrofulous abscess of the groin—he used 2 gr. to 1 oz. of water (Med. Times, ii., 1870).

Iodine trichloride—a soluble reddish-brown powder, formed by passing chlorine over iodine—has been found in weak solution ($\frac{1}{4}$ per cent.) a good injection for checking fermentation in the bladder (Year Book, 1893), and for irrigation of suppurating wounds (N. Y. Record, 1892).

Sir. W. B. Richardson speaks highly of a solution of iodine—20 gr. in 10 oz. of amyl hydride—for painting over suppurating wounds; this leaves a thin protective film. Or the vapour of iodine may be applied by putting a few grains of the element between a fold of lint, which is placed over the wound and covered with cerate and oiled silk.

In ulceration about the mouth and tonsils, and in the severe

form called "cancrum oris," touching with strong iodine solution is often curative.

Fistula—Hæmorrhoids.—In some cases, iodine injection is said to have answered well. Lachrymal fistula has been cured by it (Lancet, i., 1874), also congenital branchial fistula (Med. Record, 1879). In rectal fistula an ethereal solution has been of service (Lancet, ii., 1872), but should not be allowed to remain in the bowel as it may cause severe pain (Med. Times, i., 1860). A good colourless disinfectant and cleansing lotion for such cases is made with tinct. iodi ʒiss., glycerini ʒij., liquor calcis chlorin. ʒvi.; use ½ oz. to 6 or 8 oz. of water (Dr. Boggs). Mr. Stirton has related a case of rectal fistula in which the ordinary operation had failed several times, but succeeded when iodine injection was commenced immediately after it. In my own experience, I have never known iodine by itself cure anal fistula, and should always recommend an operation in preference to injections of any kind. Iodised injections are, however, often useful in stimulating old atonic sinuses in the neighbourhood of joints, etc. Prolapsed, inflamed piles may be successfully treated by painting lightly with tincture of iodine once daily.

Gingivitis—"Tartar."—The local application of tincture of iodine will usually cure inflammation, sponginess, or tenderness of the gums, and will soften deposits of "tartar," so that they may be removed with the brush.

Gonorrhœa.—Gonorrhœal attacks in females can sometimes be cut short by one or two paintings of the vagina, cervix uteri, labia, and urethral canal with strong tincture of iodine, after first cleansing away the discharge. The pain lasts for some hours, but the result usually is good.

Purulent Ophthalmia, etc.—M. Boinet relates a severe case of double ophthalmia and scrofulous catarrh, which had lasted for thirteen months when admitted into the St. Louis Hospital, but in a few weeks was cured by the constant employment of an iodine lotion and nasal injection. I began to use this treatment in such cases many years ago, and have often had excellent results.

In ulceration about the cornea, and in granular lids, iodine tincture is a good application; and the liniment, painted round the eye, relieves the photophobia so frequent in scrofulous children.

Catarrh.—The vapour given off by powdered camphor sprinkled with tinct. iodi has been found effective for arresting coryza (Med. Times, i., 1874); and inhaling from pure iodine, or carbolate of iodine, is also commended.

Erysipelas.—Several authors concur in stating that the local use of iodine tincture will relieve this inflammation.

Lanyon relates a case of idiopathic erysipelas, affecting the right side of the face and rapidly extending. The tincture was painted over and beyond the inflamed part; within four hours pain was relieved and sleep obtained; the malady did not advance, and, after another application next day, convalescence set in.

Boinet records two cases of "traumatic" erysipelas—one connected with suppurating wounds in the perineum, and affecting the right thigh, the other starting from a varicose ulcer, and affecting the whole leg; thorough application of iodine tincture, once daily for three days, rendered the wounds healthy, and controlled the inflammation and swelling. Dr. Davies is another advocate for the same remedy, used rather stronger (40 gr. iodine to 1 oz. alcohol).

Bartholow and others have not been so well satisfied with it, and care must be taken not to cause undue irritation by its use. It probably acts in erysipelas, like other irritating substances, by setting up a zone of inflammation which limits the spread of the erysipelatous patch, but its local antiseptic action may also be of value.

Burns—Chilblains.—In burns of the first degree and unbroken chilblains the pain, itching, and irritation may be relieved by iodine tincture, liniment, or ointment. "Coster's paste" consists of a solution of 1 part of pure iodine in 4 of "colourless oil of tar." It requires to be mixed carefully, for heat is developed during the process: the resulting liquid is thick and dark coloured. It is a good remedy for unbroken chilblains, etc.

Lupus.—In erythematous lupus, and in early stages of the tubercular and markedly strumous forms, strong iodine paint is sometimes useful; equal parts of pure iodine and iodide of potassium, in 2 parts glycerine, may be used about twice weekly; this excites "substitutive irritation," and exerts some absorptive power, though I have not myself seen curative results from it.

The plain tincture of iodine relieves the congested livid condition of the neighbouring skin if painted over it.

Acne — Sycosis. — Simpson recommended for indolent "menstrual" acne, a decolorised iodine paint made by mixing 1 part of compound tincture of iodine with 2 parts liquor ammoniæ, and allowing it to stand for forty-eight hours (Med. Times, i., 1861). I have not found this preparation so effective as ordinary iodine when applied to glands, etc., and for acne there are several better remedies. The ointment of iodide of mercury is more valuable in acne rosacea, and that of iodide of sulphur in indolent acne and sycosis.

Psoriasis.—In patches of obstinate chronic psoriasis, the ointment of green iodide of mercury, or of iodide of sulphur, is very useful. I can speak well especially of the former, made in the proportion of 1 part to 8 of simple ointment. The effects are often more rapid and decided than those of tar ointment. Occasional alkaline or vapour baths should be used during the treatment (*v.* p. 113).

Pityriasis Capitis—Alopecia.—In branny, scaly conditions of the hairy scalp, and in partial falling off of the hair from debility, painting with iodine tincture acts as a useful local stimulant. It should be combined with other treatment, such as soap frictions.

Pruritus. — In many varieties of this disorder — pruritus pudendi, pruritus senilis—iodine tincture locally applied often gives much relief.

Tinea Tonsurans.—In simple recent cases of ringworm affecting the body or the scalp, a few applications of iodine tincture or liniment may suffice to cure, but they seldom succeed in an aggravated case. Coster's paste is, however, more powerful, and should be thoroughly painted over the affected part, and allowed to form a crust, which may remain for seven to ten days. One or two such applications will often cure, but to say that they do not cause pain is a mistake. The pain is about equal to that caused by the iodine liniment, which is sometimes severe.

THERAPEUTICAL ACTION.—*Internal.*—Iodine and the iodides have a similar action ; the former is more stimulant to the general system, but more irritant to the gastric mucous membrane. It is probably better adapted for slowly modifying the general

constitutional state, as, for instance, in struma; whilst the alkaline iodides, being more quickly passed out of the system, act better where some foreign material needs elimination, *e.g.*, in syphilis, lead-poisoning, or rheumatism. Practically, however, the much less irritant effects of the alkaline compounds indicate, independently of other considerations, their employment in the majority of cases for which iodine in any form is needed. The potassium iodide is the one most commonly employed in this country, but the depressing effects of the potassium, especially when it is taken for long periods, have led many to employ the iodides of sodium, ammonium, or strontium in preference to it.

Metallic Poisoning.—Melsens found that every mercurial compound was soluble in an alkaline or neutral solution of iodide of potassium, and that corrosive sublimate, for instance, if fixed in a muscle, tendon, etc., could be dissolved out of the organic tissue by soaking it in such a solution; also, that even metallic lead was, to some extent, soluble in the same medium, with the formation of a double iodide of lead and potassium (Med.-Chir. Rev., i., 1853). Hence, he argued that in cases of mercurial- or lead-poisoning, with salivation, tremor, colic, palsy, etc., iodides introduced into the blood could form soluble compounds with metal deposited in the tissues, and enable this to be taken up by the absorbents and passed out by the kidneys, salivary glands, the mucous membranes, and skin. Support has been given to this argument by the fact that an insoluble salt of mercury or lead may be given to animals without evident effect until after the administration of an iodide, when the recognised symptoms of poisoning appear. Further, we know, clinically, that sometimes in metallic cachexia, when active symptoms are no longer present, and the poisons cannot be detected in the secretions, if an iodide be given, symptoms of acute mercurial- or lead-poisoning may be developed, and the foreign substances may be found in the urine, etc. *Chronic* conditions of illness, such as palsy or cachexia, may be present when the use of the iodide is commenced, but in the course of a few days *acute* symptoms, such as colic or salivation, may be reproduced until elimination is complete.

The case of M. Faure, recorded by himself, is a good illustration of the value of iodides in cases of lead-poisoning. Engaged in white-lead manufacture, he suffered severely from the ordinary

symptoms of plumbism, and cured himself with iodide of potassium. He remarks that he could tolerate the drug better when he took it *before*, than *with* food, which he attributed to the "fasting stomach being coated with mucus" (Med. Record, 1876).

Dr. H. Thompson has given the details of a case of plumbism, in which iodide of potassium, on three or four occasions, led to relapse of colic at the same time that iodism was developed, and these attacks were always followed by improvement in the paralysed extensor muscles, as if some of the metallic poison had been eliminated, though there is not a record of its detection in the secretions (B. M. J., i., 1871).

I have myself had some very good results with iodides in cases of plumbism, the best being obtained in conjunction with a purgative treatment. The metallic iodide is excreted by the mucous membrane of the alimentary canal, and should be immediately removed to prevent its reabsorption; hence the necessity for counteracting the constipation which so frequently accompanies this condition. A good formula is, Magnesii sulphas, gr. xv.-xxx.; potassii iodidum, gr. ii.-xx.; aqua chloroformi, ʒi. M. To be taken every four or six hours. Iodide of iron is valuable in later stages.

Syphilis.—It is probable that iodine acts in this disease, much as it does in metallic poisoning, by assisting the elimination of a morbid material. It has been maintained indeed by Dr. Basham and others that its influence is best seen in cases which have been previously treated by mercury; and Dr. Budd and Sir A. Garrod have given instances in which mercurial influence was dormant until excited by the administration of iodides, when profuse salivation occurred and recovery ensued. But there can now be no question that the drug has curative powers of its own, independent of mercurial action; they are evidenced especially in the later, or tertiary stages of constitutional syphilis, when either the mucous membranes are affected, as in deep ulceration of the fauces, or the bones are attacked with periostitis or nodes, or the skin is affected with rupial or lupoid eruption, or the meninges are thickened, or gummatous deposits are formed in any of the viscera. In such conditions it usually acts far better than mercury, although this latter drug is more advisable in some *inflammations of the eye*, such as iritis; and again, in a certain proportion of

undefined syphilitic cases, an iodide of mercury will give better results than either medicine alone.

By causing the absorption of deposits and thickenings in various parts of the body, iodides cure, at the same time, many secondary symptoms, such as those due to pressure on different portions of the nervous system, nocturnal pains, neuralgia, paralysis, dulness of sense or intellect, and convulsive paroxysms. The dose of iodide of potassium is a matter of much importance, and need be limited only by the susceptibility or idiosyncrasy of the patient, and the progress of the disease; it may vary from 1 or 2 gr. up to 60 gr., two or three times daily, and the best results have sometimes been obtained from heroic doses, when ordinary ones have failed.

Elliotson gave doses of 30 to 60 gr., or even more (Lancet, i., 1832), and Ricord commonly prescribed the same amount. Sir A. Cooper, Pollock, and others have given instances of the value of such quantities (B. M. J., and Lancet, 1867-68); and more recently Dr. Buzzard has pointed out the importance of large doses, especially in syphilitic affections of the nervous system (Lancet, i., 1873).

In **Hereditary Syphilis**, the symptoms in infants are usually "secondary," and mercury is the proper treatment, though if iodides are required, they generally bear them well.

Mr. Berkeley Hill has stated that the iodide of ammonium or of sodium will sometimes cure when the potassium salt has failed; on the other hand, recent opinion in Paris is much in favour of the potassium, as compared with the sodium salt, in syphilis (Lancet, i., 1892).

Rheumatism.—Dr. Graves was one of the first to point out the value of iodide of potassium in rheumatism, and it is now well established. I connect its efficient anti-rheumatic action mainly with an eliminant action through the kidneys, and to promote this, recommend it to be largely diluted and combined with bi-carbonate of potash in acute cases. To prevent irritation of the stomach, the medicine may be given in the effervescent form. Sometimes if the patient be feeble, and the urine abundant and of low specific gravity, possibly alkaline, the iodide may be combined with hydrochloric acid and quinine, as recommended by Dr. Southey. When effusion has occurred into the pericardium or the joints, tincture of iodine or iodides are often of great value. In muscular rheumatism

they are useful, especially in those cases where the pains are made worse by warmth, as in bed at night. This is one character of periosteal and syphilitic pain, and possibly some of the good results obtained from iodide of potassium in cases of chronic painful joints, sciatica, and lumbago, may be explained by its removing a latent specific or mercurial, or other metallic taint. In cases of chronic rheumatism, small doses of iodide, continued for a long time, often act exceedingly well, but some patients are very sensitive to its physiological action, and need special care to secure its toleration. The use of iodide of potassium is now mostly limited to chronic cases, or to those acute cases where salicylate of soda cannot be tolerated.

Rosenbach and Pohl asserted that iodides, given by the mouth, were not to be found in the serum of joints, or in the serous or purulent exudations in the pleura, etc., whilst the salicylates were so found, and consequently were true remedies, and iodides were useless in acute cases; but these assertions have been proved incorrect by Leuch and by Weintrand, who, with more careful chemical tests, readily found iodine in the joints and serous effusions (Rev. des Sci. Méd., 1891).

In **Chronic Valvular Disease**—arterio-sclerosis, cardiac hypertrophy, and even fatty degeneration, the potassium salt is used by G. Sée and others, who maintain that it is a heart tonic (Year Bk., 1891). Laborde has published a case of chronic endocarditis, with mitral reflux, where attacks of dyspnœa and angina were much relieved by iodide of strontium.

Gout.—In chronic forms of gout the iodide will often relieve, as remarked by Sir Spencer Wells, who recommends 1 or 2 gr. thrice daily, well diluted with water or seltzer water. In some cases the tincture of iodine acts better. I have found gouty patients also very sensitive to its physiological effects.

Chronic Rheumatoid Arthritis.—In this condition, often considered incurable, I have known the tincture of iodine prove very useful when given in 3 min. doses thrice daily, and applied locally; in certain cases, the good effect has been remarkable when given at the same intervals, but in doses of 10 to 20 min.

Gouty Psoriasis.—In this malady the iodide deserves trial. It is possible that many of these cases may be of syphilitic origin; still, in others no definite history of syphilis can be obtained. In

one of these latter which was "inveterate," and had lasted for twenty years, recovery followed the use of 10 to 30 gr. doses daily (Lancet, i., 1871). It is not meant that this treatment—known by the name of Dr. Haslund—must be limited to cases evidently gouty. He recorded forty cases—five of them acute—cured in from three to eleven weeks, some taking very large doses—30 grammes and more daily; in only one case severe iodism occurred, and two other patients could not tolerate the drug; all were in hospital (B. M. J., i., 1888). Other cases recovered with 3 to 15 grammes daily (*ib.*, i., 1889).

Ague—Intermittents.—Iodide of potassium is stated to have proved very efficacious in intermittent fever (Amer. Journ., 1867; Med. Times, ii., 1872). The tincture of iodine is the "Elixir de Willebrand" used on the Continent in doses of 10 to 15 min., and, it is said, with success (B. M. J., ii., 1874).

Paralysis.—Cases of paralysis which are cured by the use of iodides, are generally dependent on syphilitic inflammation, or on inflammatory deposits or effusions pressing upon nerve trunks or centres. In such cases it is certainly possible for these remedies to produce absorption and consequent cure.

Muscular Paralysis, acute and general in character, has sometimes yielded to the iodides in a remarkable manner, as instanced in a case of Dr. Murchison's (Lancet, ii., 1867). The man, aged twenty-six, had gradual loss of power and wasting first of the left, then of the right limbs, and then of the respiratory muscles, and apparently progressive paralysis, with moderate pain, and no cerebral symptoms; he got worse under iron, arsenic, and galvanism, but improved markedly under iodide. Another case is given in Med. Times, ii., 1863—both were connected, probably, with a spinal meningitis.

Cerebral Palsy, due to vascular lesions, is not usually treated by iodides, but Sir E. Sieveking considers that advantage may be derived from their eliminant action after acute symptoms have subsided (Med. Times, i., 1857). They may act usefully by regulating and equalising the circulation, as well as by aiding absorption of any inflammatory products.

Neuralgia.—In cases of syphilitic or rheumatic origin, iodine is useful; and in rheumatic sciatica the combination of iodide of potassium with vinum colchici is often effective.

Chorea.—Manson affirms that he has cured seventy-two cases of chorea by giving iodide of potassium. Sir James Bardsley and Gibney make similar statements, but many of these cases would probably have come to a natural termination after six or seven weeks' rest, even without iodine. We are still much in the dark as regards the nature of chorea, and from a rational point of view iodine can only be recommended for it as likely to influence a scrofulous, rheumatic, or syphilitic taint.

Epilepsy.—Magendie stated that he had cured cases of this disease by iodide of potassium, and Franklin gave to a boy, aged eight years, as much as 180 to 300 drops of iodine tincture, with success (Köhler). It seems to me that the remedy can only be of service in such cases, if they have a syphilitic or rheumatic origin.

Struma—Rachitis.—In the different manifestations of these constitutional states, such as enlarged lymphatic glands, tumid abdomen, indolent ulceration, ophthalmia, etc., preparations of iodine, and especially the tincture, are of proved value. But though they lead to disintegration of morbid deposits, they do not appear to assist renovation of tissue, and for permanent good results require to be supplemented by good food and hygiene. Hence, also, the combination with iron—iodide of iron—is an excellent form, and the conjoint use of cod-liver oil is very desirable. These remedies are invaluable in rachitis especially, and are usually well borne by delicate children when alkaline iodides are not. Simon, indeed, concludes that the latter ought not to be given at all under two years of age (Med. Record, 1876), and even the iodide of iron sometimes excites gastric and renal irritation, especially in some delicate children with fair skin, red hair, and enlarged cervical glands, so that it is desirable to commence its use in small doses.

I have been accustomed to give 1 to 3 min. doses of iodine tincture well diluted, and continued for a considerable time, in cases of struma, and can recommend this form of medication. The iodide of ammonium is said sometimes to be of exceptional value.

Lupus.—I have mentioned the external use of iodine in the treatment of this disease, and there is some evidence in favour of its internal administration. Thus, Mr. Gay records cases of lupus affecting the face—in one man for seven years, in a

woman for twenty years—which yet got well under ½ dr. doses of iodide of potassium (Med. Times, ii., 1871). No history or distinct evidence of syphilis could be obtained, though one cannot but suspect a syphilitic taint in such cases. I have never known iodides cure ordinary lupus, nor is it a common experience. Dr. Mackey has noted two cases, in one of which the nose was affected, in the other the nose and scalp; the ulceration was deep, indolent, and slowly progressive, in spite of caustic treatment; there was but little discharge, crusts formed at the edges of the ulcers, and the cases resembled true lupus, except that there were no tubercles, and the patients were men between forty and fifty years of age when the sores commenced. Both recovered quickly under the influence of iodide of potassium and mercurial lotions, but although there was no history of syphilis, the probability remains in favour of its existence in these and similar cases.

Wounds.—Some interesting observations have shown that iodides, in moderate doses, improved granulation processes and healing of wounds apparently by "increased activity of leucocytes" —larger doses had a resolvent effect (Lancet, ii., 1891).

Meningitis.—I have had several cases of meningitis which derived much benefit from iodides, given alone or in combination. One child, aged six years, who had been ill for eight days, and was insensible, with dilated pupils, dysphagia, paralysis of one side, and convulsive twitching, and who had been getting worse under previous treatment, began to improve soon after commencing iodide of potassium, given in 5 to 10 gr. doses every six hours, with 5 min. of tincture of belladonna in the intervals. Recovery ultimately ensued, and the boy has now reached adult age. In another case, aged eight years, there were pain, vomiting, delirium, unconsciousness, convulsion, dilated pupils, tetanic stiffness of the neck-muscles, grinding of teeth, difficult respiration, slow weak pulse, and every sign of fully-developed meningitis, yet recovery took place under iodide of potassium and belladonna. Dr. Leared recorded a case of recovery under 5 gr. doses of iodide of potassium when other remedies had been used without relief. He was satisfied as to the diagnosis of "tubercular meningitis." Other desperate, but successful cases are on record (Edin. Med. Journ., 1841; Med. Times, i., 1859; Bulletin de Thérap., 1861, etc.); and M. Golfin (Montpellier) narrates three cases of this malady

which recovered from the second or third stage under frictions with an iodide of mercury ointment to the scalp. (Hydrarg. iodid. virid., gr. ij.; Potas. iod., gr. iij.; Camphoræ, gr. ij.; Cerat. Galeni, gr., xxxij.) In one child, aged four and a half years, the symptoms showed death to be imminent—the head was drawn back, the face pale, the pupils dilated and immovable, the power of swallowing was lost, partial paralysis, convulsion, and profound coma were present; the pulse was scarcely perceptible. About forty hours after commencing the iodo-mercuric frictions urine flowed, and the paralysis and convulsion gradually lessened; in the course of four days only headache and stupor remained; and by the fifteenth day convalescence had set in (Gaz. Méd. de Montpel., 1847). Niemeyer speaks favourably of iodic frictions in basilar meningitis. The degree of credence, however, to be given to such remarkable cases as the above must depend upon the accuracy of the diagnosis; congestion or anæmia of the brain in children, and especially simple meningitis, may simulate acute hydrocephalus to some extent, but I have seen improvement take place under local frictions with iodised ointment, and internal treatment with iodide, bromide, and belladonna.

Trousseau and many physicians of experience deny that the tubercular form is curable under any circumstances, and certainly a large majority of such cases end fatally. Dr. Wilks "has seldom seen any good results" (Med. Times, ii., 1868; Pract., i., 1893).

Phthisis.—Chronic congestive conditions of the lungs following on acute inflammations are usually connected with the scrofulous diathesis; in such cases, benefit may be obtained from iodine preparations. I prefer the tincture; but the iodide of iron, or the iodide of ammonium is useful, according to the case.

In the more acute form of phthisis, when the patient suffers from loss of flesh, quick pulse, high temperature, pain, cough, dyspnœa, and nocturnal sweatings, the tincture, given every four hours, and inhaled, as well as applied locally over the chest, offers a chance of arresting or ameliorating the disease, as I know from some cases under my own care. In the absence of acute symptoms, I have also seen benefit from iodine and iodides, but have sometimes noticed hæmoptysis following their use, and therefore recommend caution in cases disposed to hæmorrhage.

Earlier observers—Chevallier, Elliotson, Bardsley, and others—thought iodine really curative in consumption. It can certainly lessen pulmonary induration, and modify the irritative conditions of the bronchial mucous membrane and the character of the expectoration: in fact, I have seen most symptoms improve under its use, but this must be supplemented by good hygiene and generous living. Dr. Cotton's experience at Brompton Hospital was not so favourable: weight was seldom gained under iodide of potassium, but was generally diminished; dyspepsia was sometimes induced; usually, no definite effect could be traced (Med. Times, ii., 1859). Dr. Julius Pollock, on the other hand, found the remedy very serviceable, and his patients gained weight.

I have noted most benefit in cases of *chronic* phthisis, and especially when a syphilitic taint existed. Sir Walter Foster suggests that it acts by stimulation of the pancreas, thus promoting assimilation of fatty food, and Claude Bernard proved that it was eliminated by that gland. Iodine-inhalations in phthisis have proved of great value in my experience, exerting a disinfectant, and to some extent an absorbent, action. It is important to guard against soreness of the mouth, and undue irritation of the air-passages during their use.

Continuous inhalation of antiseptic vapour from an ori-nasal inhaler is often useful, and a solution of about 3 gr. iodine in ether 2 dr. with the same of carbolic acid, and half the amount of thymol or creasote made up to an ounce with spirit, may be dropped on the inhaler—10 min. or upwards at a time.

Bronchitis.—In the subacute and chronic stages, alkaline iodides relieve by an alterative action on the bronchial mucous membrane, thinning and ultimately diminishing the semi-purulent tough secretion, and so rendering expectoration easier. They may sometimes with advantage be combined with anti-spasmodics, etc. Potassium iodide should be given for this purpose in doses of 2 or 3 gr.; but in weakly subjects, the iodide of ammonium, in doses of from 2 to 5 gr. every four hours, may act better than the potassium salt. When there is an increase of temperature, aconite also should be given in doses of from 1 to 3 or 5 min. every two to four hours. If an expectorant be required, tartar emetic should be chosen; the dose should be small and frequent, and care should be taken to avoid emesis. With ordinary precaution in the regulation of the dose, neither aconite nor antimony need be dreaded

for their depressing action, and it is remarkable how favourably these medicines act in conjunction with iodides.

Pneumonia.—Dr. L. Gualdi of Rome recorded thirty-nine cases of pneumonia, which he treated with 40 gr. doses of iodide of potassium every two hours with excellent results. He also applied an ice-bag over the situation of the inflammation. The mortality in his cases was only 6 per cent. This method of treatment, which is rather heroic, is likely to be more successful in young than in old people, and should be commenced early in the attack; for after hepatisation has set in, the drug is not only useless but injurious (Lancet, ii., 1884).

Asthma.—I have known iodide of potassium relieve many asthmatic patients, and Horace Green (1860) found it to be the main ingredient in a secret and successful remedy for asthma. Trousseau and Jaccoud speak of its value, and M. Sée has recorded valuable observations upon twenty-four cases watched for a long time. Four of these were children, four old people, the others adults; the daily dose varied from 22 to 45 gr., being reduced as improvement progressed: if given some hours before the usual attack this was often prevented; if given during it, respiration was rendered free in one to two hours. Chronic asthma with emphysema was also benefited by the remedy; inhalations of iodide of ethyl, 6 to 10 drops several times daily, and the occasional use of opium or chloral in these latter cases, were with advantage conjoined with the treatment (Med. Record, 1878). The late Dr. Hyde Salter observed benefit from iodide of potassium in full doses—15 to 30 gr.—every two to four hours, in very diverse cases of asthma. I think that such attacks as are connected with catarrh, and are relieved by free secretion, and in which the nerve-symptoms are reflex rather than primary, show the best results from this remedy. I have known it efficacious in asthma connected with amenorrhœa and uterine congestion, and also in the asthma of rheumatic and gouty subjects. In an interesting case in a very rheumatic patient, the asthmatic attack was relieved by 4 gr. doses of iodide, but severe pain in the region of the kidney followed, with secretion of scanty acid urine; this occurred more than once, and was only relieved by producing free excretion of alkaline urine by appropriate remedies (B. M. J., i., 1875). In this case, the drug was supposed to cause renal con-

gestion by increasing the absorption of waste nitrogenous material, *i.e.*, the amount to be eliminated. I have known iodine itself produce renal congestion in some individuals.

Dr. C. J. B. Williams has seen a very large number of asthmatic cases relieved by iodide and by carbonate of potassium, with stramonium (Med. Times, i., 1872), but most of M. Sée's cases were relieved by the iodide alone. Dr. Reed recommends the liquor iodi in "dry asthma" of constitutional character, and without obvious exciting cause (Med. Record, 1879).

I believe that the drug acts directly on the mucous membrane, relieving its congested state by promoting a thin fluid secretion, but independently of any theory, it will be found worthy of trial in any obstinate case, remembering, however, that many asthmatic subjects are so sensitive as scarcely to tolerate even small doses.

Catarrh.—Iodide of ammonium, in 1 gr. doses every two to four hours, is a good remedy in ordinary acute nasal catarrh.

Hay Asthma.—In this distressing malady, iodide of ammonium, combined with arsenic, will often give a better result than either remedy alone. The vapour of iodine, or of a mixture of carbolic acid and iodine, should be inhaled by the nostrils, as recommended by Melville (Lancet, ii., 1864).

Sore Throat.—In cases of follicular tonsillitis, or when spots of ulceration about the buccal mucous membrane are induced by cold, small doses of iodide (1-3 gr.) are useful.

Croup—Diphtheria.—The tincture of iodine as well as the iodides are very valuable in these disorders, especially in their early stages; they should always be given in conjunction with aconite, and occasionally the judicious use of an emetic is serviceable. I trace the benefit following the use of the iodide partly to a local effect, rendering the false membranes less tenacious, and partly to an eliminant action on the kidneys. Further observations as to the advantage of this treatment are recorded (Bull. de Thérap., August, 1891), but the combination with mercuric perchloride is still more effective. The use of iodine by inhalation has already been mentioned and should be strictly attended to.

Albuminuria.—The prolonged administration of iodide of potassium in chronic Bright's disease is said to have retarded fibroid changes in the kidney, and induced general improvement in nutrition (Bartholow). Dr. Créqui (Brussels) recommends it

for the second or parenchymatous stage. Using commonly 6 gr. or more daily, he has sometimes given as much as 6 dr. in the day, with bismuth or opium to control irritative effects. He presumes the iodide acts by limiting morbid secretion in the renal tubules (Lancet, i., 1871). In subacute cases, with dropsy, I have frequently used this remedy in doses of 3 to 4 gr., and have seen apparent advantage from it. I think it hastens absorption of inflammatory products, but from what has been already stated as to the possibility of its causing renal congestion, it must be considered unsuitable in acute nephritis, unless in fractional doses.

Ascites—Anasarca.—Not only in renal dropsy, but in that dependent on hepatic disease, and also in general anasarca due to abnormal conditions of the blood, iodide of potassium or iodide of iron are useful. In all these cases the iodide is of value, possibly on account of the diuresis induced by it. Frictions with iodised liniment should be combined with the internal treatment. Injections have sometimes been used.

Aneurism.—In those cases of thoracic and abdominal aneurism, in which surgical treatment is impossible or highly dangerous, the clinical results obtained by iodide of potassium should not be ignored. Nélaton recorded marked relief to the signs and symptoms of an innominate aneurism under the use of this remedy, which he gave empirically at the request of the patient, and Bouillaud, following up this clue, obtained good results in aneurisms of the carotid and thoracic vessels (Med. Times, i., 1859).

Chuckerbutty, in Calcutta, published an account of three cases which were relieved; in one of these the aneurism was already projecting through the sternum when the drug was commenced; and Sir W. Roberts and Mr. Windsor recorded some equally striking results about the same time (B. M. J., ii., 1862; i., 1863).

It is, however, to Dr. G. W. Balfour that we are most indebted for drawing professional attention to this subject (Edin. Med. Journ., 1868-69). In his first paper he summarises fifteen cases, all of which, save one, were relieved, and in twelve the external tumour was actually lessened and the sac partly consolidated. In one of his earliest patients the bulging, which was evident between the second and third ribs, disappeared after a few weeks' treatment with 30 gr. doses thrice daily, and this dose was continued for nine months "without any unpleasant symptoms," but

with complete subsidence of aneurismal suffering. The same man had not improved under previous doses of 20 gr., and Dr. Balfour points out the importance of pressing the drug to saturation before considering it inert. It is very quickly eliminated—large doses within two or three days—and many of his patients took 20 to 30 gr. several times daily. In a few, coryza and headache were quickly produced, and 5 gr. only were tolerated, but, as a rule, no worse symptoms were caused by large than by small doses. Additional evidence in favour of this treatment has been furnished by Sir W. Roberts, Dr. Shapter, and others (Med. Times, 1874; B. M. J., 1873-74); and Dr. Philipson and Dr. Snow have reported cure of abdominal aneurisms (B. M. J., i., 1878; i., 1891).

Dr. Suckling has contributed an additional series of twenty cases treated by iodide of potassium, in doses of 10 gr. increasing to 60, combined with Tufnell's diet; of these twelve were benefited, but he notes that in several the pulse rate increased, and the drug then disagreed. Referring to these cases, Dr. G. W. Balfour again points out the necessity of regulating the dose by the effect on the circulation: after some days in bed the patient's normal pulse should be ascertained, and doses of 10 gr. commenced, and then later increased to 15 gr. if the pulse rate remain unaltered, the object being to lower blood-pressure within certain limits. Although in his early writings on the subject already quoted, Dr. Balfour was inclined to attribute to a sedative action on the nervous system the good effects of the drug, he has, for some time past, traced them rather to lowering of blood-pressure consequent on dilatation of arterioles, and some depression of heart-action; following this, more resisting power develops in the sac, the coats of which tend to hypertrophy and so to cure, whilst if the nutrition be unduly lowered by starvation diet, or by excessive doses of iodide removing albuminates from the system, the hypertrophy is hindered: if the pulse quickens under iodide, he concludes that tension is unduly lowered, and the dose too large (B. M. J., i., 1887; i., 1891). (In Dr. Haslund's cases of psoriasis treated by very large doses, the pulse usually went up to 100-110 in ten to fourteen days.) G. Sée states that the sodium iodide will not produce these good effects in aneurism (Lancet, ii., 1889).

It seems to me no argument against such cases to say, with Dr. Bristowe, that any remedy which coagulates the blood in an

aneurismal sac must tend to coagulate it elsewhere, and is therefore inadmissible; or to note with Mr. Holmes that aneurism may sometimes develop in patients already under the influence of iodide (Med. Times, i., 1872). This is only saying that the remedy is not infallible, and that its mode of action, whether on the blood, blood-pressure, on the nervous system, or on the walls of the sac, is not yet clear. I have myself seen remarkable advantage from its use, and suggest, in addition to the above explanations, a possible anti-syphilitic effect—for the frequent connection of syphilis and aneurism is sufficiently proved.

Chronic Inflammatory Indurations.—In simple chronic enlargement of organs, such as the liver, the spleen, the mammary gland, or the testes, iodine is often of more service than any other medicine. The cause may be syphilis, struma, or malaria, and yet the same remedy be applicable. I generally recommend 1 to 5 min. of the tincture thrice daily for a long period, though sometimes iodides are better borne. Painting with, or compresses of iodine should be used at the same time.

Bronchocele.—In simple soft goître, in which malady, indeed, the reputation of iodine was first acquired, I consider it almost a specific. In recent cases, 1 to 5 min. doses of the tincture produce the best results, for if unduly large quantities be given, the swelling becomes hard, tender, and painful. In more chronic cases already indurated, large doses—$\frac{1}{4}$ to 1 gr. of iodine—may be given in conjunction with its external use: some tonic or bitter preparation, *e.g.*, of cinchona or orange peel, should be added to prevent derangement of the stomach. Mr. Bryant has known goîtres rapidly disappear under the influence of an iodised atmosphere obtained by simply placing iodine in a perforated box in the patient's room; he recommends also the local use of an ointment of iodide of ammonium (Practical Surgery, 3rd ed.).

In **Exophthalmic Goître** I have also seen a limited amount of success from the internal use of iodine tincture, the palpitation being frequently relieved by small doses. The case of a girl of sixteen recovering in four months under iodide of potassium, in 10 gr. doses (with iron) and iodine ointment locally, is recorded (B. M. J., Epit. ii., 1892). Sée however argues that the salt *must* be injurious in this disease, because dilatation of arterioles is already too great (Lancet, ii., 1889). On the other hand, Dr.

Reynolds finds it an important element in satisfactory treatment, combined with iron and bromide. In cases with large goître and marked exophthalmos, 10 to 15 grains of iodine thrice daily could be taken and "seemed most effective in reducing palpitation of the heart and frequency of the pulse" (Lancet, i., 1890).

Uterine Fibroma.—Fibroid growths or indurations, especially those originating in the cervix, *i.e.*, in the more glandular and secretory part of the uterus, often improve under the use of iodine or iodides. Dr. Ashwell long since described them as "melting down" under this treatment (Guy's Reports, vol. i.), and mineral waters, of deserved repute in such cases, owe their efficacy to a combination of iodides and bromides.

Direct injection of the drug into the growth is also a valuable resource with due precaution. I have injected 10 to 20 min. of an aqueous solution of iodine (half the strength of the B.P. tincture) in twenty-three cases of uterine fibroids, of large size, and repeated the operation several times with encouraging results. Nearly all improved considerably under the treatment, and the tumours disappeared in five instances within twelve months of the first injection. Two cases suffered considerably from local inflammation, obliging the treatment to be discontinued after the third and fourth injections respectively, but both these cases eventually improved more quickly than any of the others.

In **Passive Uterine Congestion** tincture of iodine is often useful; and Dr. J. B. Schmidt has written to recommend minim doses for chlorotic subjects suffering from headaches, frequent menstruation, and diarrhœa (Med.-Chir. Trans., i., 1871).

Amenorrhœa—Sterility.—When these conditions depend on functional causes, such as local congestion or general weakness, iodine and the iodides are useful. I have often proved them so in the former condition, and sometimes in sterility they exert a stimulating effect on the uterus, possibly because of their elimination by the mucous membrane.

Vomiting of Pregnancy.—I have known 1 to 5 min. doses of the tincture arrest the capricious vomiting, also the pyrosis and heartburn of pregnancy, possibly by a stimulant effect on the gastric membrane. Its local application to the cervix, conjoined with its internal administration, often acts with advantage. Dr. Eulenburg recommends 10 min. doses as very serviceable, but I

prefer the smaller doses repeated every two or three hours. In other obstinate cases of vomiting the same treatment is often of service, especially in the vomiting of phthisis (Roques, L'Union Méd., 1889).

Atonic and Dysenteric Diarrhœa, etc.—I have obtained benefit from similar doses in atonic diarrhœa, and in the form which occurs during phthisis. They have been recommended in cases of passive hæmorrhage and serous flow into the intestine, dependent on "paralysis of the ganglionic centres" (Schmidt, Med.-Chir. Rev., i., 1871); also in later stages of typhoid fever. Iodised enemata have been used in dysentery to relieve tenesmus (Med. Times, i., 1857); 1 to 5 min. doses of the tincture, given every four hours with cinchona, will often cure the tormina and the tenesmus of dysenteric diarrhœa.

PREPARATIONS AND DOSE.—*Tinctura iodi* contains iodine ½ oz., iodide of potassium ½ oz., rectified spirit 20 fluid oz.: dose, 5 to 20 min. *Liquor iodi* contains 20 gr. iodine, 30 gr. iodide of potassium, in 1 oz. water: dose, 3 to 10 min. *Linimentum iodi* contains iodine 1¼ oz., iodide of potassium ½ oz., camphor ¼ oz., rectified spirit. *Unguentum iodi:* iodine 32 gr., iodide of potassium 32 gr., proof spirit 1 dr., prepared lard 2 oz. *Vapor iodi* contains tincture of iodine 1 dr., water 1 oz.: heat slightly for inhalation of vapour. *Potassii iodidum, sodii iodidum:* dose, from ½ to 30 gr. and upwards; average dose, 3 to 5 gr. The dose of the *ammonium* salt is somewhat smaller. The following are not officinal—*Strontii iodidum:* dose, 3 to 5 gr. and upwards. *Iodopyrine*, used as an antipyretic (B. M. J., i., 1892). *Amylum iodatum:* dose, ½-4 dr. *Syrupus acidi hydriodici* (U. S.), 1 per cent.: dose, 20 to 40 min. For other preparations see Iodoform.

ADMINISTRATION.—Opinions are still divided as to the best time for giving iodides with relation to food.

Dr. Parkes and others recommend them to be taken before meals, in order to prevent decomposition by acids, and to secure dilution with mucus. Some give them at bedtime with effervescence; and again, others find them better borne by a full stomach. All agree that they should be freely diluted, and not taken when there is much starchy food in the stomach, and if there are no febrile or acute gastric symptoms, a bitter infusion or tincture is a good vehicle; in other cases milk is very suitable. Large doses sometimes produce less iodism than small ones (Althaus), and arsenic is to some extent corrective of the unpleasant results (B. M. J., ii., 1871).

ADULTERATION.—The iodides sometimes contain iodates of the respective alkalies, and not infrequently an excess of water, and after keeping, free iodine is developed to some extent.

IODOFORMUM—IODOFORM (CHI_3 = 394).

PREPARATION AND CHARACTERS.—Iodoform is teriodide of formyl, and may be prepared by mixing solutions of potash, or carbonate of potash, or of soda, or of chlorinated lime, with alcohol and iodine, and evaporating, or heating (in the case of lime) to 104° F., till the liquid ceases to have a red colour. Crystalline masses of iodoform and iodate of potassium or calcium are precipitated on cooling, the former is dissolved out by boiling alcohol, and deposited in small, pearly, yellow crystalline scales of unpleasant sweetish taste and penetrating, saffron-like odour. It is nearly insoluble in cold water, but soluble to the extent of 10 per cent. in boiling spirit, and of 20 per cent. in cold ether, and entirely soluble in warm ether. It is also soluble in chloroform, bisulphide of carbon, and oils. The solutions should be neutral to litmus paper. It is partially volatilised by heat, and contains 96·7 per cent. by weight of iodine. A so-called "absolute iodoform" is prepared by electrolysis (B. M. J., i., 1886)—it is a quite pure, soft, scaly powder of citron-yellow colour and less strong odour: precipitated iodoform is pale yellow and impalpable—not crystalline.

ABSORPTION AND ELIMINATION.—Högyes states that if the drug be introduced into the stomach in the solid form, the first step is its solution in any fatty matter, such as the chyme of the intestine. The oily solution of iodoform next gives up its iodine to any albuminous substance or alkali present; these compounds pass speedily into the blood, while a few minute coagula and oil globules are left behind. From raw surfaces also it is absorbed, and if in large quantity, may give rise to toxic symptoms: there seems some idiosyncrasy in this respect. The iodine, or the greater part of it, is gradually eliminated from the system in combination with potassium or sodium and by the same channels as that which is administered in the form of tincture, or iodide, namely, by the urine, saliva, tears, milk, sweat, and the secretions of mucous membranes (Archiv f. exp. Pathol. u. Pharm., Bd. x.). It would seem that the greater quantity passes out by the kidney; there is, however, sufficient iodine set free again in the perspiration to confer upon that secretion an unpleasant odour (Binz). Dr. Gaetano Rummo finds that the drug is eliminated mainly as

iodate of sodium in the urine, but a small quantity passes off unchanged by the lungs (Arch. de Physiol., 1883).

PHYSIOLOGICAL ACTION.—*External.*—Under conditions which set free its iodine, *e.g.*, when brought in contact with suppurating offensive discharges, it acts as an antiseptic and deodoriser of considerable power. It also destroys leucocytes, and Binz finds that it prevents their migration when applied to the frog's mesentery (Virchow's Archiv, 1889). It has been said not to cause local irritation, but I have known it do so when applied to abraded surfaces, especially inflamed ulcers. It has some power as a local anæsthetic; thus a suppository containing it, when introduced into the rectum, may so diminish sensibility that defæcation may occur without the knowledge of the person or animal. Hëyn and Roosing, of Copenhagen, point out that admixture of iodoform with cultures of bacteria does not prevent the growth of the latter. They admit the usefulness of iodoform in surgery, but deny that its power is due to any germicidal properties, and so recommend the use of corrosive sublimate at the same time (Fortschr. der Med., 1887). This paper was received with some scepticism, as every surgeon could quote cases of rapid healing and cleanly wounds under the use of iodoform alone; Dr. Friedländer, however, defended the genuine character of the research, and Dr. Potess pointed out their probable error, in supposing that iodoform mixed with cultures is the same as iodoform in contact with the tissues of the body; in the latter case free iodine is liberated, and it is due to this that iodoform is then such a useful antiseptic.

PHYSIOLOGICAL ACTION.—*Internal.*—Although chemically analogous to chloroform, iodoform is not nearly such a powerful anæsthetic. This is probably due to its insolubility and consequent slow absorption. When it is given in small doses iodine is liberated in the body, and to this is due its alterative action.

Circulatory System.—It depresses the circulation when applied to the frog's heart, having a paralysing effect on the cardiac ganglia, like that of chloral. Extravasations of blood have been found post mortem in animals poisoned by iodoform (Med. Record, 1879), a condition analogous to the hæmorrhages occasionally produced by the administration of iodine or iodides. Toxic doses first show a stimulant effect in man by flushings, due to the dilating effect of the drug on the arterioles, and by palpitation

of the heart. Subsequently the heart becomes weak, and both it and the respiration are paralysed, much in the same way as in batrachia (Schmidt's Jahrb., cxv., and Med. Record, 1879).

Nervous System.—Maître compares the effects of iodoform to those of alcohol. After moderate doses—$\frac{1}{2}$ to 1 gramme—the dog experimented upon lay at rest, or if made to rise, staggered and fell; by the next day it had recovered. After 3 or 4 grammes, intense excitement set in, with quickened circulation and convulsive contractions of the limbs, and opisthotonos, like that produced by strychnine. Its local anæsthetic effects have been already noted, and it also has considerable value in relieving neuralgia (Bouchardat, Annuaire, 1857). Franchino corroborated the fact of its local anæsthetic action, and produced it to a slight extent in dogs, rabbits, and birds, by making them breathe two grammes of iodoform, vaporised by means of bellows in a closed chamber: here the two stages of the drug's action were observed—first, contraction of the muscles, followed by relaxation and anæsthesia for five or ten minutes, then gradual recovery. Binz attributes this result in part to the carbonic acid confined in the chamber (Archiv f. exp. Pathol., viii., 1877). Dr. McKendrick, comparing the drug to chloral, found that 10 gr. dissolved in about 1 dr. of alcohol, and injected under the skin of a rabbit, produced profound sleep for four hours, and 12 gr. destroyed life; but, again, Binz failed to verify this result, and attributed the sleep mainly to the alcohol. In his own experiments, 2 grammes dissolved in oil and administered subcutaneously to dogs and cats, produced moderate sleep in the course of an hour, and 3 grammes impaired the functions of the brain and spinal cord without being necessarily fatal. He concludes that moderate doses exert some narcotic effect, especially on dogs and cats, but not so much as previous observers have thought, and that toxic doses kill by general paresis, with lowering of temperature (Edin. Med. Journ., 1874).

Högyes, making observations in order to try and reconcile the discrepancies in the above statements, found that large doses cause marked drowsiness in dogs and cats, but not in rabbits, and also that during somnolence, reflex irritability is not much interfered with. Toxic doses cause death by gradual paresis of circulation and respiration (Med. Record, 1879). In man, its

toxic effects are now most often seen in cases where a large amount of the powdered drug is placed in contact with absorbing surfaces, from which there is not very free drainage, as in a sinus or nearly closed abscess cavity. The stages of the poisoning correspond to the two stages seen in animals, there being first excitement of both circulatory and nervous systems, and secondly, paresis. The former is evidenced by the palpitating heart, and the flushed face, the latter by subsequent heart-failure ; so in the nervous system there is first sleeplessness, headache, loss of memory, irritability, and in severe and exceptional cases, attacks of violent mania, hallucinations, or melancholia may supervene; this state is succeeded by one of narcosis. Many such cases have been recorded, amongst others four typical ones at University College Hospital by Mr. Stanley Boyd (B. M. J., i., 1882). In the first case there was wandering at night-time, with great drowsiness ; in the second, there was high temperature, delirium, and finally death from broncho-pneumonia ; at the post mortem, petechiæ in the lungs and on the surface of the heart were found. In the third case, that of a child, there was headache, with pyrexia, and other symptoms resembling those of meningitis were present ; when the dressing was changed to one of boric acid, these symptoms all disappeared. In the fourth case there was a high temperature, drowsiness, and a punctiform rash, which also has been observed by others ; *e.g.*, Dr. Thornaun has described a diffuse erythema, as well as circumscribed red spots (Lancet, i., 1882).

Schele, Kocher, and others have also published cases of poisoning, and even death, from similar causes. In Dr. Black's case delusions of exalted character are specially mentioned (B. M. J., i., 1885).

Digestive System.—It is remarkable that iodoform, though containing so large a percentage of iodine, does not usually irritate the gastric mucous membrane, unless in very large doses. V. Morax finds that on giving it to dogs, decomposition in the intestine is prevented to a very great extent, none of the products of such change being found in the urine (Zeit. f. physiol. Chem., x.).

Pathological Changes.—After death from iodoform-poisoning, fatty degeneration has been found in the liver, kidneys, heart, and voluntary muscles. Binz attributes this to the setting free of iodine in the body.

SYNERGISTS AND ANTAGONISTS.—*V.* under Iodine.

Potassium bromide has been used as an antidote (Therap. Gaz., 1889), and Behring states that the bicarbonate, in hourly doses of 10 gr., will lessen the toxic effects previously described (Wien. Med. Blätt., 1884).

INCOMPATIBLES.—Several substances, such as calomel and nitrate of silver, decompose iodoform on exposure to light, and especially with heat; but as the decomposition practically results only in liberation of iodine, it does not much, if at all, affect the therapeutical result.

THERAPEUTICAL ACTION.—*External.*—The antiseptic and deodorant qualities of iodoform render it useful in the prevention of decomposition, as in surgical wounds, also in cleansing and rendering inoffensive wounds and ulcerations of all kinds, especially in military surgery, etc., and where carbolic acid cannot be used. It may be powdered over the area affected,—a useful method is by means of a pepper box,—or cotton-wool may be impregnated with it, and then used as a dressing. Iodoform wool is made either by dusting iodoform over the wool, or, better, by soaking it in an ethereal solution of iodoform; the ether is evaporated off, and the cotton-wool should have gained at least 10 per cent. in weight from the iodoform which it has retained. In other cases the ointment or collodion is more useful.

Ulceration.—When the skin is broken and there is purulent discharge, as in severe burns and chilblains, iodoform, or its ointment, will disinfect the pus, promote healing, and, in virtue of its anæsthetic power, relieve pain. It favours cicatrisation in a remarkable degree, but should not be used while the ulcers are acutely inflamed. This stage being passed, the surface should be carefully cleansed, and dried, and then either the finely-powdered crystals or a solution in ether (1 part to 8 or 10) should be applied and covered with lint; the ether evaporates, leaving a thin film of iodoform (Med. Record, 1878). A dry dressing of iodoform wool is, in many cases—in burns, for instance—more serviceable. From observations in eczematous cases, it is found to be of most use during the puriform stage, and ceases to be suitable when the discharge becomes watery (B. M. J., i., 1881). In late stages of ulceration, it sometimes hinders the formation of epithelium

(Practitioner, 1889). Iodoform ointment is very useful in eczema capitis.

In ulceration about the mouth and face, even when carcinomatous, and unsuitable for operation, powdering the sore with iodoform greatly relieves the patient, lessening pain, and removing the offensive stench. There is some evidence that the crystalline form relieves the pain of such cases better than the "pulverised" (B. M. J., ii., 1889).

In syphilitic ulceration and gummata of the tongue and throat, with ragged, thickened epithelium, deep fissures and severe pain, iodoform is very useful applied locally to the part; also in cutaneous tuberculosis.

Chancre, Bubo.—M. Lailler, in a large experience at the Hôpital Loureine, found iodoform a most useful dressing for all forms of venereal ulceration (Lancet, ii., 1878). The late Mr. Berkeley Hill adopted it as an almost invariable treatment of "specific sores," and many other observers have abundantly confirmed the statement of its value (Med. Times, i., 1875; Practitioner, i., 1879; B. M. J., i., 1878). If secretion is abundant *the sore should be cleansed*, and dressed twice daily with the finely-powdered crystals or iodoform ointment. Smarting may be caused at first, but this and the pain of the disorder soon subside, and healing often takes place in a week or ten days. The unpleasant odour of iodoform is, however, a drawback to its use, and its results are not always so satisfactory as described above. Dr. Thornaun has used a solution of iodoform in almond oil or glycerine (3 parts in 10) for hypodermic injection in cases of syphilis. No local suppuration was produced, and in early cases the symptoms subsided quickly. The dose given was 0·3 at the beginning, and later, 0·7 gramme.

Gonorrhœa.—Iodoform bougies were largely employed with some success in this affection, but have fallen into disuse.

Otorrhœa.—When this arises from aural polypus, or from granulations from the membrana tympani, or from caries affecting the meatus, insufflations of powdered iodoform are most useful in keeping the discharge sweet, and promoting cicatrisation.

Ozœna.—In this obstinate disorder, and in various cases of post-nasal ulceration and discharge, the local use of iodoform

is much recommended by specialists. It is best applied as snuff, and one great relief it gives is the lessening of the stench which often renders the lives of these patients intolerable. It may also be applied to the nose in the form of a bougie containing $\frac{1}{6}$ to $\frac{1}{2}$ gr. made up with gelatine and glycerine. Dr. Woakes found an ethereal solution very painful, and obtained good results with pledgets of iodoform wool (B. M. J., i., 1878).

Eye Diseases.—In many eye disorders, especially of surgical character, Dr. Trousseau found iodoform effective (Record, 1886).

Lupus.—Iodoform deserves a careful trial in this form of ulceration also : an iodoform collodion is much used as an application to it in Vienna. It may be preceded by the thorough use of nitrate of silver.

Fissure of Anus—Hæmorrhoids.—The ointment or suppository of iodoform relieves the pain of defæcation connected with these maladies.

Dyspareunia.—In a case of hyperæsthesia of the vulva without local lesion, powdering with iodoform rendered the parts quite insensitive to pain (Tanner). A tampon of iodoform had good results in another case.

Strumous Glands — Bronchocele. — The application of iodoform ointment to the skin over the enlarged organs has often the same results as painting with iodine (*v.* Iodine). Dr. E. Marchand finds that iodoform delays the formation of giant cells (Virchow's Archiv., v. 93). An iodised collar of iodoform wool is a good method of applying the medicament in cases of goître. Mosetig von Moorhof introduced a method of injecting iodoform emulsion into soft thyroid tumours with antiseptic precautions, and a further series of fifteen cases, said to be all successful, are reported (Lancet, ii., 1891).

Orchitis—Prostatitis—Mammary Growths.—Similarly in these affections, iodoform acts in the same way as iodine when applied locally.

Pleuritis—Phthisis.—In the flying chest pains of these affections, iodoform collodion (1 part in 15 to 20) often acts better than iodine paint, and is said to exert the further effect of lowering the temperature of the body (B. M. J., i., 1879).

Erysipelas.—Dr. C. C. Burman used iodo-collodion as a paint in erysipelas, with satisfactory results (Pract., i., 1884).

Cold Abscess.—Prof. Verneuil finds that the injection of an ethereal solution of iodoform (1 in 20) into the cavities of cold abscesses promotes healthy action (Revue de Thérap., 1884). This method has since been much used and commended, and Mr. Mayo Robson has reported many satisfactory cases (B. M. J., i., 1891). V. Moorhof prefers an emulsion (*ib.*, i., 1890), for which a good formula is given by Mr. A. E. Barker: Iodoform 10 parts, sufficient spirit to damp in a clean mortar; triturate with water 20 parts and glycerine 70 parts. It is also good in tubercular joint disease (Lancet, i., 1892; *v.* Bronchocele).

Onychia.—The duration of this very painful and obstinate form of suppuration may be much shortened by iodoform ointment, of strength 1 dr. to 1 oz. (Med. Times, ii., 1872; Med. Record, 1878). I have used it frequently, with excellent results.

Supravaginal Amputation of the Uterus.—This is an operation in which it is especially difficult to maintain antisepsis. Sir Spencer Wells and Professor Howitz of Copenhagen find, however, that iodoform is the best means we have of attaining this end (B. M. J., ii., 1885).

THERAPEUTICAL ACTION.—*Internal.*—**Stomach Disorders.**—It may be given in the form of pill made up with sugar of milk, and is found useful in cases of dyspepsia, associated with fermentative changes in the stomach.

Phthisis.—Iodoform has been given internally and in the form of spray in this disease, but with doubtful results. As an inhalation, a solution may be used containing iodoform 20 gr., oil of eucalyptus 20 min., rectified spirit ½ oz., and ether ½ oz. This solution is dropped into the interior of a respirator made of cotton-wool and covered with horse-hair. Dr. Dreschfeld, who recommended this, reported gain in weight, etc., in some cases of phthisis treated by iodoform, but he often combined with this treatment croton chloral and creasote (B. M. J., ii., 1883).

Dr. Ransome records slight, but doubtful improvement of phthisis under iodoform (B. M. J., i., 1884). Dr. Shingleton

Smith speaks more positively and says that in some, but not in all, cases the number of bacilli was lessened (B. M. J., ii., 1884). Beetz obtained excellent results from the insufflation of powdered iodoform in cases of laryngeal phthisis (Berlin klin. Woch., 1882). Gussenbauer maintains, but incorrectly, that the drug is specific in arresting the tubercular process; while Dr. Hunter Mackenzie and others conclude that very little dependence can be placed upon it (B. M. J., ii., 1884).

In caseous broncho-pneumonia, however, Semmola speaks well of it (Lancet, ii., 1882); and from Liège are reports of its efficacy in hæmoptysis—2 gr. per diem in 3 doses acted in two or three days, and more quickly than ergotin; tannin was sometimes combined (Progrès Méd., 1888). Tubercular meningitis and tubercular diarrhœa have improved under it (*ib.*). Dr. Brower applying by inunction to the shaved scalp, twice daily, 1 part of iodoform in 5 of vaseline, has also seen much improvement in the former complaint (Pract., 1888). From hypodermic injections, night and morning, of an oil emulsion of iodoform, Gavoy reports very marked benefit in cases of tubercular bronchitis (Gaz. Méd. de Paris, Feb., 1891). Picot combined the same with guaiacol in phthisis (Year Book, 1892).

Diabetes.—Prof. Moleschott recorded five cases in which 40 to 50 centigrammes given daily produced favourable results (Lancet, i., 1882). Bozzolo has confirmed this, and finds also that the red corpuscles are simultaneously reduced in number (Record, 1884), and arterial tension lessened, probably through influence on the vaso-motor centre. Dr. Paolucci obtained, however, negative results (Med. Times, i., 1883).

Gout.—If Testa's observations represent the average results, the remedy ought to prove a valuable one, for he found it (1) augment organic changes, oxidation, and excretion of urea; (2) oxaluria was lessened, as also was excretion of uric acid, but this because of its increased conversion into urea; (3) the uric acid in the blood was diminished. He reports clinically that seven cases of gout taking from $1\frac{1}{2}$ to 3 gr. doses were relieved as to pain, frequency of attack, etc., but considers the drug contra-indicated by the presence of renal disease (Record, 1885).

Worms.—The use of iodoform as an anthelmintic was first advocated by Professor Sim, who stated that 1 gr. doses killed

both tæniæ and ascarides (Med. and Surg. Reporter, 1881). This was supported by Szydlowski, who had three successful cases (Vratsch, 1882), and by Makeroff, who recorded one (*ib.*, 1883). Nikolsky, however, found it of no use whatever (Russkaia Med., 1883).

PREPARATIONS AND DOSE.—*Iodoformum* : dose, ½ to 3 gr. in pill, with sugar of milk, tragacanth, and glycerine, or pastilles containing 2 gr. in each. Capsules containing a solution in ether, known as "perles de Clertan," are a good form. Bonner gives it in honey especially to children. The officinal preparations are *suppositoria iodoformi*, 3 gr. in each, and *unguentum iodoformi*, 1 part in 10. The *collodium iodoformi*, 1 part in 16, is not officinal. An emulsion is made with spirit, glycerine, and water. *Iodo-vaseline* (not officinal) consists of 1 dr. of iodoform in 1 oz. of eucalyptus oil—and 5 oz. of vaseline. Kieselguhr, a diatomaceous earth which is very absorbent, mixed with iodoform makes a good dusting powder. Iodoformum bituminatum is a combination with tar (B. M. J., ii., 1888).

ADMINISTRATION.—The disagreeable smell of iodoform may be covered by ethereal oil, such as that of peppermint, eucalyptus, or geranium, but combination with essential oils may give rise to acrid products : also by Tonquin bean (cumarin), by oleum pini sylvestris, by sanitas, by oil of camphor, or coffee. Otto of roses (mj to 3j) is good, also a combination of quinine and charcoal, but tinct. benzoin co. is sufficient for most cases.

ADULTERATION.—It may be adulterated with picric acid, which is cheaper, and has the same melting-point as iodoform.

OTHER IODISED COMPOUNDS IN USE AS SUBSTITUTES FOR IODOFORM.

(Non-Officinal.)

Antiseptol, Iodo-sulphate of cinchonine, is a brown powder, free from odour, insoluble in water, soluble in spirit and chloroform, containing 50 per cent. iodine (Therap. Gaz., 1890).

Aristol, Di-thymo-iodide, is a reddish-brown powder, insoluble in water and glycerine, soluble in ether and oils, decomposed by heat and light, contains nearly 46 per cent. iodine, neither irritant nor toxic, used in powder or ointment 5 to 10 per cent.

in various skin diseases, etc. (B. M. J., 1890-1891); 3 per cent. with 20 of olive oil and 77 of lanoline is a good application for burns, etc.

M. Brocq has treated epithelioma of the face having a large ulcerated surface, with pulverised aristol. Good results followed in five or six days; and a tendency to cicatrisation was observed. Twenty days afterwards it was far advanced, and in a few more days was complete (B. M. J., i., 1890). Eichhoff found this drug equal to iodoform in all cases in which he tried it, except in soft chancres. It acts more slowly than chrysarobin or pyrogallic acid in psoriasis, but has some advantages over the former drug. In parasitic skin diseases it is equal to other remedies, and is not so irritating. In ulcers of the leg and in tertiary ulcerations it "heals more quickly than any other known medicinal application," and he considers that in lupus it surpasses all remedies hitherto tried; he uses a 10 per cent. ointment with vaseline (Monats. f. prakt. Derm, No. 2, 1890).

Europhen, Iso-butyl-ortho-cresyl-iodide, is a yellow powder, insoluble in water and glycerine, soluble in oil, spirit, etc., resinous to the touch, and with slight odour like saffron, containing 28 per cent. iodine, decomposed by heat and light, is much lighter than iodoform, non-toxic, and acts only when in contact with moisture (B. M. J., ii., 1891, and i., 1892, etc.); it is especially useful (1 to 10 p.c.) in soft chancre.

Iodol, Tetra-iodo-pyrrol, a brownish-white powder, insoluble in water, soluble in spirit, more so in ether, collodion, and chloroform, moderately in glycerine, is non-toxic and odourless, but gives off iodine on heating. It can be used as an ointment rubbed up with vaseline or lanoline, as a powder dusted over the affected parts, or as a solution in alcohol diluted with glycerine or dissolved in warm oil. It was found useful in indolent ulcers which soon took on a healthy action; also after excision of suppurating inguinal glands it proved an excellent dressing (B. M. J., i., 1887). It is also used as an ointment in eye and ear diseases.

Sozoiodol, Di-iodo-para-phenol sulphonic acid, contains 54 per cent. iodine, with sulphur and carbolic acid, and has been combined with sodium and other metals to form salts: that with sodium is in odourless acicular crystals, soluble in water: dose,

10-20 gr. twice or three times daily. Externally, it is tolerated in a concentrated state without creating inflammation.

BROMUM—BROMINE (Br = 80).

This element does not occur free in nature, but its compounds with metals (bromides) are contained in sea-water and in some saline springs, as in those of Ashby, Birtley (Durham), Woodhall, Crieff, and Kreuznach, also in sea-weed and molluscs.

PREPARATION.—Bromine is chiefly obtained from bittern (sea-water from which the common salt has been crystallised out), in which it exists as bromides of magnesium, sodium, and potassium, by passing through the liquid, chlorine gas, which sets free the bromine. The mixture is then shaken up with ether, which dissolves the bromine, rises to the surface and is decanted. To this ethereal solution caustic potash (or soda) is added, and the ether distilled off. The crystals of bromide and bromate of potassium or sodium thus obtained are heated, to convert the bromate into bromide, and then treated with sulphuric acid and manganese dioxide, when the liberated bromine distils over and is collected in cooled receivers.

The reactions are:—(1) $MgBr_2 + 2Cl = MgCl_2 + 2Br$. (2) $6Br + 6KHO = 5KBr + KBrO_3 + 3H_2O$. (3) $2KBr + 2H_2SO_4 + MnO_2 = Br_2 + K_2SO_4 + MnSO_4 + 2H_2O$.

CHARACTERS AND TESTS.—Bromine is the only non-metallic element which is liquid at ordinary temperature. It is of brownish-red colour, very volatile, and emits an irritating, disagreeable vapour, whence its name Βρωμος, a stench. It should be kept in a closely-stoppered bottle. It boils at 135° to 140° F. Alkalies decolorise bromine, with formation of bromides and bromates; with hydrogen it combines to form hydrobromic acid (HBr). Solutions in alcohol and ether (which liquids dissolve bromine readily) lose their colour in a few days with formation of the same acid. At 32° F. it forms with water a crystalline hydrate. When agitated with solution of soda in such a proportion that the fluid remains very slightly alkaline, it forms a colourless liquid which, if coloured by adding a small quantity of the bromine, does not become blue on the further addition of starch solution, thus showing the absence of iodine.

PHYSIOLOGICAL ACTION.—Bromine coagulates albumen and combines with it in a definite proportion of Br. 23, albumen 96,

which compound is soluble in caustic potash, and is colourless (Glover, Harveian Essay, 1842).

Undiluted bromine quickly oxidises and destroys organic tissues, forming a brownish slough ; with fatty substances hydrobromic acid is developed. Bromine vapour is intensely irritating to the air-passages, it may cause coryza, or even laryngitis, bronchitis, or pneumonia, and may destroy the sense of smell. It is a powerful disinfectant, but on account of its odour is but little used as such. Dr. Warmick, however, believes that it may be utilised as follows : he exposed silk fibres, impregnated with anthrax spores, for six hours to bromine fumes from siliceous earth impregnated with seven times its volume of bromine, and found, by experiments on mice, that the virulence of the bacillus was destroyed (Lancet, i., 1882).

When taken internally in doses of 1 to 2 drops, well diluted, it has a taste "truly horrid" (Glover), and causes weight and heat at the stomach, often colic, shooting pains in the limbs, and itching in the extremities ; but after an hour or so these symptoms are succeeded by a general sense of comfort and stimulation. Larger doses may cause gastritis with symptoms of intense irritation, prostration, and collapse. Independently of this local irritant effect, the physiological action of bromine, after absorption, is exerted mainly on the lymphatic and glandular systems, their functional activity being increased, though to a less degree than by iodine.

Köhler mentions several experiments which have been made with bromine, and says "that, independent of its local irritant action, it exerts, if taken in small doses for some time, a strong action upon the brain, viz., depression of the mental functions, sleepiness, stupor, prostration, and a state resembling alcoholic intoxication."

THERAPEUTICAL ACTION.—*External.*—**Hospital Gangrene—Erysipelas.**—The value of bromine as an escharotic and caustic in these maladies was conclusively shown during the American civil war by Surgeon Goldsmith. The formula commonly employed was—"bromine 1 oz., bromide of potassium 160 gr., water 4 oz." After thorough cleansing of gangrenous wounds this was applied ; and, although very painful for a time, the pain was mitigated by bathing, and the malady was arrested better by this

than by any other means (Med. Times, ii., 1863). The same application was found valuable in diphtheria and erysipelas, and the liquid, when exposed in shallow vessels, served also to disinfect hospital wards.

Mr. Marshall and Mr. Southam used a solution of 1 scruple of bromine in 1 oz. of spirit for unhealthy wounds, and found it useful, but very painful; its offensive smell is also a drawback to its employment. The pure drug has been applied, and acts well in similar cases, but requires special precaution to carry the vapour away from the patient (Lancet, ii., 1868).

Chancre—Epithelioma.—In the few cases where a chancre can be, with advantage, destroyed at an early stage, bromine is one of the most efficient agents for the purpose.

Dr. Wynn Williams and others have reported very satisfactory results from the use of bromine injections into the substance of epithelial cancer affecting the cervix uteri, a solution of 12 min. in 1 dr. of rectified spirit being injected through a speculum by means of a long glass syringe having a platinum point; the nostrils of the operator and patient should be plugged with cotton wool (Med. Times, ii., 1866 and 1870). There can be no question of the good results obtained by Dr. Williams, but as he restricted his method to cases "in which the uterus was not fixed," some doubts were thrown on the diagnosis of cancer by Dr. Playfair and others.

Nasal Catarrh—Hay Asthma—Ozæna.—Brominised inhalations are of value in these disorders, and may be employed in the manner recommended by Bartholow. Half a drachm of bromine is mixed with 4 oz. of alcohol, and a small quantity of this placed in a wide-mouthed phial and vaporised by the warmth of the hand, furnishes a diluted vapour which should be drawn up into the nasal passages.

Diphtheria — Membranous Croup.—Brominised inhalations and external applications have been successfully used, especially by German physicians in these maladies, and in diphtheritic vaginitis (B. M. J., ii., 1872). Ozanam used also an aqueous solution internally (Brit. and For. Rev., 1869), and I have myself seen excellent results with this combined method of treatment, diphtheritic membrane disappearing under it. I have employed the inhalations of bromine internally every

three or four hours, using one or two drachms of a solution containing eight drops to the ounce, even when the disease had extended to the bronchi and great prostration had set in, and sometimes I have used the vapour and local applications of bromine whilst giving iron internally, also with very good results.

Redenbacher has reported two successful cases in which bromine and bromides were useful (B. M. J., i., 1879).

THERAPEUTICAL ACTION.—*Internal.*—**Chronic Arthritis.**—Andral treated this disorder by giving bromine at first in 2 drop doses, but later with as many as 60 drops in twenty-four hours. The gastric irritation, however, was too severe to make such treatment desirable.

Struma.—Bonnet recommended 5 to 10 drops daily in cases of glandular scrofulosis, conjoining local applications (Bulletin, 1837), but the internal use of bromine is practically superseded by that of its compounds. It is possible, however, that smaller and more frequent doses of bromine than have hitherto been prescribed might give better results, with avoidance of gastric irritation.

COMPOUNDS OF BROMINE.

POTASSII BROMIDUM—BROMIDE OF POTASSIUM

(KBr = 119).

PREPARATION.—By adding bromine in slight excess to liquor potassæ, and afterwards heating with charcoal, dissolving, and crystallising. In the first part of the process a mixture of bromide and bromate of potash is formed, $6KHO + Br_6 = 5KBr + KBrO_3 + 3H_2O$, and in the second part the bromate is deoxidised, the bromide remaining unaffected.

CHARACTERS AND TESTS.—It occurs in cubical crystals, resembling those of the iodide, but smaller. When well kept they are transparent or white, but sometimes have a tinge of yellow from free bromine. They have a saline bitter taste, high diffusion power, and are very soluble in water. Chlorine water added to the crystals liberates bromine, which will impart an orange-red colour to chloroform, ether, or bisulphide of carbon. The starch test would detect iodine, which used to be a frequent adulteration. Bromides give a yellowish-white precipitate with silver nitrate, which is sparingly soluble in ammonia solution.

AMMONII BROMIDUM—BROMIDE OF AMMONIUM

(NH_4Br = 98).

PREPARATION.—By neutralising hydrobromic acid with ammonia, evaporating, and then allowing the salt to crystallise out. The reaction is denoted by the following equation :—$HBr + NH_4HO = NH_4Br + H_2O$.

CHARACTERS AND TESTS.—It occurs in white, colourless crystals, which gradually become yellowish on exposure to the air; readily soluble in water, less so in spirit. It is rather more disagreeable to the taste than the potassium salt.

SODII BROMIDUM—BROMIDE OF SODIUM

($NaBr$ = 103).

PREPARATION.—This salt may be obtained by the process described in connection with bromide of potassium, solution of soda being used instead of solution of potash.

CHARACTERS AND TESTS.—It is a white powder consisting of small monoclinic crystals, with a saline taste, readily soluble in less than twice its weight of water, much less soluble in spirit (1 in 13).

The following compounds of bromine are not officinal :—

Lithii bromidum—bromide of lithium ($LiBr$ = 87) is a white, granular, deliquescent salt, very soluble both in water and alcohol, and containing a larger proportion of bromine than any other compound.

Calcii bromidum—bromide of calcium is a white, soluble, deliquescent salt, which readily decomposes on exposure, becoming brown in colour; it occurs in Kreuznach and Vals water; is less stable than the potassium salt (Hammond).

Magnesii bromidum—bromide of magnesium. This salt is the main source of the metalloid, and is especially abundant in the water of the Dead Sea; it is found also in the Ashby and Kreuznach waters.

Strontii bromidum—bromide of strontium occurs in lumps of small white crystals, very soluble in water; less toxic and better borne than alkaline bromides (B. M. J., ii., 1891; i., 1892); contains $\frac{1}{3}$ less bromine than the potassium salt (*cf.* Year Book, 1893).

Sodium hypobromite (NaBrO). An alkaline solution of this salt is employed in the estimation of urea (Dupré's method).

Bromum solidificatum; a variety of earth called Kieselguhr, has been impregnated with bromine in different proportions, compressed into sticks, and sold under the above name (American Druggist, Jan., 1887).

Besides, there are many *metallic bromides*, such as those of gold, iron, zinc, mercury, and lead; and many *organic bromides*, such as those of camphor, morphine, quinine, and strychnine; also of ethylene (Therap. Gaz., 1891). Their properties are chiefly those of the base, but modified somewhat, so as to act more favourably on the nervous system.

Bromol, tri-bromo-phenol, is a white crystalline substance, insoluble in water, soluble in ether and oils, used as a disinfectant like bromine (Lancet, i., 1891).

Bromoform — terbromide of formyl, $CHBr_3$ (analogous to chloroform), is obtained by the action of bromine on alcohol, in presence of an alkali, and is a clear liquid of ethereal odour, sp. gr. 2·9, soluble in alcohol and ether, slightly so in water; of sweet taste, and non-irritant. It is decomposed by light, bromine fumes being given off, and the colour turning brown.

ABSORPTION AND ELIMINATION.—The alkaline bromides are readily absorbed, and have been found in the urine and saliva five minutes after a dose of 15 gr. (Rabuteau); in ten minutes' time the reactions were very manifest. Bowditch drew blood from the carotid of an animal six minutes after 10 gr. had been taken, and calculated that even in that time a third of the dose had passed into the circulation (Boston Med. Journ., 1868). They are usually eliminated *unchanged*, and Voisin has obtained cubical crystals of the potassium salt from the urine of patients taking it. The rate of elimination varies. In some experiments, the urine gave traces of the drug in ten minutes; in others thirty minutes was the earliest period; in others twenty-five hours (Bowditch). The excretion of single large doses is usually complete in one or two days (Chauvet, Amory), though minute quantities have been detected in the urine for three or four weeks afterwards (Rabuteau). If the drug has been taken continuously for some time, the period of its excretion is prolonged: thus Namias found it continue for fourteen days (Gaz. Hebdom., 1868), and renal

disease so far impedes its excretion that upwards of thirty days may be required for its completion. Dr. Stevenson "detected bromides in the urine of a child passed about four weeks after the medicine was discontinued" (Path. Soc. Trans., 1877).

As evidence, also, of the slow elimination of these salts, Drs. Crocker, Lees, Barlow, myself, and others, have noted the increase, or even the chief development, of the rash sometimes produced by them, *after* the discontinuance of the drugs. The elimination of bromides is certainly *slower* than that of iodides. It occurs not only by the kidneys and the saliva, but also by the mammary, lachrymal, and sudoriparous glands, and by mucous membranes—by the last especially in the case of the ammonium salts. In exceptional instances, the salts have been decomposed in the system, and free bromine eliminated in the breath. The alkaline compounds do not usually pass by the fæces unless diarrhœa occur; but if bromides of the heavy metals be taken, the *metal* passes chiefly in the motions.

Thus, when experimenting with bromide of iron, Namias found bromine abundantly in the urine, but iron scarcely at all. The same observer, examining the body of a man who died whilst taking bromide of potassium, found that salt in all the fluids, as well as in the brain, liver, lungs, and other viscera (Comptes Rendus, t. lxx.). After very large doses, an unabsorbed portion has been found in the intestine. M. Doyon found a considerable excess in the *brain* (30 gr.), and next in the liver (11 gr.) of a child who had taken large quantities for about twelve months (Lyon Médical, 1889).

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Doses of 5 to 15 gr. of the alkaline bromides are well borne by the stomach, but upwards of 20 to 30 gr. will often cause irritation and nausea, with sense of weight and coldness, later of warmth. At first the gastric secretions are rather lessened and appetite slightly increased, but after a time there is anorexia, and gastric catarrh and diarrhœa may occur, especially with the potassium salt. It has been said that such symptoms, as also cutaneous eruptions, are mainly due to a septic condition of the gastro-intestinal tract, preventing proper assimilation, and may generally be obviated by combining an antiseptic, such as naphthol or salicylate, with the bromide (Féré, Soc. de Biol., 1891). (The same observer records one case taking daily 150 grains of

the potassium salt, in which an eruption persisted in spite of asepsis, but with the same dose of strontium salt no eruption occurred.) Bromide of sodium increases thirst as the chloride does. The sensibility and the reflex movements of the *fauces* and *pharynx* become much lessened under the full influence of the bromides, and even from their continued local application, so much so that in certain cases the fauces may be tickled without causing any tendency to vomit; if, however, these parts are inflamed, a strong solution may prove very painful.

Nervous System.—The action of bromides on the nervous system, especially of the lower animals, has been carefully studied by many observers, but with different and somewhat confusing results. Thus, whilst Damourette, Pelvet, and R. Amory conclude that the functions of nervous tissue become paralysed by its direct local application (Bulletin Thérap., t. lxxiii., and Essay on Bromide, 1872), Saison finds no trace of such paralysis (Du Bromure, Thèse, 1868); and whilst Laborde and Purser are satisfied that reflex function is abolished early (Archives de Physiol., t. i., and Dub. Journ., 1869), Bill holds this to be unproven, and argues that results with frogs are but little guide to effects on men (Amer. Journ., July, 1868).

I believe, myself, that in this instance there is much analogy in the action of the drug on men and animals, and a careful consideration of the evidence before us warrants the following statements.

In *batrachians*, the bromides, when injected under, or absorbed through the skin, exert a local paralysing effect on the neighbouring tissues, whether nervous or muscular. If the injection be made close to the brain or to the cord, the *centre* which is *nearest* will be paralysed soonest; but if absorption occur at a distance, *e.g.*, through the web of foot, then *reflex power* is *first* lost, so that pinching or irritation does not excite the usual contractions. The other peripheral sensory nerves lose their sensibility very soon afterwards; then the motor tract of the cord and motor nerves are affected, and lastly the cerebrum. Most of the characteristic effects of the drug may be seen on frogs after the medulla is divided from the brain, but if it be left undivided, the persistence of some cerebral action, after the cessation of reflex function, is made evident by movements.

In *warm-blooded animals*, the demonstration of early loss of reflex power is not so complete, but there is evident impairment of sensibility and of cerebral action, with partial paralysis, especially of the *hind* limbs.

In *man*, the earliest effects of *full* doses on the nervous system are usually seen in impaired sensibility, especially of mucous surfaces, such as the fauces and pharynx, the conjunctiva, and the urethra. It is possibly most marked in these regions because the drug is largely eliminated there, but loss of tactile sensibility is also sometimes observed in the palms and the soles. Affection of the nerve-centres is shown, sooner or later, by languor, lassitude, and drowsiness; giddiness is complained of, and exceptionally there may be cerebral excitement; mental working power is temporarily impaired, so that ordinary accounts become puzzling, and memory fails. The amount of the drug that produces such symptoms varies in different persons. Dr. Lockhart Clarke has noted them after half-drachm and drachm doses, but usually they are not seen until after much larger quantities have been absorbed. The impaired condition of the nervous system is known as "bromism," and when developed in an extreme degree, the special senses, sight and hearing, are greatly dulled, reflex and motor power are almost wholly lost, and the cerebral state is one of absolute apathy and indifference bordering upon idiocy. As a rule, these serious symptoms subside quickly on omission of the drug, but death has resulted from an overdose in the case of a child, who accidentally drank a mixture which contained 80 gr. of bromide of potassium; narcosis ensued, and the child died about an hour afterwards (Duncan, B. M. J., i., 1882).

In a case said to be of chronic bromine-poisoning there were vertigo, amaurosis, and some loss of co-ordination and sensation (Med. Record, 1879).

In seeking for an explanation of the *mode* of action of bromides, it is clear that the contraction of the minute vessels in nervous tissue will not account for all the phenomena observed. The drug produces in certain doses such a contraction, due either to the stimulation of vaso-motor nerves, or of the muscular tissue of the vessels; but the chief effect is directly sedative and depressing on the cerebro-spinal centres, as well as on the peripheral nerves, including, in some instances, the vaso-motor nerves, as is shown by

the relaxation of the small vessels, and local congestions which occur in certain cases. It is thus that we may explain the exceptional occurrence of diarrhœa or diuresis under bromides, and more particularly the retinal congestions found by Dr. Nicol after doses of ½ to 1 dr. (Med.-Chir. Trans., ii., 1872); this point, however, requires further investigation.

Nothnagel says the temperature always goes down after large doses in men and animals—after 10 grammes (2½ dr.) by 0·5° to 0·8° C., after 15 grammes by 1·2° C.

Circulatory System.—In a frog, if strong solutions be injected near the cardiac region, the heart is suddenly arrested in diastole, but under a slower *distal* absorption this does not occur, nor is there evidence of the specific paralysing effect upon the heart contended for by Eulenburg. On the contrary, the heart has been found beating one or two hours after complete paralysis of the nervous system and of respiration (Damourette, Saison). Drs. Ringer and Sainsbury, in their investigations on the frog's heart, found that potassium bromide arrested that organ in diastole, in which action it resembles chloral and morphine. From this they draw the practical conclusion that it is unsafe to give the drug in conditions of great adynamia (B. M. J., i., 1883). The heart's action is rendered slower, but, as a rule, the capillaries are narrowed *before* this slowing. It is not the soaking through of the cardiac muscles by bromide of potassium that produces these effects (as it does in the experiments on the frog mentioned above), but the gradual lowering of the spinal reflex activity. The observers just named, as well as Meuriot, Hammond, and Amory, have witnessed the narrowing of vessels in the web, the tongue, and the brain of frogs or dogs, but others have failed to see this, and Dr. H. C. Wood considers the present proof insufficient; neither does the observation that the divided capillaries of a brominised frog bleed less than normal ones seem free from criticism, for he suggests that lower cardiac action would account for lessened bleeding. But, these observations apart, I think the pallor of the surface that follows the use of bromides, and the lessening of secretion and discharge, point strongly in favour of the view that the vessels are narrowed. There is also post-mortem evidence that the blood in the capillaries is lessened under the influence of bromides (Saison), and we may quote, too, the clinical fact

that bromides relieve many forms of *capillary congestion*, especially cerebral and uterine, whereas in patients with cerebral *anæmia*, the effects are often distressing. Thus, whilst Dr. Wood considers capillary contraction to be "somewhat probable," I hold it to be more clearly ascertained.

That the heart's action and the general circulation are slowed in the lower animals is also evident from many experiments (Damourette and Pelvet, *loc. cit.*, and Schouten, Schmidt's Jahrb., Bd. cliv.). This is more marked with the potassium salt than with the others, and may be largely credited to the alkali; the bromide of sodium has comparatively slight effect in this direction (Eulenburg, Rabuteau). In man, the depressing effect of any bromide on the circulation is not constant; Pletzer noticed it (Schmidt's Jahrb., 1868), and Bartholow records a depression of 10 to 20 beats per minute after a dose of 2 dr., but Dr. Bill, Dr. Voisin, Dr. Russell Reynolds, and others have failed to observe such a result with doses of 20 gr. and upwards continued for some time. It is evident that the depressing effect of the bromides is less felt by the circulatory than by the nervous system. Dr. Macphail, in his essay on the blood of the insane, stated that the administration even of large doses of potassium bromide does not impoverish the blood. Dr. J. A. Campbell notes, however, a disposition of those taking large quantities to hypostatic congestion of the lungs (Lancet, ii., 1885). This probably is a result of the action of the drug on the circulation, not on the blood itself.

Generative System.—Speaking generally, we may say that bromides act as sedatives upon the genital system, and diminish the sexual feelings and the power of erection, though the secretion of the testicles is not lessened (Rabuteau). Genital excitement may arise either from *eccentric* cause (as urethral irritation, rectal or ovarian congestion, etc.), or from a *centric* cause in the cord, or brain itself. Both are controlled by bromide, the effect being partly local, and exerted through the mucous membrane of the urethra, and partly due to a lessening of congestion and depression of functional power in the spinal cord. The degree of sexual sedation induced by bromides varies in different men and animals, and any marked effect of the kind is shown only under the influence of large doses.

Action on Secretion and Excretion.—The *primary* effect

of moderate doses of bromide is to lessen most of the secretions (Bowditch and others), although, as a *secondary* effect, or after very large doses, they may be increased. There is no lachrymation, salivation, or catarrh from a pure salt, as there is from the iodides, for bromides are more stable, and although also eliminated by mucous membranes, do not part with free bromine on their surface. The mouth is rendered rather drier than usual, especially by the sodium salt. The amount of mucus in the intestinal canal is also lessened, so that constipation is not infrequent at first. The secretion of milk is lessened by the internal and local use of bromide of potassium (Tyler Smith, Med. Times, i., 1861). With regard to the amount of urine excreted, the usual result is that with small or moderate doses no increase can be made out, whilst with large or long-continued ones, diuresis occurs. Dr. Bowditch suggests that a *secondary* hyperæmia is produced more readily in the kidneys than in other parts, and Pletzer has reported albuminuria in some instances.

Bromides tend to lessen vesical irritability, and so to render micturition less frequent, though the amount passed may be really larger than usual. On the other hand, very large doses may so far paralyse the sphincter as to occasion incontinence.

Excretion of Urea and Carbonic Acid—Action on Nutrition.—From the experiments of Drs. Bill and Rabuteau, it appears that tissue-change is *retarded* under the influence of bromides. The former especially noted that the carbonic acid eliminated was decidedly less than normal, and this independently of diminished nervous power, and not proportionately to the dose, as it is with morphine and its congeners.

Rabuteau found that whilst his average daily excretion of urea was 21·25 grammes, the mean amount passed whilst he took a daily dose of 15 gr. of bromide of potassium was 19·52 grammes; for a fortnight after omitting the drug it remained at about 20 grammes; in the third week it resumed a normal proportion, and in the fourth week exceeded this. Rabuteau connected the primary result with slowing of circulation and respiration; it was not accompanied by increased quantity of urine.

Dr. Gibb also found that the ammonium salt in small doses (3 to 5 gr.) diminished body-weight "by favouring absorption of fat" (Lancet, i., 1863). Bartholow found that assimilation was

retarded by the continued use of bromides, and he traced emaciation to this cause. I have sometimes noted it from these medicines; but it is by no means invariable, as shown in ten patients at Hayward's Heath Asylum, who took daily doses of nearly 1 dr. of the potassium salt. Ordinary secretion and excretion were not affected, but all these patients increased in weight, and in another series of patients who took more than 1 dr. doses, some lost weight and some did not (Dr. Williams). The increase of weight would accord with the conclusions of Bill and Rabuteau, but minute analyses were not made.

Cutaneous System. — Perspiration is diminished under bromide of potassium. Various kinds of *eruption*, erythematous or acneform in character, are commonly traced to this drug, and although several observers maintain that they are wholly due to *iodide* contained in the preparation, they seem in greater or less degree inseparable from bromide medication, and occur with almost equal frequency after the ammonium, sodium, or other compounds. Erlenmeyer, advocating the use of several bromides in combination, makes the curious statement that acne produced by one often disappears if change be made to another, though given in equivalent dose (Record, 1885).

The eruptions affect mostly the face, arms, back, and buttocks, but may be general. They present papules, vesicles containing sebaceous matter (seborrhœa—Fox), or pustules, and even crusted tubercles of carbuncular character, and have been termed "confluent acne" (Cholmeley) and "molluscoid acne" (Neumann). Voisin distinguishes five different kinds of "bromide rash" (Archives Gén., 1866-67). Usually there is a hard, red swelling, with a small point of suppuration in the centre: this may be quite small—a mere papule—or of large size. An eruption of this kind has occurred in a child at the breast, whose mother was taking the medicine and was not herself affected (Lancet, ii., 1874). A more rare, but still recognised form, is that of erythematous patches, which may be local or general (Med. Times, ii., 1874; i., 1878). The microscopical examination of the pustules produced by bromine shows that the pathological anatomy is not the same in all cases. Mr. Warren Tay and Dr. Stephen Mackenzie found, in a case in which the eruption resembled chicken pox, pus cells in the corium, especially around the hair follicles

and sebaceous glands; the blood vessels were distended; the sweat glands were not affected (Lancet, i., 1884). Dr. Colcott Fox found in another case that the blood vessels and sweat glands were chiefly implicated, while the hair follicles and sebaceous glands escaped (Lancet, ii., 1885).

The occurrence of such cutaneous eruptions in the medicinal use of the drug is (as in the case of iodide rashes) obviated to a great extent by giving small doses of arsenic subcutaneously (Gowers, Lancet, i., 1878).

Dr. Cameron has experimented with bromates, especially that of quinine, and finds that it is physiologically more active than the bromide. This corresponds to his results with the iodates, which are more active than the iodides: the reason he attributes is the same in both cases, namely, the larger molecular weight, and the "superoxidised" condition of the former compounds (Lancet, i., 1882).

SYNERGISTS.—The sedative action of the alkaline bromides on the nervous system is assisted or modified favourably under certain conditions by chloral, chloralamide, cannabis, and opium; their regulating effect upon vaso-motor nerves especially by quinine; their depressant effect upon the circulation is aided by aconite, gelsemium, veratrum viride, and digitalis, also by nitrate of potassium and allied salts; their alterative power is increased by cod-liver oil, iodides, and alkalies.

ANTAGONISTS.—Stimulants, such as alcohol, ether, and coffee, oppose the action of bromides; thebaine, strychnine, and nicotine are also antagonistic. Strychnine especially has an opposite effect on the cord and the medulla oblongata, though without a direct action on the brain or the muscles. The difference in the capillaries of the spinal centres post mortem, after using the two drugs, was especially noted by Saison; under bromide the vessels were scarcely visible, under strychnine intensely congested (*v.* p. 141).

Atropine antagonises in some degree bromal hydrate (Hughes Bennet, B. M. J., i., 1875), and ergot is opposed, in its full action, to bromides—although any of the above-named drugs may at times be usefully combined with them, and made to modify their ordinary action for certain therapeutical results. This is evidenced by clinical experience.

Dr. Bill argues that chloride of sodium is antagonistic to

bromide of potassium, and that the latter remains longer in the system if the former salt be avoided (Amer. Journ., 1868).

THERAPEUTICAL ACTION. — *External.* — **Morbid Growths, etc.**—Bromide of potassium, applied in fine powder to indolent ulcerations and morbid growths with raw surface, is said to act well and painlessly as an alterative or caustic (Med. Times, ii., 1876). Mixed with simple ointment (1 part in 5), or with glycerine, it forms a sedative, somewhat astringent application for painful and sloughing ulcers, also for painful conditions of mucous membranes, hæmorrhoids, and anal fissure, and for chronic eczema and acne.

A lotion containing 1 part to 50 of water is said to restrain hæmorrhage (Lancet, ii., 1876).

THERAPEUTICAL ACTION.—*Internal.*— In 1826, Barthez, Andral, and some few other observers, ascertained that the bromide of potassium could relieve arthritic pain, and Pourché found it useful in bronchocele. Dr. Robert Williams (of St. Thomas's Hospital) reported such success with it in the treatment of enlarged spleen, as to contribute to its introduction into the London Pharmacopœia of 1835, and yet it is instructive to remark that so little clinical evidence of its value was obtained by others, that the medicine was omitted in that of 1851. Puche noted from it partial anæsthesia; and Thielman, a Russian physician, its sedative influence on the generative system; from these suggestions Sir Charles Locock was led to use it in epileptic or epileptiform attacks, connected especially with ovarian or uterine excitement, and the mention of his successful results at the Medico-Chirurgical Society, in 1857, was practically the commencement of general knowledge on the subject.

Epilepsy.—For this malady the bromides are now, by common consent, held to be the most trustworthy remedies. They give the best results in *sthenic* cases of uncertain causation, when convulsive attacks are very violent but have not become chronic. Attacks connected with tumour, or injury, or organic lesion, are also more or less relieved, probably in proportion to the amount of *hyperæmia* present. Dr. Wilks found better results from bromides in *traumatic* cases than in any other (Med. Times, ii., 1861), and Sir W. H. Broadbent noticed the same fact (Lancet, i., 1866). When there is *eccentric* irritation, as in the generative system or the abdominal organs, benefit is almost always obtained, and Dr.

Bill has compared the action of bromides in such cases to that of a ligature, interrupting communication between an impression or "aura," and the brain; they seem to diminish not only conductive, but reflex function. In a case in my own practice, where a large uterine fibroid produced alarming epileptiform symptoms, opium invariably increased the spasms, but bromides relieved them quickly.

Minor forms of epilepsy, as "petit mal," evidenced by transient vertigo or loss of consciousness, with perhaps some spasm, but not true convulsion, are not so certainly relieved; and when the epileptic attacks occur only, or chiefly, at *night*, and at *long intervals*, bromides are not always the best remedies; also in very chronic cases of many years' duration, they can usually do little more than modify the character of the attacks. When the patient has become nerveless and stupid, belladonna has the advantage over bromides, and when there is marked anæmia or profound depression, they are not desirable. Nux vomica, or strychnine in small doses, will act better, especially if consciousness be not completely lost during the fits. It must be noted, however, that according to statistics published by Dr. A. Hughes Bennet, all varieties of the disorder—petit mal, nocturnal or chronic epilepsy—have shown good results in large proportion under bromide treatment (Edin. Med. Journ., Feb., 1881).

Supposing the case be one suitable for this treatment, it is important for success that it should be carried out thoroughly, in sufficient doses, and continued sufficiently long. It must not be interrupted as useless in any case, unless distinct evidence of its physiological effect has been obtained without relief to the symptoms. The production of drowsiness, or of a characteristic skin-eruption, may be taken as some guide, but a better one will be found in the degree of insensibility produced in the fauces; if no irritation or retching is caused by touching the uvula or pharynx, then probably the patient is under bromic influence. From 10 to 40 gr. thrice daily is an average limit, more being given at night-time if necessary; in cases where nocturnal attacks occur, a double dose just before going to bed is found to be very useful. At first, even larger quantities may be required, and many instances of success from very large doses are on record. Puche and other French physicians have given 100 and 200 gr., but not without

some vomiting and prostration (Med. Times, i., 1874). Dr. Squibb found 60 gr. act well when less failed, and he notes that if the medicine needs to be omitted for a time, it should be resumed at the full dose again. Dr. Farquharson gave 30 gr. four times daily with benefit to a child, aged five; and Dr. F. Beach, at the Clapton Asylum, commonly gives 15 gr. every two hours for a time, and 1 or 2 dr. during a paroxysm (B. M. J., ii., 1877). Thirty grains thrice daily have been taken for twelve years, and although before treatment the patient was incapable of work, he became equal to the conduct of an ordinary business (*ibid.*). There was no effect on the sexual power. I have often myself given similar large doses, and for a long period, but there is no *one* rule to follow, as I have found 10 gr. act as effectively in some cases as 60 gr. in others. Sometimes 5 gr. will cause troublesome acne.

When the attacks are once controlled, a single daily dose of from 20 to 60 gr. will usually suffice to keep up the effect, and may have to be continued for many months or years. Bromide, indeed, has been well called the "food of the epileptic," and sometimes needs to be taken as regularly as food; still, an occasional intermission—one or two days in a week or fortnight—is usually desirable, for thus the effect of the medicine is better preserved with less injury to the patient. It is necessary to watch carefully its effect on the general health, and to omit it, or at least to lessen the dose, if the skin should be much affected, the extremities become cold, or anæmia, prostration, or diminished sexual power be traced to it. In exceptional cases there has been developed, under bromides, a peculiar general irritability of asthenic character, or even an excited condition resembling mania (Sequin, Voisin). Minor symptoms, such as headache, "stuffiness" of head, lachrymation, and gastric irritation, have been connected with the use of a preparation adulterated with *iodide* (Med. Times, i., 1872). If during the omission of treatment convulsions threaten to return, bromide should be at once resumed, but perhaps in a different combination.

For weakness or anæmia, quinine or iron may be added with advantage. Strong coffee hinders development of bromism (Echeverria), and arsenic in small doses will prevent or cure bromine acne. The addition of a small quantity of strychnine to

the bromide is recommended by Brown-Séquard and by Tyrrell (Med. Times, i., 1871); it certainly should be only in small doses, or it would antagonise the bromide. Nux vomica, in my opinion, holds but a doubtful place in the treatment of epilepsy; it will improve digestion, and give "tone" to a debilitated nervous system, and relieve convulsive attacks when consciousness is not wholly lost, but in such cases it acts better alone than with bromide.

Several alkaline bromides taken together sometimes act better than any single one (Brown-Séquard), and I have often found advantage from combining the potassium and ammonium salt (*v.* p. 157). General experience has not yet corroborated the observations of Weir Mitchell as to the superior efficacy of the lithium salt, nor of Hammond as to the bromide of calcium, but they may be useful as alternatives. The bromide of sodium is less depressing to the heart than that of potassium, as has been illustrated by Dr. Hollis (Pract., 1878).

I cannot speak well of the addition of belladonna, often recommended. That medicine has its own field in cases rather acute in character, difficult to diagnose, but on the borderland between epilepsy and eclampsia. It is especially useful when the cause assigned is sudden fright, and congestive headache is present between the attacks, and again in the eclampsia of robust plethoric children with cerebral congestion; but, when given in combination with bromides, I have found its action unreliable and confusing. Dr. Beaman combined lactucarium and lupulin with bromide (Lancet, ii., 1867), and the addition of digitalis has been found valuable (Lancet, ii., 1871). I have myself seen excellent results from the last-mentioned combination in epilepsy connected with masturbation or nocturnal emissions; it has marked control over such conditions. I find it best to give the digitalis separately, morning and afternoon, and the bromide at night, and have found this treatment stop the onanism and emissions, and cure the epilepsy. The infusion of digitalis is the best preparation, and should be given in $\frac{1}{2}$ to 1 dr. doses.

Charcot recommends the bromide of zinc (B. M. J., ii., 1877), and Bourneville the bromide of camphor (*ib.*, i., 1877). I have frequently tried the latter compound, but have never seen from it results which could not be better obtained from other bromides,

or from camphor separately. Testa found the zinc bromide specially good in hystero-epilepsy, and others have shown that it exerts some of the effects of the metal as well as bromide. Some prefer to give the oxide separately in pill, at the same time as alkaline bromides in mixture. In the same form of malady, C. Paul advocates the bromide of strontium, and Féré found it lessen the relapses and nervous crises occurring under the potassium salt. Beigel recorded good results from bromides, morphine being administered hypodermically at the same time (Med. Times, i., 1869), but morphine, when given internally for any length of time, acts injuriously, and when subcutaneously administered for a similar time is still more detrimental. I am satisfied, from careful and long-continued observation, that opium does not, in any form or combination, cure epilepsy, but when convulsive attacks occur as complications of passing mental disease, it is sometimes helpful, either alone or combined with bromides, in temporarily allaying the excitement and convulsions, and procuring sleep, but its effects are transient.

The proportion of *cures* obtained by bromides or their combinations—meaning a cessation of convulsive attacks for from six months to four years or upwards, according to the period that cases remained under observation—has been stated at about *one half* for adults and one quarter for children (Voisin, Legrand du Saulle), and even if *absolute* cure be not obtained quite in such proportion, it is so sufficiently often to prove its possibility. Probably, however, in the majority of cases, freedom from attack will be contingent upon more or less continued use of the remedy. In cases that are satisfactory, we see nothing of an effect sometimes mentioned as an objection to the use of bromides, viz., a greater violence of the attacks as they become less frequent. It is true that this occurs sometimes during the natural course of the malady, but it cannot be directly connected with the medicine; on the contrary, the drug, as a rule, diminishes the severity as well as the frequency of the convulsion.

In cases of fits due to organic lesion of the brain, and in Jacksonian epilepsy, the power of bromides in lessening their severity is very marked. At first the fit may affect the whole body, and be accompanied with loss of consciousness; after the use of bromides, although the fits may not entirely disappear, they

become limited, often to one limb, or part of a limb; each fit lasts a shorter time, and there may be no loss of consciousness. For such conditions the best results are obtained by giving iodide and bromide simultaneously, the iodide relieving or curing the syphilitic or inflammatory lesion to which the fits are due.

Binz has suggested that not only the physiological, but also the therapeutical effect of the bromide of potassium is due to the latter agent (potassium) improving the blood-condition, etc. (Pract., 1874), and Sanders even states that the *chloride* of potassium has answered equally well in his hands (Centralblatt f. Med., 1868); but whilst we agree that some of the depressant effects of bromide of potassium on the circulation might be explained by the known action of potash, its effects on the nervous system cannot be so, and the result of Sequin's observations showed that the use of chloride of potassium *increased* the attacks in cases which bromide *relieved* in the proportion of 80 per cent. (Med. Times, i., 1878). The nitrate and bicarbonate of potash have also been proved useless (Anstie, Pract., 1874).

In the Gulstonian Lectures for 1880, Dr. Gowers, stating the results of his experience in the treatment of epilepsy, says that when small doses of the bromide are given to ward off regularly recurring attacks, they should be taken only a short time—two or three hours—before the fits are expected; that they will fail if taken at longer intervals before. Larger doses may, however, be taken then. He has met with many cases in which he has noticed a cumulative effect of the drug, but many others in which, after a time, a tolerance of it, or indifference to it, is attained, and an increase of the dose becomes necessary to obtain the customary result. To *control* the fits the bromide must be given frequently, but not in larger doses than a drachm or a drachm and a half in the day; but for the *cure* of the disease he considers it necessary to keep the patient for a time under the full influence of the drug, by giving a large dose every two or three days—as much as can be well borne. Gowers has given, in this way, as much as an ounce at a time, but adds the caution not to begin with a larger dose than half that quantity. He considers that only in this way can the "stability of the resistance of the nerve-cells" be re-established. The drugs that he has found most useful in combination with bromide, where that, by itself, has failed, are

digitalis (where there is intercurrent cardiac disturbance, or in nocturnal epilepsy), belladonna, cannabis indica (when there is persistent headache between the attacks), and iron.

Convulsions.—In the wide range of convulsive and spasmodic disorders, *outside* that which we distinguish as epilepsy, bromides are very efficacious. In the convulsions occurring during *pregnancy* especially from reflex irritation at the time of parturition, they are more distinctly indicated than in the albuminuric form, but I have seen them also relieve the latter. Peaslee thought them valuable only during the threatening stage when the urine is scanty, and certainly, the earlier the patients are brought under their influence, the more satisfactory the result. In *uræmic convulsions* some observers have objected to the use of bromides, but these remedies have been found generally of some assistance in lessening the paroxysm; eliminant and other remedies should be conjoined with them. The dose in such cases should be large, ½ dr. every hour or two. When swallowing is impossible, they act well given in enemata (Gimbert and others, Med. Times, i., 1872, and i., 1874).

Dentition.—In the restlessness and nerve-irritation or convulsion sometimes attendant on dentition, bromides are exceedingly useful, "so that the gum-lancet is scarcely ever needed." The convulsions even of meningitis I have frequently seen arrested by the bromides.

Tetanus—Strychnine Poisoning.—We have shown reason to believe that bromides lessen spinal congestion, and diminish reflex irritability; and this being so, they ought to prove valuable remedies in the disorders named. In a collection of four hundred and fifteen cases of tetanus by Dr. Yandell, bromide does not seem to have been used once (Brain, Oct., 1878), but Dr. H. C. Wood has tabulated eighteen cases of tetanus thus treated, and of these only two died; in one of them, large doses of belladonna confused the result. In most of the successful cases, chloral or morphine was given at bedtime.

Dr. Southey relates a successful case, in which conium was combined with bromides (Lancet, i., 1875). Of the bromides, full doses—at least ½ oz. in the twenty-four hours—should be given.

Saison found with animals that hypodermic injections of strychnine distinctly modified the action of bromide, and *vice*

versâ ; and there are a few instances in which a fatal result from poisoning was, in all probability, prevented by bromide treatment. Thus, Dr. Gillespie records a case in which nearly 3 gr. of the alkaloid were taken, and very serious symptoms developed; but recovery took place under the influence of an ounce of bromide given in divided doses—no vomiting occurred (Amer. Journ., Oct., 1870). In Dr. Hewlet's case, more than 4 gr. of strychnine was taken, and although vomiting had occurred and opium been given, severe convulsions had set in; 90 gr. of bromide were administered, at first every half-hour, and afterwards, 60 gr. every hour, and twenty-six hours after the first dose the patient could walk (Brit. For. Rev., July, 1871). Another case of recovery after a 3 gr. dose of the poison, and similar treatment, is given by Dr. Bard (Philad. Med. Times, June, 1871—Record, 1879 ; see also Lancet, ii., 1890).

Migraine, Congestive Headache, etc.—If given in the prodromal stage of an attack of migraine, the bromides often succeed in preventing its development, and especially when the pain in the head and the nervous disturbance *precede*, or are more prominent than the nausea or gastric disorder (Yandell, Latham). Five grains every hour or half-hour may be given, but if an attack *has already set in*, a full dose of 20 to 30 gr. is better, and if this produces sleep, the patient usually wakes free from headache. After the paroxysm has *fully* set in, the remedy does not seem to control it (Med. Times, i., 1875).

In ordinary congestive headache, with flushed face, and intolerance of light and noise, and in congestive neuralgia generally, the bromides are serviceable; also in the headache occurring in delicate children from even moderate application to study. Dr. A. Boggs, after personal experience, says that the best result from the use of bromides is obtained from a mixture of the three salts of potassium, sodium and ammonium. He recommends, especially in congestive headache, a mixture containing potassium bromide 4 dr., sodium and ammonium bromides, 2 dr. each, and water 12 oz.; a tablespoonful every two, four, or six hours, as the case demands, digitalis and arsenic were added later. Prof. Charcot prescribes a similar combination in cases of epilepsy. The mixture of the bromides seems to prevent their accumulation in the system (Lancet, ii., 1884). Dr. Day

recommends their use with iodides for children who suffer from constant headache and debility (Lancet, i., 1875); but I have been disappointed with this combination under such circumstances, and find cod-liver oil and fresh air better remedies.

Chorea.—The varying results obtained in the treatment of chorea must be connected with its varying pathology, which is not yet well understood. I have seen a few patients recover rapidly under treatment by bromide, but the majority are too anæmic or asthenic to bear it well; hence it is not surprising that Dr. R. Reynolds found it even prejudicial in some cases.

Dr. Ramskill tried fully the potassium salt, "and with strong prejudice in its favour," but without satisfactory result. Camphor bromide is said to have acted better (B. M. J., i., 1877), but has not done so in my experience.

Hysteria.—In ordinary cases of hysteria, bromides alone do not give the relief that might be expected. The convulsive epileptiform seizures which sometimes occur may be controlled by them when the patients are fairly strong, but mere emotional disturbance and nervous debility are better treated by other remedies. The malady is essentially connected with enfeebled nervous power. Gubler indeed compares its paroxysms to convulsions after hæmorrhage, and in such cases bromides are not really curative. In *combination*, *e.g.*, with iron, valerian, or camphor, they may be of more service.

Uterine Irritation.—If hysterical symptoms be definitely connected with ovarian irritation or uterine congestion, then the bromides are more distinctly indicated. In the distressing condition of unrest, undue apprehension and depression which often occurs at the climacteric period, they may prove of the greatest service, quieting the restlessness, and relieving the sense of fulness in the head, and flushing of the face. Dr. Ringer found them to exert a favourable influence over the apprehensive and desponding thoughts which arise sometimes in the later periods of pregnancy (Lancet, i., 1869), and they have relieved even the sensations and symptoms of a "spurious pregnancy" occurring at the climacteric period (Simpson, Med. Times, ii., 1859).

Laryngismus Stridulus.—The bromides, but especially the bromide of ammonium, will be found very useful in relieving the laryngeal spasm of this disease; but its usual connection with

rachitis must not be overlooked, and tonic treatment, good hygiene, and improved nutrition must be combined for a satisfactory result.

Pertussis.—Dr. Gibb was one of the first to ascertain the value of bromides in this disorder, and he found the ammonium salt to act best; it quickly relieves the whoop, *i.e.*, the laryngeal spasm. Dr. G. Harley also early recorded satisfactory cases (Lancet, i. and ii., 1863). I have often verified this use of the bromides, especially in early stages. I order for children 3 to 5 gr. every two to four hours, as a rule not giving more than 20 gr. in the day, because of the depression induced in weakly subjects: I often combine belladonna, and sometimes chloral, with the treatment. Dr. Ringer reports them as useful only in simple uncomplicated cases, but neither dentition nor a pyrexial state need prevent their use if the spasm continue; they are fairly presumed to lessen congestion in the medulla as well as in the mucous membrane of the fauces, and to diminish reflex excitability.

If catarrh be present, an expectorant may be added, and if bronchitis or pneumonia supervene, the spasm generally subsides for a time, and a different treatment is indicated. The convulsion of pertussis I have frequently seen relieved by bromide, but belladonna is much more serviceable. *Bromoform* has been much commended by Stepp, Senator, and Schippers (B. M. J., ii., 1891, Epit.). In several hundred cases between six months and seven years of age, the relief of spasm, vomiting, and hæmorrhage is said to have been quicker than under ordinary treatment, and the drug had no bad effects in doses of from 2 to 6 minims thrice daily. Only in two cases, when a large quantity was taken by accident, symptoms of collapse occurred.

Dysphagia.—There is a peculiar form of difficulty in swallowing liquids which I have seen only in children; they drink readily, but the fluid either returns at once from the mouth or partly chokes them, or they remain, with open mouth, gradually swallowing small quantities with continued muscular spasm. No definite cause can be assigned. The symptoms come on a few months after birth, and I have seen it mostly amongst the children of the poor. It may be relieved by bromide, and Dr. Ringer has remarked that a similar condition, when congenital, is much benefited by bromide of potassium.

The dysphagia of phthisis, connected with local irritation and inflammation, is also relieved by the salt, which should be swallowed slowly and well diluted with mucilage.

Colic.—In cases of cramping pain in the stomach or intestine, such as occurs more frequently in children, and is independent of diarrhœa, but connected with irregular muscular contraction, the bromides usually relieve.

Spasm of Rectum and Bladder.—In cases of tenesmus, whether of the bladder or rectum, bromides will often be found useful. Hammond recommends bromide of camphor (B. M. J., i., 1877), and ½ dr. doses of bromide of potassium have given relief to a severe case of rectal spasm when opium, belladonna, and instrumental interference had all failed (Lancet, ii., 1873).

Enuresis.—In the simple enuresis of children, bromides may usually be relied upon. The good derived from them is probably due to "increasing the stability of resistance of the cells in the lower part of the spinal cord" (Gowers).

Spasmodic Asthma.—There are certain cases in which very striking results may be obtained from the bromides: *e.g.*, a man, aged thirty, subject to attacks since infancy, suffered about once in the week from evening till two or three o'clock the following morning, but after a fortnight's treatment with full doses of bromide taken at night, he had no further attacks (Saison). As a rule, it will be found that this remedy does not act so well as an "antispasmodic" during the paroxysm, but better if given during the interval, apparently by exerting a sedative influence on the central nervous system.

Dr. Begbie found it very successful in two cases (Edin. Med. Journ., 1866), and G. Sée reported that though the catarrhal element in the malady was not modified, the paroxysms were delayed, and the dyspnœa lessened or quite controlled (Bulletin, 1865). I can recommend the bromide in chronic cases of asthma, and especially when there is eccentric irritation, as of the pelvic organs; it is sometimes well combined with iodide.

The fumes of ammonium bromide are also said to relieve asthma. They may be obtained, in an apparatus like that for inhaling the chloride, by treating fused chloride of calcium with strong solution of hydrobromic acid (Lancet, i., 1890).

Angina Pectoris—Palpitation.—The bromide is sometimes

of service in severe breast-pang. Thus, Papillaud relieved severe paroxysmal attacks by the use of ½ to 2 dr. doses continued "at intervals" for two or three months. In nervous palpitation it is often a very good remedy, and I have known it especially relieve gouty patients. Berger found bromide of camphor to answer well, and bromide of iron relieves irregular action connected with anæmia and debility.

Undue Reflex Action, Vomiting, etc.—In a number of cases, somewhat dissimilar in symptoms, but connected with exaggerated reflex action, whether spasmodic in character or exhibiting altered function or secretion, the bromides prove useful. In reflex vomiting, as that of pregnancy, or in sea-sickness, especially if the administration be commenced two or three days prior to embarking, and sometimes in cerebral vomiting, they give relief. Five to ten grain doses, if retained, are often sufficient, but in obstinate cases connected with pregnancy, ½ to 2 dr. doses have been successfully given by injection (Lancet, i., 1874). Laborde has seen it useful in the vomiting of various gastro-intestinal disorders.

Diarrhœa—Dyspepsia.—When this is reflex in character, as it often is during dentition, or when "emotional," or associated with a congested relaxed state of the intestinal mucous membrane, bromides may prove the best remedies. The bromide of strontium has been found serviceable in gastralgia, flatulent dyspepsia, and pyrosis. M. Sée found it prevent fermentation and formation of gas in the intestines: in doses of x.-xx. gr. with, or after meals (Bull. de Thérap., 1891). It may be combined with pepsin.

Diabetes.—Dr. Austin Flint reported, many years ago, three cases of saccharine diabetes treated by doses of 15 to 20 gr. of potassium bromide thrice daily, with marked improvement in all symptoms (Amer. Pract., 1870); and since that date the remedy has been used alone and in various combinations, and frequently with advantage.

Menorrhagia—Leucorrhœa.—Bromides often act very well in relieving both of these discharges, but especially the former when dependent on congestion; and a good illustration, in which the attendant acne was also cured, is recorded by Dr. Arthur Jamieson: he notes that a bromide rash was distinguishable from the original one (Practitioner, i., 1889).

Spermatorrhœa, etc.—In irritation of the male genitals in plethoric subjects, with undue erections and excessive seminal losses, the bromides are often highly useful. They have a local anæsthetic effect when applied to the urethra, and when taken internally their value is evident both when sexual excitement is connected with local irritation and congestion, as hæmorrhoids, ascarides, etc., and when there is mental or central causation. They tend to lessen, also, spinal congestion and reflex irritation. When there is marked debility with anæmia, or when spermatorrhœa is unaccompanied by erections or sensations, bromides are not the best remedies, but iron may be well combined.

Cystitis—Urethritis.—Saison has seen the bromides give great relief in these cases. They should be used both locally and internally.

Subjective Nervous Symptoms.—A number of anomalous symptoms, which may be placed under this heading, are relieved by bromides; for instance, "sudden numbness, coldness, deadness, or pricking sensations in one or more limbs; distressing, indefinable feelings in the epigastrium or abdomen; or sensations akin to rigor, with much anxiety and palpitation or 'fluttering' of the heart." In such cases the local circulation may be interfered with, the pulse in one arm becoming irregular and faltering, whilst in the other it may remain unaltered, and the heart-beats continue normal.

Urticaria.—In this malady, which is connected with irregular action or paresis of vaso-motor nerves, the bromides are indicated. Thus, Dr. Andrews reports the cure of a chronic recurrent case under their use (Lancet, i., 1870).

Exophthalmic Goître.—According to Dr. Brown (U.S.) and others, the bromides have proved useful in this malady (Brit. For. Rev., i., 1868), and I think benefit may usually be expected from them, especially when combined with quinine, or with iodides and iron.

Phthisis.—There are certain distressing phthisical symptoms which are amenable to the influence of bromides on vaso-motor nerves and reflex action. Thus, a hacking cough, or reflex vomiting, or even pyrexia may be relieved; also the difficulty and pain in deglutition connected with pharyngeal irritation. Profuse sweating and even flux from the bowels may be controlled by the

bromides—especially by bromide of calcium—though usually the anæmic and depressed condition may be met better by acids or mineral astringents.

Insomnia is but a symptom, and one produced by various and often opposite pathological conditions. We accordingly find that the different hypnotics cannot be used with equal success in all cases presenting this one symptom in common, and so while bromides are of most signal value in some conditions, they are useless or even harmful in others. This may be explained partly by varying conditions of the blood-supply, partly by difference in the states of nutrition of the nerve-cells. It is when there is *moderate cerebral hyperæmia*, such as probably exists after prolonged mental effort—whether associated with study, with excitement, or anxiety—and when unrest and sleeplessness are marked symptoms, that the bromides are far more soothing, and more curative than opium, and even if inflammatory action be present they may still be very serviceable, in conjunction with aconite, ice, or other remedies.

If there be much cerebral *anæmia* it may be even increased by the remedy, and I have seen, in debilitated hypochondriacs, and in some aged people, aggravation of the symptoms, with marked increase of the prostration. In some cases of senile insomnia, I have, however, found it very useful given with the last meal, in doses of 10 to 20 gr. or more dissolved in milk, tea, soup, beer, or cold water. In the sleeplessness of convalescence from acute disease and of dyspepsia, bromide is useful, combined in the latter case with dietetic and other special treatment. In pregnancy, where pain is suffered and prevents sleep, a combination of chloral and bromide—15 gr. of each—is especially useful. In weakly subjects, and especially in the insane or hypochondriacal, bromide is best given in combination with cannabis indica. When insomnia is induced by severe pain, opium is the best remedy ; but its effect is heightened, and its tendency to produce headache, faintness, or nausea lessened by bromide. Da Costa recommends the latter to be given in full doses half an hour before, and two hours after the opium.

To choose a suitable dose is of importance, but from 20 to 30 gr. usually suffices. The bromides can be pushed without fear, or, at most, with the fear only of bromism, which, if it supervene,

will subside quickly on discontinuing the drug. Bromides are not only safe hypnotics, but the after effects are slight, as compared with those of opium.

Wolfe relates a case of insomnia with hypochondriasis and irritability from over-anxiety, when 5 gr. proved useless, but ½ dr. "acted like a charm." Behrend relates two very good illustrations of nervous excitement and anxiety, with loss of sleep, in which 25 gr., at first thrice daily, afterwards less often, proved quickly curative (Lancet, i., 1866; ii., 1864). In the sleeplessness and delirium of fevers, the bromides exert a favourable influence in procuring sleep, and they prove a valuable resource when opium is not admissible. The ammonium salt has been found less effective than that of potassium (B. M. J., i., 1891).

I have sometimes found bromide of camphor, in 3 to 5 gr. doses, procure sleep for hysterical subjects, and Deboul recommends it in the unrest of cardiac disease, and of phthisis (Brit. For. Review, i., 1865). The solid capsule of Clin is liable to cause gastic irritation, and it is better given dissolved in milk.

Delirium Tremens.—For the excitement, wakefulness, fright, and tremor which follow the abuse of alcohol, and which commonly precede a fully-developed attack of delirium, large doses of bromide often prove of great use, either with or without opium. I have known them prevent the further development of the attack; in later stages they have not the same power, but bromides have acted well combined with chloral. To this statement I must, however, add a caution as to the use of full doses of the latter remedy in delirium tremens, for I am cognisant of more than one case of sudden death traceable to it, in all probability.

Gubler has written specially on the value of bromides in alcoholic amaurosis.

Night-terrors — "Nightmare." — Children especially are liable to attacks of terror in the night, when they awake screaming, and are so deeply impressed by some imagination or dream, that they are, at first, scarcely conscious. This condition is connected with a reflex irritation of the nervous system, and is much under the control of a night-dose of bromide. The nightmare of adults may also be relieved by it, though, in their case, the discontinuance of heavy suppers would often prevent the unpleasant dreams; aperients should not be neglected in such cases.

Mania.—The use of the bromides in insane patients requires special study and care, because of their liability to be suddenly depressed, and the prostration I have sometimes seen well illustrates the clinical fact that an enfeebled, ill-nourished nervous system often contra-indicates these medicines, even if the general bodily health seems to be fair.

Dr. S. W. D. Williams records that of thirty-seven insane epileptics treated by bromides, the fits were relieved in most, but great depression occurred in some of them without any relief to their attacks; ½ dr. doses proved too large; catharsis was caused in two cases, and possibly the rapid development of phthisis in a third (Med. Times, ii., 1864). Dr. T. Outterson Wood has also recorded instances amongst insane patients of "sudden development of severe prostration and despondency" (B. M. J., ii., 1871); vomiting and abdominal pain were also caused.

Dr. Clouston, in a careful study of the effects of different medicines upon the nervous condition of lunatics, found that the bromides, if given alone, must be used in very large doses to subdue violent paroxysms. One female patient took 7 oz. in divided doses, but then suddenly lapsed into a condition of extreme "torpid depression," not free from danger to life, and continuing many days. The same physician ascertained that a combination with cannabis indica gave, even in small doses, much better results than either remedy alone, ½ dr. of each given together acting as a hypnotic better than 1 dr. of tincture of cannabis indica, or 2 dr. of bromide (Med.-Chir. Rev., ii., 1870, and 1871).

Puerperal Mania.—In acute stages of excitement and delirium connected with the puerperal state, bromides act well and should always be given. They have, doubtless, an influence over the uterine and ovarian congestion of that state, and over reflex irritability, and many successful cases of its use are on record. Curgenven has found the potassium salt act quickly and well when given by the rectum. I have often given it with aconite, with much advantage.

Erotomania — Nymphomania. — When these conditions occur in connection with a generally demented state, the bromides do not seem to relieve so much as might have been expected. Dr. Mackey, when in charge of a large asylum at the time bromides were first introduced, and were specially recommended in sexual

cases, gave the potassium salt to many of the younger patients, especially youths addicted to masturbation, but generally with the result of inducing extreme and miserable depression, without controlling the symptoms. Dr. Williams also noted that in his thirty-seven insane cases the sexual system was not at all, or but slightly, affected. Even in subjects of average mental health, but addicted to onanism, the bromides, though they lessened the venereal appetite for a time, effected no cure in Dr. Bill's experience, and he concluded that they could lessen only *eccentric* sexual irritation (Amer. Journ., July, 1868). In this they certainly are highly valuable. In the few cases that I have seen approaching to nymphomania, benefit was derived from the bromides alone, but they act best when given in conjunction with baths, counter-irritation, and moral agencies. Dr. E. C. Clarke and Dr. Begbie have recorded very satisfactory results.

Cerebral Apoplexy.—There is reason to hope for advantage from the use of bromides in the symptoms of cerebral congestion which point to an apoplectic tendency. Dr. Bastian has remarked that, in such cases, when the heart-action is forcible and frequent, these remedies, conjoined with aconite, are very suitable, and I quite concur in this statement (Lancet, ii., 1874).

Meningitis—Hydrocephalus.—I have seen the convulsions of traumatic meningitis arrested under bromide of potassium, and it is said that recovery from tubercular meningitis (acute hydrocephalus) has followed its use. In support of this statement Dr. John Brunton has recorded four cases (Glasgow Med. Journ., 1873), in which the heads were enlarged, and the symptoms were certainly serious, but there were no convulsions, and the diagnosis must be held rather doubtful.

Spinal Congestion — Cerebro-spinal Meningitis. — In spinal congestion of acute character, with pain, hyperæsthesia, cramp, and spasm, the bromides have proved so far useful as to merit always a fair trial.

In true cerebro-spinal meningitis—though a very fatal disease under any treatment—I have seen great advantage from bromides, but like all depressant remedies they must be used with caution, for there is liability to sudden failure of the circulation from conditions of the disease itself. Subject to the same caution, I think

it desirable to conjoin aconite or belladonna with them throughout the treatment.

Bronchocele—Splenic and Glandular Enlargements.—The great value of bromides in nervous disorders has led us, perhaps, to think less of them as remedies in scrofulosis and glandular enlargements, but they are often useful in such conditions. Dr. Wilks recorded their good effect in bronchocele (Med. Times, ii., 1861), and I have used them frequently and successfully in glandular swellings connected with struma. They have been recommended by others in combination with liquor potassæ (Lancet, i., 1860). The bromo-iodine waters of Kreuznach and Woodhall Spa are also good forms for their administration.

Dr. Robert Williams found the bromide of potassium extremely useful in reducing enlargement of the spleen due to malaria, and, in an appendix to his work on Morbid Poisons, gives several striking instances of its value, when other and better-known medicines had failed.

Sir Spencer Wells has confirmed the observations of Dr. Williams, and, amongst other cases, has recorded that of a child, aged eight, extremely emaciated, suffering from hectic, and with the abdomen distended by an enormously large spleen, the lower edge of which extended to the pubes. The case seemed apparently beyond the power of medicine, but yet, under the influence of 3 gr. of bromide thrice daily, some diminution was produced within a week; under 5 gr. this continued, until at the end of a few weeks the viscus was above the umbilicus, and the child convalescent. The case was either connected with ague or with blood-poisoning from an unhealthy atmosphere, and is a very remarkable one. Acting on the suggestion of Sir Spencer Wells, I have myself used the drug in similar cases, but in larger doses, and have been pleased with it. Claude Bernard has recorded equally good results, but with doses of 20 to 40 gr. daily (Bulletin, 1874).

Fibroid Tumours.—The power which bromides possess of stimulating absorption led to their use in cases of uterine fibroid, and Simpson recorded successful results (Med. Times, ii., 1859), as did also Graily Hewitt (Med. Times, i., 1861).

The Kreuznach waters, which contain bromides and iodides, have long enjoyed a special reputation in such cases; but, if we are

to judge by a discussion which took place some years ago, many eminent authorities in London have seen little or no advantage from them (Med. Times, i., 1857). My own experience, however, and personal observations made at Kreuznach, have satisfied me that a course of these waters *does* often diminish the congestion and the fibroid growths, although their good effects probably are not *wholly* due to their containing bromides and iodides. In many of my cases the waters have also removed or reduced dense infiltrated deposits around the growths, and have given much relief to the patient.

Ovarian Tumour.—The Kreuznach waters have acted so favourably upon several of my patients with unilocular ovarian cysts, that, in cases where an operation is not permitted, I now always recommend one to three courses of these waters. Bromides given in 5 to 20 gr. doses two or three times daily, and continued for months, frequently diminish the size of the cyst, and improve the general health. The dose should be varied from time to time, according to circumstances.

Absorptive Effects of Bromides.—There are other growths and deposits in which these effects have been utilised by different observers, but not extensively. Dr. Wilks observed benefit from the bromide of potassium in cases of cephalalgia dependent on thickened membrane or thickened bone (Lancet, i., 1870); Dr. Brown, in acute and chronic inflammation of testes and chronic inflammatory enlargements (Brit. For. Rev., i., 1868); and Dr. Bird states from ample experience in Australia, where hydatids are common, that the continued administration of bromides has the power of destroying the parasites, and causing absorption of the cysts (Med. Times, ii., 1873).

PREPARATIONS AND DOSE.—*Potassii bromidum:* dose, 5 to 30 gr. and upwards. *Ammonii bromidum:* dose, 2 to 20 gr. and upwards. *Sodii bromidum:* dose, 10 to 30 gr. and upwards. *Acidum hydrobromicum dilutum:* dose, 15 to 50 min. *Lithii bromidum, Strontii bromidum, Calcii bromidum:* dose, 10 to 30 gr. *Camphora monobromata:* dose, 3 to 10 gr.

Concerning the different bromides, we may here briefly state that the *potassium salt* is in most common use, but contains the least bromide of the alkaline salts, and is more depressing to the circulation.

The *sodium salt* I consider rather more powerful as a bromide, though all observers are not agreed on this point. It is less depressing, and is more easily assimilated (Clymer, Med. Times, i., 1872).

The *ammonium salt* possesses some of the stimulant characters of its base, which is liberated by decomposition. Its action is said to be more rapid, but also more evanescent (Begbie). The *lithium salt* has been said to relieve some epileptics better, and in smaller doses than the potassium salt, and to act better as a hypnotic (Gibb, 1864; Weir Mitchell, Amer. Journ., ii., 1870). The *calcium salt* is said to be more active than that of potassium, 22 gr. of the former causing sleep when the latter failed (Hammond). The *compound with camphor* (monobromated camphor) reduces heart-action and lowers respiration and temperature like the alkaline bromides; it is efficient as a sedative in smaller doses—3 to 6 gr. In the *compounds with morphine and quinine*, Dr. Richardson expects to secure the sedative and tonic effects of these drugs without the unpleasant cerebral symptoms which sometimes accompany them (Med. Times, i., 1871). I have found them useful. The *strontium salt* is specially suited for dyspeptic and depressed cases. *Bromoform:* dose, 1 to 6 min. thrice daily, up to six or seven years; 7 or 8 min. for adults. *Bromal hydrate*—in colourless prisms which melt in the hand—has been given in 3 gr. doses for sleep, but is too irritant to the stomach.

CHLORUM—CHLORINE (Cl = 35·5).

Chlorine, discovered by Scheele in 1774, is a greenish gas (sp. gr. 2·450), volatile and irrespirable, and when incautiously inhaled producing injurious irritant effects. It has a peculiar odour; it is very soluble in cold, less so in hot, water; it bleaches all vegetable colours, and is a powerful disinfectant; under a pressure of six atmospheres at 32° F., the gas becomes a yellow liquid of sp. gr. 1·33. It does not occur free in nature, but is found combined with metals forming chlorides, of which sodium chloride is the most common. It may be prepared from this or any metallic chloride, but is directed by the Pharmacopœia to be made from hydrochloric acid by the agency of manganese dioxide, the oxygen

of which combines with the hydrogen of the acid, and sets free chlorine on the application of heat: $4HCl + MnO_2 = MnCl_2 + 2H_2O + Cl_2$.

LIQUOR CHLORI—SOLUTION OF CHLORINE (CHLORINE GAS DISSOLVED IN WATER).

PREPARATION.—This, the officinal solution, is formed by passing the gas through a wash-bottle into a receiver containing distilled water, which dissolves it to saturation.

CHARACTERS AND TESTS.—The liquor chlori is slightly greenish in colour, smelling strongly of the gas, and possessing its bleaching and disinfectant properties; its sp. gr. is 1·003, and it contains about 66 per cent. of the gas, but is very unstable, and readily loses strength. On evaporation it should leave no residue.

Under the influence of light, chlorine slowly decomposes water with production of hydrochloric acid and oxygen, and the solution then loses its characteristic properties. Hence the advantage of preparing it fresh for use, and the necessity of employing stoppered dark-coloured bottles for preserving it. The *hypochlorites of lime, soda, and potash* owe their special properties to the presence of chlorine, and, as commonly met with, are mixtures of hypochlorites and chlorides, known popularly as "chloride of lime" (bleaching powder), "chloride of soda." A solution of the soda salt is known as "Eau de Labaraque," from the chemist who popularised it, and a solution of the potash salt is the "Eau de Javel" of Parisian laundries. Under the influence of feeble acids, *e.g.*, the carbonic acid of the atmosphere, these salts evolve free chlorine until wholly decomposed.

The main chemical character of chlorine is its energetic affinity for hydrogen, which element it will abstract from its aqueous, gaseous, and organic combinations. In contact with organic substances it is inactive if they are quite dry, but if any moisture be present, nascent oxygen is liberated from the water under the action of chlorine, and destroys or oxidises the organic compound. A solution destroys the lower forms of organic life, and the gas brought into contact with sulphuretted hydrogen decomposes it, hydrochloric acid being formed, and sulphur precipitated. Hence chlorine is a good disinfectant and deodorant, but limited in its power, for after it has once caused the oxidation of organic

matter, or become changed into hydrochloric acid, its disinfectant qualities are almost lost; its strongly corrosive action also limits its use.

ABSORPTION AND ELIMINATION.—Chlorine gas may be absorbed through the lungs, as proved by finding its odour in the brain, after death from its inhalation (Cameron). A dilute solution when swallowed combines with the alkaline salts, either in the stomach or the blood, to form chlorides, and as such passes out, mainly by the kidneys. Husemann suggests that hydrochloric acid rather than chlorides may be formed from small doses.

The hypochlorites, decomposed in part by the gastric acid, give off free chlorine, and then passing into the circulation, are excreted as chlorides of potassium and sodium. Kletzinski ascertained this, and taking himself for a fortnight a daily dose of 60 gr. of "chloride of soda" (hypochlorite), found an increase of 30 to 40 gr. of sodium chloride in the urine (Canstatt-Jahrb., 1851, Bd. i.). Some amount of free chlorine would also seem to pass in that secretion, for after absorption of the gas (in a chlorine bath) Wallace found the urine to possess bleaching properties, though neutral to litmus paper.

PHYSIOLOGICAL ACTION.—*External.*—Chlorine acts as an irritant, causing, when applied in vapour or strong solution to the skin, a sense of prickling, with perspiration, congestion, and sometimes erysipelatous, papular, or vesicular eruptions. Chlorine water long applied causes a fatty degeneration and peeling off of the upper layers of the cuticle (Bryk).

On denuded surfaces or mucous membranes the irritant effect is still more marked—the liquor sodæ chlorinatæ, for instance, if applied too strong to the throat or vagina, causes much discomfort. The vapour, if much diluted with air, may be breathed without other symptoms than a sense of heat and subsequent increase of expectoration; but if breathed in full strength, it acts as a violent irritant to the respiratory tract, causing spasms of the glottis, convulsive cough, and a sense of severe constriction and suffocation. Death may follow from inhaling an atmosphere of only 1 per cent. chlorine, not from convulsive closure of the glottis, as formerly thought, but from the intense irritation set up in the air passages, as shown during life by the pain, cough, bloody sputa, etc., and

after death by the secretion in the finer bronchi, hepatisation of the lungs, and rarely a membranous exudation in the trachea.

Some degree of *toleration* of chlorine may be established, for in bleaching works the men can remain many hours where a stranger is at once attacked with coughing and irritation.

PHYSIOLOGICAL ACTION.—*Internal.*—The general systemic action of chlorine is that of a *stimulant*, more or less in degree, according to the quantity absorbed; and there is no sufficient evidence of the calmative properties described by Albers.

Circulatory System.—Brought into contact with blood-serum, it coagulates the albumen, loses its characteristic odour, and forms, after a time, hydrochloric acid. In animals dying from inhalation of chlorine, the blood becomes dark red, thick, and finely granular, from a similar coagulation of albumen (Eulenberg). A solution injected into the jugular vein destroys life with symptoms of asphyxia, and the blood then also is found dark red, but fluid (Nysten).

In man, normal circulation and respiration are quickened under the moderate influence of chlorine. Husemann, however, states that in typhus fever the pulse and temperature become lower under it, and he connects this effect with conversion of the remedy into hydrochloric acid.

Digestive System.—The same observer also traces to change into acid an increase of appetite and digestive power, but an excessive dose deranges the stomach. Workmen exposed to the fumes of the gas suffer from acid dyspepsia and various symptoms traceable to gastric irritation; it is not likely that any change in the blood would occur from continuous exposure to the dilute gas, but it is possible that some local solution of gastric epithelium may follow the constant contact of hydrochloric acid formed and swallowed in the buccal secretions.

Glandular System—Nutrition.—Chlorine has been credited with a stimulant action upon the liver and kidney. Kletzinsky asserts that the excretion of urea is increased under its use, and Gubler has observed emaciation, implying increased tissue-change. Husemann only remarks that its power of stimulating the hepatic and renal functions "requires confirmation." The fæces are said by some observers to become light-coloured under its use, suggesting an alteration in, or lessened secretion of, the bile.

SYNERGISTS.—Antiseptics and deodorants.

ANTIDOTES AND INCOMPATIBLES.—In *gaseous* poisoning by chlorine the chemical antidotes are—Sulphuretted hydrogen, which forms hydrochloric acid (itself, however, corrosive to the bronchi); ammonia, very dilute, which forms a chloride of ammonium; and solutions of anilin (Husemann), which also coagulate albumen and are caustic. These are not practicable where human life is concerned: then the best remedy available would be steam-inhalation.

Poisoning by the *solution* is best treated by albumen or milk with magnesia. Kastner says alcohol and sugar are useful. For medicinal purposes, prussic acid and coloured vegetable preparations should not be prescribed with it.

THERAPEUTICAL ACTION.—*External.*—**Aphthæ—Angina.**—As a local detergent and disinfectant, chlorine solution is serviceable. In cases of aphthous stomatitis I have known it very quickly relieve when borax has failed.

In ulceration of the fauces, whether scarlatinal, septic, or syphilitic, a gargle containing about ½ dr. of liquor chlori in 6 oz. of water is one of the best for removing unhealthy discharges and sloughs: in salivation also it is useful.

Wounds—Chancre.—A lotion containing chlorinated soda or liquor chlori, about 1 part in 12 of water, is a good dressing for unhealthy suppurating wounds, and for chancres; or the poultice of chlorinated soda may be used.

Purulent and Fœtid Discharges.—An injection prepared with the chlorine solutions (1 part in 12) is effective in cases of offensive lochia after delivery, during puerperal peritonitis, etc. I have found it act better than Condy's fluid, but it produces some dryness, smarting, and irritation, if used too strong.

If an injection be required in **Chronic Empyema,** one with chlorine is very suitable, and freer from risk than some other remedies. In **Gonorrhœa** injections of solution of chlorinated lime have proved curative.

As a *disinfectant* for the hands after dissections or post-mortem examinations, liquor chlori is efficient. This was proved on a large scale some years ago at the Vienna Maternity Hospital, when the students were accustomed to pass from the necropsies to the bedside. At one time the mortality amounted to thirty per month,

but after the introduction of a chlorine wash for the hands, to be used before and after every post-mortem examination, the mortality fell to about seven per month, the ordinary average (Med.-Chir. Trans., vol. xxxii.).

As an aerial disinfectant, the value of chlorine has been variously estimated. When cholera appeared in 1830 and 1831, chlorine-fumigation was officially ordered for clothes, wool, and other imports, but there was no satisfactory proof of its efficacy. The Board of Health Reports of that period, with the evidence of Gregory, Tweedie, and others, rather negative its value in limiting the spread of fever; and Bousquet reported that chlorine would not prevent the activity of vaccine virus (Lancet, ii., 1831).[1] On the other hand, Schœnlein and Eisenmann report its value in scarlet fever, and Dr. Peter Hood expresses great confidence in it in this disorder, using towels and sheets wrung from a strong solution of chloride of lime, and placed about the room and before the door: he has never known infection spread when this was practised (Lancet, i., 1869). Mr. Stone (Manchester) reported the vapour effective in staying the spread of cattle plague; he disengaged it by dropping a few grains of chlorate of potash into a wine-glass two-thirds full of hydrochloric acid, every six or eight hours; and invented an arrangement for the continuous and regulated supply of the gas in hospital wards, etc. (Lancet, ii., 1867).

The general opinion of the profession, and the general result of experiment, is rather against the possibility of controlling infection by this means, at least by a chlorinated atmosphere dilute enough to be respirable; it must be considered doubtful whether emanations from vessels containing chlorinated lime or from sheets saturated with it, really exert a remedial effect, though as a measure of precaution they may be worth using. In an empty closed chamber, the gas, if in sufficient quantity, is, no doubt, effective. A saucer, containing common salt, binoxide of manganese, and sulphuric acid, is placed on a high shelf in the room

[1] Dr. Baxter has shown, however, that chlorine, added in quantity sufficient to render the lymph acid, abolishes its infective power, and in the same series of experiments found that chlorine, in the proportion of ·078 per cent. or more, is equally antidotal to the virus of infective inflammation (Report to Local Gov. Board, new series, No. vi.).

and warmed, when the chlorine gas comes off and diffuses through the room, as it is heavier than the atmosphere. For general purposes sulphurous acid is better, because it is obtained in a simpler manner, and is equally effective. Bleaching powder or chlorinated lime is, however, very largely used as a deodorant and disinfectant. Saucerfuls of it may be placed in sick rooms; drains and infectious discharges, such as typhoid stools, can be disinfected by its means. Its solution is used to disinfect sheets, bedding, and clothing. The solution of chlorinated lime may be applied as just described in the case of chlorine water, to disinfect wounds and ulcers of all kinds, which have a fœtid discharge. It is also a parasiticide, and may be used to cure ringworm and scabies.

Itching.—Chlorine water is sometimes useful in relieving the itching of chronic skin diseases.

Phthisis.—The literature of forty years ago contains many cases of phthisis treated apparently with benefit, both in France and this country, by inhalation of chlorine.

Elliotson recorded some advantage from it, and I remember Sir James Simpson speaking well of the method, and pointing out that bleachers did not usually get phthisis, and that the air of bleaching works was found to cure cough. Further experience has not corroborated the expectations formed, although in cases of offensive and copious expectoration some benefit may be derived from chlorine-inhalation. It is very apt, however, to do harm by the irritation which it causes.

In **Bronchiectasis** and **Gangrene of Lung,** chlorine-inhalations may certainly give much relief by their stimulant and disinfectant power.

THERAPEUTICAL ACTION.—*Internal.*—**Chronic Hepatic Congestion.**—On the hypothesis that chlorine stimulates the biliary flow, liquor chlori has been given internally in hepatic congestion, and vapour baths containing chlorine sometimes do good. It is one element, at least, in the benefit often given by nitro-hydrochloric acid, internally or in bath; but chlorine alone is not depended upon in modern practice.

In pyæmia, scarlatina, and other infective diseases, the liquor chlori has been recommended; but as it circulates in the blood in the form of chlorides, it probably has no effect as a germicide.

PREPARATIONS AND DOSE.—*Liquor chlori :* dose, 10 to 30 min. freely diluted. *Calx chlorinata*, chlorinated lime (bleaching powder). *Liquor calcis chlorinatæ* (1 of chlorinated lime in 10 of water). *Vapor chlori* (chlorinated lime in cold water). *Liquor sodæ chlorinatæ :* dose, 1 to 20 min. *Cataplasma sodæ chlorinatæ* (liquor and linseed meal poultice). *Chloralum* is a disinfectant prepared by double decomposition of sulphate of aluminium and chloride of barium. The chlorides and chlorates are treated under their respective metals.

AQUA—WATER (H_2O = 18).

In the B. P., "aqua" means pure natural water containing a minute quantity of salts in solution, but free from odour, taste, or visible impurity. "Aqua destillata," distilled water, is also officinal, and is water freed from saline constituents by distillation.

The action of water may be most conveniently studied under three headings : (1) its ordinary use as an article of diet, and its internal medicinal applications ; (2) its medicinal use in general and local baths, and as a means of applying heat and cold ; (3) mineral waters.

ABSORPTION AND ELIMINATION.—Moderate quantities of water taken into the stomach are soon absorbed, but not always at the same rate. When the body already contains a normal amount, then an extra quantity is less readily taken up, but if the system has been temporarily drained by excessive diuresis, perspiration, or hæmorrhage, absorption goes on very quickly. The condition of the intestinal canal, as regards emptiness or fulness, also has an important effect. The absorption of water occurs in the stomach and small and large intestines, but chiefly in the last.

Elimination of water takes place by the kidneys, skin, lungs, and intestine. In the kidney, it is excreted by the glomeruli and by the epithelium lining the tubules. On an average the skin eliminates only about two-thirds of the amount excreted by the kidneys, but the proportion depends largely on the relative activity of the renal and cutaneous circulation for the time being. Water, therefore, acts as a diuretic and diaphoretic : it augments the functional activity of the kidneys, and carries off a proportionately increased amount of urea, urates, phosphates, and other salts. If the extra quantity of water taken be within moderate limits, the increased elimination is accompanied, or soon followed, by in-

creased absorption. In this way the general metabolism is stimulated, and an excess of water in the dietary leads to increased disintegration of the nitrogenous tissues.

PHYSIOLOGICAL ACTION.—Water, as regards quantity, is the most important constituent of the body, averaging about three-quarter parts by weight of the soft tissues, and from 80 to 99 per cent. of the secretions, in which it holds dissolved, salts, albumen and other proteid matters, waste products, etc. It is present also in all food to a greater or less extent. What we drink as "pure water" never is so, strictly speaking, but contains salts, carbonic acid, oxygen, and a trace of nitrogen in solution. So much are we accustomed to this that distilled water tastes insipid and even unpleasant. It is, in fact, a foreign body to our organism: it irritates wounds and mucous surfaces by withdrawing salts from them, and thus ceases to be quite pure as soon as it comes into contact with the tissues.

When water is locally applied, the cells of the part imbibe it, become swollen up, softer, and more pliable. When simply held in the mouth it thus relieves thirst due to local dryness, and when inhaled as vapour in bronchitis or other respiratory affections, it softens the mucous membrane, and gets rid of the dry, tense feeling so often present.

Baths.—The subject of baths is so closely connected with the action of heat and cold on the body, that the two are most conveniently taken together. Local applications of heat and cold are most frequently made by means of water, but ice or freezing mixtures are also often employed. The most common forms of baths are water, vapour, and air baths.

Water Baths may be simple or medicated, cold, warm, or hot, local or general. Their action varies much according to the temperature, and the length of time and form of application.

The Cold Bath.—Under this head are considered baths the temperature of which varies from about 40-60° F., according to the season of the year. When a person enters a cold bath there is a sudden feeling of chilliness with roughening of the skin (goose-skin), some blueness of the lips, catching of the breath, and lowering of the pulse. But in a few moments, in fairly healthy persons (and only such should take this form of bath), "reaction" sets in, with a sense of warmth and exhilaration, quickening of

the pulse and respiration, and augmented muscular power. The first effect is due in a measure to altered conditions of the circulation (the superficial vessels being for the moment contracted, and the internal parts congested), and in part to the sudden shock felt by the large expanse of the sensory nerve-endings in the skin. A familiar illustration of the reflex effect of cold is presented when one hand only is immersed in cold water: the vessels of the opposite hand are contracted by reflex action, and its temperature also falls. That the blood-supply of internal organs may be controlled by external applications is proved, *inter alia*, by the observed contraction of renal arterioles when ice is applied to the lumbar region (Brown-Séquard), and by the immediate diminution of the volume of a congested liver and spleen under the influence of cold douching (Fleury).

Mosso and Bergesio investigated the effects of hot and cold baths upon the cerebral circulation in a patient who had sustained a fracture of the skull; a piece of bone was removed, and the cicatrix which covered this area was observed to rise and fall with the heart-beat, and with each respiration. Tracings of these movements confirmed Schüller's experiments on rabbits, which showed that cold baths increased and warm baths diminished the amount of blood in the head; and it was found that the effect of the cold bath could be divided into two stages. In the first, lasting only a few minutes, the force of the heart was increased, but the frequency of the beats diminished; in the second stage, there was still a slow pulse, but its size was lessened, whilst the brain gradually became larger, as shown by the swelling up of the cicatrix (the contraction of cutaneous vessels leading to determination of more blood to the head).

The general effect of a short and satisfactory cold bath is "tonic." The blood circulates more freely, and tissue-change is increased; yet, concurrently, appetite and digestive power are so far improved that during a course of such baths weight is commonly gained. The benefit from a course of cold baths, such as is prescribed at hydropathic establishments, is, in many cases, not due to any special characters of the water used, but is the result of the tonic action of regular and systematic bathing.

The *prolonged* cold bath, used only through imprudence by the healthy, or for definite curative results in the hyperpyrexial

patient, has a very different effect. The primary reaction is succeeded by coldness, depression, weakened circulation, and an exhaustion which may progress to collapse. The temperature is steadily lowered, the blood accumulates in the great venous trunks, capillary circulation and tissue-change generally are interfered with, and reflex symptoms, such as nausea, vomiting, and syncope, may follow. Pugibert and Bailey have described a scarlatiniform flush, limited or diffused, as occurring from the cold bath. According to two cases reported by them, this rash is the precursor of shivering, lividity, and a syncope which might prove fatal if it occurred in deep water (Med. Record, 1879). In the clinical use of the cold bath, which is a method now largely employed for the reduction of pyrexia, such results are avoided by careful watching and thermometric observation.

Intense cold is an *anæsthetic ;* a mixture of ice and salt applied to the skin for a few moments causes it to assume a white or leaden hue, and in this state incisions can be made into it painlessly ; the rapid evaporation of ether thrown on to the part in fine spray is also used to produce the same effect, and is a better local anæsthetic than a freezing mixture, such as ice and salt, for the brine subsequently causes intense pain as it penetrates to the incisions made.

Wet Towels—The Wet Sheet.—A milder method of using cold water is in the form of towels or a sheet, wrung out, and applied with vigorous friction ; it is free from the risk of serious shock to delicate subjects, and is commonly and properly applied before commencing with cold immersion.

The *towel friction* is given first to the upper part of the body whilst the patient sits with the lower limbs still covered—that is to say, the whole surface is not exposed at one time. Where there is a feeble state of circulation, or when the breathing is oppressed, the water may at first be at 80° or 90° F., and gradually lowered to cold, and more of it left in the towel as the power of reaction improves. Under this "graduated stimulation," a pale, bloodless, and sensitive skin may be educated to a good power of reaction, with marked relief to chilliness and to the frequent recurrence of catarrh, and there are scarcely any patients —certainly none who retain the power of taking and digesting food—that cannot receive towel-rubbing with advantage. In

catarrhal subjects, however, special care should be used in avoiding exposure at first, or harm may result.

The *wet-sheet friction* is somewhat more trying, since it should always be used cold, and the patient stands, quite uncovered, whilst the sheet is thrown over the shoulders and round the whole body, and friction is applied by making folds in the sheet, not by simply rubbing the smooth surface. This should be continued for two, three, or four minutes. It is suitable for persons not much accustomed to cold water, but with a fair amount of vital power. "It rouses all the activity of the nerves and blood-vessels of the skin, without taking much animal heat from, or calling for much organic exertion of the frame, and whilst doing this it transmits to the nervous centres the genial stimulation which it impresses on the great nervous outer covering of the body" (Gully). It relieves fatigue, and may be taken when a cold bath would be unsuitable; it relieves, also, nervous depression and early stages of catarrh and neuralgia. The use of a warm sheet, unless followed by a cold one, is not attended with any of the good effects of this kind of bath; by a sheet so wet as to be "dripping" a more powerful effect is exerted, whilst by wringing the sheet very dry from the cold water, quicker reaction will be ensured. The patient should not attempt to rub himself much, or make any violent exertion during this process, otherwise he may be troubled with giddiness or palpitation.

Shallow Bath.—This is given with about six inches of water in a bath long enough for the patient to sit with the legs in, though he need not lie down. The water should be splashed, and rubbed, and thrown over the body by means of a towel used by an attendant at the back, while the patient splashes his front for from one to five minutes, according to the reactive power. The frequent change of the splashing water against the body lowers temperature for the moment, and vigorous friction is required afterwards, or walking exercise. The same bath, more or less completely given, is the ordinary morning "tub" of average Englishmen, and exerts an excellent tonic and anti-catarrhal effect. During acute febrile disorder the shallow bath may be used at 70° to 80° F., and much exertion is not desirable, nor is friction required; but in the absence of acute disorder it should always be taken cold in summer, or at about 60° F. in winter,

and be followed by exercise. Some persons persist in taking their morning bath cold, *i.e.*, of the temperature of the air, however cold it may be. This does no harm to extremely vigorous constitutions, but it is a dangerous example for those to follow who are less strong, and to whom the shock of intense cold may be the very reverse of beneficial. The ultimate effect of the judiciously used morning bath is to equalise circulation, but it encourages it especially in the lower extremities, and so relieves the head and the viscera.

The Pail Douche is administered by throwing two to four pails of water (six or eight gallons at a time) over the shoulders, against the back, or the front of the chest, as the patient sits in a long bath : a dry-towel friction follows. This process adds the shock of dashing water to the splashing of the shallow bath, and imitates to some extent the wave-stroke of open-air sea-bathing. It needs more power of reaction than the baths already mentioned, and, if well borne, has much more effect in relieving internal congestion, whether of the liver, the uterus, or the nervous centres. The amount of force, and the number of pails, should be varied with the condition of the patient. In chronic hepatic and cerebral congestion much force will usually be borne.

Spinal Washing.—This is a mild and local form of douching from a jug, or can, or large sponge, emptied along the spine, as the patient sits on a board placed across the front of a bath. It may be continued from two to ten minutes, and sometimes should be commenced at 80°, and gradually cooled down, until after a few baths it can be borne wholly cold. If commenced too cold, in sensitive subjects it may give rise to headache or giddiness, and if continued too long may induce a rheumatic condition of the back muscles, and is not free from risk to the kidneys. It would seem that the spinal cord is directly stimulated by the shock of cold water, and that the stimulus is reflected to peripheral and visceral nerves ; this is what hydropathic authorities mean when they speak of "a divergent effect on the action of the heart, stomach, kidneys, uterus, etc." It is probable, also, that the sympathetic ganglia are directly stimulated, and this bath is useful in functional torpor, marked by numbness or slight paralysis of limbs, constipation, and phosphaturia, etc. Certainly, a very bracing effect and pleasant glow may be produced by a moderate

cold wash to the spine, followed by manual friction, and the effect may be further developed by the use of a "rubbing wet sheet" to the whole surface for a few minutes afterwards.

The Douche.—This bath is the most powerful within the domain of hydro-therapeutics, and has been made the basis of the system practised with much success by Dr. Fleury, at Bellevue (Paris), and other French physicians. Its effect varies with its size, force, direction, duration, and temperature. It may be a column of water from one to three inches in diameter, falling twelve to twenty feet, or propelled at right angles to the patient's body. It may be broken up into fine streams by a rose, or into more numerous jets, arranged to play at once on the body from different quarters (*douche du cercle*—needle douche). Again, it may be used tepid, hot, or cold, or all three at one sitting, and its duration may vary from ten to sixty seconds, or in healthy people more.

The cold douche should be commenced cautiously, after due estimation of the patient's reactive power, and if there be much debility, it should be applied at first to the extremities only, and for a very brief period—ten to fifteen seconds: this is a most important point: a douche which consists of a single column of water should under no circumstances be allowed to fall on the head. In disease, the douche is, as a rule, suitable only for chronic cases, but with careful management may be applied to almost all conditions.

According to Dr. Howard Johnson, the cold douche markedly increases the respiratory acts, and "thereby imparts an enlivening influence to all the vital phenomena." "It is a diffusible stimulant, and is comparable to ammonia," though it does not always quicken the pulse. According to Fleury, the general douche, in shower, jet, or circle, is powerfully tonic and reconstitutive, by virtue of its action on the circulation. With an increased force of percussion, rapid movement from one part to another, and fine division of the liquid, a more exciting effect is produced. By directing the stream upon various parts in such force as to congest them, a revulsive action is made to relieve the congestion of other parts; thus, metrorrhagia and vomiting, even when dependent upon a uterine polypus, have ceased under a course of cold douching (Fleury), and the volume of the liver and spleen

has markedly diminished. Andral and Piorry verified the extent of hepatic dulness in a certain patient as 18 centimètres (vertical) and 11 centimètres to the left of the median line (horizontal), and agreed that immediately after an energetic douche, the former measurement was reduced by ½ centimètre, the latter by 5 centimètres; and in another case, the spleen, which measured at the commencement of treatment 23 centimètres vertically and 15 transversely, measured only 9 and 7 centimètres respectively after six days of repeated local douching. The effect on other organs is similar, though less rapid. But in chronic cases, it is important not to induce such results too quickly, since fresh and more serious congestion may be produced elsewhere.

In certain disorders, such as dropsy or effusion into joints, *absorption* has been markedly stimulated by the douche (Fleury).

Wet Packing.—To avoid unduly rapid depression of circulation and general activity, it is often advisable to commence with a *partial* packing, *i.e.*, closely applying to various parts folded towels wrung from cold water, and covered with flannels and waterproof sheeting. Thus the hips and loins may be "packed" from the level of the navel to half-way down the thigh; the abdomen, from the lower edge of the ribs to the hips; the chest proper, over the ribs, or the whole front and back of the body: it is said that packing applied to the chest exhausts more than packing of other parts of the body (Gully). Again, packing of the lowest part of the belly and back, of the whole spine, or of the sides, are other varieties: the wet towels may be changed every fifteen to twenty minutes for an hour or two.

Foot Baths.—The immersion of the feet in water produces some of the effects of the sitz bath, but in a minor degree. It acts as a derivative on the brain, and relieves flatulence and slight visceral congestions. For all purposes, the thorough-going hydropathists use foot baths *cold*, or at least cool, with considerable friction, but there are some subjects in whom the *cold* to the feet produces serious symptoms, and others—such as gouty and catarrhal patients—in whom a *hot* foot bath, to which mustard or pepper may be added, relieves, and under due precaution as to exposure, does so more pleasantly and effectually than the cold. Friction of the feet with a "damp or dripping towel" is, however, an intermediate method often available. Drs. Mosso and Bergesio

found in their patient that the effects of hot and cold *foot baths* on the cerebral circulation were the same in kind as, but less in degree than, those obtained from *complete* immersion in hot and cold baths respectively.

The hot foot bath dilates the vessels of the lower extremities, pelvis, and skin, and frequently induces copious perspiration. It is often used to obviate the effects of a chill and for the same purposes as the hot sitz bath.

Hand Baths.—Dr. Vasilieff has described the physiological effect of hand baths, *i.e.*, placing patients' hands in hot or cold water. He has made 100 observations on 43 patients, the duration of the bath lasting in each case from fifteen to thirty minutes. Under hot hand baths, the temperature (taken in the ear) rises, the pulse and respirations become more frequent, the tension in the blood-vessels is increased, and the colour of the fundus of the eye becomes darker (probably from dilatation of the veins). Cold hand baths produce a lowering of temperature, pulse, and arterial tension; the fundus deepens in colour, the respirations become deeper, but their frequency is not altered. The general conclusion is that hot hand baths increase, and cold hand baths diminish, the amount of blood in the head. Three cases of epistaxis were arrested by the application of an ice-water hand bath in each case (Record, 1885).

Vapour Baths.—The vapour of water, in the form of the steam bath, lamp bath, hot wet packing, or Russian bath, may be used to accomplish still more thoroughly the same objects as those to be expected from the warm or hot bath. In one good form of vapour bath, the patient sits unclothed in a box to which steam is admitted, but the head is outside, and covered with a cold cloth. In a less complete, but more portable form, the patient sits on a chair covered with blankets, whilst steam is generated by a spirit-lamp placed under a pan of water: or a somewhat similar result may be obtained by dropping freshly-burned lime into a bucket of water under the chair, or a heated brick into hot water; or if the patient be too weak to rise, steam may be conducted under the bed-clothes raised by hoops; or a heated brick or bottle wrapped in moistened cloths and flannels, laid near each limb. The most complete form of such bath is, however, the Russian bath, which is given in a closed chamber filled with steam. On

first entering the bath there is often a disagreeable sensation of heat and burning in the skin, the pulse becomes quick, and respiration uneasy; sometimes there is a feeling of pressure in the eyes, heaviness in the head, and dizziness; but these symptoms soon pass away, and the respiration becomes more natural and deeper, the blood finds easier access throughout the body, the skin soon gets red and moist, and the patient comfortable.

Eulenburg states that the steam bath raises the body temperature to a very appreciable degree; on an average a steam bath of 41° to 42° C., by $1\frac{1}{4}$ to $1\frac{1}{2}$ degrees C. (Real Encyclopædia, 1880, i.).

Pack Bath or Sheet Bath is a variety of the vapour. The whole body except the head is enveloped in a sheet wrung out of cold or tepid water, outside which are wrapped one or more blankets. The first feeling of cold soon passes off, the sheet and water vapour are heated up to the body temperature, and the body is surrounded by water vapour. Profuse perspiration follows, which is increased by drinking water, and this is one of the surest ways to induce diaphoresis. The respiration is not impeded as in the vapour bath. It may be continued for half an hour to an hour or longer, and is easily applied.

There is more discomfort, with chilliness and depression, produced by the routine use of this agent in hydropathic establishments, than by any other measure. In febrile conditions it may be of the utmost value, but even in such cases I have seen serious results from the exhaustion induced.

Turkish Bath.—In conjunction with other baths should be considered the Turkish, or Anglo-Turkish bath, in which dry *air* at a temperature of from 100° to 160° F., or more, is employed, the patient passing through two or three graduated chambers during twenty to forty minutes; when free perspiration has occurred, and lasted for some time, shampooing is commenced, and afterwards the body is washed with copious lathers of soap and streams of water, warm, tepid, and finally cold. The effect of the warm applications and frictions is to stimulate both the general and cutaneous circulation, to relax the muscular tissue, relieve pain and congestion, to cleanse the openings of the skin glands, and to eliminate through them morbid material and retained excretion. That the skin excretes urea has been proved by finding it in the perspiration of healthy

persons (Landerer, Funke, Leube, etc.); but still more constantly in cases of scarlatina, nephritis, cholera, collapse, and chronic Bright's disease (Scottin, G. O. Rees, Fiedler, etc.). In such cases the urea may even form a crystalline powder on the skin, especially near the sweat-glands (H. Wood). Moreover, in diabetes the perspiration contains sugar; in rheumatism, lactic acid; in gout, uric acid; and in jaundice, biliary products. This being so, it is evident that the promotion of very free secretion from the skin-glands by the varied processes of the Turkish bath is a most efficient means of depurating the blood. The effect of the final cold douche or plunge is to contract muscular tissue both in the skin and deeper parts, and to stimulate and brace up the nervous system; hence this form of bath combines the good effects of both hot and cold applications. It should induce an agreeable sense of vigour and elasticity, and render the skin less sensitive to changes of temperature.

It does not, however, always succeed well; in some subjects, especially at first, sweating is not favourably induced, and they suffer from heat malaise, and headache; the use of a wet towel with friction should then be tried, or gentle douching with warm water on first entering the bath; drinking cold water is also recommended for increasing the skin secretion, and often succeeds, but in my experience it has sometimes caused nausea and gastric pain.

Persons vary in their power of resisting heat, and although there are really few who cannot go through a Turkish bath with safety, there are many who suffer at first from some degree of oppression, faintness, and exhaustion. Hence, the first bath should be taken cautiously, not prolonging unduly the time in the hot chamber—say not beyond 20 to 30 minutes (the sensations will practically guide as to time), and finishing with the cold, or nearly cold, douche for a few seconds only, not with the plunge bath. It is a mistake to go over-fatigued into the Turkish bath, or within three or four hours after a good meal; or to dress too hurriedly, and go with still-perspiring skin into the open air.

In some cases it is necessary that a patient should have a hot-air bath, and not be removed from bed. This is desired in cases of Bright's disease with impending uræmia, in cases of extensive anasarca due to kidney disease, and in other complaints where

mmediate and copious diaphoresis is indicated. The patient is wrapped in a blanket, and the bed-clothes may then be raised by hoops, the truncated end of an inverted funnel or a gas stove is bent round and inserted through one side of the cage so formed. A thermometer hung in the centre of the bed indicates the temperature.

Contra-indications to this form of bath are to be found in extreme debility from any cause, and in some conditions of pulmonary congestion or tendency thereto: chronic heart-disease *per se* does not necessarily negative the bath, but requires extra precaution.

Drs. Frey and Heiligenthal instituted experiments to determine the relative effects and value of hot-air and steam baths in the establishment at Baden-Baden. They found that the general effect of both was the same, namely, an increased sensibility of the skin both to tactile and thermal stimuli; the primary contraction of arterioles was followed by dilatation with fall of blood-pressure; respiration was but little affected; perspiration was more profuse in the air bath; the body temperature rose; the urine was diminished in quantity but its specific gravity increased; and there was a loss of weight, which was more than made up by increased assimilative power. They found these effects to be produced more readily, and in a shorter time, by the vapour bath than by the air bath; the vapour bath, in other words, is more violent, and, therefore, those with feeble constitutions should prefer the air bath to it (Record, 1882; also Monograph).

Dry or Blanket Packing.—In this process the patient is enveloped in six blankets, one at a time, each accurately adjusted about the throat and feet, so as to be air-tight; a feather bed is thrown over all. Dr. Howard Johnson speaks highly of this treatment, which he credits with producing the same results as vapour or Turkish baths, without so much general perturbation. After a time, the air next the skin is so far heated as to excite the circulation, and stimulate a flow of perspiration, and after this has lasted for half an hour or an hour, a shallow bath at 70° or 60° F. and a dry friction complete the process.

Though weight is temporarily reduced and excretion increased by this, as by other warm baths, it does not necessarily follow that the general condition is impaired; on the contrary, in satisfactory

cases, even after profuse sweatings, weight is ultimately gained owing to increased appetite and assimilation.

Compresses are partial packings, and exert a marked local soothing effect. "They serve both to prevent and to relieve irritation," and much misery of indigestion and of torpid bowels is avoided by the almost daily use of a compress over the stomach. Various forms of arthritic pain may be relieved by the cold compress, and a similar application to the epigastrium will often induce sleep in cases of insomnia from excessive brain-work or anxiety. The application of cold over the course of an artery causes it to contract, and the amount of blood to the part it supplies may be thus diminished. Winternitz showed this graphically by tracings from the radial artery before and after the application of a cloth dipped in iced water around the arm; the pulse curves after the cold was applied were markedly smaller than before.

Cold Compress.—By this is meant the application of cloths, wrung out of cold water and frequently changed so as to maintain them at a comparatively low temperature.

The frequency of changing the cold wet cloth must vary with the effect desired. A sedative effect is not induced till a certain amount of heat is withdrawn from the part, and if the compress is allowed to get too warm it is apt to *stimulate* and irritate. In acute bilious attacks, the compress over the stomach should be changed about every two hours (Gully); in chronic gastric irritation, five or six hours will be a suitable time, and in chronic pulmonary disorder, eight or ten hours; in inflamed throat, every six or twelve hours; in contusions, every half-hour; whilst in congestions, such as of the testicle from sexual irritation, or of the uterus, a change of compress every five minutes for one to three hours gives most relief. A convenient form of very cold compress is the ice poultice. This is made by enclosing finely-powdered ice in a piece of gutta-percha tissue, the edges of which may be made to firmly adhere to one another by moistening them with chloroform. A long ice poultice applied along the spinal column is most useful in reducing temperature.

Preissnitz, Fleury, Gully, and others strongly object to compresses being applied warm, but I have often found them useful.

Cold Sponging.—Sponging the whole body while the patient

lies in bed on a waterproof sheet is a very refreshing method of giving a bath when the strength of the patient does not allow him to rise. Water of various temperatures from ice-cold to tepid may be used; or if ice-cold water is to be ultimately employed, it is best to begin with tepid water and gradually cool it down; the bath must be followed by the application of dry towels and hot blankets.

Water Beds.—From the equal pressure they exert on all parts, water beds are well adapted to prevent or ameliorate bed-sores. For ordinary use they should be filled with warm or tepid water, but beds containing cold water changed every day or oftener are well adapted as a mild but effective method of applying the cold-water cure to cases of fever, as they abstract heat from the patient lying on them. In some cases it is advisable to have cold water running through the bed continuously; in such a bed one must always take the precaution of seeing that the circulation through the bed is free, for if the outlet pipe gets blocked or kinked the bed may become over-full and burst.

The Ice Cap.—This is a rubber or gutta-percha bag which can be filled with ice; it is a most soothing application to all cases where headache is a troublesome symptom. It also lowers the temperature of the whole body, perhaps by its action on the thermal centres situated in the brain. A convenient form of cap is made of a coil of india-rubber tubing through which ice-cold water is allowed to flow (Leiter's tubes).

Warm Baths.—By an action contrary to that of cold baths, these *attract* the blood *primarily* and directly to the part exposed to their influence, relaxing the vessels and tissues, and leaving them afterwards in a condition of lessened tonicity. A similar effect is exerted by all kinds of warm baths, but it differs in *degree* according to the temperature and duration. By a *tepid* bath is meant one at from 70° to 80° F., and this is chiefly used for cleansing and moistening the skin—a temperature of 92° to 98° F. gives a *warm*, and upwards to 112°, a *hot* bath. With the former there is at first a pleasant sense of soothing and refreshing warmth, the skin reddens, and the pulse quickens in frequency, whilst it lessens in tension; the respiration is also quickened, and the temperature rises. If the bath be too prolonged, a sense of

languor comes on, and after it there is less aptitude for exertion than before. Under favourable conditions, excretion is increased from the skin, the kidneys, and the lungs, at the time of the bath, and oxidation is lessened subsequently. Drs. Mosso and Bergesio found that the effect of the warm bath on the cerebral circulation was divisible like that of the cold bath into two periods; the first stage lasting only a few minutes was characterised by increased energy of the heart, and an increase in the volume of the brain; this was speedily followed by diminution of the heart's force, and a shrinking of the brain. The cerebral anæmia, to which this was due, moreover, lasted a considerable time after the bath.

In a **Hot Bath,** 98° to 112° F., the first sense of heat may be painful rather than pleasant, then a general stimulating effect is perceived, the whole surface becomes deep red, and the cutaneous veins distended. Complete muscular relaxation follows, with greatly diminished tension of the pulse, and increased frequency of the heart's action; relief is thus given to internal congestion, pain, muscular spasm and convulsion. Before very long, a sense of oppression and distension may be felt in the chest and head with general languor, giddiness, or faintness from paralysis of vaso-motor and cardiac inhibitory nerves. These unpleasant effects occur much sooner in some persons than in others.

By a hot bath perspiration is usually, but not always, increased; and sometimes from the high temperature of internal organs a restless, heated condition similar to that of true pyrexia may be induced for a time. This may be noticed, especially after a too prolonged use of the hot strong saline baths (Droitwich, etc.).

The length of stay in a hot bath should depend on the purpose to be accomplished, whether (1) mere excitation of circulation in the skin (which is effected by a short bath with or without the extra stimulus of salt or mustard), or (2) perspiration and relief of pain (which require, perhaps, half an hour), or (3) complete muscular relaxation (which needs a prolonged immersion). In contra-distinction to the ultimate tonic effect of the cold bath, decided loss of weight results from a course of warm bathing (A. Steffen).

Contra-indications.—Since the thoracic organs and the brain become more or less congested during a hot bath, its prescription needs as much caution as that of cold bathing, though for a

different reason; pulmonary or cerebral vessels may even give way, especially if they be atheromatous or the seat of aneurism. According to Dr. Steffen, hot-water baths are pre-eminently contra-indicated by congestion or œdema of the lung, and Dr. H. Wood has seen, under such conditions, "the most frightful dyspnœa result." In such an accident, cold affusion should be freely used. On the other hand, broncho-pneumonia has been relieved by hot mustard baths.

The Sitz Bath.—A valuable influence may be exerted not only on the pelvic organs, but indirectly on the whole system, by sitting in water of varying depth and temperature (60° to 80° F.) for a time varying from five to thirty minutes. The sitz bath may be taken cold or hot. In either case it "draws blood from the brain," and is one of the best means of ensuring sleep. It relieves fatigue, improves appetite and digestion, lessens headache and giddiness, regulates the bowels, and the uterine flow, and the action of the kidneys, often augmenting them when deficient, or lessening them if excessive.

To obtain these good effects after a cold bath, it is most important that thorough reaction be secured by friction, or exercise, or warm clothing, otherwise shivering and depression come on. It may be advisable to commence with *tepid* water, or a more powerful stimulus may be given by a "running sitz," fresh cold water constantly entering the bath and circulating round the body. Or again, a local upward douche may be made to act upon the lumbar region, the perineum, the uterus, etc., whilst the ordinary sitz bath is in progress. The *general* effect of the cold sitz bath is *sedative*. It slows the pulse to the extent of ten or fifteen beats during the first five minutes—of twenty beats in the course of half an hour (H. Johnson). It also lowers the respiration, though very slightly, and it lessens the body temperature. By its rubefacient effect, the sitz bath also acts as a derivative or counter-irritant. The hot sitz bath is usually taken to relieve dysmenorrhœa, or to bring on the menstrual flow at the periods.

Hot Fomentations and Poultices.—These are local hot baths, and are convenient methods of applying heat and moisture. As cold water may be usefully applied in local compresses, hot water is often of the greatest service applied in fomentation, *i.e.*, when a thickly-folded flannel, or any thick absorbent substance

such as spongio-piline, is completely wrung out of hot water, and placed on the affected part, covered with dry flannels, oil silk, or mackintosh outside, to prevent evaporation and retain heat, and changed again frequently, the process being continued for half an hour, or even for several hours if necessary. This stimulates the external skin much more strongly and suddenly than any cold compress, for every degree *above* the normal temperature of the skin is felt much more acutely than every degree *below* it (Gully), and it acts much better than the more equable heat given by hot salt, hot bran, or tins, or caoutchouc bags of hot water, because the high temperature is more constantly renewed. Hot fomentations will also be found to be more cleanly than hot poultices, and bring about the same results equally well. They may be medicated with turpentine or belladonna, etc.

If there be congestion, or even inflammation of an internal organ, it may be relieved by such external application which is especially indicated when the patient is too feeble to react to cold, or when the pain and irritation are very severe, and "of the mingled nervous and inflammatory kind, with, if anything, an excess of the former." The direct application of hot water causes contraction of small vessels and also of the uterus.

PHYSIOLOGICAL ACTION.—*Internal.*—In passing through the system, water (1) assists the circulation of the nutrient fluids; (2) renders oxidation and other chemical changes more active; (3) by its solvent action promotes absorption, secretion, and excretion; and (4) by its evaporation from the surface assists in regulating the body temperature. The tissue-change produced by medicinal water drinking is greater in the young and delicate than in robust adults; it is promoted by increase of temperature, whether of the water itself or of the atmosphere; also by bodily exercise (Parkes). The ultimate result of a judicious course of water drinking is increase of weight, and it is said of fat (Bartholow), but if an *excessive* amount be taken, the blood is rendered unduly fluid, the corpuscles become paler and less healthy, and general nutrition is impaired.

Large draughts of *cold* water, especially if taken on an empty stomach, or when the body is heated, act injuriously, by giving a shock through peripheral nerves to the abdominal sympathetic, and may cause nausea, faintness, actual syncope, and in some

cases even death. Draughts of *warm* water, if not rejected by the stomach, act more quickly than cold upon the skin and the kidneys: they usually *cause* or assist vomiting, but if a pint or more be taken it will often *stop* vomiting by distending and paralysing the stomach. I have also known even a *moderate* quantity of hot water stay vomiting when ice had failed to do so; and again, a small quantity—two or three teaspoonfuls—of hot water, taken at short intervals, has arrested reflex vomiting, *e.g.*, after ovariotomy. The sipping of water acts as a mild stimulant; during the act of swallowing it is also found that alcoholic drinks, when taken in small quantities at a time, have a more stimulating effect than the same amount taken *en masse*.

A certain amount of fluid taken with meals assists digestion, but too much impairs it by over-diluting the gastric juice, and hurrying on the passage of the food. Its *temperature* is of importance, for if taken hot, especially with a substantial meal, it is liable to distend and enfeeble the stomach, whilst if iced, it does harm by contracting the capillaries and diminishing the normal blood-supply, although, indeed, a healthy stomach will tolerate, for a time at least, these and many other injurious things. Warm liquid, such as tea, taken *shortly before* a substantial dinner, will commonly disorder the digestive functions sooner or later, but this is, probably, not wholly due to the fluid, for a warm nutritious soup at the commencement of a meal suits many persons. If they are fatigued, it supplies nourishment in a form which is readily taken up, and enables solid food to be better digested, as it excites the secretion of pepsin. Dr. Kemsen of New York has called attention to the necessity of giving water to infants, especially in hot weather. The earliest signs of the want of water are depression of the anterior fontanelle, a hot dry skin, and a constant desire to suck. If the breast is always given under such circumstances the child will be taking too much food. At the Nursery and Child's Hospital, New York, the child is given water to drink, and is often wrapped in a cold wet sheet. Among children so treated, the liability to disease and the mortality is less than among others (Med. Times, i., 1884).

Taken later on in the meal, at the end, or an hour or so afterwards, fluids, cold or warm, materially assist completion of the digestive process, and the onward passage of the contents of the

stomach. The drinking of a proper amount of fluid habitually is often sufficient to obviate a tendency to constipation : on the other hand, the systematic use of hot water is liable to cause it.

THERAPEUTICAL ACTION.—*External.*—**Hæmorrhage.**—The application of *iced* or *cold* water is an old, and commonly an efficient method of restraining hæmorrhage from small vessels. The jet of water, or the soaked cloth or sponge should be applied suddenly for a few moments at a time. Dr. Vasilieff, of St. Petersburg, has quoted three cases of epistaxis, which were arrested by the application of iced water to the hands. Mr. C. B. Keetley drew attention to the value of *hot* water as a hæmostatic, and quoted a case of thigh-amputation, where a sudden drenching with water at 120° F. stopped the bleeding after cold water had failed to do so. He suggests that in such cases it acts as an excitant to the nerves of the muscular coat of the small vessels, and perhaps directly irritates the muscles themselves (Pract., 1879). Dr. Paul Brown found water at 150° F. succeed well in staying hæmorrhage after an amputation, when Esmarch's bandage was removed (Med. Record, 1879).

Mr. Keetley has also found hot water efficacious in epistaxis, though he acknowledges that "it is powerless against it if of a certain grade of severity," and I have myself seen its use in a very severe case followed by serious results. During one attack the attendant had applied it for some time, though the bleeding continued, and the patient became alarmingly prostrate. I stayed the flow quickly with cold water, but in a second attack, some weeks afterwards, I heard the hot-water treatment was again employed, and the patient died of syncope.

In **Uterine Hæmorrhage** the results of hot-water injections have been more satisfactory. Windelband used them at 117°, 120°, 124° F. (Med. Times, 1876). Emmet (New York) and Whitwell found them safe, efficient, and disinfectant in post-partum hæmorrhage (Lancet, i., 1878). Lombe Atthill used them constantly (at 110° F.) in his practice at the Rotunda, not only in hæmorrhage, but also in chronic uterine congestions. Ricord found a hot uterine douche, 122° F., "almost infallible" in menorrhagia. C. Richter uses hot douches for hæmorrhage in childbed, and reports 105 cases occurring in the Charité (Berlin), where they had been employed with excellent results ; he recommends injections of three to five

pints at 122° F. into the uterine cavity through a catheter, and for the sake of disinfection adds a proportion of 1 per cent. of carbolic acid; he says that the hot water coming in continued contact with the inner surface of the uterus causes a soaking and swelling of the tissues, particularly of the perivascular connective tissue, and thus checks the hæmorrhage (Zeits. für Geburts. und Gynæcol. year).

Peter recommends it for cases of non-puerperal hæmorrhage; his theory is that through the irritation of the lumbar ganglia the vaso-motor nerves get into a state of "over-activity," and that the vessels contract accordingly (Centralbl. für Gynæcol. year). I have myself ordered hot-water injections in several cases of uterine hæmorrhage, directing a stream of 122° F. into the uterine cavity, and the effects have been various. When hæmorrhage arose from cancer, sometimes there was immediate relief, which lasted for some days, but in others the bleeding was increased; when the bleeding arose from a retained portion of the placenta a larger flow occurred—in such cases the retained piece of placenta should be removed; when the hæmorrhage is caused by an atonic state of the uterus, the hot-water injection alone did little good, but when alternated with cold injections, 60° to 70° F., the result was excellent. In all other cases of hæmorrhage the effect was beneficial. I am satisfied that the water should be as hot as possible, otherwise success cannot be secured; and I agree with Runge in calling it "a non-infallible but an important remedy." It is now largely used in London practice, with general satisfaction. Hot-water bags applied to the lower part of the spine also prove useful in uterine hæmorrhage.

Ulcers, Wounds, Contusions, etc.—The "cold-water dressing," with wet lint cut accurately to an ulcerated surface, or amply covering an inflamed part and overlapped by oiled silk or gutta-percha, is one of the best, as it is the simplest, application for ordinary cases. In abscess, warm fomentations expedite the pointing and relieve tension, pain, and other symptoms. This action is assisted by previously painting the part with glycerine of belladonna. They are useful in encouraging bleeding from leech-bites, etc., and in assisting the separation of sloughs. In more severe wounds, if there be much heat and irritation, it is well to keep the dressing constantly moist, uncovered by waterproof, and the most complete method of doing this is by *irrigation* from a can

of water over the bed—a small stream percolating the dressings, and draining into a basin on the floor. The addition of a small quantity of carbolic acid, or some other antiseptic, to the water in all the above cases, aids its action by keeping the discharge sweet. On the other hand, sometimes the cold-water treatment of wounds is too depressing, and leads to slowness of repair, or sloughing, and the hot-water dressing or immersion has been recommended in such cases, especially by Professor Hamilton (New York) and some other American surgeons. If recent lacerated or incised wounds of unhealthy character are kept constantly under hot water (95° to 100° F.), there is a sense of comfort induced, not absolute relief from pain. On the second or third day, the parts adjacent are swollen, but not much reddened; the integument is sodden and white. On the fifth day, or later, the swelling is sometimes great, and the granulations covered with a white exudation, but the area of acute inflammation is much limited; erysipelas and gangrene are arrested or restrained; traumatic fever has seldom, and septicæmia has never occurred in any case in which submersion has been practised from the first day (New York Med. Record, 1874). Of course, simple incised wounds and healthy amputations do not need such an elaborate method of treatment.

The system of prolonged hot baths is largely practised in Vienna, where, in the General Hospital, Hebra's water baths, which were originally made for the treatment of extensive burns and skin diseases, are utilised for the purpose. Patients who have had sloughing at the end of the stump after amputation, and also those suffering from chronic discharges from old sinuses and abscesses, as in psoas abscess, are kept in a bath of warm water day and night for weeks and sometimes months together, until healthy granulation sets in. The patients soon get used to their constant immersion, and sleep well in the bath; the discharges are removed by well-arranged mechanical contrivances, and the patients thus relieved from the necessity of getting out of the bath. The healthy skin acquires a peculiar sodden appearance, which adds to the unhealthy look of the invalids so treated. Dr. Winckel, of Dresden, has adopted the warm bath continued for twenty-four hours or more in the treatment of infantile disorders; as indications for such treatment, he mentions a state of low vitality in children from the age of twenty-eight to thirty-six weeks; prostration after loss of blood;

extensive cutaneous disease, and extreme emaciation from gastro-intestinal catarrh (Record, 1882).

Hot water is very useful in the treatment of recent sprains, the affected limb being immersed in it at the highest endurable temperature for about fifteen minutes (Med. Record, 1879).

For **Burns, Cellulitis, Sloughing Phagedæna, Sloughing and Phagedænic Chancres,** immersion in the hot bath is extremely efficacious, relieving pain, limiting the disease, hastening separation of the sloughs, cleansing the wound, etc.

Hernia.—A bag of pounded ice placed over a hernial protrusion has caused its reduction; the cold lessens the volume of the contents of the gut, especially of the gases; it also stimulates peristalsis, and causes contraction of vessels.

Heat also is used for hernia by fomentation, or better, by the hot bath. It relieves pain, allays spasm of muscles, and so favours reduction: the taxis should be employed while the patient is in the hot bath, which should be continued until muscular relaxation is complete. This is a method which was formerly employed more frequently than at present, when chloroform is used to bring about muscular relaxation.

Stricture—Retention of Urine.—A lump of ice introduced into the rectum is a good remedy for retention of urine. Immersion in a hot bath, by relieving deep congestion and allaying muscular spasm, is very useful in similar retention, especially when due to congestive or spasmodic stricture, or to either of these conditions added to organic stricture. The application of a hot sponge or fomentation to the genitals and hypogastrium is the simplest way of relieving "nervous" retention. The injection of cold or warm water into the rectum is often very useful, in causing the recommencement of secretion after suppression of urine.

In **Orchitis,** iced water made to circulate through a tube coiled round the affected testis will often relieve pain instantly, and entirely cut short the attack; it should be applied early. A similar coil applied to the penis has been introduced by Dr. Otis, for the treatment of hæmorrhage from the urethra, after internal urethrotomy. "Leiter's" tubes of metal are very serviceable.

Bubo—Hæmorrhoids.—In these maladies also the application of ice or cold water is often serviceable. At other times hot fomentation gives more relief, as it may do in orchitis. The best

rule in all these cases of inflammation is to apply cold applications in an early stage, to cause, if possible, abortion of the attack. Later, cold only does harm, and warmth is indicated as being more soothing.

Varicocele.—Suspending the scrotum in cold water night and morning braces up the dartos and the muscular tissue in the veins, and relieves this malady.

Vesical Catarrh.—Warm hip baths are of much value in this condition, and may be employed two or three times daily, for half an hour or an hour at a time. In gonorrhœal inflammations and discharges they are also good.

Catarrh.—In frequently-recurrent attacks of this affection—"always catching cold"—a condition generally dependent on impaired nerve-power and over-sensitive skin, the Turkish bath proves very useful; but when inadmissible for any reason, simple cold wet-towel friction in the morning should be substituted. The daily morning "tub" is also of much service in "hardening" such sufferers against cold.

Tonsillitis—Diphtheria.—Thick compresses wrung out of cold water, applied to the throat and covered with flannel, usually give much relief, but sometimes answer better when soaked in very hot water (112° F.) and applied over the front part of the neck and chest, covered with flannel and oiled silk, and renewed every four to six hours.

Croup.—In true inflammatory croup, a very hot compress or sponge and steam-inhalation are especially to be recommended, and having been satisfied with these I have not often used the cold applications recommended by some authors.

In **Spasmodic Croup,** however, a cold wet cloth to the back of the neck and the larynx during the attack, and douching the spine or the whole body once or twice daily, is an effective treatment. The popular treatment in these cases is a hot bath; to dash cold water over the child is however more effectual. The essential phenomenon in this affection is a difficulty of inspiration due to tonic spasm of the adductor muscles of the larynx. The effect of cold water applied to the upper part of the body is always to produce a reflex excitation of the respiratory centre in the medulla; this is instanced in sea-bathing; when the waves reach the chest deep inspirations are produced. In laryngismus

stridulus the deep inspiration produced by the cold affusion overcomes the obstruction caused by the laryngeal spasm.

Dr. Ringer recommends that children subject to this affection, and also those who suffer from "a catch in the breath," which awakes them from sleep in the night, should be sponged two or three times daily with cold water. This is best done in front of a fire in cold weather, while the little patient stands in warm water; there is then no fear of catching cold. Daily exercise in the open air acts in a bracing way, and helps to prevent the recurrence of the attacks.

Inflammatory Chest Diseases.—Niemeyer and other high authorities, chiefly German, have strongly advised continuous cold applications in the early stages of both pleurisy and pneumonia, placing compresses over the affected side, and changing them frequently; they now even prefer the ice-bag in such cases. A number of cases are now treated by this method in England. Dr. W. H. Day has recorded a case of pneumonia in a boy aged thirteen who was treated by the cold bath method with success, it being used sometimes oftener than once a day, in fact whenever the temperature reached 104°. The bath had a temperature of 90°, which was cooled by means of ice to 70° while the patient was in it. Iced water was given freely to drink (B. M. J., ii., 1883). Professor Bozzolo has used the cold, or the gradually cooled bath with success in the treatment of this disease, and says the bath may, if necessary, be repeated every three hours. Brugnatelli states that going directly into the cold bath (70° to 66° F.) gives better results than gradual cooling—he reports eleven cases (Record, 1883). Professor Flint used in preference the wet sheet; if this makes the patient feel chilly he is wrapped in blankets until that feeling has passed off, and the sheet then reapplied until the temperature is sufficiently reduced. Professor Flint used the method when the temperature rose above 103·5° and considered it free from danger. Dr. L. Gualdi used the ice-bag over the affected area of the lung, giving large doses of potassium iodide at the same time, and found this method most useful in the congestive stage of pneumonia. In children the momentary immersion in a cold bath is found very useful in certain stages of inflammation of the lungs and bronchial tubes. This practice was largely employed with excellent results

by the late Dr. Wilson Fox in the children's wards of University College Hospital. Where death is imminent from collapse of the lung, which so readily occurs in children with chest affections, the sudden cold produces deep respiratory efforts and dilates the air vesicles again, as well as causes a fall in temperature. In a few minutes the child becomes comparatively bright, and the immersion may, if necessary, be repeated several times in the course of an attack. Dr. Lees has recorded several severe cases of pericarditis, pleurisy, and pneumonia, mostly in children, treated by the ice-bag (and salicylates) with quite satisfactory results (B. M. J., i., 1893).

Inhalation of warm water vapour in bronchitis, pneumonia, croup, and other maladies of the respiratory passages, softens the mucous membrane, renders it less tense and dry, liquefies the secretions and makes them more easily expectorated. The warmth also acts beneficially by relaxing the parts and dilating the blood-vessels.

Phthisis Pulmonalis.—The cold douche is used externally in phthisis, chiefly in Görbersdorf and Davos, but less now than formerly. It is only suitable for cases where the temperature of the body is normal, and the disease not actively progressing, and should be employed with the greatest care and under medical supervision. The patient at first is rubbed with dry towels, and then, on being made to take a deep inspiration, is exposed to the cold douche for five seconds—by degrees the duration of the douche may be prolonged, if desirable, to 45 or 60 seconds—immediately after, the body is dry-rubbed until the skin gets red and warm ; the patient is then dressed, and active exercise, such as walking uphill, completes the process. Anæmic patients cannot bear the douche for more than five or ten seconds. When this treatment *can* be borne, it promotes appetite and digestion, and renders the patient less susceptible to the injurious influences of a changeable climate.

Albuminuria.—In a clinical lecture Dr. Jaccoud has stated that the cold douche forms one of the principal points in his treatment of this complaint (Med. Times, i., 1885). Besides insisting on milk diet for the first month he orders a cold douche for 15 to 30 seconds over the body and loins, followed by exercise and dry friction, and he reports excellent results from this, which would seem to many rather hazardous treatment.

Fevers.—The application of water to the treatment of these disorders is one of the most important results of modern therapeutics—or rather of a revival of, and improvement upon, older ideas, for it is not wholly modern. Wright and Currie adopted it in 1786-1796, using cold affusion, *i.e.*, dashing several buckets of water over the patient when stripped. The latter physician records an epidemic of typhus fever affecting fifty-eight soldiers, most of them severely; fifty-six were treated by cold salt-water affusion, and all recovered; the other two, considered too weak for this treatment, were the only fatal cases. He traced an evening exacerbation, and insisted on the importance of using the remedy during this access—or at least during a period of great heat, and not during a rigor, nor during a profuse perspiration (Medical Reports on the Effects of Water, London, 1798). His method of treatment, although valuable and successful, was too harsh for ordinary use; but soon after his observations Giannini, of Milan, advocated immersion in cold water for two to fifteen minutes in all forms of fever (especially intermittent, rheumatic, and scarlet fevers); he drew up judicious rules for practice, and had good success, but he objected to the use of ice (Della natura delle febbri, Milano, 1805). Fröhlich (1822) was one of the first to regulate his practice of cold or tepid bathing by the thermometer. An account of his and many other earlier observations has been given by Fleury (Traité d'Hydrothérapie, Paris, 1866). In our own time, Ziemssen has improved upon the older methods, by his process of gently lowering the patient (with a sheet) into a bath at a temperature of about 98° F., and then gradually cooling it by addition of cold water or ice to 80° or 72° F., or even lower, according to the effect produced: this should be noted by a thermometer (placed in the rectum if possible). When a distinct reduction of the fever heat is evident (it may be in five minutes or in thirty), the patient is dried, wrapped in hot blankets, and laid again in bed, and the process may be repeated two to six times daily. The temperature of the patient continues to fall two or three degrees after he is removed from the bath; care should be therefore taken that the patient is so removed when his temperature reaches 100-101° F., otherwise there may be danger of collapse with the onset of a sub-normal temperature. A less complete mode of attaining a similar result is by cold com-

presses to the trunk changed every half-hour or oftener, ice-bags to the spine and other parts, injections of iced water into the rectum, cold sponging, or the wet-sheet pack. A still milder application of cold in febrile cases is to lay the patient on a bed containing cold water, which is renewed every twenty-four hours or oftener, or through which a stream of cold water is allowed to flow continuously. This abstracts a large amount of heat from the patient, and is especially useful both in mild and severe cases of typhoid fever; it does not produce the excessive lowering of temperature which cold baths and cold affusions generally produce, probably by reflex shock; in some cases it is, however, unsuitable, as it makes the patient shiver with cold. The ice cap also is useful; and acts by abstracting heat without affecting the general or cerebral circulation (Mosso and Bergesio).

All such applications, valuable as they are, must be carefully watched: they depress the circulation, sometimes extremely, and may need, after their use, stimulants internally, and hot cloths and bottles externally, in order to relieve too cold extremities, blue lips, and tendency to collapse. The bath generally used in Germany has a temperature of about 70° F., or somewhat lower, and the patient is kept in it for about ten minutes, but very weak subjects only from five to seven minutes. Ziemssen now uses this bath, I believe, more frequently than the *gradually* cooled one, mostly mentioned with his name. Cold baths act not only by reducing the temperature in fever, and so lessening the amount of tissue-change, but they also reduce alterations in tissue such as fatty degeneration which comes on at a high temperature. Moreover, by prolonging the cardiac diastole they give more opportunity for the nutrition of the muscular tissue of the heart.

Hyper-pyrexia.—According to general, though not universal experience, a rise of temperature above 108° F. is quickly fatal, and a range between 105° and 112°, which may occur in acute rheumatism, etc., has been specially termed "hyper-pyrexia." Under the systematic use of cold applications, some remarkable recoveries from this critical condition have taken place, and two cases fully reported by Dr. Wilson Fox attracted much professional attention to the subject. They were both cases of rheumatic fever with cardiac complications: one, a woman of forty-nine,

was lowered at 9·50 P.M. into a bath at 96°, when her temperament was 109·1° F. She was unconscious, the pulse imperceptible, the face cyanotic, the respiration irregular and gasping. At 9·55 P.M. the rectal temperature was 110°. "Ice was fetched, a large lump was placed on her chest, another on her abdomen, a bag filled with ice was tied down the length of the spine, and while two assistants baled the warmer water out of the bath, two others poured ice-water, as rapidly as the pails could be filled, over the patient." At 10·10 P.M. temperature was 109·1°: at 10·25 P.M. it was 106°; the pulse now became perceptible (140), and the patient showed signs of consciousness. Brandy was freely given. At 10·35 P.M. the temperature was 103·6° F., and the patient was taken out of the bath. At 10·55 the temperature was 100·6° F., lividity had disappeared, the patient could speak, and had a certain imperfect consciousness: the temperature continued to fall, till at 11·25 P.M. it was at 97·4° (vagina), and hot applications and an enema of brandy were required to prevent collapse. Another bath was given next day, when the body-temperature had risen to 104·5° F.; the bath was at 64° F., and was continued for twenty minutes; on removal, the patient's temperature was 103·9°, and it continued to fall for forty minutes longer till it reached 99·4°. Rigors occurred, and hot applications were again required. From this time, the cold treatment was continued by ice-bags to the spine, which sometimes were effective in reducing the body-heat, and sometimes not, but within a week from the baths, the patient was sitting up convalescent, and within a month was able to travel.

The second case presented more difficulties, and required a longer treatment: it occurred in a man, aged thirty-six, suffering from double pneumonia, double pleuritis, and pericardial effusion. On the seventeenth day of his disease, the temperature rising rapidly to 107° F., and delirium setting in, he was placed in a bath at 89° F., which was cooled to 86°. The after-effect of this was a fall of body-temperature to 98°, and return of consciousness. For eight days cold applications were kept up almost continuously; eight baths were given, of duration varying from twenty-five minutes to seventy minutes, and in the intervals the ice-bag or wet-pack was used, the object being to keep the temperature under 103° F. at least. This patient also made a good recovery,

but the temperature did not remain normal until thirty-one days after this treatment was commenced (Lancet, ii., 1871).

Shortly before these cases, Dr. Meding, treating rheumatic hyper-pyrexia in a female, aged twenty-two, with enemata of iced water every half-hour, and the application of iced cold cloths, reduced the temperature in five hours from 108·6° to 99·5° F., and the pulse from 140 to 72; no further rise ensued, and no relapse.

Of course, all cases have not been so successful, and Dr. Fox refers to several that ended badly; yet those quoted are sufficient to show the immense power of this mode of treatment, and it has, since that time, been fully endorsed by many English authorities. Dr. Anstie especially pressed its adoption, and Dr. Waters (Liverpool) has given good illustrations of its value in two cases of rheumatic fever, one with pericarditis, and both reaching a temperature of 106·7° F., and treated by baths at 95° to 100°, cooled to 70°, and sometimes lower (B. M. J., i., 1878). In a careful paper, Dr. Ord has given details of the use of graduated cold baths in ten cases of hyper-pyrexia, of which two were fatal (one of these had only one bath, and died eleven days afterwards of congestion of the lungs). In several of the cases, relief to nervous excitement, and even to a congestive condition of the lungs and bronchial tubes, as well as to pyrexia, was marked; six was the largest number of baths given in any one case. The only contra-indication is excessive weakness. Dr. Ord advocates the systematic early use of this treatment, but also points out the difficulties in thoroughly carrying it out (St. Thomas's Hosp. Rep., 1879).

There is some evidence that *warm* bathing will reduce temperature, and if so, we certainly avoid some risks by it. Dr. Mackey has recorded the case of a child æt. two, suffering from broncho-pneumonia connected with rachitis; when the temperature was 105° to 106°, a bath at 94° to 96° continued for twenty to thirty minutes always reduced the temperature four or five degrees, though the case ultimately proved fatal (Lancet, i., 1885).

Acute Rheumatism.—I have often given the greatest relief in an ordinary but severe attack, with pain in all joints, sweating, pyrexia, etc., by means of a hot blanket-pack, the patient being enveloped in one blanket wrung out of hot water, and then covered with several others, and thus left for half an hour or

more. Dr. Dowse has made scientific observations on this form of bath, and reported much benefit from it (B. M. J., i., 1875). In the blanket-pack he found the temperature rise one to two degrees, and at the same time much sweating was produced. He continued it for six hours at first, afterwards for one or two hours only; brandy was sometimes required for depression. He did not use this bath when the body-temperature was over 104° F., or the patient very prostrate, nor when the aortic valves were incompetent. In *chronic* gout and rheumatism the Turkish bath is especially useful. A remedy for *rheumatism*, said to be very successful in India, consists of hot mustard baths, each lasting twenty minutes, followed by application of hot flannels; this produces profuse diaphoresis, relieves the pain, and is said to lead to a speedy cure (B. M. J., i., 1883). I have often used it for a much longer period with advantage.

Puerperal Fever.—In a very striking case reported by Dr. W. S. Playfair, a sheet or towels wrung from iced water were almost constantly applied for eleven days, the patient lying on a water-bed kept cold with running water, and having an ice-cap on the head; by these means only could the temperature be kept under 105°, and eventually the patient was saved, Warburg's tincture having some share in the result (B. M. J., ii., 1877). Dr. Wiltshire has also reported cases of this disease treated by *dry* cold, *i.e.*, ice packed in bottles and tins near the patient, with temporary good result under unfavourable conditions. Mr. Knowsley Thornton has found an ice-cap, for application to the head only, very useful in keeping down the temperature after ovariotomy.

Typhoid Fever.—The use of the cold bath in this disease was revived by Dr. Brand, of Stettin. His method was to place the patient in water of the temperature of 65° to 70° F. whenever the rectal temperature reached 102·2°, and to keep him there ten, twenty minutes, or longer, until the temperature fell 2°. Liebermeister, at Basle, systematised the treatment of typhoid fever by cold baths, and his records show a lowering of mortality from 26 per cent. to 7 per cent. So soon as the disease was declared, usually about the ninth day, the treatment was commenced with a bath at 75° F. for ten minutes; this was repeated, not at a fixed time, but so often as the temperature (taken every two or three hours)

rose above 103° F. Sometimes six or seven baths were given in twenty-four hours, but commonly a less number. It was sometimes necessary to continue this treatment for two or three weeks, but when they acted best an early remission of pyrexia occurred, and lasted for a long period; quinine in full doses, or digitalis, were often combined. Jürgensen followed a similar practice, and also Bartels, who claimed to reduce his mortality to 3 per cent. Sir W. H. Broadbent (Quain's Dictionary) considers that it may be safely estimated that in France and Germany the deaths have been diminished by at least one-half.

In this country the cold bath is not so largely employed; Dr. Cayley, however, has been able to show excellent results from its employment at the London Fever Hospital. The risk of movement and disturbance in cases with serious intestinal lesions has weighed heavily with English physicians against its frequent use. But in cases where a hyper-pyrexial condition is present, it has often been employed with success, though as a rule the *graduated* cold bath is the one usually employed; that is, one in which the temperature is gradually lowered from 90° to 70° F. For ordinary cases, daily sponging with tepid water is most grateful to many patients; in other cases the use of beds with a stream of cold water kept running through them as already described is a mild and effectual method of applying the cold treatment. In more severe cases, ice-packing and Thornton's ice-cap are often substituted for the bath. These applications have the advantage that the patient can remain in bed during the application, but they are not so effectual as a bath in reducing temperature. Albuminuria or pulmonary complications do not contra-indicate bathing; in fact, Sir W. H. Broadbent has known albumen to disappear from the urine at once, and pulmonary congestion to clear up after a single bath.

Remittent Fever.—A similar method of systematic bathing has been followed with advantage in the remittent fever of the tropics, and Dr. Lucas has described a severe case in which the patient (at 103° F.) was lowered into a bath at 83°, and a small continuous stream of cold water was poured over the body for eight minutes; after return to bed the temperature was 97°; quinine and port wine were given. After seven days of bathing—the temperature being kept under 103°—some bronchitis having

developed, injections of cold water into the rectum were substituted for the bath, and with very definite effect in lowering temperature; recovery occurred in about a month (Med. Times, ii., 1879). In intermittent fever, both Currie and Giannini used cold affusion and bathing with excellent effect, and found that it prevented or delayed a paroxysm if given an hour before the usual onset of the attack; also that the water-treatment much assisted the action of quinine. Dr. Fleury, however, claims for his cold douche much more than this, stating that he has radically cured by it more than 100 cases of all forms of intermittent fever, many of them rebellious to all ordinary treatment (including quinine, arsenic, change of climate, etc.), and he quotes evidence on the subject which should receive earnest attention. An energetic cold douche for fifteen or twenty seconds can relieve both the pyretic and the congestive, and also the anæmic condition. For preventing a paroxysm it should be used a quarter of an hour before the expected onset; if this come on before its time, the douche may even be used in the cold stage with good effect, if given strongly for a short time so as to be excitant; if necessary, a second may be given in the hot stage. In irregular intermittents the abdominal viscera are usually congested, and Fleury finds the douche competent to reduce both the liver and spleen to their normal size in a comparatively short time. Cerebral complications require compresses; pulmonary œdema and acute bronchitis contra-indicate the treatment. In bilious subjects purgatives may be required, or other methods of treatment used in conjunction with it.

Scarlatina.—In this fever, some of the very best results of cold bathing and packing have been obtained. In mild cases, tepid or cold sponging during the course of the disorder, and a few carbolised warm baths at the termination, are all that is necessary. The warm baths during the period of desquamation help the process, and give much comfort to the patient, especially if followed by inunction of carbolised oil or glycerine. They also stimulate the action of the skin, and lessen renal congestion, or the risk of it, and also the chance of infecting other persons.

Dr. Vaudrey Lush, indeed, and some other physicians, have advocated the routine use of the warm bath from three to five minutes at first three times a day, afterwards less often, for every

case of the malady (Lancet, ii., 1880); but without denying the advantages of this method, it is clearly often impracticable, and cannot be considered necessary.

In very severe cases, however, when the temperature rises to 104°, 105°, or 106° F., and there is delirium or stupor, the rash being dark and indistinct, and the urine scanty and albuminous, I have frequently seen, even in apparently hopeless conditions, the cold or hot wet-pack bring out a vivid rash, and cause lowering of temperature and abatement of all the severe symptoms.[1] Dr. Edison has reported two illustrations of this, occurring in children, with delirium, etc., and both successfully treated by frequent bathing (Lancet, 1877); interesting cases treated by cold affusion, also valuable cautions on the subject may be found in Trousseau's Clinical Lectures (vol. ii.).

I first used the *hot* pack in a case of suppressed scarlatina (where the prejudices of parents prevented the usual cold applications), and finding the results equally good, I have commonly adopted it. In the case of a boy whom I found convulsed, and with dusky purplish skin, on the third day of what was presumed to be scarlatina, the hot sheet acted admirably. The throat was much affected, albumen was in the urine, and consciousness was lost: within half an hour of commencing the hot pack he was able to speak, perspired freely, and the rash came out a vivid red; he was afterwards put in blankets, and went on perfectly well without the necessity of repeating the pack. In another still more severe case, the convulsions had lasted over two days, the child was quite blue, there was albumen in the urine, and his life was despaired of; but in the first pack consciousness returned, and recovery followed.

The vapour bath is another mode of effecting the same results, and is especially applicable when renal congestion and albuminuria are marked, and in such cases compresses, poultices, or fomentations should be kept applied over the loins. The instances given

[1] Although, as above stated, temperature is commonly reduced in the pack, I have known it rise 2° to 3° F. in five different patients in the cold pack, and in four others in the hot pack. At one time I thought such an occurrence to contra-indicate the treatment, but further experience has shown me that it does not do so, and I believe that recovery was assisted by the treatment.

will suffice to show the power of this treatment, although certainly there are cases of malignant scarlet fever which no art can save.

For the *sore throat* of scarlatina, compresses should be used externally. I find it best to have the throat bathed with water as hot as can be borne, for about five minutes every three or four hours, and directly afterwards a bandage, wrung out of water at about 112° F., should be applied round the neck and covered with oiled silk. This should be continued for three or four days as an adjunct to other treatment. Dr. H. Corson (U.S.) recommends a piece of ice, in gutta-percha tissue, over each parotid gland. Cold may also be applied to the neck in this and other forms of tonsillitis, by a coil of tubing through which cold water is kept constantly flowing. Warm water is a good gargle, or ice may be swallowed in small pieces with much advantage.

In **Erysipelas, Measles, Small-pox,** and other eruptive disorders, similar treatment by bathing and packing is valuable.

In **Erysipelas** also, with temperature 102° F., baths 95° or 85° cooled to 92° or 77° reduced the fever, acted favourably on the nerve centres, and shortened the duration of attack, though they did not influence formation of abscess or migration of the disorder (Med. Record, 1883).

Nephritis.—In acute nephritis from other than scarlatinal causes, warm packing and vapour or hot air baths, and similar means of inducing diaphoresis, are almost equally valuable for relieving the renal congestion and eliminating waste products. In chronic nephritis they act especially as eliminants, and they also lessen dropsy.

Hepatic Congestion.—In acute cases, hot packing over the liver, and in subacute and chronic cases, hot mustard-packing and a course of Turkish baths, are highly serviceable.

Catarrhal Jaundice.—Krull has written to advocate the treatment of this malady by the slow injection into the bowel of 30 to 70 oz. of water at a temperature of 60° to 72°. This may be practised for as long a time, and to the extent that the patient can bear it, once in the day: seldom more than seven "irrigations" are required. They are said to relieve gastric troubles, to improve appetite, and quickly cause the reappearance of bile in the stools. The increased intestinal peristalsis is presumed to induce corresponding contraction in the biliary passages (*v.* Gastric Catarrh).

Typhlitis—Peritonitis.—The application of an ice-bag, or of iced compresses, in these conditions often proves more useful than the usual orthodox poultice, and in early stages the local inflammation and the general pyrexial state may both be relieved by local cold. On the other hand, in some cases a prolonged hot sitz bath, or smoking-hot fomentations, renewed about every half-hour, give great relief. The nausea or vomiting is often quickly checked by administering small quantities of ice or iced water; at other times by hot water.

Diarrhœa.—The abdominal pain of acute diarrhœa is soothed by compresses, poultices, or warm bathing. In children some care is required as to the bath, for convulsions have occurred on placing a child suffering from diarrhœa in a bath at 98° F. This was most likely from an increase in body-temperature under the influence of external heat (Haddon, Pract., vol. viii.). The child ultimately recovered, but in such a case the cold sheet would probably answer better.

Cold applications are often more suitable than hot ones in choleraic diarrhœa (M'Kenna, Lancet, ii., 1876), and I agree with Messemer in the experience that cold water enemata act excellently as tonics and astringents in chronic cases. If slowly injected, they distend and keep apart the coats of the bowel, and thus save irritation (Med. Record, 1878): I have followed this practice for many years. Wenzel, an experienced naval surgeon, recommends injections of ice-cold water in dysentery, and has found recent acute cases subside quickly under this without other treatment. Fleury gives some remarkable illustrations of chronic dysentery and diarrhœa cured by the systematic use of the cold douche, one patient, aged forty, having previously used many medicinal remedies under able physicians. It is certainly a remedy to be remembered in obstinate cases.

Even in cholera, the application of water, warm or cold, may be made highly serviceable. Trousseau wrote strongly in its favour when prejudice against it was greater than it is at present. The stage of collapse may be controlled by a *hot* mustard blanket-pack; but, as a rule, more permanent good will be obtained from *cold* applications. Niemeyer is an authority for recommending the pack with iced sheets in cholera (Lancet, ii., 1876). The use of the cold sheet should be combined with friction, and under this

treatment during a recent epidemic it is said that 300 cases all recovered, though under medicinal treatment previous cases had died. After being wrapped in a wet bath sheet and strongly rubbed by two attendants over the whole body, a jug of cold water was poured over the sheet and the rubbing resumed till the body became warm; he was then rubbed with a dry sheet, and the stomach being bandaged with linen and flannel, he was made to walk in the open air. This treatment was originally carried out by Schindler, the successor of Preissnitz. Dr. Chapman has offered evidence in favour of ice-bags to the spine.

Skin Diseases.—In all forms of dry, scaly, skin disease (whether syphilitic or not), warm baths (especially when made emollient and alkaline) and vapour baths are useful. In acne, hot bathing or steaming opens up the glands and relieves congestion. In psoriasis, ichthyosis, lichen, prurigo, "pityriasis rubra," and chronic dry eczema and seborrhœa, for removing accumulated secretion or preventing contact of air, water compresses are serviceable. Hebra has tried the prolonged warm bath for from *two hours* to *nine months* at a time, in some such cases, and in extensive burns, and has ascertained that nutrition, respiration, and secretion go on in the continued bath in a normal manner (Med. Record, 1877). On the other hand, in some skins, and especially when the epidermis is removed, as it commonly is in acute eczema, water is apt to excite much irritation. As a general rule, simple water even for washing should never be allowed to touch eczema which is discharging. Cold weak gruel, or milk and water, are to be substituted for it. Water always acts destructively on protoplasmic structures such as the malpighian layer of the skin.

A course of warm baths, two daily, with occasional vapour baths, proved effective in an aggravated case of obesity, which diet had failed to influence (Med. Record, 1885).

Cerebral Congestion.—Cold applied to the head, whilst hot mustard-water is used to the feet, is one of the simplest modes of equalising the cerebral circulation. It must, however, be used with caution where cerebral anæmia is readily induced, as in weakly subjects. Ice to the nape of the neck also acts well, and sometimes the *alternate* use of cold and hot applications gives the

best results. This is especially the case in the congestion of opium-narcosis, uræmia, and carbonic acid poisoning (Bartholow).

Meningitis.—In cerebral or spinal meningitis the application of ice is a valuable resource, but if the face be pale, and there be tendency to chilliness and prostration, it is not suitable.

Sunstroke—"Thermic Fever."—When the head is hot, the pupils contracted, the pulse full, and the temperature high, cold packing is decidedly indicated, also cold affusions, especially to the head.

Delirium Tremens.—When the symptoms are violent and acute, with flushing and heat of head, full pulse, and much restlessness, a cold pack, or, if possible, a douche, or at least an ice-bag or cold compresses to the head, may be very useful in procuring quiet, and even sleep. When much depression or evidence of vascular degeneration exists, such treatment must be employed with extra care.

Insomnia.—This is often dependent upon functional congestion of the nervous centres, and is amenable to different applications of water. The general tepid bath is suitable for children especially. A cold sitz bath relieves after intellectual work, or even a cold compress of a folded wet towel placed on the epigastrium, and covered by a dry towel, is often very efficacious. A hot mustard foot bath, whilst cold, is applied to the head, or a rapid dipping of the feet in cold water and vigorous friction afterwards, tend to the same result.

Mental Disorder—Melancholia.—So valuable is the douche bath in some mental cases that there has been a tendency to overdo this form of treatment, and even fatal results have been recorded from it in cases of extreme depression. It is important not to use it too long at a time. Ten to twenty seconds is sufficient for melancholic cases, and the patient should stand in warm water, so as to secure warmth of the extremities. One or two minutes of a shower bath should suffice for excited cases, and often a prolonged warm bath (thirty minutes), whilst cold is applied to the head, is the most soothing form of treatment. The Turkish bath has recently been introduced into asylums, and with some excellent results.

Hypochondriasis.—A course of cold-water treatment, which is at first stimulating and afterwards soothing, is useful in this

affection. It generally stimulates the vital functions, promotes tissue-change and nutrition, invigorates the skin, and strengthens the physical and mental condition. Other kinds of treatment, however, are often more successful.

Impotence.—When this arises from excess, cold sitz baths and spinal washings often relieve.

Convulsion.—The reflex convulsions of infancy are often cut short by a warm bath, cold water being poured on the head at the same time. Hysterical convulsion is sometimes arrested by a sudden shock of cold to the surface, and a daily shower bath is of great service in improving the hysterical state.

In **Chorea** cold affusion, especially over the spine, is very beneficial, and I have had excellent results from the shower bath.

In **Uræmic Convulsion** this treatment is not so markedly effective, though cold to the head is advisable; but the use of packing, or of the vapour bath, so soon as the general condition admits, is often of the greatest service. Dr. Ransome recorded a case of puerperal eclampsia, in which the patient was wrapped in the warm wet sheet for six hours. Free sweating was produced, the convulsions ceased, and next day the urine was free from albumen, and the patient made a good recovery (B. M. J., ii., 1883).

Tetanus.—Currie, Giannini, and other early observers record benefit from cold applications in tetanus, and illustrations of it have been published by Dr. W. S. Playfair in his Indian experience (Med. Times, i., 1862).

Hydrophobia.—It has been recommended to treat cases of incipient rabies in man by hot vapour and other baths (Lancet, 1877); this treatment, however, has signally failed in true rabies.

Paraplegia.—In cases connected with functional disorder of the cord, hot or alternate hot and cold douches to the spine often act very well. Paralysed limbs that have become cold and wasted may often be much improved by towel-packing and douches, combined with vigorous friction.

Spinal Pain.—The sense of weakness and exhaustion referred especially to the lower part of the spine, occurring in delicate subjects after over-exertion of any kind, and due probably

to a passive congestion, is much relieved by cold "spinal washings," or gentle douching each day for a short time, and followed by good friction. Dr. Moxon drew attention to the comparatively feeble circulation in the lower part of the cord, and doubtless such remedies act by quickening and regulating the blood-current in that part (B. M. J., i., 1881).

The more acute backache, commonly felt by women, and in the absence of definite cause often assumed to be due to "anæmia of the cord," is better relieved by hot applications; and if the douche be not obtainable, then a hot sponge or fomentation will serve.

THERAPEUTICAL ACTION.—*Internal.*—Preissnitz and his early followers combined with the outward application of cold water its immoderate and excessive use internally, an error which led to some evil result, and which is now not often repeated. Water-drinking is now ordered on general dietetic principles rather than as an essential part of a hydropathic course. There is no doubt that the benefit derived by patients from a stay at a hydropathic establishment is not wholly or perhaps chiefly due to the water. The plain living, regular hours, and avoidance of excesses, materially aid in the restoration of health, especially if the illness is due to previous irregularity of living. In chronic illness good results are more rapidly and easily obtained by the use of *mineral waters* in moderate quantities, and containing salts and gas, so that the number of illnesses in which ordinary water is internally employed as a remedy is not large. Its most common internal use, medicinally, is as a solvent and diluent.

In **Fevers** of all kinds and in **Diabetes** it is used to lessen thirst, to lower temperature, and restore the balance of fluid constituents of the tissues; also to promote secretion and the elimination of waste products.

In **Cholera** most authorities consider it dangerous to give cold water, and think it better to relieve the intense thirst by giving ice to suck. Surgeon-Major Pringle has stated, however, that iced drinks are dangerous, and that water of the temperature of the air is best adapted for the relief of thirst, and tepid water for the prevention of retching (B. M. J., ii., 1885).

Nephritis.—A copious supply of pure water is an effective non-irritant diuretic, and is very useful in acute renal congestion

and inflammation, washing out the epithelium and casts from the obstructed tubules. It renders more soluble, and helps to carry off waste products, and the good effect of many infusions and decoctions is doubtless largely due to the amount of water they contain. Its diuretic effect is chiefly due to the increased blood pressure it produces throughout the body including the kidneys.

Constipation.—A glass of cold water taken, fasting, in the early morning, will assist in securing a regular action of the bowels; if taken also, the last thing at night, it has a still better effect; it acts by stimulating peristaltic action.

Hæmorrhoids.—Plentiful water-drinking is indicated in this disorder as a means of relieving the liver by securing a greater flow of bile and accelerating elimination, but a course of aperient *mineral* waters is more effective.

Chronic Metallic Poisoning.—In some cases of this kind, the taking of a large quantity of water is useful by aiding solution of minerals deposited in the tissues, *e.g.*, antimony, arsenic, lead, copper, mercury, etc., or rather their mechanical removal by disintegration of cells. If, however, anæmia be marked, as it often is, this method must be used with care, for fear of impairing nutrition.

Syphilis.—In the later stages of syphilis, or when relapses are frequent, and mercury or iodides are not well borne, hydropathic treatment is a useful resource, tissue-change being promoted by free water-drinking, but a course of baths is the most important element in such treatment.

Gout—Gravel.—In these cases, hydrotherapy can improve the general condition, and sometimes, it is said, disperse concretions; it promotes increased tissue-change, as shown by increase of urea, and the water dissolves uric acid and other urinary constituents; it will not, however, produce the marvellous cures sometimes expected of it.

Water dilutes the urine, and renders it less irritating in pyelitis, cystitis, gonorrhœa, and other affections of the genito-urinary tract. It is generally given in such cases in the form of aerated waters or mucilaginous drinks.

The dietetic use of *hot water* in gout has been recommended, one or two tumblerfuls of water at 120° being given in the early

morning; this is said to regulate the bowels, to cause the disappearance of uric acid and lithates, and diminish the frequency of acute attacks (Weber). Cadet de Vaux (1825) carried this idea to an extravagant pitch, ordering 8 oz. of hot water (120° to 140° F.) every quarter of an hour for twelve hours. Some patients bore this, but others suffered from vomiting, excitement, congestion of the brain, or fever.

What is known as the "Salisbury plan" for the reduction of obesity, and the treatment, not only of gout and rheumatism, but of fibroid and ovarian tumours, diabetes, and even phthisis, comprises the drinking of a pint of hot water at about 110° F., from one and a half to two hours before each meal, and half an hour before retiring: the hours given as the best for drinking are six and eleven A.M., four and nine P.M. From five to fifteen minutes should be taken for drinking the water, so as not to distend the stomach to an uncomfortable degree. The object of the hot water is "to wash from the stomach the slimy mucus, alcoholic and sour yeasts, and bile before eating and sleeping"; and there should be time for it to get out of the stomach before the food enters. At meals, one cup of tea or coffee is allowed in addition. Conjoined with this is the living almost entirely upon the "muscle-pulp" of beef broiled, and some other meats and fish.

Gastric Catarrh.—In this affection the habitual drinking, especially in the early morning, of large quantities of water causes the upper layer of cells in the gastric mucous membrane to swell up, die, and regenerate more rapidly than they would otherwise do. They are replaced by others with higher vitality, and under proper dietetic management the whole gastric mucous membrane becomes healthier.

Enemata.—Large enemata of warm water (1 to 3 pints) are used to clear out the lower intestine. Small enemata of cold water are often useful in habitual constipation.

SEA-BATHING.

In sea water the more important saline constituents are the chlorides of sodium and magnesium, and the sulphate and carbonate of lime; iodides and bromides are contained in minute quantity. Hence the effect of sea-bathing upon the skin and its peripheral

nerves is more *stimulating* than that of ordinary water, an effect which is much heightened by the stroke of the waves.

The incoming wave beats more upon the upper part of the person, the receding wave upon the lower extremities, providing one of the best forms of douche bath for such as are strong enough to bear it. Water in motion always feels colder than water of the same temperature which is still ; a cold bath, such as is usually taken, may feel so cold if the water is in motion, as to be unendurable for more than a very short time ; it is thus more bracing, though it may have too powerful an effect for delicate persons.

This wave-stroke is naturally more effective in some seas and on some coasts than on others. In the German Ocean (east coast of England) and in the Atlantic (south coast) it is much stronger than in the Baltic or the Mediterranean, and bathing at Cannes, for instance, is not to be compared in bracing effect with bathing at Brighton. The stimulating effect of the waves is aided by the friction of the sand against the skin, and by the active exercise, jumping or swimming, which all sea-bathers undergo while in the water.

The temperature of the water is an important point in estimating the effect of any form of bath. The temperature of the sea varies less throughout the year than that of rivers : it is highest in the Mediterranean (72° to 80° F.), lowest in the Baltic (60° to 62° F.), and intermediate in the Atlantic (68° to 73° F.). It is higher in autumn than in summer. The temperature of the water is often as much as 12° F. higher than that of the air, and at midday it is several degrees higher than in the early morning.

In considering the influence of sea water, that of *sea air* must not be wholly omitted. It contains more ozone, more moisture, and more salt than country air, with less carbonic acid, and usually less dust and foreign admixture ; in fine weather the air is more clear and the sunlight more powerful at the coast than inland, and the current of the air is usually stronger and more bracing.

PHYSIOLOGICAL ACTION.—On entering the water, under ordinary conditions, a sense of cold is felt ; the skin becomes pale and roughened (goose-skin), the circulation depressed, and the respiration more or less spasmodic ; when the water reaches the chest, strong inspirations are brought about reflexly ; in suitable

subjects the temporary depression is quickly followed by reaction —the skin reddens, the pulse rises and becomes more forcible, whilst exhilaration and a sense of increased vigour indicate the stimulation of the nervous system. If the bather avoid over-taxing his powers, and will leave the water before this period of stimulation is passed, he will probably retain, for several hours, a feeling of improved health and general well-being, and it is to such cases that the following statement of physiological results will apply.

Tissue-change is promoted, as shown by an increased excretion of urea and sulphuric acid (Beneke); not that these are immediately or inordinately increased, but the natural healthy maximum is kept up for a much longer time than usual (Ringer). Appetite and digestion are certainly promoted; but if only such a measured amount of food be taken as suffices to maintain the body-weight at a fixed point under ordinary circumstances, *loss* of weight is experienced owing to the increased tissue-change, while if the quantity of food be *increased in proportion to* the improved appetite and digestion, the body-weight is decidedly *increased* by a course of sea-bathing.

The secretion of the skin, though at first checked, is afterwards promoted: the effect of the first contraction of the cutaneous capillaries is sometimes, if the water be very cold, to determine blood to internal organs, and hence some congestion of the kidneys may occur, and a trace of albumen may be found in the urine; but this condition soon passes off, and the albumen does not persist after the bath.

The urinary water is increased at the time, though it is said that the day's *total* quantity is rather less than normal. The intestinal excretion is usually lessened, but sometimes increased (Beneke), and either constipation or diarrhœa may be induced.

Restlessness and sleeplessness are more serious symptoms occasionally caused, but in my experience as much by a residence on the *sea-level* as by simple bathing. The hot, strongly saline baths, as at Droitwich, do, however, often induce an extreme degress of restlessness, and should not be used too frequently.

It is worth noting that the long hair of women, when often soaked with salt water, may fall off, but it quickly grows again.

THERAPEUTICAL ACTION.—Sea-bathing tends to "harden the skin," to moderate undue perspiration, and to diminish the tendency to catching cold and to rheumatic attacks. It acts as a general stimulant in all conditions of constitutional debility, and also as a local stimulant, promoting absorption and improving circulation.

In **Chronic Forms of Nervous Disorder** with depression, and hypochondriasis, sea-bathing is often very beneficial through a strongly stimulant action on the peripheral cutaneous nerves: by its influence on tissue-change it is said to benefit, not only in functional disorder, but even after material change in the nerve-substance (Husemann).

Struma, etc.—In various forms of struma, scrofula, and chronic conditions of blood-poisoning, sea baths are indicated, and during convalescence from fevers and other acute disorders, or after prolonged town-residence or town-work, they have an excellent effect.

Sprains, etc.—As a remedy for the effects of sprain or of injury to joints, or of spinal weakness, douches of hot and cold sea water are exceedingly useful.

Gargles of the same are said to have proved curative in chronic relaxed conditions of the throat, "Clergyman's sore throat," etc. (B. M. J., ii., 1879).

Time of Bathing.—To bathe before breakfast is the custom of some robust persons, but is never free from risk, and sometimes seriously injures weakly subjects: for after the long fast of night the circulatory and central nervous organs are more liable to depression from sudden shock or over-fatigue. On the other hand, to bathe soon after a meal arrests the process of digestion, and may give rise to unpleasant gastric and cerebral symptoms. The best results are obtained from bathing two or three hours after the early morning meal, when the stomach is nearly empty, and there should be at least a brief interval of rest or of but moderate exercise, according to the weather, between the bath and the following meal. The object aimed at being a marked and prolonged reaction, this is best obtained from a bath taken during a condition of the greatest nutritive and functional activity, when the work of the stomach is over and the blood is enriched by the products of digestion. Sometimes it is advisable that

those not in robust health should take some light refreshment shortly before bathing.

Errors in Bathing.—The good effects already described as proper to sea-bathing may be missed, and unpleasant symptoms may arise, if attention be not given to certain points.

The therapeutical object is to secure and sustain a good *reaction*, and this is impaired if the bath be too cold, or too prolonged, or if excessive exertion be taken before, during, or after it, or if the patient be under the influence of strong emotion, as a nervous, frightened child would be. The most common errors are to prolong the bath unduly and to exert oneself overmuch during it; the sense of vigour is then replaced by exhaustion, the skin again becomes cold, and the circulation depressed; giddiness and headache occur from altered conditions of the circulation, with general malaise, and possibly shivering, nausea, sickness, and a sense of depression lasting for many hours. It is therefore important to leave the bath before the stage of reaction and stimulation is finished. With some persons the stroke of three or four good waves is sufficient for the best results, five minutes is an average time for the delicate to remain in the water, and no one bathing for *health only* should remain in the open sea for more than ten minutes. Another question which often arises is, Should one enter the bath head first or feet first? Experienced bathers prefer to dive, and state that the good effects of a bath so begun are more marked and last longer. If one enters the sea by walking into it, which is the usual practice, it is most unwise to stand hesitatingly with only the lower part of the body immersed, and then to advance timidly into deeper water. Such a proceeding may give cold, and produce a feeling of shivering and misery. Water deep enough to cover the whole body should be reached quickly and the head dipped as soon as possible. Almost immediately the head is dipped reaction begins. Many people suffer from troublesome headache from neglecting this precaution.

Contra-indications.—At the extremes of life, sea-bathing in the open should be practised cautiously. As a rule, it is unsuited for children under two years of age, or for patients over sixty. Pregnancy in healthy subjects need not prevent the use of salt baths, or sea-bathing, provided that the patient is accustomed to a cold bath previously, but, as a rule, the various incon-

veniences of open-air bathing render its risks greater than any advantage in that state. The tendency to cause congestion, more or less temporary, of internal organs, the brain, liver, lungs, and kidneys, renders open-air sea-bathing unsuitable for persons disposed to such disorders, or suffering from structural change or a sluggish circulation within the abdominal organs, albuminuria, serious cardiac disease, chronic pneumonic infiltrations, hæmoptysis, fatty degeneration, or rheumatism which is at all acute. An extreme degree of anæmia is also a contra-indication.

MEDICATED BATHS.

Artificial Sea Bath.—Sea water may be obtained readily at home, or sea salt may be added to an ordinary water bath. The effect produced is more stimulating than that of the ordinary cold bath, but less so than bathing in the sea, because the splash of the waves and various other concomitants of the actual sea bath are wanting.

Acid Bath.—(*V.* Nitro-hydrochloric Acid.)

Alkaline Bath.—A drachm of sodium carbonate is added to each gallon of water. Half the quantity of potash carbonate is sometimes used with half of soda; or borax is sometimes preferred to either. It is useful in chronic skin diseases; it allays itching, and in psoriasis hastens the separation of the scales.

Sulphur Bath.—(*V.* Sulphur.)

Mustard Bath.—Half to one drachm of mustard is added to each gallon of hot water. Such a bath is a powerful stimulant and rubefacient and is also soporific. Depression may come on if the patient stays more than ten minutes in the bath. Mustard baths quicken the appearance of the rash in acute exanthemata. Mustard added to warm foot baths increases their activity. A hot foot bath of mustard and water before going to bed, followed by friction of the feet with a rough towel, is an old-fashioned, but often very effective, remedy in cutting short a threatened cold in the head.

Pine Bath.—One minim of the oleum pini sylvestris is added to the gallon of water; a less convenient method is to add decoc-

tion of pine shoots. These baths are used in rheumatism, gout, and scrofulous conditions (Brunton).

Carbolic Bath.—A bath of weak carbolic acid (1 part in 80) is an excellent detergent and disinfectant. Medical men, nurses and others who have attended infectious (especially puerperal) cases, have found such baths excellent safeguards against propagating the disease.

The **Bran Bath** is prepared by boiling four pounds of bran in one gallon of water, straining and adding sufficient water for a bath; this is used to soften more stimulating baths and to soothe skin irritation. Oatmeal or gelatine may be used for the same purpose.

The **Conium** or sedative bath is made by putting three handfuls of the leaves into a full-length bath of hot water, and is useful in conditions accompanied by much itching. The vapour may be kept from the head by suitable covering.

Aromatic Baths are prepared by adding decoction of lavender, hyssop, etc., and are useful in some forms of hysteria and nervous disorders.

The so-called **Ozone Baths** are given with a strong decoction of sea-weed (sea-wrack) for rheumatism, etc.

In the **Electric Bath,** a current either faradaic, galvanic, or both combined, is passed through the water to the body or parts of the body. Dr. Hedley has shown that it may be conveyed through the stream of a douche (Lancet, i., 1892). Stimulating and eliminant effects may be obtained from it in some conditions of depression, paralysis, and rheumatism.

Mineral Waters and Baths.—These are waters containing such an amount of salts or gases in solution that they can be used for therapeutical purposes. In some cases the action depends very largely on their temperature. The saline constituents are chlorides of sodium, potassium, magnesium, lithium, calcium, and sometimes traces of iodides and bromides; carbonates and bicarbonates of sodium, lithium, calcium, magnesium, and iron, sulphates and phosphates of the same metals, and sulphides of sodium and calcium. Traces of manganese, silica, arsenic, and sometimes nitrates are occasionally present. The gases are chiefly carbonic acid and sulphuretted hydrogen, while oxygen and nitrogen from the atmosphere are always present.

These bodies are derived from the soils through which the waters pass, they are present in very different amount in different springs, and their absolute or relative quantity determines largely the actions and uses of individual waters.

PHYSIOLOGICAL ACTION.—Their action is the sum of that of their constituents, namely water, salts, and gases. Applied *externally* in the various forms of bath, they act like the plain water baths already described, with special powers of stimulating the skin, and indirectly the visceral circulation, or of quickening absorption and lessening pain.

Given *internally*, they act by promoting tissue-change, secretion, and excretion, and by diluting and depurating the blood.

THERAPEUTICAL ACTION.—Mineral waters are mainly used in *chronic* functional disorders, and in conditions of debility and convalescence, but are often beneficial also in the early stages of organic disease. In estimating their effects, allowance must be made for the change of climate and surroundings, and the more regular, simple, and quiet life of a spa; hence the drinking of imported waters at home will not give the same result as taking them at their source. Artificial waters made in imitation of the natural never give such good results.

Season.—The usual season for drinking mineral waters includes summer and autumn, *i.e.*, extends from May or June to September or October, and the duration of a course is from three to six weeks. Too prolonged continuance of the treatment is liable to do harm.

Dose and Mode of Administration.—It must be recognised that benefit is not derived in proportion to the quantity of water taken: at first only small quantities daily are desirable. Bathing and drinking should not be commenced on the same day. When the strength permits, early rising is advisable, so that the water may be taken before breakfast; it should be sipped slowly, and an interval allowed for a gentle walk between each glass. At certain spas it is the custom for invalids to drink eight, ten, or more glasses of water in the course of the morning promenade. This is a practice which should be strongly reprobated, and in certain cases has been known to produce Bright's disease; two or three glasses produce the desired effect; that of purgation equally well. The diet should be carefully regulated—it is usually

less generous abroad than in this country. As a rule, some physician resident at the spa should be consulted.

CLASSIFICATION.

Mineral waters are classified differently by different authors, but usually with direct reference to their chief ingredients. Braun, in his excellent treatise (edited by Dr. H. Weber, 1875), classifies "Mineral Waters" somewhat as follows:—

Class 1.—**Carbonic Acid Waters** comprise many of various character, more or less impregnated with this gas, which renders them easier of digestion, and *chemically* assists the solution of bicarbonates, *e.g.*, of sodium and iron. Their *medicinal* properties are, to lessen gastric irritability, to stimulate slightly the secretions of the stomach and of the kidneys, and to increase the peristaltic action of the intestines.

Baths in water bubbling with the gas are given with gentle and pleasant stimulating effects, at Schwalbach, Franzensbad, Tarasp-Schuls, etc.—but for drinking purposes, almost the only water of this class that is generally known is the Johannis, obtained from borings in the rock at Zollhaus, Nassau. This spring has all the appearance of boiling water—so great is the amount of carbonic acid gas constantly escaping: its odour is perceptible, and a lighted match placed over the water is extinguished: the analysis of the gas gives 98·98 per cent. of pure carbonic acid, and besides aerating the water, sufficient is given off to fill steel cylinders, when it is liquefied for export. Some iron contained in this water is precipitated before bottling.

Many other waters, though containing more or less of the same gas, find their place rather in the following classes, because of a more notable proportion of solid ingredients.

Class 2.—**Saline Waters.**

(*a*) **Alkaline Waters** (containing carbonate of sodium as a main ingredient) are such as those of Vichy and Neuenahr, Salzbrunn, Mont Doré, Bilin, Gieshübel, Apollinaris, etc.

(*b*) **Muriatic Soda Waters** contain in addition sufficient *chloride of sodium* to correct the dyspepsia or debility sometimes induced by a *pure* soda water, and are those of Luhatschowitz, Ems, La Bourboule, etc.

These and the preceding waters contain often free carbonic

acid, and may be warm or cold. They are ordered in cases of acid gravel, gout, venous stasis, and abdominal obstruction, in scrofulous exudations, in diabetes, and in chronic catarrh of the respiratory, gastric, or genito-urinary tract. In catarrh especially, waters containing chloride are to be preferred.

(*c*) **Bitter Waters** ("purging saline waters") containing sulphate of sodium and magnesium as chief ingredients are such as Friedrichshall, Hunyadi Janos, Püllna, Seidlitz, Epsom, Beulah Spa, Purton, Cheltenham, Leamington, Scarborough (*v.* pp. 231-3).

One or two wineglassfuls of these waters (preferably taken warm) act as mild saline purgatives. They are useful in habitual constipation, especially when this is connected with torpor or congestion of the liver; but if given too frequently, or in excessive dose, they are apt to bring on flatulence, dyspepsia, or intestinal catarrh in delicate subjects.

(*d*) **Compound Soda Waters** (containing sulphate of sodium in effective doses) are Carlsbad, Marienbad, Franzensbad, Tarasp, etc. (*v.* pp. 233-6). These are ordered in gout, gravel, diabetes, and catarrh, like the simple soda waters, and also more especially in dyspepsia, corpulence, jaundice, gall-stones, and hyperæmic enlargement of the liver, and in hæmorrhoids occurring in plethoric persons. These waters, if freely used, are markedly lowering in their action.

(*e*) **Common Salt Waters** include those of Homburg, Kissingen, Baden-Baden, Wiesbaden, Reichenhall, Kreuznach (*v.* pp. 236-43), Harrogate, etc. Some are cold, others warm, and are either drunk or used as baths.

These waters in moderate quantity are of benefit in dyspepsia and gastric and intestinal catarrh; also in constipation and early stages of abdominal plethora, and for hæmorrhoids and venous stasis occurring in thin depressed subjects; also in bone disease and scrofulous exudations, inflammatory effusions, and glandular and even fibroid tumours.

Strong salt springs (Droitwich, Hall, Ischl, Nauheim) are used as baths.

Class 3.—**Sulphur Waters,** which contain alkaline sulphides or sulphuretted hydrogen, are found at Aix-la-Chapelle and Aix-les-Bains, Weilbach, Barèges, Luchon, Cauterets, Harrogate,

Llandrindrod, Moffat, Lisdoonvarna, etc. (*v.* pp. 243-9). They are used for chronic syphilitic and scrofulous disorders, bronchial catarrh and phthisis, chronic hepatic congestion, chronic rheumatism, and metallic poisoning, such as that from lead or mercury. The digestive powers are liable to be taxed by a course of these waters, and more or less anæmia is apt to follow. Good meat diet is desirable whilst sulphur is being taken.

Class 4.—**Earthy Mineral Waters** (containing a relatively large proportion of lime).—Rehme, Eilsen, Leuk, Weissenburg, Wildungen, and many other waters, contain a small proportion of carbonates of calcium and of magnesium (*v.* pp. 249-52). The special springs named are used in vesical catarrh and uric acid concretions, in gouty and scrofulous exudations and skin diseases, also in bronchial catarrh and phthisis. Separate classes are made by some authors, *e.g.*, of the *iodo-bromated* waters at Kreuznach and Woodhall, and the *muriated lithia* waters of Baden-Baden.

Class 5.—**The Simple Thermal Waters** of Gastein, Wildbad, Schlangenbad, Buxton, etc., are used almost wholly in the form of *bath* in cases of rheumatism, chronic skin diseases, paralysis, and other nervous disorders (*v.* pp. 252-5).

Class 6.—**Chalybeate Waters,** those in which iron carbonate is the main ingredient, are such as Spa, Schwalbach, Tunbridge Wells, Driburg, Pyrmont, Harrogate. The sulphate occurs in springs at Brighton and at Sand Rock (Isle of Wight); the perchloride in a spring at Harrogate (Muspratt's).

These waters are used in chlorosis, direct anæmia, irregularities of menstruation, atonic conditions of the stomach and intestine, in general debility, and in various neuroses. Care is required to secure their due absorption without dyspepsia. The general rules for iron-medication are further indicated in the chapter on that remedy.

A knowledge of spas and mineral waters is so necessary in modern practice that a more detailed though necessarily brief account of the principal ones is subjoined.

CLASS 2 (*a*).—*ALKALINE WATERS.*

The principal spas with simple alkaline waters are:—*Hot:* Vichy, Neuenahr, Mont Doré, Chaudes Aigues, the last three

being feebly mineralised. *Cold :* Apollinaris, Salzbrunn, Vals, Le Boulou, Evian, Bilin, Fachingen, Geilnau, Wilhelmsquelle, Taunus, Gieshübel, Soulzmatt, and Marcolo.

Vichy, in central France, 780 feet above the sea, is situated on the River Allier, in a large open valley surrounded by vineclad hills ; the climate is mild, the season is from the middle of May to mid-September. The arrangements are on a magnificent scale, and the spa is the most frequented in Europe (Braun).

The springs used are nine in number, all clear, warm, and tasting more or less like soda water ; they contain from 36 to 39 gr. of bicarbonate of sodium in each pound (16 oz.), from 12 to 14 cub. in. of carbonic acid, and small quantities of chloride of sodium (4 gr.), of bicarbonate of potassium, and magnesium, and arseniate of sodium.

They may be used in any case in which strong alkaline waters are indicated, and either for bathing or drinking, or both. The *Grande Grille*, which has a temperature of 113° F., is in most repute, especially for hepatic disorders, the *Celestins* for urinary maladies, and the *Hôpital* for abdominal stasis and chronic enteritis. The *Hauterive*, four miles from Vichy, is cold, and contains an unusually large amount of carbonic acid. Cusset. two miles from Vichy, has also a thermal spring, the water of which is highly mineralised. One spring at Vichy is intermittent and contains sulphur, it is not however now used medicinally.

The most suitable cases for Vichy are those of uric acid gravel and calculus, gout, vesical catarrh, and chronic glycosuria. But besides these, a large number of other maladies are treated there with more or less success—such as dyspepsia, gastric catarrh, enlargement of liver and spleen, abdominal congestions, chronic metritis, and chronic rheumatism. The dose of the water is from half a pint to two pints daily.

Vals, in the south-east of France (Department Ardèche), is an important spa with cold alkaline springs, similar in composition to the waters of Vichy. The principal ones, *Précieuse*, *Désirée*, *Madeleine*, and *Rigolette*, contain rather more bicarbonate of sodium, carbonic acid, and iron. The two former, slightly laxative, are employed in gouty and renal disorders ; the two latter are more roborant. *St. Jean* is less alkaline, and is ordered

for dyspepsia; *Dominique* is arsenical. The waters of Vals and Vichy are largely exported, and keep well when bottled.

Neuenahr, in Rhenish Prussia, 300 feet above the sea, in the mild and beautifully-wooded valley of the Ahr, is easily reached from Cologne. It has excellent buildings and public gardens, and possesses a cold spring rich in carbonic acid, and four warm springs—93° to 104° F.—each containing about 9 gr. in the pound of bicarbonate of sodium, with a small proportion of calcium and magnesium, much carbonic acid, and very little chloride of sodium or iron.

Bilin, in Bohemia, and **Fachingen,** in the valley of the Lahn, contain strong soda springs, which, however, are but little used on the spot, though they are exported in large quantities. The water of Bilin contains 33 gr. of bicarbonate in the pound, with chloride 2 gr., and sulphate 6 gr., lime 4 gr., a trace of iron, and much carbonic acid, at a temperature of 53° F., and generally requires to be heated. That of Fachingen is very similar, but somewhat weaker. Both are used for severe cases of gravel, gout, and vesical catarrh.

The water of **Gieshübel,** near Carlsbad, contains a small proportion (10 gr. to the pound) of bicarbonate of sodium, with a large amount (55 cub. in. to the pound) of carbonic acid. It is pleasant and refreshing, and exerts a moderate antacid effect.

Apollinaris water, from a spring of that name, situated near Neuenahr, in the valley of the Ahr, contains about 10 gr. of bicarbonate, 3 gr. of chloride, 2 gr. of sulphate of sodium, and 3 gr. of magnesium carbonate, with a large amount of carbonic acid to the pound, so that it may be warmed without losing its pungency.

It is useful as a table water in irritable conditions of the stomach, and as a medicinal water in the lithic acid diathesis and gout; also in bronchial catarrh and tendency to gall-stones.

Salzbrunn, in Silesia, near Freiburg, situated in a wooded valley 1200 feet above the sea, has a fresh bracing climate, and has soda waters with about 18 gr. of bicarbonate in the pound (16 oz.). It has been called "the cold Ems," and has been especially recommended in bronchial catarrh and in early stages of consumption when Ems is not suitable. A much frequented establishment for the "whey-cure" and "moor-baths" is also to be found at Salzbrunn.

Mont Doré lies in a charming valley of the Auvergne Mountains, 3300 feet above the sea, and possesses a cold and several warm soda springs (106° to 108° F.). They contain only about 5 gr. of bicarbonate to the pound, but more chloride of sodium than those yet mentioned, also an excess of carbonic acid. The *Madeleine* is also arsenical. The spa is well provided with appliances for separate baths, douches, sprays, and inhalations, and has a reputation in chronic pulmonary catarrh and asthma, and in chronic hepatic congestion and rheumatism. "Most invalids employ warm bathing, the effect of which is to increase perspiration, and after some days to induce a 'bath fever,' with lassitude, constipation, etc., but this soon passes off." Dr. Emile Emond has published cases which illustrate the method adopted and the results obtained in the treatment of bronchial asthma at Mont Doré (Lancet, i., 1885): the internal use of the water is combined in these affections with the spinal douche. The general effect upon the system is sedative, and leads to the alleviation of nervous spasm. This water also has a reputation for benefiting and often curing emaciated broken-winded *horses* with bad coughs. Some of the resources of Mont Doré, including the water, which is imported, have been introduced into an English establishment of that name at Bournemouth (Lancet, i., 1886).

CLASS 2 (b).—MURIATIC SODA WATERS.

The chief muriated alkaline waters are:—*Hot:* Ems, Royat, and La Bourboule. *Cold:* Luhatschowitz, Selters, Gleichenberg, Roisdorf, Rosbach, Vic-sur-Cère, and Tonneistein.

Ems, near Coblenz, in the valley of the Lahn, 291 feet above the sea, is the oldest and most famous soda spring. It is conveniently reached from England, has excellent hotels, and English-speaking physicians. The valley is narrow, between high mountains, with attractive scenery, and possessing a mild climate. "There are few bathing resorts where a sick person may find in intercourse with nature and man, and in the enjoyment of a brilliant but unpretending spa-life, such rich opportunity both for coming out of himself, and for self-reflection. Ems is the pearl of Germany" (Braun). Cases of phthisis, however, should not be sent there, as by day the air is hot and still, and in the early autumn, mists at night and morning are frequent. The best

months are May and June, September and October. During July and August, when many English people go, the climate is likely to be found oppressive and relaxing. The mineral springs contain a medium amount of bicarbonate of sodium (10 gr.), and of carbonic acid (19 cub. in.), and of chloride (7 gr.), with very small amounts of calcium and magnesium.[1] The main difference between the springs is in temperature, the *Kranchen* being at 84° F., and the *Kessel* at 114° F. They are often given with goats' or asses' milk, and are used for chronic bronchial disorders with irritable cough but little secretion; in the dyspepsia of persons disposed to phthisis; and for eczema and prurigo; also for lithuria, though less often than those of Vichy.

The baths at Ems are much used. The well-known *Bubenquelle*, used as a warm ascending vaginal douche, has a reputation in inflammatory and engorged conditions of the uterus.

Luhatschowitz (in Moravia) is situated in a pleasant valley of the Carpathian Mountains, 1600 feet above the sea. The springs, four in number, are cold, and contain in each pound from 30 to 60 gr. of bicarbonate of sodium, 20 to 30 gr. of chloride, with traces of iodide and bromide of sodium, and a large amount of carbonic acid. "They are the ideal of strong carbonated muriatic soda waters," and are valuable in severe catarrhal conditions, especially in chronic gastric catarrh, and in abdominal congestions and gouty exudations. In cases of hyperæmic enlargement of the liver, they even come into competition with Carlsbad water, and in cases where the strong soda waters of Vichy, Bilin, etc., have failed in their effect, it is well worth while to try a water containing more chloride; this salt increases the effect of the carbonate. Whenever tissue-change is to be increased, and at the same time tissue-growth promoted, and the gastro-intestinal secretions stimulated, soda waters containing common salt are to be preferred.

La Bourboule, in the Auvergne district, 2600 feet above the sea, has five springs of different temperatures (varying from 82° to 140° F.), all containing carbonate and chloride of sodium, and appreciable quantities of arsenic, but in different proportions;

[1] In this and all the following analyses the quantities are calculated for a pound of water (16 ounces).

they also contain a large amount of carbonic acid in solution. These waters are recommended in cases of scrofula, diseased bone, rheumatism, asthma, and rickets.

Royat, in the same district, with the town of Clermont-Ferrand about a mile and a half from it, is very rich in hot mineral springs. In addition to the chloride and bicarbonate of sodium, there are also small quantities of lime and iron. These waters are especially useful in cases of anæmia, scrofula, and rickets (Lancet, ii., 1887).

CLASS 2 (c).—BITTER WATERS.

The waters included under this head are those of Friedrichshall, Hunyadi Janos, Püllna, Seidlitz, Galthof, Saidschütz, Birmeusdorf, Iwanda, Aranjuez, Bergentheim, Epsom, Beulah Spa, Purton Spa, Cheltenham, Leamington, Scarborough.

The Friedrichshall water, which is largely imported from a spring in Saxe-Meiningen, contains, in a pound, sulphate of sodium 46 gr., sulphate of magnesium 39 gr., chloride of sodium 61 gr., chloride of magnesium 30 gr., and sulphate of calcium and potassium, with a small amount of carbonic acid (Liebig). This water is useful in small non-aperient doses for promoting tissue-change, and in aperient doses is frequently prescribed for habitual constipation, hepatic congestion, abdominal plethora, etc.

The Hunyadi Janos waters contain in sixteen ounces 138 gr. of sulphate of magnesium, 129 gr. of sulphate of sodium, with 11 gr. of chloride, and 13 gr. of carbonate of sodium. They are used in the same class of cases as those last mentioned, but are more active and are rather less unpleasant to the taste; the same observation applies to Æsculap and Franz Josef.

Püllna water is of the same character, but intermediate in strength between Friedrichshall and Hunyadi Janos, containing 123 gr. of sulphate of sodium, and 93 gr. of sulphate of magnesium, some magnesium carbonate and chloride of sodium.

Seidlitz contains no sulphate of sodium, but 104 gr. of sulphate of magnesium.

The once famous **Epsom** well contains in the pound 240 gr. of sulphate of magnesium, to which it has given its name.

The Beulah Spa (Norwood) contains 61 gr. of Epsom salt, with 9 gr. of sodium sulphate, and some chloride.

The Streatham and **Kilburn Wells** resemble the Beulah Spa.

Purton Spa, near Swindon, has 23 gr. of each sulphate, together with chloride, calcium sulphate, and some carbonic acid (which is deficient in most waters of this class); also traces of bromides, iodides, and sulphuretted hydrogen. This water is used as an "alterative stimulant" in strumous sores and enlarged glands, threatened consumption, hepatic disorders, rheumatism, chronic skin disorders, and uterine derangements. Half a pint to a pint of the water is taken before breakfast, and another half-pint in the evening. The air of the place is dry and bracing.

Cheltenham possesses saline springs of several qualities. That of the *Royal Old Well*, first noted for the cure of George the Third, contains chiefly chlorides of calcium, sodium, and magnesium, with sulphate of soda and a little carbonic acid.

The Pittville Saline contains an unusual proportion of *silica*. *Spring* No. 4, *Montpellier*, contains a large amount of common salt (52 gr. in the pint), with 17 gr. sulphate of sodium, and 14 gr. of magnesium, but is deficient in carbonate of sodium and carbonic acid. This might be remedied, as Dr. Macpherson suggests, by adding a certain quantity of Bilin or of Vals water, and the temperature might be graduated, and very useful results again obtained from these waters. The *Montpellier* baths are well arranged, and include vapour douches and medicated vapour baths.

In winter the mild and equable, though rather moist climate, would give an advantage over more distant spas. By the Cotswold Hills the town is sheltered from N. and E. winds. The season is from mid-April to October.

At **Leamington** the saline spring *Old Well* contains in the pound 40 gr. of sodium sulphate, 40 gr. of sodium chloride, 20 gr. of calcium chloride, 3 gr. of chloride of magnesium, traces of bromine and iodine, and 2 cub. in. of carbonic acid; also nitrogen and oxygen; temperature, 48° F. These waters are alterative, and are slightly aperient, more active than those of Cheltenham, and hence suitable for invalids of "torpid habit." I have used them with advantage in hepatic derangement.

The town is clean and pleasant, less protected by hills than

Cheltenham, and hence the air is rather colder and more bracing; it is humid, but not raw.

At **Scarborough** the *South Well* contains 28 gr. of sulphate of magnesium with 13 gr. of sulphate and 6 gr. of calcium carbonate, some common salt, and a trace of iron. The amount of lime is rather too large for cases requiring purgative waters.

CLASS 2 (d).—COMPOUND SODA WATERS.

The principal waters of this kind as those of Carlsbad, Marienbad, Franzensbad, Tarasp-Schuls, Elster, and Bertrich. The constitution and action of the waters of Carlsbad and Bertrich are modified by their temperature.

Carlsbad, in Bohemia, situated on the banks of the Tepl, in a narrow wooded valley 1200 feet above the sea, is one of the principal, as it is the oldest of German spas. The season is from the end of May to the end of September; at other times the climate is "rough," often damp, though in May it is often not more than fresh and bracing. Amongst the advantages of Carlsbad, Braun reckons the careful diet, and amongst the disadvantages, "an excessive use of coffee" (B. M. J., ii., 1887; i., 1888). The valley is rich in warm springs, which differ little in their fixed constituents, though much in their temperature and gaseous contents. The *Sprudel*, which forms a fountain several feet high, giving off clouds of vapour, has a temperature of 164° F., contains 11·8 cub. in. carbonic acid, and sulphate of sodium 18 gr., chloride 7 gr., carbonate 10 gr., with a little lime, magnesia, and iron. The *Schlossbrunnen* at 124° F. contains 17 cub. in. carbonic acid. The *Markbrunnen* at 130° F. contains in addition some iodide and bromide of sodium.

Carlsbad waters are efficacious in several forms of dyspepsia, *e.g.*, when gastralgia and flatulence occur principally after meals, and when catarrhal conditions of the stomach or intestine are present, and morning vomiting, or diarrhœa alternating with constipation. For corpulence, with its various troubles, they are a tolerably sure and gentle remedy, independently of violent evacuations. In jaundice, and a tendency to gall-stones and allied conditions, the waters diminish the inflammation and tumefaction in the gall-ducts, and thus enable calculi to pass more easily. In hepatic and splenic enlargement following malarial fevers, especi-

ally if constipation be marked, and in passive hyperæmia of the portal system and abdominal viscera occurring in stout florid persons with a tendency to hæmorrhoids, and generally sluggish venous circulation, Carlsbad waters are very effective. "Old Indians with enlarged livers often derive remarkable benefit." The hypochondriasis dependent more or less on the above-named conditions is also relieved. In gout and gouty conditions without much affection of the joints, especially in patients with abdominal plethora and commencing atheromatous change in the vessels, in rheumatoid arthritis, sciatica, and in the tendency to uric acid concretions and consequent catarrhal affections of the urinary organs, Carlsbad waters are often quite as useful as the stronger alkaline waters. In cases of the *slower* and *milder* form of diabetes, the use of Carlsbad waters has rapidly and considerably diminished the excretion of sugar, and after some months has effected great improvement in the general condition in many instances. Even in serious cases, provided that they are not very acute and rapid in their onset, and not accompanied by phthisis, the same waters have often effected an improvement, and checked the progress of the disease.

In these observations I find myself in agreement with Seegen, Kraus and Braun, and have only to add that the course at Carlsbad need not, and should not, be so conducted as to "purge, lower, and starve" the patient. We sometimes hear complaints of the depression and debility induced, and certainly an excessive use of the waters is very lowering, but effective therapeutical results may be obtained without this. The diet, though restricted, should be nourishing, exercise moderate, not exhausting, and mental and bodily rest for some time after the treatment is very desirable. Baths of the cooled mineral waters are often beneficial, but are less used now than they formerly were.

Carlsbad waters are largely exported, as also are the natural salts. Some patients seek to imitate the method of treatment with early rising, walking before breakfast, and drinking the water during their walk. The results thus obtained are often beneficial, but cannot compare in usefulness with a visit to the place itself.

Marienbad, also in Bohemia, and about five hours' drive from Carlsbad, is situated in a broad and beautiful valley, about

1900 feet above the sea. The air is not mild, but is pure and dry, "and colds are less often taken here than at Carlsbad." It is also quieter and less crowded and is more frequented by ladies. The season begins somewhat earlier, viz., at the beginning of May, and it lasts until the end of September. Marienbad is the principal representative of cold gaseous sulphate of sodium waters, and the springs most used, the *Kreuz* and the *Ferdinandsbrunnen*, are stronger than the Carlsbad springs, and contain more free carbonic acid. They are more aperient, and given therefore in smaller doses (one to six tumblerfuls), or to patients who need more purging. In other respects, and excepting in diabetes, these waters are used like those of Carlsbad. They contain some iron, which, however, is not of importance, unless in the *Kronprinz-Rudolf* spring.

The *Carolinen* and *Ambrosius* springs are gaseous, weak in saline constituents, but containing some iron. The *Marienbrunnen* is used for drinking as well as for water and carbonic acid baths. The *Moor* or *mud baths* at this Spa are also in request, and are prepared with black mineral powder brought from a neighbouring peat-bed. The *gas baths* relieve myalgic and neuralgic pain, and soothe the *general* nervous system, while they stimulate that of the uterus; the *mud baths* stimulate the skin and promote the healing of ulcerations, and the absorption of glandular swellings.

Franzensbad, near Eger, in Bohemia, 1300 feet above the sea, has a fresh climate and good arrangements. The waters resemble those of Carlsbad, but are colder, and have more carbonic acid, and also more sulphate of soda (18 to 27 gr., with chloride, carbonate, and some iron). The treatment at this spa has always been milder and more stimulating than at Carlsbad, and better adapted for anæmic, weak, thin, and perhaps hypochondriacal or hysterical subjects. In such cases, and especially in women who have become anæmic with spinal irritation and uterine disorder, benefit is obtained here when stronger and more pronounced chalybeates would not agree. Digestion is promoted, the nervous system strengthened, and the circulation stimulated.

Mud and gas baths are also much used here, and are beneficial in chronic skin disease and ulceration, rheumatism, gouty deposits, and paralyses when no active central disease is present.

Tarasp, in the Lower Engadine, Canton Grisons, situated on the River Inn, amidst fine Alpine scenery, 4000 feet above the sea, has recently risen into fashion, and is one of the most interesting and valuable spas. The rarefied pure air acts as a powerful stimulant or tonic, and is perhaps more therapeutic in its action than the water, and the summer climate is temperate and pleasant, whilst the conditions of life are much more simple than at Carlsbad, Vichy, Marienbad, etc. The ingredients of the waters are the same as those of Franzensbad, Marienbad, or Carlsbad ; the chief springs are the *great*, or *St. Lucius*, spring, and the *little*, or *St. Emerita*, spring, having 16 gr. of soda sulphate, 29 gr. of chloride, about 40 gr. of bicarbonate, 17 gr. of lime, 7 gr. of magnesia, an effective proportion of iron, and a large amount of carbonic acid. The carbonic acid which bubbles from the water renders a bath in it exceedingly refreshing and pleasant.

The neighbouring village of Schuls has waters with the same properties as those of Tarasp.

These are used in the cases already described as suitable for Carlsbad and Marienbad, except that there is not yet an equal experience as to diabetes ; on the other hand, cases of bronchial catarrh, and even of tuberculosis in an early stage, and especially when complicated with hepatic troubles, have derived much advantage at Tarasp.

CLASS 2 (e).—COMMON SALT WATERS.

The waters under this head are the following : In Germany—Homburg, Kissingen, Baden-Baden, Wiesbaden, Reichenhall, Kreuznach, Rehme (Œynhausen), Nauheim, Soden, Pyrmont (which contains iron springs as well), Hall in Austria, Hall in the Tyrol, Hall in Würtemberg, Ischl, Kreuth, Dürkheim, St. Gervais, Salzungen, Canstatt, Cronthal, and several others. In France — Bourbonne-les-Bains, Lamotte-les-Bains, Balaruc, Salins. In Italy—Ischia, Castellamare, Monte Cattini, La Porretta. In Switzerland—Bex. In Great Britain—Droitwich, Nantwich, Middlewich, Woodhall, Harrogate, and Crieff. Leamington and Cheltenham contain also much common salt in addition to sodium sulphate.

Homburg, about nine miles from Frankfort, pleasantly situated on the southern slope of the Taunus Mountains, 600 feet above the sea, has a fresh and bracing climate even in the summer, though the growth of trees and of houses has made some portions less fresh. The *Elizabethbrunnen* (the most-used spring) contains 75 gr. of chloride of sodium, the *Kaiserbrunnen* 55 gr., whilst both have also other alkaline chlorides, lime, magnesia, a little iron, and much carbonic acid, at a temperature of 50° F. (cold). The *Ludwigsbrunnen* contains only about half the amount of chlorides, and the *Luisenbrunnen* scarcely any calcium or magnesium.

The two springs first named are stronger than those of Kissingen, and are given in doses of two to four tumblerfuls in cases of dyspepsia and gastro-intestinal catarrh, constipation, strumous glandular enlargement, gout, obesity, hypochondriasis, etc. The *Luisenbrunnen* is "very suitable for anæmia and Indian cachexia."

Kissingen, about thirty miles from Würzburg, and 600 feet above the sea, in the pleasant valley of the Saale, is the main representative of cold, moderately-strong gaseous salt springs, and is one of the most fashionable watering-places of Germany. The principal springs are the *Ragoczi*, the *Pandur*, and the *Maxbrunnen:* the latter is a very weak salt water; the other two are nearly equal in strength, containing more than 40 gr. of chloride of sodium with small quantities of other alkaline chlorides, 4 gr. of sulphate of magnesium, 2 gr. of lime, a trace of iron, and much carbonic acid (40 to 48 cub. in.); the temperature is 51° F. (cold). The *Ragoczi* is generally taken in the morning (three to six glasses); the *Pandur*, being somewhat milder, in the evening. They quicken the circulation, alter and stimulate the gastro-intestinal secretions, and are valuable in dyspepsia, with eructations, flatulence, and constipation, in some gouty and calculous cases, in moderate degrees of hepatic and renal congestion, in strumous and tubercular enlargement of glands, etc.

In prescribing salt springs for cases of chronic dyspepsia, we should bear in mind that, as a rule, they are best taken *cold*, because a high temperature counteracts the intended irritant effects, and causes too rapid absorption of the salt. They are unsuitable for cases of excessive acidity which is increased by

chlorides. The water should not be concentrated, and the dose should be small, and carbonic acid much assists its digestion. On the other hand, in some cases of gastric catarrh, the cold waters are not well borne, and then recourse is had to the *warm* spring of Wiesbaden. The strong salt bath of the *Soolsprudel* is much used, but Braun objects to the large amount of carbonic acid given off from it and inhaled by the lungs, as being apt to cause giddiness and dyspnœa.

Wiesbaden, capital of the former Duchy of Nassau, is 323 feet above the sea, and is situated beautifully on the southern slope of the Taunus Mountains, five miles N.W. of Mayence. The climate here is mild, in winter being one of the warmest in Germany, in spring and autumn usually fine, but at midsummer hot and relaxing. The season is from June till September. The principal spring is the *Kochbrunnen*, which rises like a boiling well, at 150° F., emitting clouds of steam. Its constituents are similar to those of the Kissingen *Ragoczi*, viz., chloride of sodium (52 gr. in the pound), carbonate of calcium (3 gr.), and traces of potassium, magnesium, iron, etc. The amount of carbonic acid is much less (6 cub. in.); the temperature much higher. The amount of chloride is slightly greater than that at Kissingen, but yet larger doses of the water can be taken, and increased intestinal secretion less often occurs from it. Hence, if the gastric condition does not especially need the stimulus of cold, the warm spring is to be preferred when the strong effect of salt on the blood is desired. Dr. E. Pfeiffer from experiments on himself found that the Wiesbaden waters produced an increased secretion of urine, much more than could be simply explained by the larger quantity of water ingested. This increase of urine, with which is associated increase in the amount of urea excreted, is especially noteworthy if the water be taken in one dose in the morning (Record, 1882).

In cases of chronic inveterate gout which we can scarcely hope to *cure*, but which we can benefit by moderate increase of tissue-change whilst keeping up nutrition, these springs are most useful; also, in chronic eruptions with hepatic and abdominal congestion, and in chronic rheumatism, in which disorder and in chronic paralyses the warm saline baths are specially indicated.

They may be injurious in debility, in uterine congestion, and in tendency to apoplexy or other hæmorrhagic conditions.

At Wiesbaden there are also hydropathic establishments, and the ophthalmic hospital of Dr. Pagenstecher.

Baden-Baden, 616 feet above the sea, is situated in a beautiful valley of the Black Forest, six miles from the Rhine. The air is pure and mild, so that baths can be taken late in the autumn, and the season is from the beginning of May until October. The general arrangements are agreeable, and the influx of visitors very large. Of the numerous springs only the *Ursprungquelle* need be mentioned. It contains 18 gr. of chloride of sodium, and 2½ gr. of calcium sulphate, with traces of iron carbonate, but very little free carbonic acid.

Gout and rheumatism of only moderate severity, dyspepsia and impaired nervous condition from overwork, etc., various manifestations of the scrofulous diathesis, are all favourably influenced by the waters of Baden-Baden, which are taken internally and used as baths.

Soden, in Nassau, near Frankfort, 440 feet above the sea, contains many tepid salt springs varying in their proportion of chloride from 18 to 109 gr.; the amount of carbonic acid is rather large.

The climate is mild, equable, and moist, but very hot in summer. Besides being suitable for the class of cases already mentioned, Soden has a special reputation in chronic catarrhal conditions, with or without tendency to phthisis. Near at hand, at Kronthal, are good chalybeate springs, and the bracing health-resort of Falkenstein, which is 1700 feet above the sea, well wooded and sheltered from excessive sun and wind, and forming a good residence both in winter and summer for the earlier stages of phthisis.

Reichenhall, in Bavaria, lies in a sheltered position, near fine Alpine scenery, and has a mild climate, at its best in May and autumn—rainy in the summer. Of its salt springs, the *Edelquelle* is one of the strongest in Europe, containing 23 per cent. chloride of sodium, temperature 57° F. The waters are used in warm, tepid, douche, and wave bath, and also by inhalation, patients walking between large hedges, 40 feet high, made of twigs, on which the salt water trickles and evaporates; the air of a large room is also kept impregnated with salt spray, and the breathing of such air for a limited period daily is found useful in catarrhal

conditions of he chest and stomach (Burdon Sanderson, Pract., i.). There are similar chambers at Kreuznach, Rehme, and a few other places.

Kreuznach, in Rhenish Prussia, pleasantly situated in the Nahe Valley, 286 feet above the sea, "is the chief of sool baths" (Braun).

The climate is mild in the early spring and late autumn, hot in the summer; the season extends from the end of April until the beginning of October. The *Elisenquelle*, or *Elizabethbrunnen*, contains 73 gr. of chloride of sodium, 13 gr. chloride of calcium, 4 gr. chloride of magnesium, traces of potassium, lithium, iron, and minute quantities of bromide and iodide of magnesium. There is some carbonate of calcium but no sulphate; no carbonic acid. Temperature, 54·5° F.

The water of the *Carlshalle* and *Theodorshalle* is weaker, the chloride of sodium being 59 gr. and 57 gr. respectively, whilst the *Oranienquelle* has 108 gr. of the sodium salt, and 22 gr. of chloride of calcium. The waters, which are bitter and rather nauseous, should be commenced in small doses, and are often taken with hot milk. The *Elisenquelle* readily acts on the bowels.

The warm baths at Kreuznach are used particularly strong, concentrated brine, or "mother-lye," being often added to the natural water, and the bath being prolonged for half an hour or an hour. This "mother-lye," according to the degree of its inspissation, contains in each pound from 100 gr. to more than 200 gr. of chloride of sodium, from 1000 to 2000 gr. of chloride of calcium, from 200 to 300 gr. chloride of magnesium, 130 to 160 gr. chloride of potassium, some iodide of sodium, chlorides of lithium and aluminium, and about 60 gr. of bromide of sodium.

The justly-esteemed Kreuznach system of treatment combines the use of these strong baths with injections, douches, etc., and drinking of the water—in small quantities, if a generally stimulating effect is desired, but in large doses for the absorption of scrofulous and other exudations. I have seen much advantage from it in congestion and chronic inflammation of the uterine system, in hypertrophy and induration of the uterus itself, and of the mammary gland, and in painful irregular menstruation connected with ovarian hyperæmia. It relieves, also, the local congestion and œdema commonly associated with uterine fibroma,

and I believe that it even procures, sometimes, the absorption of such growths to some extent.

Chronic eruptions and scrofulous ulcerations also receive benefit from Kreuznach water, and the local use of the "mother-lye" to distorted gouty joints has sometimes given me good results.

Braun compares with Kreuznach the more recent spa of **Rehme** (Œynhausen), which is situated 134 feet above the sea, "in a broad and fertile valley watered by the Weser and the Werre," on the railway between Minden and Cologne. The climate is fresh but mild, and is less changeable than that of many other places; the water is very rich in chloride (240 gr.), and contains also sulphate; it is used principally in the form of warm bath, and differs from the Kreuznach bath mainly in the large amount of carbonic acid it contains. There are also carbonic acid baths, a "wave bath" in the river under the mill, and a large chamber filled with salt spray for inhalation.

Rehme is suitable for the same kind of cases as are sent to Kreuznach, but in a less advanced stage, and when the subjects are weaker, and too delicate for the stronger methods of the latter spa. Benefit is said to be obtained from the baths specially in retarded convalescence after fever, fractures, etc., in general debility, anæmia, tabes dorsalis, spinal irritation, and even in spinal meningitis and paralysis. The spray is useful in catarrhal conditions of the respiratory tract.

Kreuth should be mentioned as an example of a highly-situated salt spa, being nearly 3000 feet above the sea, amidst Alpine scenery, two hours from Munich and beyond the Tegernsee. It is sheltered, and possesses a pure, rather moist, and particularly *still* atmosphere; this and the height constitute it rather a "luft-cur" (air-cure); it is closed in winter.

There is no village, only a large "Kurhaus," a "whey-cure," and strong salt and also sulphur baths. The drinking springs contain mainly sulphates, or sulphur. Cases of gout and of irritable mucous membranes of scrofulous or tuberculous character are often benefited at this place.

The baths of Lavey near St. Maurice, in the Rhone Valley, are much frequented by the French and Italians. They contain

chloride and sulphate of sodium; there are also hot sand baths and river baths.

Bex, in the Canton Vaud, 1380 feet high, with a mild refreshing climate, except in the hot summer months, possesses a fine thermal establishment with wooded grounds, and a strong lixiviated sool, which is diluted for bath use. It resembles Droitwich in being close to salt mines.

St. Gervais, on the route from Geneva to Chamouni, possessed alkaline and intermittent sulphur springs, and was of much repute in France, especially for gouty and other forms of cutaneous disease. The establishment was destroyed by a torrent last year, but its re-establishment is proposed, and the village on the higher ground is still used as a "luft-cur" for its mountain air.

Droitwich is a small salt-manufacturing town, six miles north of Worcester, and fourteen from Malvern. The climate is mild and equable, rather relaxing, and though the place itself is uninviting, there is fine open country in the immediate neighbourhood. There is now good accommodation for bathing, and an establishment close to the waters under the direction of Mr. Bainbrigge.

The proportion of saline ingredients is very high—far higher indeed than at any other known spring, there being about 2500 gr. chloride of sodium, 38 gr. calcium sulphate, and 39 gr. sodium sulphate in each pound (D. T. Taylor). Used for bathing at about 95° to 112° F., these waters are stimulating and absorbent, and are very serviceable in relieving pain and exudations, and impaired power connected with chronic rheumatic and gouty conditions; also in lumbago and sciatica, in some chronic skin eruptions, in glandular scrofulosis, general debility after illness, etc., especially when this is associated with slow circulation and mental depression; serous effusions are also absorbed under their use, and they are said to have proved a powerful stimulant and restorative during the cholera epidemic of 1831. Strong brine baths can be used at a high temperature without the exhaustion and debility that follow an ordinary hot bath. Dr. Roden states that the best results are obtained from the water when it is diluted two or three times, before being used as a bath. The patient sweats a great deal on the portions of his body which are not submerged; for instance, over the head. Languor is felt for an hour or so after a bath; this is followed by a feeling of exhilaration, accompanied

by an excellent appetite. Dr. Roden also speaks very positively concerning the absorption of local gouty deposits during a course of baths at Droitwich; possibly, he thinks, due to the actual chemical influence of the water on the concretions.

Woodhall Spa (Bromo-iodine), in Lincolnshire, has a dry and bracing climate, and is sheltered from north and east winds; there is a good hotel in the grounds, with excellent baths and good lodgings in detached houses, well suited for invalids. The water contains a good proportion of sodium chloride (120 gr. in the pound), 21 gr. of calcic and other chlorides, and also about $\frac{1}{2}$ gr. of bromide, and $\frac{1}{2}$ gr. iodide of sodium.

It is used in scrofulosis, and tubercular disease, also in chronic gout and rheumatism; half a pint of it acts as a mild aperient; the salts are crystallised and exported.

Mr. Williams reports satisfactory results also in cases of chronic skin disease and uterine fibroids, etc., such as are usually sent to Kreuznach, the waters of which spa it will be seen are similar.

There is a saline spring at Harrogate, somewhat similar to one at Kissingen, and called the "Kissingen water." It has more lime and less carbonic acid, and is moderately aperient. Most of the sulphur waters also contain a large proportion of chloride.

CLASS 3.—SULPHUR WATERS.

Under the true sulphur waters are included those containing sulphuretted hydrogen, or the sulphides of sodium, calcium, potassium, or magnesium. Thermal springs are Eaux-Bonnes, Eaux-Chaudes, Panticosa, Cauterets, Saint Sauveur, Barèges, Bagnères de Luchon, Ax, Escaldes, Vernet-les-Bains, Amélie-les-Bains, Uriage, Allevard, Aix-les-Bains, Aix-la-Chapelle, Baden in Austria, Baden in Switzerland, Lavey, Schinznach, Battaglia, Abano, Mehadia (Hungary), and Helouan (in Egypt). Cold sulphur springs are Eilsen, Neundorf, Langenbrücken, Weilbach, Meinberg, Reutlingen, Enghien, Challes, Stachelberg, Heustrich, Gurnigel, Harrogate, Llandrindod, Builth, Llanwilid, Moffat, Strathpeffer, Lisdoonvarna.

Some of these springs, such as Aix-la-Chapelle, Uriage, and Baden (Swiss), contain a considerable proportion of common salt,

which must be taken into consideration in an appreciation of their effects.

The sulphur baths of the Pyrenees have been famous from an early period. Most of them are natural baths (Wildbäder), in high mountainous situations, and with a rough climate.

Eaux-Bonnes, department Basse-Pyrenées, 2300 feet above the sea, situated in a narrow sheltered ravine at the foot of the Pic du Gers, about twenty miles from Pau, is rich in grand natural beauties, and has a remarkably pure fresh climate, though it is subject to great changes of temperature during the day.

The waters contain 0·18 cub. in. sulphuretted hydrogen to the pint, with but 2 gr. chloride of sodium, and 2 gr. of other salts, sulphates, and iodides, at a temperature of 90° F.

The dose at first taken is but small, often a tablespoonful, but this is increased gradually to a pint or more, and the good results are said to be so remarkable in tuberculosis and pneumonic consolidation of the lung, in asthma, granular pharyngitis, pleuritic effusion, and scrofulous deposits, as well as in chlorosis, amenorrhœa, and atonic dyspepsia, that many physicians "have supposed the cures to be due to some as yet unknown element in the otherwise very poor water." The high situation of the spa is probably a main agent in its action. The season lasts from June to mid-September, and residence is usually arranged for a month at a time during one or two seasons. Bathing is not much practised, but the patient is recommended to live as much as possible in the open air, and to complete the treatment by a course of sea-bathing at Biarritz.

Eaux-Chaudes, situated four miles farther on in the same valley, has waters containing sulphide of sodium, sulphate of calcium, etc., which are used more for baths than for drinking, in muscular rheumatism, neuralgia, and chlorosis.

Panticosa, in Aragon, a day's journey from Eaux-Chaudes, is situated in a valley of the Pyrenees, nearly 6000 feet above the sea. The waters contain much sulphuretted hydrogen, with chlorides and sulphates; they increase the secretions and the appetite, without stimulating the circulation. They relieve the cough of laryngeal phthisis and bronchial irritation, and are suitable for cases of hæmoptysis, but not for softening tubercle. The best months are July and August.

Cauterets, department Hautes Pyrenées, 3200 above the sea, in a narrow winding valley, has a pure and fresh, but rather variable climate. It contains more than thirty warm saline sulphuretted springs, some of which are highly stimulating, and give rise to feverishness and headache. The *Raillère,* which is famous for the cure of chronic bronchial catarrh, contains in one pound only 0·10 gr. sulphide of sodium, 0·3 gr. sulphate of sodium, 0·3 chloride of sodium, 0·4 gr. silica, nitrogen, and traces of sulphuretted hydrogen, but the water is very warm (102° F.). It is used both internally and for bathing, and sometimes gives strikingly good results in early stages of phthisis and strumous deposit, in gastric catarrh, uterine congestions and fluxes, also in chronic rheumatism and skin diseases. Animals, especially horses, with catarrh or abnormal discharges, are also benefited at Cauterets. July, August, and September are the best months.

Barèges, department Hautes Pyrenées, 4000 feet above the sea, with a bracing rough climate, is "the most famous of Pyrenean spas." The sulphurous stimulating waters are hot (107° F. *Bain de l'Entrée*), warm (98° F.), and tepid (84°). They are limpid, have an oily nauseous taste, characteristic odour, and contain nitrogen and sulphuretted hydrogen, with small quantities of sulphide, sulphate, and chloride of sodium, etc. On their surface is found a gelatinous pellicle called *barègine* or *glairine,* which is a nitrogenous organic substance, found in most sulphur waters, emollient, and supposed to be efficacious in chronic rheumatism. Sufferers from this complaint, and from sciatica, lumbago, and stiffness of the muscles and tendons, visit Barèges in large numbers; it is celebrated also in paralysis, in strumous ulcerations, and especially in bone disease and old gun-shot wounds. The swimming-baths are much used, and the waters are taken internally. They are not suitable for "irritable nervous subjects, nor in heart disease, nor tendency to inflammatory disorder" (Tanner). The season extends from early in June to mid-September. In July and August the crowding is sometimes so great that "invalids must leave their beds soon after midnight for their turns at the baths, and the air in the 'piscines,' from the small space allowed to each bather, is almost intolerable" (H. Weber); it has now become a military lazaretto.

Saint Sauveur, four miles from Barèges, has similar, but

milder waters, which are much used by women and children for hysteria, neuralgia, leucorrhœa, and uterine derangements—"pre-eminently the French ladies' spa" (Braun). The season begins earlier, and lasts later than at Barèges.

Bagnères de Luchon, department Haute Garonne, 2000 feet above the sea, is charmingly placed in a broad valley, close to splendid scenery, enjoys a mild climate, has excellent arrangements for recreation and abundant sulphurous water, double the strength of those already mentioned. There are about fifty springs, varying in temperature from 63° to 132° F., and containing sulphide and sulphate, sulphite, and chloride of sodium, other sulphides, silica, lime, etc. Analysis detects only traces of sulphuretted hydrogen in the waters at the springs, but almost as soon as drawn they become milky on account of some decomposition with development of this gas, and so much of it escapes from the large bath that the atmosphere above it contains more than 1 per cent. They are used in the same cases as Barèges and Cauterets.

Aix-les-Bains, in Savoy, near Chambéry, 790 feet above the level of the sea, in a sheltered picturesque valley of the Alps, is a celebrated watering-place—the Agnæ Gratinæ of the Romans—greatly resorted to for its sulphurous springs, which are often of much value in chronic rheumatism, gout, neuralgia, and some skin diseases, as well as in paralysis. The temperature of the waters varies from 100° to 117° F.; they are chiefly employed for baths, the douche being most in use. The hot water is made to fall in streams from a height of about 8 to 10 feet upon the patient, whilst being massaged; afterwards he is wrapped in blankets, sent home in a sedan-chair, and then put to bed for further perspiration. The climate is mild and relaxing, but hotels are now built on higher levels where the air is more bracing. During the season the place is often unpleasantly crowded; the course though effective is weakening and should be followed by mountain air for a time.

Aix-la-Chapelle, 534 feet above the sea, is the principal German sulphur bath. "The amount of sulphuret of sodium in the springs is small compared with the Pyrenean baths, but the sulphate of sodium is rather more, also the sulphuretted hydrogen, and in addition, there are 20 gr. of chloride and 5 gr. of carbonate

of sodium, with traces of iodides and bromides. This combination is of much importance for drinking" (Braun). The temperature of the water taken internally is often 130° F.

Warm baths (95° F.), prolonged from half to three-quarters of an hour, are also much used at Aix, with vapour baths, douches, and frictions, and the results of the combined treatment are very satisfactory in rheumatism, gout, chronic eruptive disorders, acne, psoriasis, and abdominal plethora; they are often good, though not so markedly in paralysis, metallic poisoning, and chronic syphilis, but Braun throws scientific doubt upon the supposed special efficacy of the sulphur in these maladies, and connects the therapeutics more with the temperature and the amount of saline liquid. Mercury is also commonly used in the treatment of syphilis at Aix, not internally, but by inunction of mercurial ointment, from 1 to 1½ dr. being used daily after a warm bath. The value of the baths and water in the treatment of this disorder lies in their (1) increasing the specific action of mercury; (2) preventing salivation and other injurious effects of the drug; keeping the skin in an active state, the glands secreting, and the pores free. The patients are directed to live well, eat freely of animal food, drink wine, and to be constantly in the open air. Rheumatoid arthritis is also treated with some success at Aix. The season begins early in June, and ends in September. As the treatment is highly stimulating, it is not suitable for apoplectic and hæmorrhagic cases.

Weilbach, in the Prussian province of Nassau, in the valley of the Main, on the eastern slope of the Taunus range, has a good sulphurous spring for internal use, the quantity of sulphuretted hydrogen amounting to 0·16 cub. in. Carbonic acid is also present; the amount of salts is small, a few grains only of chlorides and carbonates of sodium, magnesium, and calcium. "The life here is quiet and almost solitary." This spa is specially indicated in some cases of lung disease, catarrhal or tubercular, when hyperæmic enlargement of the liver exists, or congestion of the abdominal viscera with hæmorrhoidal tendency, and it will sometimes relieve when Carlsbad and other soda springs cannot be borne. Roth has given reasons for believing that sulphuretted hydrogen, taken in solution into the stomach, acts directly on the blood in the portal vein, forming a sulphuret with the iron of

effete blood-corpuscles, and thus hastening their destruction, for the diminution of swelling in the liver under the influence of Weilbach waters is accompanied by a darker and, at length, black colouring of the fæces, in which a large amount of sulphuret of iron is found. This does not come from the water (which contains none of the metal), but either from the food or the blood, and in favour of its being from the latter is the fact that, as the liver decreases in size, an anæmic condition manifests itself in spite of plentiful nutrition. Roth, indeed, insists upon full meat diet during a course of these waters, and a chalybeate course is frequently required afterwards. Dr. Braun agrees with these statements, and himself derived much benefit from the waters when suffering from hæmoptysis connected with "hæmorrhoidal enlargement of the liver."

Generally they have rather a constipating effect, and do not increase the intestinal secretions like sulphate of soda waters, though irritation and diarrhœa may be occasionally excited. The refreshing feeling and appetite caused by saline gaseous waters are not felt at the time of drinking these waters, but real *hunger* occurs in the course of the treatment Besides their medicinal use, already mentioned, in bronchial catarrh, etc., they are valuable in chronic metallic poisoning.

British Sulphur Springs.—**Harrogate,** about thirty miles west of York, is situated part on high level ground, about 600 feet above the sea, and part in a sheltered valley. It is surrounded by open and pleasant country, and has a pure and bracing though rather moist air; the sandy soil soon dries after rain. The *old sulphur well* and the *strong Montpellier sulphur well* are said to contain 25 cub. in. of sulphuretted hydrogen in the gallon of water, with alkaline and earthy chlorides and sulphides, and traces of bromide and iodide.

They are alterative, stimulant, diuretic, and aperient, and are taken in doses of from one to three tumblerfuls, at intervals before breakfast.

Milder sulphurous springs at the Victoria and Montpellier Gardens are also in use. They contain carbonate of magnesium, and are "antacid, alterative, diuretic, and deobstruent." Both these waters are naturally cold, but are commonly taken warm; they are used also for bathing, the arrangements for which are

very good. There are also saline chalybeate and pure chalybeate waters. The social resources of Harrogate and the pleasant climate of summer and autumn (June till October) attract many classes of invalids, but the most suitable cases for treatment by the waters are—dyspepsia with inactivity of liver and bowels, especially when due to high living; constipation, obesity, swellings of joints and glands, chronic skin diseases, gout and rheumatism, syphilis, etc.; cases of incipient phthisis and disordered menstruation in young women are also sent here with advantage, and use the warm sulphur baths whilst taking the chalybeate water internally.

Moffat, in the upper part of Annandale, is 400 feet above the sea, with a good climate and picturesque surroundings. The water, which is cold, contains $2\frac{1}{2}$ cub. in. of sulphuretted hydrogen in the pint, with 22 gr. of chloride, and 2 gr. of sulphate of sodium. It is used internally in much the same cases as the Harrogate sulphur water.

Strathpeffer, in a beautiful part of Ross-shire, has several cold sulphur springs, containing a good proportion of the gas with alkaline and earthy sulphates and 16 gr. of lime salts; these latter render the water somewhat difficult of digestion, and constipating. There is also a chalybeate spring.

At **Llandrindrod,** in Radnorshire, there are sulphur wells of some reputation, described by Macpherson as "mild Harrogate waters." At **Builth** (the next railway station) there is a weak sulphur well, and a saline with 66 gr. of chloride; and at **Llanwityd** there is a weak saline spring with a large proportion (0·62) of sulphuretted hydrogen. The climate at these places is pure and bracing.

The principal sulphur wells in Ireland are at **Lisdoonvarna,** situated in a bare country, about twenty miles from Ennis (county Clare). They are said to contain $\frac{1}{2}$ cub. in. of sulphuretted hydrogen, and are much used, but the accommodation is insufficient. There are also chalybeate springs of good quality.

CLASS 4.—EARTHY MINERAL WATERS.

The principal earthy or calcareous waters are Wildungen, Leuk, Lippspringe, Weissenburg, Contrexeville, Bagnères de Bigorre, St. Arnaud, Cransac, and Inselbad.

Wildungen, in the principality of Waldeck, is 740 feet above the sea, and, besides a chalybeate, has three earthy springs.

The *Georg-Victorquelle* is a strongly acidulated spring containing 33 cub. in. of free carbonic acid, with 5 gr. of carbonates of calcium and magnesium, a little alkaline sulphate, silica, and iron. The *Helenenquelle*, with 34 cub. in. of carbonic acid, has nearly 10 gr. of the earthy salts, with 8 gr. of chloride of sodium and bicarbonate, and a trace of iron. The *Thalquelle*, similar to, but weaker than the Helenenquelle, is more used. It exerts an antacid and diuretic effect, and the two other springs show this in a more marked degree. They are prescribed with much success in vesical catarrh and uric acid concretions in the kidney, and may be either continued alone for a long time, or conjoined with Carlsbad, Vichy, or other more purely alkaline waters.

Leuk (Leukerbad, Loèche-les-Bains), on the north bank of the Rhone, in the canton Wallis, at the foot of the Gemmi Pass, is 4670 feet above the sea. The principal spring, the *Lorenzquelle*, contains 10 gr. of calcium sulphate in the pound, with some magnesia and traces of alkalies and iron. It is used internally in doses of one to five tumblerfuls taken at a high temperature (122° F.), and is rather constipating, but diuretic and diaphoretic. Braun attributes more importance to the *warm fluid* than to the ingredients.

The speciality of Leuk is the mode of bathing: there are four public pools, each three or four feet deep, and accommodating about forty bathers, who, clothed in flannel, amuse themselves with conversation, games, etc., and spend the greater part of the day in the warm mineral water. The time is gradually extended from half an hour to five and even eight hours in the day for about ten days, and then gradually diminished in the same proportion, so that a course is completed in about twenty-five days. The sexes are separated under the new regulations, and a very complete system of douches and of private baths has been added. The diseases thus treated include gouty and rheumatic exudations, visceral enlargements, scrofulous and other ulcerations, paralysis, catarrh, uterine engorgements, and chronic eruptions, such as psoriasis, eczema, and prurigo. In such cases the calcium sulphate acts as a local stimulant, and often causes an erythematous or pustular eruption (poussée), which is the signal for diminish-

ing the baths. The high situation of the spa enables such stimulating treatment to be better borne than it would be elsewhere. The surroundings are fine, the hotels good, and it is an excellent summer residence for anæmic and weak subjects (B. M. J., i., 1887).

Weissenburg, in the canton Berne, near Thun, 2758 feet above the sea, is situated in a narrow sheltered ravine surrounded by mountains and pine trees. The air is calm, mild, and moist, but the weather variable; the mode of life is simple. The waters are similar to those of Leuk, but with more calcium sulphate (17 gr.) and magnesia, much less carbonic acid; temperature, 74·8° F. Excellent results in bronchial catarrh and some forms of phthisis are obtained at Weissenburg, but are to be explained rather by its general conditions than by the composition of the water (Braun). Pleuritic exudations are said to be rapidly absorbed. The waters purge in full doses (six to eight glasses), and sometimes cause dyspepsia at first. Baths are not used in phthisical cases (Rohden).

Lippspringe, a small town near Paderborn, 441 feet above the sea, on a soil of chalk and sand, has a lime spring containing 5 gr. of sulphate and 2 gr. of carbonate, with some sulphate of sodium and magnesium, a little iron, some carbonic acid, oxygen and nitrogen, the latter in comparatively large proportion (1·4 cub. in.); temperature, 70° F. Small doses (12 oz.) constipate, medium quantities regulate the digestion, whilst 30 to 36 oz. commonly relax the bowels. It is remarkable that, under treatment at this place, the appetite and assimilative power of phthisical patients in an advanced stage have improved so much as to lead to an increase in weight of "10 lbs. in four weeks, and 21 lbs. in thirteen weeks." Whatever the explanation, it would seem that the diseased lung tissue is gradually expectorated during the treatment, with slight fever and moderate suppuration, so that cavities heal up, and a cure may be completed at higher and drier health resorts. Possibly the heat of the water and its slight amount of gas, taken fasting, facilitate expectoration and assist in the softening of cheesy deposit and loosening of catarrh (Rohden). Possibly, also, the moisture of the atmosphere assists by keeping in the water of the lungs and skin; the climate is very equable and cool; moist west winds prevail; the

noons are cooler, and the mornings and evenings warmer than in other places of the same latitude. Inhalations of nitrogen are also used here.

Inselbad, near Paderborn, is commonly mentioned with Lippspringe as a resort for phthisical subjects, on account of the nitrogen in its medicinal waters. The gas is also inhaled. The weak salt spring (6 gr. chloride, with 2 gr. lime carbonate) is considered valuable in hæmoptysis (Hörling).

CLASS 5.—"INDIFFERENT" THERMÆ OR BATHS WITHOUT ACTIVE CHEMICAL INGREDIENTS.

The principal baths under this head are: Buxton, Bath, Teplitz, Plombières, Pfäffers, Ragatz, Gastein, Wildbad, Schlangenbad, Johannisbad, Badenweiler, Luxeuil, Neuhaus, Warmbrunn, Néris, Römerbad, Tüffer, Lucca and others.

Buxton, about thirty miles north of Derby, is situated on a lime-stone mountain range, 900 feet above the sea. The air is pure and bracing, but subject to sudden variation, and the rainfall is rather large. The season extends from April to November, but June is generally soon enough for a visit, for there are cold, sharp winds in the early spring, as well as in late autumn and winter. The quantity of solids contained in the mineral water is not more than 2 gr. (lime, etc.) in 16 oz. (Lyon Playfair); the gas obtained from it consists of about 99 parts per cent. of nitrogen, 1 of carbonic acid, and a trace of oxygen. Temperature, 82° F.

The water is taken internally, but used mostly for bathing at the natural temperature for about five minutes, and at a raised temperature (93° to 96° F.) for fifteen minutes (Robertson). The plunge, swimming and douche baths are very good. A course at Buxton is often beneficial in gout and rheumatism, especially when of a chronic character; also in old sprains and muscular contractions, and in debility, "when the vascular, nervous or digestive systems require stimulating." It is unsuitable for hæmorrhagic cases. Dr. H. Weber compares Buxton to Schlangenbad.

Bath, Somersetshire, has four warm mineral springs in the southern part of the town, varying in temperature from 104° to 120° F. The solid contents amount to about 10 gr., in the

pound, of alkaline and earthy salts, with a little silica and iron. Arsenious acid in small amount ($\frac{1}{200}$ gr. of arsenious acid per gallon) has also been recently detected in the Bath thermal waters, and it may be that some of their previously unexplained efficacy may be thus accounted for (Lancet, i., 1887). Nitrogen exists in rather large quantity, and oxygen and carbonic acid in small amount. From a half to two tumblerfuls are taken once or twice daily, with the usual effect of slightly raising temperature, quickening circulation and appetite, and promoting secretion; sometimes, however, headache, depression and pyrexia occur.

The accommodation for bathing is very good, and is available the whole year, but the greater number of visitors go between November and April, for the climate is relaxing in the summer; at other times it is mild and equable. Cases of gout and rheumatism of moderate severity, neuralgia and myalgia, contracted joints, etc., some forms of dyspepsia, rheumatic or metallic palsies, leucorrhœa, and *chronic* skin diseases, as psoriasis and eczema, often receive benefit at Bath. I have, however, seen much irritation in several cases of subacute eczema sent to these baths, and there seems to be many nervous irritable subjects with whom they do not agree. Dr. Spender advocates the use of Bath waters in cases of sciatica especially (Lancet, i., 1884). It has been called the English Teplitz.

Teplitz, in Bohemia, 648 feet above the sea, with agreeable surroundings, and a moderately good but changeable climate, is one of the most frequented spas in Europe, having arrangements for 4000 baths a day. They are generally given very warm, 105° to 109° F., and followed by one to two hours' gentle perspiration in bed. They are highly stimulating and rather predispose to catching cold; a subsequent course of sea-bathing increases their value, which is certainly great in many cases of gout and rheumatism.

Plombières, in the Vosges, in a deep and narrow valley, 1300 feet above the sea, is "the French Teplitz." The springs are but slightly mineralised, but very warm (143° F.). The water is taken especially in chronic gastralgia and catarrh of the stomach, and the hot baths are used much in the same manner as at Teplitz, but are commonly more prolonged.

Pfäffers and **Ragatz**, in the canton St. Gall, have also "indifferent" thermæ of the same character. The former, in a narrow ravine, 2000 feet above the sea, has warmer baths, but is much less pleasantly situated than the latter place, which lies in a broad bright valley 500 feet lower down. The waters are taken in four tumblerfuls, and the baths used for half an hour twice daily in nervous irritability, neuralgia, hysteria, etc. Season, May to September.

Gastein, a few hours' drive from Salzburg, in a beautiful part of the Tyrol, is one of the highest baths, being 3300 feet above the sea-level. "The houses are grouped round the edge of a mountain torrent, which forms a splendid waterfall," and are surrounded by grand and mountainous scenery. The climate is bracing, and rather rough and rainy, but not so variable as at other mountainous resorts. The social tone is monotonous and quieting for excitable subjects. The waters are clear and soft, temperature 96° to 114° F., and slightly mineralised—one pound contains only 2½ gr., and more than half of this is sulphate of sodium; they are used in warm baths for from ten minutes to an hour. The methods in use at Gastein are milder than at Teplitz, though there are some similar very hot baths for rheumatic exudations and atonic paralysis. The place has a high reputation in such cases, also in hysteria, hypochondriasis, and impotence. If the last-named condition be due to over-excitability of the lumbar cord from sexual excess, it may be relieved by sedative baths; but if from spinal paralysis, it is not likely to be so, and hence very contradictory results have been recorded by different physicians (Braun). Sometimes the cold water system, or that of Rehme or Schlangenbad, will succeed better. It is especially suited for slight cases of spinal congestion or weakness, marked by fatigue on slight exertion and referred especially to the lower spine, by a sense of weight or slight anæsthesia, ataxia, or startings after much walking or standing, sometimes irritability of bladder—such symptoms may be quite removed by a comparatively short course.

Wildbad, in the Wurtemburg Black Forest, 1330 feet above the sea, is situated in a beautiful richly-wooded but narrow valley, and from its excellent arrangements has become a fashionable bath in spite of a somewhat variable climate. The waters are

soothing and refreshing, and are used externally, especially in paralytic cases.

Schlangenbad is close to Wiesbaden and to Schwalbach, in a pleasant valley, 900 feet above the sea, with a mild, fresh, and equable climate, and is well suited for securing the sedative tonic results of thermal treatment. The arrangements are not on a large scale, but are excellent, the life quiet, and the surrounding forests offer varied and sheltered walks in summer, from June till August. The waters contain only a few grains of soda, lime, and magnesia, at 81° to 86° F. They are used chiefly in the form of warm baths at 87° to 92° in tabes and spinal congestions, and for allaying nervous irritability. Mud baths are also employed for the same purpose and for improving the condition of the skin.

CLASS 6.—CHALYBEATE WATERS.

The comparatively pure iron springs, that is, those with little else but the iron salt, are: Schwalbach, Spa, Brückenau, Schandau, Liebwerda, Flinsberg, Freienwalde, Recoaro, Königswarth, Liebenstein, Altwasser, Alexisbad, Muskau, Tunbridge Wells, and one spring at Harrogate. Iron springs containing in addition a moderate quantity of other salts, especially the carbonates and sulphates of calcium, sodium, and magnesium, and sodium chloride, are: Aratapak, Kniebis, Orezza, Pyrmont, Driburg, Rippoldsau, Griesbach, Antogast, Petersthal, Bocklet, St. Moritz, Reinerz, Godesberg, Cudowa, Imnau, and Santa Catarina.

Ferrous carbonate is contained in a large number of mineral waters, in amount varying from mere traces to several grains in 16 oz. The most used and the most successful contain between 0·3 to 0·9 gr., with free carbonic acid.

It is a truism that minute quantities of iron taken at mineral springs, with the advantages of change, pure air, and often an elevated situation, produce effects as good as, or better than, can be obtained from medicinal doses administered in the ordinary manner. If 0·5 gr. be taken as an average proportion in 16 oz., then only this amount, representing but 0·14 gr. of metallic iron, is taken with each pint; but when once the condition has begun to improve, the iron contained in *food* is better assimilated, so that improvement is continued by natural processes. A few cubic

inches of carbonic acid suffice to keep the iron salt in solution (Fresenius), but on exposure to air part of the acid escapes, oxygen is absorbed, and ferric hydrate deposited. A chalybeate water will keep for some time if not shaken, and it may be heated up to 87° F. without much deposit of iron. A few waters contain sulphate or perchloride.

Of alkaline waters, Gieshübel, Ems, Salzbrunn, Bilin, Luhatschowitz, Apollinaris, — of alkaline saline springs, Carlsbad, Marienbad, Tarasp, Franzensbad,—and of more markedly saline waters, Kissingen, Wiesbaden, Baden-Baden, Soden, Kreuznach, Rehme, Hall, Adelheidsquelle, and Harrogate, may all be mentioned as slightly chalybeate, and at almost all the great spas there are some pure stronger chalybeates for use besides the saline ; but amongst those frequented specially for the *iron* waters we may refer to the following :—

The **Kniebis** baths in the Badish Black Forest, 1200 to 1900 feet above the sea, with beautiful scenery and quiet bath life.

Bocklet, near Kissingen, 620 feet above sea-level, has a mild climate and a rich saline chalybeate water.

Driburg, near Paderborn, 633 feet elevation, is situated in a pleasant valley, and has a fresh climate.

Königswarth, near Marienbad, 2000 feet above the sea, in a sheltered position on the southern slope of a mountain, has a pure fresh climate recommended for chronic pneumonic and phthisical tendencies. The springs contain from 0·4 to 0·6 gr. of iron bicarbonate, 5 to 6 gr. of salts, and 30 cub. in. carbonic acid.

St. Moritz, in the Upper Engadine, a day's drive from the Coire station, situated in an Alpine valley, rich in vegetation, and 5400 feet above the sea, has become justly popular, for the air is very refreshing and agreeable even to delicate subjects, especially to those of sluggish circulation and unexcitable nervous system. It is clear and dry, and though dew falls, there is little fog or mist. For a winter residence it is also recommended. The springs contain 0·18 to 0·25 gr. of iron, with a little soda and lime and much carbonic acid (31 to 37 cub. in.), so that the baths are somewhat gaseous : temperature, 39° to 41° F.

Santa Catarina, in Upper Italy, near Bormio, is even higher

in situation (5600), and in waters and surroundings, and scenery, much resembles St. Moritz.

Pyrmont, in the principality of Waldeck, situated in a deep valley 400 feet above the sea-level, with a healthy, mild climate, and extensive, somewhat old-fashioned arrangements, was formerly the most celebrated of iron spas. If has one of the stronger compound springs, containing 0·57 of the mineral with lime, magnesia and free carbonic acid (29 cub. in.). There are also salt springs and baths.

Schwalbach, a clean, long-stretching town, on a sloping, sheltered plateau of the Taunus range, is 900 feet above the sea, and is easily reached from Wiesbaden by rail. It has pure fresh air, excellent arrangements, and strong iron springs, the *Stahlbrunnen* containing 0·64 gr., the *Weinbrunnen* 0·44 gr., the *Paulinenbrunnen* 0·51 gr., with lime, magnesia, soda, and much carbonic acid (40 to 50 cub. in.): temperature, 47° to 50° F.

Spa, in Belgium, 1000 feet above the sea, beautifully placed in the Ardennes, at the foot of a lofty wooded mountain, which shelters it on the north, is one of the most frequented iron springs on the Continent at any time from May till September; afterwards the climate is apt to be wet and cold. The *Pouhon* spring contains 0·37 gr. of iron, with only 3 gr. of salines and 8 cub. in. carbonic acid. The *Barisart* has more gas and less iron.

At **Harrogate,** the *Muspratt* spring contains perchloride of iron with salines—an unusual and effective combination. The Tewit contains 0·135 gr. of carbonate, with a little saline.

Tunbridge Wells, about thirty miles south of London, 300 feet above the sea, with healthy climate and beautiful environs, has a pure but weak spring, used formerly much more than it is at present. It contains about $\frac{1}{4}$ gr. of iron oxide in the pint, but little carbonic acid, so that it is not sparkling; it may be taken with advantage in Apollinaris water.

At **Brighton** there is a spring, St. Ann's Well, which contains sulphate of iron in small amount, and at **Malvern, Bournemouth, Sandown,** and many other health-resorts there are chalybeates more or less available.

THERAPEUTICAL ACTION.—With regard to the therapeutical use of iron waters, formerly invoked so constantly whenever

"strengthening" was desired, we must note that more discrimination is now exercised. Sea-bathing, mountain air, quinine, nux vomica, and other remedies are more used, and iron is ordered more exclusively for true anæmia and chlorosis. Modern medicine, however, recognises anæmia arising from fever, pneumonia, and most acute disorders quite as distinctly as from hæmorrhage (*cf.* Coupland, Gulstonian Lectures, 1881). The more rapidly it is produced, and the more directly from loss of blood, or of component parts of blood, as in hæmorrhage, exudation, or suppuration, the greater the indication for iron in full doses; indeed, officinal preparations are often better in such cases, and chalybeate waters find their use only in later stages.

Their advantages are that they contain a compound (generally a bicarbonate) which is readily digested by the stomach, since it is easily changed into lactate or chloride; that this is well diluted and so more readily absorbed; and that the free carbonic acid given at the same time is a useful stimulant to the gastro-intestinal membrane. On the other hand, these conditions, under certain circumstances, may be disadvantageous, and a full dose of more concentrated preparations will give better results: for instance, symptoms of *congestion* of the head or chest, under a course of carbonated chalybeate, are referred by many physicians to the carbonic acid rather than to the iron, and in such cases an ordinary pharmaceutical preparation may agree better (Braun).

Simple (true) chlorosis, occurring during the developmental period, seems connected with *direct* loss of iron, which sometimes manifests itself by an increase in the amount passed in the urine (Braun); and it is in this form of anæmia that the administration of iron proves most successful. It is seen amongst the poorer or the middle classes more frequently than amongst the higher, in whom chlorosis is often complicated with mental excitement or depression, hysteria, leucorrhœa, etc.

The more *indirect* the anæmia—when arising, for instance, from impaired general nutrition, with deficiency of albumen and fibrin rather than of blood-cells, or from special derangement of organs or nerves—the slower and the more uncertain is the effect of iron; the anæmia of mal-nutrition is often better treated by nourishment and hygiene, and even chlorotic anæmia connected,

e.g., with hysteria, may be aggravated by iron internally, but relieved by *indifferent* baths as at Schlangenbad.

Anæmia, complicated with or dependent on chronic discharges, such as from caries of bones, diarrhœa, catarrh, etc., is a generally impaired condition of the blood, and should be also treated dietetically, by meat, fat, milk, and with due attention to hygiene. The anæmia of prolonged lactation, which is often accompanied by dyspepsia, requires preliminary medical treatment—weaning the infant being naturally the first indication.

Moor Baths.—To prepare these, a large tract of moorland is saturated with mineral water, and allowed to dry during the autumn and winter, when complex chemical changes occur in it. The earth is usually in process of being converted into peat, and when mixed with water containing sulphides and other salts, the resulting mixture gradually comes to contain sulphates of many metals, acetic and formic acids, and a variety of substances formed from the humus. Iron salts and sulphuretted hydrogen are often present in considerable amount. At the end of the process the moor forms a dried or half-dried earthy mass, with an aromatic bituminous smell and marked saltish taste; for use it is mixed with hot water in a large basin, and forms a thick turbid mixture which is run off into the smaller baths.

The effects are those of warm baths, combined with a stimulant action on the skin. Such baths have been found useful in chronic rheumatism of all kinds, gout, chronic gastro-intestinal affections, functional nervous diseases, catarrh of uterus, anæmia, ovaritis, and other chronic cases where gentle alterative treatment is desirable.

Moor baths are obtainable at Franzensbad, Homburg, Marienbad, Tölz, Elster, Teplitz, Eilsen, Nenndorf, Meinberg, Driburg, and other places.

Mud Baths or Slime Baths consist of mud or slime mixed with warm water; on the Baltic coasts sea-mud is used in some places. Their composition and uses are very similar to those of moor baths.

In **Sand Baths,** the body, or any part of it, is surrounded with sand heated to a temperature of 112° to 130° F. It is simply a method of applying dry heat, with the advantage that it can be conveniently applied to any part of the body without necessarily

subjecting the whole to a high temperature. The duration is about thirty to ninety minutes. They are useful in cases where diaphoretic treatment is indicated, and are obtainable at Berka, Köstritz, Dresden, and Lavey, near St. Maurice.

ACIDUM ACETICUM—ACETIC ACID

($HC_2H_3O_2$ = 60).

Acetic acid occurs in the Pharmacopœia in three grades of strength—(1) The glacial or concentrated acid, which is about three times as strong as (2) the ordinary acetic acid, which itself is eight times stronger than (3) the dilute acid. Vinegar is an impure form of the last mentioned.

ACIDUM ACETICUM GLACIALE—GLACIAL ACETIC ACID.

PREPARATION.—This acid, being volatile, may be liberated from any acetate by distilling it with a fixed acid, *e.g.*, acetate of sodium with sulphuric acid.

CHARACTERS AND TESTS.—At the mean temperature of the air, the acid is liquid, but at 34° F. it crystallises in colourless prismatic crystals, which are not unlike ice (whence the name glacial), and this form is retained up to a temperature of 60° F. The liquid acid has a pungent acetous odour, and is remarkable for the variations in its specific gravity according to its dilution. By the addition of 10 per cent. water, the sp. gr. is *raised* from 1·058 to 1·073, but any further addition of water permanently lowers it. The glacial acetic acid of the B.P. contains nearly 99 per cent. of real acid ($HC_2H_3O_2$) which corresponds to 84 per cent. of acetic anhydride ($C_4H_6O_3$).

ACIDUM ACETICUM—ACETIC ACID.

PREPARATION.—During the destructive distillation of wood, an impure acid distils over; carbonate of soda is added to the distillate, and an acetate of sodium formed, which is purified and then distilled with sulphuric acid.

CHARACTERS.—A colourless acid liquid of pungent odour and taste: sp. gr. 1·044. It is volatile, and, on evaporation, should leave no residue. It contains 28 per cent. of anhydrous acid.

ACIDUM ACETICUM DILUTUM—DILUTE ACETIC ACID.

PREPARATION.—By adding 1 part of acetic acid to 7 of distilled water. The sp. gr. is 1·006.

ACETUM—VINEGAR.

Is an impure dilute acetic acid, derived from alcohol. In France it is made from wine, and is stronger than the English vinegar, which is obtained from a fermenting infusion of malt exposed freely to air. The sugar it contains is first changed into alcohol, which, by further oxidation, is transformed into acetic acid; thus—

$$C_2H_6O + O_2 \text{ becomes } C_2H_4O_2 + H_2O,$$

the acid being derived from the alcohol by the substitution of one atom of oxygen for two of hydrogen.

CHARACTERS AND TESTS.—Vinegar has a sp. gr. of 1·017 to 1·019, is usually brown in colour, and has a distinctive odour, due probably to a minute quantity of acetic ether: it contains 5·41 per cent. of acetic acid. It is liable to become mouldy if exposed long to the air, and in order to prevent this, a little sulphuric acid is commonly added: $\frac{1}{1000}$ part by weight is allowed by law.

ABSORPTION AND ELIMINATION.—The dilute acid is readily absorbed from the stomach, and combines in the blood, to some extent, if not wholly, with soda salts to form acetate of sodium; like other salts of vegetable acids, this is ultimately eliminated in the urine as a carbonate.

PHYSIOLOGICAL ACTION.—*External.*—Glacial acetic acid is a caustic, and applied to the ordinary skin, causes redness, pain, and sometimes vesication or even inflammation of the cutis and subjacent tissue. The diluted acids exert a moderately irritant, or simply a cooling astringent effect, according to the degree of dilution, of continuance of application, friction, etc. Mucous membranes are severely irritated by the strong acid, much less so by the weaker.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System, etc.**—Dilute acetic acid in moderate doses has a cooling eupeptic action; it diminishes thirst partly by causing a flow of watery saliva. In large quantity it lessens secretion of gastric juice, and so stops digestion and impairs nutrition. When taken continu-

ously it is apt to cause gastric catarrh, dyspepsia, and consequent emaciation.

Acetic acid is an important product of the fermentation of cellulose in the digestive tract of herbivora, and there is some evidence from the action of acetate of sodium given to rabbits that it diminishes the activity of nutritive processes (Mallière, Rev. des Sc. Méd., i., 1891).

The stronger acid, taken into the stomach, acts as an irritant poison, and has occasionally caused death; it induces burning sensations in the throat and stomach, and acute abdominal pain, with tympanitic distension, tightness across the chest, and much anguish; the buccal mucous membrane is whitened, the tongue becomes dry, cold, and tremulous, nausea and vomiting occur, with hurried, laboured breathing, and quick, small pulse; the pupils are dilated; cold clammy perspirations cover the body; nervous tremor and sometimes convulsions have occurred.

Action on the Blood.—This is very similar to that of sulphuric acid. Heine examined the effects of acetic acid brought into direct contact with the blood by injection, and came to the conclusion that the acid decomposes and sets free the hæmoglobin, expels oxygen from the corpuscles, and coagulates their albuminous substance, thus giving rise to the lake colour of the blood. The red corpuscles become finely dotted in the centre, owing to the coagulation of their albumen. The blood remains fluid after small doses, but is always coagulated by very large ones. After direct injection of the acid into the blood the temperature falls 2° C., though later on, rigors and muscular tremor occur, with embolism, and septicæmia and consequent rise in temperature. The above-described discoloration of the blood (lake colour) never takes place after the internal administration of the acid, as it does after injection into the veins (Virchow's Archiv, xli., 1867).

SYNERGISTS.—Citric, tartaric, and other vegetable acids.

ANTAGONISTS—INCOMPATIBLES.—As an antidote in poisoning by caustic alkalies and lime, vinegar is to be recommended, since it is generally near at hand, and the compounds formed by it are not injurious. It is useful also in alcoholic intoxication. Alkalies and their carbonates are chemically incompatible with acetic acid.

THERAPEUTICAL ACTION.—*External.*—The glacial acid

is sometimes employed as a *vesicant* in Bright's disease, where the use of cantharides is unsafe. Besides this it is present in the acetum cantharidis as a solvent for the active principle of the Spanish fly, and increases its efficacy.

Acetic acid has been recommended as an antiseptic, especially in puerperal cases, but Schaeffer has shown that carbolic acid is fifteen times more powerful as a destroyer of the spores of anthrax, and over two hundred times more efficient against other poisonous germs (Centr. f. Gynäk, vi., 1890).

Nævi—Corns—Warts.—These have been treated successfully with the strong acid, and warts may be removed by a few applications of it.

Lupus, etc.—In the erythematous form, and also to certain pigmentary stains, the glacial acid may be applied about twice weekly, with much advantage and without production of scarring.

For **Frost-bite,** vinegar applied with friction is a good external application.

Cancer.—Sir W. H. Broadbent states that acetic acid is still used with advantage, especially for injecting enlarged glands after operations for cancer of the breast—as also sometimes to the cancerous breast itself, which atrophies under the injection, whilst the enlarged glands disappear (Lancet, i., 1891). After careful observation of nine cases, this statement seems to me absurd. I have never seen any advantage derived from such treatment.

Parasitic Diseases.—Acetic acid (1 part in 3) has been applied in ringworm with good results, but other remedies are more commonly used. It is occasionally given as an enema (dilute) to destroy ascarides.

Psoriasis.—Acetic acid used locally promotes separation of the thick scales of psoriasis, and stimulates healthy action, just as a blister will sometimes do, but it causes much pain if the skin is fissured.

Hæmorrhage.—Syringing with vinegar is frequently used as an astringent and styptic remedy for bleeding from the nose, and sponging with it for parenchymatous hæmorrhage; in metrorrhagia it may be used by vaginal injection, or tampons may be soaked in it: these, however, irritate and become unpleasant in four to six hours. It may also be used to check oozing from leech bites, or to wash out the mouth after the extraction of a tooth.

Dr. Grigg finds that to drink a wineglassful of vinegar is as effectual as ergot in arresting post-partum hæmorrhage and causing contraction of the uterus (B. M. J., i., 1884). In some cases the drinking of vinegar has led to arrest of the menses (Record, 1885).

Nocturnal Sweating.—The night-sweats which are so profuse and exhausting in the later stages of phthisis and in some conditions of debility, are often controlled by sponging the body with warm vinegar night and morning.

Spinal Weakness.—In cases of aching and debility referred to the lower spine, and dependent probably on impaired power of the erector spinæ, I have seen much advantage from sponging the back with equal parts of spirit of wine and dilute acetic acid.

THERAPEUTICAL ACTION.—*Internal.*—**Scarlet Fever.**—Dilute acetic acid is used by some practitioners from the commencement of this fever in all cases. Freely diluted, it certainly makes a grateful refrigerant drink. Where the eruption is more or less suppressed, a teaspoonful of vinegar, given in sweetened water every two to four hours for a few doses, is said to cause diaphoresis, and to assist in bringing out the rash: however this may be, sponging the body with hot vinegar and water twice or thrice daily is often useful.

Dr. J. Dougall specially recommends the aromatic glacial acetic acid impregnated with oil of neroli, rosemary, etc.—1 dr. to the oz. of water is used for sponging, and some is volatilised in the sick room (B. M. J., ii., 1879).

Diarrhœa.—When this occurs in the course of phthisis or hectic fever, it may sometimes be controlled by the internal administration of vinegar.

Cholera.—Dr. Francis has recently called attention (B. M. J., ii., 1884) to an old method of treating cholera with acetic acid first introduced by Dr. Greene, who had favourable results with it (Indian Med. Gaz., 1866); he gave ten minims in an ounce of water every half-hour. Surgeon-General John Murray found the acid destructive to various kinds of pathogenic organisms.

Syncope.—Inhalation of the vapour through the nose is sometimes employed.

PREPARATIONS AND DOSE.—*Acidum aceticum glaciale:* not given internally. *Acidum aceticum:* used externally as a rubefacient, vesicant, and escharotic. *Acidum aceticum dilutum:*

dose, 1 to 8 fl. dr., well diluted. *Oxymel:* dose, 1 to 2 fl. dr. *Acetum* (vinegar): dose, 1 to 8 fl. dr.

ADULTERATIONS.—Sulphuric acid and metallic impurities taken up from metal vessels in which it has been kept.

ACIDUM BORICUM—BORIC OR BORACIC ACID (H_3BO_3 = 61).

PREPARATION.—It is obtained by the purification of native boric acid, or by the action of sulphuric acid on borax: the boracic acid, which is but moderately soluble in water, precipitates, and is separated from the sodium sulphate by filtration.

CHARACTERS AND TESTS.—It occurs in colourless, pearly, lamellar crystals, or irregular masses of crystals. It is easily powdered, and is unctuous to the touch; its taste is feebly sour and bitter, leaving a sweetish after-flavour in the mouth. It is soluble in water, glycerine, and rectified spirit. Its aqueous solution turns blue litmus paper red, and turmeric paper brown, the tint in the latter case not being altered by hydrochloric acid, but changing to green if potash be subsequently added. The alcoholic solution burns with a greenish flame.

PHYSIOLOGICAL ACTION.—*External.*—It has the power of destroying low organisms, and is therefore used as an antiseptic in powder, lotion, or ointment. It lessens the fœtor of perspiration. Locally it is non-irritating, and hence its great value as a dressing for wounds.

PHYSIOLOGICAL ACTION.—*Internal.*—Neumann, after giving doses of 5 to 6 grammes to dogs and other animals, found no definite effect but a fall of temperature; larger doses caused vomiting and diarrhœa. Injections of a 3 per cent. solution into the pleural or peritoneal cavities proved also harmless, but if pressed beyond certain limits of doses, caused paralysis of motor nerves and death (Lancet, ii., 1882).

Two cases of poisoning by boric acid have been recorded (Vratsch, No. 31, 1881). In one, death followed as a result of washing out the pleural cavity with boric acid lotion; in the other, from washing out the cavity of a lumbar abscess; the most marked symptoms were vomiting, and a small pulse indicative of cardiac failure, in one case also an erythematous eruption. Four other instances of toxic symptoms, such as skin eruptions, vomiting, head-

ache, insomnia, and delirium, have been recorded from the free application of the acid to wounds; they were probably connected with deficient renal excretion (Rev. des Sc. Med., 1890). The post-mortem examination gave negative results.

Boracic acid is reputed, like borax, to be diuretic, emmenagogue, and anodyne; it is excreted in the urine.

THERAPEUTICAL ACTION.—*External.*—The chief use of the acid is as an antiseptic; it is, however, not so powerful a germicide as carbolic acid or corrosive sublimate. It is applied in the form of powder or lotion (1 part in 20 of water), as an ointment, or as boric lint, that is, lint steeped in hot saturated solution of the acid and then dried. The lint and lotion are usually coloured pink by the addition of a little tincture of cochineal or red litmus.

Ulcer, Granular Lids, etc.—The acid is in frequent use as a wash for ulcers, or as a wet dressing for granulating surfaces. It has been much commended in granular lids when applied in conjunction with massage (Lancet, ii., 1890), but is not satisfactory (*ib.*, i., 1891). A lotion containing 2 to 6 gr. per ounce is, however, useful in catarrhal eye diseases.

Skin Diseases.—It is used as a good addition to zinc and other lotions, when purulent secretions tend to decompose under the crust formed,—10 gr. in the oz. of water often prevent this. The ointment is valuable in subacute eczema and dry irritable skin eruptions, and acts as a sedative for itching, but is a slight stimulant for healing. In acne, a lotion of 1 in 2 oz. of spirit of wine is often serviceable; it should be applied several times daily (Pract. i., 1890).

Gonorrhœa.—Dr. A. J. Roe recommends an injection containing 10 gr. to the oz. (Record, 1882).

Cystitis, etc.—Rosenthal has shown that about 10 gr. thrice daily of boracic acid suffice to deodorise and often to change the alkaline reaction of ammoniacal urine, with relief of symptoms of dysuria, etc.: in bad cases he conjoins washing out of the bladder with a 5 per cent. solution (Wien. Med. Blät., 1881, and Pract., i., 1884). Dr. G. V. Percy has reported clinical illustrations of the efficacy of this treatment (Lancet, ii., 1884).

Constipation.—The acid is said to act well in this complaint, when dependent on torpor of the colon with flatulence. If the rectal membrane is relaxed and prolapsed, the powder is applied

or rubbed on to it, if not, about three-quarters of a teaspoonful is insufflated through a short wide tube: it is said to increase peristalsis, so much so as to cause several actions daily (Pract., i., 1891).

Diphtheria.—Frequent local application of a strong solution or spray has given excellent results in this malady.

Dr. Atkinson used 20 to 30 grains with one drachm of glycerine and seven drachms of compound infusion of roses (B. M. J., i., 1882). The borate of magnesium (1 part of acid in 6) has some advantages (*ib.*, ii., 1887). Dr. Harries was well satisfied with boracic acid 2 drachms, in ½ ounce each of glycerine and water, applied every hour (Lancet, i., 1882), Dr. Goodhart with a saturated solution in glycerine. Almost any proportion can be incorporated under gentle heat. As a rule the stronger applications are to be preferred as surer germicides, and their non-toxic and non-irritant nature is some advantage over mercury, iron, silver, and the stronger caustics.

Endometritis, etc.—Chronic endometritis has been successfully treated by Dr. A. Duke with intra-uterine applications of boric acid (B. M. J., ii., 1890); and suppositories of the same have been found useful antiseptics after parturition (*ib.*, ii., 1892).

THERAPEUTICAL ACTION.—*Internal.*—Given internally, it is said to be occasionally useful in cases of vomiting, in somewhat the same way as sulphurous acid is. It has been also given (with ether) in septic diseases. It has been recommended as a preventative in septic diseases. In cholera epidemics, workmen in boric acid factories are said to escape (Med. Times, i., 1883).

Tuberculosis.—Gaucher found that, administered freely to rabbits, it prevented development of tubercle after inoculations which produced phthisis in other rabbits not so fed. He then gave about 15 gr. daily to phthisical patients, and it was taken easily and with benefit: it was eliminated by the kidneys and in the expectoration, which latter lessened under its use (Lancet, ii., 1890).

Boric acid has been added to milk and other foods as a preservative, to enable them to be kept longer without septic changes. Some have reported it to be injurious to digestion; it is stated to increase the nitrogen and solids of the fæces (Record, 1884). Children taking milk thus preserved got "languid and drowsy" apparently from it (B. M. J., i., 1882).

At a discussion of medical officers of health, no definite harm was traced to the drug, but it was said to lessen evidence of decomposition, and general objections were expressed to it (Lancet, i., 1892; B. M. J., i., 1893).

Boroglyceride (non-off.) was discovered and patented by Prof. Barff. It is a compound of glyceryl with boric acid, and the following formula represents its formation :—

$$C_3H_8O_3 + H_3BO_3 = C_3H_5BO_3 + 3H_2O.$$

It was originally introduced as a means of preserving food, but its antiseptic qualities have been since utilised in other ways. Mr. Lediard and Mr. Barwell both speak highly of it as a *surgical dressing*, using a solution in water of the strength of 1 in 40 (Lancet, i.-ii., 1882). Dr. MacSmith of Philadelphia has also used it largely, and speaks of it as a marked hæmostatic, antiseptic, deodorant, and germicide (Med. Times, ii., 1885). Dr. Webster Fox of Philadelphia has used it in a large variety of cases in *ophthalmic* practice, such as keratitis, corneal ulcers, granular lids, pannus, and the ophthalmia of new-born children. In *skin diseases* Mr. C. Roberts finds it most useful in both eczema and psoriasis; it is of special value in allaying the itching of these diseases, and possesses an advantage over liquor carbonis detergens in being odourless (B. M. J., ii., 1885). Dr. Shoemaker has found it effective in ringworm in a 50 per cent. solution.

PREPARATIONS AND DOSE.—*Acidum Boricum*, 5 to 30 gr. *Unguentum Acidi Borici*, boric acid, 1 part, soft paraffin, 4 parts, hard paraffin, 2 parts. Lotions of boric acid and of boroglyceride are made with water, of the strength of 1 in 40 to 1 in 20—the latter must be prepared with hot water. *Glycerinum Acidi Borici* (1 in 3 to 6). A lint and cotton wool, a lozenge, pessary and suppository are also in use.

ACIDUM CARBONICUM—CARBONIC ACID

($CO_2 = 44$). *Non-off.*

This gas occurs in the atmosphere in the proportion of 2 to 6 parts in 10,000; the air contained in the interstices of arable land has more, and in some grottoes and natural hollows, communicating probably with ancient volcanoes, carbonic acid accumulates, so as to exert toxic effect: this is the case in the well-known Grotto del Cane at Naples, the Upas valley of Java, and in many

parts of Auvergne and Vivarais ("estouffis"),—and it forms the "choke damp" of miners. The gas is contained also in all water in varying quantity, certain sparkling waters having a proportion of more than half their volume; the Johannis water has more than 90 per cent. It occurs in all the liquids of the organism, principally in the blood, but also, in less quantity, in the urine; in the former, it exists combined with alkalis chiefly soda, and also in a free state; in the latter, Morin found a proportion of 20 cub. cent. to the litre: this was increased under administration of carbonated water, also after walking exercise, it was greatly diminished by free drinking of ordinary water. It originates in the oxidation processes which are constantly taking place in the tissues, and it readily passes by osmosis through the animal membranes.

Owing to the evolution of carbonic acid in respiration and in the burning of fires, gas, etc., its percentage is always higher in dwelling-rooms than in the open air, although in London fog it is said to be higher still. When the air of a room contains 0·1 per cent. of this gas, it is unfit for continued respiration, not only on account of the deleterious effects produced by carbon dioxide, but also because, together with this gas, volatile putrescible matters are given off from the lungs and skin, and these matters act in a prejudicial way upon the health; hence the necessity there is for ventilation.

PREPARATION.—By treating any carbonate—usually carbonate of calcium—with dilute hydrochloric acid:—the resulting gas is passed into water under pressure, and a solution thus obtained.

CHARACTERS.—A colourless inodorous gas of slightly sharp taste. It is soluble in its own volume of pure water at ordinary temperature and pressure—much more soluble under increased pressure and lowered temperature of the water. The solution gives an acid reaction, and is "sparkling" from rapid escape of gas. Carbonic acid is much more soluble in water containing *phosphates* than it is in pure water, and conversely, water containing the gas can dissolve and retain in solution, *carbonates* and *phosphates* of magnesium, calcium, iron, etc., which pure water cannot. The sp. gr. of the gas is 1·526 (atmospheric air taken as 1). It is forty-four times heavier than hydrogen.

ABSORPTION AND ELIMINATION.—Carbonic acid is easily absorbed by denuded surfaces, and by mucous and serous

membranes. That it may be absorbed also through the unbroken skin is apparent from the systemic effects produced not only by carbonic acid baths in general, but by keeping separate limbs in an atmosphere of the gas whilst the respiratory organs are protected from it (Collard de Martigny). If taken in solution into the stomach, it is said to be absorbed, if the viscus be *empty*,—whilst if it be *full*, the gas is rejected by eructation and per anum as flatus (Lehmann). Up to a certain amount, it may be absorbed through the lungs by the blood. In any normal condition, the blood is never *saturated* with the gas, but is always ready to receive more as it is freshly formed in the tissues. It circulates partly dissolved by the serum and partly combined with alkaline salts. It is eliminated almost entirely by the lungs and the skin, but in small proportion by the kidneys; also by the bowel.

PHYSIOLOGICAL ACTION.—*External.*—When carbonic acid gas undiluted is brought into contact with the skin, it causes some prickling and sense of warmth, with or without redness; this is said to be most marked about the perineum and scrotum—the latter contracts under its influence. To this effect succeeds a certain degree of anæsthesia (Rotureau) or analgesia, which, however, is not complete enough for operative purposes (Demarquay). In contact with mucous surfaces, or the exposed cutis vera, the effects are more marked, and more quickly produced. The oculo-nasal membrane is especially sensitive to a current of the gas, whilst the uterine membrane and even wounded surfaces show the anæsthetic effect without much previous stimulation.

Professor Kolbe of Leipzig has advocated the use of carbonic acid as a preservative of meat, having found that beef will remain perfectly fresh, and its taste unchanged after hanging for eight days in a chamber filled with the gas.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—When taken into the stomach as it usually is, in aqueous solution, carbonic acid is refreshing and thirst-quenching. It somewhat increases the gastro-intestinal secretions, and excites their peristaltic action, but diminishes the sensibility of the mucous membrane; a moderate quantity improves appetite, but an over-dose lessens it. No such serious symptoms follow, however, as after inhalation of the gas by the lungs.

Respiratory System.—The gas is markedly more poisonous

when inhaled than when taken in any other way. It hinders exhalation of the carbonic acid normally existing in the blood, and is itself absorbed in small quantity, thus inducing dyspnœa ; a proportion of 10 per cent. in the air is irrespirable and fatal, but a much smaller amount (0·1 per cent.) causes unpleasant symptoms, such as headache, sleepiness, and depression. The undiluted gas first excites irritation and sometimes spasmodic contraction of the glottis with consequent asphyxia (Wareing) ; in any case, and independently of such spasm, it soon arrests respiration. It has been thought that the gas is itself inert, and induces death only by preventing the due interchange of oxygen and carbonic acid in the lungs (Bichat, Regnault, etc.), but recent observations suggest that it is actively poisonous, since young mammals die by cardiac arrest, after two or three minutes in an atmosphere charged with it, whilst they live fifteen to twenty minutes in nitrogen or hydrogen (Paul Bert, Rabuteau), and the heart continues to beat in the latter case after respiration has ceased.

The symptoms of carbonic acid poisoning may be divided into three stages, which are those of asphyxia ; the first is that of *dyspnœa*, the blood pressure rising ; this is due to the excitation of the centres in the medulla oblongata (especially those of respiration and vaso-motor action), by the venous blood. Insensibility then comes on, and the second stage, that of *convulsions*, begins, the respiratory movements becoming more violent and spreading to all the muscles of the body ; the third stage is that of *paralysis*, in which convulsions cease, the blood pressure falls, and the respirations, and finally the heart, stop.

Circulatory System.—The effect of respired carbonic acid in preventing oxygenation of blood is quickly shown by the appearance of more or less cyanosis, with slow, laboured pulse, and ultimate arrest of the heart's action. Provided that a normal amount of oxygen is present carbonic acid does not combine with the hæmoglobin, since this remains red and unreduced in an atmosphere even highly charged with it, but in animals dying deprived of oxygen, the blood is found to be dark coloured, the hæmoglobin being completely reduced. The effects of the internal administration of the gas, or even its careful injection into the larger venous trunks, differ from those produced by its inhalation,

and are such as slight stimulation of the heart-action, quickening of respiration, and increase of the peripheral circulation, with a slight prickling of the skin and a brief sense of exhilaration ; this is often experienced from sparkling beer, wine, and even waters. Husemann remarks that experiments with "direct injection" of carbonic acid into the blood (Nysten, Demarquay) have not led to great results, on account of the smallness of the amount that can be injected without death occurring from the entrance of air into veins. Even small quantities thus injected cause muscular weakness, a symptom which only appears *late* in the inhalation of dilute carbonic acid gas.

Nervo-Muscular System.—The most marked effects of carbonic acid poisoning (from breathing the gas) are exerted upon the nervous system. An amount of 3 per 1000 in the atmosphere of a room will cause throbbing headache, with fulness and tightness across the temples, and giddiness ; more of the gas may induce fainting, muscular weakness, somnolence, or insensibility, coma, or convulsions.

Brown-Séquard taught that carbonic acid was a muscular excitant, because of the uterine contractions observed after injecting it into the vagina, the excitement induced by arterial injections of blood charged with carbonic acid, and the convulsions said to be caused by directing the injections towards the head. Cyon further taught that the cardiac arrest caused by this gas was due to excitement of the vagus, but more modern observation leads us to regard the gas rather as a sedative. I have already mentioned the local anæsthesia it can produce, and Leven always found in his experiments anæsthesia with slowing of respiration and circulation, and finally cardiac arrest—no convulsion. I should say with Rabuteau that in therapeutical doses it modifies sensibility, whilst in toxic quantity it abolishes at once the functions of nerve and muscle. On the organs of special sense, anæsthetic effects are preceded not only by prickling and warmth, but also by muscæ volitantes, tinnitus, and other phenomena connected with congestion. Herpin found that the gas, when diluted with 80 to 90 per cent. of air, produced gradual anæsthesia without suffocation or pain.

In connection with the nervous system must be mentioned some remarkable observations of Brown-Séquard, who finds that

by the action of carbonic acid gas, or of chloroform vapour on the larynx of animals, a condition of insensibility to pain over the whole body is produced, without loss of other cerebral functions; section of the superior laryngeal nerves prevents this effect. The observation has not been verified in man, because of the difficulty of devising any means which will prevent the gas or vapour reaching the lungs; for if it enters the lungs, and thence the circulation, these effects are not produced (Lancet, ii., 1883).

Nutrition—Excretion.—The inhalation of carbonic acid modifies the processes of nutrition in a manner not yet understood; sugar has been found in the blood and liver of animals poisoned by it. More *diuresis* is caused by *carbonated*, than by ordinary water, as carbonic acid increases the rapidity of absorption in the alimentary canal. It also increases the secretion of saliva, and so sparkling waters are useful in quenching thirst.

ANTAGONISTS.—Oxygen and stimulants of the peripheral circulation.

THERAPEUTICAL ACTION.—*External.*—**Wounds, etc.**—Demarquay and Leconte found that atonic and gangrenous ulcers and diphtheritic wounds recovered under applications of carbonic acid gas when they had not yielded to other remedies; the stream of gas may be directed on to the wound, or a yeast poultice (Cataplasma fermenti, B.P.) may be applied, and this evolves the gas. The cicatrisation of wounds was also favoured by it, and when injected into the cellular tissue in cases of tenotomy, repair of tendons was said to be hastened, whilst by oxygen it was retarded. Good results in the same class of cases have been reported from Rehme, Nauheim, and other spas where the gas is employed therapeutically. Streams of carbonic acid have been applied to the eyes, ears, nose, vagina and rectum in inflammatory states of those parts. In all these cases the beneficial effect is probably due to the fact that the gas first causes a slight hyperæmia, and then by diminishing the sensibility of the peripheral nerves, lessens pain.

Vesical Catarrh, etc.—The pain, muco-purulent discharge, and irritability of bladder connected with this malady may be relieved by local injections of carbonic acid gas,—a method of treatment not, perhaps, so often used as it deserves to be. Sir James Simpson and others have reported much improvement in

severe and chronic cases (B. M. J. and Med. Times, 1858-59). The gas is disengaged from a carbonate mixed with tartaric acid, and conveyed through a catheter, the bladder being previously washed out if possible. It is desirable to avoid over-distension of the viscus, either by using only a measured quantity (Skinner), or employing a double catheter (Johns). If too much be injected, there may be some burning pain, and afterwards drowsiness and sense of exhaustion, but these symptoms are temporary, and are, in most cases, not felt at all, whilst relief follows very quickly and lasts for a long time, suggesting that the gas is retained in the bladder for several hours before being absorbed: its use is commonly, though not always, followed by excretion of urine containing much mucus and oxalates.

The gas may be employed in almost all forms of irritability of the bladder, unless acute inflammation be present; if the irritation be severe, the gas may be diluted with air.

Gout—Rheumatism—Paralysis.—At Kissingen, and other places, baths containing carbonic acid gas are much used in these maladies, as a mild diaphoretic and stimulant to the skin. Dr. Parkin wrote strongly upon the value of carbonic acid in gout, but administered it in the complex form of a strong alkaline effervescent draught (Lancet, 1843).

Pelvic and Uterine Pain.—In many painful affections of the pelvic viscera, whether neuralgic, or arising from organic disease, injection of carbonic acid into the vagina acts as an anæsthetic and sedative; but as it sometimes increases irritation for a time, it is not suited for cases with acute congestion. Dewees, De Rossi (1834-35), and other physicians of still earlier date, used the gas with advantage, and Sir James Simpson records ample and favourable experience with it in dysmenorrhœa. It gives relief even to the pain of cancer, but seems to have sometimes caused giddiness, headache, and weakness (Med. Times, i., 1858). The warm baths at Driburg (Westphalia), which are highly charged with carbonic acid, are said to be useful in cases of anæmic amenorrhœa and leucorrhœa, and to exert a favourable influence upon utero-gestation, so that healthier children are born after their use. They have been described as "champagne baths," and exert a stimulating effect upon the whole surface, especially upon the genitals; they also induce a free secretion of urine. They relieve partial or

hysterical paralysis connected with pelvic irritation, but are contra-indicated in acute congestion and in epilepsy.

At the "sool-sprudel" of Kissingen, especially when heated or when agitated by jet or wave, so large an amount of gas passes into the air as to cause sometimes giddiness and dyspnœa. At Rehme the baths are used "still" with better result, especially in certain forms of paralysis and spinal irritation. At this place, also, gas baths are given, but Dr. Braun does not attach much value to them unless in cases of atonic ulceration, and in irregular menstruation from atony of uterus. Dr. Tyler Smith has pointed out that abortion occurs where pregnant women are exposed to the poisonous influence of the gas, but this may be secondary to the asphyxia produced.

Pharyngitis—Laryngitis.—Chronic cases of this kind are treated at Ems by inhalation of the gas, and at Vichy by the carbonic acid douche.

Chronic Bronchitis—Asthma.—Simpson states that he has often seen benefit from inhalations containing 5 to 10 per cent. of carbonic acid in these maladies, and in chronic cough. Such inhalations are much better tolerated than is commonly thought (Skinner), and they are practised at St. Moritz, at Ems, and elsewhere, but Dr. C. T. Williams speaks of danger arising from them, on account of difficulty in regulating the dose (Lancet, ii., 1873).

Vomiting—Dyspepsia.—When the gastric mucous membrane is morbidly sensitive and irritable, carbonic acid gas dissolved in water is an excellent sedative, and in uncomplicated cases is sufficient to relieve vomiting. It is commonly given in combination with an alkali, as in the ordinary effervescent mixture, or in the waters of Homburg, Carlsbad, Vichy, etc., but water charged with the gas *only* often answers exceedingly well, and has sometimes cured intense gastric irritation (chronic in character with great nervous depression) after the failure of treatment at celebrated spas.

Carbonic acid gas is sometimes used to distend the stomach and intestine for diagnostic purposes. Bicarbonate of sodium in solution is given followed by tartaric acid, and this sets free the gas which distends the stomach if given by the mouth, or the intestine if given per rectum.

ACIDUM CHROMICUM—CHROMIC ACID—CHROMIC ANHYDRIDE (CrO_3 = 100·4).

This substance is an anhydride, not a true acid. It is one of the oxides of chromium, and forms salts called chromates.

PREPARATION.—It may be prepared by mixing 4 parts of cold saturated solution of potassic bichromate with 5 of sulphuric acid; as the mixture cools, the anhydride separates in crimson needles, which are dried on a porous tile under a bell-glass.

CHARACTERS AND TESTS.—The small crystals of chromic acid are either needle-shaped or columnar, dark crimson (ruby) at ordinary temperatures, black when heated, and incandescent at about 400° F., when they fuse and become changed into sesquioxide (green) and oxygen. They are odourless and deliquescent, and the watery solution has a sour metallic taste, and much oxidising power: their relation to sulphuric acid is peculiar, being insoluble in acid of density 1·55, but freely dissolved by it when either more concentrated or more dilute. On contact especially on warming, with glycerine, nitrous ether, strong alcohol, creasote, or any substance easily oxidised, explosive decomposition is liable to occur, although this may be prevented, it is said, by adding, *e.g.*, glycerine slowly, *drop by drop* (Phil. Med. Times, iv.).

The test, which is directed to the presence of sulphuric acid, is applied by dissolving 1 gr. of chromic acid in 100 cc. of cold water, adding 10 cc. of hydrochloric acid, and then 1 cc. of test solution of chloride of barium, which should not cause more than slight turbidity (white).

PHYSIOLOGICAL ACTION.—*External.*—In full strength it is a powerful antiseptic caustic and disinfectant, coagulating albumen, abstracting water and forming an eschar, destroying organisms, decomposing ammonia and sulphuretted hydrogen, and oxidising organic matter. M. M. Chevalier and Bécomt found that in certain factories where the bichromate of potassium was much used, the workmen suffered from severe ulceration of the septum nasi, glans penis and other parts, an effect which they considered to be due to the chromic acid in the salt just mentioned exercising its caustic action upon healthy tissues.

PHYSIOLOGICAL ACTION.—*Internal.*—It is not prescribed except as bichromate, but occasionally irritant poisoning has occurred from incautious application about the mouth, etc.: thus, in one case, some chromic acid, with just enough water to liquefy it, was applied to the tonsils of a woman on a cotton-wool brush, and although expectoration was encouraged, she swallowed saliva with a drop or two of acid, and half an hour afterwards got violent pain in the stomach, with "agonising vomiting" of green fluid. Extreme collapse followed, and purging, but under stimulants she recovered in about three hours: there was then free action of the kidneys (Dr. W. Fowler, B. M. J., i., 1889). In another case, the acid had been applied to the gums, and similar symptoms began with severe pain in the nape of the neck; and in another, death occurred from irritant poisoning and collapse twenty-seven hours after painting growths on the vulva with a strong solution (50 gr. in ½ oz. of water): the drug was detected by analysis in the viscera (*ib.*, ii., 1889). If after being taken internally, death did not occur from shock, it would probably do so from inflammation or destruction of the coats of the stomach.

Poisoning has also occurred from chromate of lead—chrome yellow, used to colour cakes, etc., but the symptoms caused are mainly due to the lead.

INCOMPATIBLES.—Oxidisable substances, as already mentioned.

ANTIDOTES.—Moderate doses of alkalies, and copious diluents and demulcents, such as milk and isinglass or gelatin, should be followed, if possible, by the use of the stomach tube, —stimulants and warmth being in the meanwhile applied.

THERAPEUTICAL ACTION. — *External.* — **Glossitis — Ulceration of Tongue — Syphilides.** — Mr. Butlin, after quoting Sir J. Paget for the value of chromic acid in gouty psoriasis of the tongue, gives some striking cases of improvement in the above conditions, from the frequent local application of an aqueous solution of the acid—10 gr. to the oz. (Pract., v., 30): mercury or iodides were also given. These observations have been confirmed by Dr. Feibes with regard to specific ulceration of the tongue, nodules, mucous patches, and condylomata, but he used a stronger solution—1 part to 2— every second day, and obtained healing in eight days—a much better

result than with nitrate of silver: after the application,—which is unpleasant,—he used mouth-washes of acidulated chloroform water, or of aluminium acetate (Pract., v., 48, 1892). He mentions no bad results, but the toxic cases already quoted should be borne in mind.

Goitre—Ranula.—The next most important observation as to the value of this caustic was made by Dr. Woakes, who reported good illustrations of its value in the above disorders, when applied in saturated solution "on a carrier" to the inner wall of the cysts, after evacuating or excising a portion (Lancet, i., 1890). The observations have been confirmed by Dr. Lowe and others (*ib.*, ii., 1890; ii., 1891), but the proceeding does not seem to be generally adopted, probably on account of the risks already referred to; special care, however, ought to guard against these.

Diphtheria.—Dr. Lesclure has recently maintained that the best agent for destroying the false membrane is a 40 per cent. aqueous solution of chromic acid, which is caustic, but is the weakest that is serviceable. Two or three drops are to be applied on wadding lightly to the false membrane only, and followed by thorough application of a solution of coal tar (1 in 20). For slight cases one or two applications are sufficient; in addition, glycerine of tannin is freely used daily (Bull. de Thérap., 1892).

Epithelioma (Rodent Ulcer).—I have reason to speak well of the method of use recommended by Dr. Allan Jamieson, viz.: thorough application and boring into the sore with a bead of the acid fused on a probe in a spirit lamp, after scraping and applying cocaine. The slough is allowed to separate, and the place to heal under zinc-ichthyol plaster; sometimes the application has to be repeated, because epithelioma is irregular in its growth, but the cure is generally more permanent than with other remedies. This acid is also sometimes suitable for lupus: its freedom from sulphuric acid is important that the effect may be less diffused.

Sweating Feet.—A 5 to 10 per cent. solution has been used with great success in the Prussian army. One application is sometimes sufficient, but usually several at intervals of 8-14 days are required to effect a cure (B. M. J., ii., 1889).

Phagedenic Ulcers—Poisonous Wounds.—It is used

much stronger in these affections, as a powerful caustic and germicide.

Ozœna, Leucorrhœa, Gonorrhœa.—The weak lotion is similarly employed in these affections, to lessen and disinfect fœtid discharges.

The local application of a solution of ʒi to ʒi aq. has proved useful in chronic endocervicitis, applied once a week for four or five weeks.

PREPARATION.—Liquor acidi chromici, 1 part to 3 of water. Catgut ligatures are often disinfected in a 1 per cent. solution (with certain precautions), and afterwards in sulphurous acid.

A "battery solution" is prepared with bichromate of potassium (powdered), 6 oz.; commercial sulphuric acid, 6 oz.; cold water, 48 oz. Mix carefully.

ACIDUM HYDROBROMICUM DILUTUM—DILUTE HYDROBROMIC ACID.

This is an aqueous solution containing 10 per cent. of gaseous hydrobromic acid (**HBr** = 81).

PREPARATION.—Bromine vapour and hydrogen unite slowly if a red-hot platinum wire be suspended in the mixture,—and the formation of hydrobromic acid gas is shown by white fumes if moisture be present.

The official method of preparation is by passing sulphuretted hydrogen through a mixture of bromine and water (1 to 15) until the red colour has disappeared: then filtering and redistilling. It may also be obtained by the action of phosphoric or other acids on the bromides, or better, by bringing bromine and phosphorus in contact with water, when violent action ensues with formation of hydrobromic and phosphoric acids.

$$P + 5Br + 4H_2O = 5HBr + H_3PO_4.$$

CHARACTERS AND TESTS.—The strong acid is gaseous at ordinary temperatures, colourless, non-inflammable, and irritating to the lungs: it is very soluble in water, but a concentrated solution gives off fumes, and must be kept in glass-stoppered bottles. Diluted with 90 per cent. of water, it is a colourless inodorous liquid with a strong acid reaction (sp. gr. 1·077 at 60° F.). Chlorine water when added liberates bromine which colours the liquid yellow; with silver nitrate it gives a white curdy precipitate insoluble in nitric acid, and sparingly soluble in ammonia. It gives no precipitate with chloride of barium. The solution should not become discoloured by keeping.

PHYSIOLOGICAL ACTION.—Reichert has investigated the physiological action of the drug on frogs and other animals; it closely resembles that of other bromides (Pract., i., 1882).

Circulatory System.—Small doses cause a slight rise of pressure, due to the constriction of small blood-vessels; large doses diminish the blood-pressure even to zero, on account of the depressing action of the drug on the heart. Small doses produce no effect on the pulse; moderate doses cause a slight slowing, lasting a short time; with large doses the pulse may be slowed or quickened, but the tension is always low.

Nervous System.—The effect on the cerebrum is slight, consciousness being present until near death. The effect on the spinal cord is to diminish reflex action, this being in the first instance due to its depressant effect on the sensory portions of the cord; later the sensory nerves and then the motor apparatus, including the muscular system, are also depressed (Boston Journ., i., 1881).

THERAPEUTICAL ACTION.—*Internal.*—This may be stated to be the same as that of bromides but marked by less depression. Massini considers that it has a more pleasant taste, and is borne better by weak and sensitive stomachs; he administered the drug in thirty-one cases; in four of them there was no relief, in seven others very little, but in the remaining twenty the success was very great (Record, 1882). The cases in which it will be found most useful are those of insomnia, nervous palpitation of the heart, toothache, especially in pregnant women, congestive headache, tinnitus vertigo, onanism, and hysteria.

Dr. Dana spoke highly of the drug in cases like those mentioned above, but in epilepsy found that the other bromides are more useful (Practitioner, 1883). Dr. Squibb recommended that the acid should be used intermittently with the bromides, and thus the patient kept under their influence without great depression. He also found it useful in preparing extemporaneous solutions of other bromides, for instance that of lithium, by prescribing it with carbonate of lithium (Record, 1884). It has also been recommended in palpitation and nervousness due to excessive tea drinking; but whether it is superior to other bromides is very doubtful. Dr. H. C. Wood, on the other

hand, found it very useful in epilepsy when given in larger doses than usual, viz., from ½ oz. to 3 oz. daily. It has also proved serviceable in severe cases of chorea when other remedies, including arsenic and bromide of potassium, had failed to relieve (B. M. J., i., 1885). Most observers agree in stating that it does not produce bromism so readily as the bromides do. It has been given with quinine to prevent cinchonism, but cannot be depended on for that purpose.

DOSE AND ADMINISTRATION.—On account of its great acidity the drug should always be given much diluted, and with sweetened water, or syrup of lemons. The dose of the acidum hydrobromicum dilutum (B.P.) is m. 15 to 50; but Dana gives from one drachm up to two drachms and a half, and Dr. H. C. Wood up to ½ oz. These large doses seem reasonable since one drachm of the dilute acid is only equivalent to nine grains of the potash salt. Massini uses a stronger solution (25 per cent.), of which he gives ten minims a quarter of an hour after meals.

ACIDUM HYDROCHLORICUM—HYDROCHLORIC ACID (HCl = 36·5).

Free hydrochloric acid is found in the gastric juice of vertebrate animals; in the mineral kingdom it occurs combined with metals, earths, and alkalies (sodium chloride, etc.), and in the springs of volcanic regions. The hydrochloric or muriatic acid of the Pharmacopœia is a solution of hydrochloric acid gas in water, to the extent of nearly 32 per cent. by weight.

PREPARATION.—Being a volatile acid, it can be prepared from any chloride by distillation with sulphuric acid—common salt is usually employed, and hence the acid has been termed "spirit of salt," and "marine acid." When salt is mixed with dilute sulphuric acid, sulphate of sodium is formed, and free hydrochloric acid distils over into a receiver containing water, in which it is very soluble.

$$NaCl + H_2SO_4 = NaHSO_4 + HCl.$$

CHARACTERS AND TESTS.—The pure acid is colourless, but the commercial acid yellowish, owing to the presence of some organic matter, as cork, or of ferric chloride, from the iron stills in which it is prepared. It has a very sour taste and a suffocating odour, giving off white fumes when exposed to the air, from escape of the

acid gas, and its union with the ammonia of the atmosphere. A rod dipped in liquor ammoniæ and held over a bottle of the acid forms dense white fumes of sal ammoniac; nitrate of silver produces a curdy white precipitate of chloride of silver, insoluble in nitric acid, soluble in ammonia, and becoming dark on exposure to light. The sp. gr. of the acid varies with its strength, the strongest having a density of 1·21, and the pharmacopœial acid 1·16. The application of heat should dissipate it without residue, implying the absence of lead and solid impurities. It may contain sulphurous acid, which would be detected by its blackening lead paper.

ABSORPTION AND ELIMINATION.—The mineral acids in moderately strong solution may be absorbed through the skin, as proved, for instance, by the physiological effects produced by the nitro-muriatic acid bath. Dilute hydrochloric acid, taken internally, is absorbed by the stomach, probably unchanged, but any that passes into the intestines would have time to combine in part with soda, and form chloride of sodium before entering the capillaries. It has been said that any acid introduced as such into the blood becomes so closely combined with albumen as to reach the emunctories before being wholly saturated with alkali, but if so, the acid is not traceable by test paper (F. Walter, Wirkung der Saüren, Archiv f. exper. Pathol., 1877). According to this careful observer, an acid reaction of the blood is incompatible with life. Elimination is effected mainly by the urine, the quantity and the acidity of this excretion being usually slightly increased.

PHYSIOLOGICAL ACTION.—*External.*—Strong hydrochloric, like other mineral acids, acts with energy on animal tissue, abstracting water, and combining with potash, soda and lime bases: it does not penetrate so deeply as sulphuric or nitric acid, but produces a white stain, and this part afterwards sloughs. In the digestive tract, large doses have a similar action, and excite gastro-enteritis.

Dr. John Dougall considers it, when diluted with twenty parts of water, "the cheapest, most easily used, and most effective non-aërial disinfectant," especially for typhoid excreta and the bed and body-clothes of persons with infectious disease (B. M. J., ii., 1879). It is not a deodorant, and it even intensifies the smell of fæces, but fermentation of any kind is arrested by it.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Administered in moderate dose and dilute solution, hydrochloric acid has two main effects—(1) it augments the acidity of the gastric juice, and (2) after absorption, it gives rise to the formation of chloride of sodium. It is eupeptic, and also aids the solution of useful substances which would be otherwise inert, such as phosphate and carbonate of calcium, metallic iron, oxides, etc. The augmented acidity of the gastric juice, as a rule and within certain limits, improves the digestive power and increases the formation of peptones; it is accompanied by greater secretion of saliva, and a sense of warmth at the stomach, but if carried to excess causes irritation.

A great part of the interest connected with the study of this acid depends upon the question whether it really forms an integral part of the normal secretion of the gastric glands, a question which has now been answered in the affirmative. Besides the older observations of Prout (Phil. Trans., 1824), of Lassaigne (Journ. de Chim., t. x.), and others, we have the more recent analyses of Schmidt (Die Verdauungsäsfte, 1852), and of Gautier (Chimie Appliquée, 1874), who calculate the proportion of free hydrochloric acid as 3·05 per 1000. Lactic, acetic and butyric acids may also be found in the gastric juice, as described by Cl. Bernard, Lehmann, and other eminent authorities, but they result from chemical changes during the digestion of food. Enderlin, examining the quite fresh gastric secretion of an executed criminal, could find no trace of lactic acid, nor could any *organic* acid act on fluoride of calcium as gastric juice does (Melsens). Further, Rabuteau demonstrated by an original process the existence of hydrochloric acid in the secretion of fishes (Comptes Rendus, 1873) and of dogs (Éléments de Thérap.). After a fast of twenty-four hours he gave to two animals some bits of tendon, and about an hour afterwards divided the medulla; the very acid gastric juice was collected, filtered, saturated with pure quinine, evaporated and divided into two portions. One part was exhausted by benzine, which can dissolve hydrochlorate and lactate of quinine (though not alkaline chlorides), and on evaporating the benzine, hydrochlorate of quinine was easily recognised. The other part was treated by amylic alcohol, which was then evaporated, and the residue

treated by chloroform, which took up a salt proved to be solely hydrochlorate of quinine without trace of lactate. He estimated the quantity of free acid at 2·5 per 1000—not very different from the results of Schmidt, and we may fairly presume that the acid is derived—it may be indirectly—from the chloride of sodium circulating in the blood. Lactate of sodium is not likely to circulate, inasmuch as it would, very soon after absorption, be changed into carbonate. E. Küzl finds that after the administration to dogs of iodide or bromide of sodium or potassium, small quantities of free hydriodic and hydrobromic acids respectively occur in the gastric juice, as well as the usual amount of hydrochloric acid (Zeits. für Biologie, Bd. xxiii., 1887). The formation of hydrochloric acid ceases if no chlorides are given with the food (Voit); it is probably secreted by the so-called oxyntic glands of the stomach. The amount of free acid formed in human gastric juice in cases of fistula is much less than that of the dog's gastric juice; but as pepsin and the other constituents are also small in amount, it is probable that the juice obtained in this way from invalids is poorer in its various constituents than in the secretion of the healthy.

If, then, hydrochloric acid be the normal acid of the gastric juice, it would seem to be the one most easily assimilated by the stomach, and should be preferred as a rule, when acid is indicated. It is scarcely necessary to state that if administered undiluted, this acid causes irritant poisoning with symptoms similar to those described fully under sulphuric acid.

Circulatory System.—As the blood and lymph, and almost all the secretions of the body have an alkaline reaction, it becomes interesting and important to inquire what effect is produced upon such alkalinity by the administration of acids. Some observers, as Eylandt, Wilde, and Gaehtgens, have concluded that any altered relation of acids and bases within the body occurs, if at all, within very narrow limits.[1] Hofmann held that an excess of free acid can pass through the blood to the urine, but this is probably incorrect. Miguel, after giving sulphuric acid, found the *alkaline*, especially *ammoniacal salts* of the urine increased in amount—implying that the acid combined with

[1] Souligoux attaches much importance to it, as altering galvanic reactions within the system.

alkali in the blood, and thus removed from that fluid for excretion an unusual proportion of such alkali. Salkowski arrived at a similar conclusion, and Lassar asserted, from analyses of blood, that its alkalinity was much lowered under the use of acids. But the estimation of urinary ingredients does not give a satisfactory answer to the question, and alkalimetry, as applied to the blood, is exceedingly difficult, hence another and an ingenious method of analysis has been adopted by F. Walter (*op. cit.*). Starting from the highly probable supposition that the carbonic acid contained in the blood must be almost wholly in combination with alkalies, and that its amount must therefore be proportional to, and be an index of, the amount of alkali contained in that liquid, he analysed the gas-contents of blood withdrawn from animals under acid-treatment, as compared with that of animals in a normal condition. Most of his experiments were made with hydrochloric acid, because it required less water for dilution than other acids. From 1 to 3 grammes of acid were given diluted, in three doses, by the stomach tube, in the course of twenty to forty hours. The blood was drawn from veins after decided symptoms of acid-poisoning had set in, and when compared with normal blood it showed a remarkable *lessening* of the carbonic acid, and (by inference) of combined alkalies ; this was especially the case in rabbits (herbivora). Whilst normal rabbit-blood showed an average percentage of 25 volumes of CO_2, that drawn after 1·22 grammes of acid gave 16, and after 2·44 grammes of acid, only 3 volumes of the gas ; this blood was dark, and coagulated with difficulty, but was decidedly, though weakly, alkaline in reaction. In dogs (carnivora) the difference was not so great, but a diminution of about 10 per cent. in the amount of CO_2 occurred under the influence of hydrochloric acid. This curious difference between the effects of the acid on the two classes of animals was first pointed out by Salkowski, and it was found that dogs have a certain immunity as to the general symptoms of acid-poisoning, so that they can take much larger doses than the herbivora without ill results. (This has been accounted for by increased formation of ammonia compounds in the latter class of animals under the influence of the acid, causing its neutralisation to some extent.) The experiments of Walter prove, however, that it is possible, by means of the internal administration of acids, to withdraw alka-

lies from the vital fluids, and this to such an extent as even to cause death from their deprivation.

With regard to the influence of hydrochloric acid on the general circulation, it was noticed by early observers—Boerhaave and others—that even moderate doses accelerate the pulse and cause flushing of the face; and full doses produce some excitement of the cerebral functions so that the symptoms have been compared to those caused by alcohol (Deutsch). Bobrick took 18 min. diluted with 5 oz. of water, and within half an hour noted an increase of pulse by six beats; this continued for an hour, but was succeeded by a fall of four beats below the normal frequency. He noticed excitement of similar character after internal and external applications of the acid to frogs, and concluded that it was produced through the nervous system, for it did not appear after destruction of the nerve centres.

Respiratory System—Toxic Action.—F. Walter found that in different animals of the same species, the action of the acid was different; from 7 to 8 grammes of hydrochloric acid per kilogramme of body-weight might be given to a rabbit in one day without necessarily serious result, but if the proportion of 9 grammes in the same period were exceeded, death certainly followed within a few hours. The first symptom of poisoning was an increase of frequency in respiration; then the separate inspirations became deeper and more laborious, with violent heaving of the thorax; the heart beat so quickly that the pulse could not be counted; the animal lost power of moving, and lay quiet on the side for a quarter of an hour before death. The respiration then lost its dyspnœic character, and grew superficial and weaker as collapse set in, and the heart ceased a few moments after the breathing. Post-mortem inspection revealed no sufficient change in the organism to account for these symptoms; sometimes, it is true, erosion of the gastric membrane occurred, but the course of the poisoning was not altered in such cases, and therefore it could not be dependent on such erosion: a different concentration of solution, whether 4 or 8 per cent., made no difference in the symptoms; the blood was only so far altered that it coagulated more slowly than usual, it was not found acid in reaction. Hence, apparently, neutralisation of alkali, or withdrawal of some portion of alkali from the blood and tissues, was the

cause of death; and this hypothesis was remarkably confirmed by the results of injection of an alkali into the blood-current after full and toxic doses of acid had been given by the stomach. A rabbit that had received more than 6 grammes of hydrochloric acid in three days—three times as much as would kill it—together with 0·2 gramme carbonate of soda injected under the skin with each dose, recovered without loss of appetite or any symptom of poisoning. Another animal received more than 2 grammes of acid, and just when the symptoms indicated the near approach of death 0·5 gramme of soda carbonate was injected into the jugular vein; within ten minutes the strong thoracic movements subsided, the heart's action became slower and stronger, the animal sat up and began to eat, and in an hour's time seemed quite restored. This direct antidotal action of injected alkali is very striking.

It would seem that the result of diminished alkali in the blood is first a stimulation and then a palsy of the respiratory centre, through which death may be induced. The dyspnœa is not connected with altered heart-action, and the paralysis of respiration must be distinguished from that of asphyxia, for the oxygen contained in the blood remains unchanged.

Urinary System.—Besides the observations showing that acids increase the ammoniacal salts in the urine, it should be stated that the urea is diminished, and that their administration in sufficient dose can certainly increase the acidity of the secretion; during digestion, however, the urine is less acid, and may even become alkaline. This is accounted for by supposing that the base, set free by the formation of hydrochloric acid in the stomach, is excreted by the urine, rendering it at the same time less acid (Maly); there is no such effect on the alkalinity of the saliva (Külz, Zeits. für Biol., 1887).

SYNERGISTS.—As refrigerant tonic and astringent, the other acids; as tonic and digestive, bitters, and also pepsin, possibly pancreatin.

INCOMPATIBLES.—Alkalies and bases, salts of silver especially. To neutralise irritant poisonous doses of acid, the alkali should be given in mucilaginous or albuminous liquids.

THERAPEUTICAL ACTION.—*External.*—**Stomatitis, etc.**—In inflammation, with patches of ulceration about the mucous membrane of the mouth and gums, hydrochloric acid, diluted with

an equal part of glycerine, and applied to the sloughing spots, will induce healthy action. In mercurial stomatitis, and in the aphthous conditions that occur in children, or during advanced disease, lotions containing 1 part of acid in 10 of rose water, either alone or with chlorate of potash and glycerine, are very serviceable. The acid is also valuable given *internally* in such cases. To avoid possible injury to the teeth, plain or alkalised water should be used immediately afterwards.

Cynanche Maligna Ulcerosa.—In all forms of ulcerative sore throat, whether scarlatinal or otherwise, but especially when sloughing is present, and when there is marked general asthenia, hydrochloric acid is indicated as well locally as internally. It may be applied with a brush (1 part in 15 of liquid), or in gargle (2 dr. to 8 oz.). In gangrenous or "putrid" sore throat, the nearly pure acid may be carefully and lightly pencilled over the affected part.

Diphtheria.—Bretonneau recommended the application of the strong acid mixed only with a little honey to the false membranes and adjacent tissues, and this has sometimes arrested the local progress of the malady; but, on the other hand, it has sometimes done harm by exciting irritation, which has favoured the development of membrane. A weaker solution, such as the dilute acid of the Pharmacopœia (1 in 3¼), is to be preferred, and much advantage has been traced to it (Dr. Heslop, Med. Times, i., 1858). A *weaker* gargle (1 or 2 dr. in 8 oz.), as above mentioned, may be used if the conditions admit.

THERAPEUTICAL ACTION.—*Internal.*—**Dyspepsia.**—There are two varieties of indigestion in which hydrochloric acid is especially indicated—the so-called "atonic" form, and the "acid" form—but the mode of its use is somewhat different for each.

Atonic dyspepsia occurs either in connection with general weakness or impaired hygienic conditions—for instance, in overworked factory girls, seamstresses, etc.—or in well-fed persons who tax their stomach with too much nitrogenous food whilst leading a sedentary life. The secretion of gastric juice is but scanty, and the patient suffers from weight and heaviness after food, from general oppression, and other signs of unfinished digestion. One indication for the treatment of such a condition is to supply additional acid to the gastric secretion: but, as we

have reason to believe that adding such acid *before* a meal will check the formation of the naturally acid though scanty gastric juice, it is better to allow this to do what it can, and to prescribe our medicinal acid shortly *after* food has been taken, with the object of assisting nature, and not interfering unduly.[1]

In cases of "acid" dyspepsia, the patient suffers rather from heartburn and regurgitation of sour fluid, connected either with hyper-secretion from the gastric glands, or abnormal fermentation of starchy, saccharine, or fatty food. It is true that the symptoms may often be relieved by sodium bicarbonate, but in many cases, more permanent relief will be given by dilute hydrochloric acid administered about half an hour before a meal. This will lessen the amount of the natural secretion, and will check fermentation.

It is only recently that this important distinction as to the *time* of taking an acid with reference to food has been recognised; many writers, Nothnagel for instance, are satisfied with recommending its use always before meals, and certainly if it be given after food, in cases of *pyrosis or water-brash*, it will aggravate the mischief; these are the true cases in which its use is indicated *before* meals, when it exerts an astringent action. It is contra-indicated in acute inflammatory, and also in organic disease; and in any case its use should not be continued for more than ten to fourteen days at a time, or the digestive property of the gastric juice will be impaired, or catarrh excited.

Headache, especially felt in the temple and the brow, and marked giddiness are often connected with the dyspepsia above described, and are relieved by hydrochloric acid.

Chlorosis.—Zander praises hydrochloric acid in the treatment of chlorosis, and finds that it acts even more satisfactorily than iron (Virchow's Archiv, lxxxiv., 1881), but later observations do not confirm this (Hale White, Guy's Hosp. Rep., 1891; Stockman, B. M. J., i., 1893). Dr. Smart reports a case of advanced chlorosis, with atonic dyspepsia and absence of free hydrochloric acid in the gastric contents, much improved under 100 minims

[1] Manassëin showed that in dogs made anæmic by blood-letting, the normal proportion of acid and pepsin was altered, and in such animals an addition of artificial acid to the gastric juice is, *ceteris paribus*, more effective than in the healthy (Virchow's Archiv, lv.).

daily of the acid (in divided doses): he concludes, however, that the improvement is in favouring digestion of proteids, not in restoring hæmoglobin, so that some form of iron is necessary for recovery (Lancet, i., 1893).

Diarrhœa.—In this complaint, hydrochloric is often preferred to other acids, not because it has a more energetic effect than sulphuric acid, but because it is better borne by the stomach. It is most reliable in cases that are due to abnormal fermentation in the bowels, with formation of lactic acid, as in what is called summer diarrhœa and gastric catarrh of infants; there are, however, many other remedies for this condition which must be considered better than the acid.

Vomiting.—Small doses diluted have often been found useful in many kinds of vomiting, *e.g.*, that of pregnancy, that of ordinary dyspepsia, of fevers, and even of cholera (Lancet, 1892).

Fevers.—In typhoid or "low" fever, hydrochloric acid had, at one time, a high reputation; it was said to moderate the pyrexia, to limit the alteration of the blood, and to directly influence the morbid process. We scarcely expect so much now, but still there is reason to think that a judicious use of this acid may favour the assimilation of food, if it do not exert antiseptic influence. According to the investigations of Manassëin, with the gastric juice of fever patients, it is not *pepsin* that is deficient but *acid*, and this deficiency may be supplied for a time by the artificial acid, which then much aids the impaired digestion. It matters little whether we say with this observer, and with Chambers, that we supply deficient acid, or with Richardson, that we neutralise by it excess of alkali formed during fever. Chambers records an emphatic opinion as to its value, after a fairly extensive use of it at St. Mary's Hospital, in "low" fever, apparently typhus and typhoid. The treatment by hydrochloric acid was more successful than by any other method, but we must add that he also paid strict attention to *nourishment*, giving milk and beef-tea regularly every two hours, day and night (Med. Times, 1858; Med.-Chir. Rev., ii., 1863). Henderson has reported on its value during an epidemic at Shanghai (Med. Times, i., 1863). There are several recent observations confirming those of Manassëin as to deficiency of this acid in typhus, and in febrile patients generally when suffering with dyspeptic symptoms. On the other

hand, Sir G. Johnson was satisfied with the far better progress made by his typhoid patients in King's College Hospital when he *omitted* mineral acid from their treatment; especially, that diarrhœa was less troublesome, and acids seemed to irritate the bowels, just as bread or meat would do (B. M. J., i., 1875). I cannot think the reasoning very conclusive, though the facts are of course to be accepted; I believe the acid is sometimes useful, and if well diluted the doses required will not irritate the bowels. It may be given as a refrigerant drink in lemonade, or mixed with essence of meat so as to aid assimilation.

Scarlet Fever.—There is also evidence as to the value of hydrochloric acid in scarlatina. Osborne records a prolonged experience in its favour (Lancet, ii., 1862), and more recently Egbert (Pennsylvania) has quoted nearly three hundred cases, all treated by a mixture containing this acid with chlorate of potassium (Ranking, i., 1873). He gave about 8 min. of acid with 20 gr. of chlorate of potassium every two hours to a child of six, and more or less than this according to age. Occasionally tinct. camph. co. was added to relieve restlessness; no applications were made to the throat, unless sometimes ice externally; only one death occurred. Of course it may be said that fevers tend to get well, and will do so under any treatment, but yet these results deserve careful attention. I myself constantly use hydrochloric acid internally and locally in cases of scarlet fever, where there is marked general asthenia with dark ill-developed rash, and tendency to sloughing in the fauces (*v.* Chlorate of Potassium).

Variola.—Dr. M'Donald advocates the treatment of small-pox, both internally and externally, by this acid. He uses a lotion containing ʒss. ad ʒx. of water, and finds that it relieves the cutaneous itching and irritation.

Bright's Disease.—It has been stated that this acid should not be administered in cases of renal disease, because certain cases of chronic Bright's disease suffer from renal pain and hæmaturia after medicinal doses given for dyspepsia. On the other hand, in a case of fatal poisoning by the acid, none of it was eliminated by the kidneys, and there was no evidence of irritation of the organs post mortem, so that hydrochloric acid cannot be thought to have a specific determination to them (B. M. J., i., 1889).

Urinary Deposits.—In oxaluria, Dr. Prout long ago recommended hydrochloric acid, and its use is especially indicated for the impaired digestive power, and the anxious and depressed mental condition usually connected with the malady. It may be given *before* meals with a bitter, such as nux vomica or chirata, and continued till urates begin to appear in excess in the renal secretion. In cystine and phosphatic deposits with alkaline urine it is also useful, and has sometimes been injected into the bladder for its local effect (mij. in ʒiv. of water).

Gout.—Dr. Duncan recommended this acid as a preventive of the undue formation of lithic acid (Dub. Quart. Journ., May, 1865) by its aiding assimilation; hence it should be serviceable in chronic gout, but such a view has not been supported by the experience of others, and, as a rule, gouty subjects are very intolerant of any acid treatment.

There are several other disorders in which hydrochloric acid is sometimes, though not generally, used, but in which its good influence on the digestive tract may fairly be expected to relieve.

Pneumonia.—Traube states that he has found it useful in that form of pneumonia which sets in with much biliary disturbance—nausea, coated tongue, gastric catarrh, and diarrhœa.

Eczema.—Mr. Erichsen has published cases illustrating its value in chronic eczema (Lond. Med. Gaz., 1846), but in this, and in hepatic disorder, its value is better shown when in combination with nitric acid.

Syphilis.—The former reputation of this acid as a cure for syphilis in Vienna need be mentioned only as an historical fact (Nothnagel). The aqua regia may, however, prove of service in chronic cachectic conditions.

PREPARATIONS AND DOSE.—*Acidum hydrochloricum dilutum*: dose, 10 to 30 min. freely diluted. *The strong acid*, given internally in an undiluted form, is an irritant poison.

The following preparations contain free hydrochloric acid: Acidum nitrohydrochloricum dilutum, Liquor antimonii chloridi, Liquor arsenici hydrochloricus, Liquor morphinæ hydrochloratis, Liquor strychninæ hydrochloratis.

ADULTERATIONS.—Sulphurous and sulphuric acids, chlorine, and iron.

ACIDUM HYDROCYANICUM DILUTUM—DILUTED HYDROCYANIC ACID

(HCN or HCy, = 27).

A solution in water containing 2 per cent. by weight of the anhydrous acid (Scheele's acid should contain 5 per cent., Vauquelin's 3·3 per cent.).

Amygdalin, from which the acid is developed under the influence of a ferment, exists in many plants, in the leaves of the cherry-laurel, the kernels of the peach, bitter almond, cherry, etc. In the mineral kingdom the acid is found in combination with metals as cyanates and cyanides; it occurs also in various animal secretions, and may be obtained by heating nitrogenous organic matter in contact with a base. Scheele discovered the acid in 1782, and is said to have been accidentally poisoned by it.

PREPARATION.—By distilling, with gentle heat, a mixture of ferrocyanide of potassium (yellow prussiate of potash) and dilute sulphuric acid; half the cyanogen passes over into the water of a cooled receiver as hydrocyanic acid, and part remains in combination with potassium and iron as a yellowish-white insoluble double salt (Everett's salt). Some acid sulphate of potassium is also formed: thus—

$$2K_4FeCy_6 + 6H_2SO_4 = FeK_2FeCy_6 + 6KHSO_4 + 6HCy.$$

CHARACTERS AND TESTS.—The pharmacopœial solution is a colourless volatile liquid of characteristic odour. Its taste has been variously described as "hot and bitter" (Taylor), or "cooling, afterwards irritating" (R. W. Smith); sp. gr. 0·997. If free from other acid it only transiently reddens litmus. It decomposes on exposure to air and light, but that which is prepared by the pharmacopœial process and kept in dark-coloured bottles may be retained for years without perceptible change. Stronger solutions alter more readily, and of the anhydrous acid (which has a sp. gr. of 0·697) a part evaporates on paper so quickly as to freeze the rest. Cyanides prevent fermentation, and are fatal to vegetable life (Dumas).

1. *The Silver Test.*—Nitrate of silver gives, with prussic acid solutions, a dense flocculent white precipitate of cyanide of silver, insoluble in cold, soluble in *boiling* nitric acid,—$HCy + AgNO_3 = AgCy + HNO_3$. This test may be con-

veniently applied to the detection of prussic acid vapour by means of two watch glasses, the lower one containing a little of the suspected solution, and the upper one, inverted over it, a few minims of nitrate of silver solution (1 gr. to the oz.) ; the latter soon becomes opalescent, and when dry, leaves a white stain, showing under the microscope prisms or long plates interlaced. Cyanide of silver, like other insoluble cyanides, may be further tested by placing it in a narrow glass tube drawn out at one end, and on heating this, cyanogen escapes and may be lighted at the pointed end ; it burns with a rose-coloured flame, having a bluish halo.

2. *The Prussian Blue Test.*—This is applied by adding to the solution a little liquor potassæ and a few drops of a mixed solution of a ferrous and ferric salt ; a greenish-brown precipitate falls, which, on being acidified with dilute hydrochloric acid, gives a precipitate of Prussian blue. The potassic cyanide, first formed, gives rise to ferro-cyanide and afterwards to ferric cyanide with the iron salts, thus :—

$$HCy + KHO = KCy + H_2O$$
$$2KCy + FeSO_4 = FeCy_2 + K_2SO_4$$
$$4KCy + FeCy_2 = K_4FeCy_6$$
$$3(K_4FeCy_6) + 2(Fe_2Cl_6) = 12(KCl) + Fe_4(FeCy_6)_3.$$

The acid dissolves any excess of precipitated iron oxides which might obscure the colour.

3. *The Sulphur Test.*—Add to the solution a few drops of ammonia and of yellow sulphide of ammonium ; warm gently till colourless, and evaporate slowly ; to the residue add a drop of acid solution of perchloride of iron ; a blood-red colour (sulphocyanide of iron, $Fe_2 6CyS$) is developed ; it is discharged by corrosive sublimate, and thus distinguished from the similar colour given by meconic acid. In this test some free sulphur in the ammonium sulphide unites with the alkaline cyanide to form sulphocyanate of ammonium, — $2AmCy + S_2 = 2AmCyS$. The ammonia combines with excess of free sulphur, and forms, amongst other compounds, sulphydrate of ammonium, which should be removed by boiling and evaporation, and if this be not carried far enough, some of the latter compound remains and gives rise to black sulphide of iron instead of sulphocyanide, on addition of the perchloride solution.

These two tests are also applicable to the vapour by means of watch glasses.

4. *The Copper Test.*—To the liquid, rendered slightly alkaline by liquor potassæ, add solution of sulphate of copper ; a greenish-white precipitate falls, containing cyanate of potash and of copper with some blue hydroxide ; when this is dissolved by a little hydrochloric acid, the precipitate becomes nearly white.

ABSORPTION AND ELIMINATION.—Hydrocyanic acid is absorbed to some extent, even through the unbroken skin, especially if a strong solution be applied with friction ; from a wound, or from mucous membrane, it is, however, absorbed much more readily. When placed on the tongue or swallowed in the ordinary way, it passes sooner into the circulation than when injected into the stomach, rectum, or vagina (Coullon, Krimer). In less than thirty-six seconds after a little of the strong acid is placed on an animal's tongue it may be detected in the circulating blood (Krimer, Horn's Archiv, 1826) ; after intravenous injection, also, it quickly produces its effects, but most quickly after inhalation. Guinea-pigs made to inhale the anhydrous acid for one second, die within fifteen seconds, and strong rabbits exposed to the vapour for three seconds, are destroyed within thirty (Preyer, Die Blausäure). The weakly, the young, and the aged amongst warm-blooded animals are much more easily affected by the acid ; whilst frogs, and all cold-blooded creatures, are much less sensitive to its action, and survive toxic doses for several hours. Horses are said to be insusceptible to quantities of one or two ounces (Amory).

Although so rapidly poisonous to most animals and to men, there is yet no difficulty in concluding that absorption must precede any general action, and Stillé has shown that if a tight ligature be placed round a limb exposed to the acid, constitutional effects do not occur, so long as the local is cut off from the general circulation. Ordinary blood is not essential to its action, for the bloodless " salt frog " exhibits the same symptoms under prussic acid as the normal creature (Lewisson, Reichert's Archiv, 1870).

Elimination is rapid, and for ordinary medicinal doses is probably complete within an hour ; even after a full or poisonous amount, if life can be prolonged for that time, recovery may be

hoped for. The acid passes out partly by the saliva, to a slight extent by the kidneys, but mainly by the lungs, as evidenced by the characteristic odour of the breath.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Small medicinal doses—2 to 5 min. of the officinal acid—seldom exert more than a transient sedative effect on the gastric mucous membrane; 10 to 20 min. induce slight local irritation of the fauces and stomach, with increased flow of saliva and nausea; breathing the vapour, or taking by the mouth 20 to 30 min. or more of the diluted acid, causes such symptoms in a marked degree, though not always immediately (Taylor).

Toxic Action.—In animals under doses not rapidly fatal, there occur vertigo and loss of muscular power, with slow breathing and quick weak pulse: later, general convulsions, protruding eye-balls, lividity and death from asphyxia, or gradual recovery. Post-mortem congestion of venous trunks and cerebral membranes is marked.

In man, more than 60 min. of the dilute, or 1 gr. of the anhydrous acid, will be usually a fatal dose, though symptoms may not be developed for some minutes; after as much as $\frac{1}{2}$ fl. oz., however, they will come on in a few seconds, or even during the act of swallowing. Volition and power may be retained just long enough to walk a few paces, to arrange the bed-clothes, or to cork a phial; but suddenly the subject, if standing, will fall prostrate, often with a scream, or in convulsions. Within two minutes he will be insensible, paralysed, with fixed and glistening eyes, dilated insensible pupils, cold clammy skin, and swollen cyanotic face: the jaw is set, saliva exudes from the mouth, and evacuations occur from the bladder and bowel: the breathing, at first perhaps hurried, soon becomes convulsive and gasping, with long pauses and prolonged expiration: the pulse, after a brief quickening, is soon imperceptible, and death occurs from asphyxia within three to five minutes after the fatal dose.[1]

Respiratory System.—In man, ordinary medicinal doses do

[1] The glistening condition of the eye usually described, and the evacuation of the bladder and bowel, are not, I think, so constant as commonly supposed: in four cases within my experience, the former symptom was not present, and in only one did the evacuations occur.

not affect respiration, but 10 to 20 min. may render it irregular and laboured. Under small doses, the rate of breathing in animals either remains unaltered at first or is markedly lowered; it is never increased. With larger doses and concentrated solutions, the course of poisoning is so rapid, that the respirations can scarcely be counted; convulsive movements also interfere with observation, but we can say that in this stage the rate is lowered, and continues so. As the animal passes into a comatose condition, a slight rise may occur, which increases if recovery is proceeding, but which soon gives place to marked slowing and then complete cessation of breathing. The heart may continue to beat for some little time after this, and if so, even if in other respects the animal seems dead, *artificial respiration* will restore it to life.

The general character of the respiratory changes resembles, not that occurring in apnœa, but that which occurs when the vagi are divided and the central end stimulated by electricity (Preyer). At the beginning of the poisoning the inspirations are deeper than normal, then follows a pause, and then short shallow expirations. In many instances during the convulsive stage there occurs on inspiration a tetanic spasm of the diaphragm, such as Traube found after direct vagus irritation.

Nervous System.—Doses which disturb the digestive and circulatory systems—10 to 20 min.—may cause not only giddiness, but also a sense of constriction and heaviness of the head, prominence of the eyes, some confusion of intellect, and muscular weakness. Impaired vision and hemiopia seem to have followed inhalation of the acid used in cleaning lace (B. M. J., i., 1884). Upon which part of the nervous system the special effects of larger doses are exerted—whether upon the vagus, the nerve centres, or the peripheral nerves—has been disputed.

Vagus Nerve.—Arguing from the conditions already described, and from the fact that poisoning by prussic acid is most rapid if the vapour be inhaled, Preyer concluded that its chief action was exerted on the terminations of the vagus in the lungs, the irritation being propagated to the respiratory centre, and causing the phenomena of asphyxia. That the stimulation was not, in normal conditions, exerted directly on the respiratory *centre* he held to be evident from the fact, already noted, that section of the vagi—*i.e.*, interruption of communication between the ends and the centre—

delayed the course of the poisoning and the time of death: the occasional occurrence of tetanic spasm of the diaphragm he explained by a secondary transfer of irritation from the medulla to the *phrenic nerve*. In animals with divided vagi, the respiratory changes were somewhat different, and death in such cases was explained either by an action on the terminals of other (unknown) nerves of the lungs, or by direct action on the centre in the medulla, or when occurring under large doses, by direct paralysis of the heart.

Nerve Centres.—On the other hand, Boehm and Knie conclude that the main change is always exerted on the *central* nervous system—the medulla—the functions of which are for a brief period stimulated and then destroyed (Archiv f. exper. Path., ii.). In cats prepared for experiment according to their method, there occur under prussic acid at first two to four deep laboured inspirations, then quick and convulsive expiration, "resembling that caused by irritation of the superior laryngeal nerve" (Rosenthal); they observed no inspiratory cramp or tetanus, and no influence of the vagi, whether it be left entire or divided, upon the course of the poisoning, nor upon the heart. (The practical result is that these observers attach no value to atropine as an antidote, though equally with Preyer they recognise the excellent results to be obtained by *artificial respiration*.)

I am not prepared to reconcile the differences between these and other observations, but in a more recent essay Preyer attributes the differences to *undue manipulation* of the animals, maintains his conclusions unaltered, and offers additional facts in support of some of them (Archiv f. exper. Path., 1875). We must add, however, that Lecorché and Meuriot, whilst agreeing with him that cyanic death is connected with intense excitation of the vagus nerve, and that section of the vagi delays it, yet attribute such excitation to a *central*, not peripheral, action of the poison. A striking experiment made by Prof. Jones bears in the same direction: having found, with alligators, that the internal giving of the poison did not easily or quickly take effect, he applied it *directly* to the medulla oblongata, and within sixty seconds there followed complete expiration of the air contained in the lungs, with collapse of those organs, and tetanic contraction of the respiratory muscles (New York Med. Record, vol. ii.).

The convulsions which often occur in cyanic poisoning are *cerebral* in origin, for they do not occur in parts situated below a transverse section of the spinal cord—*i.e.*, in parts with which cerebral communication has been interrupted (H. C. Wood). We may further conclude that they are connected with disturbed cerebral circulation, for they have been noticed to commence directly after cardiac arrest (Laschkewitsch, Coze). The convulsions though resembling those of asphyxia differ from them in the circumstance of the blood being red (or non-venous), and in not being remedied by artificial respiration (Brunton).

Peripheral Nerves and Muscles.—We are unable to conclude positively with Preyer that the peripheral ends of the vagus receive the first and main influence of the poison, for the mere extent of absorbing surface and ready contact with blood in the lungs would go far to account for the greater rapidity of the effects of inhalation, and there is other evidence that the respiratory *centres* are affected. This question, however, apart, we may accept the careful observations of Kölliker, that peripheral sensory nerves are paralysed by *local contact* with sufficiently strong solutions, and the early disappearance of reflex function in cyanic poisoning is connected with such paralysis rather than with paralysis of the cord (Kiedrowski), although the spinal cord is affected later. Nerve-tissue placed in a solution of prussic acid loses its conducting power, and muscular tissue loses its irritability still more quickly, although the nerve-trunks are probably acted upon at the same time as the muscles after internal administration of the acid (Virchow's Archiv, Bd. x.). When the whole blood is rendered venous, as in later stages of poisoning, there is increased action of the involuntary muscular tissue, and hence, often increased peristalsis of the intestine, contraction of the bladder, and evacuations from those viscera. The same result occurs sometimes in asphyxia from hanging, carbonic acid poisoning, etc., and is commonly attributed to the same cause (venosity of blood), though indeed it *may* result from *paralysis* of sphincters, as it does under chloroform, or during an epileptic attack.

Circulatory System.—Continued small doses—1 to 5 min. —given at moderate intervals of two to four hours, lessen the force and rapidity of the heart-action ; 10 to 20 min. taken by the mouth, or inhaled, may cause giddiness and faintness, with slow-

ing, or sometimes quickening, of the pulse, and suffusion of the face. With animals, full or large doses cause a sudden arrest of the heart in diastole; this continues for a variable time, and is followed by quickened action, and afterwards by diminution, and then by either gradual return to the normal number of beats, or total cessation according to the dose, and to the age and strength of the animals.

A point of much interest is the statement that *section of the vagi* in the neck prevents this primary diastolic arrest, and Preyer after numerous experiments affirms that after such section no slowing of the heart's action occurs under doses that would with uncut vagi stop the heart (*op. cit.*); also that death, under toxic doses, is much slower when these nerves are divided than when they are not. We know from Pflüger's researches that weak stimulation of the vagus causes slowing of the heart, and a very strong stimulus of it causes stoppage in diastole, and Preyer argues that the action of prussic acid on the heart is exerted through the *vagi* in accordance with these results, and the secondary and temporary quickening which occurs with certain doses is due to a secondary paralysis of the controlling influence of the same nerves.

On the other hand, we have directly contradictory observations upon cats by Boehm and Knie, who found no primary diastolic arrest, and no influence exerted either way by section of the pneumogastrics; but their animals, though more accurately dosed, were in a still less natural condition than those of Preyer, for they were chloralised and tracheotomised, and the acid injected through an exposed jugular vein; we cannot think their observations conclusive.

With very large toxic doses death is instantaneous, and the heart is arrested in diastole without any recurrence of ventricular contraction, though some movement of the auricles may be perceived on opening the chest (Lecorché and Meuriot, Archives Gén., t. xi.); with such doses the result is not influenced by section of the vagi, and death is presumed to follow direct cardiac paralysis (Preyer). Applied directly to the heart, the acid arrests its movement and destroys its muscular irritability.

Arterial pressure in the vessels is said to be increased under the action of prussic acid (Wahl), but such increase is temporary only; the pressure soon falls below normal, and after large doses

remains so for some time ; this is accompanied by slowing of the pulse.

The startling rapidity of action of prussic acid suggests an immediate toxic effect on the *blood*, and there is indeed a remarkable colour-change induced, which has been thought to give a clue to the intimate working of the poison. Thus, if the jugular vein of a rabbit be exposed, and seen to contain dark blood, and a toxic dose of acid be then given by the mouth, so soon as convulsive movements indicate its taking effect, will the stream of venous blood take on a clear red colour, and the vessel greatly enlarge in size. If the blood be let flow from an incision, a similar change is observed, and if the right heart be examined *in sitû*, the dark blood contained in it is equally seen to become red ; it is so also in the nose and ears (Gaehtgens, Med.-Chem. Untersuch., Berlin, 1868). This has been noticed, though with less detail, by earlier observers, by Claude Bernard (who got a similar result with carbonic oxide), and by Preyer, who found the same appearance caused not only by diluted sulphuretted hydrogen, but also by the mere removal of any obstructions placed in the air-passages. It is not, therefore, due to a specific action of prussic acid. The apparently contradictory observations of Bischoff and others, to the effect that all the blood found in the body after cyanic poisoning is unusually dark and venous, are explained by a difference mainly in the *rapidity* of the poisonous action ; if life be prolonged for a few minutes, the red colour is gradually replaced by dark, whilst if death be very sudden, red blood only is found in the heart —sometimes even on the following day. In cold-blooded animals, the red colour persists much longer than in the warm-blooded.

Theory of Action.—It is easier to ascertain than to explain these facts. Hoppe-Seyler suggests that the acid enters into loose combination with hæmoglobin, and that the red corpuscles lose for a time their power of giving up oxygen in the capillaries—that oxidation of tissue is suspended (Med.-Chem., Untersuch., 1866). Geinitz argued that a change in the *physical form* of the corpuscles would explain change of colour, and found that the acid mixed with blood *outside* the body caused various alterations of their form (Pflüger's Archiv, Bd. iii., 1870) ; but according to Preyer the blood of a poisoned animal taken from the vessels directly after death, and examined by the microscope, exhibits *no*

change in the character of the corpuscles (Chemismus, Leipsic, 1840). He inquires whether the deepened breathing could for a time induce a hyper-oxygenated condition, as in animals dying from apnœa and found by Pflüger to have bright red blood (Archiv, i., p. 106), or whether the increased blood-pressure could drive the blood so quickly through the capillaries as to prevent its giving up oxygen as usual. Kobert states that a new hitherto undescribed combination of methæmoglobin with cyanogen is formed (Ueber Cyanmethæmoglobin, 1891).

I cannot satisfy myself as to a clear explanation, but believe that during the first stage of cyanic poisoning oxidation is arrested, and that the venous condition of blood found in later stages of poisoning is connected with spasm of the pulmonary arterioles, and paralysis of the respiratory and cardiac muscles.

It would seem that no *permanent* toxic combination is formed with the corpuscles; they are not at once fatally spoiled, nor is oxygen wholly driven out, but for the moment (and it may be finally) its interchange with tissues is prevented. The results of many careful spectroscopic examinations by Preyer and others, and of many laborious gas analyses by Gaehtgens, confirm this view; the red blood shows still the absorption bands of oxyhæmoglobin, and the dark blood those of hæmoglobin; although outside the body, prussic acid forms a new compound, cyanohæmoglobin, it apparently does not do so during life. Laschkewitsch could not detect such compound, but on the contrary found oxyhæmoglobin (Reichert's Archiv, 1868), and Hiller and Wagner, examining blood whilst still within the mesenteric vessels, obtained characteristic though feeble lines of oxyhæmoglobin (Lancet, ii., 1877). If withdrawn from the body, the dark blood, shaken up with oxygen, resumes its normal red tint, and—a most important practical point—the condition just described may be remedied during life by securing access of additional oxygen by *artificial respiration*. This is in distinct contrast with what occurs in poisoning by carbonic oxide, in which case a new compound, carboxyhæmoglobin, with well-marked chemical and physical properties is undoubtedly formed.

Gaehtgens proved (1) that the property of de-oxygenated blood to abstract oxygen from surrounding media is not destroyed by prussic acid; (2) that blood saturated with oxygen exposed to the

action of prussic acid gives off no oxygen, and that substances which would usually withdraw oxygen from fresh blood do so with much difficulty under the influence of the acid. Both oxygen and carbonic acid are excreted in less than normal *total* quantity during the poisoning (on account of the slow rate of the breathing), but not only is the actual percentage of carbonic acid in the expired air less than normal, but the *percentage* of oxygen in the same expired air is greater than normal—*i.e.*, it has not been used up in the system.

SYNERGISTS.—Cyanides, cherry-laurel water, and essence of bitter almonds owe their activity and chief properties to prussic acid, and exert a similar action.

ANTAGONISTS—INCOMPATIBLES.—The effect of medicinal doses is lessened by diffusible stimulants, by strong acids or alkalies, and by opium (Gubler). Warmth quickly volatilises the acid, otherwise it favours its action. The most reliable antidote to poisonous doses is *oxygen*, which may be introduced into the system by *artificial respiration*, or by direct inhalation.

Preyer strongly recommends atropine as a "dynamic antidote," since it acts upon the vagus nerve in a manner contrary to that of hydrocyanic acid. I must agree with Boehm and others that his observations are wanting in scientific accuracy, as when he speaks of injecting "a little atropine," or says simply, "Injected sulphate of atropine, and afterwards a rather large dose of prussic acid, which would assuredly have caused death"; still they hold true to a certain extent. A practical difficulty in their useful application must always be the extremely rapid course of cyanic poisoning, and the (comparatively) slow diffusion of atropine; to be of any service, the alkaloid would have to be used almost on the instant of poisoning.

Sal-ammoniac was strongly recommended by J. Murray (Edin. Phil. Journ., 1822), and although Orfila and Elwert showed that it could not be depended upon as an antidote, I think this and other compounds of ammonium well deserve further trial. Modern observation credits the drug with a power of directly stimulating the respiratory centres, and this, in addition to its general stimulating power, seems specially to indicate its use in cyanic poisoning.

Chlorine and chlorine water have been used with advantage by

A. Chevallier and Orfila, but they are not manageable. The object aimed at is to decompose the hydrocyanic acid by the chlorine, practically an impossible task in cases of poisoning. Turpentine, though recommended as a specific antidote, has value only as a stimulant. I cannot see that phosphorus offers a resource of value, nor can much be expected from coffee.

Some indefinite evidence exists as to an antidotal power possessed by strychnine. Thus, a puppy that had taken ½ gr. of prussic acid quickly recovered after swallowing a dose of the alkaloid (Med. Times, ii., 1859), and some other instances are reported (Lancet, i., 1868). Stannius also found that strychnine-convulsions were modified by the acid, but Dr. Lauder Brunton concluded "that although the acid may somewhat lessen the convulsion, it cannot be employed as an antidote to strychnine with any hope of success," and G. Harley thought "that it rather hastened death from strychnine" (Med. Times, ii., 1861).

Silver and metallic oxides, generally, form insoluble compounds with prussic acid, and fresh carbonate of iron has been recommended (Med.-Chir. Trans., ii., 1865); practically, however, their influence can scarcely be exerted quickly enough.

It remains that *artificial respiration* is the main resource in all forms and stages of cyanic poisoning—it may be carried out in the ordinary methods, or excited by the sudden affusion of water, first cold and then hot, thrown over head and chest, or pure oxygen gas may now, perhaps, be available for inhalation. This does not exclude the use of an emetic, the application of ammonia to the nostrils, or even its injection into the veins, or the hypodermic use of brandy and ether, whilst stimulating frictions and warmth should be applied to the limbs; by the steady use of these means, patients have been revived from apparently hopeless insensibility, and if life can be prolonged for an hour, the chances of recovery become greatly increased.[1]

THERAPEUTICAL ACTION.—*External.*—**Urticaria—Prurigo.**—I have seen great relief given, in obstinate forms of these maladies, by lotions containing hydrocyanic acid in sufficient strength. Pereira states that he did not observe benefit in such

[1] When immediate danger from collapse or apnœa is past, treatment should be directed to the probable congestion of the stomach or brain.

cases, but he seems to have used only 2 dr. of acid in ½ pint of water. I have recommended ½ oz. or more in 10 oz. of liquid (rose water), and have never seen ill effects; but such a remedy should not be placed in careless hands, nor ordered if the skin be excoriated: *sometimes* a much smaller proportion will answer well, and especially when mixed with lead or soda lotion. The cyanide of potassium has also been used for lotion and ointment in the strength of ½ dr. to 8 oz. of liquid, or 1 oz. of cerate; a greater strength has caused severe irritation.

THERAPEUTICAL ACTION.—*Internal.*—Hydrocyanic acid has a certain value in relieving spasmodic pain and irritation, but its use is limited by the extreme care required in dosage, and the risk of causing unpleasant symptoms; yet, to say with Trousseau that "it is often dangerous, almost always useless, and very rarely curative," overstates the facts.

Gastrodynia—Enterodynia.—Cases described under these names, and which seem to be frequently of neuralgic type, are often quickly relieved by suitable doses of prussic acid. Pereira gives instances of severe spasmodic pain, without pyrexia, faintness, or ordinary symptoms of dyspepsia, but such as to cause suspicion of organic disease, had it not disappeared under the use of the acid. In one case it was seated in the intestine, came on about two P.M., and lasted until night, unrelieved by many remedies until this one was used; Pereira observed that its action is exerted quickly, and either produces complete relief or none at all. Sir T. Watson "has seen more rapid and decided relief from it in gastrodynia than from anything else."

Dyspepsia.—Dr. Elliotson, in a special treatise on the subject, makes several groups of cases in which he found prussic acid extremely useful; some were marked by pain and tenderness only, others by flatulence, nausea, anorexia, liver troubles, and vertigo, others again by pyrosis, heartburn, and palpitation (Med.-Chir. Rev., 1821). A. T. Thompson made somewhat similar observations, especially noting benefit when the tongue is hot, red, and sore (Dispensatory). Bailey also published illustrative cases (London Med. Repos., 1828), and alluded to its value when there was sympathetic heart-disturbance, palpitation, etc. In such cases it is still in frequent use, although other remedies may be required if there be marked symptoms of unhealthy secretion. Dis-

appointment as to its effects may be sometimes traced to the inertness from age of the preparation, or to admixture with other drugs.

Vomiting.—The acid is useful in the vomiting of fever, and in sympathetic vomiting, and is sometimes indicated in that of ordinary gastric derangement: it may be added to effervescent or bismuth mixtures, but as a rule is better given alone in distilled water. In some patients, or in some conditions, and more especially when the dose is too large, nausea and vomiting seem to be increased or caused by the drug, and then it is better omitted: on the other hand, I have seen severe cases recover with 6 to 8 min. doses, when smaller doses and all ordinary means had failed. In simple intestinal obstruction, even when fæcal vomiting had occurred, I have used 10 min. doses with the effect of staying the vomiting, but care is necessary in watching the results. Dr. Brinton found the acid useful in the vomiting of gastric ulcer; Dr. Harley combined it with bismuth, opium, etc., in that of enteric fever; Pereira recommended it in the vomiting and purging of phthisis, and even of cholera, and it may well be tried in the "nervous" form of vomiting, that connected with pregnancy, or with cerebral concussion or disorder.

Phthisis.—In the early part of this century, Dr. Granville published a small treatise "to establish the claims of a new and powerful remedy," and in his second edition (1820), congratulates himself on the conclusive and numerous facts which have proved he was "not indulging in the chimeras of a revery," when he recommended prussic acid for treating, if not curing, consumption. Being before the days of physical diagnosis, his cases scarcely bear examination, and his peculiar egotistic style jars upon the professional reader; but he may be credited with pointing out the relief often given to the general nervous irritability, the dyspepsia and harassing cough of phthisical subjects. The exaggerated views entertained both by the eminent Majendie and by Granville as to its powers of checking the disorder and curing asthma, chronic cough, etc., have not been verified by later experience. We can only say that it is a useful palliative for the irritative dry cough, especially in cases where morphine is not suitable, and that with alkalies and calumba it is often serviceable in phthisical dyspepsia. The vapour of the acid is

sometimes used to lessen irritability of the respiratory passages and cough.

Whooping-Cough—"Nervous Cough."—Dr. Granville states, "without presumption," that in almost every case of whooping-cough this medicine, given early, removes the disease, and Dr. Hamilton Roe, in a special treatise (1838), records equally excellent results. He was rather in advance of his time in concluding pertussis to be not always inflammatory, but "a nervous affection, having its seat in the mucous membrane of the bronchi and the pneumogastric nerve," and for the "nervous element," *i.e.*, the peculiar whooping or spasmodic cough, he valued prussic acid more than opium, belladonna, or any other remedies then in use: he gave very full doses, such as $\frac{3}{4}$ min. of Scheele's acid to infants, and $1\frac{1}{2}$ drops every quarter-hour for twelve hours to a child of ten years. I think this another illustration of the benefit to be obtained from the medicine, when it may be justifiably and yet cautiously pressed, but for average practice it would be dangerous, and I agree with Sir T. Watson, who thinks the remedy in such doses "too gigantic for such young subjects"; also with Dr. C. West, who finds it "sometimes magical" for diminishing the frequency and severity of the paroxysm, but sometimes inert, sometimes poisonous. Dr. Atlee, judging from two hundred cases, gives a most favourable report of it (Amer. Journ., vol. x.), and my own experience is decidedly in the same direction—the more purely nervous the paroxysms, the better will the remedy act, though some difficulty in graduating its dose will always remain: also, as is well known, the results obtained from remedies unaccountably vary in different epidemics and different individuals. In other forms of irritative cough, connected with spinal or vagus irritation, I have seen more benefit from this acid than from any ordinary sedatives; and the long-recognised clinical value of the drug in such conditions is of marked interest, taken in connection with the special effect on the medulla and vagus, mentioned under Physiological Action.

Asthma.—Much relief may be given to patients suffering from simple spasmodic asthma, by small and repeated doses of prussic acid.

Palpitation.—Whether palpitation arises from cardiac hypertrophy or from ordinary functional derangement of the heart

dependent upon nervous exhaustion or dyspepsia, hydrocyanic acid or remedies containing it will often prove useful.

Vertigo—Cerebral Irritation—Mania.—The acid certainly exerts some control over disordered cerebral function, whether by acting through the circulation or otherwise. Vertigo, especially if dependent on gastric derangement, may be relieved by it. Dr. M'Leod has furnished evidence of its calmative power in acute mania and acute melancholia, recording forty cases, in most of which the relief given to violent excitement was marked and rapid; about 5 min. of Scheele's acid was the usual dose, or 3 min. injected under the skin (Med. Times, i., 1862).

In **Delirium Tremens,** Dr. Dow has seen it serviceable (B. M. J., i., 1873), and Dr. Maudsley recommends its combination with digitalis (Pract., 1869).

PREPARATIONS AND DOSE.—*Acidum hydrocyanicum dilutum* (contains 2 per cent. of anhydrous acid): dose, 2 to 8 min. *Vapor acidi hydrocyanici* (inhalation) is prepared with 10 to 15 min. in 1 fl. dr. of cold water. "Mix in a suitable apparatus, and let the vapour that arises be inhaled." As a lotion, 2 dr. to 1 oz. in ½ pint of rose water; it should not be applied to an abraded skin. It is also contained in *tinctura chloroformi et morphinæ*, *aqua laurocerasi*, and some non-officinal remedies. Scheele's prussic acid, which contains 5 per cent. of anhydrous acid, should never be prescribed.

ACIDUM NITRICUM—NITRIC ACID—AQUA FORTIS (HNO_3 = 63).

Nitric acid, the highest known oxide of nitrogen, may be detected in the atmosphere after thunder-storms, for electricity determines the necessary combination of the gases. United with potash, soda, lime, or ammonia, it forms nitrates which are found native in efflorescence on the soil of some countries; its salts occur also in some minerals and in certain plants.

PREPARATION.—Being a volatile acid, it may be prepared from any nitrate (usually nitrate of potassium or sodium), by distilling it with the more stable sulphuric acid, when acid sulphate of potassium is formed, and nitric acid being set free, rises with the vapour of water and condenses in the receiver.

$$KNO_3 + H_2SO_4 = HNO_3 + KHSO_4.$$

The pharmacopœial acid contains 70 per cent. by weight of nitric acid, which corresponds to 60 per cent. of the anhydrous acid (N_2O_5).

Acidum nitricum dilutum is prepared by adding to 6 oz. of the strong acid, 24 oz. of distilled water, and to this as much more water as is necessary to bring the volume of the mixture up to 31 oz. At the temperature of 60° F., heat is developed during its preparation, and condensation of volume occurs. The dilute acid is approximately of a fifth part the strength of the concentrated acid.

CHARACTERS AND TESTS.—The pure acid, protected from light, remains colourless, but if exposed becomes yellowish, from development of orange-coloured oxides, mainly nitrogen peroxide, N_2O_4; with a sp. gr. of 1·42 it is a stable compound, boils at 250° F. and distils over unchanged; it has a very sour, corrosive taste, and an acrid, suffocating odour; its affinity for water is great, and the white fumes which it emits on exposure are caused by the combination of its invisible vapour with atmospheric moisture, forming a cloud of minute drops.

A good test for nitric acid is its action on metallic copper or iron; when *undiluted* and poured on them, it gives dense red vapours of peroxide of nitrogen and other oxides, but if first *diluted*, a colourless gas, nitric oxide, **NO**, is given off, which changes into peroxide, N_2O_4, and becomes orange-red in colour on contact with the air. If the colourless gas, **NO**, be passed into a solution of ferrous sulphate, it will combine with a portion of it, causing a dark-brown colour. Morphine and brucine become oxidised, and give a bright-red colour with the acid.

There is no precipitation test for nitric acid, because all neutral nitrates are soluble, but its adulteration with sulphuric or hydrochloric acid is detected by chloride of barium and nitrate of silver respectively.

Nitric acid is a powerful oxidising agent, and is used in pharmacy to prepare the nitrates of different metals; also for the making of certain organic compounds, as gun-cotton, nitrite of amyl, nitro-glycerine, etc.

ABSORPTION AND ELIMINATION.—Dilute nitric acid in medicinal doses is readily absorbed. In the blood it either combines with alkaline bases forming nitrates, or it circulates, loosely joined with albumen (Gubler): it cannot be detected *free* in the blood by analysis. It is eliminated mainly by the urine as nitrate of potassium or sodium, not as free acid. From its effects

upon the intestinal glandular structure, and from the comparatively small amount passed in the urine, it is probable that some is excreted by the lower bowel.

PHYSIOLOGICAL ACTION.—*External.*—Strong nitric acid applied but for a moment, stains organic tissue yellow, and leads to desquamation of the epidermis. The yellow colour is due to the coagulum it forms with albuminous materials or proteids in the tissues. This colour is turned orange by the addition of ammonia, and forms a delicate test for proteids: it is known as the xanthoproteic reaction.

Dilute solutions exert a stimulant, moderately astringent effect; by continued contact they change most animal and vegetable substances into oxalic, malic, or carbonic acids. Nitric peroxide is an efficient but irritating disinfectant.

PHYSIOLOGICAL ACTION.—*Internal.*—For a general statement as to the action of acids on the organism, reference may be made to hydrochloric acid.

Digestive System.—Given internally, in medicinal doses, dilute nitric acid exerts a stimulant effect on the glandular system of the alimentary canal, and some tonic bracing effect on the mucous membrane, so that appetite is improved by it, and undue secretion lessened; this is probably owing to a direct local action. Salivation sometimes occurs under the use of nitric acid, either in consequence of the gastric irritation, or of direct stimulation of the salivary glands by the medicine. It is commonly credited with some power of stimulating the secretion and excretion of bile. Like other acids, it exerts an antiseptic action.

Large doses act like other violently corrosive irritant poisons. In a case that proved fatal on the eighth day after swallowing 1 dr. of the strong acid, the œsophagus and stomach were found inflamed and ulcerated, the colon was in the same state, but the small intestine was sound; suppression of urine had occurred.

SYNERGISTS—ANTAGONISTS.—The same as those of sulphuric acid.

THERAPEUTICAL ACTION.—*External.*—**Disinfectant.**—Nitrous fumes may be generated by the action of sulphuric acid on nitrate of potash. They efficiently disinfect unhealthy wards, prisons, etc., but the use of less irritating substances has practically replaced this method.

Phagedænic Ulceration.—In cases of sloughing chancre, phagedæna, hospital gangrene, cancrum oris, etc., when it is necessary to destroy portions of diseased tissue, and to stimulate to healthy action, strong nitric acid is one of the best caustics. The affected part should be cleansed and dried, so that the acid be not too diluted by secretion, the neighbouring parts should be protected by oil or ointment, and the caustic then thoroughly applied with a glass brush, splinter of wood, or pledget of lint, until a firm dry yellowish mass is formed ; the pain is at first severe, but soon subsides under cold water dressings; the eschar formed is not very deep, and usually separates in one or two days; the application may sometimes require to be repeated.

Bubo.—The strong acid may, with advantage, be lightly pencilled over torpid suppurating buboes, to destroy the integument and stimulate to healthy discharge ; should a sinus be formed, the upper wall should be touched in the same manner.

Lupus.—The same application is indicated for the indolent edges of an ulcerating lupus, though acid nitrate of mercury is perhaps better.

Uterine Disease.—Dr. Lombe Atthill has had the best results from applications of strong nitric acid to the interior of the uterus, in cases of fungoid granulation and excessive hæmorrhage : lint bound on a uterine probe conveys the caustic through a small speculum placed in the cervix. It is a good application also in chronic inflammatory disease of the same part and in granular erosion of cervix, if there be not excessive tenderness (B. M. J., i., 1876). H. Lee has found the acid good in uterine disease, if the mucous membrane be not too much thickened ; it is important that it be not diluted by secretion, and that an alkaline injection be used after it (Lancet, i., 1874). As injurious effects have sometimes followed the use of nitrate of mercury, and of strong iron solutions, I myself prefer the nitric acid for vaginal and uterine disease of the kinds named, but in cases of hæmorrhage from the vagina or uterine neck, connected, *e.g.*, with carcinoma, I think the perchloride or persulphate of iron mixed with glycerine, are better hæmostatics.

Internal Hæmorrhoids.—It has been thought that strong nitric acid would supersede all operative interference in this disorder, but its curative power is really somewhat limited.

Its local application is only useful in small granular piles, and in "velvety" conditions of the mucous membrane; it checks the bleeding, but severe hæmorrhage may occur when the slough separates. One or two applications ought to suffice for the cure of such a condition, but for large masses, or for hæmorrhoids with narrow vascular attachments, other treatment is better. Billroth, however, reports much success with nitric acid in most forms of internal hæmorrhoids, but especially in the flat form: after protrusion, he applies the remedy till the part is "stiff and yellowish-grey in colour," and then oils it well—he notes the importance of not touching sound parts with the acid, for it causes great pain (Ranking, i., 1872). Dr. Houston first proposed this treatment (Dub. Med. Journ., vols. xxiii.-xxvi.), and Mr. Henry Smith has used it extensively, and written in its favour.

In less severe cases where the parts bleed and are somewhat swollen, Dr. Ringer recommends a lotion containing 1 to 1½ dr. dilute acid to ½ pint water.

Prolapsus Recti.—If the strong acid be applied in one or two horizontal bands to the prolapsed mucous membrane of the rectum, in such a degree as to cause moderate but not too deep sloughing, these bands, on healing, will leave cicatrices, which, by their contraction, are often sufficient to cure the complaint. In children, in whom prolapsus ani is rather common, benefit is often obtained from bathing the part with a weak nitric acid lotion, and giving the same acid internally.

Condylomata on the limbs or genitals, especially when of a syphilitic origin, disappear under the external use of nitric acid.

Warts and Corns.—Sir Erasmus Wilson recommended nitric acid for the treatment of callosities, the cauterised portion being removed occasionally by the knife. I have used it extensively for the removal of moles on the face; the cicatrices are hardly visible.

Dog and Snake Bites.—If applied immediately after the bite, nitric acid like other caustics, will probably destroy the virus and prevent its absorption.

Nævi.—Superficial nævi may be safely destroyed by painting with strong nitric acid; Mr. T. Holmes speaks highly of this method. Due precaution should be taken to protect the sound skin, and an alkaline lotion should be used afterwards. If the

affected part be extensive, a portion only should be treated at one time, the caustic being applied about every second day, until its full effect be produced (Lancet, ii., 1866, and 1867). For small nævi on the face, I can recommend puncture with a needle dipped in the acid: it is safe, effective, and leaves comparatively little scar.

Indolent Ulcers.—For ordinary indolent or moderately sloughing ulceration, a lotion containing nitric acid diluted, about 1 dr. in ½ pint of water, is a good dressing.

Pruritus.—A similar lotion will often relieve itching in papular and neurotic diseases, such as lichen and prurigo; it may be conjoined with prussic acid, or with the liquor carbonis detergens.

Alopecia.—The acid, diluted with so much olive oil as will prevent the caustic though not the stimulant effect, makes a good liniment in some cases of falling off of the hair from debility.

THERAPEUTICAL ACTION.—*Internal.*—**Dyspepsia—Debility.**—Dilute nitric acid is a serviceable tonic in cases of nervous debility and of convalescence from acute disease, when appetite and digestive power are impaired. It acts well in combination with a few minims of tincture of nux vomica, stimulating the gastric glands and the biliary secretions, and may be given between meals, or shortly before or after, according to the conditions already mentioned under hydrochloric acid.

Hepatic Disorder.—Nitric acid has long been held in repute for the treatment of chronic hepatic congestion, or chronic hepatitis, especially when occurring in Anglo-Indians, and after mercurials have been used. Dr. Hutchison met with marked improvement, even in cases of *waxy liver*, from the continued use of nitric acid with vegetable bitters, but in later writings he remarks that there is no evidence of its assisting the flow of bile, and that its action is less direct than that of alkalies; that in congestion (of acute character), or when lithiasis is present, it either does no good, or aggravates the malady, though it may relieve the dyspepsia of debility: he sometimes gives alkalies before a meal, and acid after (B. M. J., i., 1874). Sir R. Martin, Thudichum, and indeed the majority of writers thirty years ago, allowed to nitric acid a larger sphere of usefulness in hepatic disorder, jaundice, etc.; it was presumed to "lixiviate biliary deposits, tone digestion, and act antiseptically" (B. M. J., ii., 1860). Annesley noted that it

acted better the more freely it was diluted—he used it in chronic splenic disorder. I have found nitric acid useful in chronic hepatitis, when watery diarrhœa and constipation occur alternately. Nitric acid is specially good in that form of dyspepsia known as biliousness.

Phosphatic Urine—Chronic Cystitis.—Sir B. Brodie constantly employed strong nitric acid, in full doses—30 min. or more largely diluted, and given in divided doses during the day, for phosphatic and alkaline urine. In cases of chronic cystitis, and even of phosphatic calculus, he also employed local injections containing 1 to 2 min. of the strong acid in the oz. of warm water. The best mode of administering dilute nitric acid under these conditions is to give 5 to 10 min. in 1 or 2 oz. of decoction of pareira every three or four hours.

Diarrhœa.—When the dejections are frequent, serous or "watery" in character, especially if markedly alkaline, and if there be no evidence of acute inflammation and not much pain, then nitric acid acts well, and in cases of profuse purging from summer heat, and in the diarrhœa of phthisis, it has a deserved repute; if necessary, it may be combined with a small quantity of opium,—also in dysenteric diarrhœa with tenesmus, blood, and profuse discharge of mucus.

Constipation.—Dr. Graves says: "In constipated habits I have occasionally derived very remarkable benefit from the use of nitric acid given in sufficient doses. It seems, like the carbonate of iron, to possess the advantage of combining tonic with aperient qualities" (Clin. Medicine, ii.). I think that this different action of the medicine depends upon dose, and perhaps combination, and is not contradictory to that mentioned in the last section. Nitric acid in *small* or moderate doses is astringent, especially if prescribed with opium; but nitric acid in *full* doses has an aperient effect, especially in combination with bitter infusion, such as gentian; this may be traced either to direct intestinal irritation or to hepatic stimulation.

Otorrhœa, occurring in scrofulous children or in syphilitic patients, is often controlled by a course of this acid. Local antiseptic treatment must also be employed.

Purulent Ophthalmia, with extensive ulceration of the cornea, whether of a gonorrhœal or scrofulous form, is much

benefited by a course of 5 to 10 min. of the dilute acid three or four times a day, together with local treatment.

Fevers.—Dr. Osborne has recorded a good experience of nitric acid in typhoid fever (Lancet, ii., 1862), and Dr. Bailey (U.S.) in intermittent fevers; he prescribed it to relieve profuse sweating, and unexpectedly found a curative effect on the ague; of ninety cases, eighty made a rapid recovery. Dr. Hammond has corroborated his results (Ranking, 1862).

Secondary Syphilis.—A course of dilute nitric acid will often be of service in later syphilitic cachexia, especially after mercurials have been used, and in debilitated subjects. It benefits ulcerations of the mouth, throat, and nose, and also periosteal swellings, and may be applied at the same time in the form of bath—1 to 2 oz. for each bath. Mercurial salivation is relieved by the acid.

Skin Diseases.—In chronic syphilitic cutaneous eruption, such as rupia or psoriasis, this acid has been rightly commended. In ordinary non-specific disorders, it is indicated whenever general debility is a marked symptom, and especially when nerve-power is impaired. Dr. Tilbury Fox frequently gave it, in conjunction with a bitter tonic, for psoriasis in weakly subjects.

Chronic Laryngeal Congestion.—In this malady, when brought on by excessive vocal exertion, as in singers and readers, 5 to 6 min. doses of dilute nitric acid in sugared water have been found very useful, bracing up the relaxed membrane and throat follicles, and relieving hoarseness; also in chronic laryngitis dependent upon a syphilitic taint, it is of much use.

Chronic Bronchitis.—I agree with some good observations made by Dr. Glover, drawing attention to the benefit obtained sometimes from nitric acid in cases of chronic catarrh and bronchitis when secretion is fairly free, when nervous exhaustion is a prominent symptom, and when ammonia and expectorants fail to relieve (Lancet, i., 1865); this fact deserves more attention than it has yet received. Dr. Glover combines nitrous ether with the acid, and sometimes tinct. camph. co. is also indicated, the precipitated camphor, etc., being readily suspended in cetraria or mucilage. In the subacute exacerbations of phthisis the acid is similarly useful.

Pertussis.—Nitric acid has been found by some observers

valuable in relieving the spasmodic recurrent attacks of cough, and lessening profuse expectoration; it may certainly be credited with tonic bracing action on the faucial and laryngeal mucous membranes. Arnoldi, who introduced this mode of treatment, ordered as much acid as would render a tumblerful of sugared water "like lemon juice," to be taken every three or four hours. Dr. Gibb, who reported the best results, gave as much as 10 min. to infants, and 40 min. to children of ten years; and some other practitioners have used this medicine with success, as Ussher (Med. Times, i., 1862) and Berry—in an epidemic at Lancaster—who found it effective, safe, and cheap (Med. Times, i., 1873). I have been reluctant to press it for fear of injuring the teeth, and when I have used it as freely as could be borne, I have not seen definite benefit.

PREPARATIONS AND DOSE.—*Acidum nitricum—Aqua fortis:* dose, 1 to 3 min. freely diluted. *Acidum nitricum dilutum:* dose, 10 to 30 min. freely diluted. Nitric acid is also contained in the following pharmacopœial preparations: *Acidum nitro-hydrochloricum dilutum*, *liquor ferri pernitratis*, *liquor hydrargyri nitratis acidus*, and *unguentum hydrargyri nitratis*.

ADULTERATIONS.—Chiefly sulphuric and hydrochloric acids.

ACIDUM NITRO-HYDROCHLORICUM DILUTUM—DILUTE NITRO-HYDROCHLORIC ACID—AQUA REGIA.

PREPARATION.—It is prepared by mixing 3 parts of nitric, with 4 of hydrochloric acid, and 25 of distilled water: the mixture is allowed to stand for fourteen days to allow of the escape of free chlorine and nitrous compounds.

$$2HNO_3 + 6HCl = 4H_2O + 2NO + 3Cl_2.$$

At the same time two other compounds are formed—chloronitrous ($NOCl_2$) and chloronitric ($NOCl$) gas.

CHARACTERS AND TEST.—A colourless or yellowish liquid, with the odour of chlorine, volatile, and easily decomposed by light; sp. gr. 1·074. It has the power of dissolving gold, the "king of metals"—hence its old name, "aqua regia."

PHYSIOLOGICAL ACTION.—In its full strength this acid is irritant and corrosive; in moderate doses it has an alterative

tonic action; it stimulates the glandular system, causes salivation and an increased flow of bile. Its actual chemical composition is not thoroughly known, and its difference in action from the other and simpler mineral acids has not yet been verified.

THERAPEUTICAL ACTION.—It is useful in many of the diseases mentioned under nitric acid, but seems to possess exceptional power to influence the liver and glandular structures of the alimentary canal.

Hepatic Disorder.—In hepatitis, not so much in the acute as in the chronic form of the malady, which usually ends in enlargement and induration, it has been praised by reliable authorities. Sir R. Martin strongly recommends its application by means of a bath, putting about $1\frac{1}{2}$ oz. of acid to each gallon of water. Two gallons represent an average quantity for a foot bath, which should be used warm, and whilst the feet are immersed, the inner side of the limbs and the regions of the liver and spleen should be sponged alternately for ten to fifteen minutes altogether, or compresses wrung out of the acid may be applied. Martin recommended this bath morning and evening, but I have usually found an evening bath sufficient, and have seen excellent results from it; generally it has regulated the action of the bowels, and even produced laxative effects. Some patients are nauseated and weakened by its use, though they receive benefit; it requires watching, and smaller quantities of the acid should be tried first in delicate subjects. If it does not relax the bowels, an aperient should be taken occasionally during the course of the baths.

In hepatic torpor, or chronic catarrhal jaundice, if no inflammation be present, and in *chronic dysentery* with hepatic congestion, this form of bath is also valuable, and may be conjoined with the internal exhibition of the acid; even in *cirrhosis* and the consequent dropsy, benefit has been derived from this treatment.

Nitro-hydrochloric acid may affect the tissue-change in the liver in the following way: the acid administered reappears in the urine in the form of ammoniacal salts, and the ammonia with which it is combined appears to be the representative of so much nitrogenous waste, which instead of being converted into urea in the liver has combined with the acid and been excreted as ammonia (Lauder Brunton, B. M. J., i., 1885).

Syphilis.—In the later stages of syphilitic cachexia, when the blood-condition is impaired, and elimination by the liver and skin is often inefficient, the acid used internally and in the form of bath has been recommended; a spare but nutritious diet should be enjoined in these cases.

Rachitis.—Attention has been drawn by Mr. Brodhurst to the value of nitro-hydrochloric acid baths in rickets (Lancet, ii., 1868); they should be conjoined with hygienic treatment, iron, and cod-liver oil.

Chronic Bronchitis.—When the expectoration is profuse and semi-purulent, sponging of the chest and trunk with the acid solution already mentioned gives much relief.

Acne Rosacea.—A lotion containing the dilute acid, 1 or 2 dr. to 8 oz. of rose water, is sometimes a useful stimulant to the affected part, and an acid foot bath tends to relieve the internal congestions with which the disorder is generally associated.

Oxaluria.—This is, in most cases, dependent on some fault in primary digestion (I have known it produced apparently by continued use of a drinking water containing much lime), besides the renal symptoms, malaise, depression, and hypochondriacal feelings accompany the malady. Relief may be given by the mineral acids conjoined with attention to diet and drinking water; and of the different acids the nitro-hydrochloric seems to be the best, as originally stated by Dr. Prout; he advised its continuance for a few weeks at a time, or until lithates appeared in the urine. Deposits of cystine are relieved by the same treatment.

Sciatica—Rheumatism.—In the great majority of these cases, an alkaline rather than an acid treatment is indicated, but when they occur in connection with oxaluria the acid should be given (Fuller). In rheumatic gout in cachectic subjects it is also serviceable.

Dyspepsia.—In dyspepsia or "apepsia," connected with deficient action of the intestinal glands, and accompanied with a chronic looseness of the bowels, the acid has given very good results, used in the manner directed under hydrochloric acid. In such cases it often relieves the accompanying headache, and also eructations of sulphuretted hydrogen.

PREPARATIONS AND DOSE.—*Acidum nitro-hydrochloricum dilutum:* dose, 5 to 30 min., freely diluted (it is liable to injure the teeth; they should therefore be cleansed with an alkaline wash or plain water).

Bath.—As a matter of convenience the bath may be prepared with six fluid ounces of the *dilute* nitro-hydrochloric acid added to each gallon of water in a wooden or porcelain vessel, but the more active formula of Sir R. Martin is the following :—Acid. nit. fort. ʒij., Acid. hydrochloric. fort. ʒiij. ; mix and allow to remain together for at least twelve hours ; afterwards add 5 oz. of water. Of this mixture 3 oz. should be used for each gallon of water : two gallons are an average quantity for a foot bath. The bath may be kept in use for several days by adding ½ oz. of acid solution and 1 pint of water each time to compensate for evaporation, warming only as much as is necessary (96° to 98° F.). The towels and sponges used should be kept in cold water during the intervals.

ADULTERATIONS.—Chiefly sulphuric and hydrochloric acids.

ACIDUM LACTICUM—LACTIC ACID

$(C_3H_6O_3 = 90)$.

The officinal lactic acid contains about 25 per cent. of water. It occurs naturally in willow bark, and in sour milk, and in many vegetable products that have turned acid.

PREPARATION.—It is prepared by adding chalk to sour milk, and decomposing the lactate of lime with sulphuric acid. $C_{12}H_{24}O_{12}$ (milk sugar) gives rise by fermentation to $4C_3H_6O_3$ lactic acid, which gives its name to this kind of fermentation.

CHARACTERS AND TESTS.—It is a nearly colourless syrupy liquid, with an acid taste and reaction, the sp. gr. being 1·21. It is soluble in water, alcohol, and ether, but scarcely in chloroform ; it coagulates albumen. When strongly heated, it decomposes and burns with a suffocating odour. Treated with hot potash solution, the acid should not change colour ; if browned, extractive matters are present. Acetic and butyric acids are recognised by their odour. The ordinary tests for lead, zinc, calcium, and the mineral acids are applicable.

Lactate of Calcium is an opaque, white, crystalline powder, soluble in water when freshly prepared only.

Lactate of Iron is in greenish-white crystals ; it is readily absorbed and well borne.

Lactate of Quinine is a granular, white, amorphous powder: solubility 1 in 10.

Lactate of Zinc occurs in white crystalline pieces of metallic taste, soluble in water, not in alcohol; is well borne by the stomach.

ABSORPTION AND ELIMINATION.—In the digestive tract, lactic acid (which is normally present in the stomach) is readily absorbed, and is eliminated mainly by the perspiration and urine, which secretions are rendered more acid by it; the alkaline lactates have an opposite effect. A portion is converted into water and carbonic acid, and especially is this the case if administered in the form of an alkaline lactate, such as lactate of soda as it exists in soured milk.

PHYSIOLOGICAL ACTION.—**Digestive System.**—Lactic acid and lactates are commonly, if not constantly, found in normal gastric juice, and their administration in medicinal doses tends to promote appetite and digestive power. Doses of 1 dr. and upwards are liable to irritate the stomach, causing flatulence, pain, etc. Sugar, starch, and similar foods more readily give rise to lactic than to acetic acid, if fermentation occurs in presence of some fatty matter (Gubler). As a fact of some importance in nutrition, its power of freely dissolving phosphate of lime should be noted.

Circulatory System.—It is doubtful whether free lactic acid occurs in normal blood, but it certainly does so in some morbid conditions (Bartholow). It has been found in the muscle fluid and in the spleen, also in the thymus and thyroid glands, but is, as a rule, quickly changed into carbonates in the blood. Prout suggested a relation between an excess of this acid in the blood and rheumatism, and Richardson reported endocarditis after injecting it into the peritoneal cavity of dogs: also a few cases have been recorded, in which rheumatic attacks occurred during the administration of the drug for diabetes, but such a result is not constant enough to be accepted as proved.

SYNERGISTS.—Vegetable acids, hydrochloric acid, salt, pepsin, etc.

ANTAGONISTS — INCOMPATIBLES.—Alkalies: mineral salts.

THERAPEUTICAL ACTION.—*Internal.*—**Diphtheria.**—The marked solubility of false membrane in this acid has led to its local application in this disorder. If the exudation is within reach of a gargle, it may be used in that form, as strongly acid and as often as can be conveniently borne; otherwise it may be applied on a "mop" or in spray, in the strength of 1 part in 20.

Tuberculous Ulceration.—Dr. Percy Kidd has recorded a case of this kind affecting the pharynx, diffused and very painful; cocaine having been painted on, lactic acid in 50 per cent. solution was applied, and after about fourteen applications healing occurred (Lancet, ii., 1892). It was not found specially useful in similar ulcerations affecting the skin (*ib.*).

Dr. F. Lemon has reported several cases where lactic acid has been applied locally in addition to treatment by creasote internally; solutions of from 20 to 70 per cent. were applied two to four times a week and firmly rubbed into the affected part—cocaine having been previously used. He considers this surpasses all previous modes of treatment (Lancet, i., 1893).

Catarrhal Cystitis.—Sir W. Roberts, finding lactic fermentation in the bladder of a glycosuric patient aged eighty-four, with maintenance of acid non-phosphatic urine, although the catheter was in daily use, has suggested that to produce an artificial lactic acid fermentation in the bladder would be a good remedy for intractable cystitis with ammoniacal decomposition and recurrent phosphatic formation; this could be done by injecting an ounce or so of a weak malt solution (Bynin) several times daily (Lancet, i., 1893).

THERAPEUTICAL ACTION.—*Internal.*—**Dyspepsia.**—Magendie was the first to recommend lactic acid in dyspepsia dependent on deficiency of gastric juice, and Dr. Connor went so far as to say that it was more active than pepsin. Pétrequin also reported the best results from the acid and from lactates. It is now recognised as a good remedy for atonic and irritative dyspepsia, especially in combination with pepsin, but is not in very frequent use. In the apepsia of infants, with undigested food in the motions, Bartholow says this combination is excellent, but if much acidity be present the acid should be omitted or perhaps may be given before the milk and so lessen the acidity. Cases of cardialgia in adults are relieved by the same plan.

Gubler remarks that the acid soups of Poland and the North are useful in this manner—also the whey cure to some extent.

Diarrhœa.—M. Hayem has recommended lactic acid in this complaint and especially in the "green diarrhœa" of infants, on the hypothesis of its being fatal to microbes—he gives one drachm doses of a 2 per cent. solution (Lancet, i. and ii., 1887).

Others have since used it in suitable doses in the diarrhœa of phthisis, typhoid, and acute and chronic catarrh, and even dysentery with good and sometimes striking results (Pract., 1889; Lancet, ii., 1892; B. M. J., i., 1892-93).

Diabetes.—Cantani suggested that lactic acid would prevent waste of tissue in this disease, and it may be presumed "to lessen the formation of sugar from starchy and other elements of food." Certainly some cases have improved under the use of 2-4 drachms taken well diluted, during the day, but cases by Dr. Ogle and others show a contrary result; it is not yet an accepted remedy but deserves further trial.

In phosphatic, and even in uric and oxalic urinary deposits, it may be useful but only by improving digestion, or locally injected as already mentioned.

Insomnia.—Mendel is commonly quoted as an advocate for its use in insomnia when produced by nervous excitement or fright—1 to 2 drachms being given in lemonade, or half an ounce by enema (the latter may require neutralising by sodium bicarbonate).

In **Epilepsy,** the lactate of zinc is used,—mostly in France.

PREPARATIONS AND DOSE.—Acidum Lacticum: dose, 5 to 20 m., well diluted. Acidum Lacticum dilutum: dose, ½ to 2 drachms. Calcii Lactas: dose, 1 to 5 gr. Ferri Lactas: dose, 2 to 10 gr. A syrup containing the former or both of these is a French speciality. Quininæ Lactas: dose, 1 to 5 gr. Zinci Lactas: dose, 3 to 30 gr.

ADULTERATIONS.—The quality of the acid is often inferior.

ACIDUM OLEICUM—OLEIC ACID

($HC_{18}H_{33}O_2 = 282$).

PREPARATION.—It is obtained by the saponification of olein by means of alkalis, lead oxide or other bases, and then decomposing the soaps so formed with hydrochloric acid; or by decomposing fats with super-heated steam and then getting rid of the palmitic and stearic acids by pressure.

CHARACTERS AND TESTS.—It is an oily straw-coloured liquid, nearly odourless and tasteless, and with a faintly acid reaction; when exposed to the air it becomes brown, rancid and strongly acid. Its specific gravity varies from 0·86 to 0·89. It is insoluble in water, but readily soluble in alcohol, chloroform and ether. Equal volumes of the acid and of alcohol, heated to 77° F., should give a clear solution with free drops of oil on the surface. At 41° to 42° it becomes semi-solid, melting again at 56° to 60°. It is completely saponified when warmed with carbonate of potassium.

Use.—Oleic acid is used for the preparation of the oleates, which were presumed to have more penetrating power than ointments, but lanolin has largely superseded them.

Oleatum Hydrargyri—Oleate of mercury.

PREPARATION.—By stirring and triturating together one part of the yellow oxide of mercury with nine of oleic acid.

CHARACTERS.—A light brown, oleaginous, semi-solid substance; gently warmed, no black precipitate settles. When heated with a piece of copper foil, the latter becomes coated with a film of metallic mercury.

Oleatum Zinci—Oleate of zinc.

PREPARATION.—By stirring and then heating together one part of zinc oxide with nine of oleic acid. It is a pearl-coloured powder. An ointment is prepared from it by mixing equal parts of it and soft paraffin.

Oleic acid, as a solvent for alkaloids, was first introduced by Professor Attfield in 1862. In 1872 Mr. John Marshall brought the subject prominently before the profession, specially recommending oleates of mercury and morphine. Since that time many other oleates have been used in practice, and have been specially studied by Dr. Shoemaker in conjunction with Dr. Wolff, a chemist: they experimented as to the best method of making neutral oleates, *i.e.*, true chemical compounds without excess of acid or base (the older oleates were simple mixtures, and unstable, because they were not neutral). Finally they adopted the plan of double decomposition from sodium oleate, which is an almost colourless substance, readily soluble in warm water, not so readily in cold water.

PHYSIOLOGICAL ACTION.—The oleates of quinine, strychnine, and aconitine, also of mercury, copper, and zinc, were

rubbed into the skin of the abdomen in rabbits. In no case was there any constitutional effect, nor were any of the bases found in the urine. From this Dr. Shoemaker concludes, contrary to what is generally stated, that the oleates are not readily absorbed; that they do not penetrate deeper than the cutaneous follicles and glands; that they do not get into the circulation; that they are chiefly local agents; and to this latter fact he traces many of their excellent effects.

THERAPEUTICAL ACTION.—*Oleatum Aconitinæ.*—This has a feeble local action in cases of neuralgia, but produces no constitutional effect: the same statement applies to *oleatum atropinæ* and *oleatum morphinæ.*

Dr. Squibb recommends that the *oleate of quinine* should be used when hypodermic injection of quinine is necessary, as it is so soluble in water, 1 dr. dissolving as much as would correspond to 17 gr. of the sulphate (B. M. J., ii., 1883).

Oleatum Cocainæ has not proved specially advantageous as a local anæsthetic, although it may be used with some benefit in itching skin diseases. It should be diluted with equal parts of some ointment basis.

Oleatum Aluminii may be made into an ointment with an equal amount of lard. It coagulates the albumen of the parts to which it is applied, constringes the blood-vessels, and is useful in chilblains and burns, and in the muco-purulent discharges of eczema and dermatitis; it also checks hyper-idrosis.

Oleatum Arsenii may be made into an ointment with nine times the quantity of lard. It has no effect on the unbroken skin, but on granulating surfaces it acts as an escharotic, and as such, is useful in lupus, and chronic scrofulous ulcers.

Oleatum Bismuthi is emollient and slightly astringent, and is useful in pustular eruptions, such as acne, sycosis, and also in cases of cracked and sore nipples. It should be lightly pencilled over the parts affected.

Oleatum Cadmii is caustic, and is but little used, though it is sometimes of value in cases of scrofulous glands.

Cupri Oleas.—This is made into an ointment with five or ten times its weight of lard. It has no effect on the unbroken skin, but on denuded or delicate surfaces it acts as an antiseptic, astringent, and stimulant, being liable to cause inflammation

and pain. Its chief use is as an antiseptic and parasiticide, *e.g.*, in ringworm.

Oleatum Ferri, applied externally, is a valuable styptic and astringent. It is useful, when diluted, in inflamed and pustular eczema, as well as for sinuses and furuncles.

Oleatum Plumbi has the usual effects of lead ointments, being astringent and sedative. Diluted with an equal part of simple ointment, it is useful in the different forms of acne, and in eczema especially in fissured forms, and in children.

Oleatum Hydrargyri is resolvent, and alterative, and anti-parasitic; it subdues inflammatory conditions. It is better than other mercurial ointments, because it does not get rancid, is economical and cleanly, and is absorbed so slowly that toxic effects from its use are rare. The strength should be 5 to 10 per cent. (liquid) and 20 per cent. (unctuous). Dr. Alder Smith uses it for chronic ringworm (Lancet, i., 1882).

The mercurous oleate is stronger than the mercuric salt, containing 1½ times as much mercury: more mercury is therefore absorbed, and it may be used for inunction in syphilis.

Oleatum Niccoli (Nickel) is very like that of cadmium, being astringent and almost caustic. It is useful as an application to exuberant granulations and to old callous ulcers.

Oleatum Argenti combines with albuminous substances, and forms a protective coating when applied to raw surfaces; it also causes contraction of blood-vessels. Sprinkled over bed-sores and ulcers, it sets up healthy action, and in superficial lupus, in eczema, especially if associated with itching, and in the early stage of boils it is a most useful, and at the same time, a painless astringent. Dissolved in oleic acid and mixed with lard, 5 to 60 gr. in the oz., it forms a dark-brown pliable ointment.

Oleatum Zinci.—The powdered oleate is astringent and stimulating, and is especially useful in hyper-idrosis; it also checks the night-sweats of phthisis. For eczema, in the weeping stage, applied either as a dusting powder or as an ointment, it is now regarded as one of our most trustworthy remedies; but the *stearate* is, by some, considered better.

ACIDUM PHOSPHORICUM—PHOSPHORIC ACID (H_3PO_4 = 98).

This acid is widely diffused, being found free or combined with alkaline and earthly bases as phosphates in soils, and in many vegetables and fruits, such as wheat, potatoes, rice, lemons, etc., also in fish, and in the bones, nerves, and flesh of animals, and in the urine and other secretions.

PREPARATION.—The officinal (tribasic) acid is prepared by distilling phosphorus with dilute nitric acid by the aid of gentle heat; some of the latter acid passes over in vapour, and therefore the distillate is returned to the retort occasionally in order to prevent loss: it is finally concentrated to a syrupy consistence (heat being used to get rid of nitrous fumes), and the resulting phosphoric acid is diluted with water to a sp. gr. of 1·5, which is a mixture containing 33·7 per cent. of water. Phosphoric acid may also be prepared from phosphorus by treatment of the product of atmospheric oxidation with water and a little nitric acid.

Acidum phosphoricum dilutum, the dilute acid of the Pharmacopœia, differs from the foregoing, which has received the name *Acidum phosphoricum concentratum* (BP), in being diluted with water till the sp. gr. is 1·08. This contains 13·8 per cent. of phosphoric acid by weight, which corresponds to 10 per cent. of phosphoric anhydride (P_2O_5). It is prepared by adding sufficient distilled water to 3 oz. of the concentrated acid, to make the total volume 20 oz.

CHARACTERS AND TESTS.—Tribasic or orthophosphoric acid is a colourless, inodorous liquid, of acid, not unpleasant taste, and even when concentrated, not corrosive, nor coagulating albumen. It gives with ammonio-nitrate of silver a canary-yellow precipitate of phosphate of silver.

All soluble phosphates give a white crystalline precipitate with sulphate of magnesia, after the addition of sal-ammoniac and liquor ammoniæ (ammonio-magnesian phosphate, or "triple phosphate"—$MgNH_4PO_4$).

ABSORPTION AND ELIMINATION.—Phosphoric acid is readily absorbed by the stomach. Ordinary doses combine with alkalies—potash or soda—probably displacing them from combination with weaker acids, lactic or carbonic, and forming phosphates; after larger or poisonous doses, Hoffmann states that he has found it free in the blood or loosely combined with albumen (Journ. de Chim., 1868).

As phosphate it is mainly eliminated in the urine, and Böcker

found the excretion of potassium phosphate especially increased under its use: some acid may possibly be eliminated in a free state.

PHYSIOLOGICAL ACTION.—The action of phosphoric bears a general resemblance to that of sulphuric acid, but in medicinal doses it is less liable to irritate the stomach or interfere with digestion, and it exerts a more stimulating effect on the general system: it has a more pleasant taste than the other inorganic acids. The pharmacopœial solution does not coagulate albuminous tissues, and, like oxalic and tartaric acid, only coagulates egg-albumen after addition of chloride of sodium or other neutral salt.

Circulatory System.—The effect of moderate doses of phosphoric acid is stimulant, but of large doses, especially when injected into the blood-current, depressant. Two c. c. of a 4 per cent. solution given to a frog increased the frequency of the pulse, and the direct application of the acid to the frog's heart at first strengthened, though it afterwards weakened, the contractions; after death, the heart-muscle was non-excitable (Munk and Leyden). In warm-blooded animals, after the subcutaneous injection of about 8 grammes, slowness, weakness, and irregularity of the heart's beat occurred, with retarded respiration, lowered temperature, prostration, and death (Meyer).

After injections of phosphoric acid into the jugular vein, the blood-pressure and the frequency of the pulse are lowered, although after small quantities they quickly rise again. Dr. Pavy found that he could inject 8 or 10 dr. of the dilute pharmacopœial solution into the jugular vein of a dog without causing death, and if, in any animal, the maximum amount compatible with life was injected, the urine and the arterial blood became highly charged with sugar (Guy's Hosp. Rep., 1861). We may connect this result with the fact that phosphoric acid acts even more powerfully than hydrochloric in diminishing the alkalinity of blood (Walter), whilst, on the other hand, injections of soda prevent the production of artificial diabetes; but the full bearing of such facts is not yet known. Injections of acid into the carotid artery caused primary slowing of pulse with secondary quickening before death, strong inspiratory cramp, convulsions and coma (quoted by Husemann). After death from excessive quantities, ecchymoses were almost always found in the lungs, and the blood was

altered, being dark but fluid, and not easily coagulable, sometimes gelatinous. The effect on the blood is not always the same: thus Dr. Pavy, in one experiment, found the "large venous trunks in the liver plugged with coagulated blood," after an injection of 30 dr. of acid into the duodenum; and Gubler says, "Introduced into the veins of animals, phosphoric acid coagulates the blood and causes death in a few minutes": this depends on the dose and concentration. Neumann states that the corpuscles are not destroyed by the acid, but may be much altered in form and vital properties.

The action upon man is of more practical interest, but very few investigations have been made with phosphoric acid. Bobrick records a rise of the pulse from 70 to 90 beats per minute, but in the course of an hour it fell to 66; this was after a dose of ½ oz. A rigor also occurred, the cause of which is not easy to trace, but it was followed by a pleasant sensation of warmth. Dr. J. B. Andrews (N. Y.) administered doses of from 1 to 3 dr., and investigated the effect by means of sphygmographic tracings taken at intervals of from fifteen minutes to one hour. He says: "Within the first interval there is an increase in the force of the pulsations, though there is little change in the number during the whole time of experimentation. The increase is most marked after the lapse of from one to two hours, and it is not till after several hours that the pulse returns to its normal condition. The first experiment I made upon myself, beginning with 20 drops, and continuing the use of the remedy in increased doses till the amount of 4 dr. was reached. The sensations experienced from 40 min. to 3 dr. were those of moderate alcoholic stimulation, slight pain through the frontal region, and a buoyancy and lightness of feeling rather agreeable. . . . In the pulse-traces, additional force is manifest in the heart's action in all cases, and in the general appearance of weakly persons placed on acid treatment the same fact is apparent—the congestion of the extremities and lips has soon given place to a more natural colour" (Amer. Journ. of Insan., 1869).

Nervous System.—The same observer and others find phosphoric acid to be a powerful nerve-tonic, but the conclusions are founded more upon clinical observations on depressed persons than on the healthy. "Moderate doses produced on the latter the

feeling of buoyancy and exhilaration already mentioned, but larger quantities caused a feeling of drowsiness, an inclination to lie down, and unwillingness for mental labour." The acid exerts also a marked control over the vaso-motor nerves, and through them improves the tone of the circulation. Hecker and Burdach concluded that phosphoric acid acts more than any other on the nervous system, heightening excitability in a great degree. Sundelin asserted that this action is directed especially to the genital organs, and although neither Neligan nor Andrews could verify this, I have myself noted it in sixteen patients, who had no knowledge of the supposed aphrodisiac quality of the drug; they all complained to me of such effects in greater or less degree.

Digestive System.—Moderate doses tend to improve the tone and functional power of the stomach, and, as already remarked, this acid irritates much less, even after continued use, than the other inorganic acids; large or concentrated doses, however, taken by the mouth, may cause gastro-enteritis, and after death, redness, erosion, and ecchymoses have been found in the stomach and duodenum (Munk and Leyden). When Dr. Pavy injected 1 to 2 oz. into the stomach of dogs it was quickly rejected, but on passing it into the duodenum, a saccharine condition of the urine and the blood was produced, just as after intravenous injections. After toxic doses, fatty degeneration has been found in the liver, kidneys, and muscular tissue.

SYNERGISTS AND ANTAGONISTS.—The same as for other mineral acids. Vegetable bitters might be included in the former.

THERAPEUTICAL ACTION.—*Internal.*—**Nervous Debility.**—The therapeutical influence of phosphoric acid is mainly exerted on the nervous system, and in the treatment of nervous debility acts much like iron in anæmia, as a chemical food supplying something actually deficient in the nutrition of the nervous system. When mental effort has been protracted till a sense of weariness renders its continuance difficult, a dose of the acid, from its stimulant effect, relieves fatigue, and seems to invigorate the mental powers, and prepare the mind for renewed exertion.

Dr. J. B. Andrews, describing a case of impaired mental power from excessive cerebral activity, observes: "The patient is languid, unable to do mental work with the usual facility, nervous,

and at times fearful, timid, and agitated, the memory weakened, and permanent impairment threatened. Such cases have been termed 'cerebral paresis,' but for their recovery, relaxation from business, and phosphoric acid, with some suitable tonic, generally suffices."

Of more serious conditions, such as dementia following acute mania, he remarks: "This is a period of nervous exhaustion, of reaction from the increased mental and physical activity which marked the previous state of the disease; tone and vigour must be supplied to the prostrated system, and for this phosphoric acid is of material service." It relieves peripheral congestions connected with impaired tone of vaso-motor nerves, and in weakened relaxed conditions akin to impotence, and resulting from sexual excess, it has proved a special help.

In **Anæmia,** and in the exhaustion of prolonged lactation, Shoemaker recommends it.

Fever.—In any fever where the nervous system is specially depressed, phosphoric acid is indicated; it assuages thirst, and helps to remove exhaustion; its pleasant taste is one advantage over the other mineral acids.

Stromeyer and others recommend it in "eruptive fevers." The following is a convenient form:—R Acidi phosphorici diluti, fl. ʒiij.; glycerini, fl. ʒj.; decocti hordei, Oij.; mix, and use when cold as a drink.

Diabetes.—Phosphoric acid often relieves the thirst of this malady, and has been recommended by Latham, Watson, and other physicians; on the other hand, the experiments of Dr. Pavy (already quoted) indicate that much of it would be injurious, and Griesinger not only states that it does not lessen the excretion of sugar, but in one case supposes it actually to have caused the malady.

Against this, we might set a case recorded by Thornley, in which the thirst was relieved and the patient apparently cured (Med. Press, 1868); but without being in a position to dogmatise on the matter, I may say that I have seen the acid on several occasions relieve symptoms and diminish the amount of sugar in the urine.

Urinary Disorder.—In phosphatic deposits connected with waste of nervous tissue, and in alkalinity of urine with nervous

depression, phosphoric acid is very useful, and it has relieved the symptoms of phosphatic calculus and urethro-vesical catarrh, when nitric and hydrochloric acids had failed; benefit has also been derived from it in *oxaluria*.

In **Rachitis,** the milky phosphatic condition of urine is cleared by the acid, though Dr. H. Wood considers that the phosphates act better. It also relieves the diarrhœa and sweating.

Phthisis—Struma.—In these conditions generally, phosphoric acid fulfils many indications as a grateful, moderately astringent tonic; it relieves hoarseness and dry irritating cough accompanied by pain and laryngeal soreness. Dr. Cotton gave it to twenty-five patients with chronic uncomplicated phthisis at Brompton Hospital, and observed benefit in a few advanced cases: it improved appetite and controlled secretion, although sometimes nausea and pain were excited: he could not trace a specific effect from it, but rather the action of a general nerve tonic; it acted specially well combined with iron (Med. Times, i., 1863). The late Dr. C. J. B. Williams recommended it with cod-liver oil (Lancet, ii., 1868).

In the *dyspepsia* so common in phthisis, it is also useful, relieving the pain, sickness, and diarrhœa which occur after meals. Profuse night-sweats and other exhausting discharges, such as occur in the bronchial catarrh of weakly subjects, are controlled by it. Dr. Todd used it in cardialgia.

Hæmoptysis—Hæmorrhage.—M. Hoffmann has written to specially recommend this acid in hæmoptysis; and the main reasons for his preference of it would seem to be its "less corrosive action," and better toleration by the stomach, otherwise its stimulant powers would make it less generally suitable than sulphuric acid; he gives 10 to 30 drops in mucilage (Journ. de Chim. Méd., 1868). I have myself seen good results from the acid in purpura and passive hæmorrhage, also in metrorrhagia.

Strumous Conjunctivitis.—This malady is often troublesome, not so much from its severity, as from its persistence and great tendency to relapse, and Mr. Balman has written to praise phosphoric acid, not only in struma, but specially "in the intermittent ophthalmia of a scrofulous constitution": he says that, given in doses of from 5 to 20 min. in calumba, the acid both cures and prevents recurrence of the affection (London Med. Gaz., 1858).

Scorbutus.—Liebig and others have held that the scurvy of sailors is mainly owing to the exclusion of phosphoric acid from their diet, since in the ordinary preparation of meat for sea-stores the greater portion of the acid is extracted from it, and the complaint has been cured by giving food containing the acid, although the sailors continued to use the salted beef to which scurvy was attributed (Letters on Chemistry). Professor Galloway has verified the presence of phosphoric acid in lemon-juice, and hence, according to Morgan and Neligan, its superiority to citric or tartaric acids, but I am not aware that the theory has been largely tested in practice.

Diarrhœa.—Phosphoric acid is suitable for cases of diarrhœa when an acid is indicated. Sedgwick strongly recommends it for choleraic cases, and argues for its use in true cholera (Lancet, ii., 1871).

PREPARATIONS AND DOSE.—*Acidum phosphoricum concentratum:* dose, 2 to 5 min. *Acidum phosphoricum dilutum:* dose, 10 to 30 min., in both cases freely diluted. Phosphoric acid is also contained in *syrupus ferri phosphatis.*

ACIDUM SULPHURICUM—SULPHURIC ACID—OIL OF VITRIOL (H_2SO_4 = 98).

This occurs native in the water near volcanoes, as in Java, and in the "Sour Springs" near the Erie Canal. It is found in combination in twenty-two natural sulphates, also with ammonium in rain-water near towns. In contains 79 per cent. of anhydrous sulphuric acid (SO_3), and about 98 per cent. H_2SO_4.

There are two other forms of the same acid, the *acidum sulphuricum dilutum* and the *acidum sulphuricum aromaticum*, which are about one-eighth of the strength of the concentrated acid, the former containing 13·65, the latter 12·5 per cent. of real acid (H_2SO_4).

PREPARATION.—By passing sulphurous acid gas (sulphurous anhydride) into leaden chambers, and bringing it there into contact with steam and nitrous fumes (nitrous anhydride); from the latter it absorbs an atom of oxygen, becoming sulphuric acid (anhydrous), and this combines with water to form a dilute sulphuric acid, which is afterwards concentrated up to a sp. gr. of 1·843; nitric oxide is simultaneously formed; this may be denoted by the following chemical equation:—$SO_2 + H_2O + N_2O_3 = H_2SO_4 + 2NO$.

The nitric oxide formed takes up another atom of oxygen from the air, becoming nitrous acid again (N_2O_3), and this is again able to act as before. Hence it is clear that a small amount of nitrous oxide acts as a carrier of oxygen between the air and the sulphurous acid (SO_2).

CHARACTERS AND TESTS.—The pure acid is an oily-looking, colourless liquid, but the commercial acid is often dark-coloured from contained fragments of charred organic matter. It is odourless, and does not fume, but has an intensely acid taste, and an energetic affinity for water, which it absorbs readily, so that a partially-filled bottle of acid, if exposed to damp air, will, after a time, overflow; if mixed with water much heat is evolved. A very small quantity of sulphuric acid, or of any soluble sulphate, can be detected by adding to the diluted solution a little chloride of barium, which gives a dense white precipitate, insoluble in acids.

ABSORPTION AND ELIMINATION.—Moderate doses of the dilute acid are readily absorbed, either as sulph-albuminates (Orfila), or, after combining with bases in the gastro-intestinal secretions, as sulphate of potassium or sodium (Miguel).

The dilute acid forms with albumen both a soluble and an insoluble compound according to the degree of dilution—the former resulting from quite weak acid (Berzelius). That dilute sulphuric acid may be absorbed through the *skin* follows from the experiments of Lebküchner, who induced an acid reaction of the urine and fæces by applications to the abdomen of rabbits.

Gubler teaches that this, like the other mineral acids, circulates in the blood, but loosely combined with albumen, and that on reaching the emunctories the combination breaks up, albumen remaining in the vessels, whilst the acid passes out with the excretions, combining with the bases therein found.

It has been a question whether, after poisonous doses, the acid may be absorbed and remain free in the blood, leading to coagulation of the latter. Geoghegan states that after the ingestion of 1½ oz., when a woman survived thirty-one hours, he found traces of acid in the pericardium and in the kidney, not in the blood, but in that fluid he found much *phosphoric* acid, derived, he suggested, from phosphate of sodium, from which sulphuric acid had displaced it (Med. Gaz., xl.). In another case Dr. Walker found a trace in the cerebro-spinal fluid and in the cardiac blood (Edin. Journ., 1850). Casper found the blood and serous fluids acid, and Carus reported sulphuric acid present in all the organs of a fœtus,

after a fatal dose taken by the mother (Beck's Jurisprudence, ii.). More recent researches state that mineral acids cannot be detected free in the blood, and that its reaction cannot be rendered acid consistently with life (F. Walter; *v.* Hydrochloric Acid). It is not likely that the coagula described by Bouchardat in the great vessels were really due to direct action of free acid,—Taylor could find no trace of it in similar coagula (On Poisons).

The acid is *eliminated* by the urine, and, according to Dr. Letheby, very quickly after full doses (Med. Gaz., xxxix.). Most observers agree that it cannot be found free in that secretion, but as sulphate (Bence Jones), and the heightened activity is really due to uric and lactic acids displaced by the stronger sulphuric acid from their ordinary combinations. Seeing the comparatively small amount of sulphuric acid accounted for in the renal secretion, Headland suggested that some passed by the lower bowel and the skin, and this is probable.

PHYSIOLOGICAL ACTION.—*External.*—The dilute acid, applied to the skin causes some burning pain and pallor, followed by redness; more concentrated, it destroys the epithelium, changing it into a firm brown mass. It coagulates albumen, and disintegrates horny tissues with formation of leucin and tyrosin. In its full strength, it causes destruction and sloughing of any tissue by virtue of its strong affinity for organic bases, as well as for the water with which they are combined. Of late years, it has been not infrequently used in revenge—thrown on the face; in such cases, an alkaline wash should be applied before the ordinary treatment of burns. The acid has disinfectant and antiseptic powers, and destroys infusorial life.

Dr. Aimé Girard has suggested that sulphuric acid may be used for the total destruction of human and other bodies after infectious diseases, and he completely destroyed the carcases of sheep suffering from malignant pustule, by plunging them into their own weight of the acid.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Very small doses give a characteristic acid taste, and lessen the sensation of thirst; 10 to 15 min. of the dilute acid, administered several times at intervals, stimulate the appetite and exert some astringent effect on the gastric and other secretions. If continued however, the medicine induces dyspepsia with acid

eructation, colic, and even diarrhœa, which may be due to the large amount of alkaline sulphates formed, as well as to direct irritation.

The local symptoms induced by *toxic* doses of the strong acid are very severe; intensely acid taste is followed by burning pain in the mouth, pharynx, and stomach, and violent retching and vomiting, the ejecta usually containing dark blood; there is extreme thirst and sense of distress—sometimes purging with tenesmus. The faucial inflammation may induce suffocation, angina, or laryngeal œdema, and thus prove fatal early in the case; or peritonitis may be set up, and if death do not occur from collapse, it may follow on perforation of the œsophagus, stomach, or bowel in twelve to forty-eight hours after the poisonous dose; should life be saved for the time, the inflammation of the alimentary tract is likely to be followed by serious contraction and stenosis, or the loss of gland tissue from the destruction of the mucous membrane will produce a permanent dyspeptic condition; swellings, and suppuration of the parotid glands may occur; any slough produced is black in colour.

Circulatory System.—Bobrick found, with frogs, that sulphuric acid, given by the stomach, or applied to the skin, caused the heart to act more slowly, and finally stopped it in diastole. Hertwig, experimenting on mammalia, found that moderate doses of the dilute acid lowered the pulse-rate and the temperature, whilst arterial tension was increased. I am not aware that similar results have been verified on the healthy human subject, nor has proof been given of the acid's power to lower temperature in febrile conditions. It has been said by some that the blood becomes less, by others more coagulable, but its exact state is not ascertained; nor do we rightly know whether the smaller vessels are contracted or not by the acid. When injected into the veins it causes instant death from coagulation of the blood and thrombosis, and the corpuscles are altered or destroyed by toxic doses taken internally.

In cases of poisoning, the disturbance of circulation is mainly secondary to the gastric irritation: there may be faintings, passing on to actual syncope or collapse, the pulse becoming later rapid and small, the extremities icy cold, and respiration laboured and superficial.

Nervous System.—Ordinary doses do not produce other than tonic effects upon this system. In fatal cases of poisoning, the mind is generally clear or but slightly clouded; exceptionally, coma has developed.

Glandular System.—Most of the secretions become more acid under the free use of this drug, and some of them, especially those of the skin and the bowel, are lessened in amount. Bobrick, however, found the quantity of urine and the amount of urinary sulphates increased by it. After large doses, Leyden and Munk distinguished different conditions corresponding to different alterations in the kidney; finding albumen alone, or with epithelial casts, or with fatty globules and epithelium, or in addition, hyaline casts, blood, and pus.

Pathological Changes.—The anatomical lesions found in the stomach after death vary according to the concentration of the acid, and the duration of its effects. In milder cases, the epithelial and the upper layer of the rete mucosum are shrunk, parchment-like, and greyish: in the severest, the whole tissue is mortified, blackened, and changed into a soft, gangrenous mass. Fatty degeneration of different organs has also been lately described as a constant result of poisoning by sulphuric acid, and particularly in the liver, the striped muscular tissue, the heart, and the renal epithelium. This change is to some extent explained by the destructive action on the red corpuscles, which are in part destroyed, and in part altered, becoming smaller, darker, and of granular appearance, and certainly unequal to their proper function; hence, the tissues are imperfectly nourished, and readily degenerate. The same alteration in the oxygen-carriers explains the lowered temperature, the feeble pulse, and the general debility, as well as the functional albuminuria from excretion of constituents of the altered blood-cells.

SYNERGISTS.—The other acids and cooling remedies are allied in action, and as regards styptic effects, ergot and astringents generally are auxiliaries.

ANTAGONISTS—INCOMPATIBLES.—Warm stimulating remedies and "fluidifying" medicines, such as mercury and iodides, antagonise some of the effects of sulphuric acid. Alkalies and bases are chemically incompatible. The best antidotes in a case of poisoning are magnesia, chalk or white-wash, and soap,

which should be given in albuminous solutions, such as milk and water. Alkaline carbonates are considered not advisable because they form irritant compounds (Christison); also they evolve much carbonic acid, but may be used in cases of emergency. Oil to protect the mucous membrane of the stomach is useful.

THERAPEUTICAL ACTION. — *External.* — The highly caustic property of strong sulphuric acid is utilised comparatively seldom, on account of the difficulty of restraining it within due limits.

Chancre—Gangrene—Cancer.—In chancre, with phagedænic ulceration, Ricord recommends a caustic paste made with sulphuric acid and charcoal, to be applied on linen for several hours—until a slough forms: the pain, however, is very great. In hospital gangrene the pure acid has been successfully employed (Med. Times, i., 1859); for such purposes and for cancer, Sir J. Simpson mixed it with zinc sulphate. The reason for using powders, especially charcoal, to mix with the acid, is to secure a full strength in convenient form without dilution with water: Syme employed sawdust, Velpeau, saffron.

Caries—Necrosis.—It is evident that a lotion containing mineral acid will dissolve out the earthy bases of bony tissue and quicken disintegration, and for this purpose it has been applied to some extent in surgery. Chassaignac recommended dilute hydrochloric acid, but more recently Mr. Pollock has brought forward much evidence in favour of the application of sulphuric acid mixed with an equal part of water, "for the more speedy removal of dying bone, or more rapid separation of dead portions, or destruction of the surface of carious cavities"; he finds it simple, safe, and comparatively painless, nor has he ever seen bad consequences from it. His first case, one of necrosis of cranial bone, was touched daily with the dilute acid,—the diseased part quickly separated, and healthy granulations formed. Cavities may be filled with lint soaked in acid, and when this is removed in two or three days, an opaque white layer may be seen and taken away; this is a slough, soft owing to removal of earthy particles, which may be found lying loose in the wound: any pain caused by the caustic ceases in a short time because the acid is soon neutralised. In some flat bones, such as those of the trunk or pelvis, the undiluted acid may be cautiously used. Recovery may be

secured "in weeks instead of months" under such treatment, though it will not always succeed without operative interference (Lancet, i., 1870).

Poisoned Wounds.—Sulphuric, like other mineral acids, when employed to cauterise poisoned wounds, bites, etc., has the advantage over solid caustic, of more *penetrating* power. Dr. W. Frazer considered strong sulphuric acid better than any other.

Parasitic Skin Diseases.—In ringworm and in scabies, an ointment containing 1 dr. of acid to the oz. of lard has sometimes proved useful (though irritating); for the latter malady it is said to be largely used in the Prussian army.

Pruritus.—In prurigo, lichen, and chronic urticaria, disorders attended with violent itching, a lotion containing 1 to 3 dr. of dilute acid in 8 oz. of water often relieves. Pereira says that its internal administration is also efficacious.

Sore Throat.—For relaxed surfaces coated with tenacious mucus dilute sulphuric acid is an excellent cleansing astringent: hence it is in constant use as a *gargle* (1 to 2 dr. in 8 oz. of infusion of roses) for relaxed uvula, etc.; in weaker proportion it is also suitable for scarlatinal throat. The addition of 2 dr. of alum to the gargle often greatly increases its value.

THERAPEUTICAL ACTION.—*Internal.*—It is commonly said that for digestive disorders requiring an acid, hydrochloric is the best: to stimulate hepatic and intestinal secretion nitric acid is indicated, whilst the astringent effect of sulphuric is of special value in controlling sanguineous and other discharges.

Hæmorrhage.—Sulphuric acid was formerly in very frequent use as an internal remedy for hæmorrhage, especially of passive character, whether from the stomach, lungs, or uterus. That there is difficulty in explaining how it can exercise astringent effect after dilution and possibly combination in the blood, would be no argument against its use if this were *proved* efficacious; but my experience is the same as that of many modern observers (amongst whom I may mention Nothnagel and H. C. Wood), who give to sulphuric acid a *secondary* place amongst hæmostatics, although I have known it succeed *sometimes* when other remedies have failed.

Diarrhœa.—Dilute sulphuric acid has a well-deserved reputa-

tion in various forms of intestinal flux, and especially in summer diarrhœa of choleraic character: it often answers well, but when given alone I have sometimes found it aggravate the disorder, whether by irritation or by increasing the acidity of secretions: the aromatic sulphuric acid should then be preferred in combination with some preparation of opium. Acidi sulphurici aromatici, ʒifs; Tincturæ Opii, ʒi; Tincturæ Cardamomi Co., ʒifs; Spiritus Chloroformi, ʒifs; Aquæ ad., ʒvi; one or two tablespoonfuls to be taken three times a day or oftener if necessary.

In diarrhœa, with coated tongue and evidence of biliary disorder, the acid has acted admirably with small doses of magnesium sulphate, tincture of rhubarb, and chloroform water; it is a good remedy for children.

Cholera.—Dr. Curtin has recorded that a severe epidemic in an institution under his direction ceased within twelve hours after the inmates were treated freely with "sulphuric acid lemonade"—the only fresh case occurring in a man who refused to take the medicine. Two days after it was discontinued two new cases appeared, and an epidemic threatened, but was again stayed by the acid, and in the surgical wards where the acid was used from the first, no case appeared, whilst every other part of the institution suffered more or less (Philad. Med. Times, iii.).

Fever.—In the diarrhœa of enteric fever, H. Kennedy, Murchison, and other authorities advocate the use of sulphuric acid. We do not expect from it, as formerly, the power of shortening the morbid process; but it will allay thirst, and, to some extent, moderate the pyrexia and the undue secretion. In any enteric cases, the dose used should be small and well diluted: the aromatic, I find preferable to the simple form.

Pyrexia—Phthisis.—Whether sulphuric acid does or does not lower pulse and temperature in the doses usually employed, it certainly is of more service in secondary pyrexial states than in specific fever. In subacute inflammatory conditions of protracted character occurring, *e.g.*, during caseous pneumonia or chronic phthisis, it alleviates the general symptoms, and sometimes the local conditions. It is well suited for phthisical cases with a tendency to undue discharges, for it acts as a grateful tonic and astringent, lessening the night-perspirations, the intestinal flux, the expectoration, and passive hæmoptysis; by combination with

opium, belladonna, or aromatics, so much relief may be sometimes given as to merit for the remedy its old title of "Elixir Vitriol."

The presence of cough does not contra-indicate its use, but irritation of the fauces must be obviated by mucilage or syrup: acids should, however, be omitted, if gastric irritation be excited by them.

Palpitation.—Nothnagel recommends this acid, combined with laxatives, in the palpitation of plethoric subjects; it is not indicated for the anæmic or chlorotic, nor specially useful in the palpitation of valvular disease.

Lead Poisoning.—Since the publication of the cases of M. Gendrin and Dr. H. Bennett in 1846, the acid has had more or less reputation as an antidote and prophylactic in poisoning by lead; but modern observation does not corroborate their estimate of it. Tanquerel especially failed to obtain any good results; on the contrary, the use of an acid lemonade seemed to make the workmen rather more liable to colic (Maladies de Plomb, ii.).

PREPARATIONS AND DOSE.—*Acidum sulphuricum—Oil of vitriol:* is not used internally. *Acidum sulphuricum aromaticum:* dose, 5 to 30 min. freely diluted. *Acidum sulphuricum dilutum:* dose, 5 to 30 min. freely diluted. An alkaline mouth-wash should be used after taking the acid, or a little butter placed on the teeth before. The aromatic acid is contained also in *Infusum cinchonæ acidum*, and the dilute acid is contained in *Infusum rosæ acidum.*

ADULTERATIONS.—The usual impurities of this acid are salts, nitrous oxides, arsenic, and lead.

ACIDUM SULPHUROSUM—SULPHUROUS ACID (H_2SO_3 = 81).

The pharmacopœial acid is a solution of sulphurous acid gas in water. The solution contains 5 per cent. of the gas by weight, equivalent to 6·4 per cent. H_2SO_3.

PREPARATION.—By deoxidising sulphuric acid by distillation with coarsely-powdered wood charcoal. The carbon combines with part of the oxygen of the acid to form carbonic acid and probably carbonic oxide, whilst sulphurous acid gas (anhydrous) passes over into a receiver containing distilled water, being previously washed from sulphuric acid and other impurities.

$$C + 2H_2SO_4 = CO_2 + 2H_2O + 2SO_2.$$

CHARACTERS AND TESTS.—A solution of sulphurous anhydride, SO_2, colourless, of strong suffocating odour and pungent acid taste, which, however, is not unpleasant in moderate dilution.

Its sp. gr. is 1·025. It bleaches vegetable colours, and is an energetic oxidising agent: it is said to absorb radiant heat in a high degree (R. Bird). The hydrated acid can be obtained in crystals, but is very unstable. A solution of the official strength and upwards oxidises on exposure to light and air (*e.g.*, when kept in partially-filled transparent bottles), with formation of sulphuric acid—an important change, since the special properties of the drug are thereby impaired or lost; contact with chlorine at once induces this change ($SO_2 + 2H_2O + 2Cl = H_2SO_4 + 2HCl$). It should therefore be carefully kept; or better still, be freshly prepared when wanted.

Tests.—1. When evaporated, it should leave no residue. 2. Barium chloride should give no precipitate, or only a very slight one. It is rare to find a solution which contains no sulphuric acid, and this it is which is precipitated by the barium chloride. 3. Sulphurous acid decolorises a solution of iodine with formation of hydriodic and sulphuric acids, thus—

$$SO_2 + 2H_2O + I_2 = H_2SO_4 + 2HI.$$

3·2 gr. sulphurous acid neutralise 12·7 iodine.

Of the gas, 1 part in 100,000 of air is perceptible to the sense of smell; 9 parts are disagreeable and provoke cough; 20 parts are irritating, and 43 parts (= 4 parts in 10,000) are irrespirable: much less than this will kill plants (Letheby). In generating it by burning sulphur in air, 32 parts by weight, in round numbers, combine with an equal quantity of oxygen to produce 64 parts of sulphurous anhydride, which occupy precisely the same bulk as the oxygen employed. Its density is high, the sp. gr. as compared with air being 2·247; a cubic foot weighs about 1206 gr., and to produce it 603 gr. of sulphur and a cubic foot of oxygen (= 5 cubic feet of atmospheric air) are requisite.

Alkaline sulphites and *hyposulphites* owe their properties to the sulphurous acid liberated from them.

Sodii Sulphis—Sulphite of Sodium ($Na_2SO_3 7H_2O$).—Prepared by saturating a solution of carbonate of sodium or caustic soda with sulphurous acid gas, and crystallising. It occurs in white efflorescent prisms which have a slight alkaline or neutral reaction, and the odour and taste of sulphurous acid; it is soluble in cold water (1 part in 4), and in less than 1 part boiling water; very soluble in spirit.

Sodii Hyposulphis—Hyposulphite of Sodium ($Na_2S_2O_3 5H_2O$) (*Appendix B.P.*)—Prepared by gently warming a solution of sulphite of sodium with finely-powdered sulphur, or by passing sulphurous acid gas through it. It occurs in colourless crystals (oblique rhombic prisms), and is bitter, slightly alkaline, and sulphurous in taste, less unpleasant than the sulphite. It is very soluble in water, but not in alcohol, decolorises iodine solutions, and dissolves salts of silver which are commonly insoluble, *e.g.*, the chloride. A solution of hyposulphite is distinguished from one of sulphite by the precipitation of sulphur on adding sulphuric acid. Hyposulphites do not act on iodide of potassium.

Potassii Sulphis—Sulphite of Potassium (*non-off.*).—Prepared by saturating a solution of potassium carbonate with sulphurous acid gas, and crystallising. It occurs in white opaque fragments or powder, with a slight odour of the gas—very soluble in water (1 in 3). Its taste is saline and sulphurous.

Magnesii Sulphis—Sulphite of Magnesium (*non-off.*).—Contains proportionately more of the acid than the other salts; it is also the most soluble, and the least unpleasant.

Calcii Sulphis—Sulphite of Calcium (*non-off.*)—It is soluble only in 800 parts water, but the bisulphite and hyposulphite are freely soluble.

ABSORPTION AND ELIMINATION.—*Sulphurous acid* is readily absorbed, and its characteristic odour has been observed in the breath and secretions after its administration (Dr. George Wilks, B. M. J., ii., 1870). It passes out also with the urine and fæces as sulphate, for it is readily oxidised in the system.

The *sulphites* are decomposed in the stomach by the gastric acid; sulphurous acid is given off, and they are mostly changed into sulphates, and are eliminated as such, partly by the intestinal canal, but chiefly by the kidneys; they pass within twelve to twenty-four hours after administration. The *hyposulphites* undergo similar changes, but more slowly, for they are more stable.

After very large doses, these salts may be found unchanged in the urine (Rabuteau), and after their application to wounds, free sulphuric acid may be traced in the same secretion (De Ricci).

PHYSIOLOGICAL ACTION.—*External.*—Externally applied, sulphurous acid is refrigerant, somewhat astringent, and in full strength irritant. The most important property of the gas

and its compounds is that of arresting fermentation, and of destroying the lower forms of vegetable and animal life, and certain infective organic poisons. Its power of controlling ferments and destroying visible parasites is readily proved.

For aerial disinfection Hoppe-Seyler, after careful trial, found sulphurous acid gas the best agent,—1 or 2 per cent. of it in the air of a room destroying all the lower organisms: this could be secured by burning ½ to 1 dr. of sulphur for each 100 cubic feet of space (Lancet, ii., 1871). Letheby arrived at similar conclusions, but recommended, for greater security, a larger proportion of sulphur—1½ oz.—to each 100 cubic feet of air (Med. Times, ii., 1873).

Dr. Baxter, taking up the same question from another point of view, concluded not only that sulphurous acid was the best of aerial disinfectants, but that its action on vaccine virus was more potent than that of chlorine or carbolic acid. Thus he vaccinated one arm of a child with points of virgin lymph, and the other arm with points previously exposed to the action of the three agents, and whilst small vesicles often resulted after the use of chlorine or carbolic acid, *none* could be obtained after sulphurous acid, "even under conditions which seemed to render the virulent particles least susceptible to destructive influences" (Sixth Report of Med. Off. Privy Council, N. S., and Lancet, i., 1876). It is true that Dr. Dougall had found sulphurous not so effective as other mineral acids (notably chromic acid) in preventing the decomposition of organic solutions, but Crace Calvert showed this was not correct, and 1 part of the former in 1000 of albuminous solution was enough to preserve it for forty days, whilst other acids only preserved it for nine or ten days. Dr. Fergus also compared glasses of beef extract heated with sulphurous acid, carbolic acid, and terebene, and found several weeks afterwards that the one heated with sulphurous acid remained sweet whilst the others were decomposed (Pract., i., 1877).

More recently Dr. Wolffhügel has found that, although the gas in the dry state is able to destroy bacteria, it cannot kill the spores of these organisms; but when the gas is employed dissolved in water, the germicide action is very marked, a strength of 0·75 to 0·1 per cent. being sufficient to kill the spores as well as the fully-developed bacteria. These experiments are quite in keeping with the property of the dry spores to resist dry heat, while they

are killed by exposure to a lower temperature if they are moistened. Dr. Wolffhügel considers that instead of using the gas in the usual way, obtained by burning sulphur in a room as a disinfectant, it would be safer, though a little more troublesome, to moisten the floors, walls, fabrics, and other articles in the room with water before setting light to the sulphur (Med. Times, i., 1882). Koch, on the other hand, finds sulphurous acid, as well as many other disinfectants, inferior to perchloride of mercury (Pract., ii., 1882).

PHYSIOLOGICAL ACTION. — *Internal.* — From the preceding and many other observations, there can be no doubt of the disinfectant power possessed by sulphurous acid in a very high degree when brought into *direct* contact with infective or putrescent material, whether in the air, or in wounds, etc., but the further question whether it can be so introduced into the circulating blood of living animals as to neutralise a septic poison therein also circulating, or so as to prevent the admission of such poison, is more difficult to resolve. Dr. Polli (Milan) held the affirmative to be proved by his experiments upon dogs with sulphites and hyposulphites; after treating an animal with these medicines, he injected septic poison, and found it did not succumb to the effects, whilst a healthy but untreated animal quickly did so. In other cases, examining the bodies of animals killed after treatment with sulphites, they were found to decompose much less quickly and less readily than others not so treated. He offered, also, some clinical evidence of the value of these remedies in septicæmia, and much practical benefit was expected from his observations; they have not, however, yet passed the region of controversy. Semmola, O. Weber, and others, deny them, or characterise them as "negative." Clinical results differ, and although I hold that much may be done by introducing "disinfectant" medicines, especially sulphurous acid, into the organism, I acknowledge that definite proofs of their power and mode of action within it are still to be desired (*v.* Carbolic and Salicylic Acids).

Digestive System.—Sulphurous acid solution may be taken internally in moderate doses and well diluted without definite effects on the healthy body, unless it be the quenching of thirst and some refrigerant action. Insufficiently diluted, the solution excites local irritation of the digestive tract, and sometimes of the

bronchial mucous membrane, some persons being more sensitive to this than others. The sulphites and hyposulphites in large doses increase peristalsis, and cause purging, though not so readily as sulphates.

Temperature.—Given during the pyrexial state, *e.g.*, of remittent fever, sulphurous acid is said to lower the body-temperature.

SYNERGISTS.—Disinfectants and antiseptics aid the action of sulphurous acid, but it is so readily oxidised that it is better used alone. Steam favours the antiseptic action of the gas, and nitre added to the burning sulphur makes it more effective (Dewar).

ANTAGONISTS.—All oxidising substances alter the chemical constitution of sulphurous acid, and impair the peculiar properties of sulphites, especially when in solution. The mineral acids, including sulphuric, decompose sulphites and hyposulphites.

THERAPEUTICAL ACTION.—*External.*—**Parasitic Skin Disease—Favus—Ringworm.**—Sulphurous acid solution is a cleanly and efficient mode of treating these maladies. It may be painted on occasionally in full strength, or used in lotion or compress, 1 part to 2 or 4 of water and glycerine—the great point is to secure its thorough contact with the diseased surface. An American method is to burn sulphur in a closed box fitting to the head for half an hour at a time (Schuster); another mode of applying nascent acid is described under Lupus (*v.* p. 346).

Pityriasis Versicolor (Chloasma).—A weaker lotion than the last-mentioned, 1 part in 8, or one containing sulphite or hyposulphite of sodium (℥j. in ℥viij.), will cure this disorder. (The same lotion, or one half the strength, is very effective in cases of fœtid perspiration.)

Pruritus Vulvæ, etc.—When pruritus is dependent on discharge, or other source of irritation, possibly parasitic, injections and lotions containing "bisulphite of soda" (gr. xv. ad ℥j.) have been found serviceable (Lancet, ii., 1871). The itching of lichen and of true prurigo senilis may also be relieved by lotions containing sulphites.

Erysipelas.—A sulphurous lotion will often give great relief to the burning pain of erysipelas, and its constant application is said to cut short the malady. Dr. Hewson records twenty-seven

cases of various degrees of severity—seven of them idiopathic, and all treated by the local use of a sulphite lotion (sodii sulphis gr. x. ad. ℥j.) applied on lint covered with oiled silk; it bleaches the skin and "destroys the inflammation" (Philad. Med. Times, i., 1868). Mr. Pairman describes great and immediate relief to pain in a severe case of facial erysipelas from a lotion of equal parts of glycerine and sulphurous acid: the patient recovered at the end of a week, but tincture of steel and other remedies were given internally; relief, however, was clearly traceable to the lotion, and it deserves to be more generally used than it is at present.

Lupus.—Dr. H. Collier has recorded several cases of lupus which had been previously treated with various caustics unsuccessfully, and which were cured by the use of sulphurous acid. He applies the remedy in one of three ways. (1) As gas: this is the most effective, though rather troublesome: fumes from burning sulphur are allowed to come into contact with the ulcerated surface for about twenty minutes every day for several days. (2) As a lotion of the pharmacopœial strength of the acid, or diluted in the proportion of 1 to 2 or 1 to 4, the last strength being the most useful. (3) As an oil: he obtained the best results from applying a mixture of the concentrated alcoholic solution of the gas with equal parts of castor or olive oil (Med. Times, i., 1884). My own experience with the more recent method devised by Dr. A. J. Harrison has been very satisfactory: he applies an aqueous solution of hyposulphite of soda (gr. xl. ad ℥j.) to the affected part during the night, on lint covered with oilskin, and in the morning a "day lotion" containing 5 m. of pure hydrochloric acid B.P. in the ounce of water. There may be some pain with their application, but it is not severe, and nascent sulphur and sulphurous acid are developed in contact with the lupus tissue, which they disinfect and destroy; a soothing cerate or lotion may be required at intervals. He reports nine satisfactory cases of various ages and duration, and found the treatment equally effective in the common and the crythematous forms, but further observation is necessary (B. M. J., ii., 1892).

Chilblains—Corns—Fissured Nipples, etc.—For these minor, but annoying ailments, sulphurous acid is a good remedy. Mr. Pairman applies the strong solution of the acid on lint

covered with oiled silk: if the skin be broken the acid should be diluted. Sore nipples are to be "soaked well with strong acid for a few times" (Pamphlet, The Great Sulphur Cure, 13th ed., 1868). Mr. Fergus applies the acid in spray to chilblains, or uses as a wash 3 parts of the solution to 1 of glycerine and 1 of water (Lancet, ii., 1870).

Bruises—Sprains.—The same surgeon, who speaks from good experience at Marlborough College, has found a lotion containing sulphurous acid very useful in "every kind of bruise and sprain." He recommends a spray of pure acid for six or seven minutes till the part feels cold, then lotion (1 in 8) to be applied and frequently changed; in forty-eight hours inflammation and pain have subsided, and on the third or fourth day the limb can be strapped or bandaged.

Wounds—Fractures.—Mr. Fergus records also excellent results from the acid used in lotion to a compound fracture and to a severe contused wound of the face (where it is always important to avoid scarring): under a lotion of 1 part in 7 constantly applied, the wounds healed quickly and without suppuration. I can corroborate this to some extent, but the treatment has not come into general use. Dr. John Balfour has had marked success with a lotion (1 in 12) applied on *thin* rag kept constantly wet for the first day or two after injury, afterwards wetted every twelve hours with tepid lotion kept covered by oiled silk, zinc ointment being substituted about the third or fourth day. Severe compound fractures of the hand with laceration of tendons, and gunpowder burns. fractures of the shoulder and other joints by machinery—all did well under this treatment, which seemed to give almost instant relief from pain, to control and greatly restrain suppurative action, and secure primary union whenever possible (Edin. Med. Journ., 1869-71).

Ulceration — Gangrene. — In cases of unhealthy open wounds, and even hospital gangrene, sulphurous acid has sometimes proved more efficacious than carbolic; this was especially seen in hospitals at Metz during the Franco-Prussian War (Med. Times, ii., 1871).

Sore Throat.—In various forms of sore throat, sulphurous acid as a gargle, or preferably in fine spray, is exceedingly useful, relieving pain, lessening inflammation, destroying parasitic

growth, and cleansing unhealthy suppurating surfaces. It is, in my experience, of great value in *aphthous* conditions such as occur during phthisis or other exhausting diseases, as well as in the ordinary form common during infancy; it often relieves the pain, tension, and ulceration of scarlatinal and variolous throats, and I have seen it of the greatest service in chronic syphilitic ulceration of the fauces.

In the acute inflammatory stage of sore throat it is not always well borne, but will be found to answer better in such cases when used of full strength, if only for a very short time, than if diluted; in the latter case it has seemed to irritate the mucous membrane without controlling inflammation, but there is no *one* rule, a short trial will be the best guide; young children do not usually bear it well. Fergus, on the other hand, says it is good "in all forms of inflammation of the throat and tonsil"; it should change the turgid redness to a light pink during the application.

Dysphonia Clericorum—Follicular Pharyngitis.—Dr. Dewar has published cures of this condition, so rapid and after so many years' duration of the malady, as to border on the marvellous. One clergyman, a sufferer for twenty years, found immediate relief from the spray—"something loose feeling braced up"; and others suffering also from general weakness, night-sweats, nervousness, partial aphonia, etc., are said to have been restored by sulphur fumes and spray. The cases are described in popular language rather than with scientific accuracy, but we may accept the fact of much relief being afforded in the class of maladies referred to (Med. Times, i., 1867).

Catarrh—Hay Fever.—A sulphurous acid spray applied to the nostrils often relieves the annoying symptoms of both these maladies. Sulphur-fumigation is also said to have cured them quickly, but this cannot always be depended upon.

Chronic Bronchitis.—In old times the sulphur vapour of Pozzuoli and similar places was resorted to, and the spray is sometimes a useful adjunct in the treatment of this condition; it acts as a stimulating expectorant, thinning the tough viscid phlegm; sulphur-fumigation is also good (Fergus). It will not, however, accomplish the great benefits at one time expected from it, and should be commenced cautiously, as it excites cough.

Pertussis.—The vapour is also of much service in this dis-

order and may be utilised in the mode described by Dr. Mohn and Mr. Manby, the patients being removed from their bedroom whilst about 1 ounce of sulphur to every cubic metre (10 grains to every cubic foot) is burnt in the room for about five hours and then the windows and doors opened: any clothing, etc., are exposed at the same time, and afterwards the patients are brought back to sleep in the disinfected room. "Cough is lessened in frequency, expectoration rendered easier, paroxysms been less violent and sickness has ceased in twenty or more cases" (Pract., 1887-1888). My own experience is also favourable to this treatment.

Phthisis.—Dr. Dewar has recorded a remarkable case in the person of a groom advanced in phthisis, with emaciation, cough, sweatings, hæmoptysis, etc., and apparently in a hopeless condition, who conducted sulphur-fumigations for cattle (*v.* p. 312), remaining with them in the sheds "with the most wonderful benefit to his own health: within one week the night-sweats had ceased, his cough abated, and expectoration diminished, he gained weight—nearly two stones in four months, and with the exception of being somewhat short-winded, looks nearly as strong and as able for ordinary work as before his illness" (Pamphlet, On the Application of Sulphurous Acid Gas, 1866). He reports four other cases of "chronic phthisis" equally benefited; and Mr. Pairman corroborates his observations; they deserve careful consideration, but up to the present there has been little further trial of the method. Additional favourable evidence in four cases has been given by Sombro (Record, 1883).

Solland reported also excellent results, and Ley sought to modify the administration so as to make it less trying. As the fumes owe their opacity to some sulphur being sublimed but not oxidised, and some of their irritating qualities to the sulphuric acid generated by aqueous vapour and oxygen in the air, he burnt the sulphur in dry air and allowed twelve hours for the sublimed drug to be precipitated before entering the room—he found ·01 to ·008 a sufficient therapeutic dose, and this can be obtained by burning 2 or 3 grains (not 10) to the cubic foot in a room whose walls have been previously saturated with sulphurous acid. Non-febrile cases are the best suited for this treatment, which promotes bronchial secretion and expectoration till the

"lung is cleared" and symptoms improved (Journ. de Méd., 1887; Pract., 1888).

It was thought that the sulphurous *spray* would be of great service in the relief of phthisical symptoms, but I have not seen important results from it, though it facilitates expectoration and may lessen laryngeal irritation; often, however, it is not well borne.

Fumigation in Infectious Disease, etc.—The burning of sulphur for the prevention or cure of infectious disorder long preceded any modern scientific inquiry. The Chinese esteemed it highly in prehistoric times. Ulysses, according to Homer, employed it to disinfect his palace after slaughtering the suitors, calling it "the remedy of all evils, and cure of all sores" (Odyssey, xxii., 481). Ovid praises it in the Fasti, and Pliny in his Natural History; but it is within quite recent years, and since the recognition of a "germ theory" in disease, that the systematic use of sulphurous acid, *within*, as well as without, has been placed upon a logical basis or fairly pressed upon the profession as a method of treatment.

When cattle plague was epidemic, Dr. Dewar found the best results from fumigating cattle sheds with sulphurous acid. His own cattle never suffered, and "a large dairy, notorious for thirty years for mortality amongst its cows (from pleuro-pneumonia), and which for eight years of the then tenant's occupancy had never been free from disease for a month, in which sixteen cows had lately died, the last three days before fumigation began; this dairy from that time till the date of writing had been perfectly healthy." He states also that "an epidemic of diphtheria was cut short by it; two cases having occurred in one house within twenty-four hours, and no others after sulphur-fumigations." Mr. Pairman reports similar experience, but neither author, however earnest and truthful in reality, writes in such a manner as to convince the profession, and hence, perhaps, they have not widely influenced practice.

The variola epidemic, arrested on the coast of Iceland by Dr. Hjaltelin seems admissible evidence of the value of the gas, though such arrest has by some been attributed to the quarantine and isolation enforced. Twenty-two cases were brought on shore from the fishing vessels; seven were **confluent**; only one died (moribund on admission); *in no instance did the disease spread.*

A workman employed in the hospital did not catch small-pox, although shortly after he proved susceptible to vaccination; in every case the attack was quickly and favourably modified: results which may fairly be connected with the treatment—constant use of sulphur fumes in the air, and the giving of sulphurous solution internally (B. M. J., ii., 1871). (An epidemic of small-pox in the last century—1707—destroyed one-fourth of the population of the same country.)

Dr. A. W. Foote, during the last epidemic of variola in Dublin, endeavoured to carry out a thorough disinfectant treatment in his wards at the Meath Hospital, giving sulpho-carbolates as well as sulphurous acid, applying the latter locally, and burning sulphur three or four times a day; he treated fifty-nine cases, of which twenty-four were confluent, six semi-confluent, and eleven died, and he concluded that the treatment was of value, and that sulphur vapour acted "as a prophylactic," but was irritating to bronchitic subjects. This fact is important, for in confluent small-pox, laryngitis is a frequent and serious complication (Dub. Journ., and Med. Times, i., 1872).

On the other hand, we have to note unsatisfactory results from the use of similar treatment during an epidemic at Trinidad. Dr. Bakewell, though not furnishing many details, states that he treated twenty-five patients with sulphur-fumigations and sulphurous acid, apparently "without any effect" (Med. Times, i., 1872).

The experience of Mr. Fergus as to disinfection after an epidemic of scarlatina is very favourable: upwards of four thousand blankets and other articles of infected bedding and clothing were exposed thoroughly for four hours to the fumes of burning sulphur, "with complete success" (Pract., i., 1877). He is accustomed to depend on a short personal exposure to sulphur fumes after visiting an infectious case, and has never conveyed infection in his own person. He lays stress upon an important point, inattention to which might possibly account for some failure: the vapour should be used at intervals for half to one hour at a time, and at its full strength, rather than by being constantly given off at low tension—the latter method is apt to be ineffective, as well as more likely to give rise to unpleasant sulphur combinations.

The acid bleaches vegetable colours, and corrodes metals, etc., but not so markedly as to cause inconvenience in practice. The pernicious effect on human air-passages, formerly attributed by high authorities to effective sulphur vapour, has been quite disproved. Dr. Angus Smith says: "This acid gas is an irritant, and causes coughing, which becomes painful and dangerous according to the amount used, and as it is destructive to animal structures it does not seem advisable to use it more than can be avoided" (On Disinfectants): such an opinion has doubtless told against its use, but after the observations of Dewar, Pairman, Fergus, and others, must now be modified.

Cholera.—The burning of sulphur fires round infected villages has been strongly urged (Tuson, Lancet, ii., 83).

Mode of Fumigating with Sulphurous Acid Gas.—Dr. Dewar, referring more particularly to the process as applied for cattle plague, recommends as the safest and most convenient apparatus, "a chaffer two-thirds full of red cinders, a crucible inserted therein, and a piece of sulphur stick"—"a piece" the length of a man's thumb will burn for twenty minutes and be sufficient for a shed containing six cattle, and if ventilation be free at the same time a man can remain without the least risk of detriment—this is repeated three or four times daily. Its efficacy is increased by simultaneous steam-fumigation, and if only "inanimate objects" are to be disinfected, nitre may be added to the sulphur, and thus some sulphuric acid generated (Pamphlet). The more recent experiments of Wolffhügel which have been already referred to (p. 343) show also that a solution of the gas is more powerful as a germicide than the gas in a dry state.

For phthisical and other patients, the room is simply filled with fumes three times a day. Mr. Pairman places half a teaspoonful of sulphur on paper on a shovel and ignites, repeating this process every twenty minutes till the patient has had one or two hours of fumigation;—the head should not be held too near, nor the fumes made so strong as to excite much coughing. He is in favour of keeping "mild sulphur fumes almost constantly in the sick room," but the occasional and temporary use of a full dose is to be preferred. Dr. A. W. Foote used "flowers of sulphur" dropped on a heated shovel, and carried about the room, and this is quite under control and readily borne by patients unless bronchitis or

asthma renders them unusually sensitive. From 1 to 2 dr. will be an average quantity : it is scarcely necessary to make an exact calculation.

If a room is to be thoroughly disinfected in the absence of inmates, the doors, windows, and other apertures should be closed —pasting paper over chinks is sufficient—coloured clothes removed, and metal protected by grease or otherwise ; then sulphur should be burnt in quantity proportioned to the space, taking Letheby's estimate of $1\frac{1}{2}$ oz. for each hundred cubic feet, or more roughly the proportion of $\frac{3}{4}$ lb. for a large room (Fergus). If dried and finely powdered, it will burn when lighted, and may be conveniently placed in a small earthen jar standing in water : mixed with $\frac{1}{10}$ part of its weight of powdered charcoal it burns, perhaps, more readily, and will not melt and run over—the charcoal will be unconsumed (Fergus). If this mixture be placed on an iron plate two feet square, it will be safe, though for precaution some would put the plate or vessel over water. After an hour's fuming, a free current of air should be admitted for several hours before occupying the room. Candles are made with a definite proportion of sulphur (Seabury Johnson, B. M. J., i., 1889) and there is an apparatus for local application of the vapour. Mr. Keates has suggested the burning of bisulphide of carbon as a convenient means of obtaining gaseous sulphurous acid, for much more of this gas is given off than of carbonic acid—especially is this the case if petroleum be mixed with it. In a room of 1,300 cubic feet, 280 gr. of bisulphide charged the air so efficiently with SO_2 that one could not remain in it, and a lamp has been contrived to burn a graduated amount (Lancet, ii., 1876). It is said too that the offensive smell of bisulphide is got rid of in the purer preparations, but still it remains highly inflammable, and the method seems more dangerous and more complex than simple sulphur burning.

THERAPEUTICAL ACTION.—*Internal.*—**Septicæmia.**—Following up the observations already mentioned as to the effect of sulphites upon dogs, Prof. Polli devised a special method of treating "zymotic" diseases—the "anti-fermentative or anti-zymotic method," which aimed at prophylaxis by saturating the blood with these remedies. The method made progress in Italy, Spain and France, not much in Germany, and lately it has lost

ground even in the former countries (Nothnagel); still I think that with modifications it has a future before it, and will mark a distinct advance in rational therapeutics. It is applied not only to the specific fevers, cholera, intermittents and the like, but also to pyæmia and septicæmia generally, to phthisis with suppuration and chronic empyema, all of which have been benefited by sulphites.

Sir Spencer Wells traced improvement in septicæmic uterine cases to the use of hyposulphites (Med. Times, ii., 1864).

Dr. McCall Anderson cured eruptions of furunculi with ½-dr. doses of sulphite of sodium (Lancet, i., 1870), and Dr. Ricci chronic pemphigus with sulphite of magnesium (Dub. Journ., vol. xxxvi.). Dr. C. B. Radcliffe, when suggesting the use of the same salt in cattle plague, states that he has seen good results from it in fevers (Lancet, i., 1870).

Snow Beck used frequent vaginal injections of sulphite of sodium in puerperal fever, and gave internally the sulphites of lime or magnesium, and advocated this treatment as better than any other (Lancet, i., 1865). Sulphite of sodium in 2-dr. doses daily (readily taken in beef-tea) proved valuable in pyæmia in the Liverpool Infirmary (Med. Times, ii., 1868); and Dr. Millar, whilst reporting the hyposulphite ineffectual in typhus, found it distinctly of service when given early in septicæmic cases connected with parturition (Edin. Journ., Sept., 1869). Since these observations the antiseptic principles of treatment have much advanced, but are carried out quite as much, if not more, with other remedies. Of course, if blood-poisoning has reached beyond a certain point, recovery is not possible under any treatment, and if the salts employed be not fresh and pure, failure also will result; irritation of the stomach and intestinal tract may also hinder their employment, and I think that sulphurous acid is really a better form to employ than its alkaline compounds; but whichever be chosen should be *early* and thoroughly given.

Variola.—We have already stated that in the hands of Dr. Hjaltelin and Dr. A. W. Foote, the internal use of sulphurous acid solution in small-pox was combined with the external application of the gaseous form, and, so far as could be judged, with good effect. The secondary fever of this malady is due to absorption from the pustular eruption, and this ought to be

influenced by the early employment of such remedies, and I believe is so influenced. In one exceedingly severe case of confluent small-pox, considered hopeless by a good practitioner, the patient was enabled to take ½-dr. doses of sulphurous acid every hour or two, and within a short time showed signs of improvement, which went on to complete recovery, not in accord with the normal rate of progress in such cases. To variolous pustules maturating, the acid with glycerine is a good application.

Erysipelas.—The relief afforded by the acid spray in erysipelas has been already noted, but the internal use of the remedy may be well conjoined with the external. In the case of an infant living under unhealthy conditions, and in whom a severe attack of the idiopathic malady affected one arm and leg, the pudenda and head, and when iron had no control over it, the internal use of sulphurous acid seemed the cause of improvement which very quickly followed.

Diphtheria.—Under sulphur it has been stated that the local application of that remedy is not desirable, but sulphurous acid acts much better, and is, as a rule, well borne, and even liked by the patient; it may be used in fumes, spray, or gargle, and conjoined with iron or chlorate of potassium (Lancet, i., 1875, B. M. J., ii., 1889).

Fergus depends on the acid with ice only, and other observers have had satisfactory results from the salts; thus Dr. Hayden had from the hyposulphite (Dub. Quarterly, 1886). I think the local application of the acid in spray highly desirable, and that painting the throat with a mixture of equal parts of the pharmacopœial acid and glycerine often aids the separation of the membrane in this disease.

Enteric Fever.—Whilst recognising the difficulty of a true judgment about the effect of medicines in this fever on account of some uncertainty in its natural course and duration, and of the usual recoveries independently of any specific treatment, yet I must state my conviction that its course may be favourably influenced by the internal use of sulphurous acid, if commenced *early* enough. I know that many authorities have taught that the materies morbi having once been received must pass through certain changes before elimination, and that the best practice is mainly intelligent nursing; but observation of many enteric cases

has led me to the conclusion that under the influence of sulphurous acid or the sulphites, the attack has been shortened, whilst high temperature and profuse diarrhœa have been relieved, coincidently with improvement in the general symptoms. In some advanced cases, with muttering delirium, sordes, and signs almost of dissolution, a favourable change has occurred shortly after commencing the acid treatment, though it cannot be depended upon if commenced only at this stage. Of thirty-six consecutive cases thus treated by Dr. Mackey, several illustrated these points, and none died. Special advantage from the acid is not claimed on the score only of the number recovered, for equal results have been recorded from other methods; the number is still too small to justify positive conclusions, but the impression made on my own mind as to the value of the acid is highly favourable.

It is true that sometimes persistent vomiting interferes with its administration, and the drachm or two-drachm doses recommended cannot always be given; 10 to 30 drops has been an average dose for an adult, repeated every two to four hours, and if urgent bronchitis contra-indicates this remedy for a time, expectorants and diaphoretics must be substituted. Several years ago, Dr. Hamilton (Liverpool), treating his last eight cases of an epidemic of typhoid with sulphurous acid, "was struck by the mild form assumed, and apparent cutting short of the fever." They were typical cases at the commencement—five children, three adults—and the dose was from 1 to 3 dr.; they were generally better on the second day, and by the fifth day improvement had set in (Lancet, i., 1869). Dr. George Wilks, of Ashford, refers to 171 cases of enteric fever treated by him with sulphurous acid, and all ending in recovery, some under very unpromising conditions; thus he instances a poverty-stricken child of four years, with violent vomiting, purging, tympanitis, and delirium, who could not have ordinary care and attention; a woman of seventy-three equally neglected; and a man of fifty-four apparently dying under the ordinary treatment by astringents, etc., and yet rapidly recovering after commencement of the acid treatment (B. M. J., ii., 1870). The patients took from 4 to 40 drops with syrup and water every four hours for many days, until they showed ample evidence of the absorption and elimination of sulphur.

Scarlet Fever. — In an epidemic of malignant type Dr. M'Donald found this acid used internally, in spray, and in fumigation, more effective than any other remedy (B. M. J., i., 1883).

Dysenteric Diarrhœa—Cholera.—Dr. Scoffern writes recommending the sulphite of lime in choleraic diarrhœa (Lancet, ii., 1866), but it has not been much used. On the hypothesis of cholera being dependent upon the absorption of organic poison, sulphurous acid ought to prove of service in its treatment, more so than the sulphites and hyposulphites, which are slower in action and liable to irritate. Professor Graham, indeed, first introduced the solution of sulphurous acid to Sir Wm. Jenner as a possible remedy for cholera, but it has never received full trial. A main difficulty, as regards any remedy in cholera, is to secure its absorption, all vital function being annihilated with such fearful rapidity : hence we can never hope for the same results as in enteric fever, but sulphur fumes should certainly be used as a disinfectant and prophylactic.

It has been pointed out that workers in copper, and in powder factories (at Madras especially), have shown special immunity in cholera epidemics ; and although Dr. Burq claims specific virtues for copper in this respect (*v.* Cuprum), the presence of sulphurous acid is a more likely explanation.

Ague.—The hypothesis of ague being dependent upon the absorption of minute fungi or spores given off by the soil of malarious districts has been forcibly maintained by H. Schmidt, Salisbury, and others, who have even reported the finding of such microscopic organisms in the blood and secretions of patients, and in the neighbouring marshes (Lancet, ii., 1867). Evidence in favour of this theory seems furnished by such instances as that of the ship *Argo*, which took on board for water supply to a band of soldiers, water from a malarious district, and almost all who drank of it got intermittent fever, whilst the *sailors* of the same vessel, who had a different water supply, did not suffer (Lancet, loc. cit.). This hypothesis of the malarial poison has been to a great extent proved by the researches of Professors Tommasi Crudeli, of Rome, and Klebs, of Vienna, who have separated a distinct organism as the cause of the disease which they call bacillus malariæ. Clinical evidence as to the value of sulphite treatment is contradictory—thus, whilst Sanger refers to four

cases of intractable ague, soon relieved and ultimately cured by scruple doses of hyposulphite of soda (Lancet, i., 1869), McClean criticises the result, and notes that quinine and other remedies had been previously used, and that it is well known quinine often does not cure, unless a blood depurant, such as potash or soda, first be given, and moreover many cases in the Mauritius were treated by the sulphites without effect, and were afterwards cured by quinine (Lancet, i., 1869). Several American writers have reported the cure of intermittents by hyposulphites after failure of quinine (Ranking, Abstract, ii., 1868); but Farelli, from an exhaustive analysis of the recorded evidence, concludes that their good effect is neither so quick nor so constant as that of the latter; they are not prophylactic, and their continued use leads to anæmia; he holds that their action, such as it is, "is reductive, not disinfectant" (Lancet, i., 1873).

Syphilis.—Several writers, chiefly American, have strongly recommended the internal and external use of the sulphites in the later stages of syphilis (Ranking, ii., 1868). I have had no occasion to prescribe them, but have found the acid locally applied most useful in ulcerations of the throat and other parts. Dr. Purdon has recorded an illustrative case (B. M. J., i., 1868).

Pyrosis—Sarcinous Vomiting.—In these conditions, which are clearly dependent upon fermentations or the presence of low organisms, the influence of sulphurous acid and its compounds ought, *à priori*, to be clearly shown; and so practically we find it, for sulphurous acid in ½ to 1 dr. doses is one of the best remedies that can be given. Sir William Jenner was one of the first to point this out (Med. Times, ii., 1853), and Dr. Henry Lawson, one of the first to secure for it the attention of the profession (Pract., vol. i.). Dr. C. Drysdale also early recorded a case rapidly relieved by this treatment after failure of bismuth, prussic acid, etc. (Lancet, ii., 1869). Other physicians have succeeded with the hyposulphites (Med. Times, i., 1853), and even with sulphites, and if Dr. Lawson found no benefit from these, as compared with the acid itself, it was probably because his dose was but small; the hyposulphites, however, must deposit sulphur, and as a rule, the acid will be found best.

PREPARATIONS AND DOSE.—*Acidum sulphurosum*: dose, ½ to 1 fl. dr., diluted. For external application the solution may be used in full

strength, or diluted with equal parts of glycerine and water, or as a lotion 1 part in 8. *Sodii sulphis*: dose, 20 to 60 gr., freely diluted: as a lotion (antiparasitic), 1 part in 8: as an injection, etc., 2 dr. to ½ oz. in 8 oz. of fluid *Sodii hyposulphis:* dose, 20 to 60 gr. *Calcii sulphis:* dose, 10 to 20 gr. *Magnesii sulphis:* dose, 10 to 30 gr. *Potassii sulphis:* dose, 10 to 30 gr.

ACIDUM TARTARICUM—TARTARIC ACID

$(H_2C_4H_4O_6 = 150)$.

An organic acid very widely diffused: it occurs in fruits partly in the free state, and partly combined with potash or lime.

PREPARATION.—From "cream of tartar"—acid tartrate of potassium—which is derived from grape-juice, and is deposited during the alcoholic fermentation. The process of preparation involves three distinct reactions.

1. The salt having been boiled with sufficient water, prepared chalk is gradually added, and an *insoluble tartrate of calcium* is formed and precipitated: but tartaric acid is dibasic, and the *neutral tartrate* ($CaC_4H_4O_6$) remains in solution.

$$2(KHC_4H_4O_6) + CaCO_3 = CaC_4H_4O_6 + K_2C_4H_4O_6 + CO_2 + H_2O$$

2. To precipitate this element of tartaric acid also as tartrate of lime, solution of chloride of calcium is added, giving rise to the formation of chloride of potassium, and precipitating the tartrate of calcium.

$$K_2C_4H_4O_6 + CaCl_2 = CaC_4H_4O_6 + 2KCl$$

3. The tartrate of calcium, having been washed, is decomposed by sulphuric acid, which precipitates an insoluble sulphate, tartaric acid being left in solution.

$$CaC_4H_4O_6 + H_2SO_4 = H_2C_4H_4O_6 + CaSO_4$$

CHARACTERS AND TESTS.—Tartaric acid occurs in fine white powder, of strongly acid taste, or in large colourless oblique rhombic prisms, which become luminous in the dark on friction. Whilst dry, these are permanent in air, but an aqueous solution becomes mouldy on keeping, with formation of acetic acid (a change which may be prevented by the addition of some rectified spirit). A usual test for tartaric acid in solution (not too dilute) is the formation of a crystalline white precipitate of tartrate of potassium on the addition of acetate of potassium. Solutions neutralized by an alkali also give with chloride of calcium a white precipitate of tartrate of lime soluble in cold liquor potassæ, but falling again when heated. Tartaric acid may be added to bicarbonate of potassium to saturation without any precipitate, but if

the bicarbonate be added to the acid, bitartrate is at once formed and precipitated.

ABSORPTION AND ELIMINATION.—Tartaric acid, in moderate doses, is readily absorbed, but we do not exactly know what changes it undergoes in the system. That it combines with earthy bases is probable, for Wöhler found it in the urine (by which secretion it is eliminated) in the form of tartrate of calcium. Dragendorff, Buchheim, and Pietrowski found only a small amount in the urine, and conclude that the greater part is oxidized in the body.

PHYSIOLOGICAL ACTION.—*External.*—On the skin, concentrated solutions of tartaric acid produce temporary irritation and burning.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Small doses have a cooling taste and quench thirst, but if continued may irritate the stomach, and large doses cause purging.

Very large quantities have toxic effects, though not of so severe a kind as those of oxalic, or even of citric acid (Husemann). A fatal result is very rare, but Taylor records one in which death followed nine days after taking 1 ounce of tartaric acid in solution: the symptoms and appearances were those of gastro-enteritis. In other cases the mucous membrane of the stomach and the intestines has been found either white (not inflamed) or ecchymosed, with partial softening.

Circulatory System, etc.—Bobrick reported weakening and slowing of the heart's action in frogs, rabbits, and men, after large but non-toxic doses; the vagus nerve was not concerned in this effect. According to Mitscherlich, rabbits die from doses of 3 to 4 dr. with symptoms of adynamia, weakened heart-action, and difficult respiration; the blood is found fluid, in some cases light in others dark red.

Bence Jones found that tartaric acid increased the acidity of the urine, and led to excretion of uric acid in a free state.

SYNERGISTS.—Citric and other vegetable acids.

INCOMPATIBLES.—Alkalies, salts of mercury and lead, and vegetable astringents are incompatible. Lime and magnesia are the best antidotes.

THERAPEUTICAL ACTION.—*External.*—**Fœtid Perspi-**

ration.—Schottin states that tartaric acid relieves this unpleasant condition, and I can corroborate the observation. For the feet it may be used sprinkled in the stockings, or these may be washed in a strong solution. The powder may also be rubbed into the axillæ, with the caution that if irritation be produced it must be replaced by some soothing application.

THERAPEUTICAL ACTION.—*Internal.*—This acid, dissolved and sweetened, is sometimes used as a refrigerant drink; and it exerts a slightly sedative effect on the circulatory system. It is sometimes used in place of citric acid, but is not so pleasant to the taste nor so well borne by the stomach. Of seidlitz powders, the "white paper" contains about 38 to 40 grains of this acid, which when dissolved and mixed with 40 grains of soda bicarbonate and 120 gr. of tartarated soda (the contents of the "blue paper"), forms a sedative, refrigerant, and slightly aperient draught. Annesley considered tartaric acid of service in excessive secretion of mucus by the stomach or intestine. In cases of ammoniacal urine with cystitis from calculi, prostatic disease, etc., I have often found it relieve the symptoms and render the secretion duly acid and clear: full doses of 20 to 40 gr. well diluted should be given three or four times daily for a short time.

PREPARATION AND DOSE.—*Acidum tartaricum:* dose, 10 to 30 gr. or more dissolved in water and sweetened. For effervescent draughts, 20 gr. neutralise 26 gr. of potash bicarbonate, 22 gr. of the soda salt.

ADULTERATIONS.—Oxalic acid and lime, sulphuric acid, cream of tartar, and alum, are sometimes found in samples of tartaric acid; also lead, which may be derived from the vessels in which it is crystallized.

Acidum Arseniosum, Ac. Benzoicum, Ac. Carbolicum, Ac. Gallicum, Ac. Meconicum, Ac. Salicylicum, and Ac. Tannicum are described elsewhere, as they do not owe their actions exclusively to their acid properties.

AMMONIUM (NH_4 = 18).—AMMONIA (NH_3 = 17).

Ammonia exists in the air in minute quantity, about 1 in 1,000,000, in sea-water, many mineral waters, and rain-water; in the soil and in animal excretions, especially the urine. It is a usual product of decomposing nitrogenous matter, and is said to occur free in certain plants, as in the leaves of aconite and the

root of hellebore. The chloride is found native near volcanoes and in many coal mines.

Its salts are commonly obtained from "gas-liquor," a product of the distillation of coal in gas manufacture: when this is neutralized by hydrochloric acid it yields a chloride, NH_4Cl (sal-ammoniac), and from this salt, when purified, are derived all the other ammonium compounds used in medicine.

The hydrogen atoms in ammonium may be replaced by organic radicals giving the class of substances known as amines and amides.

CHARACTERS.—Ammonia itself is a colourless gas, which may be liquefied and is then of bluish colour. It has a pungent odour and alkaline reaction; it forms salts with acids, and as these are very analogous in chemical relations to salts of potassium and sodium, it is believed that they have a metallic base, which is named ammonium, and is the fundamental radical of the series. But while potassium and sodium are *simple*, ammonium is a *compound* body or radical (NH_4).

LIQUOR AMMONIÆ FORTIOR—LIQUOR AMMONIÆ.

These are solutions of ammonia gas in water, the former containing 32·5 per cent., and being about one-third stronger than the simple liquor; they are commonly called "spirits of hartshorn," because formerly prepared by heating scrapings of horns and hides. The liquor ammoniæ (B.P.) contains 10 per cent. by weight of ammonia (NH_3).

PREPARATION.—By heating sal-ammoniac with slaked lime, and distilling, the gas being passed through wash bottles into a receiver containing water.

$$CaH_2O_2 + 2NH_4Cl = CaCl_2 + 2H_2O + 2NH_3$$

CHARACTERS AND TESTS.—The stronger solution is colourless, of sp. gr. ·891, of characteristic pungent odour and alkaline reaction. A piece of moist red litmus paper held in the neck of the bottle is at once turned blue. *The tests for its purity are*—When diluted with four times its volume of water, it gives no colour or precipitate (*a*) with lime water, showing the absence of carbonic acid; or (*b*) with oxalate of ammonium, showing the absence of lime; or (*c*) with sulphide of ammonium, proving its freedom from lead, copper, and other metals; or (*d*) with

ammonio-sulphate of copper, showing its freedom from sulphuretted hydrogen. (*e*) When rendered acid by excess of nitric acid, it gives no precipitate with nitrate of silver or chloride of barium, showing its freedom from chlorides, bromides, iodides, cyanides, phosphates, and sulphates.

Liq. ammon. fort. is contained in spt. ammon. fœtidus, together with assafœtida and rectified spirit.

The properties of *liquor ammoniæ* are similar, but weaker in degree; it is contained in tinct. quininæ ammoniata, and mixed with 3 parts of olive oil it forms linimentum ammoniæ.

COMPOUNDS OF AMMONIUM.

AMMONII CARBONAS—CARBONATE OF AMMONIUM

($N_3H_{11}C_2O_5$ = 157).

This complex substance is a compound of acid carbonate of ammonium (NH_4HCO_3) with carbamate of ammonium ($NH_4NH_2CO_2$) and the compound molecule is generally considered to contain one molecule of each of these salts.

PREPARATION.—By heating a mixture of chalk (carbonate of calcium) and sal-ammoniac (chloride of ammonium), when chloride of calcium and the complex carbonate of ammonium are formed; the latter sublimes, and is then purified by resublimation.

CHARACTERS.—When recent it is in colourless, translucent, crystalline masses, of strong characteristic odour and acrid taste, markedly alkaline in reaction, volatile, soluble in water, less so in spirit, and effervescent with acids. When exposed to the air it gives off ammonia and carbonic acid, loses its odour, and crumbles into an opaque mass of bicarbonate of ammonium. (This is sometimes prescribed as more palatable—it occurs in minute white crystals, solubility 1 in 8.) In consequence of ready decomposition, the aqueous solution of the ordinary salt will contain both neutral and acid carbonates. The neutral salt has not been isolated in the solid state.

SPIRITUS AMMONIÆ AROMATICUS—SAL VOLATILE.

Is prepared with the carbonate of ammonium, the *strong* solution of ammonia, the oils of nutmeg and of lemons, rectified spirit, and water: it is contained in tinct. guaiaci ammoniata, and tinct. valerianæ ammoniata.

AMMONII CHLORIDUM—CHLORIDE OF AMMONIUM—SAL-AMMONIAC.

($NH_4Cl = 53{\cdot}5$).

PREPARATION.—It is generally prepared from gas-liquor, by adding hydrochloric acid to neutralisation, evaporating the liquid, and purifying the crystals by sublimation, or by adding hydrochloric acid to a solution of ammonia.

CHARACTERS AND TESTS.—It occurs in pieces of the hemispherical cakes in which it is sublimed, of translucent fibrous appearance and pungent saline taste without odour. Its ordinary form is difficult to powder. It is soluble in one part of boiling water and three of cold, its solution being attended by reduction of temperature; it is also soluble in rectified spirit. Heated with potash, soda, or lime, it evolves ammonia.

AMMONII BROMIDUM (*v.* Bromine).

LIQUOR AMMONII ACETATIS—SOLUTION OF ACETATE OF AMMONIUM.

Acetate of ammonium ($NH_4C_2H_3O_2 = 77$) dissolved in water.

PREPARATION.—The *liquor ammonii acetatis fortior* of the pharmacopœia is prepared by adding about 45 oz. of acetic acid, or as much as is necessary to neutralise 15½ oz. of carbonate of ammonium, and then sufficient distilled water to yield three pints of product; and the *liquor ammonii acetatis* is prepared from this by adding 5 parts by measure of distilled water to every 1 of the strong solution; this is often called Mindererus spirit.

CHARACTERS AND TESTS.—When pure and fresh, it is a limpid, colourless liquid, without odour and with strong saline taste, but unless carefully kept it soon spoils. (The sp. gr. of the liquor ammonii acetatis *fortior* is 1·073, and of the liquor ammonii acetatis 1·022.) With caustic alkalies it evolves ammonia, and with sulphuric acid, acetic vapours. It must be kept in bottles free from lead.

LIQUOR AMMONII CITRATIS—SOLUTION OF CITRATE OF AMMONIUM.

Citrate of ammonium ($(NH_4)_3C_6H_5O_7 = 243$) dissolved in water.

PREPARATION.—By neutralising a solution of citric acid with strong solution of ammonia. It is a colourless liquid of saline taste.

AMMONII PHOSPHAS—PHOSPHATE OF AMMONIUM

$((NH_4)_2HPO_4 = 132)$.

PREPARATION.—It is prepared by neutralising phosphoric acid with ammonia, the latter being in excess.

CHARACTERS AND TESTS.—The crystals, which are transparent when recent, become opaque on exposure, and part with ammonia and water. They are soluble in water, insoluble in spirit, and their aqueous solution gives a characteristic yellow precipitate with nitrate of silver.

AMMONII BENZOAS—BENZOATE OF AMMONIUM

$(NH_4C_7H_5O_2 = 139)$.

PREPARATION.—It is prepared by dissolving benzoic acid in solution of ammonia, and crystallising.

CHARACTERS AND TESTS.—It occurs in colourless laminar crystals, which are soluble in water and alcohol: they are sublimed by heat. Hydrochloric acid precipitates benzoic acid from the solution, and caustic potash heated with it causes evolution of ammonia. Ferric salts give a yellow precipitate.

AMMONII NITRAS—NITRATE OF AMMONIUM

$(NH_4NO_3 = 80)$.

PREPARATION.—It is prepared by adding ammonia or carbonate of ammonium to nitric acid.

CHARACTERS AND TESTS.—It is a white deliquescent salt, which occurs in confused crystalline masses. It has an acrid taste, is soluble in less than its own weight of water, and is only sparingly soluble in rectified spirit. It is neutral in reaction. Heated with caustic potash, it evolves ammonia; with sulphuric acid, it emits nitric acid vapour. It fuses at 320° F. (160° C.), and at 350° F. to 450° F. (176°-232° C.) it is entirely resolved into nitrous oxide gas, and the vapour of water.

Use.—It is only used for the preparation of nitrous oxide.

AMMONII SULPHIDUM—SULPHIDE OR SULPHYDRATE OF AMMONIUM (APPENDIX II.) TEST SOLUTION

$((NH_4)_2S = 68)$.

PREPARATION.—It is prepared by passing sulphuretted hydrogen into liq. ammoniæ to saturation, and then adding liq. ammoniæ.

$$NH_3 + H_2S = NH_4HS \text{ and}$$
$$NH_4HS + NH_3 = (NH_4)_2S$$

It is a colourless liquid, becoming yellow when kept, of disagreeable taste and fœtid odour. It is incompatible with almost all metallic and acid solutions.

ABSORPTION AND ELIMINATION.—Ammonia and its carbonate are not wholly absorbed as such—a part becomes changed into chloride in the stomach (Rabuteau).

Though Lange did not find ammonia in the air expired by animals taking it (Archiv f. exper. Path. Bd., ii.), other observers have often done so, and Bellini concluded that caustic ammonia and the carbonate, when taken in small doses, were entirely and very quickly *eliminated by the lungs;* of large doses, some passed also by other channels. Whatever salt was taken, carbonate was eliminated by the lungs.

There is sufficient evidence that the carbonate, when taken in moderate or even large doses, is not excreted as such by the kidneys. Rabuteau took 60 gr. daily for five days without finding any in the urine, which continued acid, whereas a mere trace of ammonia added *directly* to the urine suffices to give an alkaline reaction. Dr. Bence Jones had previously pointed out this continued acidity of urine under ammonia, and suggested that the drug becomes so far oxidised in the system as to give rise to nitrous or nitric acid, which appears in that secretion. Only after very large doses (160 gr. daily) *some* carbonate of ammonium is eliminated in the urine, which then becomes alkaline, and deposits ammonio-magnesium phosphate.

Ammonium *chloride* does not readily decompose in the system; it is excreted by the urine and partly by the saliva (Rabuteau); a small quantity passes out by the skin.

As a result of more recent researches, it has been shown that ammonia administered in the form of carbonate or organic salts is converted in the body chiefly into urea, and that only a small portion can be excreted unchanged. Ammonium chloride, owing to its strong chemical combination, is excreted in the urine of carnivora for the most part unchanged, whereas, in herbivora, it also is converted into urea (Knieriem, Salkowski, Schmiedeberg, Corandra, v. Schroeder).

Frerichs taught that in uræmia an unusual amount of ammonium carbonate (arising from decomposition of urea) circulated in the blood and was excreted by the lungs, but although such an

excess may be present, ammonia is not now regarded as the cause of uræmia. Sir B. W. Richardson has pointed out that during an *actual attack* of uræmic convulsion, the amount of ammonia excreted is less than at other times, on account of the retention of urea in the system. Gull found ammonia when the albumen in the urine was not large in amount. Uræmic coma is, however, connected with the circulation of urea, or more probably some of its antecedents, rather than of ammonia.

PHYSIOLOGICAL ACTION.—*External.*—The vapour of carbonate of ammonium (smelling salts) is stimulant and slightly irritant, that of the strong ammonia is intensely irritant to the whole of the air-passages and conjunctivæ, and has even caused fatal bronchitis. Liquid ammonia is also a strong local irritant; diluted with oil it is "rubefacient," but applied in strength, and when evaporation is prevented, it vesicates, and if injected under the skin causes severe sloughing. Oertel reported that the direct application of liquor ammoniæ to the air-passages caused a membranous effusion similar to that of croup; but careful observations by Meyer on the same point verified only a local catarrhal inflammation and hæmorrhage (B. M. J., ii., 1874). Ammoniacal urine commonly irritates the bladder.

Ammonia has marked antiseptic powers: 1 dr. of liq. ammon. fort. on lint under a bell-jar preserves morbid specimens, and the same quantity with water preserves them better than spirit. A solution of 2—10 per cent. of carbonate was found to delay decomposition and to kill organisms, though a less proportion rather favoured their growth (B. M. J., i., 1889).

PHYSIOLOGICAL ACTION.—*Internal.*—**Circulatory System.**—Medicinal doses of ammonia and its compounds quicken the heart's action and capillary circulation, but only for a comparatively short time: such stimulation is not always marked in healthy persons—it is more evident in the weak and in invalids: there is increased sense of warmth, the face becomes flushed, the eyes more brilliant, and the mental condition stimulated. This effect is partially due to the rise of blood pressure which ammonia brings about. Dr. E. P. Brewer concludes that the stimulant properties of carbonate of ammonium are due to the liberation of ammonia when the salt comes in contact with the hydrochloric

acid of the gastric juice; it is the most useful salt, as it is most easily decomposed in this way (Pract. i. 1883).

Ten drops of the liquor, diluted with 1 or 2 oz. of warm water and *injected into a vein*, excite the heart so powerfully as to rouse a patient from a state of collapse (Med. Times, ii., 1872). Larger quantities—30 drops—given in the same manner, after a momentary arrest, stimulate intensely, and may induce convulsions: still larger quantities cause momentary fall of arterial pressure, then sudden and enormous rise, with corresponding increase of pulse-rate: this result occurs equally after division of the cord, hence it is not due to stimulation of the vaso-motor centre, but of the accelerator nerves of the heart (Lange).

On the other hand, according to Rabuteau, 40 gr. of *carbonate* dissolved and *injected into a vein* weaken the cardiac contractions and render them irregular, whilst 60 gr. cause a sudden arrest of the circulation, the heart-muscle being paralysed.

Drs. Ringer and Sainsbury have contrasted the action of salts of ammonium with that of potassium and sodium salts on the frog's heart, and they find: (1) That potassium salts are the most poisonous, both excitability and contractility being powerfully affected; (2) that ammonium salts come next, the excitability of the heart not being affected, but contractility powerfully so; (3) sodium salts affect excitability slightly, and contractility to a rather greater extent (Lancet, i., 1882).

The corpuscles are altered by toxic doses; they cease to contain the normal quantity of oxygen, and do not absorb it even when shaken up with the gas (Feltz and Ritter).

The continued use of ammonium salts causes similar toxic effects; the pulse becomes very feeble, and the corpuscles pale and wasted, as after typhoid fever; this is but the recognised effect of all alkalies. These results are reported by Cazenave (Bull. de Thérap., t. xxxi.), yet Pereira has given 15 gr. thrice daily for two months without apparent injury, and often a scruple thrice daily for two or three weeks, and in one case Dr. Lionel Beale gave 55 gr. daily for a year (Lancet, ii., 1884).

Ammonia or the carbonate added to blood outside the body renders or keeps it fluid, and when given internally exerts an influence in the same direction; Sir B. W. Richardson even thinks they have sometimes caused disintegration of clot already formed

in the vessels (*v.* p. 375). Coagulation of blood is not, however, due to escape of ammonia, as thought probable at one time, nor will ammonia always or wholly prevent it. A difference in *time* of coagulation was the only difference observed by Rabuteau in experiments on dogs, for whilst coagulation of their blood usually occurs in two minutes after withdrawal, it occurred only in ten minutes when 60 gr. of ammonium carbonate had been injected: the clot, however, was firm and resistant.

Chloride of ammonium delays coagulation of the blood, and when added to it with access of air renders or keeps it red, as do other chlorides.

Nervous System.—Ammonium salts in medicinal doses stimulate the general nervous system, but the special effect of large doses is exerted on the motor tract of the spinal cord, which is stimulated much in the same manner as by strychnine. Convulsions are produced, especially by strong intravenous injection, and as these occur equally when communication with the brain is severed, they are not cerebral in origin (Lange): neither do they start in the peripheral nerves, for they take place if the blood be cut off from these nerves by ligature (Funke): we conclude them, therefore, to be of spinal origin (Pflüger's Archiv, Bd. ix.), and section of the nerve-trunk of a limb stops their occurrence in that limb. Prostration follows the convulsive seizure, and a partial paralysis of the hinder limbs of animals (Comptes Rendus, Soc. Biol., 1873). Spiegelberg made certain experiments in order to test the opinion of Frerichs that the convulsions of albuminuria were due to the circulation of ammonium carbonate, and when he had injected as much as 6 gr. of that salt into the veins of a dog, general convulsions occurred with clonic spasm and trismus, the pupil was dilated, general sensibility was reduced, and coma set in; after an hour and a half, free salivation and urination took place, and the animal recovered, remaining stupid for some time: larger doses caused vomiting, afterwards tetanus and coma; the vessels were found full of dark fluid blood (Lancet, ii., 1870). It is probable that ammonia is a direct and intense *stimulant of the respiratory centres* in the medulla.

The effect of ammonia on the blood pressure when applied to the nose is a reflex one, for it stimulates the nasal branches of the fifth nerve, and thus reflexly excites the vaso-motor centre; it

has much more effect on this than on the higher centres, differing in this respect from alcohol.

The full effects of *chloride of ammonium* are not often exemplified, but in the case of a lunatic who swallowed a large (unknown) quantity, there were vomiting, giddiness, shivering, depression, delirium, convulsion, and later collapse so complete as to simulate death: recovery was effected with galvanic and other powerful stimuli, and then tetanic spasms came on (Sir J. C. Browne, Lancet, i., 1868). This salt has a paralysing effect on the muscles, which modifies the tetanus caused by other ammonium compounds. Temperature is raised under the physiological action of the chloride; lowered under that of the other salts.

Digestive System.—Ammonia and the carbonate have a direct antacid effect on the gastric secretions, and moderate doses induce a sense of warmth and stimulation at the epigastrium. More than 5 gr. is likely to irritate; 10 gr. will commonly nauseate, and 20 gr. will usually produce vomiting. Intestinal catarrh is sometimes observed from continued medicinal doses, which also are apt to impair digestion by neutralising the gastric juice. Liquid ammonia, when swallowed, acts as an irritant poison, and in fatal cases has caused inflammation and erosion of the upper part of the alimentary tract: occasionally it has acted upon the larynx, and induced rapidly fatal œdema glottidis. Death has been caused by 2 dr. of the strong solution; in other cases by 1 oz. and ½ pint (B. M. J., i.-ii., 1878).

Secretion and Excretion.—Medicinal doses of ammonia, under favourable conditions of warmth, etc., increase most of the secretions, such as those of the skin, the kidneys, and the bronchial and intestinal mucous membranes. The liquor ammonii acetatis has a special action on the skin and kidneys, the carbonate on the lungs, the chloride on the liver and kidneys. The pulmonary secretions and the bile are also rendered more fluid, ammonium chloride especially stimulates the latter secretion. The alkaline salts of ammonia are not "remote antacids," *i.e.*, they do not render the urine alkaline, because they are excreted as urea.

Influence on Nutrition.—Although ammonia is seldom taken long enough in medical practice to directly affect nutrition,

there is evidence that its continued use will produce debilitating effects like other alkalies—as indeed might be expected from its influence on the blood. Cazenave has reported pallor, anorexia, debility, and emaciation; and Huxham, a case in which hectic, hæmorrhage, and general marasmus followed upon the habitual eating of ammonium carbonate (Essay on Fevers). Richardson maintains that ammonia suspends oxidation, checks formation of all downward products of albumen, and retards nutrition (Med. Times, i., 1862, ii., 1866). Under the *chloride*, however, urea is distinctly increased, and oxidation of tissue rendered more active.

The iodide and bromide of ammonium exert the absorbent and sedative effects of alkaline bromides generally; if anything, they are more active and less depressing than the corresponding salts of sodium and potassium.

SYNERGISTS.—Diffusible stimulants, heat, and, according to Gubler, opium and iodine. Both Gull and Paget have pointed out that ammonia aids the action of iodide of potassium, and it has been asserted that 5 gr. of the latter with 3 gr. of ammon. carb. is equivalent to 8 gr. of the iodide alone (B. M. J., i., 1874). Volatile ammonia assists also the action of anti-spasmodics, such as valerian; other alkalies and bases assist its antacid power.

ANTAGONISTS — INCOMPATIBLES. — Cold, emollient drinks, quinine, and tannin, interfere with the action of ammonia, and are "dynamic antidotes" (Gubler).

Incompatibles are acids and fixed alkalies, salts of iron (except the tartarated iron), calomel, lead salts, etc. Freely diluted, ammonia and its carbonate may be used as antidotes to mineral acids. Christison, Pereira, and others, consider them also antidotal to prussic acid: they certainly have dynamic effects, opposite in character to those of the acid, though they do not chemically neutralise it: they antagonize also the toxic effects of alcohol, and in some degree those of animal poisons.

THERAPEUTICAL ACTION.—*External.*—**Neuralgia—Rheumatism, etc.**—The strong liquor ammoniæ has been used as a counter-irritant, or a rapid vesicant, in cases of muscular, neuralgic, and rheumatic pain, and to relieve deeper-seated inflammation, for instance, of the tonsil and fauces, by derivation to the skin. For such purposes the ammonia liniment may be rubbed

in, or if vesication be necessary, it may be secured in the course of five minutes by the strong liquor applied on lint. Dr. Waring recommends, as a simple method, to fill the lid of a wooden pill-box with circular pieces of lint to above the rim, saturate them with the liquid and invert over the part. M. Gondret introduced a vesicating ointment made with ammonia and one-fourth part of lard and olive oil, and it is commonly used in France. M. Ducros advised painting the liquor over the palate and gums for relief of tic.

Falling off of the Hair.—The stimulating properties of ammonia are highly useful in promoting growth of hair when it has been thinned by debility or illness. Half an ounce of the strong liquor with almond oil, rosemary spirit, and honey-water to about 6 oz. is a good proportion.

Amenorrhœa—Pruritus.—In cases of chlorotic amenorrhœa, a stimulating vaginal injection of about 1 dr. of liq. ammoniæ to a pint of warm milk has been found useful by Dr. Ashwell, and I have frequently ordered it with advantage, the breasts being stimulated at the same time by friction with weak ammonia liniment. Dr. Dewees has recorded the cure of an obstinate case of pruritus pudendi by a similar injection. In cases of amenorrhœa general tonic treatment must also be employed.

Local Inflammations. — Lotions containing ammonium chloride are very useful in inflammatory swellings of muscles, joints, lymphatic and other glands, and sometimes in the hydroceles of children—2 dr. may be used to 4 or 6 oz. of spirit and water.

In *orchitis* and in cases of *engorgement* of the breasts with milk the same application is cooling and absorbent. Guéneau de Mussy recommends for the latter cases an ointment containing 5 parts of the chloride mixed with 1 of camphor and 30 of lard, to be used frequently. It is said that threatening abscess may be aborted by the continued application of compresses wet with spirit of rosemary containing about 1 dr. of the salt to the pint, and if an abscess has formed of indolent character, such as bubo often is, it may be stimulated to heal by the injection of sal-ammoniac solution after withdrawal of some pus (Ranking, i., 1871).

Acne.—In chronic cases of acne simplex with comedones, a lotion containing the chloride with alum and sulphuret of potash is sometimes an effective resource.

Stings—Snake-Bite.—Dilute liquor ammoniæ relieves the pain that follows the sting of venomous insects, wasps, etc. ; it should be freely rubbed into the part, and given internally if there be tendency to collapse.

Professor Halford (Melbourne) has strongly advocated *intravenous injection* of ammonia in snake-bite, using 15 to 30 min. of the liquor, diluted with 3 or 4 parts of water, both as antidotal to the poison, and as a general stimulant. Many cases have recovered under this treatment, but there is yet much doubt as to how far it may be depended upon ; in some of them it is probable that the bites were not of fatal character, and when experiments were repeated with more accuracy, ammonia (injected by Professor Halford) did not avert a fatal result (Med. Times, ii., 1876). It has also been found powerless against the bite of Indian snakes (Cobra, Daboia), which are more poisonous than those of Australia ; in some cases death followed even more quickly than usual after the injection (Report of Commission).

The intravenous injection of liquor ammoniæ is a subject of much importance, and one that deserves more general attention than has yet been given to it ; it is not free from risk and danger, especially if the large dose of 30 min. be used, but in suitable quantity it has powerfully stimulated the heart, and revived cases apparently in articulo mortis (*v.* p. 368). In a severe case of coma, cyanosis, etc., due to sewer gas poisoning, 35 min. of the strong liquor ammoniæ (by mistake for the weaker form) were injected, undiluted, several times into a superficial vein in the arm, not only without injury, but with the best effects ; it was presumed that clot had formed in the heart-cavities (Eskridge, Record, 1883).

Shock and Collapse from Injury, etc.—Cases of fracture and laceration accompanied with collapse and treated by injections of ammonia have been recorded. In one man, 40 drops with 2 oz. of warm water were passed into one of the veins of the arm, and after temporary arrest of breathing, a violent convulsion occurred ; but on subsidence of this, general stimulation was evident, and he rallied for several hours. In a second case, 30 drops were injected, with a somewhat similar result ; in the third patient, when only 10 drops were given, pulse and respiration were at once restored, vomiting occurred, and recovery followed (Med. Times, ii., 1872).

Recovery, though only temporary, followed similar injections (5 to 8 m. of liquor ammon. fort, undiluted, into the median vein) given during collapse in severe *scarlet fever* (B. M. J., i., 1877), and in the same condition, occurring during *puerperal fever*, Tyler Smith injected 30 min. with 3 parts of water, and ultimate recovery followed; but two cases thus treated by Sir Spencer Wells proved unsuccessful (B. M. J., ii., 1869).

Anthrax.—Dr. L. Avendano of Peru regards ammonia as a specific in this disease. If the case is seen early, the pustule is incised, and a drop of liquor ammoniæ introduced into it: this apparently acts by killing the bacilli. Some ammoniacal salt, such as the acetate, is also given internally. He records cases of persons who were moribund in the later stages of the disease and were cured by intravenous injections of ammonia (Lancet, i., 1886).

Narcosis.—Neild injected 30 drops of ammonia into the median cephalic vein on four separate occasions in a patient fatally narcotised by *chloroform;* temporary recovery occurred each time (Med. Times, i., 1871). In a case of *opium*-poisoning, when 40 gr. had been taken, and death was imminent, revival, though only for a time, also followed directly on ammonia-injection (B. M. J., ii., 1872). Mr. Richards has specially drawn attention to the value of ammonia-injections in *alcoholic coma*, and has shown that some of Dr. Halford's patients who had much brandy (one got a bottle and a half in three hours) were really more comatose from the alcohol than from the bite, and hence their recovery; he remarks on the importance of a slow injection, and recommends 10-min. doses (Lancet, i., 1880).

Exhaustion.—In a case where extreme exhaustion was consequent on prolonged suppuration, 15 min. (undiluted) were injected into a vein, and again eight hours afterwards with permanent good result (B. M. J., i., 1877); some of the caustic entered the cellular tissue, and caused local sloughing, and in other cases, where injection has been made purposely into this tissue, serious ulceration and abscess have followed (Med. Times and Lancet, i., 1870). 1 part in 2 of water is a safer injection.

THERAPEUTICAL ACTION.—*Internal.*—**Exhaustion—Alcoholism, etc.**—One of the most frequent uses of ammonia, and one which it commonly serves very well given by the mouth in the ordinary manner, is to quicken the general circulation and

to revive failing cardiac action in cases of exhaustion and threatened syncope from almost any cause; being volatile, it diffuses and acts rapidly. The vapour of the carbonate, as disengaged from "smelling salts," is sometimes usefully given by inhalation in the same class of cases, and the vapour of liquor ammoniæ has been utilised in partial asphyxia, and in the semi-coma of drunkenness. In several extreme cases of alcoholism, wherein relapses were frequent, I have known the aromatic spirit of ammonia in drachm-doses every hour or two "steady" the patient very markedly: it has acted better than, *e.g.*, vinegar, which seemed to increase congestion of the liver and give only temporary relief to symptoms. The depression and dyspepsia which commonly follow excessive use of alcohol are also well treated by ammonium compounds, especially if combined with valerian; in the prostration of delirium tremens, the same remedies arevery useful.

Thrombosis—Embolism.—Rapid separation of fibrin in the cavities of the heart seems to occur previous to death in many acute exhausting diseases, such as pneumonia, croup, peritonitis, etc., and after prolonged or difficult parturition. Sir B. W. Richardson states that advantage may be derived in such apparently hopeless conditions from the internal use of liquor ammoniæ ɱx. every hour, alternately with iodide of potassium (Ranking, ii., 1872). The late Dr. Shepherd Fletcher has reported a well-marked case of embolism occurring in a puerperal woman and recovering under 5-gr. doses of ammonium carbonate given every hour (B. M. J., i., 1864), and Dr. Philipson has recorded another illustration of the same character (*Ib.*, 1865). More recently, Sir B. W. Richardson has written to point out distinctive signs of the separation of fibrinous coagula in the large thoracic vessels—*e.g.*, dyspnœa with open air-passages, fulness of the jugular veins, feeble pulse with tumultuous action of the heart, and weakened first sound: for such conditions he strongly advises the persistent administration of ammonia, not so much as a stimulant, but as a solvent of blood-clot, and preventive of putrefaction (Lancet, i., 1875). I cannot, however, yet adopt so sanguine a view of this medication.

Pyrexia.—In acute pyrexial and inflammatory conditions, solutions of acetate and citrate of ammonium relieve many of the symptoms by promoting secretion from the skin and kidneys.

Typhus and Typhoid Fever.—In adynamic stages of these fevers, ammonia has often been used, but not always with advantage; thus Stillé reports its failure, though largely given during an epidemic of typhus at Philadelphia. There is reason to believe that the amount of ammonia circulating in the blood is unduly increased in these maladies, and this would be a reason against using it: certainly its administration is very distasteful to the patients.

Scarlatina.—On the other hand, there is much clinical evidence of the value of ammonia in this fever. De Witt, Peart (1802), Wilkinson, and Strahl have written specially in its praise, and many illustrations of its value have been given by Hillier, Langdon Down, and others (Lancet, 1860-64-70, Med. Times, 1858-62-73, and Lond. Hosp. Reports, vol. i.). From 3 to 6 gr. of carbonate, freely diluted are to be given every one or two hours, until improvement occurs: it determines to the skin, and perhaps thus hastens elimination of the poison. I have found it especially useful in cases accompanied by malignant sore throat. Dr. Down refers to 192 cases occurring in one epidemic at Earlswood asylum; 78 had severe angina, and 49 were malignant cases: all received 5 gr. of the carbonate every four hours, and were otherwise treated alike: alcoholic stimulants were used in moderation. Ten only, of whom seven were tuberculous, died; and considering the low resisting power of imbeciles this result is good. He considered the remedy diminished febrile excitement and calmed the nervous system: it was taken readily without pain to the throat.

Dr. A. D. MacDonald gives benzoate of ammonium in scarlatina, on the principle that it is a powerful antiseptic, and finds it better than the internal administration of carbolic acid. The dose is 15 gr. for an adult every three or four hours, combined or not with liquor ammonii acetatis; the dose for children would be less. He relates cases of malignant scarlet fever successfully treated by this method (B. M. J., i., 1883).

Ague.—Dr. D. Young has recorded cases in which patients intolerant of quinine are enabled to take it and experience its benefits, when it is administered with 12 gr. of ammonium chloride to each gr. of quinine sulphate. In many cases, however, he has found that salts of sodium or potassium will

act equally as well in this direction as ammonium chloride (Pract., ii., 1883).

Chest-Diseases.—In acute stages of pneumonia, bronchitis, or pleurisy, the acetate or citrate of ammonium is often serviceable. In asthenic cases, the later chronic conditions of bronchitis, and in senile catarrh, the carbonate and liquor are good stimulant expectorants; being eliminated in part by the pulmonary membrane, they modify its condition and thin the secretion. Ammonium chloride is also valuable in such conditions, and in asthenic cases of congestion of the lungs: it may at first increase pyrexia, but generally facilitates the expectoration, "softens the cough," and improves the appetite. Dr. Patton has written to commend the carbonate in acute pneumonia, and the chloride in later stages (Pract. vol. vi.).

In the bronchitis of measles, and of rachitis, ammonia is commonly and advantageously used—Sir W. Jenner, indeed, speaks of it as *the* remedy in the pulmonary affections of the latter malady, which are generally asthenic and tend to collapse (Med. Times, i., 1860). On the other hand, Dr. Eustace Smith maintains that if too early given to children with bronchitis, especially the capillary form, it may determine even a fatal issue by increasing congestion and irritation of the mucous membrane.

Croup.—In the later stages, when the membrane is more or less loosened and secretion free, and perhaps capillary bronchitis is present, carbonate of ammonia may prove a useful stimulant, expectorant or emetic.

Pertussis.—I have seen relief given to the cough in later stages by inhalation of ammonia vapour, and Mr. Grantham has devised a simple method of effecting this by adding 1 oz. of the liquor to 1 gallon of boiling water in a bucket or bath, and then putting in a red-hot brick (B. M. J., ii., 1871). The atmosphere of gas-works has often relieved chronic cases, a good effect which has been traced to the volatile sulphide of ammonium.

Bronchial Catarrh—Hoarseness.—The chloride of ammonium in vapour deserves trial in obstinate cases of this kind, and Dr. H. Beigel introduced an arrangement of three bottles, one containing liquor ammoniæ, another hydrochloric acid, and a third "wash-bottle" with water, through which air impreg-

nated with the vapour was drawn for inhalation (Lancet, ii., 1867). Liebermann has suggested another form of apparatus for inhaling it (Bull. de Thérap., 1873), and a number of forms are now obtainable.

The bromide is of service in capillary bronchitis (Bartholow), in pertussis, and other spasmodic coughs.

The chloride in lozenge and vapour has also been advised for hoarseness and granular sore throat, but the stimulus sometimes aggravates the symptoms at first.

Nerve-Diseases—Migraine.—The acetate of ammonium in 1 to 2-dr. doses will often relieve sick-headache. The chloride, in 10 to 20-gr. doses, is indicated in bilious and nervous forms occurring in the young, and in delicate, overworked women,—"it stimulates the sensory nerves, and regulates the vaso-motors" (Anstie, Pract., vol. i.).

In headache connected with menorrhagia it is said to be more useful than in that connected with irregular or suppressed menstruation (Barallier, Bull. de Thérap., 1859).

Neuralgia.—In true neuralgia, the chloride is often of great value, as Dr. Clifford Allbutt states after observation of fifty cases (Med.-Chir. Rev., Jan., 1872): it is, however, very nauseous to some patients.

In tic-douloureux, or facial neuralgia, especially if there be a marked rheumatic element and the lower jaw be affected, ½-dr. doses of chloride should be given at short intervals, for four doses: relief will probably have then set in if this remedy is going to benefit (Watson, Lectures, vol. i.). In cases accompanied with heat and swelling, Brenchley recorded marked relief to pain, and lowering of temperature under this treatment (Ranking, ii., 1858).

In *hemicrania* from nervous-prostration it is often curative (Med. Times, i., 1875), and in *sciatica* I have found either the carbonate or chloride valuable more or less permanently, if the pain is worst when the patient is in the standing or sitting posture. In the *intercostal* neuralgia of anæmic or suckling women, in *hepatalgia*, and in *ovarian* neuralgia, Dr. Anstie also reported much benefit from the chloride; and of the latter malady Dr. W. Curran has reported six severe cases marked by acute pain, pyrexia, vomiting, etc., occurring mostly at a period, an

accompanied with fulness over the region of the ovary, all much relieved by the chloride in 15-gr. doses, which were given, however, with 5 min. of aconite (Ranking, ii., 1868).

Myalgia.—For this variety of pain, Dr. Anstie affirms "nothing in the whole list of remedies comes near the chloride in efficiency," and H. Jones speaks of its power in muscular rheumatism "as remarkable and positive" (Lancet, ii., 1859).

Dysmenorrhœa.—The acetate of ammonium will often relieve the pain of congestive dysmenorrhœa. I have frequently prescribed it with success, especially if there be a sub-inflammatory or turgescent state of mucous membrane, or when suppression has occurred from cold, shock, or fatigue (B. M. J., i., 1878).

Uterine Disorder, etc.—The chloride has often produced good results in amenorrhœa (Cholmeley, Practitioner, vol. ii.), and Dr. Anstie advised it in cases marked by general feebleness rather than by anæmia. Dr. Atlee states that the salt has in his practice caused the diminution of fibroid tumours (B. M. J., i., 1868). This observation may be compared with that of Dr. Rae, who asserts that the same salt is valuable in goître and glandular enlargements (Ranking, ii., 1858), but there is not much evidence on these points.

Hysteria.—Ammonia relieves several of the symptoms of this disorder, such as the lassitude and tendency to fainting, and the flatulent distension of the stomach. The aromatic spirit is a good preparation in common use. The liquor with asafœtida or valerian is still more effective, but nauseous; it has some power in staying convulsive attacks of hysterical character.

Epilepsy.—Dr. Radclife concluded that in epilepsy the chloride of ammonium acts like the bicarbonate and iodide of potassium, instead of which he often gave it; also, in combination with potassium bromide, in several cases it enhanced the value of that drug in epilepsy (Pract., i., 1883).

Dyspepsia—Acidity, etc.—In cases where flatulence with acidity are marked symptoms, ammonia will relieve by its alkalinity and by stimulating the stomach to contract and expel flatus; it is usefully combined with other remedies—the carbonate or aromatic spirit with soda or bitters. The chloride with hydrochloric acid relieves in some cases when the tongue is furred and the biliary secretion deficient (B. M. J., i., 1875). For gastric

and intestinal catarrh, also, it is commonly given in Germany—not so in England.

Gout.—Dr. P. Heron Watson has found liquor ammoniæ fortior in 10—15 minims, in a tumbler of water three times daily, a most effective remedy in gout. Chloride of ammonium in full doses is often useful.

Hepatic Disorders.—In various forms of hepatic disorder accompanied with congestion, ammonium chloride is a valuable remedy, perhaps not yet sufficiently known in this country. Dr. Murchison recommended it in "functional liver-disorder" accompanied with lithæmia, and Dr. Anstie in suppression of biliary secretion consequent on nervous shock. It is much used abroad in catarrh of the bile-ducts, and in the jaundice dependent on this condition; also in hepatic dropsy; but perhaps its best effects are seen in passive hepatic congestion when there is deficient intestinal secretion with loaded urine, constipation, coated tongue, and general "bilious" condition. As already stated, the chloride stimulates a due secretion of bile, increases the excretion of urea and the formation of glycogen. Dr. Stewart has especially drawn attention to the value of this remedy in *hepatitis*, and even *hepatic abscess*, and has found it act better in acute than in chronic stages of these maladies. If the skin be dry he orders first the acetate of ammonium and afterwards 20 gr. of the chloride every four or six hours: a feeling of warmth and exhilaration is produced, hepatic pain is quickly and markedly relieved, perspiration and urine are freely secreted, and sleep commonly follows (Lancet, 1870; B. M. J., ii., 1878).

Hæmorrhage.—In hæmorrhage of different kinds, usually passive in character, the chloride is praised by Copland, who gave it with hydrochloric acid. It is not much used, but Warburton Begbie has seen good results from doses of 20 gr. in hæmaturia: in the illustrative case recorded by him there was no definite cause for the malady (Lancet, ii., 1875).

Urinary Disorder.—In acute *albuminuria* the liquor ammonii acetatis is often useful, as first noticed by Addison (Lancet, ii., 1855), and in *diabetes*, Barlow, Golding-Bird, and Bouchardat, specially valued the carbonate as being a stimulant and a nitrogenous substance (Guy's Reports, vol. v., etc.). Basham recommended the phosphate to be given with the carbonate and lemon-

juice (B. M. J., i., 1869). Prout also thought the citrate serviceable, but rather as a diaphoretic than as possessing specific powers. The sulphide has been recommended to lessen morbid appetite in diabetes, but it does not diminish the excretion of sugar (Garrod), and ammoniacal salts have not retained their reputation in this serious malady.

Diabetes.—Adamkiewicz has published certain facts which relate to the action of ammonium chloride in healthy and diabetic persons (Virchow's Archiv, Bd., 76, 1879). He states that in healthy persons (1) the salt is decomposed in the intestine, the ammonia is reabsorbed and appears in the urine as urea; (2) it acts like sodium chloride in being dehydrated in the tissues and favouring the decomposition of albumen. In diabetes he finds (1) ammonia is quickly metabolised and its assimilation coincides with the metabolism of sugar, so that in slight cases the sugar may disappear from the urine during its administration. (2) So long as the sugar is not completely metabolised, the urea and water do not increase, but as soon as the sugar disappears, the urea and water begin to increase in amount.

In Vesical Catarrh and Prostatitis, the chloride has proved useful, and in a case of irritable bladder, with pale urine of low specific gravity, and deficient in urea, much relief was apparently given by the citrate; the excretion of urea was at once increased under its use (Med. Times, ii., 1863). The benzoate of ammonium is valuable in chronic catarrhal cystitis, with phosphatic deposit; also in scarlatinal dropsy (Lancet, ii., 1861; Med. Times, 1864).

PREPARATIONS AND DOSE.—*Liquor ammoniæ fortior:* dose, 3 to 10 min. well diluted (seldom used internally). *Liquor ammoniæ:* dose, 10 to 30 min. well diluted. *Spiritus ammoniæ fœtidus:* dose, 30 to 60 min. *Ammonii carbonas:* dose, 3 to 10 gr. or more as a stimulant; 30 gr. as an emetic. *Spiritus ammoniæ aromaticus* (sal-volatile): dose, 15 to 60 min. *Ammonii chloridum* (sal-ammoniac): dose, 5 to 20 gr. or more. *Ammonii bromidum:* dose, 2 to 20 gr. *Ammonii iodidum* (non-off.): dose, 1 gr. and upwards. *Liquor ammonii acetatis fortior:* dose, 25 to 75 min. *Liquor ammonii acetatis* (spirit of Mindererus): dose, 2 to 6 dr. diluted freely. *Liquor ammonii citratis fortior:* dose, ½ to 1½ dr. *Liquor ammonii citratis:* dose, 2 to 6 dr. *Ammonii benzoas:* dose, 10 to 20 gr. *Ammonii sulphidum* (in solution): dose, 3 min. and upwards (sèldom used: dangerous if incautiously given). *Ammonii nitras:* used only for making nitrous oxide. *Ammonii phosphas:* dose, 5 to 20 gr. freely diluted. *Linimentum ammoniæ* (with olive oil), for external use. *Compound camphor liniment* also contains ammonia solution.

METALLIC PREPARATIONS.

ALUMINIUM (Al = 27·5).

This metal has not been found native, but *alumina*, its oxide, Al_2O_3 (known also as argillaceous earth), is widely diffused as a silicate in clay, slate, granite, etc., and occurs nearly pure in the sapphire and ruby. The metal itself is of steel-grey colour and is not readily oxidised: specific gravity, 2·67. Aluminium, owing to its lightness, has been proposed as a material for surgical instruments, for cooking and drinking vessels for military use. Experiments carried out for the German army authorities have shown however that it is unsuitable, as it is readily acted on by coffee, carbolic acid, salicylic acid, wines, and even pure alcohol (B. M. J., i., 1892).

Alumen, the official alum, is either the double sulphate of aluminium and ammonium, or of aluminium and potassium; in each case the salt contains a large amount of water of crystallisation. The formula for potassium alum is $Al_2\,3SO_4\,K_2SO_4\,24H_2O$; and that for ammonium alum is $Al_2\,3SO_4\,(NH_4)_2\,SO_4\,24H_2O$. It occurs native sometimes in mineral waters, and in efflorescence on stone. (There are many similar "alums," or double sulphates of an alkaline base and a metal, as sodium-alum, etc.; the same name is applied even when no alumina is present, as to the double sulphate of iron and ammonia—iron-alum—and to similar compounds of manganese and chromium.)

Preparation.—The official alum is prepared by oxidation of aluminous schist, sulphates of alumina and iron being formed, then dissolved in water, and treated by sulphate or chloride of ammonium, or potassium; on concentrating the solution, alum crystallises out.

Characters and Tests.—Alum crystallises in regular octahedral, sometimes in cubical forms, but is generally met with

in irregular lumps, translucent and colourless when fresh, efflorescent and covered with small crystals after exposure. It has an acid reaction and a strongly astringent, subacid taste; is insoluble in alcohol, soluble in about ten parts of cold, and half its weight of boiling water. Heated, it dissolves in its water of crystallisation, and when this has been driven off, potassium alum remains as a dry, white, spongy mass (*alumen exsiccatum* vel *ustum*—dried, or burnt alum). This has very astringent, somewhat caustic properties; it readily absorbs moisture, but is sparingly soluble: heated beyond 400° F. it is decomposed, and alumina, the oxide, Al_2O_3, remains. This oxide is insoluble in water, and when alum solutions are decomposed, separates as a precipitate; hence the use of alum for clearing turbid water, for when it is added, the alkaline and earthly salts present in the water combine with the sulphuric acid of the alum, and the alumina which is precipitated carries with it most of the impurities present: it has also disinfecting powers.

The *acetate* of aluminium (argilla acetica), the *chloride* (aluminii chloridum), and the *single sulphate* (argilla sulphurica), though not official, are in occasional use; they are all soluble salts, of characteristic styptic taste. The *chloride* is a white, amorphous, deliquescent powder. The *sulphate* has been found native, though not quite pure; it is more acid than the ordinary double sulphate, so that it blunts steel instruments, and corrodes linen. *Alumnol* is a combination of alum with sulpho-naphtholic acid, and is a fine whitish-grey powder, soluble in water, glycerine and alcohol, but sparingly so in ether: it contains 25 per cent. of alumina, and is odourless, antiseptic, and astringent.

1. Sulphide of ammonium, when added to solution of the salts of aluminium, gives a white gelatinous precipitate of hydrated oxide of aluminium. 2. The caustic alkalies and their carbonates give a white precipitate with aluminium salts, soluble in excess of the former. 3. Solutions of the aluminium salts should not give a blue colour on the addition of ferrocyanide and ferricyanide of potassium, showing freedom from iron. 4. Ammonia-alum, when heated with caustic soda or potash, evolves ammonia.

ABSORPTION AND ELIMINATION.—Taken into the mouth, alum exerts the local action presently to be described, and its first sweetish taste is followed by a feeling of constric-

tion, and an abundant flow of saliva: after reaching the stomach, combined with albumen some of it becomes absorbed though slowly. Orfila detected it in the urine and viscera of dogs after large doses (Annales d'Hygiène, i.), and Krauss found the urine become very acid under its use. The greater part of the alum taken combines to form insoluble compounds with the bile, and other organic products, and is eliminated with the fæces. It is remarkable, that although alumina is so common a constituent of vegetable food, it is not found in the human organism, showing how completely it passes out.

PHYSIOLOGICAL ACTION.—*External.*—Alum acts as a typical simple astringent, contracting the arterioles and muscular fibres of the part touched by it, and rendering the surface pale and dry. It combines with albumin in the secretions, forming whitish flakes or membranous films insoluble in water, but soluble in acetic and hydrochloric acids (Mitscherlich). If there be not enough fluid present to saturate the alum, it affects the deeper tissues in a somewhat caustic manner: this is especially the case with the dried salt. Strong or long-continued applications excite irritation with some degree of inflammation, and under such circumstances, discharge from an affected part—*e.g.*, the conjunctiva, or the vaginal mucous membrane—may be increased rather than diminished.

The *acetate of aluminium* and *chlor-aluminium* have marked disinfectant powers, preserving organic tissue, and hindering putrefaction. Burow (1857) found that the acetate, mixed with fresh blood, formed a brown syrupy mass, in which the shape of the corpuscles was not retained but which remained, without decomposing for many months; 0·5 per cent. prevented putrefaction of urine and of meat, and 2 per cent. sterilised bacteria. (Among the minor uses of the acetate it may be mentioned that Mr. Chieux has employed a solution of that salt to render cloth waterproof; steeping the cloth in the solution for a few minutes is all that is necessary.)

The *chloride of aluminium*, chlor-alum, was introduced (mainly by Mr. John Gamgee) as a disinfectant free from poisonous or corrosive properties; it not only prevents decomposition, but removes its products by absorbing gas, etc.: it serves best, perhaps, for the disinfection of closets, drains, etc.:

in the post-mortem room it is useful, but locally applied renders the muscular tissue pale (Lund, Med. Times, 1873).

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Small doses (3 gr.) taken several times daily, in water, cause dryness of the mouth and throat, thirst, and diminished secretion in the alimentary canal, the stools being rendered harder and less coloured than normal. Doses of 10 gr. disorder the digestion by lessening the gastric secretion, and from 15 to 60 gr. cause cramping pain and nausea : 2 to 3 dr. induce vomiting without much straining, and larger continued doses may cause colic and diarrhœa with considerable *increase* of secretion from the intestinal mucous membrane.

In *rabbits*, which do not vomit, 2 dr. proved fatal, with evidence of inflammation and erosion of the stomach (Mitscherlich). To *dogs*, Orfila gave 1 to 2 oz. without other marked effect than vomiting, though if a ligature were passed round the œsophagus, 1 oz. would cause death in a few hours (Devergie). In these cases the gastric membrane was found to be either white and wrinkled, almost tanned, or was distinctly inflamed in patches.

Devergie concluded from his experiments that the human was more sensitive than the canine stomach, and certainly large doses of 1 to 2 oz. cause in man much burning pain, frothing at the mouth, vomiting, purging, and depression : the symptoms of gastro-enteritis may develop themselves, but usually the emetic action gets rid of the drug before serious injury is produced. The results vary somewhat with the condition of the stomach at the time, for at a trial in Paris it was proved that a lady, the subject of chronic dyspepsia, took about 20 gr. of burnt alum (by mistake for gum arabic), and suffered from enteritis in consequence. Orfila gave evidence that such a result was due to exceptional causes, and that 4 to 6 dr. were often given without inconvenience. More recently, death has been reported in a man aged fifty-seven from taking 13 dr. of burnt alum : he suffered from a sensation of burning and constriction, general malaise and anguish, hurried respiration, and nausea with sanguineous vomiting : intelligence remained good (Union Méd., No. 64, 1873).

Alum was at one time largely, and even now is to some extent used in the adulteration of bread, for it gives a whiter colour to the flour. Injurious effects, such as dyspepsia and con-

stipation, have been attributed to it, and though Christison failed to notice bad results from any amount that came under his notice, I have myself often traced indigestion to alum in the bread: it would certainly follow the use of any large quantity. Mallet found that in the United States most baking powders contain alum. In such doses as may be derived from eating bread, he finds that gastric digestion is considerably interfered with, and that the use of alum in baking should be strictly avoided (B. M. J., i., 1889, i., 1893). (It may be noted that ordinary natural wheat flour would give about 4 gr. of silicate of alumina to the 4-lb. loaf, and the determination of the amount of added alum has been a frequent puzzle to analysts—Med. Times, ii., 1875.)

Synergists.—Tannin, sulphuric acid, and astringents generally, favour the action of alum and are often combined with it; but as tannin decomposes alum, if given in the same mixture or compound, the substances really prove less astringent than when given separately.

ANTAGONISTS—INCOMPATIBLES.—If an over-dose of alum be taken, mucilaginous and albuminous liquids such as milk with white of egg, or gum arabic, or fluid glue, should be freely given. Magnesia should be added according to Von Hasselt, or carbonate of ammonium in small quantities (Taylor). Alkalies and their carbonates, and acetate of lead, are chemically incompatible with alum.

THERAPEUTICAL ACTION.—*External.*—Alum is one of the oldest known remedies, and was often prescribed by Hippocrates and Celsus; its properties, as already described, render it unsuitable for the acute stages of any active inflammation, but most useful in many chronic catarrhal conditions, and relaxed states of mucous membranes.

Skin-Diseases, etc.—In some forms of discharging skin-disease, such as chronic eczema, an alum lotion of moderate strength (1 dr. to 6 or 8 oz.) will act favourably as an astringent; it is also useful if sponged over the surface in profuse and exhausting perspirations. On indolent sores and fungous granulations the powder may be sprinkled, opium being added, if desirable to lessen the pain that may be caused; this combination, added to catechu, has also been praised in hospital gangrene. The "lapis divinus," which is prepared with equal parts of alum,

blue-stone, and nitre, fused together, is a stimulant application to ulcerated and discharging surfaces, much used on the Continent, and compounds of aluminium have lately proved very serviceable as disinfectant and alterative dressings.

The acetate of aluminium, and the double sulphate of aluminium and zinc, have been specially recommended in lotion for fœtid perspiration and ulceration; the former has also been much commended for sub-acute and even acute eczema, but I have found it too irritating. Thorey prescribed the chloride for diphtheritic and gangrenous sores, though others report it unduly irritant; in the form of "liquor," it is still sometimes used as an antiseptic. Alumnol is an antiseptic, moderately astringent dusting powder, useful in inflamed and pustular skin diseases (B. M. J., ii., 1892, Ep.); it is used also in lotion or ointment 2 to 10 per cent. or upwards for gonorrhœa, erosions, etc.

Stomatitis.—When small ulcerations occur in the buccal mucous membrane, and when there is gingivitis or sponginess and inflammation of the gums, and in aphthous conditions, dried alum, applied in the form of powder, or a lotion containing it with myrrh and spirits of wine, is very useful. Salivation is also restrained by its moderate use, and injurious effects on the gums during a mercurial course may be prevented by keeping a piece of alum in the mouth for a few minutes occasionally. At Aix-la-Chapelle patients are ordered to use alum gargles and washes frequently during the mercurial treatment; they are, however, acid, and apt to attack exposed dentine.

Toothache dependent on caries may often be cured by the local use of a paste made with alum, ether, and mucilage, which should be applied until the sensitive nerve is destroyed (Legaulon).

In **Catarrhal Angina** and "relaxed throat," especially for relaxed uvula, the gargle of Rivière (1 dr. of alum to 6 oz. of water) is still a frequent prescription.

In **Hoarseness,** a gargle containing 2 dr. of alum in 6 oz. of barley water has been found useful for professional singers (Bennati): the remedy is still better applied in the form of spray (10 gr. to 1 oz.).

Tonsillitis—Pharyngitis.—In early stages even of acute tonsillitis, insufflation of finely-powdered alum, or warm weak alum gargles will often assist in cutting short the attack, but if

this be fully developed before treatment is commenced, alum would be more likely to irritate than to relieve: its use is better reserved for chronic congested conditions, with or without spots of ulceration, when the fine powder should be gently blown over the affected part through a quill or suitable tube.

The *glycerinum aluminis* (1 part of alum to 5 of glycerine) acts as a powerful local astringent, especially in cases of chronic pharyngitis; it is less disagreeable than tannin. This same preparation may be diluted, and then forms a convenient lotion, gargle, or injection.

In **Purulent Ophthalmia,** as occurring especially in children, an alum lotion containing 4 to 6 gr. to the oz. was formerly much used. Mr. Tweedy has pointed out that this remedy is a dangerous one; for if there is abrasion of the conjunctiva the alum penetrates to the cornea, and by dissolving the cement between the corneal fibres produces perforation. Alum in fact, is a reagent employed by histologists to separate the corneal elements. On account of the difficulty in perceiving minute abrasions, he thinks it is safer never to use alum lotion in any case of eye-disease (Pract., ii., 1883); but practically we find it effective, and the experience of Mr. Vose Solomon is quite opposed to the view of Mr. Tweedy.

In **Gonorrhœal Ophthalmia,** and in the severe ophthalmiæ of Egypt and India, similar frequent use of alum lotions is also serviceable. I have seen cases cured by applying round the orbit a mixture of burnt alum with lemon-juice.

In **Catarrhal Conjunctivitis** and **Chemosis,** a convenient and useful application is the alum curd, made with boiling milk, or the alum "poultice," prepared by rubbing a little of the powder with white of egg till a coagulum is formed; this is placed between two layers of thin cambric and applied over the closed lids. There is here again some danger as pointed out by Mr. Tweedy, of the use of such applications producing more serious mischief.

Otorrhœa—Ozæna.—In sub-acute or chronic stages of otorrhœa, an alum injection of the strength already mentioned—4 to 6 gr. to the oz.—is cheap, and often effective; its use should be preceded by a douche of plain water, otherwise the alum will be prevented by coagulated secretion from directly reaching the

affected membrane. The remedy should not be continued too long, or it may excite irritation.

In chronic ozæna (offensive nasal discharges), a douche of double or treble strength may be used. Homolle has recommended the *single sulphate* as a better remedy for this disorder, and others have preferred the chloride (chloralum) or acetate.

Nasal Polypi have sometimes been cured or greatly relieved by the insufflation of finely powdered alum, or strong alum solution.

Leucorrhœa—Gonorrhœa.—Injections of alum alone, or combined with zinc, benzoin, or oak-bark, are often used with advantage, especially in leucorrhœal discharges: a strength of about 5 gr. to the oz. is usually sufficient, and plain water should be first injected to cleanse the surface. In the early acute stages as already mentioned, alum is not suitable, and at any time, too strong a solution applied to the vagina may cause irritation and cramping pain.

Prolapsus.—Leucorrhœa is commonly accompanied by a relaxed condition of the vaginal mucous membrane, which is also amenable to alum. A good method of using it is to place a sponge, soaked in its solution, well within the vagina for several hours; this will often relieve the slighter forms of prolapsus uteri. Dr. R. Bell recommends tampons medicated with glycerine and alum; the astringent action and subsequent benefit, especially in cases of flexion, are attributed by him both to the alum and the glycerine (Lancet, i., 1884). Rectal prolapsus should be bathed with alum water before being returned, and afterwards an injection of the same should be practised.

The severe **Pruritus** and burning about the vulva and the anus, often associated with leucorrhœa and prolapsus, may be equally relieved by strong alum solutions.

In the **Vulvitis** of children, alum is one of the best remedies, a solution of 1 dr. to the pint of water being applied constantly and injected occasionally.

Chronic Catarrhal Cystitis.—This obstinate disorder may be often relieved by the use of a weak alum-injection—10 gr. in the pint: the bladder should be first washed out with warm water, so as to avoid the clotting of discharge.

I have known vesical pain and frequency of micturition

quickly relieved by such injections, which have been followed also, in several instances, by marked diminution of the thick, gelatinous, ropy mucus commonly secreted in this malady: the alkaline reaction and acrid ammoniacal odour of the urine have been removed at the same time. The last-named conditions may be dependent sometimes on the introduction of low organisms by a soiled catheter, but even in such cases, alum-injections are equally useful by their antiseptic properties. Blockley and Parkington especially recommended the single sulphate for vesical and vaginal catarrh.

Hæmorrhage—Epistaxis, etc.—Alum is serviceable applied externally in cases of bleeding from superficial vessels, as from surface wounds or mucous membranes, *e.g.*, of the nose or vagina, from hæmorrhoids, leech-bites, or after extraction of teeth: in such cases it may be used in substance, a pointed plug or the fine powder being firmly placed on the part, or a compress steeped in a strong warm solution may be allowed to cool upon it. Such applications condense the tissues and contract the vessels, but it should be borne in mind that if too strong or too prolonged, they may give rise, especially in scrofulous subjects, to unhealthy ulceration. The alum powder is sometimes combined with zinc sulphate, or diluted with starch or sugar, and the solution may be made with decoction of logwood. Combined with benzoin and alcohol, it forms a celebrated styptic and antiseptic, the "Aqua Pagliari" (benzoin, 100 gr., alcohol, ½ oz.; dissolve and add water, ½ pint, alum, 1 oz.; boil till clear, then filter). The solution of Mentel and that of the U.S. Dispensatory is similar, but made with the single sulphate: 2-4 dr. of these in a pint of water make a useful astringent lotion or injection.

THERAPEUTICAL ACTION.—*Internal.*—The internal use of alum is combined with its external application in many varieties of hæmorrhages, though it is not depended upon so much now as formerly: it is best suited for cases of "passive hæmorrhage," dependent on relaxed condition of a mucous membrane, and when no acute inflammation is present.

In **Hæmoptysis,** when moderate but persistent, it is a good adjuvant to other remedies, *e.g.*, sulphuric acid. Skoda commonly gave 10-gr. doses with Dover's powder. A spray containing the

same quantity in 1 oz. of water may be used with advantage at the same time.

In **Bleeding from the Stomach or Bowels**—dependent as these symptoms often are upon cirrhosis, and when passive and atonic in character—alum may be a suitable remedy; its astringent effect in such cases is, in part, at least, direct and local.

In **Menorrhagia** Cullen especially commended alum, and it is still used more frequently perhaps in this flux than in any other. In the form of "alum whey," which is prepared by boiling 2 dr. of the powder with 1 pint of milk, straining off the curd and adding sugar, it is a not unpleasant medicine, of which a wineglassful, three or four times daily, will generally control the discharge.

Hæmaturia.—In bleeding from the kidneys, alum whey is also useful, but "iron alum" (double sulphate of iron and ammonia) is a still more active remedy, which has, in my experience, acted better than many others. In cases where blood comes from the mucous membrane of the bladder or urethra, and when pain, straining, and undue frequency of micturition are present, I have known speedy benefit follow the use of alum injections (20 gr. to the pint) into the bladder. Dr. J. S. Radcliffe has also found treatment with alum useful. He recorded one case in which the cause of the hæmaturia was doubtful, but which resisted all other astringent methods of treatment; the Rockbridge alum water was given and the case cured in a few days (Philad. Med. News, 1884.) The same water has been found useful in other chronic discharges, such as diarrhœa, and bronchorrhœa. In five cases of chronic hæmaturia recovery ultimately occurred under 20-gr. doses of alum given three times a day *largely diluted*—these doses did not constipate (Pract., ii., 1889).

Albuminuria.—The drain of albumen in Bright's disease is practically equivalent to a loss by hæmorrhage, and it has been sometimes restrained by the use of alum: thus Oppolzer and Heller have reported benefit from it in chronic cases, but after repeated trials I have not been able to verify their good results.

Diabetes.—In diabetes insipidus, or "polyuria," when there is an excessive flow of limpid but non-saccharine urine, alum deserves further trial, though the malady is anomalous and often

is uncontrolled by any remedies. In true diabetes a partial and temporary benefit has been derived by some patients for whom I have prescribed it.

Gastric Catarrh.—In cases with vomiting of glairy mucus, alum is a cheap and efficient remedy. Sir J. Murray, one of the principal advocates for its use, pointed out that it acted better when given in substance than in solution: thus a pill with gentian extract is a good form, or an electuary with honey.

Diarrhœa.—I have found alum very useful in infantile diarrhœa when arising from errors in diet, and attended with vomiting, acidity, and green stools: from 1 to 5 gr. may be given with syrup. Diarrhœa dependent upon relaxed conditions of the intestinal mucous membrane is also cured by alum. Fouquier and others have praised it in enteric fever (Bull. de Thérap., ix.), but it is not easily taken, and it is liable to irritate, so that other remedies are usually to be preferred. Alumina, or argilla pura, is placed in the Austrian Pharmacopœia as an antacid remedy for diarrhœa, especially in children, and is used like bismuth salts. Barthez recommends the single sulphate.

Dysentery.—Moseley, in his work on tropical diseases, considers alum to be one of the best medicines in acute and chronic dysentery, and Dr. Waring has often seen it useful in asthenic cases; it was commonly given with opium. I think that a good mode of administering it in chronic cases is by enema, from 10 gr. to 2 dr. in a pint of liquid being used at a time (Hannon, Bull. de l'Acad., xxxii.); this will also relieve the troublesome tenesmus, and the sense of itching and excoriation about the anus. One drachm to the pint is a proportion I have commonly used twice daily with good success; a strength of ½ oz. to the pint has also been used, but caused some burning pain; improvement, however, soon began, and cure resulted after about fourteen days of treatment (Med. Record, 1879). Dr. Hepburn found good result from this strength in an acute case (Lancet, ii., 1889), and a chronic case recovered well with it after failure of many remedies by the mouth (*Ib.*, i., 1891).

Constipation.—Besides the astringent power exerted by 5 to 10-gr. doses of alum, we must notice the irritant effect of larger quantities, by which probably they become useful in constipation. Alum is seldom to be preferred to other remedies for this disorder,

though it may act favourably in atonic cases, when the muscular coat of the bowel is deficient in power, and when intestinal secretion is scanty. Mr. Aldridge has published reports illustrating the good effect of 20 to 40 gr. daily in producing copious and solid evacuations ; he also associated it with sulphate of magnesia (Braithwaite, vol. xii.). Such treatment, however, is rarely worth trial, and my own experience with it is not favourable ; it either increased constipation or caused dysenteric symptoms.

Lead Colic.—In this common and painful malady, which is always accompanied by obstinate constipation, there is much evidence of the virtue of alum, dating from the last century. Dr. Copland praises it, and M. Brachet, of Lyons, writing from a large experience, awards to it the first place amongst remedies ; for eight years he states that the treatment he employed consisted of emetics and purgatives, then he gave a trial to antiphlogistics, and then to opiates : lastly, influenced by the success of Gendrin, he commenced to give $1\frac{1}{2}$ to 2 dr. of alum daily in mucilaginous liquid, and either with or without laudanum ; on the third day usually the bowels acted, and if not an aperient was given and the patient was nearly or quite cured, and this in upwards of 150 cases. The successful cases of M. Gendrin were fifty-eight in number, and he experienced no failures with the alum treatment.

The intestines have been most generally regarded as the seat of disease in lead-poisoning, either in all their structure or in their mucous or their muscular coat. Méral especially argues that the latter is in a state of paralysis, a conclusion which has been widely accepted, and alum has been supposed to act partly as a stimulant to the paralysed muscle, and partly as a direct chemical antidote to the lead which it converts into an insoluble sulphate. In support of this view it may be mentioned that other sulphates, as of magnesia, soda, zinc, and free sulphuric acid also act favourably ; but it scarcely explains the quick relief that is sometimes given, and one cannot say that its mode of action is quite clear. It would seem to have a specific power of relieving pain, because it has proved useful in other varieties of gastralgia and colic (Dr Griffin, on Spinal Irritation, etc.).

I have myself only witnessed the good effects of the drug in two cases of lead-poisoning which presented all the usual symptoms : it relieved the pain and terminated the constipation ; from

10 to 20 gr. may be given every two hours, properly diluted, and this quantity may be increased to 1 dr. or more, if necessary. Sulphuric acid and syrup of lemon form a suitable vehicle for it: it some cases it is well combined with a little opium. On the other hand, several good authorities report less favourably of the remedy: Tanquerel and Grisolle found it almost inert, and Brown records increase of pain and of constipation from its use. Husemann, who may be taken as representing the German school, speaks of it as "obsolete," but with us it certainly is not so; Dr. Bartholow, for instance, in his recent treatise, describes it as "most effective" in the relief of the pain and vomiting.

In *locomoter ataxy* the chloride of aluminium is said to relieve "lightning pains" (Gowers).

Ague.—The practice in Calcutta of giving grain doses of burnt alum in intermittent fever is described as very successful in those cases in which the attack occurs with clock-like regularity; in only 13 per cent. was the treatment unsuccessful. In cases in which the attacks come on irregularly, the remedy seems to be of no avail (Med. Times, i., 1882). Additional evidence, mainly Russian, has been furnished in favour of alum being a moderately good substitute for quinine, especially in quotidian recent ague—8 gr. were given three hours and again one hour before the expected attack: this was taken in powder and afterwards water was given freely. It is, however, an uncertain remedy and has been proved to have no effect on splenic enlargement.

Emetic Action—Croup.—Besides its astringent and stimulating power, alum, in doses of about 1 dr., is a very useful emetic, because it is prompt in action, and does not depress the system: hence it has been recommended in croup both to dislodge the false membrane and hinder its re-formation; it may be repeated every quarter of an hour for several doses. Narcotic poisoning has also been treated by it.

Whooping-Cough.—In the chronic stages of this complaint, where secretion is profuse and spasm severe, and there is not much complicating bronchitis or pyrexia, I have seen alum exert a very beneficial influence: 4 to 10 gr. in water or syrup should be given three or four times daily. Dr. Golding-Bird introduced and highly commended this treatment, conjoining the alum with conium and dill-water. Dr. Meigs states that alum has given

him, in sixty-eight cases, better results than any other remedy (Diseases of Children). Its good effect may be traced, probably, to a local astringent action on the fauces; hence it is best administered in some thick vehicle, and swallowed slowly; 2 gr. with syrup and cinchona is a good form for a child of four years old, and may be commenced as the catarrhal stage is passing off.

Asthma—Bronchitis.—It is said that a paroxysm of asthma may sometimes be prevented by placing about 10 gr. of alum on the tongue. In bronchitis, 5 to 10 gr., given every four hours, serve to facilitate expectoration, and at the same time its amount is restrained and dyspnœa relieved. Moseley praised this use of alum many years ago, and advised it both for acute and chronic cases with viscid ropy expectoration; but it is in these latter cases only that I should consider it suitable.

PREPARATIONS AND DOSE.—*Alumen:* dose as an *astringent*, 10 to 20 gr.; as a *purgative*, 30 to 60 gr. or upwards; as an *emetic*, 1 dr. to 1 oz. In lead colic, 20 to 120 gr. have been given in the twenty-four hours. *Alumen exsiccatum:* the dose should be somewhat less, and practically this preparation should be kept for external use only. The *solid drug* seems to be more effectual than the liquid form; it may be given in pill or in confection with sugar, honey, or molasses: cream of tartar may be added, if necessary, to obviate constipation, and cinnamon or other aromatics to prevent flatulence. The "*Pills of Helvetius*," formerly celebrated, contained 3 gr. mixed with "dragon's blood"; a more modern formula is with gentian, rhubarb, etc.

In *solution* it may be given with sweetened aromatic water or mucilage, or sulphuric acid and syrup of lemons may be added; or an "alum whey" may be made by stirring 2 dr. of the powder with a pint of boiling milk, straining, and adding sugar.

For a *collyrium*, a strength of 5 gr. to the ounce of rose water is suitable: for a *gargle* from 8 to 20 gr. in the ounce: for a *lotion* or *injection* it may be well combined with zinc sulphate, as in the liq. aluminis co. (L.P.), which was ordered with 1 oz. of each salt to 3 pints hot water; for an *ointment*, 12 to 24 gr. to the ounce of simple ointment; for a *liniment*, with white of egg and camphorated spirit (for bedsore). The *glycerinum aluminis* (1 to 5 parts glycerine) is the only official preparation. *Aluminii chloridum:* dose 2-4 grains. *Liquor aluminii chloridi* and *chloralum* are antiseptic solutions.

Fuller's Earth is a native silicate of aluminium, containing traces of iron. *Prepared Kaolin* is a white form of the same, purified by elutriation. These are used as absorbent powders and being unacted upon by most chemical reagents, Kaolin especially is used as a pill basis for nitrate of silver and permanganates, etc. *Cimolite* is another name for the same silicate, further purified and perfumed.

ANTIMONIUM—ANTIMONY—STIBIUM

(Sb = 122).

This substance, which in certain of its chemical properties more resembles a non-metallic than a metallic element, occurs native, but in small quantities. It is usually found in alloy with various metals, chiefly iron, lead, and arsenic, and from these its purest commercial samples are seldom quite free. Traces of it occur also in some chabybeate waters, and its oxide constitutes the "white antimony ore" (valentinite): its most common ore is the sulphide, from which crude antimony is obtained by fusion with iron, or by roasting and reduction with charcoal.

When pure it is silvery white in colour with a tinge of blue, laminated in structure, brittle, and crystalline; it is heavy (sp. gr. 6·7) and permanent in the air at ordinary temperature. In its chemical relations it is allied to nitrogen and phosphorus, and still more closely to arsenic.

COMPOUNDS OF ANTIMONY.

ANTIMONIUM NIGRUM PURIFICATUM—PURIFIED BLACK ANTIMONY (Sb_2S_3 = 340).

PREPARATION.—It is prepared from the native ore stibnite, by fusing and then reducing to a fine powder, so as to get rid of siliceous matter. If any soluble salt of arsenic be present, it is then macerated with liquor ammoniæ for five days, the supernatant liquid poured off, the residue washed with water and dried.

CHARACTERS AND TESTS.—A crystalline, steel-grey, metallic-looking powder, which dissolves in boiling hydrochloric acid, with evolution of sulphuretted hydrogen.

ANTIMONIUM SULPHURATUM—SULPHURATED ANTIMONY.

This substance is a mixture of sulphide and oxide of antimony. Sb_2S_3 and Sb_2O_3. It is sometimes called the golden or precipitated sulphuret.

PREPARATION.—It is prepared by dissolving the purified black antimony in caustic soda with the aid of heat, and adding sulphuric acid; several complex reactions occur, and sulphurated antimony is precipitated.

CHARACTERS AND TESTS.—An orange-red powder, inodorous, almost tasteless, insoluble in water, soluble in hydrochloric

acid, also in solutions of caustic alkali, and of acid tartrate of potash: exposed to light and air it partially decomposes, with separation of sulphur. Sixty grains moistened and warmed with successive portions of nitric acid until red fumes cease to be evolved, then dried and heated to redness, give a white residue weighing about 40 grains.

There are several other reddish or brown oxy-sulphides of antimony, and all have been termed "kermes mineral," from some resemblance in colour to the insect kermes (cochineal).

LIQUOR ANTIMONII CHLORIDI—SOLUTION OF CHLORIDE OF ANTIMONY ($SbCl_3$ = 228·5).

PREPARATION.—It is prepared by boiling purified black antimony in hydrochloric acid ($Sb_2S_3 + 6HCl = 2SbCl_3 + 3H_2S$).

CHARACTERS AND TESTS.—It is a heavy, yellowish-red liquid (sp. gr. 1·47), which, when poured into water, gives a dense white precipitate of oxy-chloride ($SbOCl$) mixed with trioxide (Sb_2O_3). The filtrate from this precipitate gives a copious deposit with silver nitrate. If the white precipitate formed by water is treated with sulphuretted hydrogen, it becomes orange-coloured.

The pure chloride, which may be obtained by distillation, is volatile, but concretes on cooling, into a soft white solid, "*butter of antimony*"; and this term is sometimes given to the official solution.

ANTIMONII OXIDUM—OXIDE OF ANTIMONY (Sb_2O_3 = 292).

PREPARATION.—It is prepared by decomposing the oxy-chloride with sodium carbonate.

CHARACTERS AND TESTS.—It is a greyish-white powder, inodorous, tasteless, and insoluble in water, but readily soluble in hydrochloric acid: moderately heated it fuses and turns yellow, at a red heat it burns, or sublimes in crystals. Its solution in hydrochloric acid when dropped into distilled water gives a white deposit, which is changed to orange by sulphuretted hydrogen.

ANTIMONIUM TARTARATUM—TARTARATED ANTIMONY—TARTRATE OF ANTIMONY AND POTASSIUM—TARTAR EMETIC, ($KSbOC_4H_4O_6$) = 343.

PREPARATION.—It is prepared by mixing the oxide of antimony with acid tartrate of potash and water for twenty-four hours, afterwards boiling in water, when tartar emetic crystallises out.

CHARACTERS AND TESTS.—Occurs in rhombic, octahedral, colourless crystals, transparent when fresh, but efflorescing on exposure to air; also, and more frequently, in the form of powder, which should be perfectly white, a yellowish tinge indicating the presence of iron. It is odourless, but has a sweetish, sub-acid taste, which quickly becomes metallic and nauseous, but may not be much noticed if the powder be largely diluted. The crystals are best obtained for microscopic examination by evaporating on a slide a drop of the hot solution: characteristic triangular facets are seen, and some modifications of the cube, and they are larger than *arsenical* crystals: branched crystalline forms also occur, as in many other saline solutions. The crystals of tartar emetic are isomorphous with those of the *sulphate of potassium*, but the latter do not effloresce. Tartar emetic is soluble in two parts of boiling, and in fourteen parts of cold water; less soluble in proof spirit, or in wine, and insoluble in absolute alcohol. Acids, except tartaric acid, occasion a white precipitate, as also do alkalies, alkaline earths, and their carbonates, but excess of these agents will re-dissolve the precipitates.

The dried salt, like other tartrates, decrepitates and chars on the application of heat, and its solution in water readily becomes mouldy from the development of a fungus (a little added spirit will prevent this).

Infusion of galls, catechu, cinchona, strong tea, or tannin in any form, precipitates a tannate of antimony, which is so insoluble as to be practically inert. The following tests are applicable to any soluble antimonial salt:—(1) If it be boiled in water with one-sixth part of pure hydrochloric acid and a strip of metallic copper, antimony will be deposited on the metal, violet-red in colour if the quantity be small, but iron-grey, or black, if in large amount. (2) A solution acidulated with the same acid ($\frac{1}{16}$th) gives, in the cold, a black deposit on pure tin. (3) Sulphide of ammonium, or sulphuretted hydrogen, produces, in acid solutions, an orange-coloured deposit soluble in hydrochloric acid (boiling), and if this latter solution be poured into water, a white precipitate of oxide occurs. (4) Evolution of nascent hydrogen (as from zinc and sulphuric acid), in the presence of antimony, leads to the formation of antimoniuretted hydrogen: this burns with a

blue flame, and produces on porcelain a black stain which is insoluble in bleaching powder.

ABSORPTION AND ELIMINATION.—Soluble compounds of antimony, such as tartar emetic, are readily absorbed, especially by mucous membranes, and they circulate in the blood, either unchanged or as albuminates. The infant at the breast may be affected by them through the mother, and they may be detected in the different secretions during life, and in the viscera, especially the liver, kidneys, and intestines, after death.

The degree of absorption naturally varies with the preparation used, the dose, and the state of the stomach. Metallic antimony in powder, the oxide, and the sulphuret are absorbed to some extent, but much less freely than the potassio-tartrate, which is itself more completely absorbed, and acts more powerfully, if acid wines or fruits are taken at the same time (Trousseau). Large doses are usually vomited soon, and before much absorption has occurred; but if taken with, or shortly after food, vomiting is delayed, and a poisonous amount is more readily taken up into the circulation. This does not conflict with the statement made by Trousseau, that if a patient be living *well*, irritant effects, such as vomiting and purging, are more likely to occur from medicinal doses of antimony, whilst *spare diet* favours the production of constitutional effects, such as sedation and increased secretion, without so much gastric irritation. This fact has been explained by the presence of more chlorides in a full diet (as compared with a spare one), leading to the formation of more of the irritant chloride of antimony (Mialhe); but Bellini found that no such decomposition occurred with artificial gastric juice at the temperature of the body, and the hypothesis of Mialhe has not been accepted.

Salts of antimony combine with albumen, but in alkaline solutions form no precipitate; they only do so in acid solutions, and seem only to exert an irritant action on those parts of the body where they meet with an acid secretion, such as the stomach, and the orifices of the sweat glands (Brunton).

If the mucous membrane of the alimentary tract be inflamed, the irritant effects of antimony are proportionately severe.

Absorption may occur through the skin, though not readily whilst the epidermis is intact; after frictions with antimonial

ointment, vomiting has occurred, and the drug has been found in the urine (Coze, Bull. de Thérap., 1869).

Antimony is *eliminated* by the kidneys, the skin, the mucous membrane of the bronchi, and mainly by that of the stomach and intestines. Orfila recorded its special determination to the lungs, and Millon to the liver (Annales d'Hygiène, vol. xxxvi.). An important fact is that elimination occurs by the intestinal tract, even when the drug has been given by the veins, the rectum, or any other channel (Lancet, i., 1856). The amount passed out by the kidneys, and probably by the other glands, varies at different times in the same individual, for Mayerhofer, whilst continuing to take the drug, found it only occasionally present in the urine (Heller's Archiv, 1846).

The time of its remaining in the system has been variously estimated. According to Taylor, it passes wholly from the stomach within a short time, and may then be found in the liver, the kidneys, and spleen, and in smaller quantities in the blood. After a few weeks, all traces have disappeared from these tissues, but some may be found in the fat and the bones; generally, elimination is complete in from twenty to twenty-five days, but according to Millon and Lavran, the drug may be found in the liver and intestines four months after administration.

PHYSIOLOGICAL ACTION.—*External.*—The watery solution of tartar emetic applied to the skin acts as a slight irritant, producing redness, but the ointment when rubbed in acts more powerfully, causing inflammation, a papular eruption, and pustulation. The pustules produced by antimony are very painful; they are irregular in size and shape, but being often umbilicated, resemble those of variola: they mature about the fifth day, forming scabs; sometimes they slough and leave scars. Individuals vary much in susceptibility to the ointment, and during fever, or severe visceral inflammation, pustulation is not easily induced.

It has been stated that alkalies mixed with antimonial salves prevent their pustulating effect, and also, but incorrectly, that freshly-blistered surfaces do not pustulate because of the alkalinity of the serum: on the other hand, acids increase the effect. The irritation occurs at the mouths of the sweat and sebaceous glands, where the secretions are acid.

If concentrated solutions be taken by the mouth, they are liable

to cause inflammation and even ulceration about the gums, fauces, and œsophagus, so that an "antimony sore throat" has been described, and its accompanying salivation and dysphagia may be very severe. Conditions much resembling those of diphtheria have also occurred (Med. Times, i., 1846), but are not often met with under the present more cautious use of the drug.

The prolonged contact of antimony determines in the intestinal mucous membrane local phlegmasiæ analogous to those already described as occurring in the skin; Trousseau verified this by post-mortem examinations.

PHYSIOLOGICAL ACTION.—*Internal.*—**Circulatory System.**—Under the influence of antimony, the blood is altered in its chemical characters (Richardson), but in a manner not yet well understood; it may certainly become impoverished from destruction of red and increase of white corpuscles (Schmidt), just as under the action of arsenic (Koschlakoff): in cases of poisoning by the drug, it has been found more fluid and less coagulable than normal, the amount of fibrin being diminished.

A prominent symptom of the full action of antimony is *depression* of the circulation, both as to force and rapidity; but such depression is often preceded by a rise in the pulse-rate, and a similar rise may occur before death in the later stages of poisoning.

Ackermann, indeed, experimenting upon healthy men with emetic doses (about $\frac{3}{4}$ gr. of the tartrate), found a *prolonged rise* in the pulse-rate, to an average maximum extent of 42 per minute, but this was distinctly related to the gastric symptoms. The rise began only with the onset of nausea, and increased with the occurrence of vomiting, after which the pulse fell to an ordinary level: it became also soft and weak in proportion to its quickness, but he did not observe any decided fall below the normal rate at any period (Brit. and For. Rev., 1859).

These observations were carefully made, the pulse being examined every five minutes for several hours, but they illustrate only the effect of one or two doses. There can be little doubt that a longer course of the same or a larger initial dose would have induced the slowing of pulse which has been verified by so many observers; but we may note a parallel observation made by Trousseau, that in some few persons taking antimony the pulse became and continued quick, as well as weak and irregular.

Usually, as at first stated, slowing of the pulse is a marked and somewhat persistent effect of antimony, and especially so when vomiting does not occur at all, or after it has ceased : from six to ten beats per minute is an average amount of decrease after doses of 1 to 2 gr., but it may vary from three beats to forty (Pécholier, Bonamy). Gubler has noted a proportion between the ultimate fall and the primary increase. Arterial pressure is much diminished, and the curves of a sphygmogram may be almost effaced (Bordier) : more or less venous congestion also occurs.

After very large doses, any acceleration is but slight and transient, before the blood-current becomes slow and almost imperceptible. In frogs, dogs, or rabbits, when a sufficient dose has been introduced by any channel, the cardiac contractions also soon become slower, weaker, and irregular, the auricles contracting oftener than the ventricles. When death occurs from the drug it is said to be always through cardiac paralysis (Richardson), the general state of collapse being secondary to failure of the circulation. Arrest finally occurs in diastole, and irritability of the cardiac muscle is found to be impaired or lost (Radziejewski, Bellini), probably owing to a directly paralysing influence on the cardiac muscular structure when reached by the drug after absorption. When antimony is applied to the batrachian heart removed from the body, similar slowing and arrest take place following a brief period of acceleration, which is another reason for considering the action to be directly on the muscular structure. It is curious that in animals subjected to toxic doses, death can be delayed for some hours by dividing the vagi (Majendie). The effect on the circulation is thus seen to be primarily due to the direct action of the drug on the heart and vessels ; but it partly depends (as is seen in the observations of the relation of the pulse to the nausea) on a reflex action through the nerves of the stomach.

Respiratory System.—In the experiments of Ackermann the number of respirations increased in direct relation with the increase in the pulse-rate ; but under the continued influence of the drug, independently of irritant effects, and of any preventing lung disorder, the rate of respiration is slowed. It may be so by as much as half or two-thirds the normal rate, so that only six respirations occur per minute, and this without general distress or impairment of other functions (Trousseau).

After poisonous doses the breathing is very irregular, at one time hurried, short, and painful, at another extremely slow, with laboured and forcible inspiration and expiration: this is due in part to paralysis of the heart and other muscles, in part to impairment of reflex sensibility and to altered conditions of the blood. After death in such cases, Majendie, finding the lungs partially congested and hepatised, concluded that the action of antimony was specially exerted on these organs, and Mayerhofer certainly proved its elimination by their mucous membrane: ecchymoses and emphysema are found when the act of breathing has been very laboured.

The effect of the drug upon excretion of carbonic acid has been differently stated: some observers report it lessened in amount (Coze, Mialhe, Rabuteau), but recent writers (Ringer, Bartholow) express an exactly opposite opinion, though neither gives his original authority. Further accurate observations upon this point are admittedly wanting; but having regard to the sedative effects of sufficient doses, independently of inflammatory action, the former statement seems to me more in accordance with known facts. That *arsenic* lessens the excretion of carbonic acid is now recognised, and though Gubler holds that we do not know enough of arsenical action to make the analogy of scientific value, I should hesitate before ascribing to so closely an allied drug as antimony a directly opposite effect in this important particular.

Digestive System.—Upon the alimentary tract antimony acts as an irritant in greater or less degree, according to the dose: $\frac{1}{30}$ to $\frac{1}{15}$ gr. of the tartrate, or even less when repeated, will induce some sense of warmth in the stomach, and some increase of its secretions; $\frac{1}{8}$ to $\frac{1}{4}$ gr. will cause in addition, a feeling of soreness, a flow of saliva, impairment of appetite, and possibly nausea; $\frac{3}{4}$ to 1 gr. given in a glass of water, will usually induce vomiting within fifteen to thirty minutes. The vomiting is distressing in character, accompanied with shivering, much depression, retching, and persistent nausea: the ejecta contain mucus, and later, bile. The same dose generally purges, and if taken with a *large quantity* of water will be almost sure to do so, either with or without vomiting. The evacuations at first are simply fluid, then mixed with free bile, and are passed with

some straining and griping pain. It is noteworthy that a larger dose is required to produce these effects when given by intravenous injection than by the stomach.

Large doses of 10 to 20 gr. or more, act very severely; the local irritation and burning pain are great; vomiting occurs quickly and with much distress; there is difficulty in swallowing, spasm of œsophagus, severe tenesmus and cramp in the abdominal muscles, and profuse diarrhœa of sero-albuminous fluid, containing flocculi of detached epithelium (like the rice-water stools of cholera), and sometimes blood.

In fatal cases the mucous membrane of the stomach and of parts of the intestine, especially the lower portions and the rectum, has been found acutely congested or inflamed, softened, aphthous, or ulcerated: a characteristic pustular rash has been described, and changes like those produced by arsenic have occurred in the liver (Record, 1882).

Conditions modifying the Action of Antimony—Tolerance, etc.—The preceding description requires to be qualified, especially in cases of what is called "tolerance". If the giving of antimony be commenced in fractional doses, and continued with very gradual increase, it is possible to produce full sedative effects without gastric disturbance. Again, in certain forms of illness, such as pneumonia, or in some nervous-disorders, as chorea or delirium tremens, full doses may be given without any evidence of irritation, and then "tolerance" of the drug is said to be established. Further, in some instances, ½-dr. and 1-dr. doses have been taken without vomiting (Hicks, Lancet, ii., 1876), and in other cases of poisoning from very large doses, the prominent symptoms have been those of collapse, and the patient has died without vomiting or purging, or complaint of pain. Indeed, not the least of the difficulties in studying the action of antimony, we find in the circumstance that sometimes there is no post-mortem evidence of irritation or inflammation to be found, either in stomach or intestine (Handfield Jones, Bellini, Böcker). As with other powerful drugs, there may also exist some idiosyncrasy in certain persons, leading to difference in result that we cannot otherwise explain, but the account I have given represents the effects as usually observed: as a rule, it acts with most intensity on the delicate, on women, and more especially on children, and in these subjects

"tolerance" is less easily induced than in men, and lasts for a shorter time. When tolerance has once ceased, great care must be exercised in resuming the drug, for it will more readily excite gastric derangement (Trousseau).

Glandular System.—Moderate doses increase the secretion of the parotid, the pancreas, the liver, and the gastric and intestinal glands, the drug acting as a stimulant or irritant during its elimination by these structures.

The increased secretion has been variously attributed to irritation of the gland-cells, and to paralysis of their controlling nerves : the former is the primary, the latter a secondary effect.

Cutaneous System.—Whether it has a like action on the sweat-glands has been disputed, and the increased perspiration which commonly follows its use has been attributed to the act of vomiting, or to the course of an illness (Trousseau). It is true that when the remedy is "tolerated" there is usually little sweating, but this need imply only that under certain conditions less of the drug is excreted by the skin. In my own experience, diaphoresis has occurred clearly from antimonial action, independently of vomiting, and this seems quite in accord with the increased cutaneous circulation and secretion from other glands. (I do not here refer to the profuse cold sweating of later stages of poisoning,—the result of exhaustion.)

Neither do I see any difficulty in accepting the recorded cases of pustular eruption following the internal use of tartarated antimony (Gleaves, Böcker, Mayerhofer, Taylor). The drug is certainly eliminated to a greater or less extent by the skin—the acid sweat decomposes the double salt, and the liberated simple salt acts as an irritant.

Urinary System.—There is difficulty in estimating exactly the effect of antimony on the kidneys, and statements with regard to it vary much. It is probable that more or less of the drug may be excreted by this channel according to circumstances, for, as already stated, Mayerhofer, experimenting on himself, could, at one time, detect it in his urine, and at another time, not ; he found the amount of urine at first increased, afterwards lessened. Trousseau and Gubler report a marked increase in the secretion only when vomiting and purging were absent or slight, and this was the case also in Hannon's experiments.

If the circulation be extremely depressed, or if choleraic symptoms occur, the urine is likely to become scanty, or even suppressed.

Other observers distinguish between the different constituents of the urine; Böcker, taking himself $2\frac{1}{2}$ gr. daily for nine days, found the urea and other urinary solids markedly lessened; and Beigel, giving a similar dose to four patients for four days, obtained the same results: in both instances, comparatively little food was taken.

Dr. Parkes, however, found the amount of urea increased after sulphuret of antimony; and several modern writers (Ringer, Bartholow) describe a similar increase, relying, probably, on the observations of Ackermann. His subjects received a cup of coffee and then remained in bed for a day, taking from 1 to 2 gr. of tartar emetic, which caused emesis and often purgation. He reported that the water and the chlorides were diminished in proportion to the diarrhœa, but urea was increased by one-eighth, or even one-fourth, and uric acid and pigment were also present in larger amount: these results he attributed to increased metamorphosis. I cannot, however, accept them as conclusive evidence of the full action of antimony, for the lowering of circulation and of temperature, the relaxation of vessels, and the analogy of allied medicines (arsenic) suggest so forcibly an opposite conclusion. Further experiments are required on this point: meanwhile, I cannot but agree with Rabuteau and others in classing the drug with those which moderate or diminish the nutritive processes, and which therefore tend to lessen the excretion of urea as well as of carbonic acid. As a curious illustration of the power of antimony to lessen excretion and lower true nutrition, we may refer to a custom common in Germany of using "glass of antimony" in the food to fatten fowls and animals.

Temperature.—There is a similar discrepancy in observations on temperature,—a discrepancy which must depend upon difference in dosage, or in continuance of the medication, or in the reaction of healthy as against weakly subjects. Thus, Ackermann found the hands and face become cold during the period of nausea, but after vomiting they became warmer, and the mouth temperature did not fall, but increased about 1° F. That is to say, the extremities become cold during the stage of nausea

because less blood reaches them; then, when the nausea is over and the spasm of the vessels relaxes, they become warm again or even warmer than normal (Brunton).

Dr. Ringer made a very complete experiment when he gave $\frac{1}{2}$ gr. of tartar emetic every ten minutes for seven hours, inducing vomiting and sweating, and yet the temperature did not vary more than 0·4° F. On the other hand, Pécholier observed the temperature to fall in direct ratio with the pulse, and the amount of fall has been stated at from 1° to 3° C. (Hirtz, Gubler): a brief and slight preceding rise has been noted by the latter physician.

In cases of *poisoning* the depression of temperature is very marked, and in another series of experiments made by Ackermann on animals, it amounted to nearly 7° C. in those that survived a *few* hours; this, however, must be largely due to collapse.

Nervous and Muscular Systems.—These systems are first excited and then paralysed by antimony in varying degree, according to the dose and the amount of gastric irritation. In Kobert's experiments it was found to directly enfeeble muscle. Restlessness and pain may be at first marked, with general tremor and spasmodic contraction of the muscles either of the abdomen, the jaw, the œsophagus, or extremities, especially of the hands (case of Mrs. Prichard—cases by Orfila, Elliotson, etc.).

In animals, reflex sensibility is much diminished (Radziejewski), and some degree of motor palsy occurs: these effects, so far as they are central in origin are spinal rather than cerebral, for they occur equally when the cerebral centre is separated. That they are due to the direct action of the drug on the nervous tissue, and not to its indirect action through the circulation, is shown by the fact, that in frogs the paralysis appears while the heart continues to beat. In man they have not been so marked, but great muscular prostration is quickly induced, and profound collapse is a characteristic symptom of antimonial poisoning: in some exceptional cases, it has been more in evidence than any irritant symptoms.

There may be temporary loss of consciousness and semi-narcotism (case of Mr. Bravo), or convulsion, and later delirium (Orfila), but usually the mind remains, or becomes clear, before death.

Fatal Dose.—The ordinary fatal dose for an adult may be stated at 4 or 8 gr. ; for a child, $\frac{3}{4}$ gr.

The post-mortem appearances have been sufficiently indicated. We need only note further confirmatory evidence of the power of antimony to produce fatty degeneration in the experiments of Salkowski, who found this change in the viscera of animals after adding 8 to 15 gr. per diem of an antimonial compound to their ordinary food.

Theory of Action.—There has been much discussion as to whether the vomiting and purging which are produced by antimony are due to direct gastro-intestinal irritation, or are secondary to an influence exerted on the vomitive-centres in the medulla oblongata by the drug after absorption. The former view was commonly accepted until Majendie's experiment of substituting in an animal a bladder for the natural stomach, and then causing vomiting by intravenous injection of antimony. Such an experiment seemed to prove that emesis was effected through the nervous centres independently of the stomach ; and besides this, the persistence of the nausea seemed to indicate more than an ordinary mechanical irritation. Chouppe has also concluded from recent experiments that although antimony *may* act by such irritation, it more usually acts after absorption. He divided the vagus nerve in dogs, and after subsidence of retching from the operation, injected antimony into the cellular tissue or veins, and vomiting followed as usual : as an experiment for contrast, he injected in other dogs emetine, and when the vagi were divided this caused no vomiting (Abstract, Lancet, ii., 1874). The ascertained facts, however, seem to me to show that although under certain conditions such as result from large doses, the effect of tartar emetic is on the vomitive centre, yet the earlier views that it is local irritation of the stomach and thus an *indirect* effect on the vomitive centres we have to deal with, are more correct and are supported by the following considerations:—(1) Emesis has occurred before any antimony could be detected in the blood (Mayerhofer). (2) In several instances, nearly the whole of a dose of antimony has been recovered from the vomited matters—implying that very little, if any, absorption could have occurred before vomiting (Radziejewski). (3) In almost all fatal cases, marked congestion or signs of irritation have been found in

the *stomach* after death, and this even when the drug has been given by the veins or other channels. It has clearly been proved that elimination occurs from the gastric membrane under such circumstances, and it is probable that in Majendie's experiment the drug was eliminated by the pharynx and by the intestine, and produced vomiting just as if introduced into the natural stomach (Hermann, Grimm, Brinton, Richardson). (4) A smaller dose will produce vomiting when given by the mouth than when given by the veins; this seems a crucial experiment on the point, and although an opposite statement has been made by some observers, the former one has been verified by Hermann, Grimm, and Kleimann; it is agreed, of course, that general symptoms occur also after, and in consequence of, absorption, and that nausea and prostration are prolonged in consequence of such absorption.

Another question is, whether the deeply-depressing effects of the drug are due to a special "contra-stimulant" action (Rasori), or whether they are only secondary to the emeto-catharsis (Broussais). I must conclude also on this point, that without denying a depressant effect after absorption and poisoning of the nerve-centres, the muscular tissue, etc., yet the early depression and collapse depend rather on the gastric irritation, nausea, and vomiting, and are due to reflex action on the sympathetic and pneumogastric centres. We know that nausea from any cause is accompanied with prostration, faintness, chilliness, and pallor, and antimonial nausea causes the same symptoms in a similar manner, without invoking any speciality in its action.

Tolerance we may explain in some instances, perhaps, by the fact of only partial absorption occurring, *e.g.*, through deficiency in the gastric secretions during fever; but this will not explain it so completely as some have supposed, because the induced feebleness of circulation and respiration, and occasional occurrence of organic lesions, prove that sufficient absorption must have taken place to cause the ordinary effects. A more reasonable explanation is to be found in the *impaired condition of the nervous system*, and especially the diminution of reflex excitability in the subjects of "tolerance".

We may say that all those in whom it is evident *at once* (so that they bear "Rasorian" doses of one or more drachms without

any pain or vomiting), are either suffering from some neurosis of the stomach or vagus, or from some grave malady as pneumonia, which clearly lowers their vital power: and in those persons in whom tolerance has been *slowly* induced by the gradual increase of small doses, we may presume that antimony has exerted its known power of diminishing reflex activity, and has thus reduced the patients in this respect to the condition of invalids, even if in other respects convalescent. Moreover in many cases of tolerance, though there has been no vomiting yet diarrhœa has occurred, and the absence of *vomiting*, which is a complex act, may simply mean that reflex power is too much impaired for its production, diarrhœa being a simpler process. In women and children, reflex activity is higher than in the average man, which fact would, according to the previous hypothesis, explain why tolerance is less readily induced in them.

SYNERGISTS.—Other emetics such as ipecacuanha, and other purgatives such as calomel, increase the effects of antimony. Sedatives such as bleeding, and more especially digitalis, conium, and veratrum, have an allied action: also other medicines which, under certain circumstances quiet febrile excitement, as quinine in full doses, arsenic, bromides, citric and tartaric acids.

ANTAGONISTS AND INCOMPATIBLES.—Aromatic, alcoholic, and other diffusible stimulants counteract the depressant effects of antimony. Narcotics and especially opium, hinder its special action (Rasori)—Gubler calculates that opium lessens its power by one-half, and considers it much better to give a half-dose in any case, or to give the narcotic separately, than to combine such antagonists. Graves, however, has proved a clinical value in the combination, and Laennec found antimony better borne when conjoined with opium and aromatics.

Cold acts as a partial preventer of vomiting, and *warmth* of diarrhœa. *Mechanical antidotes* are such as oil, thickened milk, and mucilaginous substances; tannin, in all its forms, is a powerful *chemical* antidote,—decoctions of oak and cinchona bark, gall-nuts, strong tea, etc., may be used, and life has been saved by these agents in apparently hopeless cases of poisoning. Small doses of sodium bicarbonate mixed with tea, or some other substance containing tannin are also useful. Diffusible stimulants like

spirits of ether or ammonia should be given to counteract the collapse.

THERAPEUTICAL ACTION. — *External.* — The ointment acts as a strong local irritant, and was much employed when counter-irritation was more highly esteemed than it is at present. The pustulation caused by antimony is more painful, but perhaps more active in its good results than that produced by croton oil.

Phthisis.—In the earlier stages of this disease, when there is evidence of local pulmonary congestion with pain and oppression, and in the later stages when acute general symptoms are not urgent, I have known it serviceable. Dr. Hogg recommended its application on plaster, sprinkling about 4 gr. of finely-powdered tartar emetic upon the surface of an ordinary warm "pitch-plaster": in the course of a few days this produced much irritation and a crop of pustules; it seems rather severe treatment, but is sometimes beneficial (Brit. and For. Rev., ii., 1860).

Meningitis—Hydrocephalus.—In these maladies, the ointment has been applied over the shaven scalp, but the results certainly do not compensate for the suffering caused.

Orchitis—Ovaritis.—Frictions with the ointment have been made in orchitis, along the line of the spermatic cord as far as the scrotum, the skin having been previously punctured. M. Isaac reports well of this procedure (Pract., 1869), but I cannot think it desirable; it has proved unsuccessful under my own observation. Dr. Rigby speaks very highly of the good effect of counter-irritation by antimonial ointment in ovaritis.

Nævus.—Mr. Bateman recommends a resin plaster made with two parts to one of tartar emetic, and applied over the nævus until inflammatory action and pustulation occur (Lancet, ii., 1869). I have several times pursued with success a similar plan.

Lupus—Cancer.—The chloride of antimony has been employed as a destructive caustic for these growths, but is now practically superseded.

Alopecia.—A lotion containing 1 gr. of tartar emetic in ʒi of water has been recommended (B. M. J., i., 1885).

THERAPEUTICAL ACTION.—*Internal.*—The double power of antimony to control the circulation and act as a sedative to the nervous system, at the same time that it increases secretion,

indicates its use in many diseases, and especially in those of febrile and inflammatory character; on the other hand, the extreme depression that may be caused by it has led to serious results in incautious hands; hence much controversy as to the true value of the drug, and whilst by some writers it has been extolled as the best of remedies, it has been described by others as too dangerous a poison to be used.

Forbidden in France by special law in the sixteenth century, it was not long afterwards, received into the Codex, and about the same time our "Earl of Warwick's powder," consisting of the sulphuret of antimony, with cream of tartar and scammony, obtained a wide reputation. The tartrate of antimony and potassium was introduced somewhat later (by Mynsicht), and has continued in general estimation and daily use down to our own time.

Within the last twenty years however, and since the value of tonic and restorative treatment has been better recognised, antimony has, like bleeding and other depressants, been more rarely prescribed, and at present it may be questioned whether its great therapeutical powers are sufficiently appreciated. We do not hold that this, more than other medicines, has a separate or specific action for each of the various diseases we are about to mention,—that it cures convulsion in general, or pneumonia, or rheumatism as separate nosological species, but rather that it exerts an exceptionally marked influence on certain pathological states, which either cause or complicate these and many other maladies.

Fevers.—At the commencement of an attack, when gastric disorder was very marked, an antimonial emetic was formerly much commended. Dr. Gregory often employed it in these circumstances, but he also pointed out the danger of inducing irritability of the stomach, and even inflammation. Dr. Graves and others have taught that such an emetic, given within thirty-six hours of the initial rigor, would often abort the fever; but this is difficult to prove, and is not generally accepted. Modern practice has rather taught us that nausea and vomiting are usually needless annoyances to the patient, though if induced in the early stages, vomiting may certainly relieve headache and severe gastric congestion when dependent upon accumulated mucus and bile.

Dr. Graves originated and highly praised also, the administration of antimony in fever (especially *typhus*) at a stage when cerebral complications are sometimes very severe, *e.g.*, from the seventh to the ninth day. Thus, to a strong adult, suffering from complete insomnia, illusions of the senses, delirium, continued tremor and subsultus, "cerebral" respiration, very quick and weak pulse, sordes, and every symptom of the worst augury, $\frac{1}{4}$ gr. of tartar emetic in water was given every hour: the patient vomited freely (though not immediately) after each of the first four doses, then purging began, the general condition improved, and the man slept: after temporary omission of the medicine, 2 min. of "black drop" (opium) were given every two hours, and on the following day there was free perspiration, natural sleep, and a rational mind; ultimately a good recovery followed (Clin. Lectures).

In other equally severe cases the same dose of antimony has been given from the first with 2 or 3 min. of laudanum, and the results have been such as to warrant much confidence in this method of treatment; it is necessary, however, to use it cautiously, and to bear in mind its weakening effect upon the cardiac muscle, which is already enfeebled from the effect of the disease (Murchison).

Enteric Fever.—Antimony has been commended in this fever, but the intestinal condition requires exceptional caution in its use; it does not of itself forbid the remedy, for diarrhœa and pain have often subsided under it (Trousseau), and when the lungs are implicated it may be especially useful.

M. Bériard records a case of fever with secondary pneumonia and delirium, rapidly passing into a hopeless comatose condition, which was relieved at once by free vomiting and purging from a large dose (nearly 6 gr.) of tartar emetic, and ultimately recovered (Bull. de Thérap., 1873).

Intermittent Fever (*Ague*).—The paroxysms may sometimes be prevented by an emetic dose of antimony, but this is not a special effect of the drug, for it will occur after the use of other emetics.

Scarlet Fever — Measles — Small-pox. — In these disorders, especially when the eruption is scanty or suppressed, antimony may be useful by determining to the skin, and thus relieving the febrile condition and obviating grave symptoms.

I have given tartar emetic in small-pox in varied doses, but have never known it exert a modifying influence on the disease itself. In certain complications, however, such as pneumonia, bronchitis, or acute delirium, doses of $\frac{1}{15}$ to $\frac{1}{4}$ gr. every two or three hours, have given relief.

Antimony is exceedingly useful in the bronchial catarrh which is often a serious complication of measles; besides controlling the general pyrexia, it relieves the oppression of the chest, acts as an expectorant, and tends to diminish a too abundant secretion of mucus, probably by lessening congestion.

If $\frac{1}{2}$ gr. of tartarated antimony be dissolved in 4 oz. of distilled water, a teaspoonful may be given frequently or occasionally, according to the severity of the cough or the oppression. In the case of weakly children, the amount of depression which may be induced requires to be carefully watched.

Rheumatic Fever.—Laennec, Bricheteau, and other eminent physicians of a past generation advocated the use of large and repeated doses in acute rheumatism; but later experience is against their adoption. I formerly used $\frac{1}{4}$-grain doses with advantage, especially when the temperature was not very high. Barbeau quotes cases illustrative of its value in acute rheumatism, when used as an evacuant previous to commencing quinine (Med. Chir. Rev., i., 1857), and Dr. Nias has urged that this drug should be more frequently employed in rheumatism (Pract., vol. ii., 1885). In serous effusions complicating acute rheumatism, the treatment which is often successfully adopted by Jaccoud involves the production of both the emetic and purgative effects of the drug: 30 centigrams of the tartrate are dissolved in 130 grams of julep, and of this a tablespoonful is given hourly, till full effects are produced; a dose of bark is then given, and after an interval, if the temperature again rises, the antimonial is repeated (*Ib.*). He also uses antimony in depressant doses or until vomiting occurs, in cases where the pain has been relieved by salicylates or other remedies, but where high temperature remains or hyperpyrexia develops (*Ib.*, ii., 1888).

Lumbago.—In obstinate cases of ordinary lumbago and local muscular rheumatism, I have ordered the same dose every one or two hours for a short time with excellent results.

Erysipelas.—Desault recommended the frequent use of

minute doses of antimony in erysipelas, giving 1 gr. dissolved in a quart of water in the course of twenty-four hours. Dr. A. J. Walsh has reported a number of satisfactory results under this treatment (Dub. Quart. Journ., Aug., 1850), but I consider that other remedies act still better.

Traumatic Pyrexia.—In febrile conditions resulting from severe injury, antimony has been found useful. Thus, Mr. Denny found it "act like a charm" in a case of gun-shot wound of the chest with inflammatory reaction, rigors, delirium, etc.; some nausea was induced, the pain quickly subsided, and in twelve hours the fever aborted, and sleep set in (B. M. J., i., 1871). Dr. Payne has also used the drug in surgical cases, especially fractures, and finds recovery rapid and fever rare, when it is used; he, however, gives opium at the same time (B. M. J., i., 1884). Surgeon-Major Lawrie speaks in similar terms of its value in the small frequent dose, by which method he is able to use it safely even when muco-enteritis is present (Internat. Jour., 1890). Speaking, however, from large experience, I am satisfied that aconite is a more trustworthy remedy in such cases.

Acute Inflammations—Orchitis, Tonsillitis, etc.—In minor local forms of inflammation, such as of the breast or testicle, of the tonsil or parotid, or of a varicose vein, the good effect of small doses of tartar emetic is often conspicuous. Dr. Beatty especially noted their power of controlling mammary inflammation, as if by "specific action on the gland". After purgation, he gave $\frac{1}{16}$ gr. every hour, never desiring an emetic action, but not objecting to slight nausea (Dub. Journ., vol. iv.). Dr. Churchill found the same plan "more effective than any other" (Midwifery). A case of inflamed varix cured by this method is related by Dr. Spender in his essay on the advantages of small, frequent doses, and he believes that the dose may be adjusted with mathematical precision and certainty: "$\frac{1}{20}$ to $\frac{1}{16}$ gr. given every hour is bound to control a local phlegmon." I have found it good in tonsillitis and parotitis, the pain, congestion, and pyrexia being often quickly relieved, and yet this is not the treatment I usually adopt, nor do I think it so good as that by aconite or belladonna. Surgeon-Major Lawrie recommends the drug highly in cases of acute gonorrhœa, giving 15 min. of antimonial wine every two hours, and this combined with injections

of corrosive sublimate (1 in 15,000) has, in his hands, rarely failed (Ind. Med. Gaz., 1885).

Purulent and Strumous Ophthalmiæ.—In these affections, tartar emetic was a usual remedy some years ago, and doubtless acted by abating local congestion; modern practice, however, places more reliance on the use of topical remedies and of tonics.

Acute Skin Diseases.—When acute eczema occurs in persons of full habit—especially if also of gouty tendencies—and when pyrexia, severe local irritation, gastric disorder, and loaded urine are present, I have seen much advantage from combining antimony with magnesia or other saline aperients, or with diuretics. Meade also writes in its favour (B. M. J., ii., 1864). More recently the claims of antimony as a remedy in inflammations of the skin have been advanced by Mr. Malcolm Morris (B. M. J., ii., 1883), and Dr. Spender (Pract., i., 1885.) Both of these observers give small and frequent doses, 7 to 15 min. of the wine, or $\frac{1}{32}$ to $\frac{1}{16}$ of tartar emetic. Pointing out the chemical analogy between arsenic and antimony, Mr. Morris contends that the latter drug is often as useful as the former in cases of eczema, erythema, prurigo, urticaria and psoriasis.

Dr. Allan Jamieson has recorded cases of dermatitis, eczema, and lichen planus benefited by the same treatment, a usual dose being, however, $\frac{1}{8}$th grain (Brit. Journ., Dermatol., Sept., 1891). In conjunction with Dr. Douglas he has published also remarkable cases of psoriasis passing into exfoliative dermatitis, markedly relieved by antimony: under other treatment one patient got worse from admission to hospital in October till January, but after this was commenced he was convalescent in six weeks: the drug was found to lower temperature, to soften and improve nutrition of skin, to diminish hyperæmia and augment the insensible perspiration,—it did not much affect tissue change: it was good in early congestive eczema and later dry stages, not when oozing:—it contrasted advantageously with pilocarpine (Edin. Med. Journ., June, 1892).

Bronchitis.—Tartar emetic seems to me to exert almost a specific effect on the inflamed bronchial mucous membrane. In the case of old people it is useful especially when the cough is convulsive in character, most troublesome at night, and attended with loud wheezing respiration, paroxysmal dyspnœa, and pro-

fuse secretion of mucus, which is with difficulty expectorated. When inflammation affects the smaller tubes of young adults, an emetic dose may be found sometimes desirable, but as a rule, $\frac{1}{16}$ to $\frac{1}{8}$ gr. every two or three hours will suffice to render free and less tenacious the bronchial secretion, to lower the blood-tension, diminish pyrexia, and relieve local congestion and oppression. The action of the skin and of the kidneys is increased usually in inverse ratio—if one is more, the other is less marked. If cough be very severe, a little morphine or belladonna may be combined with the antimony, whilst in later stages, if more stimulus to expectoration is needed, squill is a useful adjunct.

In the *capillary bronchitis* of children, tartar emetic often proves valuable. Referring to the notes of thirty-three cases treated by it, I find they were all under two and a half years old, and suffered from distressing paroxysmal cough, which caused much exhaustion ; the respiration was much quickened, the pulse 130 to 140, small and feeble, the temperature 101° to 103° F. ; there were the ordinary physical signs in the lungs, the face was dusky and œdematous, the skin covered with a clammy moisture; restlessness was extreme, and cerebral symptoms, such as sopor, delirium, and even in some cases coma, were present ; these patients were ordered small but frequent doses, $\frac{1}{64}$ gr. every half-hour for four doses, afterwards every one to three hours, according to the amount of cough or oppression : of the thirty-three cases, ten vomited within two hours of the first dose, and all showed signs of exhaustion under the medicine, but all of them made good recoveries :—with larger doses I have seen serious depression rapidly develop in old people and young children.

Pleurisy.—In this and other cases of serous effusion, Dr. Nias recommends the more frequent use of antimonials, and has recorded numerous cases of good results following their administration, more especially in pleurisy (Pract., ii., 1885)—Napier corroborates (*Ib.*).

Pneumonia.—The proper treatment of this disease has long been a crucial question, and opinions have varied as to the amount of influence possessed over it by antimony. Very much depends upon the time and mode of administration. Rasori, with his "contra-stimulant" method, aimed at exciting, in or near the inflamed part, an artificial irritation, more powerful than the

original disease, and gave from the commencement large doses, which he rapidly made enormous. Thus one adult was ordered on the first day about 24 gr., and by the eighth, 144 gr. per diem; the amount was then reduced up to the twelfth day, when death occurred: the same patient was bled several times in the course of the attack, this being considered to favour the special action of the drug; there was no evidence of its irritant effect, but such a mode of treatment could not be sanctioned at the present time; and although the mortality in the practice of the Italian physician was less than that of his contemporaries, it was yet very large, and must not be taken as illustrating the results of a judicious use of antimony.

Laennec usually recommended 1 gr. every two hours till 6 gr. had been taken, and then an intermission for the same period; sometimes, however, he increased the dose gradually to 30 gr. in the twenty-four hours. His mortality was about one in twenty, reckoning only well-marked cases; that of Louis, following a very similar method, was about three in twenty. Trousseau and Grisolle, who have treated the subject fully, agree in speaking highly of this antimonial treatment, the former, indeed, so highly that he foresees "a future generation will tax him with exaggeration". The latter observer has specially analysed forty-four cases, showing some strikingly good results as to relief of signs and symptoms and as to brief duration, but these reports must be read in the light of our later knowledge of the *natural history* of pneumonia, which would explain some of the rapid recoveries by the occurrence of a natural crisis: vomiting and purging were often caused to a serious extent (cf. Sturges, On Pneumonia, Appendix G.).

Dr. W. Stokes was one of the earliest British physicians to report favourably of this remedy in pneumonia; he stated that it acted better when given before hepatisation had commenced than afterwards. Sir Thos. Watson also commended it, especially in the stage of engorgement, and Dr. Walshe laid stress upon its value when not given to emesis. Dr. C. J. B. Williams advised $\frac{1}{8}$ to $\frac{1}{2}$ gr. doses every two, three, or four hours during the early stages, combining them with citrate or nitrate of potash (Med Times, i., 1872).

Three grains is the minimum and 16 the maximum daily dos

recommended by the German Pharmacopœia, and this nearly accords with the quantities already mentioned: with them vomiting has generally been observed at first, and is said to have proved useful rather than otherwise, and later on, tolerance has become established so that irritant effects have not been marked; nevertheless, smaller doses are to be preferred. I have found the best results from those ranging between $\frac{1}{100}$ and $\frac{1}{4}$ gr. given every two or three hours, beginning with the smaller amount and increasing gradually so as to produce general effects without vomiting or even nausea. In severe cases with high temperature, small frequent doses of *aconite* are valuable in combination or alternation with antimony, and I believe by this treatment may be effected all the good Rasori expected from preliminary bleedings. In moderately severe attacks with less pyrexia, antimony alone is a good and sufficient treatment from the first, although its special value is shown best when "resolution" begins; it assists the clearing up of consolidations in the lung. Another indication for the remedy is to be found in the presence of various complications, such as bronchitis or whooping-cough, or when the malady deviates from an ordinary course, or occurs after influenza or in emphysematous subjects; then I have reason to express the greatest confidence in it. It is true that Nothnagel, Nöbiling, and others, hold a different opinion; but this may be attributed partly to giving larger doses than the patients could bear, partly to the indiscriminate use of the medicine in all stages and phases of the disease; for Nöbiling speaks of emetic doses which induced *cardiac collapse*, and of small doses being continued till *intestinal ulceration* occurred, results of which I have never seen any indication under the method above recommended. I must, however, guard myself from seeming to imply that it is the only or the best treatment for every individual case: in exhausted broken-down subjects the appropriate time for it is but short, and ammonia, bark, phosphorus, and alcohol must soon replace it, whilst in septic forms of the disorder, which indeed are not infrequent, tinct. ferri perchloridi is rather indicated.

In the serious *lobar pneumonia*, as it commonly affects young children, many authors—Stillé, for instance—question the propriety of giving antimony in any dose, because of the risk of sudden depressing effects; this must be borne in mind, but yet

I have myself seen the remedy so efficient that I advise its employment very much as in the lobular form connected with capillary bronchitis.

Sir George Buchanan, whilst hesitating to recommend antimony as a usual treatment, records that he has seen more benefit from emetic doses of it given at an early period ($\frac{1}{6}$ to $\frac{1}{4}$ gr. every quarter of an hour till vomiting occurred), than from any single remedy,—it seemed to control the severe symptoms and secure a favourable progress afterwards (Lancet, i., 1868); this is, of course, one mode of using the drug, but I prefer small continued doses.

In a careful paper giving comparative results of treatment by aconite, quinine, ammonia, and antimony in 213 cases, Dr. Arthur Jameson concludes that the last gave the best results both as to present relief and lessening of after complications, such as consolidation, etc. He had reason to prefer small doses frequently repeated, about $\frac{1}{20}$ gr. every hour at first for young adults, less frequently when the symptoms are relieved, but continued for some days or a week after the temperature has fallen to normal; he met with neither sickness, diarrhœa, nor cardiac failure (B. M. J., i., 1888).

In cases of *phthisis with intercurrent acute pneumonic attacks*, the remedy is often as useful as in the idiopathic malady, but special care must be taken to avoid emetic or irritant effects, because of the possibly tuberculous condition of the intestine. In "incipient" phthisis, during the stage of cachexia with febrile reaction, small doses lessen irritation and congestion; and even in the developed malady, when there is general pyrexia and constant irritative cough it often relieves, rendering the cough "softer" and expectoration easier.

Inflammatory or True (Membranous) Croup.—In this serious disease antimony often proves useful, especially in the early stages. It first obtained its reputation at a time when spasmodic and catarrhal croup were not well distinguished from the more serious malady, and when recovery from those varieties was reckoned as recovery from true croup; but at present, on account of its depressing effects, most physicians limit its use to a few emetic doses in cases with very severe spasm, and evident obstruction from false membrane (Klemm, Schmidt's Jahrb., Bd

clx.). Dr. Elliotson, however, records cases occurring in infants, and treated successfully with $\frac{1}{4}$ and even $\frac{1}{2}$-gr. doses every four hours—in one case 27 gr., and in another 33 gr. being taken: vomiting occurred and some tetanic spasm, but good recovery was made from critical conditions. Mr. Meek and others report in the same journal cases where $\frac{1}{2}$-gr. and even 1-gr. doses were given with favourable results to children of four and seven years; but, on the other hand, Mr. Kesteven and others record injurious effects (Med. Times, ii., 1856). Professor Bouchut advocates giving $\frac{1}{6}$ to $\frac{1}{3}$ gr. frequently, until emesis and diarrhœa are produced, and he records several cases of recovery in the second and third stages (Journ. f. Kinderkn., 1861, Lancet, ii., 1872).

I cannot adopt the above doses as quite safe, and think that great caution should be exercised as to their use. I recommend rather a solution to be made with 1 gr. in 4 oz. of water, and of this one teaspoonful ($\frac{1}{32}$ gr.) may be given every half-hour for four or five doses; it will often suffice to excite vomiting, which, however, is not desirable unless there be evident obstruction in the trachea; so soon as this obstruction is lessened, the remedy should only be given at intervals of two to three hours: the dyspnœa is commonly removed for a time after vomiting, but if it recur the same effect should be induced again: of course, the patient's strength is to be supported by suitable nourishment, and fomentations, sprays, or other adjuvants may be used. With this plan of treatment I have many times noticed an early abatement of the cough, dyspnœa, and hoarseness, lowering of the pulse-rate, return of natural warmth and colour, and quiet sleep. It is true that the sulphate of copper is often preferred as an emetic; but under the sole use of antimony, as described, I have seen very severe and advanced cases relieved, and if the dose mentioned be found really too small in a given instance, it may be cautiously increased.

Spasmodic Croup—Laryngismus Stridulus.—Antimonial emetics have been very strongly recommended to arrest the paroxysms of this malady (Stillé), but yet, remembering its clear connection with rachitis and impaired nutrition, tartar emetic is not the remedy we should choose for curing its essential cause: bromides, belladonna, and cold bathing, with tonics and nutrients, are more indicated.

Nephritis.—In acute nephritis, whether induced by cold or by fever, antimony has been specially commended by Dr. Bence Jones, Dr. Barlow, and others (Guy's Reports, vol. x.). It would certainly seem, *à priori*, that the action of small doses on the skin and the intestinal tract, as well as on the inflamed organ, should be of favourable character, but practically I have seldom found it to be so. Tartar emetic does not appear to exert any direct special power in controlling disease of the genito-urinary mucous membrane.

Muscular Spasm—Rigidity of Os Uteri—Colic.—Muscular spasm, such as occurs in dislocations, herniæ, etc., may certainly be relieved by emetic or nauseant doses of antimony, and these were, at one time, commonly employed.

In difficult labour connected with rigidity of the muscular structure of the cervix uteri and perineum, relief may also be given by the same means. Dr. Kennedy of Dublin, strongly recommended this treatment, and Dr. Gilmour (Liverpool) quoted a large experience in its favour; he claimed for it also not only an immediate favourable effect, but a good influence on the after-progress of the case, as he found a marked freedom from inflammations where it had been used (Lancet, ii., 1852): practically, however, chloroform has superseded it. It has sometimes been injected into the veins to cause vomiting in cases of obstruction in the œsophagus from impaction of a foreign body, and to cause the expulsion of a calculus in the gall duct.

For **Intestinal Colic,** tartar emetic has sometimes been given successfully by enema. In a case dependent upon obstruction, 3 gr. dissolved in 8 oz. of water were injected per rectum, and after some hours, the obstruction yielded and the colic subsided, without additional nausea or prostration (Lancet, i., 1856).

Constipation.—In obstinate cases connected, in part at least, with deficient intestinal secretion, and occurring especially in old people, small doses of tartar emetic will assist the action of saline purgatives such as sulphate of magnesia. Dr. Nevins has recorded a good illustration of this, and finds that less than $\frac{1}{4}$-gr. doses will usually suffice (Comment., Lond. Pharm.).

It has been maintained by some distinguished writers (Gubler, Chomel, Rayer, etc.), that not only the above-described but all other therapeutical effects of antimony are dependent upon, or

connected with, its emetic, or at least its nauseant action, and are explained either by an elimination of morbid material, or by the profound disturbance and subsequent reaction induced in the economy; but—not to speak of the older cases in which benefit was conferred during "tolerance," *i.e.*, when there was little or no vomiting—I am satisfied that most maladies are better treated by small and frequent doses, which do not cause vomiting, and that only a few cases require the production of nausea.

Mania—Melancholia.—There can be no doubt that the large doses—12 to 30 gr.—formerly given to patients with mental disease, and especially to those suffering from acute or violent mania, served the purpose of quieting their violence for a time, but the general results were rather injurious (Greisinger), and professional opinion is justly opposed to producing temporary quiet by this means (Bucknill). A smaller quantity, however—$\frac{1}{2}$ to 1 gr., thrice daily—I have often known to be well tolerated by men who are in fair bodily health, and it certainly acts better when nausea and depression are not induced. The same observation has been made by Schroeder van der Kolk, a deservedly high authority: he has seen marked benefit from the remedy, and recommends it in pill after meals (to avoid vomiting), the dose to be cautiously increased from $\frac{1}{4}$ gr.

In **Puerperal Mania** the last-named physician has also found small repeated doses very useful, and Dr. E. Kennedy recommends them especially for phlegmatic patients (Amer. Journ., v. 17). Dr. Madden has seen doses of $\frac{1}{8}$ gr. every four hours act very favourably, subduing delirium in a comparatively short time; sometimes he has used doses of 1 gr., which quieted excitement still more quickly, but were liable to depress the action of the heart unduly (Med.-Chir. Rev., ii., 1871).

Puerperal Convulsions.—For convulsions occurring in vigorous muscular objects, with high arterial tension, it is possible that antimony may be sometimes indicated; it has been with advantage combined with bromide of potassium (Pract., ii., 1869). Before the latter drug came into use, I often had recourse to antimony, and in cases connected with renal disorder I observed relief, mainly owing as it seemed to increased activity of the cutaneous and intestinal glands.

Delirium Tremens.—Though antimony is seldom now pre-

scribed for this condition, the good results obtained from it, by Dr. Peddie especially, require some notice. He speaks of uniform success in upwards of eighty cases, treated mainly by $\frac{1}{2}$ to $\frac{1}{4}$-gr. doses, given every two hours until improvement set in; emetic action was not marked, but occurred to some extent with the early doses: secretion from the kidneys and the skin was increased, but he attributed the benefit rather to a sedative effect on the nervous system and the lowering of vascular excitement (Edin. Month. Journ., 1854). In America and in Germany, larger doses have been successfully used—Schroff, for instance, giving 4 to 6 gr. daily, and others the same dose every hour. The practice, however, is dangerous, because in this malady the circulation fails so readily, and Dr. Anstie has pointed out that antimonial treatment, though certainly successful in some cases, has ended unfortunately in others (Reynolds' System, ii.). I have found its moderate use valuable in young robust men, especially in the first attack, and even when much gastric derangement was present: it is not so suitable for old or debauched subjects.

Chorea.—The emetic action of antimony has been utilised for the relief of chorea, and the influence of the remedy has been explained as reflected through the vagus nerve to its central origin in the medulla, inducing sedative effects in that part (Ringer). Boulay and others have recorded successful cases from the use of nauseating doses (Bull. de Thérap., v., 52-4, Lond. Med. Rev., 1861), and Dr. West recommended it; but I cannot consider it a desirable treatment, nor is the evidence in its favour very strong. Comparing it with arsenical treatment in twelve cases in Parisian hospitals, only half the number were reported cured by antimony, and some of these lasted long enough at least for natural recovery (fifty-eight days); whereas of eleven cases treated by arsenic all got well (M. Long). Of course, in comparisons of this kind we must make some allowance for the tendency of chorea to recover under judicious management, independently of medicine, but the general evidence in favour of arsenic much outweighs that in favour of antimony.

Asthma.—Some forms, especially of dry spasmodic asthma, are much relieved by repeated small doses. Dr. Ringer has noted their value in attacks of wheezing and orthopnœa of asthmatic

character to which some children are subject after exposure to cold, and which sometimes follow measles. In such cases he recommends one teaspoonful every quarter-of-an-hour of a solution containing only 1 gr. in ½ pint of water: even this amount may cause vomiting, though that effect is not necessary for relief. Dr. Koch has remarked that the remedy is most useful when the attacks are brought on by peripheral irritation (cold, etc.), rather than by emotional causes; and he speaks highly of a combination with arsenic acid—the arseniate of antimony—which he administers in the form of vapour from a cigarette (Pract., vol. iv.).

Emphysema.—Dr. Koch has found the same salt act well as a nervine and muscular tonic in emphysema, and according to my experience, it certainly deserves further trial.

CONTRA-INDICATIONS.—General feebleness, and especially feebleness of the circulation or digestion, would usually prevent the giving of antimony; hence it should rarely be prescribed in *infancy* or in *advanced life*. To children it has proved specially dangerous sometimes, by inducing a condition of collapse without much warning, but a remedy so valuable in their acute inflammatory affections should not be wholly withheld: in old persons it is more liable to derange the stomach. Before emetic doses are ordered for a patient, inquiry should be made, if possible, as to the existence of hernia, aneurism, or other arterial or cardiac disease, cerebral congestion, uterine displacements, or pregnancy: such conditions should contra-indicate the production of vomiting.

PREPARATIONS AND DOSE.—*Antimonium sulphuratum:* dose, 1 to 5 gr. as an *alterative;* 10 to 20 gr. as an emetic; is seldom prescribed unless in the compound calomel pill (Plummer's). *Antimonium tartaratum:* often given dissolved in plain water, but the pharmacopœial solution of it is the *Vinum antimoniale*, containing 2 gr. to the oz; this is convenient for giving small doses of the drug, especially in febrile conditions, but is not very suitable when larger quantities for depressant effects are required. Dose: *as diaphoretic and expectorant,* $\frac{1}{16}$ to $\frac{1}{8}$ gr. of the powder, or 15 to 40 min. of the wine every one to three hours; for children, smaller doses; *as vascular depressant, or sedative,* $\frac{1}{16}$ to 1 gr.; *as an emetic,* 1 to 2 gr. and upwards. *Unguentum antimonii tartarati* (contains 1 part of tartarated antimony to 4 of simple ointment). *Antimonii oxidum:* dose, 1 to 4 gr. *Pulvis antimonialis* (1 part in 3), the official substitute for James's powder: dose, 3 to 10 gr.—the latter dose causes vomiting. *Liquor antimonii chloridi:* used only as a caustic. *Antimonium nigrum:* not used except in the preparation of antimonium sulphuratum and liquor antimonii chloridi.

ADULTERATIONS.—The powdered tartar emetic may contain free tartrate of potash, lime, copper, iron, or arsenic.

ARGENTUM—SILVER (Ag = 108).

This metal occurs pure in nature, but more often in the form of alloy, as with lead (galena), or combined with sulphur (argentite), chlorine (horn silver), and with iodine, bromine, etc.

Refined silver (argentum purificatum) is placed in the Pharmacopœia as a source of the nitrate, but is otherwise used only in the form of silver-leaf as a coating for pills: its official compounds are the nitrate, the oxide, and the double nitrate of silver and potassium.

ARGENTI NITRAS—NITRATE OF SILVER ($AgNO_3$ = 170).

PREPARATION.—It is prepared by crystallisation from a solution of pure silver in dilute nitric acid: when fused and solidified in moulds, it constitutes the small pencils known as "lunar caustic". Toughened caustic is prepared by adding 5 parts of potassium nitrate to 95 parts of silver nitrate before fusion:—it is also officinal.

CHARACTERS AND TESTS.—The crystals are tabular and colourless, (the primary form is the right rhombic prism), and they form a neutral solution with distilled water: their specific gravity is 4·3. They are soluble in four parts of rectified spirit; when pure they do not blacken on exposure to light, but do so, and readily decompose, on continued contact with any organic substance.

An aqueous solution of the nitrate is precipitated by any soluble chloride, a characteristic curdy-white chloride of silver being formed, which becomes dark on exposure to the air: it is soluble in ammonia, insoluble in nitric acid. A black sulphide of silver is precipitated from a solution of the nitrate by passing sulphuretted hydrogen through it.

ARGENTI ET POTASSII NITRAS—NITRATE OF SILVER AND POTASSIUM.

PREPARATION.—This substance, which is also known as mitigated caustic, is prepared by fusing together 1 part of silver nitrate with 2 parts of potassium nitrate.

CHARACTERS AND TESTS.—It occurs in white or greyish white cylindrical rods or cones: is freely soluble in

distilled water, but only sparingly so in rectified spirit. Hydrochloric acid gives with the aqueous solution a white curdy precipitate of silver chloride, the filtrate from this mixture gives the tests for potassium, *e.g.*, a yellow precipitate with platinum perchloride, and it also evolves ruddy fumes when combined with sulphuric acid and copper, showing the presence of a nitrate.

ARGENTI OXIDUM—OXIDE OF SILVER (Ag_2O = 232).

PREPARATION.—It is prepared by precipitating it from a solution of the nitrate by means of lime-water; it must be kept in a well-stoppered bottle.

CHARACTERS AND TESTS.—It occurs as an olive-brown powder which has a specific gravity of 7·2. It is reduced to the metallic state by a red heat, is soluble in ammonia and in nitric acid, but slightly soluble in water, to which it gives a metallic taste and an alkaline reaction.

Chloride of Silver, AgCl (non-off.).—It is readily obtained by decomposing any silver salt with hydrochloric acid, when it precipitates as a white caseous powder (horn silver): it darkens on exposure, and is soluble in ammonia.

The ammonio-chloride (not official) is an unstable salt, soluble in water. The *chloro-albuminate*, the *iodide*, and the *double iodide* of silver and potassium are soluble salts that do not coagulate albumen. The *hyposulphite* of sodium and silver is astringent and less irritant than the nitrate; the *cyanide* is said to be more readily absorbed.

ABSORPTION AND ELIMINATION.—Nitrate of silver, when taken into the stomach, forms with the mucus and epithelium a thin pellicle, which to some extent hinders absorption. It has a special affinity for the cement substance of epithelial tissues, and the ground substance of connective tissues, and is employed by histologists for staining them a dark brown colour. The chemical change which all silver salts undergo more or less, when in contact with the gastric secretions, results in the formation of a double chloride of silver and sodium, and although *ordinary* chloride of silver is insoluble in water, this *double* chloride is readily dissolved by the gastric fluids; its combination with peptones is also soluble (Bogolowsky, Virchow's Archiv, xlvi., 1869, and others). As chloride and albuminate it

probably passes into the blood, and circulates with it, being retained in solution by the alkaline plasma (Rouget), though Frommann thought that it separated in the molecular form (Archiv f. Path. Anat., 1859). Dragendorff considers that the chemical changes occur chiefly in the duodenum, and that the gastric juice being here neutralised by the bile, silver sulphide is ultimately formed: certainly of unabsorbed silver compounds the greater part passes off by the bowel as sulphuret, colouring grey or black the mucous membrane and the fæces. More of the salt will be absorbed if given in solution in distilled water on an empty stomach, than when given in pill in the ordinary manner. Riemer has shown that in pills (? bread) four-fifths of the silver nitrate is decomposed even before administration (Archiv der Heilk., xvi., 1875). The same observer also sought to prove that molecules of silver pass in a mechanical manner through the intestinal walls, but Fragstein could detect no absorption of freshly-precipitated silver-chloride introduced into the intestine of frogs (Berlin. Klin. Woch., 1877). Orfila and Heller failed to find traces of silver in the blood after its administration; but Orfila and Panizza found it in the urine, and Cloez isolated a globule of the metal from the collected urine of several patients at the Salpétrière. It has been found also in the liver and the bile, and some is eliminated by the cutaneous glands. Rozsahezzi found it in the intestinal contents, after its hypodermic injection.

The most important practical point is, that elimination of silver salts by any channel occurs but *slowly*, so that if they are taken continuously for a long time the reduced metal becomes deposited in the tissues, giving them a dark-grey coloration known as "*argyria*". The gums show the earliest indication of this condition by a bluish line (which is darker than that produced by lead), and parts exposed to light show the colour more than others—thus the lunula of the nail (Falck), the eyes, the face and hands are affected early; the deposit is in the true skin (corium). Neumann examined minutely a portion of the skin of a man who had partial argyria from frequent applications of nitrate to reduce large papillæ on his tongue: dark granules of the metal were found in the upper part of the cutis, in the walls of the sweat-glands, in the connective tissue of hair-follicles, in sarcolemma, neurilemma, and also in the middle coat of vessels;

none were deposited in the epidermis, the mucous layer, or the epithelial lining of hair-follicles or sweat-glands (Med. Record, 1877). When the discoloration is fully developed, the skin assumes a peculiar metallic greyish-blue hue, modified in the cheeks and other vascular parts by the red colour of the subcutaneous vessels.

If the drug be stopped on the earliest appearance of affection of the gums, the general discoloration is not likely to occur. This was shown in the case of a woman who took nitrate of silver for two months—at first $\frac{1}{5}$ gr., and later 2 gr. daily—swelling and redness of gums, with a purple line at the edges, appeared, and there was much tenderness of the mouth, but on ceasing the medicine these symptoms subsided (Bull. de Thérap., 1871). In other cases when large quantities have been taken, every part of the body has been affected. Van Geuns reports that a youth took about $\frac{1}{2}$ gr. of the nitrate daily (with occasional intervals), from his fourteenth to his nineteenth year, none afterwards: he died of phthisis at the age of thirty-five, and not only was the skin coloured, but also the cerebral and spinal membranes, the laryngeal and bronchial membranes, the peritoneum, the papillæ and malpighian bodies of the kidney, the marrow, and the bones; the nervous, the hepatic, and other parts of the renal tissue were reported normal. Heynsius concluded on analysis that the dark granules were not chloride of silver (for ammonia did not affect them), nor oxide, but minutely divided particles of the reduced metal, and this conclusion is now generally accepted (Abstract, Dub. Quart. Journ., Aug. 1858).

Charcot has recorded the presence of silver round the renal glomeruli and in the malpighian pyramids, and Liouville has made a similar observation as to the kidneys, and also as to the choroid plexus of a patient who had taken 110 gr. in the course of nine months, three years before his death. Virchow recorded renal argyria after absorption from connective tissue. (Louisville, Ollivier, and Friedreich have stated that albuminuria may be produced by the prolonged use of silver salts.)

Argyria may follow even *local* applications of nitrate, as in the case of a girl whose throat was repeatedly cauterised—perhaps fifty times in the course of twelve months; she is said to have swallowed the products (Gaz. de Paris, xxviii., 1874). In a case

recorded by Mr. Hutchinson the recent coloration could only be traced to a gargle used many years before without any such effect at the time, which seems almost incredible (B. M. J., ii., 1891). It has occurred also after tracheotomy, the wound having been pencilled "for a long time" (Dict. Encyclop., v., vi.), and in a woman after the continued use of a nitrate pomade for dyeing the hair.

It is important to ascertain, if possible, what quantity of the drug is liable to produce coloration, and the time during which its use may be safely continued. The actual amount deposited is certainly very small: Versmann found only 0·047 per cent. in the liver in a well-marked case, but Krahmer estimated that there must be the residue of at least 1 oz. of the salt to cause discoloration: from 3 to 5 oz. are mentioned as the quantities taken in several instances, but judging from Liouville's case it is probable that less than 1 oz. might suffice, and it would be well not to exceed 300 grains. Six weeks has been named as a safe limit of time for the continued administration of the drug, and I should think it almost impossible for any ordinary dose to produce bad results within that period. Riemer relates a case of tabes in which the patient took 5672 pills of silver nitrate, and the first traces of argyria occurred after twelve months' use of the drug, that is after 2900 pills had been taken, which contained 1740 grains of silver nitrate (Archiv für Heilk., 1875). Krahmer states that the minimum amount of silver which will produce argyria is 450 grains (Husemann).

The sulphide was the salt used in the first authentic recorded case of coloration (Weigel): the iodide is said to be free from this risk, and no case has been traced to it, but Husemann considers this as accidental: the double iodide of silver and potash is also regarded as less liable to be deposited (Delioux). Once established the discoloration is permanent.

PHYSIOLOGICAL ACTION. — *External.* — If moistened nitrate of silver be applied lightly to the skin, it combines with albuminous material, and leaves a white stain, which soon darkens on exposure to air or light, because of its reduction to metallic silver; the darkened epidermis peels off in a few days time. A lotion which will be found useful in removing stains of silver nitrate from the hands is as follows: Iodine, 1 part; potas-

sium iodide, 10 parts; ammonia, 1 part; and water, 100 parts (Med. Times, ii., 1884), but a moistened crystal of cyanide of potassium is a simpler means. Strong applications, such as the moistened stick, or solutions of 1 to 2 dr. in the ounce, cause more or less severe burning pain, and in delicate skins, vesication. On mucous membranes, or moist denuded surfaces, a whitish layer is formed by combination with chlorides and albuminous secretion: this layer soon becomes grey and then dark, and when it peels off may leave the part tender. Applied to a suppurating surface, the solid nitrate combines with the purulent secretions to form a greyish layer, stimulates the healing process, and causes some burning pain and redness near the part; when the superficial eschar falls, as it does in twenty-four to forty-eight hours, fresh and healthy granulations are usually found on the wound. The action cannot extend deeply because of the pellicle which is formed, and the so-called "caustic" effect of nitrate of silver must be distinguished from that of destructive agents, such as potash or acids, for it is produced by coagulating and hardening organic tissues, rather than by destroying them. The affinity of the salt for albumen, and its forming with it an insoluble compound, explain most of the local effects of the nitrate.[1]

A solution of about 20 gr. per ounce brushed over a moderately inflamed part not only discolours it, but reduces its size, controlling inflammation, and constringing the blood-vessels. Rossbach found that the local effect of silver nitrate on the bronchial mucous membrane was to make a limited patch of a white colour, over which the secretion of mucus was absent, and below which the vessels were probably constricted (Berl. Klin. Woch., 1882). The conjunctiva has sometimes been discoloured by continuous use locally of medicinal drops, and in this and other very sensitive parts, such as the schneiderian, buccal, or urethral membranes, much pain, irritation, and increased secretion follow the use of strong solutions. Weak solutions (1 to 3 gr. in 1 oz.) have an astringent and slightly stimulant

[1] The chemical formula of the silver-albumen compound seems to vary under different conditions. Lassaigne gives 84·5 per cent. albumen, 15·5 of nitric oxide of silver; Mulder, 16 of the latter in one experiment, 8·9 in another; Krahmer, nearly 12 per cent. Delioux pointed out that the affinity of the nitrate for albumen is greater than it is for chlorine (Husemann).

action, and do not cause pain except to a delicate membrane like the conjunctiva. Rosenstirn found that solutions of 1 to 10 per cent. always caused contraction of both arteries and veins within a minute after application to the frog's mesentery (Rossbach's Pharmakolog Untersuch, ii., 1876). Fikentscher obtained a similar action on the mucous membrane of the frog's tongue (Inaug. Diss. Erlangen, 1877).

Silver solutions possess also antiseptic power, in degree somewhat proportionate to their strength, and dependent in part, though not wholly, on coagulation of albumen. Nitrate of silver is specially antagonistic to certain forms of vegetable growth; thus aspergillus will not grow in a nutrient liquid, if one-millionth part of silver nitrate be added (Lancet, i., 1885).

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Small doses of the oxide ($\frac{1}{4}$ to $\frac{1}{2}$ gr.), and still smaller ones of the nitrate of silver ($\frac{1}{8}$ gr.) are usually well borne by the stomach; but the latter salt produces a metallic bitter taste in the mouth, and, unless well diluted, causes burning sensations in the fauces. In $\frac{1}{2}$ to 1 gr. doses it is apt to induce nausea or vomiting, pain, and diarrhœa; headache and vertigo are usual accompaniments. The continued use of smaller medicinal doses impairs the appetite, and may induce intestinal catarrh and hæmorrhage. Any amount over 4 or 5 gr. would be usually rejected by vomiting, otherwise it would excite inflammation. After death from toxic doses, the gastro-intestinal membrane has been found soft, eroded, or covered with grey patches. In chronic cases the muscular and mucous coats become hardened and thickened.

Nervous System.—The main point determined by modern investigation into the action of silver compounds is their special effect upon the nervous system. The best experiments have been made upon animals by hypodermic injection of hyposulphites and albuminates of silver, which do not coagulate albumen. Charcot and Ball reported, as usual results of such injection, paraplegia and paresis of pulmonary nerves, probably reflex in character, leading to profuse bronchial secretion and asphyxia (Gaz. Méd., 1864). Rouget found that in mammalia small doses caused excitement somewhat like strychnine; toxic doses induced convulsion and asphyxia. Batrachians got convulsions or tetanic

spasm with suspension of voluntary movement, of reflex action and of respiration, whilst circulation continued; weakness, torpor, somnolence and paralysis also occurred in various degrees (Archives de Physiol., 1873). Professor Curci, experimenting on animals with hypodermic injections of hyposulphite of silver, reports that at first they stimulate sensory nerves, and through them the posterior columns of the spinal cord, so that sensibility to impressions and reflex excitability are increased—this condition extends more or less to the motor nerve-tracts, muscular irritability is heightened, and tetanus may be produced; afterwards follows a secondary effect of paresis of sensory nerve-centres, and of those connected with respiration; ultimately reflex action is arrested, and respiration and circulation cease. We may accept these facts without assenting to the conclusions drawn by Professor Curci from them, viz., that since silver compounds ultimately paralyse, they cannot be of service in paralysis, myelitis, etc., but are only indicated in spasmodic disorders, especially such as affect respiration (Med. Record, 1877).

Bogolowsky, in his experiments, sometimes found the spinal cord so far affected that the bladder became greatly distended.

An exceptional illustration of the effects of the drug on the nervous system may be found in the case of a man accustomed for twelve months to dye his hair and beard with a strong solution, and who suffered general weakness, confusion of thought, loss of memory, tinnitus aurium and defective sight, which symptoms ceased soon after stopping the dye (Bresgen, Schmidt's Jahrb., 1874, Bd. clxii.). Within my own experience I have known men suffering from giddiness, vertigo, and marked nervous depression, amounting almost to melancholia for a similar reason, and recovering quickly after ceasing the application. Convulsions occur in children after toxic doses of the nitrate, but they are probably reflex—*i.e.*, dependent upon gastric irritation (B. M. J., i. 1871).

Circulatory System.—After intravenous injections of silver salts, the blood has been found dark, pitchy, impaired as to coagulating power, and containing small crystals, and "whitish granulations," which were supposed to be chloride of silver (Rabuteau), but are more probably derivatives of hæmoglobin (Rouget). Ecchymoses have occurred, and, together with the

asphyxia and increased bronchial secretion, have been attributed to the altered chemical condition of the blood (Krahmer, Monograph, 1845), but such alteration is not produced (in an acute form) by silver administered in any other way than by direct injection into the blood. Even toxic doses given in other ways do not alter that fluid beyond some lessening in the amount of hæmoglobin and increase of fibrin (Bogolowsky, Rouget); the spectrum remains normal. But after the continuous use of full doses of albuminate or phosphate of silver, the condition of the blood certainly becomes impaired; the fluid is found to be thinner and darker, and it tends to stagnate in, and transude through, the vessels, whilst the corpuscles part with their hæmoglobin, and become pale, transparent and angular or oval, with projections: according to Bogolowsky, they do not contain silver, as sometimes asserted.

Sudden arrest of the heart's action, as well as asphyxia with profuse bronchial secretion, were symptoms noted by Charcot and Ball after injections of silver nitrate into the veins of animals. Rabuteau, arguing from the same results, considered the drug to be a "cardiac poison," but it is clear that when thus injected directly into the circulation, the production of thrombosis or embolism may complicate and obscure the special effects of any substance. Rouget found that after hypodermic injection of toxic doses in the lower animals, the heart continued beating after respiration had ceased—*i.e.*, it was not "poisoned"; nor is there any clinical evidence of the salt depressing the circulation, unless in a secondary manner during irritant or chronic poisoning.

Respiratory System.—Orfila first described asphyxia as a result of injecting silver nitrate into the veins, and after death he found partial consolidation of the lungs, and excessive secretion in the bronchial tubes. Several observers have corroborated these results, and it has been a question whether they are mainly mechanical from thrombosis, or reflex effects of irritation of the lung (Charcot), or dependent upon direct irritation and paresis of the respiratory centre in the medulla, and of the neighbouring vaso-motor centre. The observations of Rouget point to the latter conclusion. He found that in most animals urgent dyspnœa occurred, and post mortem the lungs proved to be

healthy in texture, but much contracted in volume—the muscular tissue of the bronchi being in a state of spasm similar to that of asthma. In adult specimens of only one order of animals (carnivora) did he find the excessive secretion described by Orfila, and he considered that only in these were the vaso-motor centres affected. That the main effect is exerted on the central rather than on peripheral nervous elements, he further supported by showing that nerves and muscles retained excitability after death. Later observations by Rozsahezzi on rabbits show that in chronic poisoning by silver there is constantly hyperæmia of the laryngeal and tracheal mucous membranes, also of the lungs, and in these organs often œdema was found, with congestion, ecchymoses, effusions, cheesy masses, and sometimes a condition resembling phthisis (Archiv, f. Expl. Path.).

Nutrition.—Krahmer concluded from observations on himself that the presence of silver in the system lessened oxygenation and the excretion of urea, of uric acid, and of the watery constituents of urine; the non-nitrogenous elements were however increased, and the specific gravity rendered higher. If the administration of silver salts be continued beyond a certain point cachexia sets in, appetite and digestion are impaired, catarrh and effusions take place, the temperature is lowered, and the action of the heart and lungs weakened. The general debility and emaciation are mainly dependent upon gastric irritation, but the drug seems to exert a special "alterative effect" on tissue-change. Dr. H. Wood classes it with "mineral astringents," Dr. Bartholow with "agents increasing waste," but I think it better placed amongst those that moderate or retard nutritive processes. Rozsahezzi proved a very marked diminution of tissue-change and of weight, under the continued influence of small doses of nitrate: this occurred even whilst the animal was taking a good amount of food, and when no increased excretion could account for the loss; he thinks it indirect, and due to impaired condition of the blood and muscles. He finds (as opposed to Bogolowsky) that small doses cause a rise in temperature, but agrees with Falck that large ones lower it.

When death has followed the long-continued use of the drug, the epithelial structures, and the solid tissues generally—the liver, heart, muscles, kidneys, etc.—have been found in a state

of "cloudy swelling" and fatty degeneration, and the metal has been detected in most parts of the body.

Fatal Dose (Acute Poisoning).—This varies with the gastric condition, period of vomiting and of treatment, etc.: 30 gr. of nitrate have caused death in one case, whilst 1 oz. has failed to do so in another (that of Poumarède). Large doses have been neutralised by excess of natural mucus, or of albuminous food.

SYNERGISTS.—As regards local effects, the nitrate is allied with irritants and caustics, such as iodine and arsenic. In its general action especially in therapeutical doses, a resemblance may also be found with these medicines as well as with compounds of chlorine, bromine, and salts of bismuth, and in a less degree, of zinc. Some analogy with strychnine has been traced (Charcot).

ANTAGONISTS AND INCOMPATIBLES.—Sulphuric, hydrochloric, and tartaric acids and their compounds are chemically incompatible, as well as alkalies and their carbonates, astringent infusions, and lime-water; also creasote. All soluble chlorides and cyanides are incompatible, since they precipitate an insoluble chloride or cyanide of silver respectively, and most natural waters do so because they contain common salt: this salt is the best antidote to poisonous doses of the drug, and should be given freely so as to cause emesis as well as to neutralise the poison.

The oxide has been given as an antidote in chronic arsenical neuritis to form an insoluble arseniate of silver, and apparently with benefit (Lancet, ii., 1890).

THERAPEUTICAL ACTION.—*External.*—Nitrate of silver may be applied either as (1) a caustic, (2) an astringent and alterative, (3) a counter-irritant, or (4) a direct irritant.

1. *Caustic.*—**Lupus.**—In cases of tubercular and ulcerating lupus the "lunar caustic" is sometimes suitable, and in the hands of Hebra, Neumann, and others, has given good results. No ordinary application or simple pencilling will be of any service, for it will not extend deeply enough, but a well-pointed "stick" should be firmly pressed into the soft tissue, in various directions and until hard tissue is met with: this is an extremely painful process, and in my experience can seldom be thoroughly done except under chloroform. As a rule, I prefer the nitrates o

mercury or of zinc, but silver has the advantage sometimes where the face is affected, because its action can be so precisely limited to the diseased part, and does not cause so marked a cicatrix. Dr. Piffard recommends fine needles to be coated with the caustic and passed into the growth, finding this to be less painful than Hebra's method. Soothing applications such as poultices and lead lotions should be made after the cauterisation, which may require repetition once or even twice weekly for some time. M. Claude specially recommends the double iodide of silver and potassium (internally) in lupus and skin disorders.

Warty Growths—Corns, etc.—The use of the stick-nitrate for destruction of these growths is familiar in practice, and is safe and painless though not very quick in its results, for only a thin layer can be acted upon at each application: the part should be thoroughly softened and pared before the remedy is applied.

Carcinoma.—For the removal of cancerous growths, Thiersch has employed injections into their substance of solutions of 1 part of nitrate in 2000 or 3000 parts of water; this is followed by a similar injection of dilute chloride of sodium (1 in 1000), and is said to cause quick disintegration and wasting of the morbid tissue. There is some independent confirmation of his results, but usually suppuration and sloughing have occurred—an effect which Thiersch did not intend (Archives Gén., Jan., 1867). I am not aware that the method has been extensively tried.

Poisoned and Dissection Wounds.—In such wounds a liquid and penetrating caustic, like nitric acid or caustic potash, is more thorough in its effects, but nitrate of silver being portable and at hand, has often been employed with good results; its antiseptic power is a recommendation. Mr. Youatt reports that he was bitten several times by rabid animals, and after a free use of this remedy had no ill results; but the degree of security given must vary with the thoroughness and time of the application.

Variolous and other Pustules.—Lunar caustic has proved useful sometimes in aborting purulent formations. The absence of pitting after small-pox being dependent upon the small size and limited inflammation of the pustules, Velpeau and others have endeavoured to secure such a result by puncturing the vesicle on the third or fourth day, and touching the interior with a fine point of the nitrate; if well carried out this plan has often

succeeded, but it is painful, tedious and not free from danger; the plan devised by Dr. F. Bowen is an improvement upon it, and is much more feasible, *viz.*, puncturing the vesicle with a fine needle dipped in a solution of the salt (20 gr. to 1 oz.),—a nurse can do this quite well. In one case all the parts thus treated recovered perfectly, whilst the vesicles that were untouched left deep scars (quoted by Ringer). Mr. Higginbottom recommends painting of the face with the same strong solution that he used for erysipelas (80 gr. to $\frac{1}{2}$ oz.), but this it too painful for ordinary use.

Parasitic Skin Diseases.—Nitrate of silver has been employed in tinea, pityriasis versicolor, and other cutaneous affections due to parasitic growths. The rounded, white, firm tumours of molluscum contagiosum are efficiently treated by evacuating their contents and applying nitrate of silver to the interior, as above described for variola.

Chancre.—Opinions have differed as to the possibility of preventing venereal infection by applications of nitrate to the sore soon after its appearance; authorities in favour of such practice are to be found amongst earlier writers, but modern opinion is decidedly against it. Hunter, Ricord, and Acton (writing in 1846) agree in stating that if the commencing chancre, the vesicle, or pustule be thoroughly cauterised within three to five days of its origin, the cure is rapid and systemic infection very rare; but they agree also that if the sore be indurated no effect is produced, so that some of the cases they relied upon were probably "soft and non-infecting chancre": on the other hand, Diday, Langston Parker and others, have thus destroyed chancres within a few hours of their appearance, and yet an indurated sore and secondary symptoms have followed. We must conclude that cauterisation of a true Hunterian chancre at any stage will not prevent its development or the occurrence of secondary symptoms.

Early cauterisation of soft chancres will, however, sometimes cause rapid healing, and is a good treatment for sloughing or rapid spreading; but it is very painful, and the sore will usually heal under simple treatment. In syphilitic ulcers of the leg I have seen solid gelatinous fungating growths, which are well treated locally by pushing in a point of caustic and breaking them down freely with it, as already described under lupus. For

syphilitic cracks, fissures and ulcers on the tongue, fauces and cheeks, the solid nitrate applied daily is very useful.

Granulations.—A minor degree of the caustic action of nitrate of silver will repress exuberant granulations in wounds; they should be pencilled every day or every second day.

2. *Astringent and Alterative.*—By the latter term we mean to express the modifying effect exerted on tissues, and especially on mucous membranes, whereby an unhealthy condition usually inflammatory in its nature is subdued, and healthy action is set up in its place. Trousseau taught that this effect is due to the new agent (nitrate of silver) causing a more powerful inflammation than the original one which it displaces, afterwards itself subsiding; and this idea he developed at length under the term, "médication irritante substitutive" (Mat. Méd., i.), but we cannot prove the occurrence of any substitutive inflammation of this kind. We refer the effects of the remedy partly to its known physical properties of constricting vessels, of coagulating and disinfecting secretion, and of forming an adherent protective membrane; also, in certain conditions, *e.g.*, in ulceration, the vessels immediately acted on being constringed, those in the neighbourhood receive a better supply of blood, and the processes of repair are quickened; the remedial power which is special to the drug, which distinguishes it from other astringents, and by which it modifies nutritive processes, we can only express by the term alterative.

In many forms of disorder accompanied by *discharge*, whether hæmorrhagic, mucous, serous or purulent, the nitrate, either solid or in injection or spray, is very valuable. Delioux recommends the hyposulphite of soda and silver as equally astringent and less irritant.

Hæmorrhage.—In cases of continued oozing from small points in the skin or mucous membranes, such as occurs after leech-bites, a finely-pointed stick of nitrate firmly pressed on the part is a good astringent. In bleeding from the mucous membrane of the bladder, such as accompanies vesical tumour, injections should be made beginning with weak solutions, and increasing the strength by degrees if necessary. Mr. Christopher Heath speaks highly of this plan, and I have seen several instances of its successful use in his hands.

Chronic Cystitis.—After washing out the bladder, a solution containing 1 to 2 gr. in 1 oz. of distilled water should be injected and allowed to remain for some minutes, or until micturition occurs; this lessens the muco-purulent ropy secretion from the vesical membrane. Mr. Reeves has used with success 20 gr. in 1 oz. (Lancet, i., 1853).

Gonorrhœa.—At the commencement an injection containing 30 or even 60 gr. to the ounce has sometimes succeeded in aborting the malady, but it causes severe pain, and may lead to serious inflammation. In the female a similar solution applied thoroughly, per speculum, to the vagina has given better results, and offers less risk on account of the anatomical conditions; but, as a rule, the frequent use of a weaker solution is more advisable. I recommend, so soon as the acute inflammatory stage begins to subside, an injection containing $\frac{1}{2}$ to 1 gr. in the ounce every three or four hours, or sometimes a strength of only 1 gr. in 8 oz., to be injected every half-hour for the first eight hours, and afterwards every four hours until cure is effected, which should be in twenty-four to forty-eight hours. I have had most excellent results in many obstinate cases from this method; it should not be wholly omitted at the end of forty-eight hours, but used once, or twice, or if the discharge continues, a little oftener for the following two or three days.

Balanitis.—Gonorrhœal inflammation of the glans penis is effectually treated by the frequent use of a weak lotion (1 gr. in 1 oz.) in addition to light pencilling with the solid stick.

Spermatorrhœa.—The treatment by local application of a strong solution to the prostatic urethra in the neighbourhood of the openings of the seminal ducts was strongly commended by Lallemand, but his statements are exaggerated; it is useful sometimes, and was markedly so in the hands of Dr. Dawson (On Spermatorrhœa), but it should not be employed without due consideration: I have seen serious consequences follow it.

Leucorrhœa.—Injections of silver nitrate have been found effectual in the vaginal form of this disorder, the strength of application being proportioned to the duration of the malady: a drawback to its use is the staining of linen. (There are several varieties of leucorrhœa, and each must be treated on its own merits, as some will require internal remedies as well as injections

—the checking of discharge by this or other astringents is only one part of successful treatment.)

In *uterine* leucorrhœa the discharge is glairy and stiffens the linen, and is accompanied with distinct suffering. It is usually connected with cervicitis or endometritis, and in chronic stages, especially when the os uteri is patulous, solutions, and even the solid nitrate, have been passed into the uterine cavity with good result (Dr. Henry Bennet): this, however, has led to some abuse of the remedy, and I have seen very painful symptoms connected with induration of the cervix and narrowing of the canal as a consequence of too prolonged a course of cauterisation.

Granular Erosion of Cervix (formerly known as *ulceration*). —The nitrate has been much used in this condition, but the solid salt can exercise only a limited influence. In chronic cases, where the part is enlarged, and the epithelium so long absent that the bared villi resemble granulations, I have found benefit from recently-prepared iodide of silver, as recommended by Dr. Henry Wright.[1] All mechanical causes of erosion of cervix such as impacted fæces, must be considered, and if present, treated at the same time.

Real *ulceration* of the cervix, as distinguished from erosion, is usually connected with syphilis, struma or malignant disease, and although the nitrate has been often used for it, more potent remedies, such as the acid nitrate of mercury, are really required.

Ulceration.—When an ordinary ulcerated surface is discharging freely, a lotion of moderate strength is usually more suitable than the solid nitrate, because it does not involve confinement of discharge under a limiting membrane (though, indeed, such membrane may be punctured if necessary).

The best use of the solid stick is made in indolent ulcers with pale small granulations, and but slight discharge. The remedy should be lightly applied over the central parts, avoiding the new tissue at the margins, and under this stimulus and the protection of the film which is formed, healing will be much quickened. The brittle stick nitrate is superior to the prepared points of "lunar caustic," for it is more soluble. Cuthill insists on the

[1] To a little of the strong silver solution (ʒj. in ʒj.) a few drops of tinct. iod. are added, and the iodide of silver precipitates at once in white flakes, which should be quickly applied—through the speculum.

importance of stimulating an ulcer rather by dots and lines of silver nitrate than by coating its whole surface, better exit for discharge being thus given (Edin. Med. Journ., 1877).

Purulent Ophthalmia.—In the ophthalmia of new-born children, and also in the epidemic and the gonorrhœal forms of the disorder, solutions of nitrate are extremely valuable, though they often cause severe pain for a time. The lids should be separated and the eye cleansed by a stream of tepid water, and in acute not very severe cases, a few drops of a solution (2 to 5 gr. in 1 oz.) should be instilled—in very severe cases with chemosis, a strength of 20 or 30 gr. in the ounce may be employed once or twice daily, but should be followed by a syringeful of plain water, or of weak salt-solution, in order to neutralise any excess of nitrate. In chronic cases, especially when scrofulous in character, with thickened conjunctiva, photophobia, lachrymation, etc., the solid stick may be lightly used to the lids with advantage; but in all cases the liability to discoloration must be remembered, and the remedy not be used too often nor too long; when ulceration is present, or the membrane not entire, other remedies should be preferred.

Otorrhœa, with perforation of tympanum and with tendency to formation of polypus, is best treated by touching the tympanic mucosa with a concentrated solution of the nitrate; the discharge should be daily removed by ordinary antiseptic lotion.

Ozæna—Coryza.—In chronic nasal discharges if the bones be not seriously affected, and in ordinary coryza, benefit may be derived from injections of nitrate of silver (2 to 5 gr. in 1 oz.). In the former condition, a cleansing and disinfectant nasal douche should first be used, and afterwards the astringent should be injected from behind forwards by means of a curved tube passed to the back of the fauces, and connected with a rubber ball.

Nitrate of silver in various forms is an important agent in the treatment of diseases of the *throat and air passages*, but its strong caustic action is invoked much less frequently now than formerly; we require rather the astringent or alterative action to relieve congested, or brace relaxed parts. Dawosky concludes, after extensive experience, that whenever local applications are required for congested mucous membranes, nitrate

of silver gives the best results; besides its chemical influence, it stimulates the congested vessels to contract and get rid of their excess of blood. For congested conditions of the fauces with adherent secretion and patches of redness and swelling, he recommends a strength of 1 part in 8 (Med. Record, March, 1878), but I think it better to *begin* with half this proportion.

Tonsillitis.—In the early stage of this inflammation—it must be at least before suppuration has set in—a strong solution (30 to 60 gr. to 1 oz.) applied once in twenty-four hours will sometimes abort further progress. Judgment is required to determine the suitability of cases for this treatment, for if the inflammation be very acute, irritant applications may increase it. In sloughing ulceration about the fauces, strong nitrate solutions are sometimes serviceable, and are better than the solid caustic; but more active disinfectants, such as iodine or carbolic acid, are still better. In chronic enlargement of the tonsils, the occasional application of a finely-pointed stick of nitrate of silver thrust well into the substance of the enlarged gland causes cicatricial contraction and diminution of size.

Diphtheria.—In diphtheritic inflammation with membranous deposit, I cannot recommend the strong nitrate; if the part be irritated it is more liable to inflame, and if the membrane be roughly detached the absorbents more readily receive morbid material, so that although this remedy was at one time commended, I am satisfied that the use of a solvent or disinfectant spray is more serviceable, and is far more thoroughly and easily effected. Strong nitrate of silver is not a suitable local remedy for membranous croup (laryngeal diphtheria), or *acute* congestion of the larynx. I have seen almost fatal suffocative spasm of the vocal cords induced by the application of the solid nitrate in the latter condition. Guillon, however, states that the insufflation of finely-powdered nitrate may be very useful (Med. Record, 1877); sometimes a weak spray (1 gr. to 1 oz.) has been of service. Dr. Gibson recommends the inhalation of air from a bottle with a quantity of powdered silver nitrate at the bottom of it; this should be diluted with dried starch, tragacanth or lycopodium, in the proportion of 1 gr. of silver nitrate to 19 of the diluent (Lancet, i., 1882).

Œdema Glottidis—Chronic Congestion.—This severe

form of œdema is sometimes quite controlled by strong silver nitrate solutions, which may obviate the necessity for scarification or more serious procedures. In *chronic* laryngeal and faucial congestion, a curved brush carrying a solution of 20 to 30 gr. to the ounce may be applied with the help of a mirror to the exact part affected, and with very good result. Dr. Horace Green and the late Dr. Hughes Bennett were early advocates of this method of treatment. Many surgeons, however, now prefer solutions of copper, zinc, or iron, as causing less irritation, and less risk of subsequent contraction, than the silver salt. A *weak* spray is of very little service in these conditions, and the use of the brush has largely superseded the method of insufflation which was approved by Trousseau. He used 3 gr. of the nitrate mixed in fine powder with 60 gr. of sugar of milk, and this was blown into the patient's mouth during a deep inspiration, by which some of it was carried into the larynx.

Laryngeal Phthisis.—The solution is, according to my own experience, of much service in the early stage of this disease, and was recommended by the late Hughes Bennett, Dr. Marcet, and others, but objected to by L. Thomas (B. M. J., i., 1878); menthol is now generally preferred. It has been advised in malignant disease.

Relaxed Throat, etc.—It is however in chronic relaxed conditions of the fauces and pharynx, with dysphagia and constant discomfort, aching in the throat, cough and hawking of phlegm, that the remedy gives most relief. There is no acute inflammation present, and the affected parts are either pale with prominent follicles, or swollen and of purplish colour, with more or less viscid, yellowish secretion. In " clergyman's sore throat," the follicles of the pharynx mainly are affected, and in all these cases a solution of 20 gr. to the ounce, with glycerine, should be applied once daily or on alternate days, whilst tannin, borax, etc., are used in the intervals.

In *aphonia* connected with local debility and relaxation, silver applications relieve by their astringent tonic action, and in hysterical aphonia the irritation excited is often sufficient to restore the voice.

Relief may also be given to obstinate *coughs* arising from relaxed faucial conditions, and not amenable to internal remedies.

by a solution containing about 5 to 10 gr. in the ounce, applied once or twice daily.

Chronic Bronchitis.—In cases accompanied with profuse muco-purulent discharge, I have often proved the efficacy of a spray containing nitrate of silver. I use only weak solutions—from 1 to 4 gr. in the ounce—and find that they alter and restrain the secretion in a very satisfactory manner.

Erysipelas.—The power of the remedy in this disease depends much on the mode of its application; the mere drawing of a line of caustic round the inflamed margin (as sometimes practised) is illusory. The best method is that of Mr. Higginbottom, who advises previous cleansing of the part with soap and water, then with pure water, and afterwards the thorough application of a saturated solution (20 gr. in each fluid drachm) two or three times over the whole affected surface, and beyond it on the healthy skin for about two inches. This is effective in the superficial forms of erysipelas, but not, according to my experience, when much œdema or cellulitis are present, and I am reluctant to advise it over an extensive surface, or in the idiopathic form. It causes severe burning pain, and in the latter condition at least, does not always stay the inflammation, so that I prefer milder applications and appropriate internal medication.

Whitlow—Furuncle—Erythema.—These conditions are sometimes advantageously treated by the method of Higginbottom, but the solution may be made weaker, and nitrous ether employed as the vehicle: it does not dissolve so much as water, but 30 to 40 gr. in the ounce will be strong enough; this should be painted over the affected finger, or the commencing boil, or the inflamed and irritable patch, but practically carbolic acid has superseded it. Chilblains are relieved by the nitrate, and it is said to prevent a threatened eruption of herpes if used early enough. To *bedsore*, in any stage, a solution of 5 to 10 gr. in the ounce may be applied with advantage.

Eczema.—The use of strong nitrate of silver in eczema should be reserved for chronic patches with much infiltration. Nitrous ether proves the best vehicle, because it dissolves sebaceous or fatty secretions, and allows the remedy to act better on the distended capillaries—30 to 40 gr. in the ounce may be used. Eczema in the neighbourhood of ulceration yields to lotions of

moderate strength. For eczematous or aphthous conditions affecting the genital organs or the nipple, and commonly accompanied with severe itching and irritation, a solution containing 4 or 5 gr. in the ounce should be first used in cases that are somewhat acute; but if relief be not given, a paint containing 30 to 40 gr. in the ounce should be carefully and lightly brushed over the part. Quite the best treatment for fissured nipples is to touch them thoroughly but lightly with a fine point of nitrate: all secretion should be cleansed from the part before such applications, and warm fomentations should be ready for use afterwards, as the pain may be severe. In abrasions or aphthous conditions about the mouth, the solid nitrate is one of the best remedies although a painful one.

Burns and Scalds.—In superficial burns the strong solution has been applied, and to deeper injuries when the true skin is affected, the solid stick has been used with the object both of forming a covering from air, and of lessening the degree of cicatrisation (Fricke). This method has not met with general support, but a modified plan was recommended by Mr. Skey, who used a lotion containing about 6 gr. in 1 ounce for infants, and twice that strength for adults, covering the part immediately afterwards with cotton wool (Lancet, ii., 1861). A mixture with linseed oil has been commended (Wernher), and the solid stick is always useful in later stages when ulcerations are slow to heal. Hebra applies it once or twice daily, especially where there is liability to adhesions.

3. *Counter-irritant.*—The action of the remedy when applied locally in superficial inflammations, has earned for it the title of "caustique antiphlogistique," but we cannot recognise in it any distinctly caustic action, any more than we can verify the production of a "substitutive inflammation," which replaces for a time the original malady, and then itself subsides. The main factor in the result is an astringent effect on the vessels and nutritive processes, but there are cases in which, when the nitrate is applied to some other than the affected part, it will relieve by an action which may properly be called counter-irritant or derivative, the "médication irritante transpositive" of Trousseau. Thus, Liston and Elliotson treated erysipelas by its application to the neighbouring *sound* skin, and Lubanski,

Egan, and others treated amenorrhœa by pencilling the os uteri (Dub. Journ., 1848).

Orchitis—Synovitis.—In these deeper-seated inflammations, benefit may be obtained from strong nitrate of silver applied on the principle of counter-irritation. The best position for the application has been much discussed, some placing it as near the part as possible, others insisting that it shall be between the heart and the inflamed tissue, and others that it shall affect vessels which receive their supply from a different source than the affected part. The simple rule adopted by Mr. F. Jordan, with much success, is to apply the nitrate over the *adjacent vascular territory;* thus, in orchitis he acts upon the great vessels in the groin and front of the thigh (Pract., vol. ii.). In synovitis it is used round the affected joint, though iodine is usually preferred in this disorder.

In irritation of the *prostrate gland or seminal ducts*, it may be applied to the perineum, rather than to the urethral membrane itself.

4. As a *direct irritant* (the "médication excitative" of Trousseau), the nitrate finds some applications.

Hydrocele.—The solid stick may be applied, for instance, to the interior of a hydrocele-sac after evacuating the contents, but an injection through a trocar is more under control: the object is to excite sufficient inflammation to induce adhesion; this is now better effected by iodine.

In **Sciatica** of chronic and obstinate character, 10 to 20 drops of the solution injected deeply near the seat of pain will lead to a localised suppuration which sometimes quite cures the original malady: it is best used in the nates at the point of emergence of the sciatic nerve.

In other chronic obstinate neuralgiæ, and according to Le Dentu in any deep-seated neuralgic pain of any part, he injects deep into the cellular tissue 2 or 3 drops of a solution containing 1 part of silver nitrate in 5 of water: this causes acute pain for the moment, and sometimes a small abscess afterwards, but never serious trouble (Med. Record, 1877). Dureau (Thèse, Paris, 1877) sums up very favourably the experience recorded of this method of treatment; it is said to be both certain and rapid in its effects, and not to cause much irritation of the deep tissues.

Luton used a 10 per cent., also a 5 per cent. solution, and others one of 25 per cent., injecting 5 min.—all with successful results (Record, 1882)—but chloroform is now generally preferred for use in a similar manner.

In **Chronic Joint Disease, Synovitis,** etc., equally good results have been recorded from the method of Luton—*i.e.*, deep injections into the joint-cavity (Med. Record, 1877). The process may be compared with that of Thiersch for cancer, in which weak solutions only are used, and suppuration is not intended.

THERAPEUTICAL ACTION.—*Internal.*—The value of silver compounds is acknowledged in certain disorders of the gastro-intestinal mucous membrane, and of the central nervous system. In the former their action is a local one, doubtless of the same character as that exerted upon the external surface; in the latter they are given for a "constitutional" effect of tonic or indirectly sedative character, which may perhaps be resolved into a regulating or astringent effect upon the capillaries.

Dyspepsia—Chronic Gastritis and Gastric Catarrh.—The nitrate and the oxide are both valuable in many of these cases, and in judging of their suitability in a given instance, it is not easy nor is it essential, to draw a definite line between functional and organic disorder. Gastric pain, especially when severe and coming on some time after food, with tenderness, distension, pyrosis and vomiting, are sufficient indications. Dr. J. Johnson, one of the earliest observers of this use of the nitrate, found that mental depression, or motor disturbance of convulsive character, furnished additional indications for it (On Indigestion, 1826). Dr. Symonds recommended it "in nervous irritability with passive or chronic congestion of the stomach." In Dr. Hudson's cases, pain of very acute character and long duration, with distension, thirst, constipation and vomiting of sour fluid, were relieved within one or two weeks, but he gave the remedy ($\frac{1}{4}$ gr. doses) with opium ($\frac{1}{4}$ gr.) and hop (Dub. Journ., 1840). Dr. Osborne, a distinguished Dublin physician, found it valuable in gastralgia with "sour vomiting" (1831), and more recently we find Dr. Spender praising it as the "best remedy in pyrosis" (Pract., 1868), and Dr. H. Wood, "in vomiting of much yeasty fluid." I should attribute importance to its disinfecting pro-

perties in such cases. Dr. Wilson Fox added his testimony to the "well-established reputation of the silver salts in chronic gastric catarrh," and placed them next to bismuth: he would generally prescribe them however with opium, whilst Frerichs, also a high authority, gave them with belladonna. The absence or the presence of constipation will be a useful guide to the choice of these adjuvants. In gastritis Dr. A. Fleming obtained very good results from the nitrate, and his mode of using it would seem to obviate, if that be necessary, the objection urged by Brinton, and to some extent by Husemann, viz., that the smallness of the dose and the dilution and chemical change of the drug must make it almost inert. He was accustomed to order $\frac{1}{2}$ oz. only of distilled water containing from 1 to 4 gr. of the salt, to be taken fasting, and in the recumbent position, the patient then to turn himself from side to side so as to ensure contact of the remedy with different parts of the stomach wall; in some cases he even injected the dose directly into the viscus with a syringe and perforated tube (Med. Times, i., 1859). Dr. Hartshorn valued the nitrate in chronic gastritis, and gave it in pill (Amer. Journ., 1849). My own use of the remedy has been generally in doses of $\frac{1}{20}$ to $\frac{1}{4}$ gr. every four or six hours in distilled water, and I have observed from it much relief of discomfort and pain, flatulence, heartburn and pyrosis, yet there is some uncertainty in its action. Women suffering from the above symptoms, together with severe retching and vomiting of tenacious fluid, and a too frequent and profuse menstruation, are almost always relieved by it, but the maladies in question assume so many phases, and are more or less amenable to so many forms of treatment that we cannot be surprised at difference of opinion as to the true value of this one.

It has naturally been thought that risk of caustic and irritant effects might be obviated, and equally good curative effects obtained by the use of the oxide of silver instead of the nitrate, and this was brought prominently before the profession by Mr. Lane (Med.-Chir. Rev., 1840-41), and afterwards, in a special treatise, by Sir James Eyre. The former records a number of cases with severe but intermittent gastrodynia, general uneasiness, nausea, and watery eructation, almost all relieved quickly by $\frac{1}{4}$ or $\frac{1}{2}$ gr. doses of the oxide: nothing is said about diet or

other adjuvant treatment. Mr. Lane states further, that if organic mischief have resulted—if the tongue be tumid and cracked, and the pain constant, or the ejected fluid "glairy" (as in Todd's "follicular gastric dyspepsia"), then the remedy is of no service; but it is not necessary to adopt these limitations if other indications for the remedy exist.

Uterine Disorders.—Dr. Hudson and others remarked the great improvement in certain uterine symptoms during the exhibition of silver, and recorded cure of many cases of menorrhagia, of uterine leucorrhœa, and of painful menstruation, though not with the scientific precision now expected. Many cases occurred at the menopause, some during pregnancy, and in several a previous long sterility was followed by fecundation: simple vaginal leucorrhœa was not benefited.

Guided partly by this marked sympathy between the gastric and the uterine conditions, I have prescribed the oxide for nervous, highly-sensitive women suffering from gastrodynia and pyrosis, with coincident uterine flux, and have often seen marked and immediate improvement in both symptoms, and without any drawback. The use of the medicine need not however be restricted to such cases; its action is somewhat similar to that of bismuth, and it may be used if that should fail to relieve. It has the advantage of being effective in a much smaller dose: $\frac{1}{10}$ to $\frac{1}{2}$ gr. is usually quite sufficient, and in the form of a minute pill this is readily taken. I have not seen the irritation from it which has sometimes been described, nor the salivation which might be produced by its too-prolonged use, nor any symptoms of argyria; it should not, however, be continued for many weeks consecutively. It is useful for cases in which arsenic also relieves, and an interesting fact is that this remedy and bismuth have often an equally good influence over uterine loss when connected or coincident with gastric disorder.

In the *cardialgia and vomiting of pregnancy* I have found it useful when many other remedies failed to give the slightest relief.

Gastric Ulcer.—In so serious an organic disease, which must of necessity often end fatally, it is not surprising if the powers of the silver compounds have been called in question. Cases of marked relief, if not cure, by these remedies have however been recorded (Stillé), and it seems reasonable to allow that

if they can relieve ordinary gastritis, they may relieve the same condition when dependent on a local lesion; they lessen local congestion and local irritation of the gastric nerves, and in some cases, at least, form a protective layer of albuminate, and probably thus relieve the pain of gastric ulcer.

Jaundice.—Dr. Peebles (U. S.) has recorded several cases of jaundice in which rapid improvement followed the use of nitrate of silver given in $\frac{3}{4}$ gr. doses twice daily for two to ten days: he attributes its good effects to its modifying the state of the mucous membrane, and relieving a chronic gastro-enteritis, and lessening the obstruction of gall-ducts by diminishing glairy mucus (Amer. Quart. Journ., 1849).

Chronic Diarrhœa—Dysentery.—I have obtained great benefit from nitrate and oxide of silver in many forms of these disorders—in serous diarrhœa, in chronic and periodic forms, in diarrhœa after fever, and in that of dysenteric character.

Graves preferred the nitrate (which he gave in grain doses) to any other astringent or to opium, but he avoided it in cases of ulceration, when really its advantages may best be proved. Dr. J. MacGregor reports several cases of exhausting diarrhœa during advanced phthisis, in which the relief was marked and immediate; he gave the remedy also in 1 gr. doses with $\frac{1}{4}$ gr. of opium, and in enema (Brit. and For. Rev., Sept., 1841). I have myself often found it of the greatest advantage in such cases, restraining the profuse discharge, and aiding to strengthen the patient; I have given from $\frac{1}{10}$ to 1 gr. In the form of enema, containing 3 to 4 gr. in 2 oz. of distilled water, it is a valuable remedy for chronic dysentery and ulcerative conditions of the rectum; the enema should be slowly injected and repeated every six to twelve hours for three or four times, if necessary. The slow injection of copious enemata—3 pints containing from 45 to 60 gr. of argenti nitras is a valuable resource in obstinate cases (Lancet, i.-ii., 1882). I have often tried this with success: any after-pain or tenesmus may be relieved by opium. If ulceration or congestion be situated higher up in the intestine, the nitrate is best given by the mouth in pill, since it is thus most likely to reach the affected part unaltered, and to exert the local action which is desired. The chloride of silver has also been used with advantage in chronic dysentery.

Diarrhœa of Children.—The nitrate has been recommended by Trousseau, Mauthner, etc. I do not think it advisable for acute cases, for it is uncertain in action, but in prolonged and obstinate cases a few doses often act well; they may be given by the mouth or rectum.

Typhoid Fever.—Dr. Pepper has recorded fifty cases of typhoid fever in which, after the second week, the medicinal treatment was nitrate of silver ($\frac{1}{4}$ gr.), with small quantities of belladonna and opium; only one case was fatal, and he considers that these remedies act favourably by limiting follicular catarrh and modifying its secondary effects (Boston Journ., 1877).

Diseases of the Nervous System.—It is curious that silver was early appropriated to the treatment of cerebral disorders by the theories of astrology, which associated both the metal and the malady with the influence of the moon: by the time of Linnæus its medicinal virtues were so far distrusted that he describes only its "power as political, its use commercial." It retained, however, some reputation in epilepsy, and of late years there has been further evidence of a neuro-tonic power exerted by it rather upon the spinal than the cerebral nervous system, as illustrated in some forms of paralysis.

Epilepsy.—Unless we are wholly to reject past records, and the opinion of distinguished physicians, the nitrate has given good results in a large number of epileptic cases. Heim considered it the best of remedies, and Trousseau who used also the chloride, places the silver salts second only to belladonna. We need not however quote many authorities to the same effect: we recognise that it has relieved, sometimes even seemed to cure, cases of this disease, and may therefore, under certain conditions, relieve others. We should not, with Krahmer, consider it most suited for the robust, with symptoms of cerebral congestion, but rather for the delicate with a morbidly irritable and susceptible nervous system, and a languid state of the organic functions (Stillé); it is in the pallid and anæmic that strychnine acts well sometimes (Tyrrell), and it is in similar cases that I should be hopeful of good results from silver. Curci considers that it does good in epilepsy connected with spinal disease, but when dependent on local lesion—as hæmorrhage, softening, or tumour—the malady is not influenced by it. More definite indications we

cannot at present lay down, and must acknowledge that of any given number of cases, the majority at least will not yield to this remedy, and others, if they receive temporary benefit in the prolonging of the interval or lessened severity of the attacks, will ultimately relapse. The greatest objection to nitrate of silver, and one which has led to its comparative disuse, is the possibility of its discolouring the patient, and this even without curing his malady,—I have seen epileptics discoloured by the medicine, and yet suffering as severely as ever from their convulsions. Unfortunately the nature of the disease requires a long continuance of treatment, and therefore a medicine must be preferred which shall at least not inflict so visible an injury, and we need seldom prescribe the silver salt until a fair trial has been made of bromides, of belladonna, etc. If however it be decided upon, then a purgative should be given at the commencement of, and occasionally during treatment; the remedy should be omitted for a few days at intervals, and the gums should be carefully watched for signs of systemic saturation. The use of nitrate for *epilepsy in children* has been objected to by Lœbenstein, but I have seen it of service in chronic cases. Brenner recommends the chloride in infantile convulsions, and also in the brain-affections of typhus. Niemann found advantage from the ammonio-chloride in epilepsy and melancholia.

Paralysis—Ataxia.—We cannot speak with any confidence of the power of silver compounds to relieve serious or chronic cases of this kind, though there are not wanting records in improvement, more or less marked, obtained under their use. Wunderlich reported seven cases of ataxy arrested in progress under 5 gr. doses, two or three times daily; whilst Charcot and Vulpian related five cases that had lasted respectively two, four, five, and two of them fifteen years. A pill containing $\frac{1}{6}$ to $\frac{3}{4}$ gr. of nitrate was given daily for from thirty-five to sixty days, and in every case in the course of a week, improvement commenced as to sensibility, power of placing the limbs, as to sight, and especially as to lessening of pain (Mémoire sur le Nitrate, Bull. de Thérap., 1862). The report of such cases caused much sensation, but Topinard who criticises them closely, asserts that in some the diagnosis was imperfect, and that admitting it in the others to be correct, there were unsuccessful cases to be compared

with them, and many others unrecorded (De l'Ataxie Locomotrice, Paris, 1864). He has collected altogether twenty-eight cases, more or less favourable to the efficacy of the nitrate, and nine unfavourable; to these, he has added seventeen cases carefully noted under his own observation: commencing with $\frac{1}{12}$ gr. daily, he continued it for ninety days, interrupting the course every eight days for a week; then $\frac{1}{6}$ gr. was given for four months. In the first case reported no good result was obtained, though erections recurred; at the end of the treatment the patient was worse, and the same has to be said of eleven other cases: in the remaining five there was some amelioration of symptoms. Althaus on the other hand, has had on the whole a favourable experience with this remedy, and I believe that I have seen benefit from it in relieving the "lightning pains," and in arresting for some time at least, disorder that was progressing, but it is no specific against locomotor ataxy.

Diphtheric and Mercurial Palsy.—A case of the former kind, cured under the use of nitrate, is recorded (Amer. Journ. Med. Sci., 1865), but I am not aware of others. Fairly rapid recovery in six instances of mercurial palsy is reported by Sementini with doses of from $\frac{1}{8}$ to 3 gr. daily.

Nervous Debility — Headache. — In some few cases of nervous debility and depression connected with overwork, anxiety or excess, and exhibiting hypochondriacal symptoms—morbid fear, impaired mental capacity, and frequently rather deep-seated fixed headache—I have seen improvement under the use of nitrate, and have felt justified in connecting it with this drug, because iron, and bromides, and other remedies had been used without advantage, and the patient's mode of life and circumstances were not altered when the silver was commenced.

In *hysterical* or *nervous* headache it was valued by Dr. Graves, and others have found it useful in neuralgia, for which Paterson recommends especially the iodide. If the headache be accompanied with constipation or gastric disorder, an occasional laxative is required.

Various Diseases.—Other disorders which may either be called "nervous" in character, or are connected at least with reflex nerve-disorder, and which the salts of silver have been found sometimes to relieve, are such as *chorea*, *angina pectoris* (Copland,

Dict.), *spasmodic asthma* (Waring, Curci), *palpitation* (Kopp), *vertigo* (Redemachar), *pertussis* (Berger): for this last the iodide is especially recommended. They have been given also in more general diseases, as *intermittents* (Sokolow), *diabetes* and *phthisis* (Brady, Moore), the object desired in these latter cases being mainly to lessen the excessive discharges from the kidneys, the skin and the bowels; in some instances they have certainly succeeded, though we could not expect them to alter the ultimate termination of such maladies. In *dropsy* the nitrate was given by Boerhaave as a purgative in 2 gr. doses, and has been more lately commended by Dreyer (Husemann). In *syphilis* the chloride and oxide were given by Serres and others, but their value was disproved by Ricord. The ammonio-chloride has been used as a cathartic and vermifuge.

PREPARATIONS AND DOSE.—*Argenti nitras*: dose, $\frac{1}{6}$ to $\frac{1}{3}$ gr. (B.P.); it may vary from $\frac{1}{20}$ to $\frac{1}{2}$ gr., and more has been sometimes prescribed. *Argenti oxidum*: dose, $\frac{1}{2}$ to 2 gr. in the form of pill.

The dose of the *chloride* is about the same as that of the oxide, though upwards of 30 gr. have been given without gastric pain (Trousseau): the dose of *iodide* and other salts is also about the same as the oxide.

As a caustic the solid nitrate may be used alone, or "mitigated" with nitrate of potassium. In default of a metal, or caoutchouc or quill holder, melted sealing-wax forms a convenient coating, and a file, or friction with wet lint, sharpens the point better than a knife: for small fistulæ or numerous leech-bites, a silver probe, dipped as required in the melted salt, or made red-hot in a spirit lamp and then dipped into the powdered nitrate are convenient. The finely-powdered nitrate, diluted (as with sugar), has been used for the throat and larynx, and abroad, charpie dipped in a strong solution and dried, is used as a dressing for indolent wounds, and known as the black or caustic charpie of Riboli (Husemann).

Of solutions, 40 gr. in the ounce will prove *caustic* to mucous membranes, and from 80 gr. upwards caustic to the skin; distilled water, glycerine, or nitrous ether may be used as solvents; after a strong application the part, especially if it be the eye, should be bathed with warm salt water to neutralise any excess of caustic—20 gr. to the ounce is a useful strength for an *astringent* solution, but a proportion of 10, 5, and even 1 gr. to the ounce is suitable

according to the condition of the affected part, and may be used in lotion, injection or collyrium as already described, it being remembered that the weaker solutions require to be used the more frequently: the disadvantage of the salt staining linen must be borne in mind.

Both the nitrate and oxide have been used in stimulating and astringent ointments: thus, in the Hamburg Pharm., 15 gr. are ordered with 1 dr. of Peruvian balsam and ½ oz. of zinc ointment (Ungt. Nigrum), and Lane used the oxide in specific and other ulceration, but I do not think ointments a good form of the remedy.

Since the salts of silver are readily decomposed, they should be mixed as little as possible with organic or mineral substances, and haloids, sulphides, alkalies, soaps, tannin and astringent extracts should be excluded from prescriptions for silver compounds: it is important to mention also, the exclusion of creasote, for explosions have occurred from its trituration with oxide of silver and organic substances. Solutions of the nitrate for internal use should be kept as much as possible from air and light, and are therefore commonly ordered in covered or dark-glass bottles: they may be made with distilled water or with glycerine, and sometimes a few drops of nitric acid are added to prevent reduction; syrup may be given with it for children. Delioux prescribed it with an equal part of salt in a weak, sweet, albuminous solution (white of egg), and Deniau added to this a small proportion of bromide of potassium to re-dissolve the precipitate; but in such combinations, the object of which is to secure solubility and absorption, we are not giving the nitrate, but a complex chloro-albuminate. Discoloration of the lips and teeth, and nauseous taste, are however drawbacks to the use of any solutions. A pill may be made with crumb of bread according to an old and well-known formula (Boudin): the decomposition into chloride that may occur is unimportant, but argilla, silica, kaolin and chocolate have been recommended as vehicles, in order to avoid it.

The oxide is always given in pill or confection, and this form is to be preferred for "constitutional" effects, or for an action on the lower parts of the intestinal tract. It is usual to direct a patient taking these medicines to abstain from much salted food

before or after the dose, as likely to hinder absorption into the blood. Eulenburg has used the chloride, nitrate, and albuminate hypodermically without bad local result, and with some evidence of absorption, but not with much definite advantage (Record, 1883).

ARSENIUM—ARSENIC (As = 75).

The name arsenic is applied by common usage both to the element and to its *trioxide*, which is more correctly termed arsenious anhydride; it is also called white arsenic, or arsenious acid.

The element, which seems to be a connecting link between the metals and the non-metallic elements, occurs sometimes native, but generally in alloy with iron, copper and other metals, as oxide and sulphide. Nearly all sulphur contains some arsenic, and from these different compounds it is liable to pass undesignedly into many pharmaceutical preparations. Mineral waters also frequently contain traces of it; Tripier has noted its almost constant occurrence in chalybeate, and Thénard in saline springs, though in minute proportion: those of Plombières contain but 0·0008 gr., Vichy 0·01 gr., and La Bourboule (the largest amount) $\frac{1}{10}$ gr. in 16 oz. Royat also contains it, and the Madeleine spring of Mont Dore is strongly arsenical; Bath waters also contain it (Lancet, i., 37). The strong Levico water (South Tyrol) has $\frac{1}{12}$ gr. per pint, with iron 30 grains.

CHARACTERS.—The metalloid is a steel-grey solid of metallic brilliancy, readily oxidising and tarnishing on exposure to air; it volatilises at a dull heat, the colourless vapour having a garlic-like odour; it burns when heated in the air.

ACIDUM ARSENIOSUM—ARSENIOUS ACID, OR ARSENIOUS ANHYDRIDE—WHITE ARSENIC (As_2O_3 = 198).

PREPARATION AND CHARACTERS. — Arsenious acid is prepared by sublimation from arsenical ores, and condenses in the *cooler* parts of the retort as a heavy powder, fine and white like flour; in the *hotter* parts it forms a vitreous mass, transparent and amorphous, which becomes on exposure to air, opaque and crystalline, and is usually seen in smooth milk-white or yellowish pieces not unlike porcelain, and stratified in appearance according to the different opacity of its layers; the change from the

amorphous to the crystalline form is accompanied with phosphorescence (one of several of its analogies with phosphorus). The two forms differ in density and in solubility, the transparent acid dissolving in about 100, the opaque in about 80 parts of water at 15° C.

The powder is not readily wetted by water, so that it is apt to remain floating on the surface or adherent to the sides of a vessel. Organic products milk or mucus, render it *less*, acids and alkalies *more* soluble; oils and alcohol also dissolve it. It crystallises from a saturated solution or after slow sublimation, in minute shining octahedra, or in rhombic prisms (like oxide of antimony, with which it is isomorphous): sprinkled on a red-hot surface it evolves scarcely visible vapours of metallic arsenic, which have an odour like garlic, and at a few inches from the hot surface, change to dense white odourless smoke, being the acid re-formed by oxidation. Arsenious acid itself has no smell; its taste is sharp and rather nauseating (Hirtz), but in such small quantities as may be taken for trial, nothing more than a slight sweetness and grittiness will be detected (Christison).

LIQUOR ARSENICALIS—ARSENICAL SOLUTION—FOWLER'S SOLUTION—LIQUOR POTASSÆ ARSENITIS.

PREPARATION.—It is prepared by boiling together arsenious acid and carbonate of potassium, and adding to the solution (when cold) tincture of lavender and sufficient water to make a proportion of 4½ gr. in the ounce (1 per cent.).

CHARACTERS.—A reddish, alkaline liquid, with the odour of lavender; it contains a mixture of arsenite and carbonate of potassium.

LIQUOR ARSENICI HYDROCHLORICUS—HYDROCHLORIC SOLUTION OF ARSENIC.

PREPARATION.—It is prepared by boiling arsenious acid with hydrochloric acid and distilled water, preserving a proportion of 4½ gr. to 1 oz. (1 per cent.). (This solution corresponds in strength with liquor arsenicalis; it is nearly three times the strength of liquor arsenici chloridi, Lond., and of the original acid solution of De Valangin.)

CHARACTERS.—A colourless liquid of acid reaction and sp. gr. 1010.

ARSENII IODIDUM—IODIDE OF ARSENIUM (AsI_3 = 456).

PREPARATION.—It is obtained by the direct combination of iodine and metallic arsenic, or by evaporating to dryness an aqueous mixture of arsenious and hydriodic acids.

CHARACTERS AND TESTS.—It occurs in small orange-coloured crystals, which are readily soluble in water and in rectified spirit; its aqueous solution has a neutral reaction. Heated in a test-tube it almost entirely volatilises, violet vapours of iodine being set free.

LIQUOR ARSENII ET HYDRARGYRI IODIDI—SOLUTION OF IODIDE OF ARSENIUM AND MERCURY—DONOVAN'S SOLUTION.

PREPARATION.—It is prepared by dissolving the iodide of arsenium and the red iodide of mercury in water in such proportions that the strength of the solution is about 1 per cent. by weight, both of arsenious iodide (AsI_3) and of mercuric iodide (HgI_2). The original Donovan's solution contained nearly 42 grains of each iodide in 10 fl. oz.

CHARACTERS AND TESTS.—A clear, pale yellow liquid with a metallic flavour. Its specific gravity is 1·016.

SODII ARSENIAS—ARSENIATE OF SODIUM.

PREPARATION.—It is prepared by heating together arsenious acid, nitrate and carbonate of sodium, dissolving and crystallising.

The *liquor sodii arseniatis* contains $4\frac{1}{3}$ gr. of the anhydrous salt in 1 oz. of distilled water (1 per cent.).

CHARACTERS.—The salt occurs in colourless transparent prisms soluble in water and alkaline in reaction: the solution is also colourless and alkaline. The salt may combine with twelve or seven molecules of water of crystallisation ($Na_2HASO_4\ 12H_2O$ or $Na_2HASO_4\ 7H_2O$).

Arsenic Acid, As_2O_5, the higher oxide of arsenic, is also white and solid, but is so soluble as to be almost deliquescent, and it has a strong acid reaction. It is not employed in medicine in its free state, but in combination with soda and iron. In the arts it is largely used in the printing of cotton stuffs and in the manufacture of aniline dyes.

Ferri Arsenias—Arseniate of Iron (*v.* Iron).

TESTS.—1. Sulphuretted hydrogen gives a bright yellow precipitate of arsenious sulphide (As_2S_3) in acid solutions of arsenious acid or the arsenites. With arseniates the same precipitate is obtained, but very gradually, as they must be reduced to arsenites previously.

2. *Hume's Test.*—Ammonio-nitrate of silver gives a lemon-yellow precipitate of arsenite of silver (Ag_3AsO_3) with a solution

of arsenious acid or the arsenites, but with arsenic acid and the arseniates, a chocolate-coloured precipitate of arseniate of silver (Ag_3AsO_4).

3. Ammonio-sulphate of copper gives with compounds of arsenious acid a light-green precipitate of arsenite of copper ($CuHAsO_3$), Scheele's green; with arseniates, a somewhat similar precipitate of arseniate of copper. This test is not trustworthy as many harmless vegetable substances behave in the same way.

4. *Marsh's Test.*—Generate hydrogen by the action of sulphuric acid on zinc in a Marsh's apparatus, and add the solution supposed to contain arsenic; if arsenic be present it will combine with the nascent hydrogen to form arseniuretted hydrogen ($As_2O_3 + 6H_2 = 3H_2O + 2AsH_3$). On igniting the jet of gas (which burns with a bluish flame), and depressing upon it a cold porcelain plate, an arsenical stain will be deposited, whilst the hydrogen is burned off into water. The stain has the following characters: (*a*) metallic brilliancy; (*b*) hair-brown colour; (*c*) volatility; (*d*) solubility in solution of bleaching powder; (*e*) non-solubility in cold sulphide of ammonium; (*f*) when evaporated with a drop of nitro-hydrochloric acid it yields a residue of arsenic acid, which gives a brickdust-red turbidity on the addition of nitrate of silver.

Fleitmann has shown that if the hydrogen be generated by heating zinc and caustic soda or potash together ($Zn + 2NaHO = H_2 + Na_2ZnO_2$) the hydrogen combines with arsenic but not with antimony; this reaction is valuable in the presence of both metals.

5. *Reinsch's Test.*—A piece of copper foil when boiled in an acid solution of an arsenical compound, will become slate-grey from the deposition of a fine film of metallic arsenic. This test to be complete must be verified by heating the coated copper in a narrow glass tube, when a mixture of arsenious acid and metallic arsenic will sublime, and be deposited in octahedral crystals and globules on the cooler part.

For the "reduction test" of white arsenic, it should be placed with "black flux" in a similar tube perfectly dry, and on heating first the charcoal and then the arsenic, the latter sublimes and is deposited in a metallic ring as above mentioned.

ABSORPTION AND ELIMINATION.—Since the observations of Schmidt, Mialhe and others, *metallic* arsenic has been considered inert. Schroff however has shown that it may exert a strongly poisonous action, and that doses of 8 to 15 gr. have caused gangrene of the stomach and death in from thirty to forty hours (Zeitschrift der Aerzte, i., 1858). It is probably oxidised before absorption.

Arsenious acid in all its combinations, and by whatever channel introduced—by mouth or by rectum, by the lungs or by the skin—is readily absorbed, and has been detected in the blood a few minutes after its administration. It passes out by the skin and mucous membranes, by the various glands, as the salivary and even the lachrymal, but mainly by the kidneys.

Brouardel and Pouchet record that a man had tried to poison his wife by arsenic while she was suckling a child. The woman had vomiting and diarrhœa but recovered, while the two-months-old child died with similar symptoms in forty-eight hours; its body was exhumed and 5 mgrm. of arsenic were found in 2 kilos. (The earth outside the coffin contained no arsenic.) They also gave nursing women from 2 to 12 minims of Fowler's solution per day, and arsenic was always present in the milk. In animals which got non-lethal doses of arsenic, their suckling young often died, and arsenic was found in their corpses (Annales d'Hygiène, pub. 1885).

Paschkis and Obermayer found that metallic arsenic in fine division in oil, or as an ointment, given hypodermically or rubbed into the skin, was absorbed. In every case arsenic was found in the fæces and urine, and during life symptoms of poisoning were manifested, while the post mortem appearances were those of arsenical poisoning (Wien. Med. Jahrb., 1888).

The rapidity of elimination varies; in some cases, none of the substance could be detected in the secretions three days after the last dose, but in Ludwig's observations on animals, if small quantities were given for a fortnight and then omitted, the urine was not quite free till three weeks afterwards (Med. Record, 1877). Gubler gives six weeks as the time during which it may continue to pass out, and when it has ceased to do so it may reappear after administration of iodide of potassium; hence it

seems probable that elimination is not always complete, and that of what is taken, a part may be deposited in the tissues and occasion so-called "cumulative" effects. It has been found to be specially deposited in the *nervous* system; thus, if in fresh muscle 1 part is found, the proportion in liver is 10·8, in brain 36·5, and in spinal cord 37·3 (Scolosuboff, Annales d'Hygiène, 1876). This became a matter of great importance in a French trial (Danval), when the experts were blamed for not examining the brain and cord (B. M. J., ii., 1878); these parts should henceforth be analysed as carefully as the abdominal viscera. Caillol (de Poncy) offers some analyses to show that arsenic partly displaces phosphorus in the chemical constituents of nervous tissue (Med. Record, 1878), and Roussin, that it does the same in bone (Lancet, ii., 1889). Dr. Putnam found traces of arsenic in the urine of 30 p.c. out of 150 specimens examined —the patients had obscure symptoms of illness not definitely arsenical—he supposes its absorption from many articles of domestic use (Lancet, ii., 1891). If any be contained in the body at death, it may be detected after an almost indefinite period.

PHYSIOLOGICAL ACTION.—*External.*—Preparations containing arsenic produce local irritation, inflammation or destruction of tissue, in varying degree, according to the strength and character of the application. Dry white arsenic in mass may not injure the unbroken skin, but arsenical powders are apt to produce eruptions of various kinds on exposed surfaces, and especially irritative effects on the pudenda, in those who are employed in the manufacture of green dresses, wall papers, artificial flowers, etc. (Annales d'Hygiène, B. M. J., ii., 1863). Perforation of the septum nasi has been noted, and anal ulceration has followed the local use of a green paper coloured with arsenite of copper. Arsenic dissolved or moistened is still more irritating, and those who use it, for instance in sheep-washing, generally suffer from eczema of the scrotum, etc. (Lancet, 1857). Those who work with arsenical powders are liable also to various degrees of acute and chronic arsenical poisoning, and green colours are not the only dangerous ones: fuchsine, a *red* dye, contains much arsenic (Med. Record, 1877), and *blue* gloves have shown arsenic on analysis (B. M. J., ii., 1878) The us

of green-coloured cards has caused a disease of the nails resembling psoriasis, and green hat-lining has caused eczema (Farquharson, B. M. J., ii., 1879). The external use of a "violet powder" adulterated with arsenic, proved fatal to thirteen children out of twenty-nine subjected to it (B. M. J., ii., 1878).

The continued application of a strong arsenical compound has a caustic destructive effect, which is not simply a *chemical* one, like that of caustic acids or alkalies, and is not exerted on the dead subject, but is produced by interference with nutritive processes in the part, causing rather a condensation and "mummifying" of tissue than an actual destruction. It is much more active in unhealthy, ill-nourished tissue (*e.g.*, that of lupus), than it is in normal tissues. Very strong arsenical applications produce much local inflammation, and so far interfere with the action of the absorbents that the effect remains local only; but unless in such strong concentrated form, arsenic is readily absorbed, especially from wounds and mucous surfaces; hence its surgical use has led to serious constitutional symptoms, and even to death. Roux describes the application of an arsenical ointment—1 part in 32—over a space of $1\frac{1}{2}$ square inches of a cancerous breast for one night only, with death from poisoning on the second day. Sir Astley Cooper relates a fatal case from the use of an arsenical solution to a "fungus of the eye" (Lancet, i., 1837). Arsenical paste applied to an inflamed tooth-pulp has also proved fatal, and Graham has recorded vomiting, severe pain, convulsions, and death from the application of a plaster containing half its weight of arsenic to a cancerous breast (Glasgow Med. Journ., 1869); the prescriber of the plaster was tried for homicide, and many similar cases have been before the law courts.

The *antiseptic* power of arsenic deserves mention: it is largely utilised in the dissecting room, and seems to have retarded the process of post-mortem decay in some cases of poisoning when large amounts have been used. The researches of Johannsohn assign it, however, but a limited power: he found that small quantities checked fermentation in yeast and syrup, but only for a time: in lactic fermentation it diminished the growth of one fungus, but favoured another. The same thing

occurred in urine: it exerted no influence on non-organised ferments, such as pepsin, etc. (Archiv f. exper. Path., Bd. ii.).

PHYSIOLOGICAL ACTION.—*Internal.*—The blood and the metabolic processes are altered by arsenious acid and its compounds, but the symptoms of its physiological action are mainly evinced in the *alimentary canal*, the *mucous membranes*, and the *nervous system*, and in different cases these parts are affected in different degree, according to the dose, the time and mode of its administration, and the constitution of the individual.

Digestive System. — Very small doses—$\frac{1}{30}$ to $\frac{1}{15}$ gr.—may be taken for some time without other effects than such as are of stimulant and tonic character—*e.g.*, improvement of appetite, sense of warmth at the stomach, and general invigoration; but usually, sooner or later these symptoms are replaced by those of irritation and malaise. Trousseau quotes from Kœpl the case of a servant who, desiring to get rid of a severe mistress, mixed with her food for some time very small doses of arsenic: the mistress however improved in appearance and in stoutness, and the plot was only detected after the use of a large poisonous dose. Doses of $\frac{1}{10}$ to $\frac{1}{2}$ gr. are liable to produce soreness of the mouth, with some salivation and dysphagia, fœtid or sour taste, thirst, heat and constriction in pharynx, with nausea or vomiting, gastric pain, flatulence amounting to tympanitis, and diarrhœa. Vaudrey found copious pultaceous stools follow the medicinal use of arsenic without toxic symptoms. One of the early symptoms of the physiological action of the drug is a slimy silvery aspect of tongue, "as if nitrate of silver had been lightly applied" (Begbie), an appearance produced by a thin coating of mucus secreted under the influence of irritation. After continued doses, the tongue becomes red or brown, cracked and tremulous, the gums bleed, and the buccal mucous membrane becomes covered with aphthous or even membranous patches like a true diphtheric condition (B. M. J., i., 1862). Vomiting becomes so frequent that all food is rejected, and emaciation sets in rapidly, an effect which has been termed "tabes arsenicalis."

After poisonous doses, which may be stated at 2 gr. and upwards, the symptoms already described become intensified; pain especially of most severe burning, cramping, spasmodic character comes on within half to one hour, in the region of the

stomach and navel, spreading thence over the whole abdomen which becomes contracted and hard : the ejecta are offensive and yellowish or greenish in colour, not unlike bile (unless, as often occurs in cases of poisoning, arsenic mixed with soot or indigo has been used) ; hiccough attends the vomiting and purging ; the latter becomes involuntary and is accompanied with severe tenesmus, and the general symptoms may closely simulate those of cholera (Lancet, ii., 1870).

On the other hand in some exceptional cases, the vomiting has been only moderate, and there has been complaint of coldness rather than heat. (In Mr. Maybrick's case the moderate degree of the gastric symptoms has been attributed to the drug being given in a soluble form, B. M. J., ii., 1889). In others, there has been almost entire absence of pain, the patient remaining in a dull and semi-narcotised condition, and in several even severe cases, a remission of symptoms has occurred for some days before death (Guy's Reports, 1850).

In experimenting with frogs, Dr. A. Lesser found that intestinal peristalsis was increased by arsenic, and local tetanic contractions occurred from direct irritation of ganglia in the intestinal coat (not indirectly from influence of the central nervous system) : gastro-enteritis was also produced by the drug, but he did not, as Böhm did, find it more poisonous when given by the mouth than by a vein. It was eliminated by the intestinal mucous membrane (Virchow's Archiv, 1878 ; Lancet, ii.), and we may add here that by whatever channel toxic doses of the drug are given to men or animals, gastric inflammation is commonly produced.

Nervous System.—The early effects of very small doses are usually tonic in character, there being a general sense of improved power. The same fact was noted when describing effects on the digestive system, and it is possibly not a primary tonic effect upon the nervous system itself, but rather dependent on improvement in appetite and assimilation of food. In several neurotic subjects very sensitive to medicines, I have noticed a general condition of nervous irritability and especially of sleeplessness, amongst the earliest effects of even moderate doses of arsenic.

In the Maybrick case, some evidence—not very convincing—was given to show that the drug was habitually taken as a nerve

stimulant, although in Mr. Hutchinson's experience, its general effect is not to give vigour but to diminish it (B. M. J., ii., 1889).

Full medicinal doses, continued for a long time, give rise to numbness and pricking sensations with tremor or stiffness of the limbs.

Irritant doses cause gastric pain, as already described; sometimes *headache* has been a marked symptom, as for instance in a large number of children who each received about 1 gr. of white arsenic in milk (Taylor), and in many persons poisoned by the accidental admixture of a small quantity of arsenic in bread: they suffered also from a feeling of constriction over the forehead, vertigo, and tinnitus (Lancet, i., 1880), from visual sensations of light or flame, prostration, and feebleness of the lower extremities, and in these as well as in other cases; pain in the back has been a marked symptom (B. M. J., i., 1873); sometimes the extremities have been very sensitive. Restlessness, insomnia, grinding of the teeth, giddiness, irritability and depression are frequent symptoms.

The effects of *poisonous* doses (6 to 8 gr.) are often ushered in with rigors, profound depression, and extreme anxiety. Restless tossing of the arms is commonly noted, and later, numbness, cramps and twitchings of all the muscles. The œsophageal spasms may simulate those of hydrophobia, and the muscular cramps may amount to opisthotonos—convulsions alternate with delirium, the special senses become impaired or lost, the mental faculties torpid (the stupor may suggest narcotic poisoning), and syncope or collapse may close the scene. There may be local palsies, as of the limbs and sphincters in the course of arsenical poisoning, and as the effect of the drug in this direction is not so generally known, we may, with advantage, speak of it more fully.

Arsenic exerts a paralysing influence certainly upon sensory and motor, and we also may say *probably* upon vaso-motor nerves. Dr. Sklarek experimenting on the frog, found that arsenical injections, in minute quantities, destroyed common sensibility, probably by its influence on the cord (Reichert's Archiv, 1866). Lesser whilst verifying this, noted a transient increase in reflex irritability, then diminution of it, then cessation; after some time the frog became completely paralysed.

Drs. Ringer and Murrell, remarking that paralysis occurs in the same order after *mechanical arrest of circulation* (as by ligature or excision of the heart), instituted experiments to show whether the latter was the real factor in Sklarek's results, and concluded that they were due rather to a toxic action on the central nervous system; peripheral motor nerves retained their function for some time, for the muscles continued to contract under direct galvanic stimulation; ultimately both nerves and muscles were paralysed by arsenic, and ceased to react long before similar muscles did in a *brainless* frog, and the observers named conclude that "arsenious acid is a protoplasmic poison, affecting first the more highly organised nervous centres, next the nerves, and last the muscles: . . . that it is a poison to all nitrogenous tissues" (Journal of Physiology, 1878-79).

Clinical records clearly indicate *paralysis* as a symptom of arsenical action. So early as 1711, Morgagni notes "tremor of limbs and palsy of feet" (Op., vol. iii., Trans. Alexander, Letter 59). Mr. Trend reports the case of a pregnant girl, who took 2 gr. twice daily for three months, and besides intestinal symptoms, suffered from pricking pain in both legs, impaired sensation, and loss of power (B. M. J., ii., 1858). Partial paralysis and numbness from habitual taking of the drug are recorded in Schmidt (Bd. clxv., p. 238), and tremor and partial palsy from exposure to arsenical vapour in aniline works by Dr. G. de Mussy (Lancet, i., 1876). Dr. Leroy (d'Etiolles), who has written specially on the subject, describes a case of paraplegia succeeding to acute arsenical symptoms after the application of a caustic paste to a cancerous breast, and another aggravated case of paraplegia, with weakness, anæsthesia of the arms and diarrhœa; ultimately death occurred from marasmus (Gaz. Hebdom., 1857).

A very severe case of arsenical neuritis, following on one toxic dose, is recorded by Dr. H. C. Wood (Pract., 1889).

Christison has remarked that arsenical palsy resembles that of lead in its character, and Gubler and Duchenne have found it sometimes identical. Leroy, however, points out that it does not so invariably affect the *extensors*, and that it is more generalised.

The *wasting* of limbs is more general, and they may become semi-flexed; when all are affected, the upper recover before the lower,—a point of difference from cerebral palsies. An average

duration is from four to ten months, and the prognosis is favourable under treatment.

Dr. Mills found marked myelitis in a case of arsenical poisoning (Med. News, 1885). Popow found that in dogs, arsenic produced a central and then a diffused myelitis (Virch. Archiv, Bd. xciii.). Dr. Seguin is also of opinion that a myelitis lies at the root of all the pathological changes produced by arsenic (Med. Press and Circular, ii., 1883). M. Vrigens considers that the fundamental character of arsenical poisoning is a perversion of the entire nervous system, the vagus, sympathetic and vaso-motor nerves being specially paralysed (Archives de Physiol., viii., 1881). Krehl also records a case of arsenical paralysis. The patient in four months had taken 1·346 gramme arsenious acid (about 20 gr.); sensation in the hands, muscles and tendons was disturbed, and the muscles degenerated and wasted, but they did not show the reaction of degeneration (Deut. Archiv f. klin. Med., xliv.).

Falkenheim has reported three cases of atrophy of muscles (after acute arsenical poisoning) with diminished electric irritability, and well-marked reaction of degeneration, the extensor muscles being more affected than the flexors, and peripheral neuritis being the probable cause (Cbl. f. d. med. Wiss., 1888). An interesting case of multiple peripheral neuritis in a lady of fifty-six, obscure in origin and development, was at length traced to chronic arsenical poisoning, induced by continuous working for several months with muslin which she tore up for curtains, cushions, etc., and which was found to be impregnated with arsenic. Dr. Gowers notes the implication of sensory afferent and motor efferent nerves as distinctive; there was some pigmentation of the skin (McClure, Lancet, i., 1889). Two good examples are also recorded by Dr. S. Barton, and equally illustrate the obscurity of origin: a wife first was admitted to hospital with peripheral neuritis, which had commenced after severe headache and diarrhœa; there was also pigmentation of the skin, but the case was not cleared up until later, when the husband was admitted with similar symptoms, and was found to be a "naturalist" accustomed to rub arsenical powder into his specimens as preservative. Arsenic was readily detected in the urine when tested for (Lancet, ii., 1890). The neuritis commenced in one case, seven days after a dose of $2\frac{1}{2}$ gr., and in others, three and four weeks

after *acute* toxic symptoms (Pract., 1890). One man, a shoemaker, was affected after handling green labels (*ib.*, 1891).

Circulatory System.—After administration of arsenic, analysis has detected it in the clot—*i.e.*, united with the corpuscles and not simply dissolved in the plasma. Claude Bernard taught that it acted on the corpuscles in such a manner as to diminish the activity of interchange of oxygen and carbonic acid (Med. Times, ii., 1861). The experiments of Brodie had already indicated *undue fluidity* of blood as an effect of arsenic, and modern observations refer this condition to a solvent action on hæmoglobin: thus, if arseniuretted hydrogen be passed into defibrinated blood it becomes black, and gives with the spectroscope one large dark band instead of the two normal ones; by degrees, the spectrum wholly disappears, the hæmoglobin is destroyed, and the liquid turns yellowish-green. It seems probable that the same gas is developed to some extent from arseniates absorbed into the living organism, and that it exerts a similar destructive action on the corpuscles; this would explain the anæmia, and the consequent œdema and anasarca met with after continued use of even medicinal doses, as well as the icteric tint of skin, and the petechiæ and hæmorrhages in cases of poisoning. Though there is evidence that in certain forms of anæmia the number of the corpuscles is increased under arsenic (Gowers, Pract., July, 1878, and Bramwell), there can be no doubt that an opposite result follows both its long-continued use in disease, and any appreciable quantity of it taken by healthy persons. Thus, Lemare-Piquot (Honfleur), suffering from cerebral congestion, had himself bled many times, and by careful observations of the proportion of clot to serum, showed that the continued use of arsenic could markedly lessen the former. The normal maximum proportion of clot he reckoned at 54 per cent.; with any amount above this, cerebral symptoms such as giddiness and oppression, appeared. In October, 1845, when suffering from such a condition, he found on being bled, that the proportion of clot was 68 per cent., the serum being at 32 per cent. only. During the next four years he was bled more than twenty times with but partial and temporary relief. In March, 1849, he began the use of arsenical solution in small doses twice daily, at that time his proportion of clot being 69 per cent. After one month's arsenical treatment he felt well, and the proportion found on

bleeding was reduced to 52 per cent. In succeeding years the same result occurred several times; he illustrated it also in other cases and concluded, both from analyses and clinical results, that arsenic always rendered the blood less coagulable, and lessened the number of corpuscles (Bull. de Thérap., t. lvii., 1859). Cutler and Bradford also found the red and white corpuscles to be diminished in number under arsenical medication, and Mr. Malcolm Morris reports diminution in some cases of psoriasis when the general health was good—*e.g.*, F., aged twenty-three, on August 14, showed 58 corpuscles in each square (of Dr. Gowers' instrument), was ordered Fowler's solution (♏ v. ter die), and on 21st showed 48 only per square: continuing treatment, on September 11 there were only 37·3—the eruption was nearly gone (Pract., 1880).

The force and frequency of the heart's action and the activity of the capillary circulation are usually increased by minute doses (Feltz, Harless) and especially in weakly persons; larger quantities induce palpitation with quick, small, and irregular pulse; the face is flushed, while the extremities are cold.

Poisonous doses markedly depress the circulation, and ultimately arrest the heart (in diastole) in the lower animals, and as found by Sklarek in batrachia and in cats there was no previous stage of excitement (Reichert's Archiv, 1866). Although the frog lives on for ten minutes after arrest of cardiac action, no stimulus will re-excite this, and yet irritability of cardiac *muscular* tissue persists, so that Sklarek concluded that arsenic paralysed the motor ganglia of the heart. Unterberger also records a very pronounced fall in the blood-pressure and pulse-rate (Archiv für exper. Pathol., Bd. ii.). There is clearly a direct depressant effect on the heart—in fact this causes death in cold-blooded, though not usually in warm-blooded animals. Some palsy of the vaso-motor nerves is also indicated, and according to several experiments, this is limited to the abdominal division of those nerves: the exact explanation, however, requires further development. Though Lesser verified Sklarek's observations he did not come to the same conclusion that arsenic causes death by paralysis of the heart, but denies it for the simple reason that frogs survive excision of the heart for more than thirty minutes, whilst arsenic kills them in ten minutes. Drs. Ringer and

Murrell found (in frogs) a *varying* effect upon the heart, it being sometimes completely arrested, sometimes continuing to beat after complete general paralysis, but they explained the difference by a variation in dose; a large one being quickly absorbed and conveyed to the heart arrests it at once, leaving little for the circulation to distribute, whilst a small dose paralyses the central nervous system before the heart (*loc. cit.*). In warm-blooded animals the pulse-rate was increased at first by small and medium doses injected into the veins, afterwards it was diminished; by a large dose it was decreased at once, and the blood-pressure reduced. The increase of the pulse-rate was traced to lessened influence of the vagus and increased action of cardiac ganglia, the decrease of pulse-rate to contrary conditions. Stimulation of vaso-motor centres was not marked unless injections were made directly into the carotid, and Lesser could not verify paralysis of those centres under any conditions (Virchow's Archiv, 1878). In the human subject, the pulse usually becomes weak, rapid and gradually more irregular till the heart's action ceases: venous stasis naturally occurs, and there is pallor, lividity and finally cyanosis of the surface and of the visible mucous membranes.

Respiratory System.—Lesser verified a markedly stimulant effect of small doses, both on the respiratory centre and on the pulmonary terminations of the vagi; large quantities on the other hand, extinguish irritability in these parts. That the effect is directly on the *centre* is clear from its occurrence even after section of the trunks of the vagi, but when these nerves are entire the effect is greater, so that they have some share in it. Small doses taken under certain conditions—as, for instance, by the Styrian mountaineers—render the respiration easier, less laboured and less hurried under severe exertion. On the other hand, even medicinal doses if long continued, will induce in some persons a dyspnœa, allied to that of emphysema or even asthma, with dry cough or hawking of mucus. This I have verified several times in the subjects of eczema, observing its cessation with the omission of the drug, and its return under arsenical influence; there may be also hoarseness, coryza, tonsillitis or even, according to some observers, bronchitis (McCall-Anderson), probably from irritation excited in the bronchial mucous mem-

brane by the elimination of the drug; it has certainly some special determination to the pulmonary tract. After large poisonous doses the dyspnœa is often urgent, and the respiration stertorous.

Cutaneous System.—In frogs, one effect of arsenic is to cause a ready peeling or stripping of the whole cuticle some hours after hypodermic injection (Ringer and Murrell); this has been shown by Miss Nunn to be due to the degeneration of the lowest layer of the epidermal cells (Journ. of Physiology, v. 1). Other epithelial structures are also affected, and Cornil has found fatty degeneration of the epithelium lining the air-cells in the lungs of animals poisoned by arsenic. In man, small doses continued for a limited time, improve the condition of the skin, and often (but not always) impart freshness and ruddiness to the complexion, whilst in animals they render the hairy coat more glossy and bright. Köhler remarks that since arsenic is eliminated by the sweat-glands (especially when they are acting vicariously for the kidneys), there is nothing remarkable in its modifying the circulation and nutrition of the skin, and its effects are explained by a capillary congestion and the presence of more blood in the superficial vessels, and this again has been attributed to a vaso-motor palsy allowing dilatation of such vessels.

Rabuteau thinks such a view cannot be accepted, because temperature is not raised as it is in experimental vaso-motor palsy—*i.e.*, after sections of sympathetic. This I think is a question of degree—the rise might be more or less according to the amount of paralysis induced by a drug—it would not be so complete as after section. Moreover, Harless reports a distinct rise, though recent experiments indicate a fall of temperature as the more *usual* condition connected with arsenical action (Lolliot). Rabuteau prefers to explain the florid colour by an "altered appearance of the globules."

When the drug is omitted after continuous use, an opposite condition—one of pallor and anæmia—is said to follow (Med. Times, ii., 1854). Certainly arsenic if long continued, leads to an unhealthy, dry, and somewhat scaly condition of the skin, which has been called by some *pityriasis*, and by others even *psoriasis*, though I have never seen anything like a true case of

the latter malady thus caused. Rabuteau observes: "We never see squamous affections from arsenic, contrary to the assertions of homœopaths."

Perhaps the extreme and most characteristic cutaneous result of arsenical saturation is a brown colour of the face and various parts of the body; it is not common, but has been sometimes seen in such a form as to resemble argyria, as in the following illustration: a lady had taken for fifteen months comparatively large doses of arsenic for gutta rosacea, and two months after commencing the medicine, a change of colour had been noticed in the skin, first over the abdomen, then on the breast, neck, face and hands. When seen by Prof. Wilson the face was yellowish-brown, the eyeball dark, the whole body coloured more or less; chronic erythema affected the palms, there were hard dry points at the sweat-glands, the eyelids and the extremities were œdematous (Journ. Cutan. Med., vol. i.). In some of Mr. Hogg's cases, children got a "dusky skin eruption in patches" from arsenical wall papers (B. M. J., i., 1879). Some bronzing in a child suffering from chorea has been recorded from 5 min. of liquor arsenicalis, given thrice daily for about one month—it affected only the covered parts of the body and ceased on the omission of the drug (B. M. J., i., 1886). Such a condition depends not on chemical combination (as with silver) but on abnormal pigmentation (Gubler).

Cold clammy perspirations have also been connected with arsenical action, and pustules and ulcerations have sometimes followed it. In acute cases, either of poisoning or of unusual susceptibility to the action of the drug, patches of erythema or of urticaria (local congestions of skin) and even acute general lichen may occur. Macnab recorded an eruption like measles produced by 3 min. doses of Fowler's solution daily for three weeks (Med. Times, i., 1868), and Wyss says that he traced to it a case of alopecia areata—from affection of the trophic nerves of hair-follicles (Archiv der Heilk., 1870).

Amongst rarer consequences, erysipelas with bullæ has been credited to arsenic, herpes zoster has been traced to it by Mr. Hutchinson, and an obstinate eczema by Dr. Balfour (Edin. Med. Journ., 1860). Dr. Imbert Gourbeyre has specially written on arsenical eruptions, and in cases of acute poisoning when the

patient survived several days, has seen them petechial, papular, vesicular, and pustular.

A degree of cutaneous swelling, characteristic enough to have received the name "*œdema arsenicalis*," usually occurs first about the eyelids and suborbital tissues, and is one of the earliest symptoms of constitutional action. J. Feitelberg (Inaug. Diss. Dorpat, 1883) showed that a number of poisons increase the acidity of the blood by diminishing oxidation, the sarcolactic and carbonic acids being especially increased; arsenic acts markedly in this way, and as weak acids cause dilatation of vessels (Gaskell) the arsenical œdema is so explained by Dr. L. Brunton (Pract., ii., 1883). In severe cases it may affect the extremities and even the trunk, and amount to general anasarca, as recorded so early as 1819 (Edin. Med. Journ., v. 15). In Dr. Feltz's cases already referred to, there occurred on the second or third day, swelling of the eyelids and conjunctivæ—in some instances of the whole face, with a rash like scarlatina or urticaria. In most of them there was itching of the surface, and scratching gave rise to an urticarial rash; in one man the same eruption together with herpes, appeared on the scrotum.

Mucous Membranes.—We have already noted characteristic arsenical effects upon the mucous membrane of the mouth and intestinal canal. The lips, the nose especially at its orifice, the anus, and the vulva often become similarly irritated and inflamed, and urethritis has been traced to medicinal doses of arsenic (Med. Record, 1878). On the mucous membrane of the *eye* the effect of the drug is often very early seen, so that it becomes a useful index of the degree of physiological action. Itching about the lids is first complained of, and a rough sensation as of dust in the eye; the conjunctiva is seen to be congested, and purulent secretion may be formed. Conjunctivitis is a frequent symptom in arsenical poisoning, and Dr. Taylor describes "tumid, everted lids and painful vision" in patients affected by arsenical papers, etc. (Ophth. Hosp. Rep., 1859, and B. M. J., ii., 1871).

Chronic naso-pharyngeal catarrh, like a continued "cold," has been traced to the use of an arsenical hair-wash: for a long time this was not suspected, and various remedies and changes of climate were tried without good result, until the wash was stopped (Dr. D. Hood, Lancet, i., 1890).

Glandular System.—Under small doses of arsenic the secretions are increased, especially of those glands by which the drug is eliminated. Increase of the quantity of the saliva is exceptional in acute poisoning, but occurs when absorption takes place slowly and gradually. The bile, the intestinal secretions and generally speaking the urine, are augmented under its use; and if there be no diuresis the perspiration is commonly stimulated, and arsenic can be detected in it (Köhler, Handbuch). In six cases of poisoning from arsenic in the paper, etc., of rooms, jaundice was one of the symptoms (B. M. J., ii., 1889). Hoffmann, Glauber, Agricola and Pott have even recommended arsenic for a diaphoretic effect, and I have myself sometimes observed this from it.

Osseous System.—Struck by Wegner's observations on the changes in bone produced by phosphorus, and following up the paper of Maas, "On the Influence of Arsenic in Bone-growth, and its Value in Surgical Therapeutics" (1872), Th. Gies has published some careful and interesting experiments which well illustrate such influence (Archiv f. exper. Path., Bd. viii.). Using at first young rabbits badly nourished, he found that arsenic destroyed them *without* causing any changes in the bones; but having, by careful food, secured for fresh animals apparently more resisting power, the same daily doses (0·005 to 0·002 gramme arsenious acid) continued for nineteen to thirty-four days, seemed to improve their condition, as compared with rabbits from the same litter, and fed in the same manner (but without arsenic): the former were larger, heavier, with clearer skin, and healthier-looking than the latter, and after death the respective bones could be at once distinguished. In the long bones of the arsenic-eaters was a special thick layer (Arsenschichte) of bone between the epiphysis and the shaft; the shaft also was thicker, and in bones such as the ribs and the vertebræ, the structure was much more dense, and harder to divide than in normal animals; the new structure was true bone, but the bone-corpuscles and Haversian canals were smaller than the average. Comparative experiments were made with many rabbits, cocks and pigs, and in such manner as to leave no doubt whatever that increased growth and condensation of bony tissue were traceable to the action of arsenic. In old animals where epiphyseal growth had ceased, increase of thickness of the bones was found: on the other hand, if

the doses were raised beyond a certain point, reabsorption of bone occurred and symptoms of poisoning set in. Bones purposely fractured had not united under the treatment, for their small size made it impossible to keep them in position, but a false joint formed, and much callus was round the broken ends; there was fatty degeneration of all internal organs. Gies does not adopt Wegner's view of increased stimulus given to bone-formation, but rather that of Cunze and Lolliot, that arsenic diminishes tissue-change especially as regards carbo-hydrates, and hence follow increased deposit and insufficient removal of organic particles.

Genital System.—This system often shares in the general stimulation and irritation induced by small doses of arsenic, as has been noticed in the arsenic eaters of Styria, and in experiments on animals. Gies especially remarked it in the cocks used for his observations on bone-growth (*loc. cit.*). Clinically, Prof. Charcot was led in two cases to a contrary conclusion, but Devergie showed that this could not be sustained, and that stimulation to some extent was not unusual (Bull. de Thérap., 1864); this, however, is not such as to preclude the medicinal use of the drug, and it finds its place in the treatment of amenorrhœa.

In *arsenical poisoning*, inflammation of the genitals has been said to occur (Hunt), and certainly much irritation of them has been present, especially in women; but it would seem to be connected rather with the general irritation of mucous membrane than with these special organs. The young of animals subjected to an arsenical course were born dead, but fully developed; their birth was delayed rather than premature (Th. Gies), and no markedly injurious effect can be traced on the uterus. In many instances of arsenic being taken by pregnant women, even when with fatal results, abortion has not occurred (Guy's Reports, vol. vii.).

Urinary System.—The urine is commonly increased in quantity for a time under small doses, but with their continuance renal irritation may be induced, so that the secretion is lessened and elimination of the drug impeded. Hence it is an important practical point to examine the urinary condition during arsenical treatment, and to use if necessary alkaline diuretics. Lolliot traced hæmaturia and albuminuria to arsenic, and in a case of

phthisis, carefully recorded by Dr. Weir Mitchell, albuminous urine was induced by 4 to 12 min. of Fowler's solution given daily for a few weeks; anasarca also set in, and these conditions ceased and then recurred concurrently with omitting and resuming the medicine (New York Med. Journ., vol. i.). After poisonous doses the urine, though at first it may be passed too often, soon becomes scanty, and its evacuation causes scalding pain and tenesmus; it may contain blood, albumen and casts, and sooner or later becomes suppressed; urethritis has been already mentioned.

Urinary Excretion in Relation to Tissue-change.—The estimation of urea and other constituents of the urine furnishes important evidence as to the influence of arsenic upon general nutrition and tissue-change, for it is clear that if the principal urinary ingredients are increased under its use, tissue-changes must be going on rapidly, and *vice versâ*. There has been some contradiction between observers on these points. Sabelin recorded *increased* excretion of urea under arsenic (from 12 to 28 gr.)—Hubbard corroborated it (Record, 1882); also marked increase in the chlorides and earthy phosphates, and proportionate diminution of uric acid,—an incompletely oxidised product (hence G. Sée argued that the drug favoured oxidation and promoted metamorphosis (Nouv. Dict., Art. Asthme)—he has, however, himself since withdrawn these views). Fokker published two analyses showing a slight increase of urea after 0·01 gramme doses (Schmidt's Jahrb., Bd. clviii.), and Gaehtgens recorded the same in two dogs taking sodium arseniate; also decidedly increased tissue-change under toxic doses (Centralblatt f. Med., 1875 and 1876). Binz and Schulz relying upon these observations, and noting also that hypodermic injection of arsenious acid did not produce a local caustic effect but inflammation in distant organs—*e.g.*, the stomach—have recently argued that "this substance, in contact with living protoplasm, acts in the tissues as an oxidising agent or carrier from one albuminous molecule to another, being converted during this process into arsenic acid, then reduced, again oxidised, and again reduced" (Centralblatt f. Med., ii., 1879; Med. Times, i., 1879). But I think the evidence insufficient for the conclusion, and all observations upon fasting animals are open to the fallacy that *urea may be increased by the fasting*, and consequent destructive metabolism of proteids in the tissues. The

dogs utilised by Gaehtgens were kept many days on water only, and a careful examination of the whole question leads to the conclusion that the "tissue-change of inanition" is almost surely the explanation of what he attributed to arsenic (F. A. Falck, Archiv f. exper. Path., 1877, Bd. vii.). Von Böck attributed any change he could observe to the effect of fasting, and held that arsenic acid in ordinary doses exerted no essential influence on tissue-change (Zeitschr. für Biologie, vii.).

Others have concluded positively that it *lessens* excretion and change. Thus Lolliot in a careful thesis, records many observations and analyses, from which he makes evident a *diminution* of urea and carbonic acid under arsenic; he asserts, also, that it lowers temperature, and is a "médicament d'épargne"—it lessens the activity both of nutrition and denutrition (Étude Physiol. de l'Arsenic, Paris, 1868). Köhler classes it with tea, coffee, and cocoa, as "Sparmittel"—diminishing oxidation processes Handbuch der Physiol. Therap., 1876). In experiments by Dr. Tamassia (Pavia), toxic doses of white arsenic given to animals, progressively lowered temperature up to, and after death (Med. Record, 1878). Animals accustomed to an arsenical ration became pyrexial and emaciated on its withdrawal, implying that some moderating power had been removed. There is still, however, a discrepancy in the observations on temperature; Harless reported a slight rise from small doses, and Billroth, gradually increasing the dose to 40 min. daily in a case of asthma, reported a febrile access in the evenings up to 101° F. (Wiener Woch., 1871).

Schmidt and Brettschneider found the excretion of urea and carbonic acid diminished 20 to 40 per cent. under arsenic; phosphates also diminished. Schmidt and Stürzwage likewise report diminution of carbonic acid and urea in rabbits under minute doses (Schmidt's Jahrb., Bd. clviii.), and Rabuteau states that the elimination of urea in a dog was lessened for three weeks after a few doses of arsenious acid,—at one time as much as 60 per cent.; he attributes its effect in lessening tissue-change to an action on the blood-corpuscles.

I conclude that although some contradiction exists on this point between good authorities, yet the balance of recent evidence points to *lessened excretion*, and consequently to *lessened tissue-change* as an effect of arsenic.

Acute and Chronic Poisoning.—Although not here concerned with cases of poisoning further than as they illustrate physiological action, we may note that if death occurs from large doses of several drachms and in the course of a few hours, it is generally from *cardiac palsy*, and is preceded by excessive prostration and fainting. If 1 or 2 dr. have been taken, and the patient survives two or three days, the symptoms will be mainly those of *severe gastric and intestinal* inflammation, as already described, and the post mortem appearances will correspond; whilst with doses of 2 to 10 gr., when the patient survives much longer, and yet dies ultimately from the effects, these will be evidenced rather in the *nervous system* (Hunt). If the poisoning be very chronic, and result from continued doses of $\frac{1}{8}$ to $\frac{1}{4}$ gr., a general irritation of the system is apparent from the symptoms of erethism or pyrexia with chills, redness of eyes and of the orifices of the nose and anus, vesication on the palms and soles, with dryness of the skin and brownish spots, pain in the head, joints and abdomen, with vomiting, purging and gradual marasmus. The soreness of the mouth and salivation have sometimes suggested *mercury* as the poisonous agent, and sometimes the general condition has been mistaken for phthisis, or for typhoid. Gaehtgens further suggested points of resemblance with diabetes and with phosphorus poisoning (Cbl. f. Med., 1875, Bd. xiii.). An instructive case which, for a time, completely deceived the medical attendants, and yet which reveals exactly the physiological action of arsenic as we have described it—including renal and nervous symptoms—is that of Mrs. Wooller as related by Sir R. Christison (Edin. Med. Journ., 1855). Dr. F. A. Macpherson has recorded a case of chronic arsenical poisoning produced by the administration of Fowler's solution in psoriasis, in which several exceptional symptoms occurred, of which the most striking were a husky voice, throbbing in the head and ears, and a tingling of the skin; the power of mental concentration was dulled, and sexual power diminished.

PATHOLOGICAL CHANGES.—In cases of acute poisoning the principal changes occur in the stomach and intestinal tract; redness and inflammation of these parts may be found within a few hours of administration; ulceration is not uncommon, gangrene and perforation are rare. In exceptional cases no marked

redness has appeared, though arsenic has been found in the stomach (Taylor). Under full arsenical influence there is marked tendency to fatty degeneration of all tissues; in acute cases this is preceded by inflammatory change, and according to Dr. Pinkham it may be induced within forty-four hours (Med. Times, ii., 1878). Jaundice occurs, and after death, the liver-cells, the renal tubules and the intestinal glands are found choked with granules and fat-globules, their epithelium being detached or destroyed. Salkowski found these changes in poisoned animals within three to six days, the glycogenic function of the liver being impaired very early (Virchow's Archiv, Bd. xxxiv.); it is noteworthy that in such cases, the fourth ventricle may be punctured without causing glycosuria. MM. Cornil and Brandt find that the fatty degeneration produced by arsenic is less intense than that caused by phosphorus, and moreover, that in the liver it is uniformly distributed throughout the lobules. It has been said that arsenical poisoning may be certainly diagnosed if besides gastritis there are found fatty heart, kidney and liver, with fluid dark blood and sub-endocardial ecchymoses (Lancet, ii., 1889). Virchow described a swollen state of Peyer's patches and the solitary glands, with fatty degeneration of epithelium and "rice-water" secretion containing a fungus that had been previously found only in cholera evacuations (Archiv, Bd. i., 1870). The mesenteric glands are also often enlarged (Lancet, i., 1884). A yellow pigment has been found lining the stomach and intestines in bodies which have been exhumed after arsenical poisoning, and Dr. Stevenson has recorded several cases in which it was clearly shown that this is the yellow sulphide of arsenic (Lancet, i., 1884). In one case this was deposited on the endocardium (*ib.*, ii., 1892); in an other case, however, a pigment very similar in appearance contained no arsenic and consisted simply of bile (B. M. J., i., 1884). C. Gies has recently given additional evidence of fatty degeneration of tissue under continued small doses of arsenic, but notes also that the subcutaneous fat was increased, and the animals gained weight. Increase of fat and of weight have been observed in chronic arsenical poisoning in man (Boston Journ., 1876).

In cases of poisoning, several attempts have been made to determine accurately the organs in which the metal accumulates. Thus, M. Garnier states that the liver is the place where it

collects to the greatest extent. It forms no compound with albumen as some other metals do, and so he considers it possible that it forms insoluble arsenites and arseniates with the calcium salts of the fluids of the body (Ann. d'Hygiène, ix.). Professor Chittenden attempted to determine at what time before death the arsenic had been taken (Amer. Chem. Journ., 1883). In one case nearly three times as much arsenic was obtained from the mouth and throat as from the kidney, and so it was thought probable that a large dose of arsenic had been taken just before death; the absence of arsenic in the brain, an organ distant from the seat of absorption, confirmed this opinion. (In cases of *chronic* poisoning the kidney contains a good deal.) In bodies which have been exhumed, it is always necessary to analyse the soil also, for, as MM. Schlagdenhauffen and Garnier have shown in the Vosges country, arseniate of iron may exist in large amount in the earth (L'Union Méd., 1885).

TOLERANCE.—**Arsenic-Eating.**—Under certain conditions the system may be brought to "tolerate" full, and even toxic doses of arsenic as of some other drugs, without showing the usual physiological effects. To produce such a result, it is necessary to begin with very small doses, and increase them by degrees: thus Flandin, giving at first $\frac{1}{65}$ gr. of arsenious acid to animals, gave after nine months of progressive increase, 15 gr. per diem without symptoms of poisoning.

Taylor distinguishes between "*habit*" and "*tolerance*," meaning, by the latter term, only that power of bearing large doses which is shown in certain exceptional states *without any preparation;* thus, opium may be tolerated in tetanus, alcohol in fever, and antimony in pneumonia; and with regard to the ordinary form of tolerance as *induced by habit*, he remarks that it is mainly restricted to products of the vegetable or organic kingdom—as opium, tobacco, ether, strychnine. He doubts whether any human being can obtain *by habit* any real tolerance of such mineral drugs as corrosive sublimate and arsenic; and certainly experiments on the point can never be pushed far in our own experience.

Yet, on the other hand, evidence in the affirmative does exist. I understand that at Whitbeck (Cumberland), the inhabitants

habitually use a natural water which contains nearly a grain of arsenic in the gallon, and are remarkably healthy and long-lived (Chemical News, Aug., 1860). Prof. La Rue reports the case of a man who so far accustomed himself to the drug that he could take 3 or 4 gr. "without more effect than cold water" (Boston Med. Surg. Journ., 1866); but the main evidence seems curiously localised in parts of Austria and Styria, nor can it be any longer dismissed as "pure fable" (Christison) or a "Styrian theory" (Taylor), since the reports of Vogt and Tschudi in 1854 (Med. Times, ii., Wiener med. Woch., No. 28). M. Heisch, a trustworthy witness, has recorded his personal experience to the effect that he took 3 gr. as a daily dose for many years; he began it when appointed director of arsenic works at Salzburg, with the object of protecting himself from the effects of the fumes; he retained good health, but when he attempted to leave off the drug suffered from restlessness, insomnia, faintness and finally from pulmonary symptoms (Lancet, 1860). Prof. Schäfer records that $\frac{1}{20}$ to $\frac{1}{10}$ gr. is an initial dose commonly used for the first fortnight, then it is omitted for the same period, and then resumed, and gradually increased to 5 gr. or more—Heisch says that 23 gr. have been taken for a dose. Arsenious acid is the usual form, but sometimes orpiment is substituted. Dr. Maclagan saw doses of several grains swallowed, and he afterwards detected arsenic in the urine (Edin. Med. Journ., 1864); and I have myself learnt from persons at Salzburg that the habit was very common, and have seen men who had taken from 5 to 10 gr. daily for many years with occasional intermissions, and who looked robust and healthy. Near Harzburg, they have the curious custom of regulating their doses by the moon—they gradually increase to the full moon, and then diminish and take purgatives of aloes; some avoid drinking with their dose of arsenic, others avoid fat, and others keep to a farinaceous diet, but the majority eat and drink anything. The practice prevails mostly, if not entirely amongst the working-classes, but is not confined to men. Its effect is said to be to increase fat, and yet to render them more equal to exertion, and especially to mountain-climbing without difficulty of breathing; also to give freshness to the complexion, brightness to the eye, and general vigour to bodily func-

tion.[1] It is agreed that much depression and emaciation occur on the withdrawal of the drug from those who are accustomed to it, and although a certain number who commence early to take it continue its use to an advanced age, yet it is said, and we can well believe it, that it does much harm, and even proves fatal in an insidious manner to many persons, especially amongst the young. (Mr. Jonathan Hutchinson denies that patients who take arsenic for a long time get fond of it, or suffer when it is withdrawn (Archives of Surgery, ii.). We cannot depend upon securing an indiscriminate tolerance of arsenic; nothing of the kind has been reported in this country, but on the contrary many have suffered from a foolish imitation of the Styrian custom.

Effects of Arsenical Wall Papers, etc.—It is now clearly ascertained that all the serious symptoms already described may be produced in greater or less degree by arsenical emanations from wall papers and paints, hangings, dresses, ornaments, etc.; and not only from the green colours containing arsenite of copper, and which have long been suspected, but also from red, drab, blue, grey, and enamel papers generally (B. M. J., ii., 1871), and from aniline colours fixed by arsenical mordants in carpets, curtains, etc. (Taylor, On Poisons, 3rd ed.). Soon after the earliest observations on the subject, in 1858, Mr. Phillips (the chemist consulted by the Board of Trade) stated that a more than bearable heat would be required to volatilise arsenic, but Fleck has pointed out that the contact of moist organic substances (such as sizing) readily disengages arseniuretted hydrogen from Schweinfurt green (Zeitschrift für Biologie, Bd. viii., 1872), and Hamberg has verified its presence in the air of rooms (Pharm. Journ., Aug., 1874). This gas is a very powerful poison. Gehlen, the chemist, was killed by a small quantity, and in some cases it caused severe epistaxis, hæmaturia, and jaundice (Comptes Rendus, 1863; Gaz. de Paris, 1873). Dr. Stevenson considers that the glue may aid in the formation of those exceedingly powerful

[1] Gubler explains these effects by diminished oxidation and tissue-change, suggesting the connection of muscular fatigue with formation of sarco-lactic acid; he presumes this to be lessened by arsenic alike in thoracic, respiratory, and other muscles. They can therefore work longer, there is less carbonic acid to be discharged by the lung, and less labour or hurry in respiration.

poisons called *arsines;* these substances are amines in which hydrogen is replaced by arsenic. After death too, the arsenic in the system forms these bases with the decomposition products of albumen. Selmi has separated one of these ptomaine-like substances, and found that its physiological action is like that of strychnine. (It is supposed that the *aqua tofana*, a poison almost fabulous in its power, really was a solution of an arsine which was prepared by sprinkling white arsenic on pork (B. M. J., i., 1883).) Usually, however, the injury is done by material particles of arsenical dust (Chevallier, Annales d'Hygiène, vol. xii.). Some time ago I met with many cases of catarrh and irritation of mucous membranes which proved to be due to this cause, and I can quite corroborate the observations made by Mr. Clarke of Bristol (B. M. J., i., 1873), who finds that in one set of cases dyspepsia, nausea, sore throat and conjunctivitis are the prominent symptoms, whilst in another, nervous troubles, headache, irritability, prostration and restlessness are more complained of, though dyspepsia and especially a coated tongue are not absent; in a third group the prostration, headache, and nervous excitement simulate a mild typhoid. He records violent sneezing, and also an eruption of eczema and nasal ulceration as exceptional symptoms, and further points out that a case of ordinary illness may be much aggravated by an arsenical atmosphere, and that some patients are much more sensitive to it than others; arsenic was detected in the secretions of several of his patients. The symptoms are generally worse in a damp atmosphere, and in the evening when the room is heated. Dr. Hinds describes "depression, faintness nausea and colic," after reading by gaslight in a green-papered room (Med. Times, 1857). Mr. Whitehead reports similar symptoms in a youth every time he occupied a certain bedroom only (B. M. J., 1858).

The real cause of chronic ill-health may be long unsuspected, and a striking case is related of the simulation of various forms of disease in one family for upwards of twelve years before their true cause was discovered in arsenical wall papers (B. M. J., ii., 1871). Sir G. Johnson has reported the case of a medical practitioner in whom chronic dyspepsia, catarrh, cough and even asthma were due entirely to the same agency (Med. Times, ii., 1874). Similar symptoms have followed though less frequently,

from painted walls, gas-shades, green-baize curtains, etc. (Syd. Soc. Year Book, 1860 ; Lancet, i., 1892, etc.). Leifeit reports the case of a girl twenty-six years old, poisoned by arsenical stockings ; the symptoms were gastro-enteritis, acute hæmorrhagic nephritis and eczema on both feet ; she was cured in three weeks, but slight albuminuria remained (Wien. med. Wochens., 1884). Dr. F. Brown has reported several interesting and important cases of chronic illness from arsenical paints and wall papers : he notes that most of the patients had increased in weight (Bost. Med. Surg. Journ., 1876). Some years ago arsenic was purposely used for clarifying candles, and serious effects were produced which still sometimes follow the use of candles coloured green. A curious cause of several cases of arsenical poisoning occurring in counters of money at Washington, was the arsenic present in the coins (Record, 1883). Another source of poisoning occasionally met with is that of arsenical fly papers, and it has sometimes occurred from cigars and from green cigar-holders (B. M. J., i., 1879). Mr. Jabez Hogg has drawn special attention to inflammation of the eye from arsenical papers, and to other illnesses produced by them (Sanitary Record, April, 1879). The National Health Society has drawn up a list of articles which are dangerous to use on account of the risk of their containing arsenic (B. M. J., i., 1883).

Other unusual cases of poisoning have arisen from peppermint lozenges where arsenic had been added by mistake for sulphate of lime : from water in a tank that had been cleaned from "fur" by arsenite of soda, from wine put in a cask that had contained "weed-killer," and from sugar taken from the *middle* of a sack when it had been moistened with "weed-killer" owing to a leakage of a tin in a railway van (B. M. J., i., 1891 ; Lancet, i., 1891).

SYNERGISTS.—Antimony is the most complete analogue of arsenic ; phosphorus also is allied in action.

The effect of small doses, upon the nervous system especially, is allied to and supported by quinine and by alkaline bromides, whilst the tonic influence of similar doses on the vaso-motor nerves (leading to contraction of vessels, at least temporarily) is allied to that of acids, astringents, ergot, and cold applications. Doses sufficient to lessen oxidation and combustion act somewhat

like cyanides and other substances which prevent these processes.

ANTAGONISTS — INCOMPATIBLES. — Diffusible stimulants, alcohol, warmth, and, according to Gubler, opium, are the vital antagonists to arsenic. Iron in the form of hydrated peroxide, magnesia calcined or as hydrate, lime, animal charcoal and astringents generally, are chemical or mechanical antidotes. Iron and magnesia have power over arsenic in *solution*, since they precipitate the poison in an insoluble form; with *solid* arsenic "they have no more effect than powdered brick-dust" (Taylor). A mixture of hydrate of magnesia and persulphate of iron is best to use, and the resulting sulphate tends to act on the bowels. The "antidotum arsenici" of the German and other Pharmacopœias contains calcined magnesia 7 parts in 120 of water, solution of persulphate of iron (sp. gr. 1318) 60 parts in 120 of water: the two parts to be kept separately and mixed at the moment of administration. Such a mixture may be roughly prepared, in cases of urgency, by shaking magnesia with the tinctura ferri perchloridi, and then administering the bulky precipitate of sesquioxide of iron so produced. Pure dialysed iron is not antidotal, but according to Mattison, becomes serviceable if salt be added to it (Med. Record, 1878), since this precipitates a hydrate. Dr. Ballard however, speaks of the immense utility of dialysed iron in those who are compelled to inhale arsenical fumes during the smelting of lead and silver ore; the bad effects are entirely dissipated by doses of half an ounce thrice daily: Wyeth's preparation was employed (Philad. Med. Rep., 1882). Oxide of silver (2 gr. ter die) has been given as antidotal in a case of chronic poisoning with neuritis, etc., to form an insoluble arseniate (Lancet, ii., 1890). Iodide of potassium is more often given in such cases.

In cases of poisoning, vomiting should be produced and promoted as early as possible, by ipecacuanha or zinc sulphate, nor is antimony so undesirable as has been stated; many cases have recovered under its use (Morgagni, and Gaz. des Hôp., 1844), also after infusion of tobacco (Med. Times, i., 1857). Milk and demulcent drinks containing, *e.g.*, eggs, flour, or fats, should be given, and large frequent doses of any of the antidotes named, —a tablespoonful of the iron compound every five to ten minutes (B. M. J., ii., 1863).

THERAPEUTICAL ACTION.—*External.*—**Parasitic Diseases.**—In *scabies*, and in *phtheiriasis*, arsenic has sometimes been used, and a lotion containing a small proportion[1] with soft soap and spirit of wine has been much commended: it is painful in application, and has not seemed to me so good as other remedies; neither is the use of this substance free from danger, for an arsenical salve applied for scabies has produced poisonous effects.

Lupus—Cancer.—In these maladies the caustic action of arsenic is often extremely valuable, and the powdered drug may be used sufficiently strong to destroy diseased tissue without affecting the adjacent sound skin. For chronic superficial lupus, especially of the face, Hebra recommends "Cosme's Paste," containing 20 gr. of arsenious acid and 60 gr. of cinnabar in 1 oz. of rose ointment (cold cream): this is spread on linen, and applied firmly for twenty-four hours, and then renewed for the same period, a third application being made if required. I have often used this with good results; at first there is little change produced, but by the second day the growth turns grey, and by the third day commences to slough, and may be separated in a poultice. Pain and œdema may occur, but can be relieved by sedatives and warm applications. Amongst many hundred cases thus treated, no poisonous symptoms have been reported.

In *epithelioma*, arsenic has been long used in various combinations, as with cinnabar, calomel, or simply with an equal part of mucilage. The paste commonly known in Ireland by the name of Miss Plunkett's is prepared with arsenious acid, sulphur and two species of ranunculus: it often acts powerfully.

As already stated, caution is required in the external use of arsenic: not that it should be applied in a more diluted form, for then its absorption would be even more probable, but only a limited area—not more than one square inch—should be covered at one time. Dr. Walshe has specially insisted that its use should be restricted to superficial cancer.

Nævus.—Mr. W. G. Beatty and Dr. Blair have both recorded cases of cure of nævus, by the local application of liquor arsenicalis

[1] Arsenious acid 1 part, carbonate of potassium 20 parts, soap spirit 200 parts, water 2000 parts. (Soap spirit is made with equal parts of soft soap and spirit of wine.)

every two or three days for three to five weeks (B. M. J., ii., 1883, and i., 1884); diarrhœa may occur.

Dental Surgery.—Arsenious acid is in daily use for destroying the nerve-filaments in a tooth-pulp before filling the cavity, and it is still considered one of the best agents for the purpose. It is true that violent symptoms have sometimes followed its use, which always needs caution: still osteitis and its accompanying pain might occur after any destructive application, and we may fairly consider that $\frac{1}{50}$ gr., especially when combined as it usually is, with a little morphine, is free from any serious risk of arsenical irritation.

Rheumatic Gout.—Baths containing from 15 to 30 gr. of arseniate of sodium, with a few ounces of the carbonate of sodium, have been well spoken of by Dr. Guéneau de Mussy, as relieving both the pain and the deformity consequent upon rheumatic arthritis, but must be used with great caution. There is some evidence in favour of the internal use of the remedy for this malady.

THERAPEUTICAL ACTION.—*Internal.*—The therapeutical powers of arsenic, which are many and various, may be traced along the same lines as its physiological action, and without implying any definite limits as to the pathology of the undermentioned diseases, we may, for the sake of clearness, arrange them in four groups for consideration in detail: (*a*) general diseases, such as intermittent fever, phthisis, struma, lymphoma, anæmia, chronic rheumatism, diabetes; (*b*) more specially nervous disorders, neuralgia, asthma, chorea, tremor; (*c*) disorders connected mainly with capillary congestion, cerebral, renal, uterine, or cutaneous; (*d*) disorders affecting chiefly mucous membranes, coryza, chronic bronchitis, dyspepsia, gastric catarrh, vomiting, diarrhœa, English cholera, gastric ulcer.

Intermittent Fever—Ague.—Long used as an empirical remedy for ague in the East, its more scientific employment dates from Slevogt of Jena, in 1700.[1] Condemned by Baron

[1] Of the older writers on this subject, Melchior Frick and the two Plencitz, of Vienna, deserve mention. The former says: "Experientia nos docebit, arsenicum in febribus intermittentibus adhibitum omnes eas dotes possidere, quibus optima remedia prædita esse debeant" (Paradoxa de Venenis, 1710). Of the practice of the latter at the Orphans' Asylum, Harless reports: "Ejusque (arsenici) usu in millenis fere febrium intermittentium casibus, raro frustratos fuisse affirmant."

Störck, it was re-introduced by Dr. Fowler of Stafford, in 1786, after experience of the effects of a "patent ague drop" which contained it; and again condemned by Broussais. Its value was finally re-established by Boudin, in 1842, after a prolonged experience in Algeria (On Intermittent Fevers). The English physician reported several hundred, but M. Boudin, 4000 cases, almost all successful. The former was accustomed to press the remedy to its "operative" or physiological effects; the latter aimed at inducing "tolerance," commencing with fractional doses every quarter-hour, so as to introduce as much as possible into the blood, and to "substitute an arsenical for a paludal saturation." The names of Sistach, Millet, Frémy, and Isnard are associated also with records of large numbers of successful cases, whilst opposite experiences may be found in the works of Gintrac, Oesterlen, and G. Sée.

In 1860, Mr. J. Turner reported such favourable results with $\frac{1}{2}$ dr. doses of Fowler's solution, given every second hour for four or five doses, that the Director-General recommended the plan to army officers (Med. Times, ii., 1871), and Dr. Chappell supported it with an account of 80 cures out of 140 cases (Med. Times, i., 1861). The same dose was used by Dr. Broderick, but not without sickness (Brit. and For. Rev., 1866). These observers found, as did Fowler, Rayer and others, that much better results in curing ague were obtained with large doses, as of 30 to 40 drops, than with ordinary, full or unusual doses up to 20 drops; but Sistach and others observed that as soon as the fever ceased, the system ceased to "tolerate" such quantities, and there is always a possibility of the remedy doing harm. A case has been recorded of a physician aged fifty, who took 12 drops of Fowler's solution twice daily for about three months with apparent benefit to the intermittent, but he suffered from diminished secretion of urine, colic, tenesmus, weak heart, etc., and died rather suddenly with vomiting and syncope; his attendant (in South America) traced his symptoms to arsenic. It must be said, however, that an ordinary cerebral attack—*i.e.*, independent of arsenic—is not excluded by the history given (Med. Record, 1879).

We cannot doubt that arsenic suitably administered, is an effective remedy for ague, but on comparing it with quinine,

and allowing for a percentage of spontaneous recoveries from mild attacks, we conclude that the latter remedy is still to be preferred for severe and acute cases, and in "pernicious" or "malignant" forms; also it acts better usually in tertian ague. When however, it has failed to cure such cases even in excessive or long-continued doses, or when the malady is of moderate severity, subacute or chronic, especially when of quartan type and accompanied with marked œdema and prostration, then arsenic is specially indicated. The element of risk may be much lessened by careful attention to the urine and the general symptoms.

Splenic or hepatic hypertrophy may be another indication for it, as Boudin suggested. It is good in malarious cachexia (when quinine often renders but little service), also when jaundice is present; further it has some prophylactic power, and assists in preventing relapses. Dr. Peifer recommends the injection of Fowler's solution into the substance of the spleen, when it is enlarged as a result of ague. In one case a syringeful was injected ten times in the course of eight weeks. Dr. Peifer says that this method is more rapid and successful in its action than the administration of arsenic by the mouth; (after the injection an ice bladder is laid over the organ). This procedure is, however, dangerous when there is any hæmorrhagic or leucocythæmic tendency (Cbl. f. d. gesammt. Therapie., 1884).

I have records of nineteen cases of severe chronic ague of the quartan type, all successfully treated by arsenic. Most of the patients were Americans who had taken quinine very largely, being in the habit of carrying it in their pockets and taking from 5 to 20 gr. whenever they fancied an attack was impending. Many of them had clean, red, irritable tongues, and were suffering from œdema or anæmia; in most of them the spleen was enlarged, and in some the liver. I prescribed the liquor arsenicalis in 5 to 10 min. doses thrice daily, and the result of this treatment was uniformly good.

As regards the prevention of relapses, Hirtz, judging from 120 cases, found quinine and arsenic nearly equal; probably the best results may be obtained by a judicious combination of them both, full doses of the former being given to ward off an impending paroxysm, and arsenic in the intervals: this mode of treatment I have frequently adopted with success. Prof. Gubler uses arsenic

in ague as a sedative, and "indirect reconstituent," and connects its efficacy against relapses with its permanent deposition in the tissues. There is some evidence of its use as a prophylactic (B. M. J., i., 1889); both quinine and arsenic have been credited with an "anti-zymotic" power of destroying malarial germs in the blood.

Phthisis.—For the employment of arsenic in chest diseases we may go back as far as Dioscorides, who states that "sandarach (probably the sulphuret) is given to patients suffering with suppuration in the lungs, and mixed with resin is inhaled in vapour for obstinate cough." Dr. Beddoes used it early in this century, and recently the value of the drug in certain stages of tubercular phthisis has attracted renewed attention. Hérard and Moutard-Martin have especially recorded good results from it in relieving the pulmonary congestion and the general pyrexia of early stages; at the same time the latter physician observes that it is most efficacious when phthisis assumes a *slow* torpid course, acute tuberculosis not being modified by it. "It has a reconstituting action, and modifies secondarily the pulmonary lesion" in suitable cases (Lancet, i., 1868).

Before softening of tubercular deposits has taken place, I have found arsenical solution in 2 or 3 min. doses three times daily, give particularly good results; it is well to combine it with a course of cod-liver oil and also if possible, change of climate, and it should be continued for weeks or even months. I agree in general with the account given by Isnard (which is still more favourable), for he found it relieve profuse sweatings, improve appetite, and promote in some favourable cases not only healing of cavities but absorption of tubercle (Bull. de Thérap., t. lxxvii.). It controls diarrhœa in these cases in a very marked way.

Since Koch's discovery of the tubercle bacillus, the theory which has been advanced to explain the action of arsenic in phthisis is that it is preventive rather than curative, the bacillus not being able to grow in a medium in which arsenic also finds a place, but recent observations seem to show that any amelioration is due to improved appetite rather than to a lessening of the growth of the tubercles. Thus when G. Kempner gave arsenious acid in doses which he increased to $\frac{1}{7}$ gr. daily,—the appetite was improved and the fever relatively lowered.

H. Lindner found that the sweating and expectoration were lessened; whereas, R. Stinzing who treated sixteen cases with similar doses had unfavourable results in all (Record, 1883).

Cersoy traces to arsenic an effect which has been also attributed to it in bronchitis, and which really accords with what we know of its physiological action, viz., the lessening of congestion both in the bronchial mucous membrane and in peri-tubercular lung-tissue; thus he finds that it benefits hæmoptysis (Gaz. des Hôp., 1869). Prof. Stillé thinks it probable that any benefit conferred in phthisis is due to an influence upon the accompanying bronchitis.

Massart is almost alone in his recommendation of an *arseniate of gold*, which, in doses of $\frac{1}{10}$ to $\frac{1}{3}$ gr., he found useful even in advanced cases (Rev. de Thérap., 1860). The arseniate of strychnine is a more recent introduction in the form of a solution of $\frac{1}{2}$ p.c. in vaseline; from 4 to 15 min. were given subcutaneously daily to four cases which improved (Lancet, i., 1889). The general opinion of French observers, however, would restrict the value of arsenic to early stages, or to the relief of certain symptoms: thus Nonat agrees as to the good results of $\frac{1}{70}$ to $\frac{1}{30}$ gr. doses given early in the malady, and finds that in later stages, especially in the cases mostly seen in hospital practice, benefit is exceptional (Lancet, i., 1870); and Trousseau, whilst recording improvement as to diarrhœa, hectic, expectoration and cough, does not speak of cures, but of the gradual development of the malady and the formation of fresh tubercle. He prescribed cigarettes containing arseniate of sodium and pilules of arsenious acid.

I do not find many English observations on this subject, nor has this medication for phthisis been generally adopted amongst us. Dr. Williams says: "I have tried it only to a limited extent. . . . It has only seemed to be useful in chronic cases with asthmatic or cutaneous complication, but well deserves further investigation" (Pulmonary Consumption, 1st ed.). Dr. Ringer suggests that allowance must be made for a natural improvement in some forms of phthisis, but has himself seen instances of recovery under its use "in children with general tuberculosis," and "in adults suffering from subacute and chronic forms"; he corroborates also, to some extent, the statement that it will reduce temperature (Handbook). Dr. Sanger reports, from the convalescent hospital at Seaford, favourable results in a large num-

ber of phthisical patients to whom he gave 5 min. doses of Fowler's solution, but he generally combined it with iron or hyposulphites (Lancet, i., 1869). Dr. Leared based a favourable opinion upon the observation of nine cases, but finds the remedy "trying to the digestive system" (Med. Times, i., 1863), and this I believe to be a very common result, owing to the dose prescribed being too large.

Struma—Strumous Ophthalmia.—In chronic cases of glandular enlargement, pallor and anæmia, occurring in subjects with the ordinary evidences of struma, arseniate of sodium is often beneficial; it improves the appetite and colour, seeming to stimulate the lymphatic and arterial systems. I have frequently known Fowler's solution prove serviceable in strumous ophthalmia, giving relief to the redness and swelling of lids, as well as to conjunctival congestion and excessive secretion; it has seemed also to help in cicatrising ulcers, and in diminishing the exudation which would produce leucoma. Mr. Oglesby speaks of its special value in that form of strumous ophthalmia which is accompanied by herpes (Pract., vol. ii.).

Strumous Cachexia—Lymphoma.—Prof. Bouchut restricted the value of arsenic in glandular disease to cases where this was superficial and limited, and where cachexia was not present, but later experience has proved the remedy to be more generally useful than he believed. I have seen it of much service, especially when combined with iron, in relieving cachexia, and Billroth has recorded a remarkable case—that of a woman aged forty, in whom the cervical, axillary and other glands, as well as the spleen were affected, and who recovered under Fowler's solution, taking 5 to 20 drops for a dose. Dr. Winiwarter records good results in cases of malignant lymphoma or Hodgkin's disease, a malady limited to lymphatic structures, and to be distinguished from a sarcoma commencing in the glands, and spreading from thence. In the latter condition arsenic has no influence: neither is Hodgkin's disease to be confounded with scrofula, for there is no tendency to suppuration; nor with leukæmia, for there is no increase of white corpuscles. The malady referred to occurs in strong young persons, often begins in the cervical glands, which enlarge separately, and is fatal if left untreated; it has been observed to follow intermittent fever.

Under the use of arsenic continued for three or four months or more, and also injected into the tumours, they have disappeared at least for several years, and the patients have become convalescent. It is recommended to begin with 5 min. of Fowler's solution and 5 min. of tinct. ferri perchloridi night and morning, cautiously increasing the dose up to 30 to 40 min., or to the production of physiological effects (Stricker's Jahrb., 1877). Dr. S. Monckton has recorded a remarkable case of cure of the same malady—he gave pills containing $\frac{1}{13}$ gr. of arsenious acid, which were coated with keratin so as to ensure their being digested in the intestine and not in the stomach,—the result being that in the course of two months the tumours had almost disappeared (B. M. J., ii., 1885). E. Romberg has a similar case (B. M. J., Ep., i., 1892): my own experience has not been so favourable.

Scarlatina.—Dr. Walford recommends that people who are exposed to risk of contagion from scarlet fever should take 2 to 3 min. of liquor arsenicalis three times a day, with a view to preventing the development of the microbe to which this disease is attributed, and so arresting its spread; it is a plan which he has found to succeed not only in scarlet fever, but also in measles and diphtheria (B. M. J., ii., 1884). This statement is endorsed by Dr. Buckheim of Vienna, who also adds enteric fever to the list of diseases similarly preventable (Med. Record, 1883). Mr. Bryan advocates the same view and applies it to surgical operation (Lancet, ii., 1892).

Cystic Goître.—Dr. Snow has recorded a case of this disease in which other local and general treatment failed, but in which the administration of 5 min. of liquor arsenici hydrochloricus three times daily "acted like a charm"; he has had two similar cases (B. M. J., i., 1887).

Chlorosis.—In this disorder I have seen arsenic often act particularly well, and it has been strongly recommended by Isnard. Dr. Wilks also speaks highly of this remedy in all anæmic and atrophic conditions, and has recorded several cases cured by it (Lancet, i., 1885).

Progressive Pernicious Anæmia.—This remarkable and serious malady, first described by Dr. Addison as "idiopathic anæmia," has sometimes proved amenable to arsenic. It occurs

often without appreciable cause (although self-poisoning from ptomaines, etc., in the intestines has been suggested), about or beyond middle age, the patient becoming blanched and waxy-looking, sometimes jaundiced, and suffering later from œdema, dyspnœa, giddiness and coldness. The blood is found to be dull red in colour, and the red corpuscles to be diminished and altered; retinal and other hæmorrhage may occur, also occasional attacks of vomiting and diarrhœa. The patient remains, or becomes, fat, rather than emaciated, yet the disease has usually ended fatally by exhaustion and collapse, in spite of iron, good food and other forms of treatment. Dr. Bramwell has recorded a typical case, which was carefully treated in hospital for three weeks with full doses of quinine and iron, and later phosphorised cod-liver oil, and yet steadily got worse until 2 min. of liquor arsenicalis were given thrice daily, the other remedies being stopped. The dose was gradually increased to 16 min. thrice daily, and "the after-progress of the case may be described as one of slow but uninterrupted improvement." In a month's time he was able to attend as an out-patient, and continuing to take arsenic considered himself well, and resumed work. His colour improved, cardiac murmurs disappeared, and the condition of the blood was found to be normal (Med. Times, ii., 1877). Such a case, in conjunction with others, offers much encouragement in the use of the remedy, and serves to illustrate further its alliance with phosphorus, which drug has also proved useful in some similar conditions. Dr. M. Finney has reported three well-marked cases of "pernicious anæmia," two of which recovered under arsenic, and he calls it "one of our surest tonics to the blood-making organs" (B. M. J., i., 1880). Dr. Withers Moore informs me that in a similar case (idiopathic anæmia) under his care at the Sussex County Hospital, arsenic also proved of service. The patient, a woman aged thirty-two, showed characteristic symptoms of the malady nine months after a bad confinement, and after frequent epistaxis: she was extremely pale and feeble; the red corpuscles of the blood were few, small and altered in shape, the white corpuscles not increased in number. For the first three months of her stay in hospital iron was tried in various forms without any benefit whatever; for the last two months she took 3 min. of Fowler's solution, and ultimately left convalescent. The case was

a typical and severe one, with occasional pyrexial attacks raising the temperature to 104° F., and even on one occasion, to 106° F. These attacks were controlled by full doses of quinine, but excepting this, arsenic was the only medicinal agent used during the stage of recovery (*cf.* Lancet, ii., 1891).

Anæmia.—Dr. Lockie has published illustrations of the value of arsenic as a "blood and cardiac tonic in anæmia" (B. M. J., ii., 1878). Dr. W. Osler has seen arsenic of much service in puerperal anæmia, and amongst other cases, reports a severe one in which iron had failed, and the patient was subject to diarrhœa and vomiting and could not sit up without fainting, but recovered well under moderate doses of this drug (Internat. Journ., 1889).

In **Leucocythæmia** some remarkable cases of benefit have been observed at Univ. Coll. Hosp., from doses of 60 to 100 min. daily, with occasional occurrence of pain and diarrhœa (Lancet, i., 1892).

In **Secondary Syphilis** it is sometimes very useful (B. M. J., ii., 1891).

Chronic Rheumatism—Chronic Rheumatoid Arthritis.—In the condition now designated by the latter term, the value of arsenic has been frequently shown since its recommendation by Haygarth, and the elder Bardsley in Manchester (Medical Reports). I quite agree with the latter physician in his opinion that the remedy promises well in cases where the vital powers are diminished, and the ends of the bones, the periosteum, capsules and ligaments are swollen; under the continued use of the drug I have known the joints return to their natural size. Sir R. Christison records a similar experience in cases of "nodosity of joints," and Dr. W. Begbie describes fully the case of a man with swellings of the small joints of hands and feet, very painful especially at night and in changeable weather, and almost preventing any movement. The patient had received no benefit from a long trial of many remedies, but under a course of Fowler's solution recovered the use of the joints, and was able to resume his work. Dr. Fuller speaks highly of the remedy in "chronic rheumatism," and especially in rheumatic arthritis, when the skin is dry and inactive and the patient chilly.

Snake-bite.—Amongst blood diseases we may include this form of blood-poisoning, and although it is difficult to credit

arsenic with efficacy in such cases, we must admit not only a long tradition in its favour in India (*v.* Dr. Russell's History of Indian Serpents), but some amount of clinical evidence. A compound of white arsenic with black pepper and native herbs is the popular form known as "Tanjore pill," but Mr. Ireland used 2 dr. doses of the liquor arsenicalis with 10 min. of tinct. opii every half hour for four successive hours in five cases, and all of them recovered, although other patients died from similar bites (Med.-Chir. Trans., ii., p. 393). No doubt, the system, under abnormal influences, can tolerate larger doses than in its healthy state.

Diabetes.—Like most other medicines, arsenic has been tried in this malady and it has received commendation. Sir Walter Foster says that he has seen it act well in improving nutrition and lessening thirst, but not in diminishing the excretion of sugar; hence he considers it acts mainly by saving the waste of albuminous tissues (Clinical Medicine). Dr. Bartholow finds it beneficial in thin subjects with defective assimilating power, but not in the "stout subjects" who suffer from boils and carbuncles. I have frequently prescribed it in both stout and thin subjects with good results, but as a rule it only acts as a palliative, checking the sudden emaciation and prostration and relieving the excessive thirst and dryness of mouth. In several cases it lessened for a considerable time the quantity of urine and urea, and in some instances appeared to diminish the sugar; it certainly in nearly all cases improved digestion (*cf.* Med. Record, 1883-4).

Neuralgia.—Arsenic holds a chief place amongst remedies for neuralgia. Dr. Fowler's original reports contain several conclusive cases, although their relief seems somewhat counterbalanced by the gastric symptoms which he did not scruple to produce. Maculloch, in a well-known Treatise on Malaria, speaks highly of arsenic in confirmed neuralgia; and Romberg a still higher authority, notes its value especially in facial neuralgia, and in forms connected with uterine or ovarian disease; anæmia is also an indication for its use, and full doses are necessary. Amongst modern French observers, Isnard reports many cures of various typical neuralgiæ, and of ordinary neuralgic pain (De l'Arsenic dans la Pathologie du Système Nerveux). M. Boudin found it invariably succeed in periodic—

probably malarial—forms, and M. Cahen has published sixty-five successive cases with almost uniformly good result (Archives de Méd., 1863). Barella devotes a long chapter of his work in praise of arsenic, to its value in nervous disorders (Brussels, 1866). Of modern German writings on the subject we may quote Erb, who adopts mainly the views of Isnard, considering the remedy as "a neurosthenic tonic" with the power of restoring order to disturbed action. He places it in the first rank amongst specific remedies, not only in recent and periodic cases, but also in chronic forms of purely idiopathic neuralgia. In the facial variety and in sciatica, he endorses its high reputation, but in the latter affection places its value below that of turpentine (Ziemssen's Cyclopædia). In the treatment of sciatica, arsenic is most suitable when the pain is deep-seated, worst at night but with occasional marked intermissions, and temporarily relieved by hot applications.

Sir Thomas Watson notes the great use of the drug in hemicrania or migraine, and successful results in various cases from full doses of Fowler's solution were published by Mr. Thomas Turner of Manchester (Med. Times, ii., 1861). Dr. Anstie, in his Treatise on Neuralgia, speaks of arsenic as "one of the most powerful weapons in the physician's hands," "likely to act best in affections of the fifth and of the vagus nerves, but probably the most generally effective remedy in almost any given case." He looked upon it as calculated to improve the quality of the blood, to stimulate the nervous system, and oppose periodic (disordered) action. The same physician also pointed out the connection and frequent interdependence of gastralgia, angina pectoris and asthma, as neuroses of different branches of the vagus, and he illustrated this connection by the history of families in which these affections occurred in alternate generations. From my own extensive trial of arsenical medication in neuralgiæ and especially of the fifth pair of nerves, I also conclude it to be almost our best remedy, particularly as in my own person, when the pain felt is of burning, stinging character, and when the attack is connected with miasmatic influence.

Gastralgia is a term properly restricted to painful affections of the stomach unconnected with organic disease or inflammation, or even with ordinary dyspepsia. Such cases are not very

frequent nor very easy of diagnosis, but occur especially in females during youth and at the climacteric period, and are accompanied with other evidences of impaired nervous power: sometimes they are reflex (being connected with uterine derangement), and sometimes malarial (Niemeyer). Trousseau describes attacks dependent on exhaustion, and Budd on alcoholism. The neurotic character is evident when, as in Dr. Anstie's cases, the malady alternates with attacks of asthma, and Tessier (Journ. de Méd. de Lyon, 1848) and Anstie agree in estimating highly the value of arsenic in such cases. Dr. Clifford Allbutt speaks of gastralgia as readily distinguishable from dyspepsia, and describes sudden violent pain in the gastric region and back, and another form less severe and more gradual in onset, and irregular as to time, and unconnected with eating (Liverpool and Manchester Reports, 1873). Dr. Leared also restricts the term to a neurosis with cramp-like, fixed or diffused pain, coming at irregular intervals often at night, accompanied by prostration, followed by bilious vomiting, and occurring generally in middle-aged persons from mental anxiety (B. M. J., 1867). Such cases furnish a special indication for arsenic, and Allbutt says it is, for such, the "king of remedies," only I would interpret "gastralgia" in a wider sense, and without attempting to diagnose it rigorously from dyspepsia, would include under the term many forms of painful stomach disorder, not inflammatory nor organic. In this sense it is used by Barras (Traité sur les Gastralgies) and other French writers, and a reference to the observers I have named will show that in their cases, such symptoms as flatulence, vomiting and pain increased by food, were often present, and although the tongue might be clean, and certain dyspeptic symptoms absent for a time, yet they would readily occur, and to restrict the use of the remedy to purely nervous attacks is needlessly to limit its value: we shall see, in fact, that in gastric catarrh it is an excellent medicine.

The following is one of many cases of climacteric gastralgia, complicated with dyspepsia at times, and relieved by arsenic. Mrs. S., aged forty-three, auburn hair, thin, describes very acute pain in upper front chest, and sometimes in the back about the second dorsal vertebra and interscapular region, almost constant, sometimes easier after food, sometimes worse: no vomiting,

pyrosis, or hæmatemesis : no physical signs in the chest, no evident hepatic disease, and bowels regular. Pulse 64 ; no heart or lung complication. Youngest child is five years old ; menstruation lately irregular and profuse ; has some prolapsus and back pain, distinct from her gastric pain. Nursed her husband anxiously for two years, during which time the pain first came on, and it is now often induced and always aggravated by mental worry, of which she has much. The pain is generally worst on waking about 2 A.M. ; gets better after breakfast and worse again in the evening : it is sometimes referred to the epigastrium and left shoulder, and described as "like a hot bar pressing," or "like a hand gripping." Arsenic relieved the pain more effectively than any other remedy tried, and although during attacks of painful digestion nux vomica given before food did much good, the steady use of arsenical solution was, according to the patient's own statement, always the most effective.

Angina Pectoris.—This malady, even if primarily dependent on calcareous or other degeneration, is mainly a neurosis, and nearly 100 years ago was successfully treated with arsenious acid by Alexander. Philipp and others record very striking benefit in cases that had been rebellious to quinine (Syd. Soc. Year Book, 1865-66), and I can fully bear out Dr. Anstie's testimony to the great relief given by arsenic to patients suddenly attacked with spasmodic pain, embarrassed cardiac action, and sense of impending death : he found the medicine reduce the severe attacks to little more than a tightness of the chest, and it availed most in anæmic patients, suffering from overwork and anxiety. (Reference may also be made to cases in Berlin klin. Woch., 1865, and Archives Gén., 1863).

Spasmodic Asthma—Asthma Nervosum.—In this, the third of the trio of vagus neuroses, Dr. Anstie also records good results, but others had preceded him in this observation. We have already noted its improving the breathing power of mountaineers, and this had suggested to Kappel its use in asthma. Rilliet speaks highly of it, and also Trousseau, who used it partly in cigarette (Bulletin, 1861). Dr. Leared recommends a form of cigarette containing $\frac{1}{2}$ gr. of arsenic with a little nitre (Lancet, i., 1863). Dr. Thorowgood, whilst laying stress on the frequent gastric causation of asthma and its special treatment,

has found arsenic useful in gouty and rheumatic cases, and Riegel notes its value in preventing relapses in "bronchial asthma," and in the form which occurs alternately with some cutaneous diseases, known as "herpetic asthma" (Ziemssen's Cyclopædia, iv.). Dr. Berkart seems to attribute any good effect more to improving the nutrition, appetite and digestion, and to negative any specific virtues (On Asthma, 1879), but since then many cases of direct benefit have been recorded. One method of its application is by spray, which has been used with much success by Wistinghausen, and more recently by Dr. Wahltuch, of Manchester: the latter used arseniates of potassium, sodium, or ammonium in spray containing $\frac{1}{6}$ to $\frac{1}{2}$ gr. at first twice daily and by degrees less frequently; his excellent results were, however, rendered less certain for clinical purposes by the concurrent use of galvanism and other remedies (B. M. J., ii., 1877).

Martelli has recently reported immediate relief to an asthmatic paroxysm from the hypodermic injection of Fowler's solution (1 part to 2 of water): the cure was complete after 2 dr. used at intervals in divided doses in this manner (Med. Record, 1878). Arsenic acts best in simple cases of idiopathic or spasmodic asthma of neurotic origin: but it has done well in cases dependent on bronchitis, emphysema, or cardiac disease. In cases due to compression of the air-tubes by enlarged glands it may be carefully tried (Berkart).

The solution should be administered in 5 min. doses, three or four times daily, during the intervals between the attacks, and should be persevered with for many weeks, and in some instances for months, but the dose under these circumstances should be decreased. For upwards of twenty years I have used it in asthmatic cases with unmistakable success.

Chorea.—From the time of Girdlestone, 1806 (London Med. Phys. Journ.), there has been a large accumulation of evidence as to the value of arsenic in chorea. Reese of New York, in 1840, describes cures in 200 children under 6 to 8 min. doses of Fowler's solution twice daily; Rayer corroborates his results (Union Méd., 1847). Romberg calls it "the foremost remedy," when given in sufficient doses (Klin. Ergebnisse, 1856), and records severe cases—one of eight years' duration, rebellious to many other medicines, but cured in two months by arsenic; and another

patient had been unable for six months to stand or speak, having such violent choreic movements, yet recovered after two months of treatment with 4 min. of Fowler's solution thrice daily. The well-known names of Aran, Henoch, Steiner and Barthez may also be cited as authorities in the same direction, and continental work with regard to it is fully summarised in the thesis of M. Gellé (Hôpital des Enfants, Paris, 1860). He quotes cases where improvement was manifest within eight days, three days, and even forty-eight and thirty-six hours respectively, but concludes that from five to eight days is an average period. He gives also several cases equal in severity to those of Romberg and expresses similar conclusions, viz., that some failures of the remedy may be expected in neurotic sanguineous subjects, but great success in the lymphatic, chlorotic, and cachectic. M. Aran urges the rapid attainment of a full dose rather than a long-continued small one (Syd. Soc. Year Book, 1859). Exceptional success has been obtained with doses of 15 min., twice daily, continued for ten or twelve doses without any recorded ill effect (Lancet, i., 1893). Dr. Steiner on the other hand, commences with 1 min., and considers 8 min. should be the maximum daily dose: within fourteen days he expects improvement.

Amongst English observers there is a large preponderance, though by no means a consensus of opinion in favour of arsenic as the best remedy for chorea. Gregory, Babington and many others have all written to this effect. Dr. Radcliffe fully agrees as to the efficacy of the medicine, but having been obliged sometimes to discontinue it on account of gastric disturbance, he adopted its hypodermic use, and in some cases, especially of localised choreic action, with signal benefit; thus in a woman in whom the neck muscles were affected, and who was not relieved by a long trial of sedatives, 1 to 12 min. of Fowler's solution were injected locally, and before the fourth injection, improvement had taken place. He recommends dilution with half water; in some cases he has preferred the endermic use of the remedy on a blistered surface (Reynolds' System, vol. ii.). Schmidt has also practised hypodermic injection with success (Wiener med. Woch., 1871). Dr. Anstie records the severe case of a girl who had been treated in hospital with camphor, cod-liver oil, bromides and zinc, also with succus conii in the dose of many ounces daily, yet

without relief, and who recovered under 3 to 5 min. doses of Fowler's solution: he used at the same time ether spray to the spine, but this application has not proved itself of such power as he then thought it (Pract., June, 1874), and therefore I do not believe that it much influenced the result. Dr. Ringer considers arsenic by far the best remedy in simple chorea; he remarks that failure may be owing to smallness of dose, also that children above five years of age bear nearly as much as adults, and that girls seem to require more than boys. Dr. Eustace Smith and others have also specially noted the tolerance of choreic children for arsenic, and the necessity of full doses to secure success (B. M. J., i., 1875). Dr. Seguin (Record, 1882) equally considers that the dose of arsenic given in chorea and some other nervous diseases is often too small; he gives from 3 to 30 min. of Fowler's solution three times a day, and finds that children especially show a remarkable tolerance for the drug; if any toxic symptoms appear, an intermission of the drug for forty-eight hours is necessary. In my own practice, for upwards of twenty-five years, I have seldom known arsenic fail to cure simple chorea, although many of my cases were severe and of long duration and incapacitated for the ordinary duties of life; 3 to 10 min. of Fowler's solution thrice daily has been the dose usually prescribed by me, but I have frequently observed that no permanent good effects follow until the development of some physiological symptoms.

From the above quotations and remarks, though they represent an ample experience, we must not conclude that the value of this remedy is equally acknowledged by all. The counter-claims of iron, of zinc, of belladonna, etc., are urged by some observers, and the natural tendency to cure of the malady under favourable conditions is still more strongly insisted upon by others. Vogel, the distinguished Russian professor, classes arsenic with "a number of empirical remedies that are more praised than curative." Dr. Wilks attributes much more importance to rest (B. M. J., ii., 1876), and Dr. Sturges includes arsenic amongst a number of other "useless medicines" (Lectures on Chorea, 1876). In estimating the value of any remedy, we are constantly met by the difficulty of proving how far we have affected the course of nature; this difficulty is not greater with the present medicine than with

others, and even allowing that chorea will recover with proper rest, food and management, yet I am clearly of opinion that arsenic will promote, quicken and confirm the cure; I do not affirm that it will always, of itself, and in despite of circumstances, control the disease. Judging from private practice and from hospital in-patient records, a large number of cases recover whilst taking arsenic, either far more quickly than is consistent with the ordinary course of the malady, or (making the contrast more striking) recover after many powerful remedies have been tried without effect under equal conditions. The ordinary duration of a chorea well managed, but without medicines, has been stated as six to eight weeks; if it continues three months Jaccoud considers it chronic, almost incurable, yet we have already quoted and have seen many cases that improved within two or three days, and recovered within three to five weeks, and we have quoted also instances of cure after a duration of many years. A certain proportion of cases of chorea are connected with embolism, and these were excluded by Dr. Anstie from the range of the beneficial action of this drug, but from what we know of its value in cerebral congestions, we should think it often appropriate even in such serious conditions. In markedly anæmic patients we might prefer iron, or at least combine it (Levico water contains this combination; Lancet, i., 1890); if sexual excitation were present, as in the case of some girls at puberty, we might substitute bromides or antispasmodics; acute rheumatic symptoms would also modify the treatment, but with these exceptions we must consider arsenic a most valuable agent in all varieties of the malady.

Widenhofer found that hypodermically, arsenic (Fowler's solution with half water) acted more quickly than by the mouth, curing in three to four weeks; in twenty-three cases there were three abscesses (Rev. des Sciences, ii., 1886). A soluble alkaline form has also been recommended (Therap. Gaz., 1891); and internally the arsenite of copper is said to have advantages (*ib.*, 1892).

Tremor—Ataxia.—Allied to the use of arsenic in chorea is its use, which however is much less markedly beneficial, in these nervous affections. Tremor may be due to various causes, which are often central and connected with organic disease, and scarcely amenable to treatment; but Eulenburg reports several cases

successfully treated by hypodermic injection of 2 to 3 min. of Fowler's solution diluted with two parts of water (Berlin klin. Woch., 1872). Isnard says the remedy is valuable in ataxia developed during acute fevers; he gives it even during febrile accessions.

Congestive Disorders.—The value of arsenic in the following group of cases seems best explained by its power, in small doses, to regulate and equalise the circulation in capillary blood-vessels.

Epilepsy.—The older writers such as Alexander and Duncan, have recorded cases of this disease cured under arsenical treatment. It is of necessity no more a universal cure than any other medicine is, but there seem to be some cases specially amenable to it—for instance those that are connected, however remotely, with malaria. We must note a case recorded under the care of Dr. Bristowe, that of a lad of fourteen described as anæmic, but free from evident organic disease, and who had suffered severely from epileptic attacks mainly nocturnal, for about two years, and afterwards from attacks day and night, so frequently that he remained unconscious for some days, and was apparently dying; being roused however, from this condition, he remained partly paraplegic, and the fits, preceded by screaming and by an aura in the feet, recurred on movement of the legs, or on excitement; for nearly a month he took zinc sulphate in increasing doses with valerian, but remained in the same state, sometimes disturbing the ward for a whole night; he was then ordered 5 min. doses of Fowler's solution thrice daily, and although he was not made aware of any change in treatment, the attacks ceased at once for many days; they recurred for a time under excitement, and the numbness of lower limbs persisted for some days; eventually, however, he got quite well. There is evidently some alliance between such a case and one of chorea, but the periods of insensibility indicate a more serious condition; the exact character of the "fits" is not, however, described (Med. Times, i., 1862). In a case of mental weakness bordering on idiocy, much improvement occurred on subsidence of toxic symptoms after large doses of arsenic (Lancet, i., 1889).

Dr. Clemens (Frankfort) strongly recommends a "liquor arsenici bromidi" (vel bromatus) which he has used for twenty years in the treatment of epilepsy of all varieties with much success;

it has relieved even in cases connected with thickening of skull and congenital malformation (Med. Record, 1877). This preparation is said to be more reliable than Fowler's, and to act well without increase of the daily dose: it is made by boiling potassium carbonate and arsenious acid, of each 1 dr. in ½ pint of water: making up to 12 oz., adding 2 dr. of bromine, and mixing thoroughly.

Cerebral Congestion.—As a preventive of apoplexy, the remedy has a traditional and perhaps not an easily proved reputation, but one that would be quite in accord with our view of its action. Lemare-Piquot, after relating marked relief to giddiness, sense of oppression, epistaxis and other premonitory symptoms, both in his own case and that of five other persons about sixty years of age, reasonably restricts its use to cases of cerebral congestion occurring in the strong and plethoric, who have an excess of blood-corpuscles. He recommends from 4 milligrammes to 1 centigramme daily for about a month, taken at meal-times, and founds his latest conclusion upon forty-four cases occurring without one death (Bull. de Thérap., 1859, and Récherches sur l'Apoplexie, Paris, 1860). Cahen, writing upon its value in congestions generally and central hyperæmiæ in particular, traces it as we do, to a regulating influence on vaso-motor nerves (Archives de Méd., 1863), and Dr. Handfield Jones expresses similar views. Hirtz has had reason to think it efficacious in obviating apoplexy, and suggests that it would tend to prevent atheromatous degeneration (Nouveau Dict.). It is extremely useful in cerebral congestion, and especially when there is puffiness below the eyes, drowsiness and mental torpor, with sluggish venous circulation, and suspicion of commencing atheroma. By a similar action perhaps, it benefits the melancholy and those suffering from hypochondriasis, especially aged persons.

Cardiac Weakness—Mitral Disease—Venous Congestion.—For such conditions, arsenic is often found serviceable, and under its use dyspnœa on exertion, palpitation, faintness and œdema of the extremities have all improved. Dr. Papillaud has verified similar improvement and also a marked relief to palpitation, but he generally alternated or combined the remedy with antimony (Bull. de l'Acad. de Méd., 1870).

When *intermittent pulse* occurs from cardiac weakness, whether of temporary character or dependent on degeneration or mitral

disease, arsenic is often serviceable, as it is also in the same condition when due to nervous conditions. Darwin relates a case of "regular intermission" cured by 4 min. doses of a saturated solution of the drug. I have seen numerous cases cured by the continued use of 2 to 5 min. doses of Fowler's solution after each principal meal. Under such circumstances it often produces a marked diuretic action, which is quickly followed in many instances, by disappearance of any swelling, and by relief of the dyspnœa, faintness, and palpitation.

Albuminuria.—The influence of arsenic upon this condition is well worthy of further investigation. A case of "acute renal anasarca" in a woman aged nineteen, is briefly recorded from Dr. F. Farre's practice (Lancet, i., 1862); six weeks after the commencement of the attack she developed psoriasis, for which Fowler's solution was prescribed, and under its influence the albumen disappeared, and the patient gained flesh and strength. I have for many years used it in albuminuria following scarlatina; it removes the dry inactive condition of the skin, checks thirst, and causes a copious flow of urine, which gradually becomes less loaded with albumen; should dyspnœa be present the remedy, if acting well, quickly relieves it, and the œdema of face and body disappears. In 1876 a case came under my care of chronic character, occurring in a builder, aged forty-three, of dissipated though hard-working habits; he had general anasarca and epileptiform convulsions, which were relieved for a time by laxatives, but the amount of albumen was uninfluenced by them, or by a long-continued use of iron. Fowler's solution was substituted, and the albumen diminished and soon ceased to appear; then, omitting the medicine, a relapse occurred; this again yielded on resuming the remedy, and the albumen, anasarca and convulsions all disappeared, and in two to three months the patient's health was quite re-established, and he has since been quite well. I have also treated by liquor arsenicalis, with excellent results, numerous cases of *temporary or intermittent albuminous urine* dependent on imperfect digestion.

Dr. Brunton has discussed this subject in an interesting and scientific paper (Pract., June, 1877): he remarks on the important distinction between "true and false" albuminuria, including under the latter term, not only the presence of albumen

from pus or blood, but also the so-called Bence Jones' albumen, —egg-albumen,—the albumen absorbed from the intestine after imperfect digestion : it is a case of the latter kind that is recorded by him as being much benefited by arsenic, and it had several peculiarities. The patient was aged thirty-three, sallow and thin ; the first symptom was great fatigue on exertion, then albuminuria was noticed (on examination for life insurance) : it was at first present only during the summer ; it came on after work and ceased on rest ; it ceased also under strychnine (but this caused headache and sickness), and during quiet residence at the seaside. Fatty food brought it on, and meat taken in the morning, not when taken at night. Quinine and phosphoric acid at once increased the quantity, but rigid adherence to a farinaceous diet quite controlled it, and there were other evidences of its direct connection with digestion. After many years of treatment, including milk-diet, sea-voyages, digitalis, hydrarg. c. creta, etc., Dr. Brunton ordered 3 min. of Fowler's solution at meal-times, " and almost at once the albumen disappeared, and the patient was able to do much more work than usual, without its return." Later, the medicine was changed for hypophosphite of soda, and the albumen returned, to cease again on resuming arsenic. The whole case is very interesting, but we need only mention further that pancreatin, which increases pancreatic digestion and aids in the solution of albumen, was also found beneficial and it is clear that this affection should be classed under faulty digestion or assimilation rather than as renal disorder. The special form of chronic albuminuria in which I have proved its value is that dependent upon venous congestion, mitral disease, or emphysema after the right ventricle has begun to yield, but it deserves a trial also in cases where the actual structure and epithelial lining are affected. I have carefully watched many of these latter cases in which the beneficial action of arsenic was marked.

Uterine Congestion.—This condition may accompany either menorrhagia or amenorrhœa, and that arsenic may remedy either symptom is therefore, not contradictory. In the former, the catamenia being too copious and too frequent (leucorrhœa often occurring in the intervals), and the patient becoming weak and anæmic, small doses of from 2 to 6 min. thrice daily will be found

to lessen the flow and to improve appetite and general health. Mr. Hunt has recorded some striking cases of uterine hæmorrhage at various intervals after labour or miscarriage, some accompanied with symptoms only of irritable uterus, "but for the most part atonic in character" (Med.-Chir. Trans., vol. xxi.); all improved under arsenic. Sir C. Locock found great advantage from it in similar cases. Dr. A. Burns, from experience of it in all varieties of uterine hæmorrhage, has reason to express the greatest confidence in the remedy, and records several cases treated by rather large doses, 10 to 20 min., repeated every fifteen to twenty minutes (Amer. Journ. Med. Sci., 1859).

Amenorrhœa.—When this depends upon congestion or torpor of the uterus, or is connected with anæmia or chlorosis, I have known arsenic succeed well, and have several times found that when iron preparations had been taken without marked result, the addition of arsenic was quickly followed by relief—it seemed to act as a regulator of the circulation and uterine tonic.

Hæmorrhoids.—The efficacy of arsenic in this form of venous congestion has been sometimes well shown; thus in one case, a gentleman had suffered for many years, and had undergone cauterising and other operations, when this remedy was given to him for hay asthma, and he found his hæmorrhoids to be more relieved in a few days than under any other treatment; relapses occurred more than once, but always yielded in a few days to 8 min. doses of Fowler's solution (Parvin, in Braithwaite's Retros., ii., 1866). I can recommend it strongly in painful hæmorrhoids, and also for ordinary external piles.

Cutaneous Disease.—Arsenic is largely used by the profession, almost as a routine remedy, in cutaneous disease, but its value has been variously estimated by specialists of experience. We may exclude at once from its influence parasitic and syphilitic eruptions, and the rarer maladies of scleroderma, keloid, xanthelasma, and true leprosy. We may exclude also all forms of skin disease whilst in the *acute* stage, or whilst accompanied by marked inflammatory reaction, and then, speaking generally, we may say that as we have noted arsenic to be valuable in rheumatic, malarial, and neurotic affections, so is it also valuable in most cutaneous manifestations of these conditions. With regard to the last-mentioned, my own experience agrees rather with that of

Hunt and Anstie, as against Bazin and others, that in neurotic subjects with highly-strung excitable natures, arsenic is less readily borne, and more usually causes diarrhœa.

The forms of skin disease in which the remedy is of generally accepted value, are such as psoriasis, eczema in the dry or scaling stage, pemphigus, lichen, alopecia and chronic urticaria; and those in which its powers are more controverted are acne, lupus, ichthyosis, herpes zoster, sycosis, prurigo, epithelioma, cancer and elephantiasis græcorum.

Psoriasis.—From the time of Girdlestone (1806), Willan and Bateman, Biett and Cazenave, arsenic has held the first place in the treatment of this malady. Modern dermatologists agree upon this point, but some, as the late Mr. Startin and Mr. Hunt, rely upon this drug much more positively than others. The preference of Hebra for local over any constitutional treatment is well known, but even he recognises "a decided curative action of arsenic in this form of disease." Unna however, will not acknowledge so much as this, and does not prescribe it. Dr. Tilbury Fox inclined to restrict its use to the more typical cases, especially those of chronic character and accompanied with nervous debility; on the other hand, many cases will be found to occur in persons otherwise strong, and in them after preliminary purgative treatment I have found the remedy useful. "Before undertaking to deal with psoriasis," remarks Gaskoin, "it is necessary to know all about arsenic" (Treatise on Psoriasis). Its success however, is as Stillé remarks, by no means uniform, and any want of due attention to the excretions, to the presence of gouty or other constitutional tendencies, or to the proper regulation of the dose, will readily prevent a satisfactory result. It can by no means be considered a specific, but as a valuable agent only under certain conditions; neither can it be accurately stated that "the more chronic the malady the more suited it is for this remedy," for after it has lasted for eight or ten years I have seldom found it amenable, and Devergie has recorded a similar experience (Maladies de la Peau).

Mr. Malcolm Morris notes that sometimes arsenic not only does no good in psoriasis but harm, in rendering the patches more hyperæmic and irritable; he finds it impossible however, to diagnose the cases in which this may occur (Pract., 1880). I have seen a case pass on to dermatitis (called lichen ruber) under

15 to 20 min. doses given thrice daily, and improve at once on substitution of pilocarpine, etc.

In judging of its true power, we must allow for the natural improvement of the malady in certain circumstances, *e.g.*, on the cessation of lactation, at changes of climate or of season, etc., also for the effect of external treatment by tar or bathing carried on at the same time. But after these allowances there remain, no doubt, many cases which show improvement distinctly from arsenic; the best illustrations are seen in children, and then in older persons in whom the attack is comparatively recent yet not in an acute stage; chronic cases that have been left untreated often do well, but previous irregular trials diminish the chances of recovery; in any case, if cure be effected, freedom from relapse cannot be guaranteed (Wilson). Hunt has shown how important it is to secure a due action of the absorbents, and also that one preparation may succeed when another has failed; for instance, to one of two girls similarly affected he gave the potash, and to the other the soda solution; for a time both did well, and then both ceased to improve, but later on when he exchanged their medicines, they progressed to cure (Journ. Cutan. Med.).

Eczema.—In this, arsenic has not so large a measure of success as in the last-mentioned; still it is often very useful, and especially in combination with other remedies. Acute cases not only receive no benefit, but I have seen them much aggravated by it; the proper period for its use requires therefore, careful consideration. It is very suitable in scaly—which are of necessity rather chronic—stages, and have received the distinct name of "eczema squamosum," in superficial subacute forms with moderate infiltration, and in cases with persistent irregular patches about the scrotum, anus, or vulva (Rayer), or about the hands or fingers (Duhring). Sometimes the later stages of a chronic infantile eczema seem much benefited by the addition of the drug to iron or cod-liver oil, and sometimes an infant has been successfully treated by arsenical medication through the mother (Begbie, Anderson). The last-named observer, in his excellent special treatise, estimates the value of arsenic highly: he points out, as others have done, that children will readily bear a proportionately large dose; at the same time, he notes that there is much tendency to "catching cold," or even bronchitis, during an

arsenical course, also he insists on the necessity for its prolonged continuance. Mr. Erasmus Wilson considers that the treatment of eczema resolves itself into that of "debility," and advocates the use of arsenic "as a nerve-tonic and stimulant to cutaneous function"; and generally combines it with a non-astringent preparation of iron, as the vinum. My own use of arsenic in ordinary eczema is rather the exception than the rule, and I am much in accord with Dr. Piffard, who, after calling this mode of treatment "empirical, as opposed to rational," and quoting the prevalent opinion, "that if only sufficient of the remedy be used, the eruption must yield," states that, in his experience, it sometimes does harm and at other times has no influence, though in a minority of cases it will give brilliant results: these may be hoped for in the dry scaly stages when extensive tracts of surface are affected (On Skin Diseases, 1870); I would add, and when there are persistent patches on the pudenda or extremities, as already described.

Pemphigus.—There is an ephemeral form of this malady in which one or two crops of bullæ come out, and subside under mild general treatment; there is also a syphilitic form mainly congenital, and an epidemic form which occurs sometimes in lying-in and in children's hospitals, and is connected probably with blood-poisoning; in none of these do we expect benefit from arsenic. There is a fourth form, occurring sometimes in the later months of pregnancy, which may be severe, and although it tends to subside after parturition, yet may receive some benefit from the remedy; but the variety of the malady to which we would specially refer is that known as "pemphigus diutinus, in which the blebs come out freely, often symmetrically, and extensively,—which often lasts long, and almost invariably exhibits its constitutional origin in a marked tendency to recur." Mr. Hutchinson, from whom I quote, has certainly furnished us with valuable evidence of the great power of arsenic in this variety, and although by Hebra and others it is commonly held to be incurable and often fatal, Mr. Hutchinson "has never met but with one case that resisted this treatment, and has come to consider the malady as one of the most hopeful" (Med. Times, ii., 1875). Further experience leads him to state that it will prevent recurrent herpes as well as pemphigus, but that it does not act so favour-

ably with the aged (B. M. J., i., 1891). He furnishes an abstract of twenty-six cases that have been under his own observation, and refers to others in the practice of Hillier, Wilks, Fagge, Startin, etc. : many of them had relapses, but these were mild in character. In many, the influence of the medicine was proved by the rapid improvement, and by relapse, on resumption and omission of it respectively, and in at least one case it appeared to prevent a patient's death. A delicate man aged forty-four, recently become subject to epileptic attacks, presented a general rash, at first very like herpes, and attacking the face and extremities. There was much prostration, and the patient was treated with quinine and iron and liberal diet, yet became extremely emaciated, and as the pemphigus character became more developed, he was covered with large superficial sores and completely prostrated; then the tonics were stopped, and 4 min. of Fowler's solution prescribed, and from that day no fresh blebs appeared until a few weeks later when he was nearly well and able to leave his bed: then it was found that his medicine had been omitted for three days, and on resuming it the blebs at once receded, and six weeks afterwards he was in good health and wholly free from eruption. Dr. James Russell has also published a well-marked case in a child in whom the numerous relapses were always distinctly controlled by arsenic. On the other hand must be noted the observations of the late Dr. Tilbury Fox : "There is no specific for pemphigus; arsenic is declared to be one, but it often signally fails to cure the disease, and I have seen quinine in full doses do much more good."

In **Lichen Simplex,** and certainly in its more chronic forms, the value of arsenic is generally conceded. Dr. Liveing's expression is, "In chronic lichen it is the only remedy"; but as a rule, alkalies are required in addition, and mercurial treatment may succeed still better. A similar observation would apply to another form of papular disease—true prurigo.

In **Lichen Planus,** Mr. Morris and others speak well of it. Thus a lady aged fifty, with an itching eruption of flat-topped, violet-coloured papules, slightly scaly, situated on the inner side of the thighs and outer sides of forearms, took 8 min. of liquor sodii arseniatis, at first twice and then three times daily; the eruption faded in one month, and the treatment being

continued for a time, no relapse occurred (how long the eruption had lasted is not stated); he considers arsenic "an invaluable remedy." Dr. Fox has however, seen no benefit from it, nor have I. In the more generalised form of the malady, Hebra who names it "lichen ruber," places much reliance on the "Tanjore pills" (arsenic with black pepper).

Warts on the hands are said to be cured in three weeks by the use of 2 min. doses thrice daily (Lancet, ii., 1891).

Alopecia.—From the effect of arsenic in improving the coat of horses, it has been plausibly thought to have a special power in promoting the growth of hair, and certainly after any causes of baldness, such as syphilis, dyspepsia, or local irritation have been treated and removed, the internal administration of small doses may be carefully carried out for a time with advantage. Hunt practised this treatment successfully.

Chronic Urticaria is often relieved by arsenic, but any evident intestinal disorder should if possible, be remedied in the first instance. In a highly-neurotic woman, I have seen this malady controlled to some extent by the drug, but she suffered from violent colic after some weeks of treatment; it is probable she exceeded the prescribed dose.

Acne.—In acne it should be the exception to prescribe arsenic. Sir E. Wilson went so far as to say that "no one having even a rudimentary acquaintance with cutaneous pathology and therapeutics would think of doing so," and yet I have certainly seen cases cured by this remedy after others had failed. According to Dr. Bulkley, this has occurred with all forms of acne —the simple, the indurated, and the rosaceous—and his best results have been attained with De Valangin's solution of chloride. Dr. Duhring speaks well of it in the indolent papular form, and many special authorities might be quoted to the same effect. This does not seem to me so unreasonable as it does to Sir E. Wilson, for acne is frequently connected with gastric and uterine irritation, and we have seen that arsenic has great power to relieve various forms of this malady.

In "bromic acne"—the pustular rash which frequently follows the use of full doses of any bromide—arsenic is decidedly useful. If given concurrently with the bromide it will often prevent any skin trouble (Lancet, i., 1878), and I can corroborate this observation.

In "bullous" eruptions, especially iodic, it is serviceable—Dr. Bulkley recommends it at frequent intervals (two hours), and in Vichy water (N. Y. Journal, 1889).

Lupus.—There are differences of opinion as to its value in lupus: Mr. Hunt for instance, and Mr. Milton esteeming it highly, and recommending its continuous administration for months or years; others, and indeed the majority of observers, recording no definite result from it. I have never been able to satisfy myself that it controlled the disease, although the local caustic effect is, as already mentioned, highly valuable. Mr. Hutchinson traces recovery in a severe case of lupus erythematosus to the continuous internal use of arsenic for two years.

Ichthyosis is congenital, and though it may be relieved, is scarcely curable; the evidence as to the value of arsenic in its treatment is but slight.

Herpes Zoster.—Trousseau has observed that the pain in the course of the affected nerves, which is often severe and long persistent in the zoster of elderly persons, may be relieved by arsenical medication, though this will not cut short the course of the attack itself (Clinical Medicine). In my own experience, it is less serviceable than quinine.

In **Sycosis** non-parasitic in character, there is much evidence of the value of the drug, and this would accord with what we know of it in other cases of the formation of pus. Dr. Laycock has used an arsenicated glycerine (2 dr. of Fowler's solution in 10 dr.) as a local application, with good results; it is somewhat strong, and acts as a "substitutive irritant" (Med. Times, ii., 1864).

Erysipelatous Inflammation of a phlegmonous type is liable to give rise to sloughing, but if at the first appearance of this change, small doses of arsenic be administered, together with a generous diet, the more severe results may be warded off, and even after sloughing has taken place, arsenic will often control it effectually.

In **Hospital Gangrene** the results obtained strongly incline me to consider it beneficial. In twelve cases in which I have tried it, giving 4 to 10 min. of Fowler's solution every two or four hours, I was well satisfied with the result, especially as arsenic

was the only active treatment used; no local caustics were needed. In various other affections of gangrenous character the same remedy has proved very reliable, also in the so-called "cancrum oris" and ulcerations about the tongue.

Epithelioma, etc.—Cases of this disease affecting the lip, the tongue, the scrotum (chimney-sweep's cancer), etc., are stated to have been cured by its internal administration; and although Hirtz concludes that all reports of true cancer being cured by arsenic internally are founded on mala fides, or bad diagnosis, yet there is some trustworthy evidence of its relieving cancerous pain in the stomach and in the uterus. Sir C. Locock mentions his own confidence in it, together with cases from his practice, and from that of Brodie and of Sir A. Cooper (Lancet, 1837), and Mr. Hunt records a marked instance of relief under small doses frequently repeated, not amounting to more than 10 min. in twenty-four hours. The case was said to be undoubted uterine cancer, and the relief given was greater than from morphine: as a rule a pill was preferred, containing $\frac{1}{20}$ gr. or less of white arsenic. Fordyce Barker also speaks highly of its power to relieve pain and improve the general condition, in doses of about 3 min. of Fowler's solution (Amer. Journ. Obstet., 1870). Dr. Walshe prefers the iodide of arsenic (Dub. Quart. Journ., 1857). I have given Fowler's solution internally in many cases of epithelioma, when the disease was extending rapidly, and have known it apparently retard for a time the progress of the malady, relieve the pain, and improve the general condition. Cases where the lower lip or the scrotum was affected have given me the best results: the dose usually prescribed was 5 min. thrice daily.

Elephantiasis Græcorum (Leprosy).—Dr. Waring says that for this almost incurable disease arsenic is still highly esteemed in India, and Dr. Benet records benefit from the Tanjore pill (Gaz. des Hôp., 1842). The external application of arsenious acid is also reported to have cured the disease (Dub. Med. Press, 1864), but this must be exceptional.

Disorders of Mucous Membranes.—Without implying that the following maladies are *solely* disorders of mucous membranes, it will be found convenient to group them under this heading. The value of arsenic in them is very marked but is of comparatively recent recognition, and has not yet been noticed in many text-books.

Coryza — Bronchial Catarrh — Hay Asthma.—In these disorders, in which a profuse secretion is connected with local irritation and with general depression of the nervous system, Fowler's solution is often effectual, and it is especially so in patients subject to paroxysmal sneezing, with much itching about the alæ nasi. Dr. Mackenzie had previously reported satisfactory cases of catarrh treated by doses of 3 min. and upwards (Lond. Med. Journ., 1851).

Chronic Bronchitis.—I have witnessed marked improvement under the continued internal arsenical treatment of chronic bronchitis, for which cigarettes and inhalations are sometimes even more suitable than ordinary doses. Bretonneau and Trousseau have recorded good results, and the latter devised a simple cigarette, made with suitable paper soaked in solution of arseniate of sodium, or of potassium (1 to 4 gr. in 20 gr. of water for twenty cigarettes). Four or five mouthfuls are inhaled several times daily,—more often when the patient becomes accustomed to it. M. Papillaud recommends, in chronic bronchitis and emphysema, a combination of the drug with antimony (an arseniate of antimony), and considering the relations between these two substances, the recommendation is likely to prove very good (Gaz. de Paris, 1865).

Dyspepsia.—In many cases even of irritative dyspepsia, when the tongue is furred, with red edges and tips, and there is pain after food, heartburn and tendency to diarrhœa, I have had ample experience of the value of Fowler's solution given in 2 or 3 min. doses after meals. Dr. Thorowgood finds that it acts best when the attack seems localised in the stomach, and is independent of hepatic congestion (Pract., 1870). Dr. Anstie, whose first published observations were directed to the value of arsenic in gastralgia, previously mentioned to me its equal efficacy in the dyspeptic conditions described.

Vomiting—Diarrhœa.—In chronic forms of vomiting connected with ordinary dyspepsia, and in that of alcoholism which occurs usually in the early morning and is of a bilious character, with painful straining, arsenic is often useful: also in the retching and vomiting of pregnancy I have obtained excellent results from 2 to 5 min. doses. Dr. Décamp has highly recommended the same treatment (Philad. Report., 1872), and Bartholow men-

tions as additional indications for it, the rejection of the food streaked with blood, or blood only, also gastralgia and interscapular pain. It is not only serviceable in cases of the rapid passage of half-digested food occurring very soon after meals, but also in cases where the motions are frequent, watery, containing mucus, offensive and irritating to the anus, and even when bloody and dysenteric in character, and accompanied with tenesmus, prostration and vomiting. In true dysentery, especially when of malarial origin and verging into a chronic state, arsenic is often of the greatest value.

Chronic Gastric Catarrh.—In cases of this malady marked by oppression and discomfort after eating, with a sense of weakness and emptiness at the stomach, thirst, offensive breath, coated red-edged tongue, flatulence and pyrosis, with rejection of glairy acid fluid, and general symptoms of depression, coldness of extremities and emaciation, I have had ample experience of the good effect of small doses. In acute gastric catarrh also, I have not been often disappointed, though a more cautious use is needed, but in the chronic forms, especially when co-existing with emphysema, with chronic bronchitis, or with phthisis, arsenic always gives some relief. Germain speaks favourably of the treatment (Gazette Hebdomadaire, 1860), and Trousseau remarks that the evidence in its favour is such as to warrant a fair trial of it. Many mineral waters that have a reputation in chronic gastric maladies contain an appreciable quantity of arsenic, notably those of Mont Dore, Plombières, and Bussang. Dr. Wilson Fox however, whilst referring to the favourable reports of others, states that "he has not had successful results himself, possibly because he has not seen definite indication for the remedy"; sometimes it seemed to aggravate the symptoms (Reynolds' System, ii.).

Gastro-enteritis—"English Cholera."—Fowler's solution is an effective medicine in severe cases of this disorder. I have seen it give relief when the patient was suffering from retching and bilious or sanguineous vomiting, passing white, odourless, or slimy flocculent stools, with pain, tympanitis and tenesmus; other symptoms present have been—thickly-coated tongue, thirst, pyrexia and prostration, muscular cramps, scanty urine, pinched and anxious features. Even when the stage of collapse has commenced, and the surface is dusky and covered with cold perspira-

tion, the medicine has seemed to me of great service—5 min. every one or two hours was the dose given, lessening it as the patient improved. Black has written very fully in praise of this remedy in English cholera, recommending 10 to 15 drops every ten to fifteen minutes till the symptoms abate, then less frequently. He has found this most valuable in various forms of choleraic attack, but especially in serious cases connected with defective drainage, and presenting the symptoms of vomiting, purging and rapid collapse; he records several instances of immediate and striking improvement (Lancet, ii., 1857). Dr. Hitchman speaks equally strongly, and describes fully the indications for arsenical treatment in such cases.

Cholera Infantum.—This term has been applied to dysenteric diarrhœa in children, probably because of the collapse so readily induced. The child looks pale and thin, and refuses food, the motions are very frequent and brown, offensive and mixed with blood; tenesmus also is commonly present, and often with such symptoms minim doses of Fowler's solution produce excellent results.

Gastric Ulcer.—Not only in chronic inflammation, but in ulceration of the mucous membrane of the stomach, I have seen very beneficial results from arsenic, the appetite returning, and the thirst, vomiting and pain subsiding, so that the patients became strong and stout, although before weak and emaciated. Dr. Ringer has observed similar results, and has seen relief from this remedy in chronic ulcer, after failure of the more commonly-used medicines. I usually prescribe 1 to 5 min. doses four times daily with a little nourishment. Dr. Strahn reports three satisfactory cases treated by min. i. four times a day on an empty stomach (B. M. J., i., 1884).

PREPARATIONS AND DOSE.—*Acidum arseniosum:* dose, $\frac{1}{60}$ to $\frac{1}{12}$ gr. in solution or pill. *Liquor arsenicalis—Fowler's solution* (4½ gr. in 1 fl. oz.): dose, 2 to 8 min. *Liquor arsenici hydrochloricus* (4½ gr. in 1 fl. oz.): dose, 2 to 8 min. *Sodii arsenias:* dose, $\frac{1}{10}$ to $\frac{1}{8}$ gr. *Liquor sodii arseniatis* (4½ gr. in 1 fl. oz.): dose, 5 to 10 min. *Liquor arsenii et hydrargyri iodidi:* dose, 10 min. to ½ fl. dr., diluted. *Ferri arsenias:* dose, $\frac{1}{10}$ to ½ gr. *Arsenii iodidum:* $\frac{1}{25}$ gr. *Liq. Arsenii bromidi:* (*v.* p. 505), dose, 1 to 5 min. *Cupri arsenis:* dose, $\frac{1}{500}$ gr. frequently for diarrhœa, etc., during a limited time: $\frac{1}{50}$ gr. for anæmia (Therap. Gaz., 1891 and 1892). *Quininæ arsenias:* dose, ⅛ to ½ gr. *Strychninæ arsenias:* dose, $\frac{1}{60}$ to $\frac{1}{15}$ gr.

Liquor arsenicalis if long kept, is liable to vary in strength on account of the deposition of a thin film of metallic arsenic; the compound tincture of lavender contained in it is nauseous to some palates, and would be better omitted.

The solution of chloride is liable to become cloudy in warm weather, from the development of a fungus: this may be prevented by the addition of a little perchloride of iron (Hunt).

The liquor sodii arseniatis, as will be found by calculation from its molecular weight, contains only about half as much metallic arsenic as the liquor arsenicalis, and the liquor arsenici hydrochloricus.

In acute or subacute maladies, as of the stomach or intestine, small doses, 1 or 2 min., either every hour, or every four or six hours, are suitable; in chorea, or neuralgia, or struma, where there is no visceral irritation, the dose may be gradually raised to 10 or even 15 min., and in chronic conditions of ague or of cutaneous disease, the secret of success will be found in securing the tolerance of a moderate dose for a considerable time.

In agues, it is true that a large dose may be required, and may be well borne during a certain condition of the system, but as soon as that condition is relieved the large dose cannot be tolerated.

In skin diseases large doses are never desirable, and any increase beyond 4 or 5 min. should take place only after this dose has been used for three or four weeks without physiological symptoms. This remark refers especially to the potash and to the acid solutions, not to that of the arseniate of sodium, for although nominally of the same strength, the last-mentioned contains less arsenic, and is often better borne in doses of 6 to 8 min., or more, than the others in less quantities. The remedy, sufficiently diluted, should always be given in several such moderate quantities daily, rather than in one full dose, and always at a meal or with some food, so as to lessen the degree of local irritation; the symptoms of its physiological action, such as irritation of conjunctivæ, œdema, nausea, etc., should be constantly watched for and the dose diminished rather than entirely omitted, if the reason for its administration remain. In some obstinate cases, especially of chorea and of skin disease, it is justifiable and not harmful to keep up a moderate degree of physiological action for some time, but this must be done very cautiously.

It is a matter of daily experience that the secretions must be in good order if we are to expect the full advantage of the remedy in chronic disease. Mr. Hunt observes: "Above all, the bowels must not be allowed to act sluggishly. In many cases a full dose of calomel and compound colocynth pill will be required two or three times a week, and these doses are sometimes essential to the cure. If the legs, or feet, or abdomen become œdematous, and the urine scanty, the case will not go on well till we have roused the kidneys to vigorous action by full doses of spiritus ætheris nitrosi and acetate of potassium, etc." (Journ. Cutan. Med., v. ii.).

The administration and the powers of arsenic in combination with other remedies require special consideration. We have already noted that it enhances the value of iron for instance, in amenorrhœa, anæmia, struma, eczema, etc.; there is a good effervescing citrate of arsenic and iron, which I have often found serviceable. Iodide of arsenic has been esteemed by some practitioners on the Continent and in Ireland, especially by Neligan: as much as from $\frac{1}{10}$ to $\frac{1}{4}$ gr. in pill thrice daily has been given. The same physician employed also an ioduretted solution, containing 5 min. of Fowler's solution, 1 gr. of iodide of potassium, and $\frac{1}{4}$ gr. iodine in 1 dr. of orange syrup; it is rather agreeable, keeps well and has given good results, and has seemed preferable to Donovan's solution (Dub. Journ., vols. xvi., xxii.). This has been specially used in syphilitic skin disease, but it is, as Mr. Hunt observes, though "very active, yet a most unmanageable preparation." The mercury is liable to injure the general health of some weakly subjects, and to interfere with the effects of arsenic or of iodine, which are quite powerful enough, and require special caution as to their own effects.

AURUM—GOLD (Au = 196·6).

This "king of metals," as it was formerly termed, is found native in the "veins" of rocks, and as gold-dust or nuggets in the sands of certain plains and rivers; it is separated by washing, or by means of mercury, which is afterwards driven off by heat; it occurs also in alloy with silver, copper and iron, but not as an oxide, nor in any other than the metallic form. Fine gold is placed in the appendix to the Pharmacopœia, to be used for the preparation of the perchloride.

CHARACTERS AND TESTS.—When pure it is of yellow colour, in films transmits green light, and is greenish when liquefied; it is of great density, having a sp. gr. of 19·2, and is remarkably malleable, 280,000 thin leaves making only one inch in thickness. It is less easily oxidised than any other metal, and will not combine with oxygen by direct action, only through the medium of another oxide: thus the suboxide of gold is prepared by adding a solution of potash to one of protochloride; it is precipitated as a green powder. Gold combines also with chlorine and iodine, not with nitrogen or hydrogen. It is soluble only in a mixture of nitric with hydrochloric acid (aqua regia).

PULVIS AURI—POWDER OF GOLD (*non-off.*).

PREPARATION.—It is prepared by triturating gold leaf with some hard crystals, as of potassic sulphate, or with some glutinous substance as honey; and after complete disintegration of the metal, the foreign ingredients are removed by washing,—the resulting powder retaining the colour of the metal.

COMPOUNDS OF GOLD.

AURI PERCHLORIDUM—PERCHLORIDE OF GOLD—"POTABLE GOLD" OF ALCHEMISTS ($AuCl_3 = 303$).

PREPARATION, etc.—It is prepared by dissolving the metal in nitro-hydrochloric acid, with gentle heat; on evaporating, yellow crystals of the salt are left in combination with some free acid ($AuCl_3 2HCl H_2O$). After the acid has been driven off, the colour of the crystals is red, and they have the composition $AuCl_3$. This salt is used in photography and in analytical chemistry, and a solution of it, freed from excess of acid, is placed in the appendix to the Pharmacopœia as a test solution for atropine.

AURI PEROXIDUM—PEROXIDE OF GOLD—"AURIC ACID" ($Au_2O_3 = 441·2$) (*non-off.*).

PREPARATION, etc.—It is prepared by treating the perchloride with magnesia, washing the precipitate, and digesting in dilute nitric acid which removes the magnesia. The peroxide forms when dried, a brown powder, insoluble in water and decomposed by exposure to light.

AURI ET SODII CHLORIDUM—CHLORIDE OF GOLD AND SODIUM (*non-off.*).

PREPARATION.—(According to the American Pharmacopœia.) This is a mixture composed of equal parts of perchloride of gold ($AuCl_3$) and

chloride of sodium (NaCl), and is prepared by dissolving gold in nitro-hydrochloric acid, and evaporating to dryness to obtain chloride of gold. This is dissolved in water, and mixed with its own weight of pure dried common salt also dissolved in water; the mixed solution is then evaporated to dryness. It is an orange-yellow powder, slightly deliquescent, odourless, with a feebly acid reaction and a saline metallic taste which is very nauseous;—the salt should therefore not be given in solution. It is very soluble in water and in alcohol. When exposed to a red heat it is decomposed, and metallic gold separates out.

AURI IODIDUM—IODIDE OF GOLD (AuI_3) (*non-off.*).

PREPARATION, etc.—It is prepared by mixing solutions of iodide of potassium and perchloride of gold. The precipitate when collected, washed and dried, forms a greenish-yellow powder insoluble in cold, but slightly soluble in boiling water.

ABSORPTION AND ELIMINATION.—Salts of gold are readily decomposed by organic substances and coagulate albumen, but when the soluble chlorides are given internally they become absorbed to some extent (probably in the intestine), as oxides combined with albumen. When rubbed upon the gums and tongue, according to an old-fashioned method of administration, they are also absorbed, but are liable to cause much local irritation. Neither metallic gold nor the oxides can be absorbed (although poisoning by gold leaf is said to be an aristocratic method of suicide in China), nor is an ointment containing either these or the chlorides likely to produce any effect through the skin.

Elimination occurs through the liver, intestinal canal and kidneys, but is very slow (Husemann): the urine is coloured yellow during the process. Rabuteau maintains that the elimination of gold is never complete, some of the metal being reduced and deposited, especially in the epithelial- and nerve-tissues; for on examining these parts in the body of a rat that had died after taking 15 gr. of gold chloride in fourteen days, he found the contour of epithelium from the intestinal tract to be very strongly marked, as by nitrate of silver, and the axis-cylinder of the nerve-tubules to be coloured slightly green; he considers that this deposition of the metal explains why gold seems more active than mercury, for having nearly the same atomic weight and specific heat, their properties should (according to the analogies of other substances as observed by him) be also very similar, were it not that the gold is less completely eliminated. We must

remark however, upon this point, that though mercury may, as a rule, be more readily eliminated than gold, yet it has also often been found deposited in the bone, the liver and other parts of the body long after its administration.

PHYSIOLOGICAL ACTION.—*External.*—The chloride of gold has an irritant caustic effect, and stains the skin of a yellow colour, which becomes violet and later black, from reduction of the metal.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Small doses increase appetite and digestive power, and stimulate the secreting organs, but under larger or continued doses, this stimulation readily passes into irritation, and there are often dryness of the tongue, redness of the pharynx, and some gastric irritation, with colic and diarrhœa (Cullerier); on the other hand, though the intestinal secretions are increased, constipation has been noticed by several observers.

Glandular System.—*Salivation* has been commonly described as a result of this medicine, and is said to occur after a longer period, and with less marked stomatitis than when produced by mercury. Martini met with ptyalism only after the long-continued use of small doses, and found that the double chloride of gold and sodium might be taken for many months without injurious effect; only in one case did ptyalism occur, and then one-third of an oz. had been taken (Schmidt's Jahrb., 1870). The secretion of the sweat-glands is increased, especially during the night, and this alternates with or accompanies an increase in the quantity of urine (Gozzi, 1817). The stimulation of the glandular system and of growth is said to be such that adenitis has followed the use of gold, and tumours of osseous or of glandular character have become painful and inflamed (Percy, Rapport à l'Academie). Some excitement of the genital organs occurs, so that in men priapism may be caused, and in women the catamenia increased (Legrand, De l'Or).

Nervous System.—The intellectual powers are said to be stimulated by gold somewhat in the same manner as by alcohol. Gold salts cause paralysis of the central nervous system of frogs, and this appears to affect the optic lobes and cerebellum first, then the spinal cord, and lastly, the cerebral hemispheres.

Respiratory System.—Large doses injected into the veins

cause œdema of the lungs, and death from asphyxia; there is also a catarrhal condition of the respiratory passages.

Toxic Effects.—A peculiar febrile condition—"auric fever"—including headache and many of the above-mentioned symptoms as sweating and diuresis, may supervene if a course of the remedy be continued for two to four weeks, and seems to be analogous to mercurial fever (Niel, Récherches, Paris, 1820). In animals, general emaciation and convulsive twitchings have preceded death, and besides the evidence of metallic deposition in the tissues, Rabuteau records a yellow coloration of the gastro-intestinal mucous membrane. Large doses of gold compounds may certainly cause gastritis and death, with cramp and other severe nervous symptoms (Majendie). The cause of death in acute cases seems to be asphyxia, produced by the pulmonary lesions mentioned above.

SYNERGISTS.—Mercurials.

ANTAGONISTS — INCOMPATIBLES. — Albumen in any form,—milk, flour, etc.

THERAPEUTICAL ACTION.—*External.*—As a caustic, the chloride has been used by Landolfi and Recamier in lupus and in carcinoma. Legrand employed it in ulceration of the neck of the uterus, and also as a lotion and a vaginal injection. Mechanically, gold leaf is employed by dentists for stopping teeth, and by druggists for coating pills.

THERAPEUTICAL ACTION.—*Internal.*—In former times, when fanciful analogies of colour or of accidental qualities largely determined opinion as to the medicinal value of any substance, gold was praised as a remedy for melancholy and for the dyspepsia often connected with it, and after several centuries of disuse, confidence in its therapeutical power has been, to some extent, revived mainly by a few French and Italian physicians. The double chloride of gold and sodium is the preparation most recommended.

Syphilis.—M. Chrestien of Montpellier, and later M. Legrand, have recorded many cases of both primary and secondary syphilis cured under the influence of gold, and Trousseau observes that such results are now well proven and incontestable. Chancres and condylomata have got well under this remedy in a manner not likely to be due to nature, and in my own experience its

efficacy has been still better seen in the later developments, such as ulceration in the nose and larynx, cutaneous syphilides, hard nodes, etc. It is said to cure without local applications, but often an "unguentum auri" has been used in addition. Gold may especially be employed in long-standing cases with chronic periostitis, and when mercury has been already given to saturation.

Dietrich, whilst denying to gold any true anti-syphilitic power, thought it most valuable for mercurial cachexia (Journal des Connaisances Méd.-Chir., 1840), but this has not been corroborated by many observers. Auric fever may occur during a course of the remedy, and for a time the general health may suffer and the local manifestations may be more irritable, but on lessening the dose the pyrexia subsides, and good effects are more conspicuous.

Croup.—Dr. G. A. Linn states that gold chloride is a specific for simple croup, and that even in diphtheritic croup it is valuable in relieving the spasm of the larynx, which he considers more potent as a cause of obstruction than the actual membrane. The doses for a child vary from $\frac{1}{50}$ to $\frac{1}{30}$ gr., and in the case of diphtheria it is usefully combined with mercuric chloride (Med. Times, ii., 1884).

Scrofula.—Advocates of the medicinal use of gold—especially Niel and Legrand—have spoken strongly of its value in scrofulous disease of the bones, in glandular enlargements, "white swelling," goître and even elephantiasis, but Velpeau and others have not corroborated their statements in hospital practice. No doubt, as Trousseau remarks, the treatment of scrofula amongst the poor really requires more than any drug can effect, and it would be unfair to discredit gold altogether because it has not cured some hospital patients. I think myself that it may prove a useful adjunct, or at least a good alternative treatment. Majendie and Roux have reported some illustrations of its value, and Mr. Chatterley has recorded a case of extensive and indolent scrofulous ulcer affecting the right foot, unrelieved by iodide of iron, etc., but cured by small doses of the gold chloride (Lancet, ii., 1852); also another case of cure of a cachectic child suffering from enlarged and indurated cervical glands (Med. Times, i., 1854); he recommended $\frac{1}{24}$ gr. mixed with orris-root to be rubbed on

the tongue for one to five minutes daily. A case of hypertrophy of the tongue with induration, which was probably syphilitic or scrofulous in character, was cured by the use of 1·5 gr. internally, and local frictions with 1 gr. mixed with lard (Amer. Med. Journ., vol. xix.). It is probable that the so-called cures of *cancer* by aurum have really been of scrofulous ulceration.

Recamier's caustic was prepared with the chloride, and *lupus* has been treated by hypodermic injection of it (B. M. J., ii., 1891).

Recently the chloride of gold has been brought forward as almost a specific in *phthisis*, but has not yet commended itself to professional use.

Uterine Disorders.—Nöggerath refers to the value of this medicine in amenorrhœa and in chronic ovaritis, and says it is suitable for cases of the former dependent upon torpor; it should not be given during pregnancy, nor to persons liable to undue flooding. Martini states that it is serviceable in cases with a tendency to abortion, in chronic metritis, and in cases with mental symptoms of hysterical character, especially when these were connected with definite uterine disorder.

Chronic Bright's Disease.—Dr. Bartholow draws special attention to the value of salts of gold in the treatment of granular and fibroid disease of the kidney and "depurative disease." He has observed remarkable improvement from the persistent use of small doses of the chlorides—$\frac{1}{30}$ to $\frac{1}{20}$ gr., three times daily; they are not suitable for acute stages of the disease. A cure of two cases of *diabetes* under the chloride of gold and sodium is reported in the Edin. Journ. for Oct., 1891.

Dyspepsia, etc.—Dr. Bartholow is also one of the most decided of modern writers in recommending small doses ($\frac{1}{20}$ gr.) of the double chloride for "nervous dyspepsia," as "indicated by a red glazed tongue, epigastric pain increased after food, and tendency to relaxation of the bowels: also in duodenal and biliary catarrh, and jaundice." Vertigo and vertiginous sensations connected with stomach disorder, are often relieved by small doses of gold chlorides, but plethora and increased intracranial blood-pressure contra-indicate their use. On the other hand, they do good in cerebral anæmia, so that they may be prescribed when bromides would not be suitable. Melancholia and hypochondriasis with depression are often connected with

gastric disorder and with cerebral anæmia, and are susceptible, to some extent, of relief by the same remedy (*cf.* B. M. J., ii., 1891).

It is said to be serviceable in chronic alcoholism but (as already remarked of phthisis) has not yet received professional trial or assent (B. M. J., ii., 1892). In *epilepsy* and *hysteria* the bromide of gold in $\frac{1}{5}$ to $\frac{1}{2}$ gr. doses has been useful (Lancet, i., 1890).

Hemi-Anæsthesia.—I must not omit to notice the most modern application of gold as a remedy, and that is in its metallic form in "metallo-therapy," as developed mainly in Paris by Prof. Charcot and others some years ago. It seems that rather a large proportion of nervous patients on the Continent suffer from impaired sensation of one-half of the body, and that by the application of two metals, as a gold and a copper coin over several nerve-trunks, sensation may be "transferred," returning to the affected side in about a quarter of an hour, but often leaving at the same time, the previously sound side. Such a peculiar circumstance is not yet wholly explained, but has been connected with a gentle galvanic action (Med. Record, 1878-79). Dr. A. Hughes Bennett and others explain the phenomena rather by "expectant attention," and I believe that mental influences of various kinds are a much more likely explanation than any specific properties of metals thus applied. Since the last edition of this work, very little has been heard of this method.

PREPARATIONS AND DOSE.—Fine gold, and the solution of the chloride, are placed in the appendix of the B.P., but no directions for their internal use are given. *Pulvis auri:* dose, $\frac{1}{4}$ to $\frac{1}{2}$ gr. gradually increased to 2 to 3 gr.—may be given in pill with confection of roses, but is not a good form. *Syrupus auri*, containing 24 gr. to the ounce, has been used by way of friction on the tongue, but cannot be depended upon. *Unguentum auri*, $\frac{1}{2}$ dr. to the ounce of lard is also not dependable. *Chloride of gold and sodium:* dose, $\frac{1}{30}$ to $\frac{1}{10}$ gr. once or twice daily, in pill—the best preparation, but its irritant and poisonous properties should be remembered. *Peroxide of gold:* dose $\frac{1}{15}$ gr. twice or thrice daily. *Iodide of gold* (French codex): dose, $\frac{1}{15}$ to $\frac{1}{10}$ gr. is said to be more active than corrosive sublimate.

BARIUM (Ba = 137).

This is not met with native, but abundantly as the base of an alkaline earth, called *baryta* or *barytes* (an oxide), which occurs extensively as native sulphate ($BaSO_4$, heavy spar, its

most common compound) and carbonate (witherite). The metal itself has not yet been obtained in a coherent state, but only as a powder.

BARYTA (BaO = 153) (*non-off.*).

CHARACTERS AND TESTS. — A greyish-white earthy-looking substance, heavy, sp. gr. 5·4, of sharp caustic taste and strongly alkaline reaction; sprinkled with water it becomes hot, and slakes with energetic action, falling into a fine white powder, hydrate of barium ($Ba(HO)_2$), which contains eight molecules of water of crystallisation, and is soluble in 10 parts of boiling water.

BARII CHLORIDUM—CHLORIDE OF BARIUM

($BaCl_2 2H_2O$ = 244).

It is placed in the appendix as a test for sulphuric acid.

CHARACTERS AND TESTS.—It occurs in translucent soluble crystals, which have a bitter acrid taste; they contain two molecules of water of crystallisation. The solution gives with any soluble sulphate a heavy white precipitate of barium sulphate, not soluble in nitric acid.

Carbonate of Barium is a white insoluble powder.

ABSORPTION AND ELIMINATION.—Orfilad etected the chloride of barium in the liver, spleen, and kidneys of animals poisoned by it (Annales d'Hygiène, ii., 1842). Neumann has made numerous observations on this subject, and after injecting *sulphate* of baryta into the veins of animals, he searched for it in the urine and also in the blood some hours afterwards, but without detecting it: it was, however, found deposited in liver, spleen, kidney, and bone. When the *chloride* of barium was given in the same manner, the greater part passed by the bowel, but some was found in the urine and saliva, as well as deposited in bone. He concluded that the drug was not easily eliminated (Rev. des Sci. Méd., 1886).

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Small doses ($\frac{1}{12}$ to $\frac{1}{8}$ gr.) of the chloride exert a stimulant effect on the stomach, increase the appetite, and often produce loose stools. Larger doses prove irritant or caustic; three grains taken several times daily, soon induce a sense of pressure at the

epigastrium, nausea, vomiting and purging, with faintness (Fergusson, Dub. Journ., 1844). Dr. Shoemaker refers to a death from $2\frac{1}{2}$ gr. taken in daily doses of $\frac{1}{4}$ gr., but this must be very exceptional; the minimum fatal dose is commonly put at 1 dr., which has caused much vomiting and purging, and death in convulsions in seventeen hours (Walsh, Lancet, 1859). Two and a half dr. were given to a girl by mistake for Carlsbad salt, and caused vomiting in twenty minutes, death in four and a half hours (B. M. J., i., 1892). Half an ounce caused similar irritant symptoms, and death in two hours—evidence of severe gastro-intestinal inflammation being found (Taylor). The nitrate and acetate of barium have also caused death, and the carbonate is commonly used as a poison for rats and mice. Although one teaspoonful has destroyed life, much larger doses have been taken without fatal results.

Since strontium salts have been more used in medicine, the amount of barium commonly contained in them has become an important consideration; it has been estimated recently as not more than 1 in 1000, which should be well under an injurious dose.

Nervous System.—The nervous symptoms caused by toxic doses of barium compounds are clonic convulsions and motor paralysis, with impairment of reflex excitability. From the slow respiration observed in cases of poisoning, it has been concluded that the vagi become paralysed (Walsh). According to Cyon, the lesion is central, for even in advanced poisoning the muscular irritability and the sensibility of peripheral nerves remain intact (Reichert's Archiv, 1866). Severe pains in the head, throbbing in the temples, giddiness, dimness of sight, double vision, deafness and tinnitus, have been experienced: also muscular cramp, especially in the legs.

Circulatory System.—The heart's action is at first stimulated, afterwards quickly and powerfully depressed by full doses of barium compounds. After some palpitation, the pulse becomes irregular, feeble, or imperceptible, and the surface cold and pale. Blake found that small doses ($\frac{1}{4}$ gr.) raised blood-pressure, while larger doses caused a transient rise succeeded by a fall, or from the first a sudden fall according to the dose given: he also observed that voluntary muscles were apparently stimulated and

twitched for a long time after death (Edin. Med. Journ., 1841). Boehm concludes that the action is very similar to that of digitalis (Archiv expt. Path., iii.). Onsum suggested that barium compounds caused embolism by precipitation of the sulphates of the blood (Virchow's Archiv, Bd. xxviii.), but Cyon has shown both that the normal sulphates exist in very small amount, and that if they are artificially increased, still no precipitate occurs on giving baryta.

Dr. Ringer has also pointed out the great similarity of the effect of barium compounds and digitalis on the frog's heart: the pulse is slowed, and the heart finally stops in systole; the blood-pressure is raised, probably from the direct action of the metal on the muscular tissue of the vessels; these actions take place independently of the nervous system (B. M. J., i., 1883). In a circulating fluid, Drs. Ringer and Sainsbury have found, as Blake did previously, that small quantities of strontium or barium salts will replace calcium salts with which they are chemically analogous. Strontium accelerates the beats of the heart more than calcium (Pract., ii., 1883).

Glandular System.—We have no clear evidence of the effect of baryta on the lymphatic system, but it is presumed to exert some absorptive "deobstruent" power on inflamed or hardened lymphatic glands. Small doses increase the secretion of urine and of perspiration.

SYNERGISTS.—Lime and other alkaline earths. The chloride of barium has some analogies with corrosive sublimate.

INCOMPATIBLES.—All sulphates are chemically incompatible with barium salts, forming insoluble compounds. The sulphates of sodium and magnesium have been used as antidotes in cases of poisoning (Walsh), also white of egg and sugared wine (Perondi, Bull. de Thérap., t. x.).

THERAPEUTICAL ACTION.—*External.*—**Depilation.**—Dr. McCall Anderson recommends the sulphide of barium for removing superfluous hair, one part of it being made into a paste with four parts of zinc oxide and a little water; this should be left on the part for about three minutes, and then washed off.

THERAPEUTICAL ACTION.—*Internal.*—**Scrofulosis, etc.**—Barium chloride was introduced at the end of last century as effective in scrofulous and syphilitic dyscrasiæ, in gonorrhœa,

white swelling, etc. (Crawford, 1780). Lisfranc and Torget used it in such cases and in glandular tumours, and reported much advantage from it; the former began with $\frac{1}{8}$ gr. every hour, and increased the dose to much larger quantities than we should consider safe (40 gr.). In a child, many glandular tumours subsided under a month's treatment, but frictions with iodide of potassium were used at the same time (Amer. Journ., 1838; Bull de Thérap., 1840). Mr. R. Phillips recommended barium chloride as superior to iodine in many cases marked by pallor, languid circulation, and irritable mucous membranes (On Scrofula, 1846), and Mr. Balman used it in chlorotic and cachectic states generally (Med. Times, ii., 1851). In amenorrhœa he gave $\frac{1}{2}$ to 1 gr. doses with perchloride of iron. Many cases of successful treatment of scrofulous joint disease, of ophthalmia, and of enlarged glands by barium chloride ($\frac{1}{12}$ gr. doses), were recorded some years ago (Ranking, 1846).

Cardiac Disease.—Barium chloride has also been used to a limited extent in valvular heart disease as a substitute for digitalis. Da Costa praises it highly in restoring compensation and lessening cardiac pain; he gave $\frac{1}{10}$ gr. in pill three or four times daily, for about three weeks. Larger doses may be given, but in his opinion tend to cause diarrhœa (Amer. Journ. Med. Sc., 1888).

Dr. A. H. Hare finds that it slows and steadies the heart, that it acts as rapidly as digitalis, and does not disorder the stomach (Pract., 1889). Dr. J. S. Carpenter agrees as to its value but advises caution, for a patient æt. thirty-one, having taken $1\frac{1}{2}$ gr. three times, was attacked with symptoms of gastro-enteritis and collapse: he recommends as a dose $\frac{1}{2}$ dr. of a 1 per cent. solution gradually increased to 2 dr. (*ib.*, 1891).

Aneurism.—Dr. F. Flint considering that it gives tone to the vascular wall, used it in a case of fusiform aneurism of the abdominal aorta in doses of $\frac{1}{5}$ gr. thrice daily; within a fortnight improvement ensued, and in five months cure was complete. Prolonged rest and rigid dietetic treatment were used at the same time (Pract., 1879).

Epilepsy—Tetanus, etc.—Hufeland introduced this remedy for epilepsy in scrofulous subjects, but it is now seldom used. Brown-Séquard however, whilst reporting against its efficacy, remarks that it may diminish reflex excitability, and therefore

deserves trial in tetanus and in paralysis agitans. A somewhat doubtful case of traumatic tetanus is said to have recovered under the use of about 16 gr. of the chloride, given in twenty-four hours (Edin. Med. Journ., 1862). In satyriasis, or excessive sexual desire, it has also been employed. Dr. Hammond recommends it in diffuse and multiple cerebral sclerosis.

PREPARATIONS AND DOSE.—*Barii chloridum :* the dose mentioned by Dr. Garrod and others is from $\frac{1}{2}$ to 2 gr., but Mr. Kennedy, after much experience, maintains that $\frac{1}{16}$ to $\frac{1}{12}$ gr. is much more suitable and safer to commence with ; very few persons, he says, can bear $\frac{1}{8}$ gr. without irritation (Lancet, ii., 1873). The U.S. Pharmacopœia contains a *liquor barii chloridi* (1 part in 4 of distilled water); the dose ordered is 5 min.

As an *eye-lotion*, from 1 to 2 gr. may be ordered with 10 oz. of water. As a *depilatory*, 1 part of sulphide to 4 of excipient.

BISMUTHUM—BISMUTH (Bi = 210).

Bismuth occurs native, and also as an oxide, a sulphide, and variously combined in metallic ores with silver, iron, copper, arsenic, tellurium, etc.

PREPARATION.—The Pharmacopœia directs the preparation of a "*purified bismuth*" (bismuthum purificatum), by fusion with sulphur and potassium cyanide, and subsequently with a mixture of the dried carbonates of sodium and potassium.

CHARACTERS.—This element is grey-coloured with a roseate tinge, and may be obtained in masses of cubical, iridescent crystals ; it is tasteless and inodorous, heavy (specific gravity 9·83), hard, brittle, and like antimony, volatilises at a high temperature.

BISMUTHI OXIDUM—OXIDE OR SESQUIOXIDE OF BISMUTH (Bi_2O_3 = 468).

PREPARATION.—Is prepared by boiling the subnitrate of bismuth with excess of solution of soda.

CHARACTERS.—A smooth, yellowish powder, insoluble in water, more definite in composition, and more constantly pure than other bismuth compounds.

Bismuthum Peptonatum.—Peptonised Bismuth is a brown powder containing $3\frac{1}{2}$ per cent. of oxide.

The Oxychloride of Bismuth (*non-off.*) is prepared by adding an acid solution of the tri-chloride to water, or by mixing

a solution of nitrate with one of common salt. It should be an impalpable, neutral, non-irritant, white, insoluble powder, and is known as "pearl-white."

The oxy-iodides of Bismuth (non-off.) are either yellow or darkish-red amorphous powders, insoluble and free from taste or smell: the yellow is the milder, containing less iodine.

BISMUTHI SUBNITRAS—SUBNITRATE OR OXYNITRATE OF BISMUTH—WHITE BISMUTH—SPANISH WHITE

($BiONO_3$, H_2O = 306).

PREPARATION.—The true *nitrate* ($Bi(NO_3)_2 + 5H_2O$), which is crystalline and more irritant than the subsalt, is formed by dissolving the metal in nitric acid, and when this solution is poured into a large quantity of water it is decomposed, an insoluble basic salt, the *subnitrate* of bismuth falling as a white precipitate.

CHARACTERS AND TESTS.—The subnitrate is crystalline, but when well prepared, should be in smooth and fine powder. It is heavy, white in colour, and becomes yellowish-grey on exposure to light from the formation of some sulphide, or from the presence of silver; it is insoluble in water, soluble in nitric acid. A solution of bismuth subnitrate and sodium hydrate in water and glycerine is the Lowe test for sugar in urine: it has the advantage of being stable.

BISMUTHI CITRAS—CITRATE OF BISMUTH

($BiC_6H_5O_7$ = 399).

PREPARATION.—It is prepared by adding a solution of the subnitrate of bismuth in nitric acid to a solution of sodium bicarbonate, which has been boiled previously with citric acid, a process in which carbonic acid is given off. The citrate of bismuth falls as a white precipitate.

CHARACTERS AND TESTS.—It is a white powder which contains $2\frac{1}{2}$ per cent. of absorbed moisture. It is soluble in ammonia, and is used in the preparation of liquor bismuthi et ammonii citratis.

LIQUOR BISMUTHI ET AMMONII CITRATIS—SOLUTION OF CITRATE OF BISMUTH AND AMMONIUM—LIQUOR BISMUTHI.

PREPARATION.—It is prepared by adding ammonia to citrate of bismuth made into a paste with a little water, until the salt is just dissolved. It is then diluted with water.

CHARACTERS AND TESTS.—A colourless liquid, of saline metallic taste, sp. gr. 1·07, miscible with water. Liquor potassæ precipitates the white hydrate, and hydrochloric acid the white oxychloride, but an excess of acid re-dissolves this as chloride. The official solution is neutral, or slightly alkaline.

BISMUTHI ET AMMONII CITRAS—CITRATE OF BISMUTH AND AMMONIUM.

PREPARATION.—It is prepared by evaporating the solution of citrate of bismuth and ammonium to dryness.

CHARACTERS AND TESTS.—It occurs in small, shining, translucent scales, which are slightly metallic in taste, very soluble in water, and yield ammonia when warmed with a solution of potash or soda.

BISMUTHI CARBONAS—CARBONATE OF BISMUTH

$((Bi_2O_2CO_3)_2H_2O = 1042)$.

PREPARATION.—It is prepared by adding a concentrated solution of bismuth in nitric acid, to an excess of carbonate of ammonium in cold solution.

CHARACTERS AND TESTS.—The salt is precipitated as a hydrated oxycarbonate, which is, like the subnitrate, insoluble in water, but is more soluble in the gastric juice, and has antacid properties.

On passing a current of sulphuretted hydrogen through an acid solution of a bismuth salt, the black sulphide of bismuth (Bi_2S_3) will be thrown down. Concentrated acid solutions of bismuth salts poured into water give a white precipitate of a basic salt, *e.g.*, the nitrate when thus treated yields the subnitrate. Caustic alkali added to a solution of a bismuth salt precipitates the white hydrate of bismuth ($Bi_2O_3H_2O$). Papers saturated with sulphocyanide of potassium are coloured yellow by soluble bismuth salts.

The salicylate of Bismuth (*non-off.*) is obtained by mixing solutions of the nitrate and of salicylate of sodium; and is an insoluble, white, or pinkish powder. *The salicylate of Bismuth and Cerium* (*non-off.*) is a double salt of similar character. *The subgallate* (Dermatol) is a yellow insoluble powder, free from odour (*non-off.*).

ABSORPTION AND ELIMINATION.—Bismuth in substance, is not absorbed by the skin, and the supposed instances of poisonous effects from its use as a cosmetic are not trustworthy (Husemann). A soluble bismuth salt such as the ammonio-citrate, is, however, quickly absorbed from the cellular tissue after hypodermic injection. From wounds also, bismuth has sometimes been absorbed so largely as to cause toxic effects.

Steinfeld, injecting a soluble salt of bismuth into the skin and the circulation, found it excreted fairly rapidly by the kidney (Record, 1886), and Hans Meyer corroborates this to some extent, but finds that the presence of sulphuretted hydrogen readily precipitates bismuth as a sulphide on the mucous surface of the intestine, and in adjacent capillaries (Lancet, i., 1886).

Much difference exists in the degree of absorption of bismuth-compounds taken by the mouth, and the difference is proportionate to their solubility. The acetate, the double tartrate, and the ammonio-citrate dissolve in the gastric fluids, and are readily absorbed, whilst the oxide and subcarbonate are but slightly soluble, and the ordinary subnitrate still less so.

Headland taught that it was as insoluble as charcoal, but Orfila and Lewald have detected the drug in the liver, the milk, and the urine, after its administration, though in the last secretion it appeared later than other metallic salts usually do. Bergeret and Mayençon detected it in the same fluids and in dropsical exudations, and after giving small doses to rabbits they found it, within half an hour, in the blood, the spleen, the muscles, etc., and continued to find traces of it for eight days after administration. In one man they also found it five days after ; in another, testing sixty-two days afterwards, they did not find any (Journ. de l'Anatomie, 1873). We may conclude, therefore, that some amount of absorption even of the subnitrate occurs (and probably as chloride), although the greater part of what has been taken has been found unchanged in the stomach in some cases, or converted more or less into the black sulphide in the intestinal canal, or has been eliminated with the fæces during life. It may accumulate in the intestinal canal and sometimes prove serious, as in the case of a woman who died from cancer, and in whom a large agglutinated mass of bismuth salts was found distending the stomach ; she had taken no bismuth for

at least two months before death (Pract., i., 1882). It is probable that more absorption occurs with small doses (such as the grain or less used originally by Odier, of Geneva), than with the very large ones (several hundred grains daily) prescribed by Monneret.

PHYSIOLOGICAL ACTION.—*External.*—The pulverulent bismuth compounds have an absorbent and protective effect: they are also somewhat astringent and sedative. The crystallised nitrate especially when dissolved in glycerine, is also astringent, but is more irritating, even somewhat caustic. Dr. H. Wood recommends the oxy-iodides as excellent antiseptic absorbent remedies in emulsion, powder, or ointment, for use like iodoform, and in similar cases: they seem to be mild, fairly stable preparation of *iodine*, which however, they readily give off when in contact with organic bodies (B. M. J., i., 1889). The salicylate has also marked antiseptic power, and the subgallate (Dermatol) is said to be astringent without being irritant: but that is not my experience with regard to mucous membranes at least.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Bismuth salts taken in the form of powder exert upon the gastric mucous membrane a sedative, slightly astringent effect, similar to that already described as their external action. Taken in a liquid (more soluble) form, the effects are still of the same kind, but produced by smaller doses and with more tendency to irritation. Whether pure bismuth salts, when taken internally, can exert an irritant poisonous action, or are in the largest doses practically innocuous, has been much disputed. Orfila and Meyer, in experiments on animals, found that both the nitrate and the subnitrate, in doses of 1 to 2 dr., caused vomiting, tremor, depression, and death, with post-mortem evidence of gastro-enteritis (Toxicologie, ii., and Wibmer, Wirkungen). Kerner also records the case of a man who took 40 gr. of the subnitrate, and suffered from gastric oppression and burning pain, thirst, griping, bilious vomiting and relaxation, with vertigo and headache; and another of a man who swallowed 2 dr. (mixed with cream of tartar), and died after violent symptoms of irritant poisoning, such as burning pain in the throat, purging, vomiting, cramps and paralysis: after death, inflammation and gangrene were found in the alimentary tract. Sobernheim subjoins to these cases, one that after a 2 dr. dose proved fatal in

nine days, with similar symptoms, including also delirium and general swelling; inflammation and gangrene of the stomach and intestines were found (Arzneimittellehre). Trousseau alludes to a similar case recorded by Pott in 1739, and Dr. Traill reports one where vomiting and pain followed the taking of 6 dr. (in divided doses). Christison describes "bismuth, in its saline combinations, as an active poison," and Taylor quotes some of the above cases as "proving that a substance very slightly soluble in water may exert a powerfully poisonous action on the human system."

On the other side we must place the strong evidence of Trousseau and Monneret, and the daily experience of a majority of practitioners. Trousseau states that during a very extensive use of well-prepared subnitrate in doses of from 15 to 60 gr., he has never seen the slightest accident, or the least cause for apprehension (Mat. Med., i.), whilst Monneret prescribed the enormous doses of 150 up to 900 gr. per diem, without any inconvenience resulting. He noted only slight constipation with lessened odour and blackened colour of the fæces; there was no thirst, nausea or pain, and the appetite was rather increased than diminished. Such doses as the above are not likely to be now prescribed, but many physicians order 10, 20, or 30 gr. several times daily without any evil result.

The toxic symptoms above noted have been attributed to the presence of *arsenic* as an impurity, and in some cases correctly, as shown by Taylor. H. C. Wood also records a case of bloody purging from the use of an adulterated drug, and the effects are certainly those of an irritant poison. Still as a rule, there is no evidence of the presence of arsenic sufficient to produce serious results, even in the most adulterated specimens of bismuth. Stillé speaks of one-sixth per cent. as the maximum proportion found, whilst Parral and Garnier ascertained that preparations containing 0·129 per cent. did not poison dogs, even in doses of 200 to 500 gr.

Monneret suggested that in the above cases, either a previous illness became suddenly exaggerated, or an excess of *soluble nitrate* acted as an irritant: the last alternative seems possible after recent evidence, that soluble compounds of bismuth have an activity hitherto not supposed to exist in pure preparations. The acetate

(according to Bricka), the double tartrate (Rabuteau), and the ammonio-citrate (Stephanowitsch) given in large doses, produce poisonous symptoms very like those of the allied metals, gold and quicksilver. Rabuteau "at first held the classical opinion as to the remarkable harmlessness of bismuth," but his observations with the double tartrate or "emetic" of bismuth and potash ($C_4H_4K(BiO)O_6$) have convinced him that *slight solubility* explains the general absence of dynamic effects after large doses of the ordinary preparations. The tartrate is soluble in water without decomposition, and has a metallic taste like that of ordinary "tartar emetic"; it causes vomiting, and 30 to 60 gr. prove fatal to small dogs. In connection with this observation, it is noteworthy that in Kerner's fatal case, the patient took cream of tartar with his dose of bismuth, and the salt referred to by Rabuteau would probably be formed. Stephanowitsch records of the ammonio-citrate that its hypodermic injection, in the proportion of 1 gramme to each 1000 grammes of body-weight, will kill animals, and that salivation and buccal abscess follow its use, as well as fatty degeneration of the liver, kidneys and heart. The glycogen of the liver disappears under its prolonged administration (Lebedeff).

Although, therefore, some of the older cases were connected with the presence of arsenic, yet bismuth cannot be held entirely innocuous, and its activity clearly depends upon its solubility. The oxide, carbonate, and subnitrate, though but slightly soluble, may be taken up to some extent, especially when small doses are used. Thus, Odier, of Geneva, gave only a few grains, or less than a grain, and noticed occasionally vomiting, diarrhœa, a sense of heat, vertigo, and drowsiness. M. Guersant has noted colic and "sense of anxiety," and Rabuteau some general sedation, like the effect of antimony, and I have observed some clinical evidence in the same direction; but the existence of a chronic form of bismuth poisoning, marked by anæmia, swelling of the gums, hæmorrhage, etc., as described by Lusanna in man,[1] and by

[1] Dr. Lusanna remarks that Monneret's results with large doses "have destroyed the Orfilian scarecrow," but his own conclusions are almost as alarming as those of Orfila. From large doses, used apparently chiefly in tuberculous diarrhœa, he witnessed no irritation, nor any arrest of the malady, but supervention of a "colliquative and scorbutic state," connected,

Stephanowitsch in animals, though much doubted cannot now be ignored. Feder-Meyer describes an acute form marked by increased pulse and respiration rate, diarrhœa, muscular spasm, and death from asphyxia with extravasation of blood into various organs, also a chronic form accompanied with fatty degeneration (Abst. Lancet, i., 1883). Steinfeld verified a systemic action on the medulla oblongata, shown by early excitement and after-depression of all the functions of the nervous system, resembling the effect of picrotoxin and also of barium in several respects (Internat. Journ. Med. Sci., i., 1886). In several of the surgical cases treated locally by bismuth there is a record of the supervention of a general scorbutic state as described by Lusanna and especially stomatitis and gingivitis (Rev. Gén. des Sc. Med., 1884-86). In connection with this may be mentioned Dr. Brinton's statement that the subnitrate taken continuously will cause a bluish-red line on the gums "similar to, but wider and more red than that known to be caused by lead" (Dis. Stom.). There is, however little, if any, experience of toxic effects from bismuth in English medical literature.

The action of *Liquor Bismuthi et Ammonii Citratis* differs somewhat from that of the solid compounds, and probably represents rather the real activity of the drug, independently of the mechanical effect of a powder; it is more irritant, and it has failed to relieve gastric pain when the subnitrate has succeeded. The carbonate is less liable to irritate than the subnitrate, and yet it is more soluble in the gastric juice; it does not perhaps absorb intestinal gases so readily as the subnitrate or oxide, but has better antacid powers, and is not so likely to constipate. Hannon traced to it also some primary sedative effects, like those described by Rabuteau of the nitrate, viz., weakening and slowing of pulse, lessened appetite, and increased excretion of urine, but found that its continued use improved strength and vigour like iron preparations. The oxychloride seems a still better local mechanical sedative, and is more soluble.

SYNERGISTS.—Mechanical absorbents, antacids, and seda-

he presumes, with a solvent action on globulin, and he traces a profuse epistaxis in a case of mesenteric tuberculosis to the use of bismuth, but gives no sufficient details of the cases on which his exceptional conclusions are based.

tives. Magnesia is specially suited for combination with bismuth salts.

INCOMPATIBLES.—Acids are said to be incompatible with the subnitrate of bismuth (Gubler), and some have advised the omission of all acids from the diet during its administration. Practically however, their effect is only to favour the production of the more soluble nitrate, which should, in suitable doses, act favourably without discomfort, and a few minims of nitric acid are not infrequently prescribed with it; they should be omitted however, if a merely protective effect is desired from an insoluble preparation. Bismuth prescribed with a strong solution of iodide of potassium is precipitated as a red iodide, which is insoluble and apparently inactive (B. M. J., ii., 1870), unless as an antiseptic.

THERAPEUTICAL ACTION. — *External.* — **Erythema, Eczema, etc.**—In these and allied forms of congestive and inflammatory skin disease, bismuth compounds are often extremely useful, by virtue of their absorbent, astringent and soothing properties. In erythema and erysipelas, intertrigo and bedsore, they may be applied in powder, alone or diluted with starch or magnesia, or made into a cream with water and glycerine, or into an ointment in the proportion of 30 to 120 gr. in the ounce of prepared lard, cold cream, or vaseline. (Dr. McCall Anderson, in praising this ointment, notes that it should not be made with *benzoated* lard, or else, for some unexplained reason, it becomes liable to irritate.) An oleate of bismuth is also a good preparation, and forms an excellent dusting powder; according to Dr. Louis Lewis, oleic acid may be made to take up 20 per cent. of oxide of bismuth (Pharm. Journ., Dec., 1876).

In subacute stages of eczema, in burns, etc., when there is much irritability and much serous discharge, these preparations are also very serviceable; they seem to be sufficiently astringent, yet not so much so as lead, zinc, or tannin, and will often act better than those remedies. A 10 per cent. ointment of the subgallate with vaseline is said to be good: a stronger one is liable to irritate. In later stages, when there is infiltration with redness and scaliness, a stronger solution of the soluble nitrate becomes suitable.

In the erythema connected with acne of the face, bismuth is good either as oleate or as an ingredient in soothing lotions: a

small quantity of corrosive sublimate (2 gr. to 8 or 10 oz. of liquid) is often combined with great advantage, when sulphur and other stimulants could not be borne.

As a cosmetic under the name of "blanc de perle," bismuth salts have long been celebrated: they are liable to become darkened by contact with sulphur (*e.g.*, the sulphuretted hydrogen of ordinary gas, etc.), some proportion of the black sulphide being generated.

For chaps and fissures about the hands, lips, nipples, etc., bismuth ointment is very good, and especially with a little tincture of benzoin (20 to 30 min. to 1 oz.). Trousseau specially commends it for anal fissure, and others for ulceration of the septum nasi, and excoriations of the cervix uteri. Follin used a glycerole, containing 1 or 2 parts in 3 of the liquid, for chronic granular conjunctivitis.

Catarrh—Chronic Discharges.—Monneret recommended the insufflation of bismuth powders for coryza, and in chronic catarrhal conditions Soubrier used a snuff containing 4 parts of the subnitrate with 8 of liquorice and 30 of iodide of sulphur. For acute cases Dr. Ferrier re-introduced a formula containing $\frac{1}{2}$ to 1 gr. of morphine, well triturated with 60 gr. each of the subnitrate and of gum acacia, and this often acts well in cutting short a troublesome "cold in the head"; I have frequently prescribed it, but have found patients complain of its causing frontal headache and clogging of the nostrils. In leucorrhœa, bismuth has been applied in powder or paste, on charpie, or as injection in the proportion of 1 to 8 of water, and has been used with advantage in gonorrhœa and gleet (Caby). The subnitrate has been found useful in soft chancre—but after bathing with perchloride solution—and it acted sometimes well as an astringent and germicide (Med. Record, 1884-85). It is well spoken of in bromidrosis (B. M. J., i., 1886).

Wounds, etc.—Many observations have been lately made on the Continent as to the use of bismuth for wounds, and after surgical operations. Rocher reported many cases healing well under 1 per cent. of bismuth subnitrate suspended by careful trituration with water, and he was corroborated to some extent, but when large quantities of the drug were used in substance, some toxic symptoms appeared as already mentioned (Amer.

Journ. Med. Sci., 1883). The general conclusion now is unfavourable to this mode of treatment as compared with that by more active antiseptics.

THERAPEUTICAL ACTION.—*Internal.* — **Dyspepsia.** — According to Monneret, "pain arising during digestion, from whatever cause," may be relieved by mixing the subnitrate freely with the food, but more definite indications may be given. Gastric pains dependent on indigestible food, marked constipation or hepatic congestion, require emesis or purgation, whilst in vomiting connected with fermentation of food, dilatation of stomach, gastric catarrh, etc., antiseptic remedies (*e.g.*, salicylate of bismuth, Lancet, ii., 1886) and perhaps washing out of the viscus may be necessary.

Bismuth is specially indicated in cases of difficult digestion with tendency to diarrhœa, in subacute or chronic gastritis, and gastralgia with marked irritability of the gastric mucous membrane : for such cases, Odier first introduced it (in Geneva, 1786) ; he describes severe gastric pain as frequent amongst the servants there who lift and carry on their heads large vessels of water—the pain was either spasmodic, sudden, intense and relieved by pressure, or more persistent and accompanied with sensations of gnawing, sinking and pulsation ; eructation, nausea and vomiting occurred in greater or less degree, and the general health and mental state became much depressed. Such cases were much relieved by bismuth in moderate doses : and Marcet, Bardsley, and other English physicians have published similar experiences.

Nothnagel finds it especially useful when pain occurs after food in badly-nourished, over-worked persons ; but when there is marked anæmia or a general neuralgic condition it is not so serviceable alone, nor is it very permanent in its good effects. Prussic acid, or opium, alkalies, and later iron and bitters may be conjoined with it. Caizergues especially praises a combination of 4 gr. with $\frac{1}{3}$ gr. of extract of belladonna in the gastralgia of chlorosis (Lond. Journ. Med. Sci., 1851).

When *acid pyrosis* is a marked symptom, bismuth is particularly indicated either alone, or combined with magnesia, especially if constipation be usual. According to Trousseau, if the rejected fluid be insipid, glairy, or sour ropy phlegm, bismuth *alone* is contra-indicated, but in most cases it deserves

trial, requiring only that constipation be remedied. The nausea and vomiting of gastric irritation is commonly amenable to bismuth, *reflex* vomiting, such as that of pregnancy, not so (Husemann), which is an argument in favour of the local protective effect of the drug, the oxychloride has some advantages in these cases.

In *infantile vomiting*, which is frequently dependent on acidity or ill-digested food, and accompanied by diarrhœa and pain, bismuth is exceedingly useful, being, as it is, practically harmless and tasteless—1 to 2 gr. may be placed on the infant's tongue with a moistened finger. A minute dose of creasote, $\frac{1}{10}$ of a drop, may often be usefully combined with it (B. M. J., ii., 1875). A special indication for the use of bismuth in the dyspepsia of children, is said to be a tongue either clean, or slightly coated, but with redness and enlargement of the papillæ fungiformes at its base; besides this will be found the ordinary symptoms of pain after food and nausea (Dunbar, Pract., v., ii., 1882).

In **Ulceration of the Stomach,** when pain is very severe and exhausting, and when vomiting is frequent, much relief may be given by full doses; I have noticed that distressing thirst has been rather relieved than increased by the remedy. Dr. Brinton attached great value to it; it is often given with opium in such cases, and the oxy-iodide has been recommended.

In **Malignant Disease** even, I have found bismuth palliate for a time the most severe symptoms; and in both these conditions it acts mainly by forming a smooth layer over exposed and hyper-sensitive nerves, and so preventing the contact of food and unhealthy secretions: to obtain such a result it is evident that more than ordinary doses are required.

Gastro-Uterine Irritation.—Trousseau undervalued the virtues of bismuth when he held it unsuited for gastric pain connected with leucorrhœa. It has really a special sphere of action in various uterine disorders which induce or follow on gastric derangement, as has been well shown by F. W. Mackenzie (Lond. Journ. Med., 1857). His cases seemed to prove the stomach primarily at fault, since complaint was made of pain, sinking, flatulence, etc., before the ordinary symptoms of uterine irritation appeared; bismuth greatly relieved them, and my own experience is somewhat to the same effect. In dysmenorrhœa, with severe pain in the back, hips, legs, and hypogastric region,

palpitation, etc., I have often given it with good effect, and in uterine hæmorrhage (profuse menstruation) it has proved strikingly efficacious when recognised styptics had failed, being thus allied in action with oxide of silver and arsenic; apparently a sedative influence is exerted both on the stomach and the uterus through the mucous tract and connected nerve-ganglia.

Diarrhœa.—In irritative diarrhœa, with red tongue, nausea, heartburn, griping pain worse after meals, and frequent ill-formed stools, I have found bismuth invaluable. In some persons, mostly women, such a condition becomes habitual, and even ordinary articles of diet may cause severe aggravation of symptoms; the constant use of this remedy, however, gives them the greatest relief, and enables them to take food with comparative comfort; much flatulence is often present, and sometimes the diarrhœa depends on irritation from the development of sulphuretted hydrogen (Chambers). Bismuth is then also very suitable, for it combines readily with that gas and absorbs it (Pract., 1869); sometimes charcoal, or aromatic chalk powder, or rhubarb, may be added with advantage, or the salicylate may be found preferable.

Infantile Diarrhœa.—When infants at the breast suffer from eructations, sour vomiting, diarrhœa, light-coloured papescent stools of bad odour, with crampy pains in the stomach, I have always found bismuth act well. In that form of diarrhœa which so readily affects children whilst being weaned, or during hot weather, or that which continues even after irritation has been removed, it is also of great service; from 1 to 5 gr. may be given several times daily to children of one year and under. Weller prescribed for children as much as 30 to 60 gr. of subnitrate every hour (interdicting milk during the treatment), with no other than good results (Amer. Journ., 1870).

The *ulcerative diarrhœa* and aphthous condition connected with phthisis is alleviated by full doses. Traube (one of the first to recommend the remedy in such cases) supports the view of its acting mainly as a mechanical protective, lessening local irritation, and consequently reflex peristalsis. The powder is sometimes found to line the whole tract, and it is evident that for such protective effect large doses are necessary. Dr. T. Thompson, who prescribed about 5 gr. of the subnitrate with magnesia and

mucilage, and Monneret, who gave many drachms for a dose, are strong advocates of its advantages. The latter observer states that he had seen many persons who were apparently dying with tuberculous diarrhœa, restored for a time to comparative health (Med.-Chir. Trans., v. 31), but the results of others have not been so favourable. The persistent diarrhœa of enteric fever is sometimes well treated in the same manner, and in this also the salicylate is a good preparation.

Dysentery.—M. Brassac, of the French naval service, records the best results from bismuth in epidemic dysentery. Finding little or no benefit from small doses, he followed the teaching of Monneret, and beginning with 230 to 300 gr. daily, increased to more than 1000 gr.; he divided this into about five doses according to the case, giving it in broth or milk, or sometimes by enema, and so long as more than one stool occurred in the day. This plan was very successful and had no ill result; as a rule, his patients began at once to eat better and to gain strength (Edin. Med. Journ., 1867). Trousseau also used bismuth injections in dysentery (Lancet, i., 1855), and Dr. Houghton wrote from Borneo, concerning their great value in subacute and chronic cases in tropical climates; he prescribes 30 gr. with mucilage to be injected two or three times daily, and retained if possible (Lancet, ii., 1879). In acute and chronic colitis, Lasèque also used, with the best results, enemata of 30 to 150 gr. with egg or mucilage.

Cholera.—In the epidemic at Warsaw, in 1831, it was highly approved by Leo, and in later epidemics at Paris it was commended by Trousseau, and very largely used for the premonitory diarrhœa; at the commencement of the attack only, a little opium may be added with advantage; afterwards, two full doses of bismuth daily will suffice.

The reputation which has been sometimes claimed for bismuth as a valuable remedy in intermittent fever, and in nervous disorders, as epilepsy, cephalalgia, asthma, and in whooping-cough, must be traced either to its relieving gastric complications of such maladies, or to the presence of contained arsenic: it has not been sustained in recent times.

PREPARATIONS AND DOSE.—*Bismuthi oxidum:* dose, 5 to 15 gr. or more. *Bismuthi subnitras:* 5 to 20 gr. or more (see below). *Tro-*

chiscus bismuthi: dose, 1 to 6 lozenges (each lozenge contains 2 gr. with lime and magnesia). *Liquor bismuthi et ammonii citratis:* dose, ½ to 1 fl. dr. and upwards (contains about 3 gr. of oxide in each fl. dr.). The preparation of Schacht is said to contain only 1 gr. of oxide to each dr.: dose, 1 to 4 dr. *Bismuthi carbonas:* dose, 5 to 20 gr. or more. *Bismuthi citras:* dose, 2 to 5 gr. *Bismuthi et ammonii citras:* dose, 2 to 5 gr. Of the oxychloride and salicylate and the double salicylate with cerum the dose is from 5 to 20 gr.—of the oxy-iodide, from 5 to 10 gr.; of the peptonised bismuth, ½ to 1½ dr.

Preparations of bismuth should be taken about a quarter of an hour before, or with meals, and if a mechanical protective effect is most desired, acids are better avoided during the medication.

Subnitrate.—The dose should depend upon its molecular state. Thus, if it be very dry and likely to become caked together in the stomach, very large doses may not act at all, or may cause irritation, whilst if moistened or formed into hydrate, or carefully mixed with some other fine powder, moderate doses will give a much better result. Thus, Quesneville took 80 grammes without much advantage, but afterwards using the drug thoroughly soaked in water, soon obtained good effects with 5 to 10 grammes; his "*bismuth-cream*" is a valuable preparation better known abroad than in this country. Doses of 1½ to 2½ dr. are now seldom used, 5 to 10 gr. representing an average prescription for adults. Much more may, however, be given in organic disease when there is erosion or ulceration of the alimentary surface; milk or almond emulsion is a good vehicle. The subnitrate forms a part of the "*poudre de Wendt,*" also of the powder of Robert Thomas; combined with magnesia it is "Patterson's or American powder," and with pepsin, the "*poudre de Royer.*"

The *liquor bismuthi et ammonii citratis* is miscible with water and spirit, but not with alkalies without precipitation. The so-called "lac bismuthi" (Syme) contains the hydrate mechanically suspended.

A lactate, a tannate, and a valerianate of bismuth have been described: the first is a soluble salt, and may be given in small doses; the compound with tannin, like that with gallic acid, is designed to favour its astringent, and the valerianate any powers as a tonic to the nervous system that it may possess. A citrate of iron and bismuth is sometimes useful.

Besides these, there are many private preparations, as of bismuth and pepsin, bismuth and strychnine, etc.

A glycerole of the neutral nitrate is best prepared by dissolving ½ oz. of the crystallised salt in 2 dr. of pure glycerine and an equal quantity of distilled water, afterwards adding glycerine to 6 oz. *Unguentum bismuthi* may be prepared with ½ to 1 dr. of any bismuth salt in 1 oz. of cold cream (not benzoated). An *oleate* is made with oleic acid and the oxide in strengths of from 10 to 20 per cent. A lotion or injection is made with 1 part to 8 of liquid. Pessaries are made containing 15 gr. in each.

ADULTERATIONS.—Besides being variable in its chemical constitution, in the amount of oxide and of acid present, the *subnitrate* may contain added carbonate and phosphate of lime, carbonate of lead, subchloride of bismuth, and other metals introduced in the process of manufacture, also certain natural impurities not removed, *e.g.*, traces of iron, copper, silver, and arsenic: the last is the most important. In the older preparations it was probably always present, and so long ago as 1743, Geoffrey expressed his fear of bad results from it (Materia Medica). In later times, Dr. Taylor found it in three out of five specimens; and Mr. Edin found it in many specimens of liquor bismuthi when it was first introduced (Pharm. Journ., 1868).

The practical bearing of such adulteration was illustrated in a trial for arsenical poisoning at Philadelphia. It was proved that bismuth "nitrate" had been prescribed shortly before death: a specimen of the particular salt dispensed could not be found, but of ten others purchased in the city, a majority contained arsenic, and although the irritant symptoms had commenced before bismuth was prescribed, and the proportion of arsenic found in the viscera was much more than bismuth adulteration would account for, yet the trial was stopped, and the accused person discharged (Amer. Med. Journ., 1858).

At the present time, however, adulteration with arsenic is exceptional. Of six chance specimens examined under the direction of Dr. Anstie, not one contained it (Pract., 1871); and Prof. Siebold, after much experience, reports that it is now rarely found (Pharm. Journ., 1875). Of seven samples of the basic nitrate of the American codex, one only contained arsenic—·33 per cent.

In the oxide he often found traces of sodium and lead, and commonly subchloride and subnitrate.

Selenium and *tellurium* have been found in some specimens of bismuth salts, and a Colorado ore of the metal has been found to contain 34 per cent. of tellurium. This would explain the offensive alliaceous odour which is sometimes given to the breath by special samples of bismuth preparations. In 1824, Gmelin noticed the peculiar odour of the breath caused by taking tellurium. Hansen found that, in a few minutes after the first dose, the garlic odour was perceptible, and it became so strong that he had to exclude himself from society. The odour persisted for eight days after the last dose (Liebig's Annalen, 1853). Reissert took 5 milligrms. of tellurous oxide (TiO_2) three times in one day. Fifteen minutes after the first dose the breath had a strong garlic odour, and in one hour a metallic taste was observed; the urine, sweat, and fæces had the same odour. The metallic taste lasted 72 hours, the odour in the urine lasted 382 hours, in the sweat 452 hours, and in the fæces 79 days, and in the breath 237 days. He calculates that $\frac{1}{166000}$ gr. of tellurium is enough to impart the peculiar odour to the breath (Pharm. Journ., May, 1884). Sir James Simpson also made trial of the drug, and Dr. Maclagan relates that on one occasion a student took a dose which obliged him to sit apart from the class for the rest of a session! (Edin. Med. Journ., 1854). Further confirmatory evidence is given by Ekin. The nature of the odorous compound is not known (Pharm. Journ., 1875). Hansen thinks it must be a volatile organic substance formed in the body.

The *carbonate* of bismuth is liable to contain chlorides, also sodium, and sometimes lead. In five specimens examined by Prescott no arsenic was found (Pharm. Journ.). The Pharmacopœia directs that bismuth and its preparations should yield no evidence of arsenium by Marsh's test; no blue coloration with ammonia, showing the absence of copper; no precipitate on filtering and saturating the ammoniacal filtrate with nitric acid, showing the absence of tin and cadmium; no red or black precipitate with sulphite of sodium, showing the absence of selenium and tellurium; and no blue precipitate with ferro-cyanide of potassium, showing the absence of iron.

CADMIUM (Cd = 112).

This is a somewhat rare metal, found associated with zinc in nearly all its ores, and obtained from these by distillation.

CHARACTERS AND TESTS.—Tin-white and lustrous, fibrous in fracture, ductile and malleable, of specific gravity 8·6. In air, at ordinary temperatures, it tarnishes gradually; heated strongly it takes fire, forming a brown oxide, CdO; at 176° F. it becomes very brittle, and fuses at 442° F. Treated with dilute mineral acids, it sets free hydrogen and forms a colourless solution; this when further diluted, gives with sulphuretted hydrogen a bright yellow precipitate of cadmium sulphide (CdS), insoluble in ammonium sulphide. Caustic alkalies and their carbonates give with cadmium salts gelatinous white precipitates, which except in the case of ammonia, are insoluble in excess. Zinc precipitates metallic cadmium.

CADMII IODIDUM—IODIDE OF CADMIUM (CdI_2 = 366)

(*non-off.*).

PREPARATION.—It is prepared by the direct combination of the metal with iodine in the presence of water.

CHARACTERS AND TESTS.—Occurs in flat, micaceous white crystals, of pearly lustre, which melt at 600° F. into an amber-coloured fluid; they are anhydrous, permanent in air, but decompose at a dull-red heat, with evolution of iodine in vapour. In water and spirit they are freely soluble, the solution being acid to test paper, and answering to the tests for cadmium already mentioned.

The Sulphate of Cadmium is official in the United States. It occurs in oblique rhombic prisms, translucent and colourless like those of zinc sulphate; it has an acid, astringent taste, effloresces on exposure, and dissolves readily in water.

The Bromide of Cadmium resembles the analogous salt of ammonium, and has been taken by mistake for it; it is used in photography.

ABSORPTION AND ELIMINATION.—Cadmium salts coagulate and combine with albumen, but these albuminates dissolve in an excess of the salt, especially in excess of a double salt, such as the chloride of cadmium and sodium; even in

alkaline chlorides they are partially soluble, so that we can readily understand their absorption from the stomach. Absorption occurs also after their injection into the cellular tissue, the bowel, etc., as evidenced by the finding of cadmium compounds in the organs and secretions (Marmé, Schmidt's Jahrb., iii., 1867).

Elimination of the drug begins soon after its administration, and takes place mainly by the kidneys.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Cadmium compounds, except the sulphide, resemble each other in action. The sulphide, though considered poisonous by Van Hasselt, has been given to animals in drachm doses daily for a week without evident effect, and is therefore pronounced inert by Marmé. The oxide, chloride, sulphate, iodide, etc., given in doses of $\frac{1}{2}$ to 2 gr., cause pain at the epigastrium, vomiting and purging, and in somewhat larger doses gastro-enteritis, which may may pass on to ulceration. Similar effects follow their hypodermic injection, and after toxic doses given in this manner, the gastro-intestinal mucous membrane has been found inflamed; irritation and suppuration also occur at the site of injection. The continued administration of small doses induces a chronic form of poisoning marked by dyspepsia and emaciation, which in animals has terminated in death from exhaustion. In the case of two women who took by accident a quantity of bromide of cadmium (not less than 5, or more than 16 gr.) a pungent taste and sensations in the mouth and throat were felt, and burning pain at the epigastrium, vomiting and purging set in and continued for five hours, and after recovery the stomach remained very irritable (Boston Med. Surg. Journ., 1876). In a man who took 9 gr. of a cadmium salt, salivation, colic and catharsis followed in the course of an hour, and four hours afterwards violent vomiting, gastralgia, and tenesmus (Burdach). In a dog, death has followed the injection of $\frac{1}{6}$ to $\frac{1}{3}$ gr. into a vein, or the giving of 5 to 9 gr. by the mouth.

Nervous and Circulatory Systems.—Foret has described in cases of poisoning by cadmium carbonate, besides the symptoms of gastric irritation—giddiness, prostration, loss of consciousness, cramp, and slowing of the heart and of respiration. In the ladies above mentioned, somnolence was marked after subsidence of the irritant symptoms.

SYNERGISTS.—Salts of zinc and lead.

ANTIDOTES.—In acute poisoning by cadmium salts, the alkaline carbonates with albumen (white of egg) are the best antidotes. In Marmé's experiments, injections of dilute soda solutions into the stomach soon after the exhibition of the poison, quite prevented bad effects.

THERAPEUTICAL ACTION.—*External.*—The iodide is used in the form of ointment in glandular scrofulosis, and has been recommended by Guibert and Garrod; other physicians have prescribed it in splenic enlargement and in strumous skin disease (Waring). I have used it repeatedly in cases of enlarged glands, of nodes, and of chronic joint-inflammation, with satisfactory results. It does not stain the skin, like iodide of lead, but is liable to cause irritation unless diluted. The oleate of cadmium is said to be a good form, and to act well as a local gland-stimulant.

In **Ophthalmic Surgery,** cadmium sulphate has been used as an astringent in the form of lotion or ointment for inflammation of the eye, and for corneal opacities (V. Gräfe, Middlemore).

THERAPEUTICAL ACTION.—*Internal.*—The sulphate of cadmium has been recommended in syphilis, rheumatism and gout (Grimaud), but there is, at present, little evidence of its special powers.

Gonorrhœa—Leucorrhœa.—In these maladies injections of sulphate of cadmium have been used by Lincke, but possess no evident advantage over injections of sulphate of zinc.

PREPARATIONS AND DOSE.—*Unguentum cadmii iodidi* (contains 62 gr. in 1 oz. of simple ointment). *Cadmii sulphas:* dose, $\frac{1}{12}$ to $\frac{1}{2}$ gr.; for *collyrium*, $\frac{1}{2}$ to 4 gr. in 1 oz. of rose-water (Fronmüller); for *ointment*, 4 gr. in 1 oz. of lard; for *injection*, 2 gr. in 1 oz. of water; these formulæ seem somewhat inconsistent with Bouchardat's statement that the salt is ten times as powerful as the sulphate of zinc.

CALCIUM—LIME (Ca = 40).

Calcium is a greyish-white metal: as a carbonate it occurs naturally in chalk, marble, etc.; as a sulphate in gypsum; as phosphate and carbonate in shells, bones, and various organic tissues; and as silicate and fluoride in various minerals and vegetables. When heated, it becomes quickly oxidised and con-

verted into *lime*—calx : when set fire to, it burns with a bright light.

CALX—LIME—QUICK-LIME (CaO = 56).

PREPARATION.—Lime is commonly prepared from its carbonate (marble or limestone) by heating it to full redness,—to drive off the carbonic acid.

CHARACTERS AND TESTS.—A greyish-white solid, of specific gravity 3·18, and of alkaline, caustic taste. When water is poured on it to the amount of about three-fourths of its weight, it swells up, evolving great heat (up to 500° F.), and falls into a soft, white powder, in which the oxide is combined with one molecule of water (hydrate of calcium); the process is called "slaking."

CALCII HYDRAS—SLAKED LIME ($Ca(HO)_2$ = 74).

PREPARATION.—It is prepared from quick-lime as already described.

CHARACTERS AND TESTS.—The hydrate of lime, though it can absorb 31 per cent. of its weight of water, remains perfectly *dry*, and is itself very sparingly soluble in water (1 part in 730 of cold, but only in 1300 of boiling water); at 32° F. twice as much lime is dissolved as at 212° F. At ordinary temperatures water dissolves only about ½ gr. to the ounce, but its solvent power is increased by sugar or by glycerine to the extent of nearly 8 gr. to the ounce. Lime does not melt at the highest temperature, and hence its use for the electric and oxyhydrogen lights. Its specific gravity is 2·078.

The chief test for lime is the white precipitate formed with oxalate of ammonium, insoluble in acetic acid, but soluble in hydrochloric or nitric acid. Lime readily absorbs carbonic acid, the presence of which is detected by effervescence with other acids.

The Liquor Calcis of the Pharmacopœia is a solution in water containing about ½ gr. of hydrate of lime to the ounce, (that being its point of saturation). It is prepared by digesting slaked lime in eighty times its weight of cold water for some hours, and is a colourless liquid when recently made, but on exposure to air, or if breathed into, an insoluble carbonate readily forms and is precipitated. If warmed, the liquor calcis becomes

turbid from deposition of some of the lime. It forms an ingredient in the black and the yellow "mercurial wash."

Liquor Calcis Saccharatus.—Saccharated lime-water is prepared by mixing slaked lime with twice its weight of sugar, and digesting in water for a few hours; it becomes yellowish by keeping; its taste is more caustic and unpleasant than that of the simple liquor; it contains 7·11 gr. of lime (CaO) per ounce.

Linimentum Calcis is an emulsion or soap formed with equal parts of lime-water and olive oil.

CALCII CARBONAS—CARBONATE OF CALCIUM

($CaCO_3 = 100$.).

Four forms are official: (1) *Marmor Album* or white marble; (2) *Creta*—chalk—the native, friable, and impure carbonate; (3) *Creta præparata*—prepared chalk—the same substance well washed or "elutriated," after being reduced to fine powder; and (4) *Calcii carbonas præcipitata*—precipitated carbonate of calcium.

1. *Ordinary chalk* and *marble* are used only to produce carbonic acid gas.

2. *Prepared chalk* occurs either in white powder or in small conical masses. The process of "elutriation" consists in treating the powder with a large quantity of water, allowing it to stand for a time, decanting from heavy particles, and allowing the milky liquid to gradually deposit—this form is used in mistura cretæ, pulvis cretæ aromaticus, pulvis cretæ aromaticus cum opio, and in hydrargyrum cum creta.

3. *Precipitated carbonate of calcium* is prepared by mixing a solution of carbonate of sodium in excess, with solution of chloride of calcium. Carbonate of calcium and chloride of sodium are formed, and the precipitate is washed until all the latter salt is removed. This preparation being crystalline and somewhat gritty, constitutes an ingredient of tooth powders, but is not otherwise used except in bismuth lozenges.

CALCII CHLORIDUM—CHLORIDE OF CALCIUM

($CaCl_2\,2H_2O = 147$).

PREPARATION.—It is prepared by neutralising hydrochloric acid with chalk or white marble, and adding to the solution a little chlorinated

lime and slaked lime. In the first process carbonic acid is evolved and chloride of calcium formed: $2HCl + CaCO_3 = CaCl_2 + CO_2 + H_2O$.

In the second process the added lime frees the solution from iron and magnesia; it should then be filtered and evaporated to dryness at a temperature of 400° F. If the solution be simply evaporated, the chloride is left combined with water of crystallisation, $CaCl_26(H_2O)$, when dried it still retains two molecules of water ($CaCl_22H_2O$), and it is only at a heat sufficient to fuse the mass that it parts with all its water.

CHARACTERS AND TESTS.—This salt has a great absorbent power for water, is deliquescent and very soluble; it occurs in whitish agglutinated masses of bitter, acrid, saline taste. It must be distinguished from *calx chlorinata* (chlorinated lime), and does not, like that compound, evolve chlorine on addition of hydrochloric acid.

Liquor Calcii Chloridi contains 1 part of chloride of calcium in 5 parts of water. Its specific gravity is 1·145.

CALX CHLORINATA—CHLORINATED LIME.

PREPARATION.—It is prepared by saturating slaked lime with chlorine gas.—$CaH_2O_2 + 2Cl = H_2O + CaOCl_2$—but as to its exact constitution there is still some difference of opinion. Many chemists, following Ballard, consider it to be a mixture of chloride and hypochlorite of calcium, which would correspond to the above formula *doubled*; thus, $2CaOCl_2 = CaCl_2 + CaCl_2O_2$, and this, with the addition of two molecules of water, is the formula adopted by Garrod.

CHARACTERS AND TESTS.—It occurs in whitish powder or lumps having the odour of chlorine, and an acrid, caustic taste; if it contain much chloride of calcium it will be moist. It is unstable in composition, readily giving off chlorine when exposed to the air, and being decomposed by any acid. When pure it is wholly soluble in water, but it generally contains some free hydrate, and is only partially soluble. It has powerful deodorant, disinfectant and bleaching properties, which depend on the presence of chlorine, and the test of its value is directed to estimating the amount of this gas (chlorimetry). Thus, by adding hydrochloric acid to chlorinated lime, chlorine gas is liberated, and this being brought into contact with iodide of potassium sets free an equivalent amount of iodine, which is estimated by hyposulphite of sodium.

Liquor Calcis Chlorinatæ—Solution of Chlorinated Lime—contains about 2 to 3 per cent. of available chlorine.

Vapor Chlori—Chlorine Inhalation.—Prepared by moistening 2 oz. of chlorinated lime with cold water in a suitable apparatus.

Liquor Calcis iodinatæ (*non-off.*).—This is a non-irritant form of administering *iodine*.

CALCII PHOSPHAS—PHOSPHATE OF CALCIUM.

It is official in two forms: (1) *os ustum*—bone-ash; (2) *pure tribasic phosphate* ($Ca_3(PO_4)_2$).

PREPARATION.—(1) *Os Ustum.*—When bones are calcined in *close* vessels, the residue consists of earthy salts mixed with charcoal (carbo animalis): but when calcined in *open* vessels, all animal and carbonaceous matter is burnt off, and the white friable residue consists mainly of phosphate and carbonate of lime (bone-earth, bone-ash). This, when treated with hydrochloric acid, and afterwards with ammonia, is changed into (2) *tribasic* (or *tricalcic*) *phosphate*, $Ca_32(PO_4)$, which is washed and dried at 212°, and forms a crystalline white powder, insoluble in water, soluble in acids.

This form is the one most commonly found in nature, sometimes almost pure (phosphorite) or in friable masses, resembling chalk (osteoliths), or in the fossil fæces of ancient saurians (coprolites), in shells and sedimentary earths. From the soil it is absorbed by plants, by the help of water and carbonic acid, and is contained in *seeds*. From plants it is received by herbivorous animals, and in *their* flesh and blood and bone it is sought by the carnivora. It has been said that the amount of phosphate of lime found in different animals is proportionate to the *activity of their movements* (Dusart and Blache). (The salt was obtained formerly for medical use from the excrement of dogs when hard and white, as it is passed after they have eaten many *bones;* it was known as "album græcum.")

Besides the tribasic phosphate there are two others, a *neutral* and an *acid phosphate*. The former, $Ca_2H_22(PO_4)$, is a white, crystalline powder, tasteless and insoluble; it occurs in some (carbonated) mineral waters, and may be prepared by mixing neutral phosphate of sodium with chloride of calcium. The *acid phosphate*, $CaH_42(PO_4)$, is very soluble and even deliquescent, and is left in solution when sulphate of calcium is precipitated after treating bone-ash with sulphuric acid.

Calcii Sulphas—Sulphate of Calcium.—This is the native sulphate ($CaSO,4H_2O$) rendered nearly anhydrous by heat; it is used in the preparation of calx sulphurata.

Calx Sulphurata—Sulphurated Lime.—This mixture which is often spoken of as sulphide of calcium, should contain not less than 50 per cent. of sulphide (CaS). The remainder consists of calcium sulphate.

PREPARATION.—It is prepared by calcining sulphate of calcium with wood charcoal when part of the sulphate is reduced to sulphide. It must be kept in a stoppered bottle.

CHARACTERS AND TESTS.—It is a nearly white powder with a smell resembling that of sulphuretted hydrogen. If 8 gr. be added to a cold solution of 14 gr. of copper sulphate in 1 oz. of water, a little hydrochloric acid added, and the mixture then well stirred and heated to a temperature approaching that of ebullition until all action has ceased, the filtered liquid should give no red colour with ferrocyanide of potassium.

CALCII HYPOPHOSPHIS—HYPOPHOSPHITE OF CALCIUM

($Ca(PH_2O_2)_2 = 170$).

PREPARATION.—It is obtained by heating phosphorus with hydrate of calcium until all phosphuretted hydrogen ceases to be evolved, then filtering the liquid, removing the uncombined lime with carbonic acid, and evaporating the remaining solution to dryness.

CHARACTERS AND TESTS.—A white crystalline salt with a pearly lustre and a bitter nauseous taste; soluble in water; insoluble in cold alcohol. Heated to redness it ignites, evolving phosphuretted hydrogen which is spontaneously inflammable.

Bromide of Calcium (*non-off.*).—Is a white, granular, deliquescent odourless salt, with a pungent, saline bitter taste, and a neutral reaction. (It is sometimes used instead of potassium bromide, and is said not to be so depressant in its action as that salt.)

ABSORPTION AND ELIMINATION.—The various salts of calcium differ somewhat as to their absorption and their action. The *tribasic* and *neutral phosphates*, in small doses (less than 5 or 6 gr.), with but little water, are wholly absorbed under the influence of the acid gastric secretion; but if given with much water, the acids are so far diluted that they do not act upon the insoluble drug, and it passes off mainly by the fæces. If large doses be given, the greater part passes out unchanged.

Gouriet has suggested that the solubility necessary for

securing the absorption of calcium phosphate is effected partly by means of the phosphate of sodium contained in the saliva, partly by the phosphate of ammonium and the acids in the stomach juice; when it has passed into the veins, solubility is still further assisted by the carbonic acid present in venous blood. During respiratory interchange of gases, when carbonic acid is given off and lactic and other acids altered, the phosphate that has been taken is only retained in solution by the help of the normal alkaline phosphates of the blood: if these be in small proportion the calcium salts become soon deposited (more in bone than in other tissues), and little passes in the urine: if, however, in any given case the alkaline phosphates be in excess, then most of the calcium salt is retained in solution in the blood until it is (mainly) excreted through the kidneys (Lancet, ii., 1860). This explanation seems rather too chemical, and it must be compared with the important observations more recently made by Paquelin and Jolly. They conclude that the tribasic phosphate of calcium is not acted upon in the stomach, unless it be by part becoming super-phosphate, and this again is precipitated in the intestine under the influence of alkaline biliary and pancreatic secretions, as *insoluble phosphate;* it is not capable of absorption, except in very small quantities; the circulation conveys very little, and the tissues, except bones, contain only traces; the bile has rather more. A certain amount of lime must enter the system from the food, and does so mostly as carbonate, which becomes changed and prepared for absorption by contact with alkaline phosphates and gastric acids, but phosphates given experimentally are eliminated almost entirely unchanged, only some of the acid being absorbed. Hence they conclude that the *addition* of such compounds to the food is rather an *obstacle to nutrition*, and that even the soluble acid preparations (lacto-phosphates, etc.) act only as acid principles, and pass out of the system as phosphates of another base. The calcium phosphate contained in urine and phosphatic calculi, even when primary, is said to be almost entirely formed within the bladder. These views, as they are not quite in accordance with commonly received clinical evidence, seem to require confirmation, but they suggest *moderate* expectation of cure by calcium salts.

The bicarbonate, as occurring in Carrara water, is soluble by

virtue of the excess of carbonic acid, and readily absorbed. *The neutral carbonate*, in small doses (5 or 6 gr.), is soluble in the gastric juice, and is absorbed as a *chloride*. The *chloride* itself in similar doses, and diluted sufficiently to disguise its caustic taste (as with 3 oz. of sugared water), becomes absorbed without gastric disturbance; but larger doses are apt to cause a sense of oppression, with nausea and diarrhœa. Unduly large doses of lime-water, or of phosphates or carbonates, may also cause gastro-intestinal irritation.

Of that which is absorbed an equivalent quantity is eliminated, except during the period of growth, and especially of bone-development. There seems to be a power of laying-by some of the substance for this purpose, for, *e.g.*, during the early months of pregnancy, bony growths (osteophytes) sometimes form in the bone of the parent, which diminish with the growth of the fœtus. The excreted calcium is found in the urine as acid phosphate, and in many other secretions such as the pancreatic juice; some may be detected in plastic exudations; sometimes it forms calculi. It is often deposited in tumours, fatty, fibrous, and sarcomatous, and in old inflammatory exudations, as in tubercle of the lung and strumous glands.

Some recent researches by Hoppe Seyler show that the elimination of lime salts is much augmented during prolonged rest in bed, although after a time it becomes again of average normal amount: it is increased also under mercurial treatment, diminished during febrile maladies (Rev. Sci. Med., 1891); about 45 gr. are daily eliminated by an adult man.

PHYSIOLOGICAL ACTION.—*External.*—Lime unslaked, or "quick," decomposes and destroys organic matter, and is used sometimes as a caustic, more often as a disinfectant, *e.g.*, in dissecting-rooms and in grave-yards; its affinity for water, and its ready combination with sulphur (as in sulphuretted hydrogen), will explain its good effects. It is used by tanners to remove the hair from hides, and by farmers as a fertilising agent. Its action upon the living skin is irritant and to some extent caustic, but as it has less "diffusion power," is more superficial and more limited than that of the alkalies proper,—potash and soda. On the mucous membranes however, its effects may be very severe, as when by accident it enters the eye,

or when too strong a solution of it, or of its haloid salts, is taken into the mouth. Local inflammation and ulceration may follow, and even a fatal result be produced when the stomach is affected.

Weak solutions or the neutral salts, carbonate and phosphate, in powder, have a local astringent and sedative effect. The "lime-water" of the Pharmacopœia is not strong enough to be caustic but controls secretion especially from mucous membranes, and renders any tissues pale and dry.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Lime-water and calcium carbonate, when taken internally in moderate doses, produce similar local astringent and sedative effects, and act also as absorbents and antacids. The phosphate is astringent to some extent, but the sulphate may alternately confine and relax the bowels, according as astringent or irritant effects are produced.

Circulatory System.—No effect upon this system is commonly traced to calcium compounds, but full doses of the chloride are said to produce sometimes the symptoms of a "muscular poison" like potash, with lowering of temperature, slowing of pulse and arrest of heart-action (Comptes Rendus, Fev., 1873).

Dr. Ringer has found that calcium salts play an important part in the circulation and in most of the other functions of the body; the heart, or any other muscle deprived of calcium will no longer contract. In the case of the frog's heart, this fact can be illustrated by the following experiment: by means of a perfusion-cannula, normal saline solution (*i.e.*, 0·6 sodium chloride) can be passed through the heart, which gets gradually weaker and weaker, and finally stops in a state of systole, but resumes activity when a trace of calcium salt is added to the saline mixture; the beat becomes perfectly normal and will continue for many hours after the further addition of a trace of a potassium salt. This saline fluid will, in fact, keep the heart alive as long as one containing blood (B. M. J., i., 1885).

Fishes immersed in distilled water soon die; in tap water they live a long time, but they live almost equally well in distilled water to which a trace of calcium chloride is added (Journ. Physiol., vi.). Blake had previously shown that calcium, barium and strontium exerted a similar action (Pract., 1884).

Dr. Ringer has written also on the coagulating power of calcium salts (Journ. Physiol., 1892) and 1 per cent. of the chloride is added to complete the preparation of the "fibrinogen styptic" which has remarkable power of arresting hæmorrhage (Lancet, i., 1893).

Nutrition.—The most interesting point in the physiological action of calcium salts is their influence on nutrition, the necessity of phosphate for healthy growth whether vegetable or animal, being especially evident. Experiments with plants have shown that the phosphates are in close relation with the nitrogenous elements. If for instance, the nitrogenous husk or coating of a seed be removed, the phosphates are removed with it, and in the starchy part of the grain none are found. In the leaves they occur in the parenchyma, not in the nervules, and generally are most abundant in the cellular parts of vegetables wherein nutrition and reproduction are most active (Liebig). Wheat planted in earth containing phosphates, germinates and thrives, but if all phosphate of calcium be removed, it germinates indeed, but soon dies. Peas (which contain a larger proportion of azotised matter), when similarly treated, germinate and even bear a crop, but if this crop be sown in a soil without phosphates, it does not flower (Ville, Conférences, Paris, 1865). That the improvement in nutrition is not due to the presence or absence of *phosphorus* as such, but to phosphate of lime, is shown by experiments on birds. Wheat contains a large quantity of *phosphate of potassium*, and when pigeons are fed upon this alone and are prevented from getting any carbonate or other salts of calcium, they waste away, and their bones become weak and brittle. If on the other hand, they can obtain lime in any form, it becomes changed into a chloride during digestion, and combining with the alkaline phosphates of wheat, provides them with calcium phosphates and secures or favours their due nutrition (Chossat).

There is also evidence that calcium phosphates serve especially to nourish cartilage, bone, tendon and muscle, so that they have been fairly called "restorative or analeptic tonics" to the *locomotor* organs, as iron is to the blood, or phosphorus to the nerve-tissue. Thus, as the result of observations on the reproduction of the shell in crabs, Schmidt found that a combination of

phosphate of calcium and albuminous material was most favourable for the formation of osteoid cells; phosphate was required for the first growth, though carbonate was formed later. Mr. Bridgman noted the formation of "artificial cartilage" by the passage of an electrical current through a viscous solution of carbonate of calcium (Hughes Bennett, Lancet, i., 1863). Beneke found that phosphate of calcium was specially abundant in plastic exudations and wherever new growth was going on, and he adopted the microscope as a ready means of its detection—for if a drop of sulphuric acid be added to the liquid, crystals of calcium sulphate are very quickly formed (Lancet, i., 1851). The organism can assimilate phosphate of calcium either in the soluble acid form (for the liquids and soft tissues), or to some extent in the basic insoluble form (for the skeleton); but its effects are produced slowly, and without the evident stimulation which we associate with the action of wine, iron, or quinine, so that we describe such calcium compounds rather as restoratives than as general tonics and as *modifying* rather than *stimulating* nutrition.

Besides their effect on ossification, etc., M. Mouriès a distinguished chemist, has described a special effect of calcium salts upon "irritability," or vital organic changes, so that if these salts are *absent*, assimilation and nutrition do not go on and emaciation and death ensue, whilst if they are simply *deficient*, various degrees of lymphatic and osseous disease are produced. He has calculated especially that the food of those who live in towns is deficient in these principles, and that whilst every one ought to have at least 90 gr. daily, many, women especially, receive only about half that quantity; hence a secretion of poor milk and consequent weakly children, and he claims that by the use of a certain food containing calcium phosphate with albumen, the proportion of still-born and of rachitic children in many families has been markedly reduced (quoted by Trousseau).

Any difference in the amount of urea and carbonic acid excreted under the influence of phosphate of calcium, is not exactly ascertained. The chloride of calcium is said to increase the amount of urine (Giacomini); and it is probable that like other chlorides it increases the excretion of urea (Rabuteau). Drs. Chittenden and Ely have shown that a small percentage of

calcium phosphate increases the diastatic action of saliva (Pharm. Journ., 1883).

Lime in Potable Waters.—Waters that do not contain calcium are flat and insipid, whilst a proportion of from 7 to even 20 gr. of carbonate in the gallon is compatible with their being good, wholesome and pleasant (Parkes); such waters may be rendered sufficiently "soft" by boiling. Hardness dependent upon a soluble bicarbonate of calcium is best treated by Clark's process of adding slaked lime, which precipitates an insoluble carbonate.

Calcium sulphate is contained in water from selenitic rocks, and a proportion of from 6 to 21 gr. per gallon must be considered unwholesome; it is liable to irritate the bowels, causing alternately diarrhœa and constipation, as was verified especially in some prisons and hospitals of Paris, by Parent Duchatelet; such water is not much softened by boiling.

Nitrate of calcium is sometimes found in drinking water, being derived probably from organic sources; it is likely to cause diarrhœa.

Water from *magnesian limestone*, containing magnesia with some carbonate, and 4 to 12 gr. per gallon of *sulphate* of calcium, has been considered specially likely to cause *goître;* but professional opinion, though still divided on this question, is now more inclined to the negative view.

Dr. McClelland (in an able report on the medical topography of Bengal) certainly gave remarkable instances from many villages scattered over a large district where the inhabitants, though living close together, were affected with goître or not, according as to whether they drank or not of certain wells, to which they were restricted according to caste; and he found that the wells used by goîtrous persons contained up to 25 per cent. *carbonate* of calcium (Brit. and For. Rev., 1861: Watson's Practice of Physic); the presence of magnesia is not mentioned. Dr. Inglis in his treatise on the subject, Dr. Coindet of Geneva, and other authorities have agreed in blaming lime-waters mainly for the production of goître, and its greater prevalence along ranges of lime-rock, as in Nottinghamshire, Derbyshire, and parts of South America, is quoted in favour of the same view. Some connection has been further traced between this cause and *cretinism*, as well as goître; and Kölliker and others maintain,

not without the support of post-mortem evidence, that by the habitual use of such lime compounds ossification is increased at *the base of the skull*, so that the cranial foramina become narrowed, and the supply of blood to the brain lessened. On the other hand, Dr. Mitchell has published a careful report upon the "Nithsdale neck," prevalent in that part of the south of Scotland, and has shown that some other element than the water must be concerned. It is true that many of the wells used contained from 4 to 14 gr. of carbonate in the gallon (with magnesia), but that limit is compatible with health, and several wells in the same district contained the same quantity, and even to 24 gr., without the production of any goître (Brit. and For. Rev., April, 1862).

SYNERGISTS.—Alkaline and earthy bases have a similar absorbent action to that of the *carbonate of calcium*, and reconstituents generally, such as iron and cod-liver oil are adjuvants to the calcium phosphates; aromatics also are often well combined.

ANTAGONISTS AND INCOMPATIBLES.—Mineral acids, laxatives and irritants either decompose or neutralise the action of lime compounds, with the exception of *phosphoric acid*, which is sometimes used with the acid phosphate to render it more soluble.

Saccharated lime is said to be a specially good antidote to *carbolic acid*, and the following is Ferraud's formula: ℞. Sugar 15 parts, water 40 parts; dissolve, and mix thoroughly with quick-lime 5 parts (Lancet, i., 1876). *Hypochlorite* of *calcium* is an antidote for sulphuretted hydrogen.

THERAPEUTICAL ACTION.—*External.*—**Epithelioma.**—A mixture of quick-lime (2 parts) and caustic potash (1 part) is sometimes a useful escharotic for superficial forms of epithelial cancer; it should be mixed just before using, with sufficient alcohol to form a paste ("Vienna paste"), and spread over a suitable aperture in diachylon plaster previously placed on the part; its action begins immediately and lasts for about half an hour; the eschar is dark-coloured, and separates in from ten to twelve days. A proportion of 6 parts of lime to 5 of potash is recommended by some authors, and for application to deeper-seated parts, such as the neck of the uterus, a combination of 1 part of lime with 2 of potash is used, especially by French

surgeons ("caustique Filhos"); it is fused by heat, and poured into a small mould of lead, which can be cut away as the caustic is required.

Chronic Tonsillitis.—A mixture of equal parts of lime and caustic soda has been recommended under the name of "London paste" for occasional application to chronic conditions of enlarged tonsil (Mackenzie), but has not come into general use.

Onychia.—Prof. Vanzetti has recommended the application of caustic lime in preference to nitrate of lead for onychia maligna, and has reported two successful cases, in one of which the application was renewed several times, and in the other it was left in continuous contact (Pract., vol. xiii.).

As a **Depilatory** to remove superfluous hair, lime is sometimes used with arsenic (as in the Turkish "Rusma"), or in the form of a hydrated sulphide, prepared by passing hydrogen through a mixture containing 2 parts of lime with 3 parts of water: when saturated with the gas this forms a greenish jelly, which is spread upon the part for a few minutes, and then removed with an ivory knife (Trousseau).

As a **Moxa,** or to produce an issue, a fragment of lime may be slaked on the skin by adding to it a few drops of water; much heat is produced, and the neighbouring skin requires to be protected.

As a **Vapour Bath,** a piece of unslaked lime half the size of a man's closed hand is wrapped in a moist cloth, and this again in a dry one doubled several times and fastened securely: if one of these packets be placed on either side of a patient whilst in bed, the moist heat soon induces a copious perspiration lasting for one or two hours (Bull. de Thérap., 1846). Dr. Hassall has recommended this as a ready means of establishing reaction in cholera, and others have used it in tetanus.

Hay Fever.—In this malady the vapour evolved from chlorinated lime has been found serviceable, when the air of the patient's house is impregnated with it as far as possible; the solution should be used as a wash to the face and hands. It acts by destroying the activity of the pollen grains which form the source of the irritation of the mucous membrane, especially of the nose.

Croup and Diphtheria.—In the form of a warm, finely-

atomised spray, solutions of lime (1 in 30), have been much commended as chemical solvents of croupous membrane. Förster, Biermer and others have shown that such membranes, and especially their fibrinous constituents, are soluble in lime-water (Archiv der Heilkunde, v.), but doubts have been expressed whether such an effect can be usefully and practically obtained in the living body. Biermer treated a true case of membranous croup (verified by expulsion of membrane) by means of a warm lime-spray, and although the patient was in great peril, he obtained relief and finally recovered;—this physician however, generally gave calomel at the same time (Brit. For. Rev., 1865). Kuchenmeister has recorded several good cases treated successfully by the spray (Bull. Gén., 1865), and the experience of Steiner proved that diphtheritic layers on the fauces were dissolved by it in a marked manner: subsequently, however, the growths formed again, and could not be controlled by the remedy (Jahrb. für Kinderheilk., 1870). Beigel has reported good results with it in croup, and Geiger in diphtheria (Pract., i.); but Senator has more recently written against its employment, even from a theoretical point of view, and doubts its power of dissolving membranes "in situ." Gottstein and others consider the direct application of lime-water to the larynx by means of a brush to be more advantageous than the spray, and Albers in desperate cases has injected the solution into the larynx from below, passing his syringe between the tracheal rings: cough was caused, and shreds of membrane were ejected (Berlin klin. Woch., 1869). Mackenzie found it useful "when the false membrane is not very thick." The experience of the profession is not yet such as to enable us to decide the real value of lime-water applied locally in the treatment of these affections, but my own results have not been largely in its favour.

Lactic acid and carbonate of lithium act similarly, and even better, in dissolving croupous membranes; Kuchenmeister however, still maintains the superiority of lime-water. Sanné recommends the saccharate of lime.

Cancrum Oris—Ulcerations.—Applied in substance or in weak solution, the chloride of calcium is a valuable antiseptic and stimulant to fœtid discharging surfaces. In cancrum oris, a little of the dry powder may be applied by the finger, and

washed away immediately afterwards, and in unhealthy ulcerations about the gums in general, and in salivation, a wash may be used containing 2 dr. to the pint of water with glycerine; or ordinary lime-water may be used with nearly equal benefit.

A proportion of 1 to 10 or 15 of water has been found extremely useful applied as a compress in cases of ruptured perineum, when the torn surface is apt to discharge offensively, and in unhealthy and indolent ulcerations of any part, the same remedy or even ordinary lime-water, will diminish discharge, cleanse the surface, and promote a healthy action. Weak chloride of calcium lotions are also good in *erysipelas*.

Skin Diseases.—In pustular and erythematous skin diseases, preparations of lime are often very useful. In *chronic acne*, I have often ordered lime-water mixed with an equal part of rose-water, and applied three or four times daily with the best results. In *ecthyma*, it is commended by Mr. Wilson, and in the discharging stages of *eczema* and *impetigo* it makes a useful lotion. In *impetigo capitis*, and in *fissured nipples*, lime-water mixed with oil is good. In chronic eczematous and scrofulous disease, calcium salts are often useful when given *internally* (Tilbury Fox speaks well of "saccharated wheat phosphate" in such conditions). Cazenave thought the chloride good in lupus. Dr. Spender finds that in chronic *dermatitis* eczematous in origin, finely levigated chalk made into an ointment with lard and a little tar ointment, is most useful; in some cases a small percentage of blue ointment in addition is serviceable (Pract. i., 1883). In *carbuncles* and *boils*, a compress soaked in lime-water and covered with oiled silk, often acts beneficially; it checks inflammation, soothes pain and promotes suppuration more quickly than ordinary poultices. In *erythema* and the *pruritus* of reddened irritable skin, lime-water has a sedative, moderately constringing effect, and may be used either alone, or as a vehicle for other similar remedies. In *pruritus pudendi* it is often useful when applied freely and tepid, and in *osmidrosis* it will relieve the unpleasant secretion from the sweat-glands. Dusting powders containing precipitated carbonate of calcium are used for *erysipelas* and *erythema*, and in cases of much sebaceous secretion, especially about the face. Combined with lard as "chalk-ointment" it is often a good application for

indolent and irritable sores. In *tinea capitis* after thorough cleansing, lime-water may be brushed in, but as a rule stronger remedies are necessary: a lotion of the chloride is more satisfactory. In *scabies*, a strength of 1 oz. of chloride to 1 pint of water has been found sufficient to cure, but a more dependable preparation is made by boiling together 1 part of quick-lime and 2 of sulphur with 20 of water down to 10; this should be constantly stirred till well mixed, and the liquid poured off for use; it is too strong to be rubbed in like sulphur ointment, but should be applied lightly with a brush, and afterwards removed with a warm sponge, if necessary (Lancet, i., 1865). Pharmacists now commonly make such a preparation under the name of liquor calcis c. sulphure (*v.* Sulphur).

Burns and Scalds.—Lime-water, mixed with an equal part of linseed oil ("Carron oil") or better, of olive oil, was long since commended by Boyle and by Velpeau as a suitable dressing for the early stages of burns in every degree, and though rather unpleasant, it has come into general use. It may be applied on carded cotton, and if the skin be unbroken, resolution of inflammation is promoted by it, whilst if suppuration occur the liniment controls it, and hastens cicatrisation. It relieves pain and inflammation in cases of wasp and other stings (Dauverne).

In severe cases of **Small-pox**, Dr. Joseph Bell recommended the same liniment to be applied to the face on cotton wool carefully arranged to cover the affected part, but leaving apertures for the eyes, nose and mouth: the wool should be fastened with another covering or with tape, so as to prevent admission of air, and by this means pitting may be prevented or decidedly lessened. An improved formula is a saturated solution of lime, made with sugar, water and glycerine, which forms a cool, drying varnish, and for burns may be well diluted with oil, or ether may be added (Pharm. Journ., Oct., 1873); the latter rather irritates.

Chronic Discharges.—In chronic mucous and purulent discharges, lotions and injections of lime-water exert a most beneficial influence, as may be observed in chronic urethritis and in leucorrhœa, syphilitic or otherwise; in the former, a combination with mercurial oxides, such as the "black or yellow wash," is still more potent, and is in daily use for all forms of syphilitic ulceration.

The profuse nasal discharge so usual in scarlatina, and also muco-purulent otorrhœa, may be well and safely treated by washing out the affected parts with a tepid injection of milk and lime-water three or four times daily: over the affected ear a compress of lime-water worn at night, is often advantageous. In chronic purulent ophthalmia a very weak lotion containing chloride of calcium is said to be effective.

Ascarides.—Rectal injection of a few ounces of lime-water several times repeated, is effectual in curing ascarides, and Dr. Price and Kuchenmeister have reported some successful instances of this treatment (Lancet, i., 1864); it has long been a favourite prescription of mine.

THERAPEUTICAL ACTION.—*Internal.*—Lime-water was formerly much esteemed as an internal medicine, and was given not only as an antacid and astringent, but also as an antiseptic, and especially as a lithontriptic or solvent of calculi. It was not unfrequently given in excess and produced irritant effects, but its use now is more restricted, and the doses given are smaller and more diluted.

Dyspepsia—Vomiting.—When digestion is accompanied with discomfort and oppression, or with acidity, pyrosis and flatulence, especially if there be a tendency to diarrhœa and to acidity of urine, lime-water and the carbonate of calcium are often more serviceable than alkalies, because they are not only antacid but astringent. I have found them especially useful in the dyspepsia of chlorotic women marked by the above symptoms, and generally by craving for acids and dislike to animal food. G. Sée advises the chloride (Internat. Journ., i., 1892). When flatulent distension affects the lower bowel, lime-water has been used in enema as absorbent of carbonic and other gases; Dr. Habershon has recommended the carbolate of calcium in such conditions (Lancet, i., 1868). For cases of acid dyspepsia, when flatulent distension is not so prominent a symptom, but when there are heartburn and pain with evidence of gastric congestion, the bicarbonate of calcium dissolved with an excess of carbonic acid in the slightly effervescent form known as Carrara water, is very useful, for it is less nauseous to some patients, and more easily tolerated than lime-water, so that more of it may be given at a time; it may be mixed with an *equal* part of milk,

whilst of lime-water not more than *one-eighth* part should be used.

For the special symptom of nausea and vomiting from irritative gastric conditions, milk and lime-water is a simple and often effective treatment; given frequently in small quantities iced, it provides digestible nourishment which is sometimes better retained than any other. It is valuable in the vomiting of pregnancy, and even in that of gastric ulcer, in which latter malady only a dessertspoonful in a wineglassful of milk should be tried at a time. The lime acts partly as a sedative to the mucous membrane, partly as an antacid, and partly mechanically by breaking up the curd of milk; hence it is particularly useful as an addition to cow's milk for children brought up by hand, only in any case where constipation is marked, soda-water may be substituted for a time.

Mr. Metcalfe Johnson has written highly of the value of hydrated *phosphate* of calcium in the sickness of pregnancy; and Dr. Leared of the chloride (½ dr. to 1 dr. liq. calcii chloridi) in sarcinous vomiting. Dr. Cleland specially recommends the saccharate as a better antacid than magnesia, and useful in dyspepsia dependent on either too little or too great secretion of gastric juice; it does not constipate like other lime compounds; it may, however, cause nausea if taken on an empty stomach (Edin. Med. Journ., 1859).

Carrara water is suitable for taking with wine at the later meals, and several other natural mineral waters containing lime are of acknowledged value in gouty and acid forms of dyspepsia generally: Seltzer contains 3 gr. of carbonate in the pint, Pyrmont 4, Kreuzbrunnen 4·13 with much carbonic acid, Wildungen 5·4 to 9·7, and Pouges (a spa between Paris and Lyons) contains as much as 12 gr., and is in great repute. Dr. Basham found such waters especially suitable for hypochondriacal, but not for anæmic cases.

Intestinal Catarrh—Diarrhœa.—Lime-water and calcium carbonate are useful in these conditions, especially if gastro-intestinal acidity be present, as it usually is in young children; the breath is then offensive, the motions frequent, loose, greenish, sour-smelling, and deficient in bile; the abdomen is distended, cramping pain occurs at intervals with drawing-up of the legs,

and there is often sickness. Restriction to milk and broth diet, with the addition of 1 or 2 gr. doses of carbonate of calcium will often cure this disorder; in the diarrhœa of dentition as well as in the more chronic forms connected with strumous or mesenteric disease, such treatment is specially indicated. (Castor oil may be required at first to remove any cause of direct irritation such as undigested food, mucus, etc., and the use of insoluble calcium salts should not be prolonged more than necessary, otherwise irritation, or some degree of obstruction may be caused.)

In *chronic diarrhœa* dependent upon a relaxed condition of the alimentary canal, and also when kept up by ulceration of the bowel, I have used lime preparations with the best possible effect. Bretonneau recommended them in enema for these cases.

In the *diarrhœa of enteric fever*, and of *tuberculosis*, milk and lime-water may prove of great, if only temporary service, but should not be used in large quantities if hæmorrhage or symptoms of acute inflammation be present. The alkaline earth is plausibly supposed to combine with the secretions of the ulcerations and to form a layer which protects the terminations of sensitive nerves against contact with the contents of the bowels. Mialhe especially applied this explanation to the phosphate of calcium, which salt has been much used in the treatment of diarrhœa and of acidity, and owing partly to its phosphoric element, is considered to exert a special restorative power: according to him, if given with bread and sugar, it becomes changed by the slight acid of the former and by the gastric acids into a soluble acid salt, which does not itself coagulate albuminous material, but when brought into contact with a small proportion of alkali, becomes converted into an insoluble basic phosphate of gelatinous character, which protects the mucous membrane, and checks diarrhœa: the nitro-phosphate is said to be especially good (Pract., v., 28).

This salt was the principal ingredient in the "white decoction" of Sydenham. The quinovate of calcium is specially commended by Kerner (*v.* Vegetable Kingdom).

Aphthous Conditions of the mouth and alimentary tract, when occurring in infants, with green but not necessarily liquid stools, may often be cured by lime-water or prepared chalk.

Bone Disease—Fractures.—Piorry furnishes evidence of the value of phosphates in osteo-malacia, or softening of the bones generally, also in spinal caries or "Pott's disease" (Gaz. des Hôp., 1856) and I have certainly seen them very beneficial in cases of caries and joint disease. Reasoning from the observation that birds with a broken limb lay eggs without shell during the process of repair, Dr. Fletcher was led to administer a mixture of calcined bone, prepared chalk, and lime-water in cases of fracture (in man), and reported several cases of very early union of long bones (Lancet, 1846). Milne Edwards made similar observation on dogs and rabbits, producing fractures as nearly as possible alike, and then finding that the animals who got calcium phosphate recovered more rapidly than the others; and M. Gosselin found the same results in men (Comptes Rendus, xiii.; Brit. For. Rev., 1856): on the other hand, it has been pointed out that in fractures of old persons, in whom the bones are brittle, calcium salts are better avoided. They have been strongly recommended during pregnancy and lactation in enfeebled mothers, both to relieve their neuralgia, debility, and dyspepsia, and also to favour the development of healthy non-rachitic children (Prakt. Arzt., 1869); and I have for years recommended their use in backward dentition, delayed power of walking, and retarded closure of the fontanelles. These are usual signs of a rachitic tendency, and in the fully-developed malady of rachitis, saccharated lime is strongly to be recommended. It is true that although parts of the bones become softened in this disease and are deficient in lime, often at the same time calcium phosphates are largely excreted in the urine, so that the fault is one rather of mal-assimilation than of actual deficiency, yet I agree with Dr. Ringer that the administration of lime, and especially of calcium phosphate, "appears to control this defective and perverse nutrition, and to induce healthy growth, so as to favour consolidation of the skeleton and improve the condition of soft parts," and that practically they are extremely valuable, though not always alone curative. He compares this use of it to that of iron in anæmia, where the fault is equally one of want of assimilation rather than of quantity. As already mentioned, the objection has been made that it is so little soluble that sufficient may be introduced

with ordinary food, and to give it in medicine rather interferes than otherwise with normal nutrition (Paquelin and Jolly); but practically we do not find it so. Considering however, the evident insolubility of ordinary tribasic phosphate, M. Dusart and others have introduced acid solutions—lacto-phosphate—which have come into vogue and are sometimes suitable, but often in rachitic children the secretions are too acid, and need rather to be neutralised by a basic earthy salt; any excess of acid would tend rather to dissolve osseous salts, and cause them to be eliminated, not deposited. It may often be better to give the ordinary salt (phosphate) recently prepared if possible, and with flour or milk, and to trust the stomach to absorb what is needed, and the surplus will pass through the intestine. The combination of calcium phosphate with sodium chloride (calcaria phosphorica salita) has been found very soluble (Sabellin, Husemann). The *sulpho-carbolates* of calcium have been specially recommended in rickets, but Dr. C. Ritchie did not find them serviceable (Med. Times, i., 1871).

There is reason to think that natural salts of calcium, such as have recently passed through *organic* structures, are preferable to such as have been deposited as *mineral*. Thus, Piorry recommended in softening of the bones and spinal curvature, fine filings of fresh bone, 1 oz., to be taken in milk or rice-milk, and found it succeed when proper light, warmth, and food had failed (Gaz. des Hôp., 1856; Med. Times, 1857).

Others have derived medicinal phosphates from the *vegetable* kingdom. Thus Dr. Hake and Dr. Tilbury Fox recommend a strong decoction of good bran to be made and evaporated, and the residue mixed with sugar; and a preparation of this kind known as "saccharated wheat phosphates" has come largely into use for mal-nutrition, rickets, etc. (Med. Times, i., 1866). It may be desirable to state again that the advantage of calcium salts in bone disease is not traced simply to chemical and physical processes, but also to direct improvement of digestion, absorption and nutrition.

Struma—Glandular Disease.—Lime-water was long since commended for the treatment of suppurating glands and of ulcerations, as well internally as locally (Shapter, Pereira). The phosphate was especially found serviceable, though not always

curative, in the different manifestations of scrofula, by Beneke (Lancet, 1851), and by Stone; whilst Dr. Beddoes collected upwards of 100 cases, including many of so-called "tabes mesenterica," benefited by the chloride, and Dr. Begbie has corroborated the good results to be obtained from doses of 10 to 20 gr. daily. He records also the subsidence of enlarged parotid and lymphatic glands under the same medicine, when iodine and cod-liver oil had failed to cure (Edin. Med. Journ., 1872). It must be stated however, that in the experience of most other observers, these latter remedies have superseded the calcium salts, and that Mr. Benjamin Phillips and other writers on scrofula have expressed themselves much less favourably concerning them. Dr. Sinclair Coghill and others have however recorded further observations in favour of the chloride (Pract., 1877, 1885, and 1886). In one very chronic case with many glands affected, this salt, commenced in 10 gr. doses and gradually increased up to 40 grs. and continued for twelve months, had a distinctly good effect in lessening the size of glands, etc. Dr. Crighton found it effective even when suppuration had occurred—and this is reasonable, though not commonly accepted: he refers to cases of scrofulous caries and of tabes mesenterica, and found the crystallised salt better than the anhydrous.

Of late years, a mineral water in the West Indies has obtained great repute in the treatment of glandular enlargements, and has been found to contain calcium chloride, though in small proportions: the Bridge of Allan waters also contain it. I have myself given it a fair trial in 1 to 5 gr. doses twice daily for lymphatic disease in children, and have sometimes seen good results from it when persevered with; though, as a rule, I prefer the carbonate to other lime compounds.

Sulphide of calcium is of proved value in strumous and scrofulous sores and enlarged glands, and in localised suppurations of any kind, (*v.* Sulphur).

Anæmia.—In anæmia and debility, the consequence of overwork, of close confinement, etc., Dr. Ringer speaks highly of the phosphate of calcium, especially when combined with the carbonate and with iron.

Chorea.—Rodolfi has recorded cases of chorea treated by calcium chloride, 7 to 15 gr. in twenty-four hours, and found it

suitable for all cases provided that there was no "cerebral hyperæmia"; improvement began at once, and cure resulted in about sixteen days (Med. Times, i., 1869). Aperients were also given, and as Jaccoud remarks, belladonna was combined with the lime, so the results must be held doubtful.

In nervous disorders with sleeplessness, and in infantile convulsion, Dr. Hammond has found the *bromide* of calcium more readily taken and more effective than that of potassium, and I can to some extent confirm his observations.

Phthisis—Chronic Bronchitis.—In the early stages of phthisical anæmia and debility, especially in excitable florid persons with tendency to headache and dyspepsia, also when in later stages profuse sweating, or expectoration, or diarrhœa is present, or when the menses are frequent or profuse, the carbonate or phosphates of calcium often exert a good influence in lessening such discharges and in improving strength; even when actual softening has occurred and cavities formed, I have given these salts with the object of assisting cretaceous deposits and often with benefit. Lime well supplements cod-liver oil, and the two remedies may be suitably combined, since they form an emulsion readily taken by children—$1\frac{1}{2}$ parts of lime-water to 1 of cod-liver oil is perhaps the best proportion (Med. Times, i., 1862). Van den Corput, though praising this combination, recommends rather the chloride flavoured with anise or such proportions of lime-water, etc., as will make a solid jelly ("jecoro-calcaire savon"), which is still better taken (Med. Times, ii., 1870); it has not, however, come much into use in this country. Cod-liver oil does not mix well with syrup of lacto-phosphates, and is liable to become rancid when in contact with it. At a hospital in Moscow excellent results were obtained in the treatment of phthisis by freshly-calcined bone.

The hypophosphites of lime were introduced as the best compound for the treatment of phthisis, owing their value in part to the base, and in part to the hypophosphorous acid contained. The rather extravagant praise which was bestowed upon them has not been supported by the majority of the profession, and opinions are still divided as to their real powers,—I believe myself that they are sometimes of much service. Rabuteau remarks that as hypophosphites raise animal temperature, the

phosphates would seem more rational remedies for phthisis; that dogs never (?) have phthisis, probably because they eat so much bone; also that phosphates are commonly in excess in the urine of the phthisical, and therefore to supply them artificially is reasonable. Charters has published illustrations of their value in night-sweats (Lancet, 1876), and Gugot has made a similar observation (Husemann). Mr. Pidduck specially praises the iodide of calcium in struma and phthisis; it is tasteless, non-irritant, easily decomposed, but does not readily produce iodism (Med. Times, i., 1858). Sir J. Sawyer states that he has seen in chronic phthisis, better results from calcium chloride than from other medicines, hypophosphites of calcium and sodium included. He recommends 10 gr. of the chloride with 1 dr. of water and of glycerine, to be taken in milk after meals, and finds this often "check night-sweats, increase weight, and dry up pulmonary lesion" (B. M. J., i., 1880). The use of calcium salts in this direction has been revived by Dr. Kolischer of Vienna under the title of a "cure for consumption"; there is not much however, in the recent history of the treatment of phthisis to render one sanguine that such a consummation has yet been reached.

In *chronic bronchitis*, I have frequently seen lime-water and also carbonate of calcium, act well in diminishing profuse expectoration and troublesome cough; it should be given internally, and the lime-water applied locally by an atomiser. In *gangrene of the lung*, Dr. Graves advised the chloride with opium.

Cancer.—Besides the local application of lime-water and calcium chloride to cancerous sores, a power has been claimed for these remedies taken internally, to diminish malignant growths; thus, a curious case, in which an extensive mammary cancer separated and fell off after a prolonged use of calcium carbonate, is recorded by Dr. Peter Hood (Lancet, 1867); the patient was advanced in years, and for a long time took the carbonate as prepared from the inner side of oyster shells, 10 to 20 gr. twice daily; another case cured by the same remedy, is also mentioned.

If the taking of calcium salts have any power in inducing the calcification of tubercle—and there is some clinical evidence to that effect—and if they can diminish the blood-supply of a fibroid

tumour and hasten calcareous degeneration of it, as suggested by Sir Spencer Wells, then it is not unreasonable to expect advantage from them in some cases of cancerous degeneration, but I am not aware of other evidence in this direction.

Uterine Disorder—Menorrhagia—Fibroid Tumour.—There is a general consensus of opinion as to the power of calcium salts to relieve uterine hæmorrhage. Dr. Rigby published a marked case dependent on "fibrous tumour" (Med. Times, 1854) treated by the chloride, and Drs. Rogers, Routh and others have recorded similar experiences; doses of 10 drops of the liquor calcii chloridi, increasing by degrees to 30 or 40 drops and continued for some months, are recommended (Ranking, 1871; Lancet, 1873). In too early and too profuse menstruation, I have been accustomed for many years to prescribe the carbonate of calcium with much success. Sir Spencer Wells believes that the chloride acts by leading to atheroma of vessels, and hence is useful in lessening the growth of uterine fibroids and may even cause their disappearance (B. M. J., 1868). Certainly, in some instances under my care, uterine and other tumours have diminished under treatment by carbonate and chloride of calcium.

It is true, as remarked by Dr. Meadows, that large quantities have been given to many patients with uterine fibroid tumours without any result, and he ridicules the idea of any possible promotion of calcification by such means (Lancet, 1873), admitting only that a natural process of atrophy may occur, of which calcareous degeneration is a consequence, not a cause: he ridicules equally the idea of lime curing rachitis.

Uric Acid Deposits—Calculus.—In these maladies lime has not retained the reputation it formerly held, but it may give some relief. The secret remedy of a Mrs. Stephens received so much commendation about one hundred years ago, that Parliament purchased the recipe for £5000 and it was found to consist mainly of calcined egg shells (calcium carbonate) and soap, with vegetable bitters, and though benefit may be set down to the alkali of the soap, yet Whytt obtained very good results afterwards from simple lime-water. Calcium salts may relieve vesical pain and inflammation, and by a constringing and sedative effect on the mucous membrane of the bladder may lessen the

ropy discharge and the general sensibility; a solvent action may also be exerted, but not probably to a great degree; the benzoate of calcium has been credited with more decided effect. Lime-water should also be injected, after washing out the viscus with soothing mucilaginous liquids. Professor Stillé remarks: "There is reason to believe that uric acid gravel may be dissolved and eliminated under the use of lime compounds. How far they are superior to the carbonate of the alkalies for this purpose will depend chiefly on the state of the digestive organs—when these are feeble, lime-water is the better preparation."

The waters of Wildungen, which are much used in lithiasis, owe their efficacy principally to calcium carbonate.

Albuminuria.—On account of the power of calcium salts to dissolve organic membranes, they have been recommended in chronic Bright's disease, and in post-scarlatinal albuminuria "to dissolve proteinous infiltrations of the kidney." Kuchenmeister reports cases treated by large doses of lime-water and soluble calcium salts, with immediate and marked increase in the quantity of urine passed, and with corresponding subsidence of the dropsy. The amount of albumen was lessened, but sometimes slight hæmorrhage occurred (Ranking, 1869; Rev. Méd., 1870). His results have not been widely corroborated, but Baudon reports a case in which the iodide of calcium seemed to succeed after iodide of potassium failed; quinine and iron were given also (Pract., i., 1869).

From our knowledge of the styptic properties of calcium salts, we should rather expect them to restrain renal hæmorrhage than to cause it, and Stromeyer and Caspari report the value of the phosphate for this purpose.

PREPARATIONS AND DOSE.—*Liquor calcis:* dose, ½ to 4 fl. oz. or more (contains ½ gr. to the ounce). *Liquor calcis saccharatus:* dose, 15 min. to 1 fl. dr. (contains 7·11 gr. to the ounce). *Liquor calcis chlorinatæ* not given internally. *Linimentum calcis* (lime-water and olive oil, equal parts). *Creta præparata:* dose, 10 to 60 gr. *Mistura cretæ:* dose, 1 to 2 fl. oz. (contains chalk ¼ oz., gum acacia ¼ oz., syrup ½ oz., cinnamon water to 8 oz.). *Pulvis cretæ aromaticus:* dose, 10 to 60 gr. (contains cinnamon, nutmeg, saffron, cloves, chalk, cardamoms, sugar). *Pulvis cretæ aromaticus c. opio:* dose, 10 to 40 gr. (contains 1 gr. of pulv. opii in 40). *Calcii chloridum:* dose, 3 to 10 gr. and upwards. *Liquor calcii chloridi* (1 part in 6 of water): dose, 15 to 50 min. *Calcii phosphas:* dose, 10 to 20 gr. or more. *Calcii hypophosphis:* dose, 5 to 10 gr. *Calcii carbonas præcipitata:* dose, 10 to 60 gr. *Calx sul-*

phurata: dose, $\frac{1}{10}$ to 1 gr. Besides these official preparations, there are many compounds such as the iodide and bromide of calcium of which the lime is the less active ingredient, and of which the properties are mainly those of iodine, bromine, etc. There are also many non-official preparations of lime, such as the lactophosphate, the compound syrup of the phosphates (Parrish), and others. A number of formulæ for lime sucrates, hypophosphates, etc., are given in the Pharm. Journ., June, 1877.

Of saccharated wheat phosphates the dose is from ½ dr. and upwards with food. Various formulæ for "phosphated bread" and natural forms of phosphate have been published. Superphosphate of calcium ½ oz., carbonate of iron ½ oz., butter and sugar, of each ¼ lb., flour ¾ lb., treacle ½ lb., make 80 cakes (Med. Times, i., 1859). Acid phosphate of calcium and moist carbonate of sodium may be used as a good "baking power" (Horsford, Ranking, ii., 1860). Chevrier has an aerated water containing tribasic phosphate (Pharm. Journ., Sept., 1874). Dannecy recommends to wash and powder beef bones, and boil them for an hour with carbonate of sodium and water, then to wash in a filter—to dry and sieve (Bull. de Thérap., 1858).

CERIUM (Ce = 141).

This metal, which is not a common one, was discovered by Berzelius in a Swedish ore called cerite or heavy-stone—a silicate of iron, calcium, lanthanum, didymium and cerium, which last is obtained from it in the form of a grey metallic powder: oxalic acid is used in the process, and hence oxalate of cerium is the best-known commercial salt: it is the only one official.

CERII OXALAS—OXALATE OF CERIUM

($CeC_2O_4 3H_2O = 283$).

PREPARATION.—It is prepared by mixing a solution of any soluble salt of cerium (*e.g.*, the chloride) with solution of oxalate of ammonium; the oxalate of cerium is precipitated.

CHARACTERS AND TESTS.—A white granular powder, which when heated to redness gives a reddish-brown residue of impure oxide, soluble in boiling hydrochloric acid without effervescence; this solution gives with sulphate of potassium, a white double sulphate of potassium and cerium: the oxalate itself is insoluble in water; it usually contains some oxalate of lanthanum, and oxalate of didymium. The soluble salts, such as the chloride and nitrate, have a sweet astringent taste:

with alkalies and their carbonates they give yellowish-white precipitates.

PHYSIOLOGICAL ACTION. — *Internal.* — There is some clinical evidence in favour of attributing to cerium a sedative action upon the gastric mucous membrane and upon the nervous system, and especially on reflex excitability.

SYNERGISTS.—Bismuth, silver, and cyanides.

THERAPEUTICAL ACTION.—*Internal.*—**Vomiting, etc.** —Sir J. Simpson introduced the oxalate of cerium "as a sedative tonic resembling bismuth and silver," valuable in irritative dyspepsia and vomiting, especially when sympathetic, or dependent on pregnancy (Edin. Month. Journ., 1854; Med. Times, 1855-59). He calls it "the simplest and surest remedy," with which he has cured more cases than with any other medicine, and records several illustrations of its prompt and effective action when ordinary treatment had failed: he gave 1 to 2 gr. doses in pill. Drs. Lee and Curran have recorded similar experience, but the latter rather confused his results by giving bromide and bark at the same time. Dr. C. K. Mills (U. S.) found that the nausea and vomiting of pregnancy almost always yielded promptly to a few doses: of eleven cases reported, ten were relieved permanently, one only for a time. Similar symptoms associated with dysmenorrhœa, flexion and other uterine disorders, and with hysteria from anxiety, grief, overwork and the like, were also relieved by cerium. Obstinate vomiting occurring in the course of phthisis and during typhoid fever, was successfully treated by 2 to 3 gr. doses (Med. Record, 1876). The amount of published evidence as to the general use of the drug is meagre, but I have myself often obtained excellent results from it. Dr. Image attributed occasional disappointment to the use of too small doses, recommending 10 gr. with tragacanth, tincture of orange and water every four hours, the first dose being taken half an hour before rising. He quotes a case in which vomiting always had commenced in the fourth week of pregnancy and lasted till the eighth month, but with this remedy the attacks, though recurring at intervals, were invariably checked in two or three days, and of a great many cases of pregnancy with vomiting, not a single one was unrelieved by the same treatment (Pract., 1878). I have not required to use so large a dose, but it should certainly be

tried if smaller ones fail. Dr. Busey has recommended oxalate of cerium to obviate the nausea and headache produced in some persons by opium, just as Da Costa prescribed bromide, and others coffee; it has the advantage of small bulk and of tastelessness (Pract., 1879).

Dyspepsia—Gastrodynia, etc.—Simpson recommended the oxalate in primary as well as in reflex gastric disorder, and Dr. C. Lee has given instances of its value in pyrosis, in phthisical and atonic dyspepsia; it may be used in the class of cases in which bismuth is indicated. Dr. Mills found it act best when morbid sympathetic influences were a main cause of the indigestion, and depressed or deranged innervation of the stomach existed: in diarrhœa from nervous irritation, cerium was also successful; "it seems to have the power of diminishing reflex excitability of the alimentary tract;" in dysentery, gastric ulcer, cancer and gastro-enteritis, he tried the medicine, but with less satisfactory result.

"Chronic Cough."—Mr. Clark has recorded cases of chronic pulmonary disorders with partial consolidation, and accompanied with dyspnœa on exertion and violent *morning cough* producing sickness, the symptoms of which were much relieved by the sedative effect of oxalate of cerium, given in 5 gr. doses half an hour before rising (Pract., 1878).

Chorea.—Although occasionally prescribed for this disorder, it is of doubtful utility.

PREPARATION AND DOSE.—*Cerii oxalas:* dose, 1 to 2 gr. or more—up to 10 gr. For an infant or child under two years, $\frac{1}{4}$ to $\frac{1}{2}$ gr.

COBALT—(Co = 58·9) (*non-off.*).

This is a reddish-white, tenacious and strongly magnetic metal of sp. gr. 8·5. It occurs in nature in combination with arsenic and sulphur.

PHYSIOLOGICAL ACTION.—The most complete study of the action of cobalt has been made by Anderson Stuart (Journ. of Anat. and Phys, xvii., 1883), working in Schmiedeberg's laboratory. He used a double salt of the metal which did not precipitate albumen, and hence could be injected directly into the blood without causing clots, or could be given by the stomach

or subcutaneously without vomiting or irritation. (Previously little was known of its action, except that large doses caused such symptoms (Gmelin)).

In frogs it caused twitching of the muscles, increase of reflex excitability and tetanus, followed by muscular and nervous depression. In cats and dogs toxic doses given subcutaneously or intravenously, induced severe diarrhœa and vomiting and tetanic convulsions, with intervals of great depression. The nervous system became greatly exhausted, respiration failed and death ensued in a final convulsion, or quietly; the heart went on beating for some minutes after death.

In chronic poisoning, persistent vomiting, serous diarrhœa, very severe stomatitis, and increased reflex excitability were the most prominent symptoms; the urine was coloured of a rich brown colour. Excretion of cobalt takes place from the blood into the bowel when it is given hypodermically. The blood pressure falls after the administration of cobalt, not from cardiac failure, but from dilatation of the blood vessels. Post mortem the intestinal canal was always found covered with extravasated blood. The action of cobalt is, therefore, almost, if not quite, identical with that of nickel. In both cases the greatly increased spinal reflex is the prominent outstanding feature of the poisoning. It must be remembered that these results were obtained with large doses and there is no reason to suppose that the administration of small doses of a double salt by the mouth (say $\frac{1}{4}$ to $\frac{1}{2}$ grain) would have any deleterious effects. Stuart's double salt did not act as a poison either to striped muscle or to the blood corpuscles.

THERAPEUTICAL USES.—These are at present practically nil. Small doses have been used as a substitute for iron in anæmia but without beneficial result.

CUPRUM—COPPER (Cu = 63·4).

This metal (which derives its name from Cyprus) is now obtained chiefly from the mines of Cornwall, of the Pyrenees, and of Fahlun in Sweden, in the form of a double sulphide with iron (copper pyrites, Cu_2S, Fe_2S_3): an oxide, a sub- or red oxide

(cuprite), and an oxycarbonate (malachite), also occur, as well as arseniates, phosphates, etc.

The metal is extracted from the ores by a process of roasting and fusion,—a purer form by electrolytic decomposition of the pure sulphate; ordinary commercial copper may contain arsenic.

The official metal consists of fine wire about No. 25 gauge, or about 0·02 inch; it is used in the preparation of the nitrate and sulphate, and of spiritus ætheris nitrosi. Copper foil is placed in the appendix of the Pharmacopœia as a test.

CHARACTERS AND TESTS.—Copper is the only red metal; it is lustrous, malleable, and ductile, of sp. gr. 8·93; unaltered in dry and cool air, in moist air it becomes coated with hydrated carbonate, and at a red heat is oxidised. In contact with acids, alkalies, or fats, it is readily acted on with the formation of various green compounds, acetates or oxides, commonly known as verdigris. It is soluble in nitric acid, in sulphuric acid with heat, and in hydrochloric acid if air be present,—also in ammonia. It forms cuprous and cupric salts.

Tests may be remembered by their colour, as (1) *the red test*, shown by immersing clean iron in an acid solution of copper, when the red metal will be deposited; (2) *the blue test*, shown by the coloration produced with excess of ammonia; (3) *the brown test*, by the bulky reddish-brown precipitate which occurs with ferrocyanide of potassium.

CUPRI SULPHAS—SULPHATE OF COPPER—BLUE VITRIOL —COPPERAS, OR BLUE STONE ($CuSO_4 5H_2O$ = 249·4).

PREPARATION.—It is prepared by dissolving copper in sulphuric acid, with the aid of heat,

$$Cu + 2H_2SO_4 = CuSO_4 + 2H_2O + SO_2,$$

treating the product with hot water, filtering, and crystallising; or by dissolving the black oxide of copper in hot dilute sulphuric acid, filtering, evaporating, and crystallising.

CHARACTERS AND TESTS.—It occurs in oblique prisms of deep-blue colour and metallic styptic taste; soluble in 4 parts of cold, and 2 of boiling water, insoluble in alcohol, effloresces slightly in dry air; its aqueous solution is blue and reddens litmus strongly. The anhydrous salt is *yellowish-white*, but

turns *blue* when moistened with water, and hence serves as a test for the presence of water in absolute alcohol. The sulphate answers to the tests for copper already given, and like other sulphates gives a white precipitate of sulphate of barium with barium chloride.

Ammonio-Sulphate of Copper in solution is used as a test for the presence of sulphides in liq. ammoniæ fort., and also as a test for arsenious acid, with which it produces a light-green precipitate of arsenite of copper (Scheele's green).

CUPRI NITRAS—NITRATE OF COPPER

$(Cu(NO_3)_2\,6H_2O = 241{\cdot}4)$.

PREPARATION.—It is obtained by dissolving copper in dilute nitric acid, evaporating, and crystallising.

CHARACTERS AND TESTS.—It occurs in deep-blue prismatic crystals, very deliquescent and highly corrosive.

With one-third of its weight of water, it forms at a temperature below 70° F. (21·1° C.) tabular crystals ($Cu(NO_3)_2{\cdot}6H_2O$). With a little more water added directly or absorbed from the air, it yields a styptic, caustic, corrosive fluid. The diluted aqueous solution is only faintly acid to litmus.

SUBACETATE OF COPPER—VERDIGRIS—ÆRUGO

$Cu(C_2H_3O_2)_2CuO$ (*non-off.*).

PREPARATION.—It is manufactured by exposing copper plates to the action of pyroligneous acid.

CHARACTERS.—It occurs in powder, or lumps of small crystals, bluish-green in colour, of sour odour and metallic taste. From it by the addition of acetic acid and water is prepared the official solution of acetate of copper ($Cu(C_2H_3O_2)_2H_2O$), as a test for butyric acid in valerianate of zinc; the acid is precipitated by it.

ABSORPTION AND ELIMINATION.—Metallic copper, even when powdered, is not usually absorbed. Drouard gave large doses to animals without any result (Paris, 1802), but when finely divided some may be rendered soluble by the gastric acids, and traces may be detected in the urine and saliva (Mialhe, Mitscherlich, Portal). Copper coins have often been swallowed

with impunity, but profuse salivation is recorded in the case of a child after swallowing a penny (Barton, quoted by Gubler). That the sulphate can be absorbed from wounds has been both affirmed and denied. Langenbeck and Städeler have traced poisonous symptoms to this cause only when fatty acids were present, but such absorption, though it may occur, is certainly not frequent. Workers with alloys or salts of copper are said to absorb it, for their secretions, hair and teeth may be coloured green by it during life; it has been found in their urine, and after death in the bones, and even in the earth in which they are buried (Millon, Bull. Acad. Méd., t. xii.). (It has been asserted and is now generally believed that these discolorations are due simply to external deposits of copper, which form green salts with the fatty acids of the skin, etc.) Soluble salts of copper combine with albuminous secretions and form a bluish coagulum; this, when resulting from a salt of an organic acid (as the acetate) is still soluble, but from a salt of a mineral acid (as the sulphate) it is more resistant (Mitscherlich). In any case, only a portion of even a moderate dose is absorbed into the blood, and this probably as an albuminate—the larger portion passes off by the bowel, and appears in the dark-brown fæces as sulphate.

Elimination occurs by the bile, the saliva and bronchial secretion (Flandrin and Danger, Annales de Thérap., vol. i.): these observers did not detect it in the urine, but others have done so. Elimination is *slow*, for Orfila found copper in the viscera seventy days after its use had been omitted. It is apt to be deposited in the liver especially. Ellenberger and Hofmeister found it eliminated in bile and urine, with liability to deposit in liver and pancreas, but not showing cumulative effects like lead (Med. Record, 1884).

It must be recognised as a very usual constituent of the normal organism. Sargeaux detected it in the blood of many animals, and Odling and Taylor in the liver, kidneys and other organs, irrespective of poisoning (Guy's Reports, 1866). In the bodies of domestic animals fed on vegetable food Wackenroder found no perceptible amount of copper, but in snails and shell-fish comparatively much; in man and carnivorous animals he found also a rather large proportion both of copper and lead, and concluded that they were derived from the nutritive or medicinal

substances taken (Brit. For. Rev., 1855). Fredericq has found that the blue pigment of the blood of crustaceous cephalopods, and other invertebrate animals is an albuminous substance which contains copper; this substance fulfils the function in respiration which is carried out by hæmoglobin in vertebrate animals, and copper here seems to take the place of the iron in hæmoglobin. Odling and Dupré found copper in bread, flour, shell-fish, etc., and in the human liver and kidneys not invariably, but usually (Guy's Reports, 1858). Stevenson remarked that copper might be derived in the course of an analysis from a copper lamp used for incineration, so that the greatest care is required in such investigations (Lancet, ii., 1872). Schwartzenbach found 0·004 gramme of copper and rather more lead in 2100 grammes of liver (Brit. For. Rev., 1857); Orfila had reported ten times as much. More recently, the average amount found in the entire liver and kidneys in fourteen bodies was 2 to 3 milligrammes ($\frac{1}{33}$ to $\frac{1}{22}$ gr.), and it was found also in the fœtus. The specimens used in the investigation were carefully chosen as not having been exposed to absorption of copper, and the metal was excluded from all apparatus employed. We may therefore conclude that any quantity above 4 milligrammes ($\frac{1}{16}$ gr.) found in these organs is abnormal, and results from direct administration of the drug (Lancet, i., 1875). In the case of the two wives of Moreau, 120 milligrammes and 80 milligrammes were found respectively (B. M. J., ii., 1874, and i., 1875). In a case where ammonio-sulphate of copper had been taken three months before death, nearly 300 milligrammes ($4\frac{1}{2}$ gr.) were obtained from the liver, a good instance of its slow elimination (Rev. Scientifique, 1874). Rabuteau found 16 centigrammes ($2\frac{2}{3}$ gr.) in 1000 grammes of liver also three months after the last dose—43 grammes in all of ammonio-sulphate had been taken (Gaz. Hebdom, 1877).

PHYSIOLOGICAL ACTION.—*External.*—The sulphate, which is the salt most commonly used, has little action on the sound skin, but when applied to wounds or mucous membranes it coagulates the albumen, and forms a thin film on the surface. The pure salt or its concentrated solution acts as a caustic; weaker solutions act as stimulants and astringents, both forms producing more or less condensation of the neighbouring tissues. They exert also some antiseptic power, partly by decomposing

sulphuretted hydrogen, and partly by destroying low organisms, whether animal or vegetable. Any conclusions drawn from the effects of the smoke and vapours of copper foundries are rendered doubtful by the co-existence of sulphurous acid, arsenic, etc. Vegetable life of all kinds is destroyed in the immediate neighbourhood of such works. A solution of copper sulphate has been recommended as a cheap and useful disinfectant for washing the floors of sick rooms; the salt works into the boards, and thus renders them uninhabitable for germs of disease (Med. Press, i., 1883).

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—In the lower animals, salts of copper seem to be uncertain in their effects, at least when given by the mouth. According to Orfila, vomiting is the earliest and most marked symptom, and Drouard found that 12 gr. of sulphate caused fatal gastric inflammation in dogs. On the other hand, Galippe could not poison dogs with pure copper salts, for small doses were tolerated, and large ones were so nauseous that he could not get enough swallowed or retained (Bull. de Thérap., 1875). Ducom and Burq also report that dogs can take from 15 to 60 gr. daily of soluble salts of copper for a varying time without ill effect on the general condition, with the exception of vomiting at first; long-continuance of this medication at length impaired appetite and digestion, and thus led to death from exhaustion *ib.*).

In man, small doses ($\frac{1}{4}$ gr.) of a soluble salt of copper exert a tonic astringent action, but if continued for a long time impair appetite and digestion, and cause diarrhœa from irritation. The effects of frequently-repeated minute doses have excited special attention, on account of the adulteration with copper of many preserved vegetables. Thus, in the French preserved *green peas*, 0·31 to 0·56 gr. has been found in each tin, and by some chemists, and medical men, this quantity has been pronounced injurious (B. M. J., 1876-77). In a case tried at Glasgow, 1·54 gr. of copper sulphate was found in each pound of peas (*ib.*, 1890). Vulpian however, says that any copper compound contained is insoluble and harmless, and that no evidence exists to the contrary; and Galippe, after the crucial test of eating them freely for some time, found

no bad result (B. M. J., 1877). In a 4 lb. loaf of bread ·4 to 1·8 gr. has been found, and the latter amount might become serious (Med. Times, i., 1871). Doses of 1 to 3 gr. induce a sense of constriction in the gullet, and vomiting occurs in a few minutes without much nausea, and is commonly attended with diarrhœa ; 5 to 15 gr. act as a powerful irritant emetic.

Drs. Lauder Brunton and West have experimented to ascertain whether cupric salts cause vomiting by irritation of the stomach, or of the vomitive centre in the medulla. Into the jugular vein of cats they injected a neutral albuminate of copper (which would not cause coagulation of blood), and retching and vomiting followed. Previous section of the vagi did not prevent the retching, but it did prevent evacuation of the stomach, and after section of the vagi and the splanchnic nerves neither retching nor vomiting occurred : hence they conclude that these symptoms depend upon gastro-intestinal irritation, not upon a direct excitement of the central organs (Barth. Hosp. Rep., 1876).

Toxic Action.—Half an ounce given at one time by the mouth produces severe symptoms of irritant poisoning, including metallic taste, feeling of constriction, thirst, salivation, nausea, vomiting, purging, and severe cramping pain with tenesmus ; the abdomen is distended and tender, the evacuations greenish or containing blood ; the face may be flushed and swollen, the gums ulcerated, and sometimes jaundice occurs ; death may follow from enteritis or exhaustion within a few hours or days. From 1 to 2 oz. of sulphate or acetate may be reckoned a fatal dose, though recovery has occurred after 5 oz., when vomiting has been free (Toussaint and others) ; in practice a fatal issue is rare. Dr. Dumoulin states that he has given large doses continuously to animals without ill effects, and has in the treatment of scrofula and croup given as much as 40 grains in a few hours to patients, without any but good results (Semaine Médicale, ii., 1885).

Blandet asserts that *enteritis*, though commonly produced by carbonate or acetate of copper, does not occur from the sulphate, and in one case where 300 grains were taken, vomiting, suppression of urine, and subsultus occurred, yet recovery took place without enteritis (Med. Times, i., 1874) ; the danger of the drug has doubtless been exaggerated, and Hönerkopf gave in seventy-two cases, 5 grammes, and in eighteen cases, nearly 3 grammes

without injury, but in other cases enteritis has been caused by it.

Acute copper-poisoning occurs most often from accidental contamination of food cooked in copper vessels, which when perfectly clean and pure are not harmful, but under the influence of air and moisture, vinegar, salt, or hot fats,—carbonate, acetate, and oxychlorides of copper are formed, and the admixture of these salts ("verdigris") with the food is exceedingly injurious, causing severe colic, vomiting, headache and pyrexia; tympanitis is sometimes very marked, and numbness and tremor of the limbs have been noted (Med. Times, 1844). Similar symptoms, with scanty urine and excoriations about the mouth, followed the use of water boiled in a copper kettle, and of injections from a brass syringe (Amyot, Med. Times, i., 1859; Boggs, Lancet, ii., 1869). An epidemic much resembling dysentery, occurred on board an Indian emigrant ship from using copper for the cooking of rice with ghee or butter (Moore, Lancet, i., 1846). If only one portion of the contaminated food has been taken, recovery is usually rapid and complete in proportion to the amount of vomiting; but if more be taken and not rejected, there remains a tendency to colic, vomiting, or diarrhœa, with much debility. Should death follow, there will be found intense redness of the intestinal tract or actual ulceration, according to the stage of the poisoning; perforation is rare.

Chronic copper-poisoning—"*Cuprismus chronicus.*"—Whilst by some observers this condition has been described as marked and frequent, by others its existence has been denied, and the symptoms explained by adulteration with lead, or other metals. The truth lies between extreme views—some amount of copper-poisoning may be traced amongst workers with the metal, but it is not very serious. Working in pure metallic copper without heat causes no bad symptoms (Hirt, Maisonneuve), but particles of oxide and cupric salts in the air of heated rooms may induce dyspnœa and laryngeal spasm. "Gold printers," working with brass alloy in fine powder, sometimes get vomiting, gastric pain, and anæmia; the hair becomes green-coloured (Taylor). Dr. G. Harley has described a case of sudden colic with nausea, but neither diarrhœa nor constipation, in a copper-plate printer after cleaning plates coated with verdigris: there was a purple line

on the gums (Lancet, ii., 1863). Blandet was the first to describe a more serious chronic cuprismus as existent in Paris workshops, and marked, besides the green coloration, by colic with remissions, fever, lassitude, nausea, bilious vomiting and diarrhœa alternating with constipation (Gaz. Méd., 1845). Sir D. Corrigan recorded seven instances in brass-founders and engineers with similar symptoms, also emaciation, cough and night-sweats; but two of these had organic lung disease, and the cases are not conclusive (Dub. Hosp. Gaz., 1854). Mr. H. H. Latimer, surgeon to the Swansea Copper Works, describes what he calls "Copper-man's chest" as a fibrosis of the lung; the most marked symptom is dyspnœa, with asthmatic exacerbations; this is associated with cardiac irregularity (Lancet, i., 1887). A light or reddish-purple line on the margin of the gums, is described as characteristic, but really indicates an *inflammatory* condition which may arise from other causes (Bucquoy, Union Méd., i., 1874). Bailly describes the true copper bluish-green or blue line as on the *teeth* only, not on the gum, which, however, was commonly inflamed: by analysis he detected copper in the blue line. Perron reported the prevalence of dyspepsia, "enteritis," and phthisis, amongst Swiss watchmakers working with an alloy of gold and copper; they had green coloration of the teeth, but mal-hygiene was a more likely explanation of their impaired health (Med. Times, ii., 1861). Dr. Clapton brought before the Clinical Society cases of irritative dyspepsia in a flower-girl and a coppersmith, but his inquiries about copper-workers verified the absence of any special disease amongst them (Transactions, vol. iii.). Chevallier, after an exhaustive inquiry, concluded Blandet's statement to be exaggerated, and failed to verify a true "copper colic" (Annales d'Hygiène, 1859); any severe cases were found complicated by the presence of lead in the material used. Christison and Chomel reached the same conclusion. Hirt, whilst allowing that verdigris-makers may suffer from intestinal catarrh, and even from some amount of paralysis, blames rather lead, zinc, or arsenic in observed cases of severe "colic." I have known brass-founders get periodic attacks of colic and vomiting followed by rigors—a condition known in the workshops as "brass-founders' ague," and induced when the alloy is melted and they are much exposed to its

vapour—but have connected it rather with zinc or arsenic than copper. Pécholier and Pietra Santa, reporting on the health of verdigris-workers, describe local irritation of mucous membranes, but otherwise good health: they note especially the absence of colic and of chlorosis (Med. Times, i., 1864); and Maisonneuve concluded that though gastro-intestinal disorder may be induced by such work, the symptoms are neither severe nor persistent (Ranking, i., 1865).

Pathological Changes.—In animals that had taken copper for a long time, Mair observed softening and degeneration of the liver, and in one case of poisoning by the sulphate, Maschka attributed the jaundice to fatty degeneration; the kidneys were similarly affected (Syd. Soc. Year Book, 1873).

Nervo-Muscular System.—If a solution of tartrate of copper and sodium (equal to $\frac{3}{4}$ gr. of oxide of copper) be injected under the skin of a rabbit, there will quickly follow unsteadiness in walking, which will gradually pass into complete motor paralysis: the respirations and pulse become feeble, and muscular irritability becomes less, till finally death occurs from paralysis of the respiratory muscles (Harnack, Archiv f. expt. Path., iii.). Falck noted very similar effects, with fall of temperature and progressive general paresis ending in death from cardiac palsy, after hypodermic injection of sulphate, nitrate, and chlorate of copper (Deutsche Klinik, 1859); sensation was unimpaired, and the paralysis was limited to transversely striated muscular tissue. Harnack has since shown that small doses of copper salts exert a preliminary stimulating effect on the frog's heart; no such action has, however, been demonstrated in mammals (*op. cit.*, ix.).

It has been remarked that many *emetic* medicines, *e.g.*, antimony and apomorphine produce also muscular paralysis, and there may be some direct connection between it and severe vomiting: in Falck's experiments however (with hypodermic injections), vomiting was not produced. In cases of acute copper-poisoning in men, the nervous symptoms are such as headache, giddiness, prostration, restlessness, tremor, subsultus tendinum, convulsions alternating with stupor or comparative clearness of mind, and sometimes a motor or sensory palsy, partial and

temporary in character: such symptoms are mainly secondary to the gastric irritation.

Respiratory and other Systems.—There is not much to be said about the special action of copper on other parts of the body, but in the course of acute poisoning, respiration becomes hurried and laboured, the pulse small and usually quickened, and the extremities cold; suppression of urine has been recorded, but amongst workers in copper absorbing slight amounts daily, *diuresis* was a usual symptom (Clapton).

SYNERGISTS.—Salts of lead and zinc, silver and gold, are allied in action to those of copper. Depressing vital conditions favour the development of its irritant properties.

ANTAGONISTS—INCOMPATIBLES.—Metallic sulphides, alkalies and alkaline earths, iodides, and vegetable infusions containing tannin, are chemically incompatible with salts of copper: a boiling solution of certain forms of sugar like grape sugar, also reduces them. In cases of poisoning, the action of sugar seems to be useless because too slow and magnesia though it may retard bad effects, does not wholly prevent them, since the hydrated oxide of copper is soluble. Sulphide of iron decomposes copper salts (forming an insoluble cupric sulphide), and may be used, but the best antidote is said to be ferrocyanide of potassium (yellow prussiate of potash), which should be given freely: the resulting copper salt is insoluble (Med. Times, ii., 1854). Albumen, which may be given in the form of egg and milk, forms an albuminate of copper, but this is not inert and should be removed afterwards by the stomach-pump (Schrœder).

THERAPEUTICAL ACTION.—*External.*—Applied in lotion, ointment, powder or crystal, sulphate of copper, "blue-stone," or "blue-vitriol," acts as a stimulating astringent, or a moderately severe caustic. It unites with albuminous secretions to form an insoluble albuminate of copper, which, acting like a new cuticle, protects the injured part from the atmosphere, and promotes the healing process. Equal parts of sulphate of copper, alum and nitre, fused with four parts of camphor, form a caustic of some celebrity known as "lapis divinus," or green-stone.

Tinea Tarsi—Trachoma.—In these chronic, recurrent disorders of the eye-lashes and lids, the crusts and muco-purulent discharge, and in severe cases the lashes should be carefully

removed, and a crystal of copper sulphate lightly applied to the affected parts. In trachoma the lid should be everted, and the blue stone applied to each little new growth separately. This treatment has the recommendation of Sir W. Wilde, Galezowski, and other authorities, and Mr. Williams (Boston) has published good practical instructions concerning it (Ranking, ii., 1870). I myself commonly prefer this remedy to either zinc or silver, since it is milder and causes less pain; I generally combine with it the use of a dilute mercurial ointment.

An improvement upon the use of copper alone, seems to be the subsequent application of a rod of metallic zinc, which further tends to destroy granulations by the galvanic reaction excited (Rec., 1884).

Aphthous Stomatitis.—Sulphate of copper either applied lightly in substance, or brushed over the affected part in strong solution, removes the white curdy deposit and induces healing of abrasions and ulcerations about the gums: 10 gr. mixed with about 1 oz. of honey is a good form for its use in children. Sir James Paget recommends a gargle containing 1 to 2 gr. of sulphate in 1 oz. of water, as useful in salivation,—free purging being secured at the same time (Med. Times, i., 1858); a similar lotion will destroy diphtheritic membrane.

Indolent Ulcer—Rectal Ulceration.—The solid crystal of the sulphate is a good stimulant to indolent ulcers, and a good caustic for exuberant granulations. The nitrate acts similarly to the sulphate, but is a more powerful caustic and styptic; it is specially useful as a local application to syphilitic sores on the tongue. Dissolved and used as an injection it is of service in various forms of ulceration affecting the rectum, especially, according to Mr. C. Heath's experience, in the later syphilitic forms, when the dorsal surface, or sometimes the whole circumference of the bowel within two inches of the anus, is affected, and there is much muco-purulent discharge. For such cases Mr. Heath recommends an injection containing about 10 gr. of sulphate to the pint, a fourth part to be used at one time and retained for ten minutes: this has an excellent astringent effect, and should be combined with the use of mercurial ointments locally, and iodides internally (Lancet, i., 1873).

Hæmorrhage.—It is used as a styptic to arrest the flow of

blood from leech bites. In solution it may be employed as an injection to stop epistaxis.

Cancer.—The arsenite of copper is said to be a valuable application for cancerous sores. Mr. Taylor (Liverpool) used it with an equal part of mucilage, and found it a good escharotic, disinfectant, and at the same time sedative dressing (Lancet, ii., 1864); it has not, however, been much used.

Skin Diseases.—In parasitic cases, such as ringworm and scabies, the sulphate of copper has been applied with success: in the former, Dr. Graves recommended a wash containing 10 gr. to the ounce, a strength which may, with advantage, be doubled. The oleate of copper in about 10 per cent. dilution has been commended by some for ringworm, but I have not found it superior to other and better known remedies. Dr. Crocker has recently reported it of service when epilation is necessary, since it has a loosening effect upon the hairs, so that many could be removed entire and with little pain (B. M. J., ii., 1893). An ointment containing a similar proportion mixed with lard has cured scabies (Lancet, i., 1846). In ichthyosis, this ointment has also been recommended by Mr. E. Wilson, and the solid crystal is often used for verruca (wart) and molluscum.

Gonorrhœa—Leucorrhœa—Gleet.—In these disorders an injection containing sulphate of copper, 1 to 2 gr. in the ounce, is often a useful alternative to injections of zinc or lead, or it may be combined especially with the acetate of lead. Dewees and also Diday have shown the value of cupric injections in such cases (Archives Gén., xviii.), and Dr. P. Foster has illustrated the same (Med. Times, ii., 1873). In balanitis a copper lotion is useful.

M. Charpentier considers that a 1 per cent. solution of copper sulphate is quite as efficacious and much safer than the perchloride in obstetric practice, and therefore ought to replace it (B. M. J., i., 1884).

Bubo, etc.—Good results have been obtained after surgical evacuation of a suppurating bubo, from injecting a weak solution of copper sulphate into the cavity. M. Danielli found this quickly diminish the secretion, which after simple opening is very apt to re-form (Bull. de Thérap., 1868). M. Diday recommended a strength of 3 gr. to the ounce. The solid sulphate is

a good application to syphilitic cracks, patches and ulceration about the mouth and tongue.

Hydrocele.—As an injection for hydrocele, 2 to 8 parts of sulphate in 200 to 250 of water have been used with success. Dr. Pereira (Oporto) states that twenty-one out of twenty-five cases were cured with this treatment (Med. Times, i., 1861).

Caries—Fistulous Tracts.—Strong stimulating and astringent lotions are sometimes of service in these conditions, especially after the carious bone has been removed, or the fistula divided. The "liquor Villati" has been much used abroad in such cases without previous operation; it is made with ½ oz. of sulphate of copper and of zinc, and 1 oz. of lead subacetate, dissolved in 7 oz. of vinegar; M. Notta and M. Nélaton have used this with advantage, but it is painful, and should not be injected more than two or three times in a week (Union Méd., 1866).

THERAPEUTICAL ACTION.—*Internal.*—In small doses the salts of copper exert a tonic influence upon the nervous system, and an astringent effect on mucous membranes, whilst doses of 5-10 gr. are emetic. The salts in question resemble in action those of zinc, but are more irritant.

Chorea.—Although preparations of copper are not now much used in this affection, I can refer to some very good results from the sulphate in my own experience, and especially in cases connected with tænia and other intestinal worms. I think it well worthy of use in cases where there is even a suspicion of their existence; it will aid their expulsion if present, and in any case act as a good nervine tonic. I have seen permanent good results from ¼ gr. given three times daily, though sometimes this dose needs to be gradually increased.

Hysteria.—In some cases of hysteria, with general debility, shyness, muscular twitching, etc., marked benefit may be derived from the same treatment.

Epilepsy.—It is probable that of the older cases called epilepsy and reported as cured by copper, a large proportion were hysterical, but Voisin reports from the practice of Herpin (Geneva) several illustrations of its power to cure chronic and obstinate cases of true epilepsy. He generally used the ammonio-

sulphate alone or alternately with zinc, for many months; the cure continued permanent some years afterwards (Bull. de Thérap., i., 1870). Halford made great use of copper combined with quinine in this malady (Med. Times, i., 1858), but general experience is not in its favour. Charcot has published a case carefully treated for three months with full doses of the ammonio-sulphate, but the convulsive attacks were rather increased during its use (B. M. J., i., 1875). I have given the sulphate and the acetate in varying doses and for long periods in many cases, but have not seen benefit from them in true epilepsy, although for epileptiform attacks dependent upon intestinal worms, they have several times proved useful.

Spasmodic Asthma.—In cases where there occur well-marked paroxysms, terminating in the ejection of quantities of mucus, small doses of sulphate of copper, repeated frequently until vomiting occurs, will usually give relief; but independently of vomiting, in asthma of more purely nervous type, I have observed benefit from $\frac{1}{6}$ gr. and upwards, given every one to three hours during the attacks, and continued night and morning in the intervals, so as to secure a tonic effect on the nervous system.

Tapeworm.—I have often known tæniæ dislodged and passed under the use of small doses of the sulphate; about $\frac{1}{6}$ gr. in solution is a suitable amount to commence with, and may be given every morning, fasting. If this dose be steadily and gradually increased, upwards of 3 to 5 gr. may be administered without causing vomiting or purging; but should these symptoms occur, the medicine is better omitted for the time, to be resumed in smaller doses if required again. This treatment should be continued for eight to ten days or longer, an occasional dose of castor oil being given when necessary.

Chronic Diarrhœa and Dysentery.—Sulphate of copper is an excellent remedy in these disorders, given in doses of $\frac{1}{2}$ to 1 gr., three or four times daily. Elliotson recommended it in somewhat larger doses, and generally combined with opium in a pill (Med.-Chir. Trans., vol. xiii.); but if opium be really required for pain, I find it better given separately, especially in the form of Dover's powder at bed-time. Morehead also recommends this treatment (Diseases of India, i.). In *infantile* diarrhœa,

objection has been taken to the use of copper, but I have seen it act most beneficially in obstinate cases, not only when chronic, but also when acute in character, and especially when connected with dentition—the dose may vary from $\frac{1}{20}$ to $\frac{1}{4}$ gr. several times daily. Pereira specially recommends the remedy in $\frac{1}{12}$ gr. dose. Eisenmann has also recorded its value in the diarrhœa of dentition and of weaning, and states that he has seen many cases treated by it and cured, when others, not so treated, have become chronic and ended in marasmus (Bulletin, 1859).

In the *diarrhœa of phthisis*, dependent as it commonly is on ulceration of the intestine, we often require to use different forms of astringents, and the sulphate of copper is a valuable alternative. Small doses only should be used, in order to avoid nausea and irritation—$\frac{1}{4}$ gr. with the same quantity of opium is advised by Sir T. Watson (Lectures). The acetate of copper is said to be useful in the general symptoms of advanced phthisis, lessening sweating, pyrexia and cough (Record, 1886).

In **Enteric Fever** with severe diarrhœa, a similar combination is highly praised by Dr. John Harley (Reynolds' System, i.), who "considers it more efficacious than any other medicine." The dose may be increased up to 1 gr., but must be kept small enough to avoid vomiting; quite small doses rather allay gastric irritability.

Cholera.—In this malady, the sulphate has been considered by some physicians so valuable as to be almost a specific. I cannot place great reliance upon it, though I have sometimes observed it relieve the cramps, the retching and purging, strengthen the weak intermittent pulse, and assist in warding off collapse. The careful observations of Gutmann have rendered improbable any specific action of the drug.

Some *prophylactic* power against cholera has been claimed for copper; for the neighbourhood of towns where large copper-works are situated, such as Swansea, Birmingham, and Rio Tinto, has been markedly free from the disease, but other circumstances, and other components of the vapour, such as sulphurous acid, must be taken into consideration (Med. Times, ii., 1854; ii., 1871). A similar immunity is recorded at the large powder factory at Madras, where the mixed chemicals are said to be exposed to a

temperature of 500° F., which would be sufficient to develop sulphurous acid from the sulphur (Lancet, ii., 1873). More important is the fact, that amongst more than 5000 copper-workers in Paris, not one was attacked by cholera during an epidemic which affected other workmen in the proportion of about 1 in every 140; and of the former, not one died of cholera in the course of five epidemics (Burq, Lancet, ii., 1873). Dr. Clapton also remarked that the copper-workers seemed to have almost complete immunity from cholera and from choleraic diarrhœa, when it was very prevalent amongst the neighbours; and the same observation has been made by others. Still, such prophylactic virtue of copper is not usually recognised, perhaps because it is difficult to understand, but Dr. Clapton suggests as some explanation, the disinfectant power of the metal, and its destructive action upon fungi; the subject deserves further investigation, and has since been much discussed (B. M. J., ii., 1883; i., 1884; Revue, etc.). The evidence above given still remains, but Vulpian has negatived many of Burq's conclusions. Working in copper clearly does not antagonise the development of ordinary infectious disorder—such as typhoid or scarlatina, but it has, apparently, influence in lessening epidemics of, and mortality from, cholera.

Croup (Laryngo-tracheal Diphtheria).—In this malady the sulphate of copper has been highly esteemed, especially by German and French physicians, since its first introduction by Hoffmann; he used it mainly as an emetic, but the question has arisen whether it does not exert a *specific* action upon the false membrane. Kissel, who reports successful cases from the use of non-emetic doses of the acetate, supports this view (Journ. f. Pharmaco-dynamik.); and Missoux, who also speaks highly of the remedy, but who gave 5 gr. doses, argues in favour of specific action, because the false membrane after becoming detached, either does not form again, or if it does so is no longer so plastic, tough and adherent (Bull. de Thérap., Dec., 1858). In judging of the curative results, we must bear in mind the distinction between simple catarrhal laryngitis and the membranous form (true croup), since the former is more likely than the latter to have a favourable issue independently of treatment, but allowing for this, there can be no doubt that most of the cases of Godfrey

and of Beringuier were of the more serious malady; these observers used emetic doses (2 to 4 gr.) and also depletion. Trousseau used it mainly as an emetic, in doses of 5 gr., twice repeated (Gaz. des Hôp., No. 39). I do not ignore the six fatal cases recorded by Dr. Hannay (Lond. Med. Gaz., 1840), nor the adverse opinion of Nothnagel, who fears its injurious effects on the intestinal tract, but still I consider the remedy of value. Dr. Crighton states (Edin. Med. Journ., 1868) that out of fifty cases of croup treated by him with the sulphate, only six died; he gave $\frac{1}{2}$ gr. every ten to fifteen minutes till vomiting or marked relief occurred; but even these doses are rather large for children, and in fact, he records that two of them had violent diarrhœa. I recommend doses of $\frac{1}{8}$ to $\frac{1}{4}$ gr. for children, to be given every quarter to half hour until vomiting is induced; then the dose should be diminished and given at longer intervals so as to avoid too severe effects, and later it may be increased again should it become necessary to produce emesis. This plan may be adopted in true croup during the stage of development of the membrane, when there is a dry barking cough and a sense of constriction across the chest, with much difficulty of respiration: and it is also serviceable in cases where a loose catarrhal cough assumes a dry croupy character, when there is partial aphonia, and often some sanguineous discharge from the throat and nostril.

Diphtheria.—In the ordinary form of diphtheria the sulphate of copper has also been found useful by some observers. Dr. W. Squire speaks of it as one of the most effectual emetics, and recommends a solution of 5 gr. to the ounce to be given in divided doses—a teaspoonful only to young children, so as to induce moderate vomiting (Reynolds' System, i.). In cases of formation of diphtheritic membrane on the cutaneous, or nasal, or vulvar surface, lotions of the sulphate are found to destroy it, and to prevent its re-formation.

Intermittent Fever.—In obstinate quartan forms more particularly, the salt has been commended by Hoffmann, Chapman, and others, in $\frac{1}{4}$ gr. doses combined with opium, but it has not come into general use.

Phosphorus Poisoning.—Bamberger, Eulenburg, and others have recommended the sulphate as an antidote in this form of

poisoning. The emetic effect also is serviceable, as it is in other cases of poisoning.

Syphilis.—Aimé Martin and Oberlin have recently published the results of fifty cases of secondary and tertiary syphilitic affections treated with sulphate of copper; in many of these it is said to have acted more promptly than mercury; only in one patient vomiting took place on the first day, but very soon the metal was borne well; a green margin of the gums without an inflamed state of the mucous membrane was observed in a few cases, but disappeared soon; the remedy was given in solution, and 4 to 8 or 12 milligrammes were used daily. To a full *bath* 20 grammes were added (Gaz. Méd. de Paris, 1880). Zeissl has tried copper in syphilis, but his results were only partly satisfactory (Wien. med. Presse, 1880).

Preparations and Dose.—*Cupri sulphas:* as a tonic and astringent, $\frac{1}{4}$ gr. to 1 or 2 gr.; as emetic, 5 to 10 gr. (for adults)—best administered in divided doses at short intervals; a child may have $\frac{1}{8}$ to $\frac{1}{4}$ gr., according to age and strength, repeated every five to fifteen minutes till vomiting occurs, it should then be omitted for a time, or purging may succeed. The *oxide* of copper has been used in doses of $\frac{1}{4}$ to 1 or 2 gr., and the *double chloride* with ammonium in $\frac{1}{4}$ or $\frac{1}{2}$ gr. doses, every two or three hours. A *tinctura cupri acetici* has obtained some favour on the continent under the auspices of Rademacher. It is prepared by making 24 parts of copper with 30 parts of acetate of lead in 136 parts of distilled water: boiling this in copper vessels, then adding 104 parts of spirit, and macerating for four weeks in a closed glass vessel, then filtering. It forms a green liquid of metalic taste, and is used as a remedy, "especially for hyperæmiæ, stases, and exudations"—5 to 15 drops and upwards are given thrice daily (Kissel, Husemann). As a *lotion*, 1 to 2 gr. of sulphate in the ounce, as a *parasiticide*, 10 to 20 gr. to the ounce may be used, or a stimulating astringent *ointment* or oleate may be made in the same proportion. *Cupri nitras* is not used internally.

FERRUM—IRON (Fe = 56).

Iron, the most abundant and the most useful of metals, occurs extensively in the mineral kingdom, its principal ores being either oxides, as the magnetic iron ore, or carbonates, as clay iron-stone. It occurs also in many mineral, so-called *chalybeate* waters, generally as carbonate with excess of carbonic acid, sometimes as ferrous chloride or sulphate. In the animal kingdom

it is an essential constituent of blood, being contained, though only in minute quantity, in the hæmoglobin of the red corpuscles. It occurs largely also in the vegetable kingdom, and may be traced in the ashes of almost all plants. Sometimes the pure metal is found native, and is then commonly supposed to be of meteoric origin.

CHARACTERS AND TESTS.—Iron is hard, malleable, ductile and of great tenacity; its specific gravity is 7·8. Exposed to moist air it becomes covered with a reddish layer—rust—which is mainly hydrated sesquioxide. It forms two distinct classes of compounds known as proto- or ferrous salts, and per- or ferric salts, and has a different atomiticity accordingly. In ferrous oxide (FeO) and chloride ($FeCl_2$) it is diatomic, while in ferric oxide (Fe_2O_3) and chloride (Fe_2Cl_6) it is triatomic. *The ferrous or proto-salts* are commonly greenish in colour, less astringent and less soluble in alcohol; they have a marked tendency to absorb oxygen and to become ferric compounds, hence most of the official ferrous salts are in a partially oxidised state, but to some, sugar is added to prevent such change, as in syrupus ferri iodidi, and ferri carbonas saccharata. *Ferric or per-salts* are generally brownish-yellow, astringent, soluble in alcohol and not prone to change: within the body, however, they are probably reduced to proto-salts.

The general tests for iron are: (1) Tannic and gallic acids give a bluish-black colour or precipitate with per-salts, and act similarly though more slowly, with proto-salts. (2) The yellow prussiate of potassium (ferro-cyanide) gives a deep-blue precipitate (Prussian blue) with per-salts of iron, and a whitish or light-blue one with proto-salts. (3) The red prussiate (ferrid-cyanide) gives no precipitate with the per-salts, but the liquid becomes of a dark colour:—a deep-blue precipitate with proto-salts (Turnbull's blue).

Sulphuretted hydrogen and ammonium sulphide are also used as tests for iron salts; thus, in acid solutions of pure *ferrous* salts, the former gives no precipitate, whilst with *ferric* salts it throws down a nearly white precipitate of sulphur, with reduction to the ferrous state:—$Fe_2Cl_6 + H_2S = 2FeCl_2 + 2HCl + S$. Ammonium sulphide gives a black precipitate with both classes of salts.

By acids iron is readily dissolved, with formation of metallic salts and evolution of hydrogen.

The form of the metal which is official is annealed iron wire, with a diameter of about 0·005 inch (about No. 35 wire gauge), or wrought iron nails free from oxide.

Compounds of Iron.

The large number of official iron compounds may be with advantage considered in the following order:—The preparations of the metal itself and its oxides; the astringent preparations; and those which are not at all, or not markedly, astringent.

Ferrum Redactum—Reduced Iron—Quevenne's Iron.

This is metallic iron minutely divided by chemical processes, and must be distinguished from simple filings or powder produced by mechanical processes; it contains a variable amount of oxide of iron.

Preparation.—It is prepared by adding dilute ammonia to dilute ferric chloride. Ferric oxyhydrate is thus precipitated and then washed and dried. It is placed in an iron tube and raised to a strong red heat, a stream of hydrogen is passed over it, and water and iron in a fine state of division are thus produced—$Fe_2O_3H_2O + H_6 = 4H_2O + Fe_2$. At the same time, by incomplete reduction, some magnetic oxide is formed—$3Fe_2O_3 + H_2 = 2Fe_3O_4 + H_2O$.

Characters.—Pure reduced iron is a fine greyish-black powder, strongly magnetic, and showing metallic streaks on firm pressure. The oxide can be separated from the metal, and its amount ascertained by digestion with iodine and iodide of potassium, which dissolves the metal alone; of this, it should contain at least 50 per cent.; a little sulphide is sometimes present, and is liable to cause disagreeable eructation.

Ferri Peroxidum Hydratum—Hydrated Peroxide of Iron ($Fe_2O_3H_2O$ = 178).

Preparation.—It is prepared by precipitating dilute solution of persulphate of iron with dilute solution of soda, drying at a temperature not exceeding 212°, and then reducing to fine powder.

Characters.—A tasteless reddish-brown powder, not magnetic. Heated to dull redness it yields about 10 per cent. of moisture.

LIQUOR FERRI PERCHLORIDI FORTIOR—STRONG SOLUTION OF PERCHLORIDE OF IRON ($Fe_2Cl_6 = 325$).

PREPARATION.—It is prepared by dissolving iron wire in an excess of hydrochloric acid (by which a ferrous chloride is obtained), and treating this with nitric acid to peroxidation—thus:

$$Fe + 2HCl = FeCl_2 + H_2$$
$$6FeCl_2 + 2HNO_3 + 6HCl = 3Fe_2Cl_6 + 2NO + 4H_2O.$$

Sufficient distilled water is added to give a specific gravity of 1·42. The per-salt could not be formed by the first-mentioned acid alone, because the nascent hydrogen which is set free reduces ferric salts to the ferrous state.

CHARACTERS.—The liquid is at first black from the combination of some nitric oxide (NO) with the ferrous salt, but on heating the mixture the gas is expelled, and an orange-brown solution remains: it generally contains some free acid, and has a very strong styptic taste.

Liquor Ferri Perchloridi. Made by mixing 5 fluid ounces of the strong solution with water up to 20 ounces.

Tinctura Ferri Perchloridi. Made by mixing 5 fluid ounces of the strong solution with 5 ounces of rectified spirit and 10 of water.

LIQUOR FERRI PERNITRATIS—SOLUTION OF PERNITRATE OF IRON ($Fe_2(NO_3)_6 = 484$).

PREPARATION, etc.—By dissolving iron wire in nitric acid, and diluting to the proper strength, and a specific gravity of 1·107. It is a clear solution of reddish-brown colour, acid and astringent.

LIQUOR FERRI PERSULPHATIS—SOLUTION OF PERSULPHATE OF IRON ($Fe_2(SO_4)_3 = 400$).

PREPARATION, etc.—By boiling a solution of the proto-sulphate with some additional sulphuric and some nitric acid. It is a dense solution of reddish-brown colour, is very astringent, and is used for making other preparations.

LIQUOR FERRI ACETATIS FORTIOR—STRONG SOLUTION OF ACETATE OF IRON.

PREPARATION, etc.—It is prepared by dissolving ferric hydrate in glacial acetic acid, and then diluting till it has a specific gravity of 1·127. It is a deep-red fluid of a sour, styptic taste and acetous odour.

Liquor Ferri Acetatis: 20 fluid ounces of it contain 5 of the strong solution of the acetate of iron.

Tinctura Ferri Acetatis. This contains 5 fluid ounces of the strong solution in 20 ounces. It is a deep-red liquid rather apt to decompose and become muddy; its taste is not unpleasant and its degree of astringency moderate. It is the same strength as the liquor.

FERRI SULPHAS—SULPHATE OF IRON ($FeSO_4 7H_2O$).

The proto-sulphate of iron is the salt from which the greater number of the other compounds are prepared. Three forms of it are official—ferri sulphas (green vitriol), ferri sulphas exsiccata, and ferri sulphas granulata.

PREPARATION.—It is prepared by dissolving iron wire in dilute sulphuric acid and crystallising.

CHARACTERS.—The *sulphate* occurs in oblique rhombic prisms, of greenish-blue colour and very styptic taste, soluble in water, insoluble in spirit. Exposed to air it absorbs oxygen and turns brown from formation of ferric sulphate: if nearly free from any ferric salt, the precipitate with yellow prussiate of potash will be nearly white. The crystals effloresce slightly in dry air; at 238° F. they lose most of their water of crystallisation, and at 400° only one atom of water is retained, and the salt becomes a yellowish-grey powder.

Ferri Sulphas Exsiccata—Dried Sulphate of Iron ($FeSO_4 H_2O$). This does not alter on exposure, and is not gritty: 3 gr. are equal to 5 gr. of the crystallised salt.

Ferri Sulphas Granulata—Granulated Sulphate of Iron. It is prepared by filtering a boiling solution of ordinary sulphate into cold rectified spirit, constantly stirring. It occurs in small green granules which are stable, and if carefully dried retain their properties many years.

FERRI IODIDUM—IODIDE OF IRON ($FeI_2 = 310$).

(*Non-off.*)

PREPARATION.—It is prepared by heating together iron wire with twice its weight of iodine, and eight times its weight of water, until the solution becomes colourless; it is then filtered and evaporated to solidity.

CHARACTERS.—A crystalline, green substance with a tinge of brown, containing about 18 per cent. of water of crystallisation

and a little oxide of iron, without odour, deliquescent, soluble in equal parts of water, forming a greenish solution which very readily absorbs oxygen, and changes into free iodine and ferric peroxide. It is decomposed also by heat, emitting coloured vapours of iodine; the altered solution may, however, be restored by warming with more iodine and iron, and may be preserved in strength by keeping a piece of iron in it; so that as iodine is liberated, it can re-combine to form iodide. Syrup will preserve it to a great extent, and it is in the form of syrup that it is most frequently ordered; it is incompatible with alkalies and their carbonates.

Pilula Ferri Iodidi: contains gr. 1 in $3\frac{1}{2}$.

Syrupus Ferri Iodidi: contains 4·3 gr. of iodide of iron in 1 fl. drachm.

FERRI CARBONAS SACCHARATA—SACCHARATED CARBONATE OF IRON.

This is a mixture of carbonate of iron ($FeCO_3xH_2O$) with peroxide of iron and sugar; the carbonate (if reckoned as anhydrous) forming about one-third.

PREPARATION.—It is prepared by adding carbonate of ammonium to ferrous sulphate, each salt being dissolved in boiling water, so as to avoid the presence of air; the precipitate is collected, washed, and rubbed with sugar.

CHARACTERS.—The precipitate is at first white, then green, and finally becomes reddish from absorption of oxygen and formation of ferric oxide. There is no *ferric* carbonate, but what is often sold as carbonate is a brown ferric oxyhydrate containing only a trace of the desired salt, which is very unstable and prone to oxidation; to preserve it from this as far as possible, it is rubbed up with sugar.

Pilula Ferri Carbonatis.

PILULA FERRI—IRON PILL—BLAUD'S PILL.

PREPARATION.—This pill contains sulphate of iron (120 parts) and carbonate of potassium (72 parts) made up with refined sugar (24 parts), powdered tragacanth (2 parts), glycerine ($4\frac{1}{2}$ parts), and water (a sufficiency). Divide into 5 gr. pills. In mixing, the ferrous sulphate and potassium carbonate undergo double decomposition, so that each pill contains about 1 gr. of carbonate of iron.

FERRI PHOSPHAS—PHOSPHATE OF IRON.

This contains at least 47 per cent. of ferrous phosphate ($Fe_3(PO_4)_2 8H_2O$), with ferric phosphate and some oxide.

PREPARATION.—Sulphate of iron is precipitated by phosphate of sodium, some bicarbonate of sodium being also added to neutralise any free sulphuric acid that would be liberated from the iron salt. The precipitate is dried at a low temperature to prevent oxidation.

CHARACTERS.—A slate-blue amorphous powder, almost tasteless, insoluble in water, soluble in acids.

Syrupus Ferri Phosphatis.

FERRI ARSENIAS—ARSENIATE OF IRON.

PREPARATION.—It is prepared from a solution of the sulphate by the addition of a mixed solution of arseniate and bicarbonate of sodium; the precipitate is filtered and dried at a low temperature to avoid oxidation.

CHARACTERS.—Arseniate of iron is an amorphous powder, white when first formed, but becoming grey or greenish-blue from absorption of oxygen: insoluble in water; soluble in hydrochloric acid. Thrown on live coals it evolves the garlic odour of arsenic, and is essentially an arsenical remedy, for the quantity of iron in any admissible dose is insignificant.

LIQUOR FERRI DIALYSATUS—SOLUTION OF DIALYSED IRON.

This is a solution of highly basic ferric oxychloride or chloroxide of iron from which most of the acidulous matter has been removed by dialysis.

CHARACTERS AND TESTS.—It is a clear, dark, reddish-brown liquid, free from any marked ferruginous taste. It is neutral to test paper, and has a specific gravity of 1·047.

SYRUPUS FERRI SUBCHLORIDI—SYRUP OF FERROUS CHLORIDE.

PREPARATION.—To make one pint: Iron wire (300 grains) is dissolved in hydrochloric acid (2 oz.) and water (1 oz.) at a gentle heat. Citric acid (10 grains) is then added, and the solution is filtered into 10 ounces of syrup. Two drachms of water are passed through the filter, and sufficient syrup added to make one pint. Its specific gravity should be about 1·340.

FERRUM TARTARATUM—TARTARATED IRON.

PREPARATION.—Freshly precipitated hydrated peroxide of iron is dissolved in solution of acid tartrate of potassium and allowed to stand for twenty-four hours, concentrated at a moderate temperature, and poured, when of syrupy consistence, on flat plates to solidify.

CHARACTERS.—It occurs in dark garnet-coloured scales; soluble in water, sparingly so in spirit. If boiled with potash or soda it deposits peroxide of iron, but is distinguished from the ammonio-citrate by not evolving ammonia under the same conditions, and also by leaving an alkaline ash.

FERRI ET AMMONII CITRAS—CITRATE OF IRON AND AMMONIUM.

PREPARATION.—By dissolving freshly precipitated hydrated peroxide of iron in citric acid with heat, adding ammonia to neutralisation, evaporating to consistence of syrup, and then drying in thin layers on plates.

CHARACTERS.—It occurs in transparent ruby-red scales, of sweet astringent taste and slightly acid reaction, soluble in water, almost insoluble in spirit. If boiled with soda or potash, it evolves ammonia, but alkaline carbonates do not readily decompose it, and it may, therefore, be given with them in effervescence with citric acid: the iron salt should be put into the acid solution.

FERRI ET QUININÆ CITRAS—CITRATE OF IRON AND QUININE.

PREPARATION.—It is prepared by dissolving freshly precipitated peroxide of iron and quinine in solution of citric acid, adding ammonia and evaporating to dryness at moderate temperature. The product is a triple citrate of iron, quinine and ammonium, and contains both a ferrous and a ferric compound.

CHARACTERS AND TESTS.—Occurs in greenish-yellow scales which become darker by age; they are at first deliquescent and very soluble in cold water, but become less so on exposure to light; it has a chalybeate, and at the same time a bitter taste. It should contain 20 per cent. of Fe_2O_3, and 16 per cent. of quinine, but the proportion of the latter varies, falling sometimes to 4 per cent. The solution is slightly acid: soda precipitates the reddish-brown peroxide $Fe_2O_3H_2O$, and ammonia a white deposit of quinine.

The citrate of quinine with *iron* and *zinc*, with *iron* and

strychnine, and many other double compounds, have also been prepared in granular effervescent form. There are also a number of preparations of iron which are not official; the most important of these are the *bromide*, the *hypophosphite*, the *valerianate*, the *oxalate*, the *lactate*, the *succinate*, and the *sulphate of iron* and *ammonium*.

ABSORPTION AND ELIMINATION.—The absorption of drugs is now commonly accepted as a necessary condition of their general action on the system, and yet the absorption of medicinal doses of iron has been doubted by some eminent men, mainly because, after giving the drug to animals, they have failed to detect an increased quantity of it in the vena portæ or in the urine. On appeal to the clinical evidence of improved colour and tone after the use of iron in anæmia, the objectors attribute such results to a local tonic action upon the gastric mucous membrane, leading to improved digestion; but apart from iron salts having often rather a contrary effect on the stomach, mere improvement of digestion would scarcely account for the rapid chemical changes produced in the blood, and the corresponding benefit to the general condition. It seems more reasonable to allow that the medicine, which is proved to be soluble to some extent at least in the digestive juices, is really absorbed to the extent of its solubility. Most articles of diet contain iron, and it is freely admitted by all, that iron in such organic combination can be readily absorbed and utilised for the needs of the organism; if there be some failure in its supply, or its assimilation, then colour and strength fail, and conversely health and colour usually return when the ordinary medicinal inorganic preparations of iron are added to the nutriment,—the inference being that they have become absorbed.

Definite facts in proof of absorption are such as the following: Tiedemann and Gmelin administered to a horse about 6 dr. of sulphate of iron, and found an increased amount of the metal in blood from the splenic and hepatic veins, and sometimes in the lymph also. Menghini recorded a distinct increase in the amount of iron in the blood of dogs when he added the metal to their food (Bayle, Bib. de Thérap., v. iv.).

Quevenne, in his careful memoir, says that only a minute quantity can be detected in normal urine, but after medicinal

doses the amount is increased slightly, and in the bile and fæces the increase is greater (Archives de Physiol., 1854). Bistrow verified the presence of nearly double the ordinary amount of iron in the milk of a goat after the administration of 15 to 40 gr. of lactate of iron, the increase of elimination beginning forty-eight hours after the dose (Virchow's Archiv, Bd. xlv., 1869).

(Objections have recently been taken to these and many similar observations which are not cited, chiefly on the grounds of inaccuracy, from want of appreciation of the sources of fallacy arising from the constant physiological presence of iron in the tissues in varying amounts.)

More modern observations are those of Rabuteau, who passed into the stomach of dogs doses of about 4 to 8 grains of protochloride of iron, and on killing the animals two or three hours after, only found small amounts of iron in the gastro-intestinal canal, most of it having been absorbed (Comptes Rendus, lxxiii.). This is confirmed by Cervello, who gave a dog 0·015 grams of ferric chloride by the mouth and two and a half hours after recovered only 0·006 grams of ferrous chloride from the intestinal canal (Archiv gen. per le Sci. Med., 1880). Kunkel fed two dogs on the same diet, but to one gave iron in addition; after some time he killed them, and on determining the amount of iron in the various organs, found that those of the dog which had taken iron along with its food contained considerably more of the metal than those of the other dog (Pflüger's Archiv, 1891).

Further, some experiments by Coppola seem to me conclusive. He fed cocks on a diet containing no iron, and found that the amount of hæmoglobin in the blood diminished rapidly and considerably; on adding lactate of iron to their food this loss was soon made good—the iron salt must have made up the deficiency and therefore must have been absorbed (Lo Sperimentale, 1890).

These results taken together carry conviction, and although I must admit that rigorous accuracy of experiment has not always been obtained, yet I cannot doubt that absorption of inorganic iron-compounds does occur through the gastro-intestinal mucous membrane. It may be often partial and incomplete with any one dose, and is almost certainly always limited in amount, yet that

it does occur seems to me to be proved by our clinical experience in anæmia, supported by the experimental results quoted. Absorption doubtless varies according to the preparation used, the condition of the digestive juices, and the state of the stomach as to food, etc. Possibly purely accidental circumstances may also influence it, as Woronichin states that the simultaneous administration of the chloride of sodium or potassium increased absorption and elimination of iron (Ztschr. der Aerzte zu Wien, 1868), and Nasse that fats have a similar effect (Cbl. f. med. Wiss., 1877). Brücke states also that after prolonged administration of iron to rabbits, the system became so charged with the metal that it was no longer retained, but passed almost wholly in the urine (Husemann), thus implying that continuous absorption to form an integral constituent of the organism does not occur under the circumstances; these observations have, however, never been confirmed.

If doubts have been expressed as to the *fact* of absorption of iron, there has been still more controversy as to the *mode* in which it is effected. It must be confessed that we have little or no exact knowledge of what occurs, and that opinion rests on theoretical considerations more than on direct observations or experiment. It is possible that the soluble salts are absorbed unchanged, or perhaps in loose combination with albumen. Rabuteau held that the sesquioxide and other compounds were converted first into perchloride and then into protochloride, in which form they were finally taken into the blood, and the generally held opinion at present is, that the carbonate, the various oxides, and reduced iron are converted into protochloride by the hydrochloric acid of the gastric juice before being absorbed. Bunge, on the other hand, states that all preparations of iron are converted in the stomach into perchloride or protochloride, but in the duodenum the carbonate of sodium always present there, converts the perchloride into ferric oxyhydrate which is kept dissolved by organic matters, while the protochloride becomes protocarbonate which is also soluble in the intestinal contents. In the absence of any very convincing experiments it is difficult to decide as to the correctness of any view, but I am inclined to think that iron may be absorbed in several forms.

It was formerly held that all proto-salts became quickly changed into per-salts in the body, because this change occurs so readily outside, but various conditions will prevent or even reverse this. Thus, Quevenne notes that a natural protocarbonate remains as such in many mineral waters, that per-salts are reduced by alkaline tartrates, by charcoal, or simply by cold. Stenhouse found per-salts to be reduced by organic substances generally, and C. Bernard, after injecting a per-salt into the jugular vein, recovered only a proto-salt from the urine. Bubnow also has shown that if ferric salts be given by the mouth they gradually become reduced to ferrous during their passage along the intestinal canal (Ztschr. f. phys. Chemie, 1883), and Glaevecke after subcutaneous injection of a ferric salt found it ferrous in the urine, but ferric in the blood and peritoneal fluid (Archiv f. expt. Path., 1883). Zaleski however, has found both ferrous and ferric organic compounds in the liver, and it is possible that the state of oxidation may be dependent largely on local or temporary conditions. When iodide of iron is given, the whole of the *iodine* has been found eliminated in the urine after a few days, while but little of the *iron* has passed out (Quevenne, Melsens), proving that complete separation occurs in the system. It has been suggested also that salts of the organic acids—lactates, citrates tartrates—have their acids rapidly oxidised, leaving the iron in the organism. Strong solutions of the per-salts must for their first effect, coagulate some of the albuminous matters met with in the stomach, and Mitscherlich, H. Rose and others have shown that such combinations are readily soluble under these conditions.

There is no want of evidence, therefore, that all manner of iron preparations are soluble in the contents of the gastro-intestinal canal, but we lack reliable information as to what actually takes place. Dr. H. C. Wood in his valuable treatise on Therapeutics expresses the opinion that "the subject of the absorption of iron urgently needs re-investigation," and this opinion I cordially endorse.

After its absorption from the stomach and intestine, the further fate of the metal has not been directly traced. Some of the older observers report having found it in the serum of the portal vein after administration by the mouth, but modern

research has failed to confirm this. It seems probable from Zaleski's (Ztschr. f. phys. Chem., 1886) and other researches, that iron is deposited in the liver, where it is retained and elaborated gradually into more or less complex organic compounds; this view is strengthened by the fact that it is not eliminated by the kidneys (*vide infra*) and therefore probably does not immediately reach the general circulation. The organic compounds thus formed are no doubt, ultimately carried by the blood stream to the blood-forming glands to make hæmoglobin, or if not needed for this purpose, are gradually excreted by the ordinary channels. Here again, however, I find that definite knowledge and convincing experiment are lacking.

In studying the *elimination* of iron, it is necessary to determine what takes place under physiological conditions when no medicinal preparations of the metal are being administered. An ordinary diet supplies about one grain of iron per diem in organic combination, and this suffices to make good bodily wear and tear in health. Minute traces of the metal are present in all excretions, but the great mass is found in the fæces, although it was formerly thought and is still frequently stated that the bile, and to a lesser extent the urine, were the chief channels of excretion of effete or useless iron. From Dr. Young's analyses (Journ. Anat. and Phys., 1871) it is estimated that about $\frac{2}{3}$ gr. of iron is excreted daily in the bile, and Kunkel, Hoppe-Seyler and others regard it as varying from about $\frac{1}{3}$ to $\frac{1}{2}$ gr. Novi, in dogs with biliary fistula, got somewhat, similar amounts. On the other hand, Bunge found only unweighable traces of iron in large quantities of bile from man, oxen, pigs and dogs (Physiol. Chemistry), and Hamburger in a dog fed on flesh also failed to get more than mere traces. Anselm found only $\frac{1}{9}$ gr. in the bile of a dog during twenty-four hours (Arbeiten des pharmak. Instit. Dorpat., 1892). I am inclined to regard these latter researches as the more accurate, as they were made with a full appreciation of all the difficulties involved, and hence we are forced to the conclusion that the amount of iron in the bile is always extremely small.

Nor is any considerable quantity of iron excreted normally in the urine. As early as 1824 Wöhler failed to find iron in this secretion, Quevenne and Boussingault, Fleitmann, Gottlieb and

others estimate it only at from $\frac{1}{22}$ to $\frac{1}{11}$ gr. per diem, and all recent observers are agreed that only minute traces are ever present in health. Hamburger states the amount at $\frac{1}{6}$ gr. daily, but Damaskin (Arbeiten des pharmak. Instit. Dorpat., 1891) and Kumberg (*ibid.*) have definitely shown that only about 1 milligram ($\frac{1}{65}$ gr.) is excreted in the urine of a healthy adult in twenty-four hours, while Socin found only unweighable traces, and sometimes even none (Ztschr. f. phys. Chemie, 1891).

The chief channel of excretion is the intestinal mucous membrane. When iron is given subcutaneously or by a vein, about 50 per cent. of it is retained by the liver, about 10 per cent. or less is excreted in the urine, while the remainder is deposited in the spleen, kidneys, and intestinal wall. In two or three hours after administration the blood is quite free from iron (Jacobi, Archiv f. expt. Path., 1891). According to Gottlieb and others the greater part of the iron is ultimately excreted by the mucous membrane of the intestinal canal; further, in starving animals or those fed on an iron-free diet, there is always a considerable amount of iron excreted into the intestine derived from the breaking down of iron-containing tissues (Coppola, *loc. cit.;* Forster, Ztschr. f. Biol., 1873, and others).

When iron salts are given *by the mouth,* Gottlieb and Anselm (*loc. cit.*) have conclusively proved that the normal amount of iron in the bile is not augmented, and there is consensus of opinion (Hamburger, Bunge, Damaskin, Kumberg, Socin, Jacobi and others) that the amount in the urine is also not increased.

Excretion of iron (given by the mouth) by the mucous membrane of the intestine has never been directly demonstrated. The difficulties of demonstration are at once recognised when we remember that iron is always present in the food, and that a portion of the iron administered never becomes absorbed; we cannot distinguish therefore, between iron excreted by, and iron which has remained in the bowel. That it does occur, however, is rendered fairly certain by the fact that iron given by a vein or subcutaneously is excreted almost entirely in this way (Mayer, Thesis, Dorpat, 1850, and many subsequent investigators). Excretion is always very gradual and only a small amount of iron can be detected in the gastro-intestinal wall at any one time. A

full account of the recent literature on the absorption and elimination of iron is to be found in a paper by Dr. R. Stockman, "The Treatment of Chlorosis by Iron and some other Drugs" (B. M. J., i., 1893).

Other theories regarding the absorption of iron.—It has been supposed by Buchheim, Dujardin-Beaumetz, Kobert, Kletzinsky and others that iron preparations are not absorbed, but exert their beneficial effect in anæmia by a stimulating action on the gastro-intestinal mucous membrane, whereby appetite and digestion are improved, so that the food supplies the necessary iron to reconstitute the blood. They base their arguments chiefly on the fact that iron given by the mouth does not increase the amount excreted in the bile or urine, hence that it cannot be absorbed; and further that the iron of the food is sufficient to supply any deficiency present. It has been shown, however, that the absence of iron from the urine and bile is fully accounted for by its retention in the liver and subsequent excretion through the intestinal mucous membrane, and further, mere stimulation of the gastro-intestinal tract by other drugs has been abundantly proved to be inadequate to cure anæmia.

More recently Bunge has re-introduced a theory of the action of iron which has attracted much attention (*v.* Manganese). He holds that the ordinary preparations of iron cannot be absorbed from the alimentary canal, and that only iron organically combined—as found in food-stuffs—can be utilised to form hæmoglobin. In chlorosis, he says, digestion is greatly disturbed, with formation of sulphuretted hydrogen in the alimentary canal. This gas combines with and separates out the organic iron in the food, forming sulphide of iron, an *inorganic* compound which according to him cannot be absorbed; hence the blood loses its necessary supply of iron and anæmia results. When in this condition inorganic iron is given medicinally, he supposes it to combine with and neutralise the sulphuretted hydrogen, and thus to protect the organic iron of the food, which becomes absorbed and goes to form hæmoglobin. It is, however, simply an assumption, that sulphuretted hydrogen is found in the bowel in great excess in chlorosis, and Stockman has shown that ferrous sulphide given by the mouth is as curative as other iron preparations, although it is scarcely likely that it can absorb any

sulphuretted hydrogen in the intestinal canal. Moreover small doses of iron ($\frac{1}{4}$ to $\frac{1}{2}$ gr. daily), given *subcutaneously*, will cure anæmia satisfactorily, and iron given in these small amounts can scarcely tone up the gastro-intestinal mucous membrane, or neutralise any (hypothetical) excess of sulphuretted hydrogen in the bowel.

PHYSIOLOGICAL ACTION.—*External.*—Compounds of iron with the mineral acids act as caustics, irritants, or simple astringents, according to the kind and strength of preparation used; they are also antiseptic. A caustic, destructive action is exerted by the solid perchloride, especially upon raw surfaces or mucous membranes, but it is not so deep or thorough as that of the mineral acids alone, because of the rapid coagulation of albumen. The astringent effect of dilute preparations is explained partly by such coagulation, and partly by the constriction of capillaries.

Kulischer has made curious experiments to test the comparative effects of certain astringents and hæmostatics; having divided some blood-vessels in the limbs of frogs, he stayed the bleeding with different astringents applied for various lengths of time, and then injected liquid into the larger blood-vessels, and calculated the amount of force required to re-open those that had been divided and closed; from his results he concluded that of iron solutions a strength of 30 per cent. gave the best results, and the good effect was proportioned rather to such strength than to the duration of its application (Schmidt's Jahrb., 1876). Some researches by Rosenstirn upon the same subject, though conducted in a different manner, show also how much the action is dependent upon a definite strength of solution, and enable us to compare the effect of iron with that of other astringents. He examined and measured under the microscope, the amount of contraction of blood-vessels in a frog's mesentery after application of 10 per cent. solutions of nitrate of silver, acetate of lead, and perchloride of iron, and the last acted not at all; he then used 50 per cent. solutions, and found the iron one very effective—it narrowed both veins and arteries at the place of application, arrested circulation, and acted as a true styptic on the blood itself; the adjacent vessels became dilated.

The coagulum formed in the living vessel by perchloride of iron

is soluble, to some extent, in the stream of alkaline blood, and especially so if the astringent solution used be unduly weak; it is also soluble in slightly acid liquids, but is rendered more consistent by combining the iron with alkaline chlorides (Piazza, Bull. de Thérap., 1868). The blood-clot with lactate of iron is said to form more slowly, and to be more permanent.

The antiseptic powers of astringent iron preparations are connected with the coagulation of albumen, and strong solutions are fatal to the lower forms of vegetable life. Ferreil ascertained that the neutral strong solution of perchloride arrested decomposition that had commenced in a blood-clot, and formed with fresh blood a coagulum that remained unaltered for many months (Union Méd., 1859); iron salts are now extensively used as disinfectants.

PHYSIOLOGICAL ACTION.—*Internal.*—**Circulatory System.**—Under the use of iron preparations the pulse is said to become more full and forcible, and the colour of the face and mucous membranes more florid, but it is questionable if this occurs when the health and blood-condition are normal. It is also commonly said that if iron be pressed beyond a certain point, symptoms of plethora and of congestion set in, as shown by flushes and giddiness, engorged viscera, and tendency to hæmorrhage, although such effects must be rare, if they ever do occur. The blood will not take up more than a certain quantity, and it is impossible by giving iron to raise the corpuscles or hæmoglobin above the normal amount. Hirtz asserts that he has never seen congestive symptoms, vertigo, etc., except from the excessive use of chalybeate waters containing carbonic acid, to which gas he attributed such effects (Nouveau Dict.); and Nothnagel and Rossbach (Arzneimittellehre) state that in the *healthy* they have never been able to observe any physiological effects whatever after giving medicinal doses of iron by the mouth. In anæmics, on the other hand, all the bodily functions gain tone and vigour.

According to Sasse and Pokrowsky, the use of iron salts increases the heart's action, but their observations were limited to sick persons, and there is no doubt that in disease the circulatory and other systems may be greatly stimulated, not so much by the direct action of iron as secondarily by its recon-

stituent action on the blood. We have seen that iron is probably never absorbed in large amounts at one time, and that what is absorbed is retained in the liver until it has been elaborated into an organic compound suitable for the needs of the organism; we should therefore expect its action to be slow and "alterative" in character rather than rapid and striking, and experience shows this to be the case, as an immediate and direct effect on the heart or circulation is seldom observable. On injecting a neutral tartrate of iron and sodium into the jugular vein, Meyer and Williams found that the blood pressure fell greatly from paralysis of the vascular walls, the heart muscle itself not being so much affected (Archiv f. exp. Path., xiii., 1881), but the effects of iron thus administered are scarcely comparable with those seen after giving it in the usual way.

Action on Blood.—According to the most trustworthy analyses there exists in 1000 parts of blood about 0·547 of iron although there are slight differences in the results of different observers. Hæmoglobin contains 0·42 per cent. as a constant quantity in organic combination in the red corpuscles; when dried these contain seven times as much as the fibrin, and four times as much as the serum (Boussingault). Being required then for the normal constitution of red blood, iron is essentially a *food*, but since illness follows deficiency in the number or quality of corpuscles, and iron in substance will often remedy such illness, it equally comes within our province as a *medicine*, and from its curative effects we may, inverting the general rule, deduce some part of its physiological action. That it can increase the number of red corpuscles in anæmia is shown by the observations, *e.g.*, of Rabuteau, who counted them by Malassez' method, in a case of chlorosis before and after twenty days' treatment by protochloride of iron, and found the number in a cubic millimetre to be nearly doubled (Gaz. des Hôp., Jan., 1875), and in a specimen of blood analysed by Prof. Simon, the globin and hæmatin were more than trebled (Animal Chemistry, Syd. Soc.). I need not multiply examples of this fact (though it has been denied), but there is something further to be learnt from the numerous and careful observations of Hayem, on the blood of anæmic persons. He found that in cases of moderate chlorosis, the *number* of corpuscles was not markedly less

than normal, but they were altered in shape and size, apparently in consistence, but most markedly in *colour*, so that a given quantity showed a red tint not deeper than that of half the number of normal corpuscles. Further, after a course of iron the number of corpuscles in the same patient was not always increased, sometimes it was diminished, but then the corpuscles individually had grown larger and of normal shape, and of so good a colour as to equal even a greater number of the ordinary kind; he concludes then that iron acts by improving the internal nutrition of the discs, "it solicits them" to take up more colouring matter. These observations confirm the older ones of Le Canu (Thèse, 1847), that iron is the main constituent of hæmatin, is inseparable from the colouring matter, and must be at least an important element in the colour itself. Hayem's conclusions are of still more importance as bearing on the assertions of Denis and of C. Bernard, that there is no real deficiency of iron in chlorotic blood, because they prove such a definite change in its *vital* characters under the medicinal use of the drug. Granted that there is no numerical, there is clearly a physical or a vital change produced by iron; and although it may be true that ordinary nutriment contains as much iron as should be wanted (Bernard), yet it seems equally true that we may sometimes have to give much that we may get a little absorbed (Gubler), that we must therefore give it *en masse*, as we do, and (apart from all theory) Hayem furnishes us with a rational basis for our therapeusis. Some very careful and prolonged observations on the good effect of both iron and arsenic, on the size, shape and number of the corpuscles (using Dr. Gower's hæmacytometer for counting) have been made by Dr. Willcocks (Pract., ii., 1883). That the proportion of iron can vary in blood is proved by the analyses of Picard (Comptes Rendus, Nov., 1874); in 100 cub. centim. taken from three dogs respectively young, adult, and weakened by hæmorrhage, he found that the amount of iron was ·092, ·065, and ·041, and he established also the fact of a definite and constant relation between the amount of iron in any specimen of blood, and the amount of contained oxygen as liberated in vacuo from quantities of 100 cub. centim. As the administration of iron increases the amount of hæmoglobin in the red corpuscles, it must thereby increase the oxidation processes in the

body, seeing that hæmoglobin is the oxygen carrier of the organism. The researches of Picard, Preyer, and Hüfner proving a definite ratio between the amount of iron and of oxygen contained in the blood are of much interest in this connection, and it is an axiom that iron preparations exert their best curative effect when the supply of oxygen is ample.

Different action of proto- and per-salts.—Blake has published some experiments to show that there is a marked difference between the action of proto- and per-salts on the blood and circulation (Journ. Anat. and Phys., 1869). It is however, scarcely necessary to discuss his results, as the method of experimenting was extremely fallacious. He injected solutions of ferrous and ferric salts directly into the blood-stream, and the differences in effect were undoubtedly due to the different action of the two classes of salts in determining coagulation of the blood. Meyer and Williams, Kobert and others, using a neutral double salt of iron which does not coagulate albumen, have shown that iron *per se* always has the same action, though ferric salts are more astringent and coagulate albumen much more markedly than ferrous; this has an important bearing upon their use for local injections as styptics, etc. The compound which ferrous salts form with albumen is soluble, and is not a coagulum, hence they are not nearly so useful for local astringent purposes. Gaglio states that ferrous lactate, tartrate and sulphate, when injected, even *hinder* coagulation of blood (Rev. des Sc. Méd., 1891).

Digestive System.—Most of the soluble salts of iron have an inky astringent taste, and by continued use, stain the teeth and mouth of a dark colour (sulphide of iron). Compounds with a mineral acid exert a local astringent action on the mouth and stomach, and if the dose be small and diluted, may improve the tone and functional power of the gastric mucous membrane: but these, or any other preparation if given in undue quantity, may irritate and cause indigestion (from lessened secretion), with sense of weight, nausea, or diarrhœa. Iron pills taken in quantity have caused obstruction, and sometimes accumulation has occurred from a soluble salt, as in a case where 20 gr. of citrate were taken thrice daily for some weeks—an insoluble black sulphide was apparently formed (B. M. J., ii., 1887).

Quevenne experimented with gastric fluid withdrawn through a fistula from the stomach of dogs, and judged of the effects of iron on digestion, by the precipitates of peptones obtained from the fluid at certain periods after a meal. There was less precipitate when the juice was acid than when partly neutralised, but he concluded that various forms of iron, given with food, improved the character and amount of the precipitate: they did not increase the proportion of pepsin, nor alter the duration of the digestive process, but were quite readily absorbed, and the dogs thrived and gained flesh under their use. (The method of precipitating peptones was very rough, as it is only within the last few years that a certain method,—the ammonium sulphate method—of separating peptones from other proteids has been discovered by Kühne.) On the other hand, when given without food and especially in the metallic form, iron did not stimulate the formation of sufficient secretion to dissolve itself, but acted as a foreign body and impaired digestion: 10 to 20 gr. of reduced iron would cause diarrhœa, hence a reason for the ordinary rule of ordering iron preparations at the time of a meal, and in small doses (2 to 3 gr.). The sulphate and chloride of iron have sometimes, by mistake or for criminal purposes, been taken in large quantities (1 oz. and upwards), and have caused violent pain and vomiting, with other symptoms of irritant poisoning and gastro-enteritis, but have rarely proved fatal (Taylor).

Secretion.—Astringent preparations will usually lessen the secretions, especially those of the gastro-intestinal tract. Upon the kidney in health, the effect as to quantity of secretion is not much, but irritation of the bladder and the urinary tract may lead to increased frequency of micturition. In some persons however, and in some diseases, iron preparations especially the tincture of the perchloride, the citrate and the tartrate, have proved good diuretics, directly or indirectly: the tincture, in fact, is termed by Simpson a "renal purgative" when recommending it in "surgical fever" (Med. Times, i., 1859). Rabuteau comparing the results of five days when taking daily 2 gr. perchloride of iron, with a like period on the same diet but without iron, found that the quantity of urine was not increased, nor the urea, but the solid constituents were somewhat augmented owing chiefly to an increase in the phosphates.

From what has been previously said regarding the absorption and secretion of iron and from clinical experience, I incline to the conclusion that iron as ordinarily given has no diuretic power. The case is different when iron is injected directly into the blood, as it then comes to be excreted partly by the kidneys, and thus Kobert after injecting iron into the veins of animals, found the drug in the epithelium of the convoluted tubes and in the tubes themselves,—thus accounting for renal irritation; he did not find it in the glomeruli (Revue, t. xxii., 1883).

The secretion of milk has diminished or ceased in cows drinking a ferruginous water, and in some suckling women taking a course of iron (Martin); Bistrow records a similar result in a goat under the use of lactate of iron (*v.* p. 609): on the other hand, there is clinical evidence that non-astringent preparations taken by *anæmic* women during lactation will improve the secretion as well as the general health (Routh, Med. Times, i., 1859). The effect is clearly that of a restorative, and as we find so often in the use of iron, it will vary with the preparation and the patient taking it.

Generative System.—From an early period iron has had the repute of specially stimulating this system. A classical cure by iron-rust of impotence amongst the Argonauts is commonly quoted, and we may rescue from oblivion the curious marriage-contract said to be common at one time amongst the burghers of Frankfort, to the effect that their wives should not visit the iron springs of Schwalbach more than twice in their lives, for fear of being too fruitful (Dr. Jacques, Thèse, Paris, 1843). There is clinical evidence of its value in sexual debility, and in derangement or suppression of the ovarian function, but it seems more explicable by a general tonic and hæmatinic power than by a special local action, though Trousseau attributes to iron aphrodisiac power. The tincture of the perchloride is in somewhat common use as a supposed abortifacient. Taylor regards it as a dangerous drug for pregnant women, but his examples scarcely corroborate this, and the clinical evidence and experience as to medicinal doses mentioned later on, tend to an opposite conclusion. We may recognise, however, that very large doses of astringent preparations are not safe—they may injure by general

irritation or local congestion, as shown in some cases reported in Med. Times, ii., 1860.

Nervous System.—Its action on the nervous system varies with the dose and mode of administration. Injected subcutaneously in frogs, iron salts cause slight excitement and then paralysis of the central nervous system; in later stages, the irritability of the voluntary muscles is diminished, but the heart is not affected. In mammals they cause congestion of the stomach and intestine, often diarrhœa, and may produce paralysis both of motion and sensation. The blood pressure falls, owing to paralysis of the vaso-motor nerves especially of the intestine, resembling that produced by arsenic and antimony (Brunton). Both on the nervous and generative systems, the action of iron as a tonic is probably an indirect one through the blood and digestion.

SYNERGISTS.—Manganese, and most tonics and acids: as astringent,—ergot, turpentine, etc.

ANTAGONISTS — INCOMPATIBLES. — Weakening and fluidifying agents such as alkalies and mercurials: the former are also, together with sulphur and tannin, chemically incompatible with acid iron preparations. One cannot prescribe the greater number of vegetable bitters with iron, as they contain tannin; quassia and calumba form exceptions to this rule. Gubler mentions nicotine as antagonistic.

THERAPEUTICAL ACTION.—*External and Internal.*—In this instance I find it undesirable to separate the external from the internal application of the remedy, for they are very closely connected, and if one set of observers prefer the one in any particular form of disease, parallel observations will be found in favour of the other; thus it is as regards hæmorrhage, diphtheria, erysipelas, and even varix.

Iron in the metallic form was in early use as an astringent and roborant, though we note the absence of any mention of it in Hippocrates. In extraordinary demand at the early part of the last century, as a secret remedy, under the names of "Elixir d'Or," "Gouttes d'Or," "Teinture de Bestuchef," etc., the perchloride solution with ether was priced at a golden louis per ½ oz., procured pensions and promotions for its makers, and served as a present for sovereigns; but when its last patentee revealed

the secret, "for fear his death should lose it to the world," and when Catherine of Russia purchased the precious recipe for many thousand roubles, and presenting it to the St. Petersburg College of Medicine allowed it to be published (1780), this remedy which had been held to cure "gout and epilepsy, cramps and paralysis, rheumatism and hypochondriasis," sank into an obscurity as little deserved as was its previous reputation. Bayle, whose treatise is an excellent epitome of the therapeutical knowledge of his time, mentions only the metal and the carbonate as remedies in neuralgia and chlorosis (Bib. de Thérap., iv., 1837), and the general use of soluble ferric compounds—a use so frequent and so valuable in modern practice that we may wonder how our predecessors fared without it—dates really from about 1850.

Hæmorrhage.—The astringent compounds of iron with a mineral acid are excellent local styptics in all forms of capillary hæmorrhage, such as from leech-bites, wounded gums, hæmorrhoids, bleeding from the nose, etc. The part should be thoroughly cleansed from clot, and then a plug or compress moistened with the solution should be firmly pressed upon it, or in cavities an injection (diluted) may suffice. Sir James Simpson strongly commended a solution of the perchloride in glycerine, used it freely for all forms of hæmorrhage, and with special success in some severe cases of bleeding from the vagina and uterus (Med. Times, i., 1858). Demarquay, Lallemand, and Deleau were using the same hæmostatic with great advantage in France about the same time (Gaz. des Hôp., 1858-59).

The liquor ferri perchloridi fortior B.P. is serviceable for the purpose, but is more acid, and proves often more irritating than need be, and may be well diluted with an equal part of water or glycerine. The liquor ferri sulphatis is preferred by many surgeons, and by others the liquor ferri subsulphatis, or Monsel's solution [1] of the American Pharmacopœia; this is made with sulphate of iron, sulphuric and nitric acids, and is much less caustic and irritant than our solution; it is used in rectal hæmorrhage—1 part to 4 of water (Allingham, Lancet, i., 1874)—

[1] The original Monsel's solution was made with persulphate, as described by him (Recueil des Memoires, t. xvii., 1856, quoted by Buisson).

and the "hæmostatic cotton" used by Marion Sims was prepared with it. The so-called "iron alum" is probably an equally effective preparation; it is well spoken of as a local application to the uterus for hæmorrhage (Record, 1884).

Tonsillar Hæmorrhage—Wounds.—Wetherby of New York, records a very severe case of bleeding from the tonsil (cases which are specially anxious ones, on account of the proximity of the carotid) completely controlled by the application of Monsel's solution (Ranking, ii., 1866); and I have seen instances in which a large vessel must have been wounded by an incision in the tonsil, effectively treated by the local use of tincture of the perchloride; it should always be tried before more serious measures are commenced. As styptic applications to the bleeding surfaces of wounds, iron compounds are not so suitable as some others, because they necessarily prevent union by "the first intention," and they leave a coagulum, on the separation of which hæmorrhage is apt to recur. Maisonneuve however, performed some of his boldest operations with their help; thus, he removed a growth occupying half the face and head and involving numerous vessels, applying perchloride on pledgets of charpie at almost every stroke of the knife, and so that the weakened boy lost but little blood; a brown eschar formed, and separated about the twentieth day (Med. Chir. Rev., ii., 1856). Bourgade applied perchloride to the bleeding surface immediately after all operations—calculating to render them by this means "as painless and as safe as if caustic had been used instead of the knife," and to prevent septicæmia; the application was painful for a few hours, but not much pus formed, and granulation occurred in a healthy manner; he reports ninety-five cases (Union Méd., 1867). The perchloride is still thus used sometimes in operating upon soft tissues in anæmic subjects when hæmorrhage is likely to be serious. I have seen it applied in the removal of a cancerous tongue and of a cancerous breast, and also in a thigh-amputation, but in each case secondary hæmorrhage occurred, and I was not at all satisfied with the action of the styptic; further, it is not free from risk of causing embolism.

Hæmoptysis.—In various forms of hæmoptysis phthisical and otherwise, preparations of iron are useful if active febrile

reaction is not present. For internal use I prefer the acetate or sometimes the sulphate, to other preparations, and they are especially indicated in the passive hæmorrhage of anæmic weakly subjects (of the acetate, I give the tincture in 5 to 20 min. doses every half-hour to two hours). Caution is needed as to their internal use in phthisis, but their local use in spray or powder is advisable whenever the loss is severe or alarming. A striking case, in which death seemed imminent, and in which the insufflation of powdered sulphate at once and permanently controlled the bleeding, is given by Wetherby (Ranking, ii., 1866). Brondgeest (Brussels) treated successfully three phthisical cases by an atomised spray containing the perchloride (Bull. de Thérap., 1866), and Cornil has related similar results.

I have treated several severe cases with satisfactory results by an "iron spray" containing either $\frac{1}{4}$ part of liquor ferri perchloridi, or 1 to 2 gr. of sulphate in the ounce of glycerine and water. It might be thought that blood thus coagulated *in situ* would increase a tendency to congestion of the lungs or chronic pneumonic phthisis, but practically I have not found it do so.

Epistaxis.—When this occurs frequently in patients already anæmic, or when the amount of blood lost threatens to bring on anæmia, iron will be found of great value, and especially in the form of acetate or perchloride: it should be commenced as soon as possible while the hæmorrhage is going on, and continued for some time after it ceases. I have seen this treatment useful in the severe epistaxis of habitual drunkards; it is not, however, always safe for epistaxis occurring in the old, or those disposed to apoplexy.

Hæmatemesis.—I have frequently treated this form of hæmorrhage successfully by means of the perchloride of iron given internally; it has a direct local styptic effect, and in some aggravated cases when the hæmorrhage has occurred frequently, it has arrested it at the time, apparently prevented relapse, and certainly lessened after ill-effects, such as anæmia. In recent acute cases, ipecacuanha powder in doses of 1 or 2 gr. is often efficacious, but in semi-acute cases it is well to alternate this remedy with 15 to 30 min. of the iron tincture in water. I have known this method check severe hæmorrhage in cases of gastric ulceration, after other remedies had failed, and Mr. Bowles

records similar instances ; he used 1 dr. of the tincture in 1 oz. of water, giving it after the stomach had been emptied by emesis, so that it could directly reach the bleeding part (B. M. J., i., 1872). Deleau, Pleischl, and others have also recorded excellent results from this treatment (Med. Times, i., 1857 ; Med. Chir. Rev., 1859), and it might with advantage be more generally adopted. Iron alum (a double sulphate of iron and ammonia) is also very valuable in this and other forms of internal hæmorrhage (Lancet, i., 1871).

Intestinal Hæmorrhage.—The perchloride is often useful in hæmorrhage from the bowel, and I have known it answer well. Several cases somewhat obscure in character, but recovering under it, are given in Bull. de Thérap., 1877. The ordinary cause of such hæmorrhage would be either cirrhosis of the liver or ulceration, and I do not think iron suitable for the former condition, but in the latter it is more indicated, since we know that it relieves hæmorrhage from gastric ulcer. In the diarrhœa and hæmorrhage of enteric fever, benefit has commonly been derived from its use. Dr. Russell Reynolds has used the perchloride (Med. Times, i., 1867), and Sir W. H. Broadbent the sulphate in enteric fever (B. M. J., ii., 1869), but I have not met with any published conclusions as to the value of these remedies. " Iron alum " I should myself prefer as a styptic in such cases.

Hæmaturia.—The internal administration of perchloride of iron is not desirable in acute renal congestion, but I have occasionally met with chronic recurrent hæmorrhage apparently from the kidney, the subjects of which were anæmic and suffering from chilliness, nausea, faintness, etc., and who received much benefit from the perchloride. The dose should be from 15 to 30 min. every six hours, and its efficacy may often be increased by 2 gr. doses of ipecacuanha powder, given midway between. A very successful case illustrative of treatment by perchloride is reported by Vigla (Gaz. des Hôp., 1858). In urethral and vesical bleeding the same treatment is very serviceable, and in the latter malady iron injections into the bladder have been employed with advantage, but the solution must be weak, for if rapid and solid coagulation of blood within the viscus were produced, the effects might be worse than those of the hæmorrhage itself.

Purpura—Scorbutus.—Iron has sometimes succeeded well

in purpura of passive character, but it is not of much advantage in the bleeding of true scorbutus. Both the sulphate and the perchloride have cured purpuric cases when other remedies, such as sulphuric acid and change of diet, have had no effect. Homolle was the first physician to recommend the sulphate (Union Méd., 1856), and Dauvergne, recording a striking instance of benefit from the perchloride, remarks that it acts better in cases with large effusion (in plaques) than in the merely petechial forms, and this I believe from my own experience to be correct (Bull. de Thérap., 1867). Other cases may be found in Bulletin, 1868, Brit. For. Rev., i., 1861, and Med. Times, ii., 1861; they include one patient at seventy, and one a child; in one, the malady was connected with deficient supply of animal food; the *arseniate* answered well in another case (Lancet, ii., 1872). On the other hand I consider that a too early recourse to iron has sometimes aggravated the hæmorrhage.

Uterine Hæmorrhage.—All cases of uterine hæmorrhage must be carefully considered from every point of view, before resorting to medicinal or local styptic treatment. In a large number of such cases iron is highly useful, but it must not prevent the proper manual and surgical management of, for instance, retained placenta or fibroid growth, nor the depletive treatment of a congested uterus. In menorrhagia occurring in the young or the delicate, and accompanied with a generally lax anæmic condition, and often with intercurrent leucorrhœa, the sulphate or perchloride are suitable as internal medicines; the former, with sulphate of magnesium, is especially good. The excessive loss, as well as other and general symptoms which often occur at the *climacteric period*, may be also relieved by these remedies.

Uterine Cancer, etc.—Simpson knew the value of perchloride in relieving the hæmorrhage and discharge of cancer, and French surgeons equally proved it. The liquor ferri perchloridi fort. is exceedingly serviceable, as shown in a good paper by Dr. Gibb, of Newcastle; he either filled the vagina with a dilute solution for a few minutes, or plugged with tampons, or painted the strong liquor on the affected part, and so far relieved bleeding and pain, and improved the local condition, as to give, at least, a period of comfort (Lancet, ii., 1874). I have myself made the same application with excellent results, and Dr. Potter constantly

uses in cancerous cases a plug of lint or cotton wool soaked in a solution of liquor ferri perchlor. fortior and glycerine (equal parts) and firmly pressed against the uterine surface, the vagina being filled with wool soaked in glycerine. Another method is to apply the saturated solution of perchloride to the affected surface on a Playfair's uterine probe wrapped with cotton wool; this is best in cases when the vagina will not tolerate the presence of tampons.

In cancer other than uterine its application is also valued by myself and many observers, independently of its power as a hæmostatic; it constringes and modifies the affected surfaces, inducing a less rapid growth. Iron cannot cure cancer, but the accompanying debility and the anæmia may be much relieved by a course of it.

Villous Growth.—A severe and obstinate menorrhagia dependent on this cause, was successfully treated by Breslau with an intra-uterine injection of equal parts of liquor ferri (Bavarian) and water; it was made through a catheter, left only one minute and then withdrawn (1858). This was one of the earliest cases of the kind, and illustrates a method which I have several times employed with advantage; but a more modern and often curative practice is to scrape the surface of the lining membrane with a curette.

Fibroid Tumour.—If the patient is suffering from marked anæmia and from continued loss when she first applies for advice, considerable relief to the symptom may be given for a time by the internal administration of the perchloride, especially when combined with ergot; it may possibly be required as a styptic to the cut surface after incision of the cervix; in cases of emergency, plugging of the vagina with saturated tampons is a valuable temporary resource.

Puerperal Hæmorrhage.—The local application of so excellent a remedy has not been neglected in this—perhaps the most anxious form of hæmorrhage with which we have to deal. Sometimes the use of plugs or tampons steeped in the solution and packed in the vagina, has seemed the best mode of treatment, but it is not free from risk, for it may only conceal serious internal hæmorrhage, and moreover, the prolonged contact of strong preparations, even though at the time painless, has been

followed by serious loss of substance, and permanent contraction and cicatrix (Gaz. des Hôp., 1869). In post-partum hæmorrhage the rapid application of a saturated sponge to the interior of a non-contracting uterus has proved efficient (Barnes), but the contact of a strong solution so quickly corrugates the membrane of the vagina and the os uteri, as to cause difficulty in carrying the instrument far enough, or in withdrawing it (Braxton Hicks).

Intra-uterine injections.—Few surgical procedures have more widely and earnestly engaged professional attention of late years than the intra-uterine injection of strong ferric solutions. Schreier, of Hamburg, was accustomed to use weak injections ($\frac{1}{2}$ to 1 dr. in 4 oz. water) for hæmorrhage, either before or after delivery (Med. Times, ii., 1855), and still weaker injections (1 dr. to the pint) have long been practised in the Vienna school, if cold and ergot failed. Ford recorded the successful arrest of severe hæmorrhage after abortion by intra-uterine injection of ferric sulphate (1 dr. in 4 oz. water), also three other cases (Amer. Journ., 1868). Probably other instances might be found, but general interest in the subject was first thoroughly aroused by Dr. Barnes. The mode adopted by him was to mix $\frac{1}{2}$ pint of the liq. ferri perchlor. fort. B.P. with water up to 1 quart, and to inject this slowly through a Higginson's syringe, of which the delivery pipe was passed well to the fundus uteri; by this plan he was satisfied that life had been saved several times, and he held it specially applicable to cases when contractile power could not be roused, and the uterus remained dilated and inert after a prolonged labour. The styptic mechanically stayed the hæmorrhage by sealing the vessels, and usually induced also uterine contraction (Med. Times, i., 1865; Lancet, i., 1862; B. M. J., ii, 1873). Dr. Hugh Norris recorded a similar experience about the same time (B. M. J., 1869-70). Cases for and against were soon reported from different parts of the country, and it was not long before a vehement controversy arose, tinged unfortunately, with some personal animus. A case of secondary hæmorrhage really dependent upon retained placenta, but in which several injections of perchloride solution (the last one being of the strong and undiluted tincture) had been practised, died ultimately of septicæmia, and furnished the text for a full discussion at the Obstetrical Society. Such a case was not really illustrative of Dr. Barnes'

mode of treatment, and although it proved fatal, the opinion of practical and experienced accoucheurs was expressed decidedly in favour of such injections in suitable cases (Lancet, i., 1873). On the other hand instances were referred to in which such injections did apparently cause septicæmia and embolism. In Dublin, the favourable experience of Dr. Barnes was amply corroborated by Dr. Lombe Athill, whilst Dr. E. Kennedy took a much more cautious view, and urged the reservation of the method for a *dernier ressort* (Dub. Journ. Med. Sci., 1874).

In Edinburgh, the discussion of an unsuccessful case showed a balance of opinion against the procedure. Dr. Matthews Duncan especially questioned its propriety, though Dr. Alexander Simpson expressed a more favourable view (Edin. Med. Journ., 1875). In France, if we may judge by the observations of M. Budin, of the Maternité, professional opinion is decidedly adverse (Bull. de Thérap., 1876). In Germany ferric injections seem to have been scarcely tried, those of hot water being much preferred.

An impartial estimate of English writings on the subject leads to the conclusion that the greater part of the favourable testimony comes from those who have really used the method of Dr. Barnes, whilst objections are made chiefly by those who have not ventured to try it. The latter urge (1) that the proper object in the treatment of post-partum hæmorrhage is to secure uterine contraction (not simply a plugging of the vessels with clot), and that cold, friction, etc., are better and safer agents for the purpose; (2) that there is too great tendency to neglect these measures for the more energetic iron treatment; and (3), which is most important, that such treatment exposes the patient to grave risk from the formation of emboli or the injection of air into veins, or the forcing of fluid through the Fallopian tubes. The first objection as to uterine contraction is met by the statement that highly-experienced men have, in some instances, failed to secure uterine contraction by any ordinary means, and have succeeded with the ferric injection, and have thus stayed severe hæmorrhage, and probably saved life, without any ill-result; but much weight must be allowed to the other objections. It is within my own experience that iron injections have sometimes been employed far too soon, from over-anxiety to stay what I should consider not

excessive hæmorrhage, and which would have yielded, I believe, to cold, or the injection of hot water, and the judicious use of ergot. I am also cognisant of at least five cases in which death has followed apparently from embolism, and yet I do not blame the principle of the treatment so much as some defect in carrying it out. Thus, sometimes the uterus has not been properly emptied of clot beforehand; sometimes the solution has not been strong enough, and at other times the exit has not been free: the greatest care is required as to all these points. The patient should be on her back, the womb emptied of clot and gently compressed, the uterine tube should be long enough (about 9 in.) to reach to the fundus, the solution should be of about 2 oz. dry perchloride to 12 oz. water, or 2 oz. liquor ferri perchloridi fort. to 10 oz. water, free from air, and injected slowly and steadily, and the os must be patulous, and the exit quite free, so that no undue pressure or distension should force fluid into vessels or through the Fallopian tubes. If these precautions be all adopted, I believe the ferric injections may be used with safety and with the best results, even in most serious cases; they are an important addition to our means of saving life, but of late years the injection of *hot* water into the uterus has been found to be as efficacious as solution of iron and devoid of its dangers, and promises to entirely replace it in practice.

Injections in Aneurism, etc.—In 1852 Pravaz of Lyons, excited the utmost interest by his discovery of the coagulating powers of ferric perchloride, its effects when injected into the vessels of animals, and its successful use in various forms of aneurism. His observations were confirmed and extended by Giraldés, Broca, and others, who formulated rules for securing a good and firm clot, and obviating the dangers of inflammation and embolism which were soon found to be involved. The greatest importance was attached to the purity and neutrality of the preparation, its due density and proportioned amount to the size of the aneurism, and to the securing of pressure on the vessel above and below the seat of operation. Five drops of an aqueous solution at 30° density (Beaumé) = 1·261 sp. gr., or 10 drops at 20° (1·160), was the calculation for each cubic centimètre (15 gr.) of blood to be acted upon. Dieulafoy has calculated even less than this. If too strong a solution, as of 45° to 50° (Beaumé) =

sp. gr. 1·449 to 1·526, be used, the vascular coats may become inflamed or gangrenous, and if compression be omitted, embolism certainly may occur ; and it will be found that some fault in these respects would explain most of the serious and fatal results which excited the vehement opposition of Malgaigne and others to the new procedure.

I think that scarcely sufficient importance has been attached to some of the successful cases—notably to one of aneurismal tumour of the orbit—recorded by an American surgeon (Brainard, Lancet, ii., 1853). The ligature of one carotid had given only temporary relief, and the actual cautery still less, but a complete cure resulted from several injections of the lactate of iron (8 gr. to 1 dr.). Brainard considered this salt more suitable than the perchloride, as acting more slowly, and with less irritation or tendency to suppuration. Bribosia (Brussels), in a special treatise on the use of coagulant injections, considers them best adapted for such aneurisms as contain more liquid blood than fibrin, and are situated on the smaller arteries (*e.g.*, those of the cranium), and not too near the trunk. It must be acknowledged, however, that the general opinion of modern surgeons is adverse to the use of the perchloride as a coagulant in aneurism : Mr. Hart points out that compression of the affected vessel above and below the sac is a *sine quâ non*, and when this can be obtained usually safer methods of treatment may be employed (Holmes' System, 1870). Marsacci, in a recent work, came to the same conclusion ; Gross and Erichsen also discourage it, though the latter speaks of curing with it a gluteal aneurism after some suppuration.

Nævus—Erectile Tumour.—The application of ferric injections to these cases, though often successful, was soon found to require as much caution as in the more serious malady of aneurism. Thirty drops of the tincture injected into a nævus of the scalp caused erysipelas and sloughing before cure resulted (Med. Times, ii., 1853) ; in a few cases situated about the face, immediate death resulted, this being sometimes clearly due to a clot formed in a large vein (Archives de Méd., 1868 ; Lancet, ii., 1867). In some cases cerebral embolism and softening or pyæmia followed (Lancet, i., 1874 ; Bull. de Thérap., 1873). On the other hand, Mr. Cooper Forster had good success after dividing the nævus-tissue subcutaneously and then injecting a "few drops"

(Med. Times, 1853). Mr. Morgan made an excellent cure of a large erectile tumour of scalp, using circular compression by plaster and pasteboard; and other good results might be adduced, and with very great care might, I believe, be still obtained, but by common consent the operation has been discontinued on account of its danger (Braithwaite, ii., 1875). A more recent Paris thesis, however, re-directs attention to the subject, and presents it in a favourable light (Auguste Rigaud, 1876).

Another and a safer method of using the perchloride in nævus is described by Leclerc, who applied it on pledgets of lint to the part, and obtained a cure at the expense of some erythema and suppuration. Guillot used it after first destroying the epidermis with caustic potash, and Guersant after vesication (Bull. de Thérap., t. lxvii.).

Varix.—Varices without pain or ulceration, should seldom be interfered with by external treatment; but I have frequently known a marked improvement in them while patients were under a regular course of 15 to 30 min. of the perchloride of iron, three times a day, for other affections. To judge by the recorded results of iron *injections* in varix, a large amount of success has been obtained with much less risk than in the last-named diseases; but yet the method is not generally approved by most modern authorities. Minor reports five good cases in which either the scrotum or the legs were affected, and three or four drops of a solution of persulphate (1 part in 4 of water) were sufficient for cure: the patient was in the upright position, and pressure was carefully applied above and below the seat of puncture (Ranking, ii., 1860). Sentoux, collecting 126 cases, found 100 cured, 19 relieved, 6 unaffected, and only 1 death. Denucé reports many successful cases (Moniteur des Sci. Méd., 1862; Brit. For. Rev.), in which the perchloride was used with certain precautions. Desgranges thought the method, with ordinary care, to be free from danger—2 drops sufficed for the largest varicose lobule; he notes the improvement in varicose ulcers after the operation (Brit. For. Rev., 1858). Morgan of Dublin, succeeded in obliterating part of the saphena vein by injecting 5 drops of Monsel's solution in two places, carefully isolated: a coagulum formed in fifteen minutes, and the case did well; in another, with irregular dilatation, and large varicose clusters about the knee,

the same method of injection above and below was equally successful (Med. Press, 1869). Brainard's experiments on the formation of clot in veins under the use of sulphate were very satisfactory; and Gross speaking of nævus, and discouraging the use of perchloride, yet says that by "Monsel's solution any case of arterial or venous tumour, unless very bulky, may generally be promptly and effectually cured" (System of Surgery); this would seem sufficient to warrant a further trial. Cases of benefit and even cure have been reported from the application of lotions of perchloride applied on compresses in the course of the varix (Lancet, ii., 1884).

Hæmorrhoids.—The perchloride is not only frequently of service as a styptic injection into the rectum to relieve bleeding from internal hæmorrhoids, but has been used sometimes by direct injection into the tumours, and has cured when other expedients have failed (Dub. Journ., 1874). Monsel's solution succeeded equally well in two cases of large external piles (Med. Press, 1869). Hæmorrhoids occurring in anæmic or debilitated patients with copious bleeding, are in my experience often well treated by the internal administration of the perchloride.

Relaxed and Discharging Surfaces—Relaxed Throat, etc.—The liquor ferri perchloridi, with a little glycerine added, is a good astringent locally and internally in catarrhal sore throat, and in relaxed conditions of the fauces with increased mucous secretion; also in the œdematous, honey-combed condition which remains after follicular tonsillitis, or more serious inflammations of the throat.

Leucorrhœa.—In catarrhal and relaxed conditions of the vaginal mucous membrane, injections containing about 1 dr. of the tincture, or 10 gr. of sulphate of iron in each ½ pint of water, are often useful, but they have the drawback of staining linen. When the leucorrhœa is mainly dependent upon general debility, the internal administration of iron is often sufficient to relieve, without any injection; and in severe cases, occurring in anæmic and cachectic females with œdematous swelling (from excessive losses of blood), I have found the citrate of iron and quinine useful. Montgomery commonly recommended the per-nitrate for leucorrhœa.

Gonorrhœa.—In the chronic stages of urethral inflammation

sulphate of iron forms a good injection. I recommend about 12 gr. with 1 dr. of laudanum, in 10 oz. of water--a little to be used three times a day; another form recommended by Dr. Ringer contains ½ dr. of the perchloride tincture, with 1 dr. of laudanum in ½ pint water. "It often speedily checks the discharge, and relieves pain on micturition." Barudel, writing from a large experience, would absolutely restrict the local use of perchloride to chronic cases, but he advocates it *internally* for all forms of urethritis, acute and chronic (Med.-Chir. Rev., 1859). I would not myself recommend its use, even *internally*, in acute stages, but in the later ones of gonorrhœa, or gleet, full doses of 10 to 15 min. are of real advantage. Pereira advised it in combination with tincture of cantharides.

Phagedænic Ulceration.—The combined internal and external use of tinct. ferri perchloridi is advised by Ricord (Med. Times, i., 1859). Roget adduced instances of it curing chancre when applied early, and he maintained that the local use of an acid solution directly after exposure would prevent gonorrhœal, and even syphilitic contagion (Traité sur le Perchlorure de Fer, 1860, Paris). Rabuteau speaks favourably of the remedy—substituting only citric acid for the more irritant hydrochloric. He adopts the following formula—R. Tinct. ferri perchloridi (30° Beaumé = 0·879 sp. gr.), 12 grammes; acidi citrici, 4 grammes; aquæ, 24 grammes; solve f. lotio.

Spermatorrhœa.—For seminal losses occurring in the young and the debilitated, tincture of iron is of great use; it should be given in full doses twice daily, and preferably not at night; plenty of outdoor exercise should be conjoined.

Enuresis.—When this occurs in scrofulous children, or in those affected with worms, the perchloride or phosphate of iron gives ready help. One teaspoonful of Parrish's food twice daily, in water, is an excellent remedy for the nocturnal as well as the diurnal form when arising from irritability of the mucous membrane of the bladder. The alternation of iron with tincture of belladonna, or bromide of potassium, acts still better if there be much spasm of the sphincter, and combination with ergot has also succeeded well (Guimaud, Bull. de Thérap., v. 63). Da Costa strongly recommends the bromide of iron in this malady.

Vesical Catarrh.—Iron taken internally has proved of great

value in catarrhal affections of the bladder, but it acts chiefly by improving the general health. The carbonated iron waters of Schwalbach are especially recommended (Schmidt's Jahrb., 1877), and are certainly less irritant than the acid preparations. In cases of catarrh and hæmorrhage following the injudicious use of the catheter, weak injections of tinct. ferri perchloridi, retained for about half a minute, check the hæmorrhage and improve the catarrhal condition (Med. Times, ii., 1870; see also Hæmaturia). Other instances of the value of iron in vesical catarrh are reported by Vigla (Med. Times, 1857-58).

Skin Diseases.—In congestive and exudative forms of skin disease much benefit may be obtained from the tincture of iron; thus, severe *pruritus* may be relieved by it (Lancet, ii., 1874). In a case of chronic infiltrated *eczema*, when tarry preparations had failed, painting with the tincture, and afterwards with collodion, not only cured the intense itching, but also the malady itself, leaving only a dry and brown, but sound skin, and I have seen a case of pityriasis rubra in which the intensely red, dry, and scaly condition was more relieved by the application of this remedy combined with glycerine than by anything else. *Lichen agrius* is also relieved by it. Devergie drew attention to its value in chronic pustular disorders, such as *rupia*, *ecthyma*, and *impetigo* or *pustular eczema* (Med. Times, ii., 1860), in which it may be locally applied as well as taken internally. It is a good application for *variolous pustules* (Med. Times, ii., 1856; Ranking, ii., 1866), and has favourably influenced the course of *anthrax;* a striking case is reported by Dauvergne (Bulletin, 1867).

Herpes.—Baudon found immediate good results from painting the vesicles of herpes with tinct. ferri perchlor. and glycerine; he recommended opening the larger vesicles for the application, but Gressy obtained equally good results without opening them, using a concentrated alcoholic solution, which gave rapid relief (Bulletin, t. lxiii.). An ointment containing 6 to 10 gr. of sulphate of iron in the ounce is recommended by Palmer (Med. Times, ii., 1861).

Ringworm.—The local use of iron in ringworm is an old practice, which has been revived (B. M. J., 1877). After cleansing the part, tincture of perchloride may be painted upon it three or four times, at a day or two's interval; a brown scale forms,

which should be left undisturbed, glycerine will lessen the sense of dryness and constriction. I have found this treatment succeed in slight and recent cases; also in old ones, after more active remedies had been used, and it has the advantage of being not so unpleasant as some other applications.

Onychia—In-growing Nails.—Very successful results have been obtained by using the perchloride locally; for instance, a delicate girl who had suffered for several years and undergone removal of the nail and most ordinary modes of treatment without relief, was cured mainly by the use of an ointment made with perchloride, and a few applications of the solid compound; the latter gives pain and requires to be almost immediately washed away (Bulletin, 1853). The persulphate has been used in other cases (Med. Times, ii., 1868).

Ulcerations.—In chronic indolent ulceration the perchloride is a good stimulant; also the carbonate finely powdered, has been applied in substance to old and excavated ulcers of the leg, and with good bandaging has succeeded well (Lancet, i., 1862). The salicylate of iron is said to make a useful lotion (Edin. Med. Journ., 1877).

Hospital Gangrene.—The perchloride and Monsel's solution have been largely used as local applications, especially in military practice. Salleron gives a very favourable report of these from experience in the Crimean hospitals and elsewhere (Buisson, Traité, etc., and Med.-Chir. Rev., ii., 1860). A "gangrenous throat" was also treated successfully with perchloride (Med.-Chir. Rev. i., 1861).

Polypus—Tumour.—The perchloride has been applied, it is said successfully, to the cure of polypus nasi by injections, and by continued contact (Boston Med. Surg. Journ., 1861). It has been injected also into the substance of tumours, and one case is on record when it was selected for injection into a laryngeal growth, but a drop of the fluid escaping, sudden death followed from laryngeal spasm (Union Méd., 1873).

Erysipelas.—Preparations of iron have been largely used both externally and internally, in the treatment of this malady. A strong ointment or lotion of the sulphate (about 1 in 4) was recommended by Velpeau after many comparative trials with other remedies; it does not however, always prevent the exten-

sion of the inflammation (Bulletin, 1855). Mr. Hulke recommended a lotion containing 10 gr. in the ounce (B. M. J., ii., 1871). The application of equal parts of liq. ferri perchloridi and spiritus vini rect. would seem still more valuable (Oswald White, B. M. J., i., 1876); and Mr. Foster of Leeds, obtained so much success by painting the ordinary tincture of perchloride over erysipelatous surfaces, that this plan became known as the "Leeds method"; it was applied also to inflamed lymphatics, breasts, etc., and seems to have been especially useful in erysipelas after vaccination (Lodge, Med. Times, i., 1875). Mr. Hamilton Bell was the first to publish cases of remarkable benefit from the *internal* administration of the same remedy, or rather of the old "tincture of muriate of iron"; he gave 20 to 30 drops every three hours, so that sometimes 2 oz. were taken in eight days (Edin. Month. Journ., 1852). In severe cases of "idiopathic" erysipelas, the spread of inflammation was arrested, the pulse lowered and the fever relieved, and equally good results were reported by Balfour, Begbie, and other eminent men; but although Lehmann writes more recently in praise of the treatment (Lancet, i., 1880), we cannot concede to iron the "specific" virtue in erysipelas that has been claimed for it, nor is it the best remedy for every case. Todd curtly denied its efficacy (Med. Times, i., 1860); also H. Bennett and Estlander found it useless in traumatic cases (Med. Times, ii., 1871).

Dr. Marshall (Dover), after relating two acute cases cured by 20 min. doses (and purging) states that he has found the remedy of *less* use in the traumatic form (B. M. J., i., 1872). The limited experience of Parkes need not weigh with us, because his cases received only 10 min. doses or less, and were therefore not tests of the method in question; but Aran, commenting on ten satisfactory cases recorded by Mathez (Thèse, Paris, 1857), points out that iron is not the best remedy for young, robust subjects with high fever.

It is fair to add that Mr. C. Bell still maintains its very great value in all forms of erysipelas, and attributes the failures of other practitioners to the use of too small doses, or of less excellent preparations; he states that under his own care patients have recovered so soon as the old "tincture of muriate" was substituted for the modern "perchloride." The former, made with

sesquioxide and hydrochloric acid, contains more free chlorine and some protochloride of iron, but the present tincture of the B.P. is a more definite preparation; any difference in curative power can be ascertained only by clinical experience, and Mr. C. Bell's observations deserve attention (Edin. Med. Journ., 1876). Some practitioners have sought an indication for iron in the locality affected, finding it least useful for erysipelas of the head or trunk; but Pirrie has obtained the best results in such cases. I think that in choosing a remedy for erysipelas we should look rather to the general constitution of the patient, the nature of the tissues affected, and the character of the inflammation; thus, I find iron to be really the best remedy in anæmic, weak patients, or in lymphatic constitutions when there is rapid extension or flitting of the inflammation, when the affected surface is dark-red or bluish, when the pyrexia is slight, and when, owing to debility, the attack tends to linger.

In the erysipelas consequent on surgical operations it is also useful if the subject has been reduced by long-continued suppuration or other causes of exhaustion. I believe it has also some prophylactic power.

Diphtheria.—This malady is clearly allied to erysipelas, and has been successfully treated by the same preparations of iron both locally and internally. Some of the earliest observers recommended the application of perchloride to the seat of exudation, on the ground of the effused membrane being parasitic (Jodin, Laycock), but other physicians, regarding exudation as only one sign of constitutional infection, and also believing that fungus elements were not essential to diphtheria, discouraged the use of such local means as might irritate; Trousseau, for instance, was disappointed in a strong tincture of perchloride used "as a caustic," and such application is not to be recommended; his remarks, however, do not apply to the use of a more dilute form, for blood-poisoning may occur from the affected surfaces, and I agree with the late Dr. Heslop, Sir Wm. Jenner, Sir Geo. Johnson, and others, that judicious local disinfection is very important and advantageous; various remedies may serve, but the gentle application of diluted ferric solutions has given very good results in competent hands. Dr. Nelson (New York), after ample experience of several methods of treatment, expresses the strongest

conviction in favour of local applications of Monsel's solution (liq. ferri subsulphatis) diluted with glycerine and water; amongst forty cases thus treated he had only three deaths (New York Med. Journ., 1874). Dr. Billington, in an excellent practical essay, maintains that diphtheria is at first a local affection, and to be treated most successfully by early local disinfection; he has used lime-water, carbolic acid, etc., but gives a decided preference to the tinct. ferri perchlor., 2 parts, to 1 of glycerine; this he paints especially over the tough adherent membranes, and all adjacent parts. Three hundred cases treated upon this principle, show a large percentage of recoveries, and other physicians corroborate Dr. Billington's results (New York Med. Record, 1876).

Bertheau describes a severe epidemic of "diphthérite" affecting 220 people (Indre), and in which the most useful of all the means employed was the local application of tinct. ferri perchlor. (30° Beaumé); when the membrane was unusually thick, this was painted on three or four times daily (Du Traitement de Diphthérite, etc., Paris, 1876). Dr. Fera applies the finely-powdered sulphate of iron freely to the affected part, and attributes to this the successful termination of eighty cases, whilst De Sabbata speaks in equally favourable terms of the use of an acid solution of the same salt (Lond. Med. Rev., 1876).

Referring to my own experience, I find detailed notes of twenty-seven consecutive cases of diphtheria, in which the perchloride was used locally or internally; for the local application I employed an atomiser with equal parts of the solution and water, and continued its use for about five minutes every one to three hours. In six cases no internal medication was ordered, but besides using the spray, the throat was swabbed out with solution of perchloride mixed with an equal part of glycerine, two or three times in twenty-four hours. The age in these six cases varied from five to nine years, and five of them recovered; but the attack lingered longer, and its course was more unsatisfactory, and convalescence more tedious than in other instances when internal treatment was conjoined; one child, aged four years, had nasal diphtheria, and sank on the third day. In another series of six cases, including children of from two to seven years, I gave iodide of mercury ($\frac{1}{40}$ to $\frac{1}{30}$ gr.) and also liquor arsenicalis, and used freely a spray of perchloride of iron locally, and these six cases

did well. The remaining fifteen, varying in age from two to ten years, were also treated by the spray, and in addition they received from 5 to 10 min. of the liquor ferri perchlor. every one or two hours, and of these cases twelve recovered. Nine of the total number had albuminuria on being first seen by me, and three hæmaturia; another had severe epistaxis, and all showed much exhaustion, with more or less dyspnœa and delirium. The iron given internally seemed to exert a sedative effect on the circulation, lowering the frequency of the pulse, and rendering it more full and forcible. I have never seen hæmorrhage, or albuminuria, or congestive symptoms of any kind which could fairly be traced to its action, and am satisfied that its effect on the course of the disease is beneficial, though we cannot, any more than in erysipelas, consider it a "specific."

Admitting, however, that twenty-seven cases do not furnish sufficient basis for a positive conclusion, it will be desirable to review briefly the experience of previous observers; this we shall find to be strongly in favour of the iron treatment. Dr. Godfrey, of Enfield, reported three cases of diphtheria treated by the perchloride at the very commencement of the epidemic, and speaks of it as the best remedy (Lancet, ii., 1857). It was strongly recommended to the profession at about the same time by Aubrun, in France, and soon after by the late Dr. Heslop in this country (1858-59). The mortality before that date was most severe—thus, of twenty-six cases related by Aubrun, and treated without iron, twenty-two died. In the next series of cases, in which he used the remedy both internally and locally, out of twenty-seven three only died, and in another series of twelve cases there were no deaths at all (Gaz. des Hôp., 1859); nor does it seem that any natural lessening of virulence in the epidemic accounted for this striking difference.

Aubrun was most particular in his method of administration, ordering one or two teaspoonfuls of a solution every five to fifteen minutes through the day and night, for the first three days of the attack, "because usually membranes would be detached, or would cease to form after that time"—then the medicine could be taken less frequently (Comptes Rendus, 1860). Da Silva, commencing with only the local application of perchloride, soon found improved results from using it internally, and recorded

many successful cases (Gaz. des Hôp., 1859). Isnard was a still more earnest advocate for this treatment. Following Aubrun in the principle that "iron strengthened the vital power" he reasoned also that it might prevent exudation just as it might hæmorrhage, rendering the blood more plastic and also less liable to contamination (blood-poisoning); whilst acting as an alterative on the mucous membrane of the respiratory tract, it was better than alkalies, for they were too slow in action and too lowering; it should be given early and repeatedly so as to influence the condition of the blood as soon as possible, and in support of his reasoning he adduced thirty-nine cases, of which thirty-five got well without operative interference, and two after tracheotomy. Dr. Heslop, after referring to the then excessive mortality of diphtheria, and the failure of all accepted modes of treatment, records several striking cases of recovery from almost hopeless conditions under the internal use of tinct. ferri perchlor.; he conjoined with it local applications of dilute hydrochloric acid; at the same time that he praises the remedy, he cautions against regarding it as "a specific" (Med. Times, i., 1858). Mr. Pound relates equally favourable results (B. M. J., i., 1858), and Mr. Houghton (Dudley) contributes four striking cases of recovery under very unfavourable conditions (Dub. Journ., Feb., 1859). A severe epidemic in the fen country was controlled, according to Mr. Stiles, by the same treatment (B. M. J., ii., 1858), and of fifty-six cases reported by Mr. Prangley, only two died after commencing the remedies; he used iodine locally, and perchloride with potassium chlorate internally. Mr. Salter contributed additional testimony to the same effect, and altogether the change of tone, and of the amount of mortality recorded in writings of this period, abundantly testify to the benefit derived from iron tincture, allowing even for accidental circumstances. Mr. Fisher attaches much importance to the use of a preliminary emetic or purge (Lancet, ii., 1862), and Sir George Johnson, agreeing that treatment with perchloride internally is the most successful of all, conjoins with it local chlorine applications (Lancet, i., 1875). Sir W. Jenner, careful to place mere medical treatment in a subordinate position, states that in his experience benefit has accrued from the perchloride, as from other medicines, only in certain cases suited for it (Clinical Lectures); whilst Dr. Wade expresses some distrust of the remedy,

fearing it may increase the renal congestion, for he has found, in fatal cases, more pronounced alteration in the kidneys of patients treated by iron than in others (Lancet, ii., 1862) ; he would prefer iodide and chlorate of potassium. Certainly there are arguments in favour of Dr. Wade's view, and iodide with perchloride of mercury is perhaps now the best treatment in vogue, but I think it will be conceded that the illustrations and authorities already given furnish ample evidence of the value of perchloride of iron in diphtheria. The appearance of albumen, blood, or tube-casts in the urine does not contra-indicate the use of iron in this disease, but on the contrary calls for its administration ; and when blood or tube-casts are present the iron should be given in conjunction with nitric or hydrochloric acid ; under the same conditions stimulants should be judiciously regulated, but seldom withdrawn. Ordinary diuretics are injurious, but as a rule demulcents should be freely taken. Patients should be well nourished with beef-tea, soups, eggs, milk in any form, chicken panada, etc., and ice sucked or swallowed is very agreeable and relieves the painful condition of the fauces ; the skin should be kept clean and warm, and the house and room well ventilated ; aperients as a rule weaken the patient and cause an extension of the exudation in the throat ; all these and other matters as they arise should be carefully attended to during the administration of any iron preparation in diphtheria.

Scarlatina—Scarlatinal Angina—Variola.—In many of these cases I have used the perchloride internally, and applied it to the throat mixed with equal parts of glycerine and water, or through an atomiser, with satisfactory results, but I recommend it most in cases which assume a malignant or putrid form ; benefit is often obtained by painting the swollen cervical glands with the liquor ferri perchloridi.

I have treated many cases of articular inflammation occurring during scarlatina, and closely resembling articular rheumatism, showing high temperature and great prostration, with 5 to 10 min. doses of tincture of perchloride three or four times daily, with excellent results, the joints being also painted with the liq. ferri perchlor. Meade writes to recommend the same medicine in frequent doses of 10 to 15 min. (Med. Times, i., 1858) ; and Arlidge believes it to be not only valuable as a remedy during the attack, but as a preventive of dropsy (B. M. J., ii., 1871). Fears

have been expressed—as in the case of diphtheria—of its increasing renal congestion, but I have never seen injurious effects which could reasonably be traced to it, and Dr. Crighton makes the same observation (B. M. J., i., 1869). He considers that any risk of this kind may be obviated or lessened by combining liquor ammonii acetatis with the iron compound, thus assisting the action of the skin, and I believe the combination to be very serviceable in febrile and inflammatory cases. Dr. Reed states that an elegant preparation of iron may also be made by mixing half a drachm of citrate of potassium to every drachm of the tinct. ferri perchloridi (Pract., i., 1882).

The latter has sometimes been used with very good effect to relieve the throat condition in variola (Med. Record, 1873), and the course of the malady itself seems to have been favourably modified; ½ dr. doses of the tincture were given every four hours in a severe case occurring in the seventh month of pregnancy, and the patient did well (Ranking, ii., 1866). In typhoid fever the perchloride has been used with some success (B. M. J., ii., 1891).

Whooping Cough.—Dr. H. H. O. Sankey has found that carbonate of iron in doses of 1 to 6 gr., according to the age of the patient, is very useful in this disorder; he gives it with chocolate to conceal the taste (Med. Times, i., 1884).

Rheumatism, Acute and Sub-acute.—To ascertain the value (or the reverse) of iron in acute rheumatism, I must refer rather to the experience of others than to my own. Pétrequin seems to have been the first to use it, and reported marked advantage from doses of 40 to 80 min. given in the course of twenty-four hours; he prescribed it with lemonade, and made trial also of the sulphate and the citrates (Eaux Minérales, Thèse, Paris, 1855). Dr. Russell Reynolds—led to use the remedy by consideration of its value in erysipelas—brought before the profession a series of eight cases in which the average duration of high temperature was shortened (to five and a half days as against fifteen), and in several of which pain was quickly relieved and no discomfort produced; but, on the other hand, one patient died comatose after delirium, and another of pneumonia and pericarditis, whilst a feeble or intermittent pulse of 56 to 60 caused anxiety in two of the others; most of these patients had some

cardiac inflammation before coming under treatment, yet the results can scarcely be considered favourable (B. M. J., ii., 1869). In another series of cases he had more success; thus, out of a total of sixty-five, 44 per cent. of first attacks were convalescent in the course of a week, and most of those suffering from second, third, or fourth attacks in the second week; one-half of the whole number were severe cases, yet the temperature became normal within fifteen days: hyper-pyrexia occurred in three, and proved fatal in two instances (B. M. J., ii., 1872).

If we examine other observations that have been published on this subject, we find satisfactory results obtained by Mr. Bott (*ib.*, 1870), and in six cases by Dr. Dyce (*ib.*, i., 1876); Dr. Rose finds the remedy "prophylactic of rheumatism" (Lancet, ii., 1871), but on the other hand, of three cases treated by Dr. Buck, one had urgent dyspnœa, and one unusual cardiac pain (B. M. J., i., 1870), and of three recorded by Mr. Greene, one died with cardiac lesions, and one had tetanic spasms; so that it seems desirable to ask (with Dr. Trestrail) whether the perchloride given in acute rheumatism may not increase the disordered condition of the blood, and the tendency to embolism, and to embarrassed pulmonary circulation: at least we must say that there is more doubt as to the suitability of this remedy in acute rheumatism than in erysipelas or diphtheria, although when the urine is alkaline and the patient is anæmic and feeble, tincture of steel seems appropriate; also rheumatic pain is often relieved by it, and it is of recognised value in the anæmic condition following acute attacks, and in sub-acute and chronic varieties of rheumatism. The late Dr. Anstie drew attention to its power of cutting short sub-acute cases as observed amongst the out-patients at the Westminster Hospital. In such as were really rheumatic (and not gouty) in character, with sallow patchy face, deep furring of the tongue, oily moisture of the skin, obscure aching of the limbs, slight rise of temperature, and troubled respiration, he found that 30 to 40 min. doses, given three to six times in the twenty-four hours, often arrested the progress and relieved the symptoms in a few days; this occurred in seventeen cases out of twenty-nine (Pract., Sept., 1871). (These observations were made before the discovery of salicylic acid as a remedy for acute rheumatism.) Compounds of

iron are now almost restricted as to their use in this disease to the relief of the anæmia which follows it.

Chronic Rheumatism.—Iron is also useful in chronic rheumatism when the patient is much reduced in strength and flesh after an acute attack; it should be continued for some time, for its favourable effects are but slowly produced.

Rheumatoid Arthritis.—Sir A. Garrod recommends iodide of iron "in some cases of rheumatoid arthritis, especially when the joint-pains are increased by the heat of the bed." I have tried it, but have not myself seen good results from it.

Anæmia.—The various preparations of iron form our most dependable remedies in ordinary and simple cases of anæmia and chlorosis; and indeed their good effects are usually so evident that iron was at one time considered a panacea for all forms of these affections, but in reality if prescribed injudiciously, it may not only fail to cure but may produce ill results, and observation of such instances has led some observers to depreciate a remedy which had been considered so universally curative. Thus, Trasbot has denied to it any reconstituent or hæmatinic power, whilst Dujardin-Beaumetz holds the employment of iron in anæmia "une grande illusion thérapeutique" (Journal de Thérapeutique, 1876). The former observer states that in experiments on dogs he obtained better hæmatinic results from calcium phosphate, coffee and wine, than he did from iron, which proved simply exciting; and Dujardin-Beaumetz relies upon an argument of C. Bernard's, that even if the normal amount of iron in the blood of chlorotics be lessened, it is only by a very small amount (10 or 20 centigrammes),—more than which is introduced daily in the food: but the true answer to such observations is, that all theory and even all physiological experiment must stand or fall by the clinical results obtained on man, and in the majority of cases these are satisfactory. The objections of Trousseau were limited to the use of iron in "false chlorosis"—that is to say, in cases when the suppression of the menses, pallor, etc., were really connected with incipient phthisis, which malady he found to be accelerated by ferruginous medicines (Traité, vol. i.). His observations have been corroborated by Millet (Bulletin, 1862), but the cases quoted by the latter author illustrate mainly the injudicious domestic use of certain preparations without due examination of

the patient, and his remarks apply only to the abuse, not to the medical and proper prescription of the remedy.

By the terms "anæmia" or "oligæmia," we understand a condition in which the red blood-corpuscles are fewer than in normal health; instead of being in the proportion of 5,000,000 in each cubic millimetre of blood, they may be 2,000,000, or even less, and this may arise from direct loss of corpuscles (hæmorrhage), or from insufficient formation of new ones on account of disease, or bad air, or unsuitable food, and under such conditions the corpuscles that are formed are small and misshapen. The most marked symptom of anæmia is pallor, which affects the mucous membranes as well as the skin, and may be noted in the conjunctivæ, the gums and the lips; other symptoms are difficulty of breathing especially on exertion, lassitude mental and bodily, malaise, restlessness, dyspepsia, constipation, headache, neuralgia, palpitation and œdema especially of the lower extremities; the pupils are commonly dilated. Some varieties of anæmia benefit by iron more than others, and it is not easy to lay down definite rules concerning them. If there be much dyspepsia, this should first be treated by other appropriate means; but on the other hand, the simple atonic dyspepsia of anæmic persons is very amenable to iron. Congestive headache is a contra-indication, but the pulsating acute headache which follows profuse hæmorrhage really requires iron medication. Important points for securing its good effects are, to obviate constipation by aperients if necessary, and to secure fresh air for the proper assimilation of the remedy, and I think that many failures in the treatment of anæmia are traceable to want of management on these points.

Direct anæmia dependent upon excessive hæmorrhage; or the indirect anæmia which follows loss of animal fluids generally (such as in obstinate leucorrhœa, empyema and suppurations, seminal losses, profuse perspiration, diarrhœa, prolonged lactation, or too frequent pregnancies); also the anæmia produced by acute disease such as rheumatism, and that connected with dyspepsia and inanition when the albuminous constituents of blood are really most deficient,—all these forms, though complicated with extreme debility and general hydræmia, may gradually improve with good food, rest and pure air (especially if the cause be removed); but

iron, given in suitable doses so as not to disorder the stomach, will greatly assist and hasten recovery.

In other cases the best dietetic measures alone are insufficient, and iron is indispensable for cure ; in the congenital anæmia of children born after profuse uterine hæmorrhage, or whose parents were affected with anæmia, tuberculosis, constitutional syphilis or other exhausting diseases, iron is of special value ; also in strumous and rachitic cases (when the iodide or the phosphate is the most suitable form), but it requires to be continued for a long time. I have always found in the treatment of simple anæmia, that when under the judicious use of iron, etc., the blood assumes a healthy aspect, and the formidable symptoms disappear if the iron medication is not persevered with for a considerable time longer, the malady returns in an aggravated degree.

Anæmia arising from severe and continuous mental strain is best treated by the phosphate conjoined with cod-liver oil—many cases have come under my observation when this treatment proved highly beneficial. In the anæmia due to mal-hygiene, to sedentary pursuits, prolonged residence in a town atmosphere, or continued exposure to carbonic acid, iron compounds are also markedly useful. In all these forms their advantage has been often verified by the enumeration of the blood-corpuscles, and estimation of the amount of colouring matter.

Idiopathic or "Pernicious" Anæmia is an interesting but obscure and often fatal form of disease ; and iron, at least in the forms usually employed, has seemed to possess little or no remedial power against it ; arsenic, and perhaps phosphorus, have succeeded better (*v.* p. 495). Benefit has, however, been reported even in this malady from the *hypodermic* use of iron. Dr. Finlay has also reported a case in which the dried sulphate proved efficacious when arsenic had failed (Lancet, i., 1883). (Intestinal antisepsis is an important part of the treatment of this disorder.)

In ordinary *goître*, iron alone is inefficient, and in *exophthalmic goître*, although anæmia is commonly a marked symptom, I have seen disadvantage from it,—it has often increased headache, though it may be suitable in some cases. In the anæmia of incipient phthisis it must be given with caution ; and in

that connected with diabetes and malignant or malarious disease, its effects though often good, are rather uncertain.

The success of iron in anæmia will clearly vary with the different causes, forms, and degrees of the malady, and an accurate knowledge of them is a great help towards cure of the disease, and utilising the power of the drug. Cases coming under treatment at an early stage usually admit of a favourable prognosis, but when the anæmia is congenital, or occurs at the climacteric period, recovery is more uncertain, and the anæmia of old people (unless when directly consequent on an acute illness) is the least tractable of all; intercurrent disease, especially if of febrile or inflammatory character, renders the prognosis as to the anæmic condition, very doubtful. (Dr. Willcocks' able paper has been referred to already.)

It is worth while, even at the present time, to refer briefly to two of the earliest facts which fixed the value of iron in suitable cases of anæmia. An epidemic malady, apparently unknown at the time (1804), attacked the workers in the coal mines of Anzim: it was probably anæmia from carbonic acid poisoning, for they became pale, feeble, short of breath and died of asthenia or chest disease. Treatment by quinine, opium, good food, etc., failed to relieve, and four cases were sent to a hospital in Paris for the opinion of the physicians; of the four men, one died shortly, and at the section, Hallé noticing the exsanguine appearance of the body, thought of iron and prescribed it for the others who got well, and returning home cured their companions with the same remedy (Quevenne, Mémoire, etc.). Something similar occurred at the metal mines of Chemnitz, where the workers at one time died rapidly with "anæmia, asthma, phthisis and dropsy," when the epidemic was stayed with iron medicines by Hoffinger (Ozanam, Histoire des Epidémies).

Chlorosis.—The relationship of chlorosis to anæmia is not exactly clear, but it has this in common with it—that the number of red corpuscles is diminished, and all are pale-coloured; the blood plasma forms a larger proportion of the blood than natural; after the blood has clotted and contracted, the clot is found to be small owing to the small number of corpuscles entangled by the fibrin, and therefore the serum appears to be more abundant than usual; the amount of hæmoglobin is always

notably diminished, and in much greater degree than is proportionate to the lessened number of corpuscles. Thus, with a reduction of 20 per cent. in the latter, there may be a fall of 60 or 70 per cent. in the amount of hæmoglobin. In causation also, the malady is allied to anæmia, since it occurs often in young girls obliged to live in close, ill-ventilated rooms or workshops, and it has also sometimes, seemed directly due to the hæmorrhage of the first menstruation (Wade).

As an entirely primary disease it seldom occurs in any but unmarried women, and chiefly from thirteen to twenty-four years of age; if it occur later in life, it is usually traced to frequent confinements coming rapidly one after another, and especially if the women nurse their children. It is connected with deranged menstruation and certain sexual causes which we are at present unable to distinguish accurately; it occurs either before the menses have appeared, or after symptoms of disordered menstruation have continued for some months; dysmenorrhœa and leucorrhœa are frequent precursors of it. It is often hereditary; the children of tuberculous parents and delicate women with irritable nervous systems are the most susceptible to it; sometimes, in exceptional cases, menstruation is too frequent and profuse. The patient is subject to most of the symptoms already described under anæmia, especially dyspnœa, palpitation, headache, giddiness, and dyspepsia; the face is œdematous and pallid, with a greenish hue; the condition lasts longer than ordinary anæmia, and relapses are still more liable to occur.

The cure of this affection is often readily accomplished with suitable diet, pure air, exercise, healthy mental occupation and a steady course of iron, which latter is almost a specific in simple cases. It was formerly thought that the metal acted by supplying some deficiency in the blood, or at least by directly increasing the number of corpuscles. Béhier considered that it was always indicated when he found, on microscopical examination, that the red discs were reduced to a proportion of 60 per cent. of the normal, and to some extent this is a guide. General improvement will usually occur *pari passu* with an increase in their number towards the normal amount, but it must be understood that the action of iron is not simply a mechanical or chemical one. Claude Bernard has endeavoured to show by analysis

that the metal as such, is not always deficient in amount in chlorotic blood (but it is), and Hayem has shown that the number of corpuscles is not always diminished before, nor increased after the use of iron ; on the other hand, the latter observer has clearly shown that the hæmoglobin is increased, and that the size, colour, and "vital character" of the corpuscles are remarkably improved by it. Others have attributed the benefit of iron in chlorosis partly to its causing a slight irritation of the intestinal tract which favours absorption of organic iron, and partly to the artificial supply lessening the ordinary destruction of the same in the system (Rev. des Sci. Méd., 1892).

With regard to the preparation that is most suitable, we may refer to the observations of M. Coste. He made trial of different forms in 118 cases, fifty-five being of chlorosis, and he concluded that the choice of any particular one was not in itself important, if irritation of the stomach did not result—every preparation that did not irritate produced the good effects of iron ; the reduced metal taken at meal times in small quantities, proved on the whole the most satisfactory form, and the experiments of Quevenne, and the observations of Chomel, Trousseau and others, are to the same effect. Sydenham obtained remarkable success with iron filings and iron wine, and, as a rule, we may say that the simpler the form used the better, and chemical theories as to solubility, etc., do not guide as to the therapeutical result. Reduced iron, the dialysed solution, the oxides and proto-salts, especially the carbonate, are certainly to be preferred in the earlier stages of chlorosis, unless the occurrence of mucous or other discharges indicates a necessity for astringents : sometimes the metal itself causes unpleasant eructation, and the oxides are liable to adulteration, and hence the recently precipitated carbonate which is not astringent or irritant, is preferred by many, and in the form of mist. ferri comp., or Griffiths' mixture, has had great repute in the treatment of anæmic amenorrhœa. The "Pilules de Blaud" contain carbonate of potassium and sulphate of iron, and have for many years retained a high reputation in the treatment of chlorosis, especially on the Continent (Niemeyer): his original memoir recording thirty successful cases, is republished by Bayle, and will repay perusal (Biblio. de Thérap., iv., 1837).

The choice of a compound in any case of anæmia or chlorosis

seems to me always to depend on the susceptibilities of the patient to the drug. Some are never able to take the astringent preparations even when the alimentary canal is not deranged. Dr. Ringer teaches, however, that the best results are always to be expected from these preparations—either the perchloride or the dried sulphate : the latter being especially useful in the shape of 5 gr. pills two or three times a day. Dr. S. Mackenzie recommends a form with 2 gr. of sulphate and 1 of carbonate of potassium, but Dr. C. Allbutt finds even this amount of alkali unnecessary for good results. Many patients again, can only take iron after their food ; indeed it is always best to give it at this time so that it may be more readily assimilated. In others, again, constipation is produced, though this may be obviated by giving the sulphate mixed with magnesium or sodium sulphate. In those unable to take astringent compounds in any form, one or other of the blander preparations must be employed, such as the citrate of iron and quinine ; one of the most valuable of these, however, is "dialysed iron" recommended by various observers, and the usefulness of this compound was so marked that it was admitted into the Pharmacopœia (1885). I have had excellent results from the protochloride, and sometimes the citrate with ammonia will be borne better than any other. Doenitz specially recommends an albuminate (see Preparations), and in the anæmia so common in Japan, and traceable to intestinal catarrh, found it better borne than any other compound. I have seldom seen the astringent forms, when given in a right dose and at a proper time, produce any injurious effect on a weak or irritable stomach ; indeed in many such cases I have found them particularly suitable, and we need not often be deterred from their use by fear of irritating effects : also they should be given in "menorrhagic chlorosis," for it is found practically better to treat the anæmia in such cases than to omit iron for fear of increasing hæmorrhage (Trousseau). This applies especially to cases where the discharge is profuse and frequent, but pale and coagulating imperfectly ; though even when it is florid in character iron may be ordered with advantage, if due attention be first given to such symptoms as hepatic congestion and constipation. Astringent preparations are also useful if there be a tendency to palpitation, general relaxation or undue discharges of any kind, and also when impairment of nervous power is a marked symp-

tom ; sometimes very large doses are most successful, thus extremely anæmic girls took a quart daily of a solution gradually increased in strength from 5 to 25 min. and upwards of perchloride tincture to the ounce of water : 30 oz. of the tincture were taken in twenty-seven days with nothing but good results, an aloes pill being taken daily (B. M. J., i., 1891). Aloes is often added to reduced iron or iron carbonate for phlegmatic subjects, and saline aperients to medicines containing iron sulphate, especially if the patient be *plethoric ;* sometimes small doses of belladonna will regulate the bowels, preventing constipation better than purgatives. In all cases, success will depend not upon giving a large quantity of the medicine, but upon *securing its due assimilation*, for which purpose air and exercise are important, and fatty food certainly aids the digestion of iron (Nasse, B. M. J., ii., 1877). Jeannel found that an oleo-stearate of iron, prepared with the sulphate and white soap, was very well borne : the chloropeptonate is also good, and the succinate will almost always agree well. Nitro-hydrochloric acid baths favour the absorption of iron (Chambers, Med. Times, i., 1862).

As already remarked it is important to continue the remedy sufficiently long, and not to omit it on the first symptoms of improvement ; permanent benefit can seldom be expected under five or six months ; Sir D. Duckworth has insisted upon this (B. M. J., i., 1887).

In cases where iron had not been given properly, and when it afterwards failed to produce due effect, I have found great advantage from *arsenic* alone, or in conjunction with iron. Manganese has also been recommended.

Anæmia of Pregnancy.—We consider iron not a direct, but an indirect emmenagogue, by virtue of its improving the condition of the blood ; but since the continued use of the mineral may cause congestion of the pelvic, as well as of other organs, it becomes an important question as to whether its use is admissible or is dangerous during pregnancy. Certainly the perchloride has been in frequent popular use as an abortifacient, but the evidence of its power for this purpose is not cogent. Its use has often furnished occasion for prosecutions, but few instances of its really causing abortion are recognised, and in many of these, as well as when the sulphate has been used, the effect seems to have followed from

violent irritation of the intestinal canal. It is true that cases in which abortion is deliberately produced would not, as a rule, find their way into the press; but allowing for this, I recognise a general impression gaining ground that iron may be taken during pregnancy without injurious effects. Ramsbotham and Barnes recommend it, the latter stating that he has never seen it do harm (Lancet, i., 1874). It was asserted during a trial that 10 gr. doses of ammonio-citrate of iron were dangerous to a pregnant woman, but Dr. Woodman contradicted this from his own experience, and Dr. Graily Hewitt said that he and others constantly prescribed it during pregnancy (B. M. J., i., 1870). Dr. Bassett brought before the Obstetrical Society many cases illustrating the value of the citrate and tartrate of iron in averting miscarriage and serious hæmorrhage in delicate women, and there seems to have been no difference of opinion upon the subject (Lancet, i., 1874); he considers that the addition of an alkali to the iron medicine renders it better borne, and points out that aperients should be given occasionally during the course. I can corroborate the experience of Dr. Bassett, and I think that the neutral preparations of iron are the most suitable during pregnancy, though some observers speak well even of the perchloride (Day, B. M. J., i., 1870). Trousseau remarks that iron has no direct emmenagogue power, and Hirtz has never seen any objection to using iron in the anæmia of pregnancy, though he has not found it very useful (Dict. de Méd.); altogether we must conclude that the older fears of injury from its moderate medicinal use were unfounded.

Phthisis.—A great deal of fear has also been expressed about the use of iron in this malady, and it has been said by eminent observers to hasten and aggravate its course, especially when given in full doses and in the early stages (Trousseau, Millet, Bull. de Thérap., 1862, etc.). If there be acute pyrexia and evidence of pulmonary congestion leading to hæmoptysis, then I think that iron is better avoided, because it can increase blood-pressure and congestion, and stimulate blood-formation; in any case it should be given with much caution during the early stages of the malady, and special attention should be directed to supplying at the same time any deficiency of fatty food, and to securing a due amount of oxygen (Dobell, B. M. J., i., 1867). Iodide of iron is one of the best preparations to use, especially in "scrofulous

phthisis," and it should be combined if possible, with cod-liver or other oils. In *later* stages of phthisis, all are agreed as to the value of iron in relieving many of the most distressing symptoms, and assisting any measure of recovery that can be obtained; the astringent preparations control purulent formations and discharges of various kinds, such as expectoration and passive hæmoptysis, diarrhœa and profuse perspiration, and they often improve the strength and the appetite. Bonorden used the sulphate in a number of cases, giving from 2 to 4 gr. every two hours for several days at a time; the dose seems large, but he obtained very good results (Schmidt's Jahrb., May, 1852). Dr. Thompson employed chiefly the perchloride at the Brompton Consumption Hospital, and calculated the effects of iron medication in more than 1500 cases—54·6 per cent. were found "improved," 23 per cent. much improved, and only 21 per cent. not improved. He does not give the details of any cases, nor does he mention the stages of the disease when iron was used, but states generally that the patients grew stronger, and were able to eat better, and suffered less from flatulence, diarrhœa, night sweats, and hæmoptysis; he considers that iron is clearly required in the treatment of phthisis, because "it improves the condition of the blood," and he advocates its continued but moderate use "as a food" (Pract., i.). Others have written special treatises in favour of this medication. Dr. Cotton obtained favourable results from the iodide and ammonio-citrate (Med. Times, i., 1860), and Sir Thomas Watson recommends iron in non-inflammatory forms of phthisis, and "finds the mist. ferri comp. very useful when it is well borne"; if sweating be profuse, he uses the perchloride. Dr. Cameron recommends the basic iodate of iron as better than the iodide; it contains 51 per cent. iodine and 11 per cent. iron (Dub. Quart., May, 1869).

Chronic Bronchitis—Emphysema.—In chronic bronchitis with profuse expectoration, I have found iron compounds, especially the perchloride and the phosphate, often useful; besides improving the general health, they lessen the amount of secretion and modify its character. In emphysema the perchloride is often valuable for its tonic power and its action on the capillaries, as well as for improving the impaired condition of the blood.

Cardiac Disease—Dropsy—Serous Effusion.—Cardiac pain and dyspnœa may often be relieved by iron preparations,

which act probably in an indirect manner, by improving the blood in the first instance,—hence their advantage is seen most in cases of anæmia: in such conditions occurring after acute rheumatism, even the physical signs—murmurs, etc.—may improve under a course of iron (Jones, Med. Times, i., 1861). Increased frequency of pulse is not, in itself, a contra-indication, but only when increase of tension is also detected. In mitral disease with dropsy, the acetate or perchloride is especially useful if combined with diuretics: in some cases of fatty degeneration of the heart, in many of chronic valvular disease and in dilatation, these and other compounds are well combined with digitalis. It also acts powerfully in dropsy resulting from a state of anæmia or hydræmia of the system, and good effects may be obtained from 3 to 5 gr. of ferrum redactum taken at meal times, or 15 to 30 min. of tincture of perchloride about half an hour after meals. Dr. Anstie has written strongly in favour of this in chronic pleuritic effusion, and my own experience quite corroborates his observations. Easton's, or a similar syrup of the phosphates of quinine, iron and strychnine, is useful in intermittent pulse, especially if anæmia be present; if there be much restlessness, bromide may be combined. Where the intermittency of the pulse is associated with general prostration and organic disease, the sulphate of iron is a good remedy (Asclepiad, 1884).

Albuminuria.—The astringent preparations of iron are often exceedingly useful in controlling the loss of albumen by the urine: we must remember however, that it is also possible to do harm by these remedies in renal diseases, and I have seen congestion increased by recourse to them during the acute stage (*cf.* Rotta, "Fer en Hydropisie," Annuaire de Thérap., 1857). The best effect is certainly obtained at the decline of this stage, when the urine is free from blood or inflammatory casts, when pain in the back and in the head, and the general febrile conditions are relieved, but the patient is pallid, weak and suffering from more or less anæmia and dropsy. Husemann praises it in "cachectic dropsy," and in that form which is connected with chronic nephritis and amyloid degeneration of the kidney. Then the value of such preparations as the perchloride or acetate is often very marked, both as regards the general health and the discharge of albumen. Dr. Hassall,

indeed, attributes these good effects more to a reconstituent action on the blood, "than to any direct astringent power, because he could not detect either the metal, or the acid combined with it (hydrochloric), in his analysis of the urine" (Lancet, ii., 1864). Dr. Parkes was one of the first to show, by quantitative analysis, the gradual lessening and final cure of the discharge of albumen under the influence of perchloride: this was in a sub-acute case, when the early inflammation had subsided, and hospital nursing and the use of gallic acid had quite failed to relieve (Med. Times, ii., 1854). In all cases of this kind it is desirable to feel one's way with iron preparations, to begin at first with a small dose; and the recommendation of the late Dr. Basham to combine with it the acetate of ammonium, is a very good one. The addition of ergot will increase the astringent effect, and in albuminuria following scarlatina especially when dropsy is present, tincture or infusion of digitalis alternately with tincture of perchloride of iron, is a valuable prescription: it increases the flow of urine, at the same time that by its action on the blood and the capillaries it restrains the transudation of albumen: Dr. Goodfellow and Dr. Cheadle have reported favourable results with it (Med. Times, ii., 1871; Ranking, i., 1873).

In chronic forms of albuminuria iron will require consideration: it is often extremely useful, improving the condition of the blood more than any other remedy, and Dr. Lionel Beale testifies to its good effects even in chronic structural change and fatty degeneration (Med. Times, i., 1865), but the cases in which it does harm are those with granular kidney, when the heart is large, the pulse hard and of high tension, and when there is much tendency to headache (Dickinson, Lancet, i., 1876). Hirtz says that he has seen it hasten a fatal termination by uræmia, lessening the amount of urine, and increasing the production of urea (Nouv. Dict., Art. Fer.), so that its effects should always be carefully watched: a very important point when ordering iron in any case of albuminuria is to obviate constipation.

Chyluria.—The perchloride of iron has sometimes proved very useful in cases of this kind, even when they have lasted for several years (Lancet, ii., 1862).

Diabetes.—Carbonated iron waters are much esteemed as adjuvants in the management of diabetes; and Dr. Mackey

informs me that the bromide of iron, or rather a combination of bromide of potassium and citrate of iron, has given him better results than other medicines; but I believe the iron only acts to a small extent, the bromides producing the best effects. Of course the diet and hygiene must be regulated, and when we can more accurately distinguish the varieties of the malady we may find that certain medicines are more appropriate to some forms than to others, but, meanwhile, I believe the bromide of iron is available in any ordinary chronic case: I have frequently seen the general health improve and the amount of sugar grow less under its use.

Dyspepsia.—Although iron is contra-indicated in cases of acute and irritative dyspepsia and mal-assimilation, yet certain forms of "atonic dyspepsia" which are connected with debility and an impaired condition of the blood, are well treated by it. There are the general symptoms of anæmia, and also a sense of weight and heaviness after food and impaired appetite, rather than of acute pain, and the preparations usually most suitable are such as the citrate or ammonio-citrate combined with soda and calumba, or reduced iron with nux-vomica: the headache which often accompanies this condition is also relieved by these medicines: when there is much general relaxation or gastric catarrh of chronic character, the perchloride preferably with quassia, is valuable. In the dyspepsia of chlorosis, iron will often not agree if the tongue be furred, or the urine loaded: but if these conditions are present only in a minor degree, then the citrate may be used in effervescence with soda (Budd, On Dyspepsia). Dr. Milner Fothergill, in an article "When not to give Iron," insists on the importance of clean tongue and freedom from "biliousness," and quotes Sir J. Fayrer to the same effect (Pract., 1877): he remarks also that toleration of it diminishes with age. The hypodermic use of the drug may be indicated for dyspeptics.

Diarrhœa.—In simple cases occurring in weakly children, and continuing after preventable causes have been removed, the vinum ferri is a mild but very useful astringent tonic, which is often sufficient both to stay the discharge, and to prevent its recurrence. In more serious cases of chronic mucous and dysenteric diarrhœa with slimy, bloody, offensive stools and tenesmus,

whether met with in adults or in children, the best preparation is the liquor ferri pernitratis in doses of from 1 to 5 drops, as originally recommended by Neligan, and I have seen also much benefit from its use in the colliquative diarrhœa of phthisis. Dr. Graves specially advised it in the "nervous diarrhœa" which is liable to occur from emotional causes, and is more frequent in women: in cases with nausea and impaired appetite, calumba may be well added to the iron (B. M. J., ii., 1870). In diarrhœa with offensive stools the sulphate is often a good remedy (*ib.*, ii., 1836). The citrate, of which 5 gr. are recommended for infants, or 30 gr. or Blaud's pills for adults, is also said to be of much benefit and to remove the offensive odour of stools, whilst the perchloride with a little morphine is best for the diarrhœa (and cough) of phthisis (*ib.*, ii., 1892).

Dysentery.—I cannot recommend iron preparations during the acute stage of dysentery, for I believe there are much better remedies, but some practitioners have found them valuable. Bandon reports twelve cases suffering from tormina and very frequent sanguineous stools, which were treated by 12 to 30 min. doses of steel tincture internally, at the same time that about 12 min. with water (and sometimes laudanum) were injected; these cases were much relieved or cured within a week (Bull. de Thérap., t. 71). Blanvillon corroborated these results (Gaz. des Hôp., No. 130), and the same medication was largely used during the last German war (Lancet, ii., 1870): as a general rule, it is better restricted to chronic stages of dysentery, and for the anæmia and debility attendant upon this condition it is of great value. Dr. Maclean's favourite remedy, especially in men returning from tropical regions, anæmic from loss of blood and the depraving influence of malaria, was the solution of the pernitrate of iron. Under this remedy the whole system often rallies wonderfully, the condition of the blood improves, and the stools become natural and less frequent; the citrate of iron and quinine may after a time be substituted (Quain's Dictionary; *cf.* B. M. J., ii., 1893).

Cholera.—Iron is one of the numberless remedies recommended for cholera, but I have very little personal experience of its use: it would of course, not be depended upon alone, and Robiquet has reported a number of successful cases treated by the

citrate and by reduced iron with quinine,—frictions, warmth and nutriment being conjoined (Journ. de Méd., 1873; Pract., vol. xi.).

Nervous Disorders—Hypochondriasis, etc.—The nervous system naturally suffers when it does not receive a due supply of healthy blood: depression and a sense of oppression will be felt, whilst hysterical or hypochondriacal symptoms will be more or less pronounced: in such cases, iron is often a valuable adjunct to other treatment and is especially suitable when combined with bromides. In the nervous symptoms which commonly occur in women at the climacteric period, including restlessness, anxiety, fluttering and sinking at the epigastrium, giddiness, clavus, and sometimes menorrhagia, the perchloride, with or without bromide, gives great relief.

Dipsomania.—Morbid craving for drink and alcoholic insomnia, have been controlled by drachm doses of tincture of iron when many other remedies have failed (Med. Times, i., 1875). The sulphate has also given relief in such cases, especially when combined with aromatics.

Neuralgia.—Before the introduction of many modern remedies for neuralgia, large doses of the carbonate or oxide of iron were much relied upon, and when there is a chlorotic anæmic condition of system they are of service. I should not myself consider iron a remedy for "idiopathic neuralgia," but some observers have attributed to it almost a specific power, especially in neuralgiæ of the fifth nerve: thus, Mr. Hutchinson recommends it in "prosopalgia," and according to Schobelt, the phosphate of iron acts well in neuralgia of the teeth: the citrate of iron and quinine is a very good form when the remedy has to be long continued.

When *neuralgia of the stomach* occurs in anæmic or chlorotic patients, who complain of cramping pain and distension, accompanied with nausea and vomiting of mucus and water principally before breakfast, and of frequent acid and insipid eructations after meals, iron is useful especially when the neuralgia depends on loss of blood or on protracted diarrhœa; I have notes of many such cases cured by it.

Chorea.—When this disorder is dependent upon anæmia, iron is clearly indicated and may prove of great service, as it did in the hands of Elliotson, who used large doses of oxide (Med. Times, i., 1869). Sir T. Watson recommended the carbonate.

Many cases occur about the time of commencing puberty, and others evince obscure rheumatic symptoms: in these also iron is useful, but it often acts better when taken in conjunction with arsenic.

Epilepsy.—Ferruginous medicines were at one time much esteemed in the treatment of epilepsy or of attacks resembling it, but as diagnosis became more exact, and more reliable remedies were discovered, iron passed out of use. Brown-Séquard taught that although it might improve the condition of the blood, it tended to aggravate the malady itself, and Dr. Hughlings Jackson after much observation, expressed the same opinion. Dr. Gowers writing more recently, acknowledges that it is sometimes the case, but on the other hand, he has found that iron has a true place in the therapeusis of epilepsy: he has observed benefit from it in cases that are on the borderland between epilepsy and hysteria, and in others when the attacks were limited to the night-time, and in many of these cases the improvement was fairly permanent: he suggests, and I should think very plausibly, that it acts like other metals (as silver or zinc seems to do in such cases), as a nerve-tonic, rather than simply by hæmatinic properties (Pract., 1877). Fabre has published a thesis showing the value of the medicine ("Fer contre l'Epilepsie, Paris, 1853). On the whole, we may conclude that iron has been unduly discredited in epileptic or epileptiform conditions. I think that when these arise from onanism, or when a patient is anæmic, it should be used but generally in combination with bromides.

Constitutional Syphilis.—This malady like all others in which a poisonous material circulates in the blood, much impairs the condition of that fluid rendering the corpuscles fewer, smaller and paler; in such cases iron becomes very serviceable, though it will not take the place of more special remedies for the principal disease. Ricord recommended the potassio-tartrate even in primary syphilis, and especially for phagedænic ulceration in debilitated subjects: the theory sustained in opposition to him by certain French writers, that iron aids the development of the malady, is not tenable. The iodide of iron I have found very useful in the later stages of syphilis in cachectic subjects.

Struma—Rachitis.—In the different forms of disease included under these headings, and characterised by enlarged or

suppurating glands, irritable mucous membranes, caries and swelling of the knee and elbow joints, emaciation, etc., iron, although much lauded by Hufeland, is not so serviceable when given alone as are certain alteratives—iodine, lime, etc.—but when combined with such remedies it is of great value for the cachexia, anæmia, and torpor of the blood-forming glands, which are its usual accompaniments; I have indeed, found the iodide of iron to be an excellent remedy for most affections of a scrofulous type. The perchloride, as already mentioned, is a good external application for discharging glands. The vinum ferri or an alkaline citrate with aromatics, is very useful in the *mucous diarrhœa* of rachitic children.

Worms.—The astringent tonic effect of the perchloride on the gastro-intestinal mucous membrane renders it a good adjunct to purgative treatment for these parasites, and a useful prophylactic. When diluted it may be injected into the rectum for destroying ascarides: I generally use about 1 dr. of the liquor in 4 oz. of infusion of quassia: a stronger solution is liable to cause unnecessary pain.

PREPARATIONS AND DOSE.—Iron preparations especially the liquid astringent forms, discolour the teeth and stain the tongue black—they should be taken through a glass tube: glycerine lessens the rough astringent taste, and a gargle of milk will relieve it (Guibout). A lotion of quadroxalate of potassium (½ dr. in ½ pint of rose-water) will remove the black staining.

Mistura ferri aromatica (made with iron wire, cinchona, calumba and aromatics): dose, 1 to 2 fl. oz. *Vinum ferri* (made with iron wire and sherry): dose, 1 to 4 fl. dr. and upwards. *Ferrum redactum:* dose, 1 to 5 gr. for adults, ¼ to 1 gr. for children. *Trochisci ferri redacti:* each lozenge contains a grain of reduced iron. Reduced iron may be taken with advantage during a meal, the powder being mixed with the food. *Ferri peroxidum hydratum:* dose, 5 to 30 gr. or more in treacle or honey. *Emplastrum ferri—Chalybeate plaster* (contains hydrated peroxide of iron, Burgundy pitch, and lead plaster). *Ferri carbonas saccharata:* dose, 5 to 30 gr. or more. *Mistura ferri composita* (contains sulphate of iron, carbonate of potash, nutmeg, sugar and rose-water): dose, 1 to 2 fl. oz. *Pilula ferri carbonatis* (contains saccharated carbonate of iron and confection of roses): dose, 5 to 20 gr. or more. *Pilula ferri:* dose, 1 to 3 pills.

Syrupus ferri iodidi (contains iodine 2 parts, iron 1 part, with sugar and water): dose, 30 to 60 min.; each fluid drachm of the syrup contains nearly four grains and a half of iodide of iron. *Pilula ferri iodidi:* dose, 3½ to 8 gr. or more; one grain of iodide of iron is contained in about 3½ gr. of the

pill. *Syrupus ferri subchloridi :* dose, ½ to 1 dr. *Ferri sulphas :* dose, 1 to 5 gr. *Ferri sulphas exsiccata :* dose, ½ to 3 gr. or more (3 gr. with 2 of manna make a good pill). *Ferri sulphas granulata :* dose, 1 to 5 gr. *Ferri arsenias :* dose, $\frac{1}{16}$ gradually increased to ½ gr. in pill. *Ferri phosphas :* dose, 5 to 10 gr. *Syrupus ferri phosphatis :* dose, 1 dr. and upwards (contains about 1 gr. of anhydrous phosphate of iron in each fl. dr. ; is colourless when fresh).

Liquor ferri perchloridi fortior : dose, 3 to 10 min. *Liquor ferri perchloridi* (contains 1 part of the last-mentioned to 3 of distilled water, sp. gr. ·995) : dose, 10 to 30 min. or more. *Tinctura ferri perchloridi*[1] (contains 1 part of the stronger solution to 3 of rectified spirit, sp. gr. ·995) : dose, 10 to 30 min. or more. *Liquor ferri dialysatus :* dose, 10 to 30 min. *Liquor ferri pernitratis :* dose, 10 to 40 min. *Liquor ferri persulphatis* (chiefly used in preparing other ferruginous salts).

Ferri et ammonii citras : dose, 5 to 10 gr. or more. *Vinum ferri citratis* (prepared with orange wine gr. 1 in each ʒi) : dose, 1 to 4 dr. *Ferrum tartaratum :* dose, 5 to 10 gr. *Ferri et quininæ citras :* dose, 5 to 10 gr. *Liquor ferri acetatis fortior :* dose, 1 to 8 min. *Tinctura ferri acetatis :* dose, 5 to 30 min. *Liquor ferri acetatis :* dose, 5 to 30 min.

The non-officinal preparations are very numerous, and include the following :—

Ferri oxidum magneticum, ferri peroxidum humidum, ferri iodidum.

Preparations of Tisy (French) : these are all proto-salts and are sent out in capsules—as of Fer ioduré, etc. ; analysis shows the quantity contained in each capsule to be very small, and not constant (Pract., vol. vii.).

Preparations of Creuse (American) : these are double salts, such as a phosphate with ammonio-citrate—non-astringent : also a tasteless iodide and chloride (Pharm. Journ., May, 1873, and Feb., 1874).

Preparations of Robiquet (French) : these are double salts, as a citro-ammoniacal phosphate ; they are not definite in composition. *Preparation of Béchamp* (French) : this is a peroxychloride, obtained by treating neutral perchloride with a varying quantity of peroxide ; it is tasteless, not caustic or irritant, but hæmostatic (Med. Record, 1874). *The preparations of Lebarqui, Bravais, Squire, Chateaud, Mungham, and Wyeth*, are different forms of oxide—"dialysed," "soluble," "colloid." *Van den Corput's preparation* is a double citrate of iron and magnesium (Belgian) : that of *Saquet* is a pyrophosphate

[1] The tincture of perchloride often becomes turbid, which is due to its not containing sufficient chlorine, part of this gas being driven off by the long process of evaporation which is required in order to drive off nitric acid ; the quantity of acid ordered in B.P. is 25 per cent. over the quantity required by chemical calculation, and Schacht finds that by using less (20 per cent. less) he obtains a preparation having less hyponitrous ether, and which keeps better (Pharm. Journ., Sept., 1872). The U.S. Pharmacopœia specially provides for the development of muriatic ether in the tincture.

with soda, ammonia, and malt extract. *Lightfoot's solution* is said to be a magnetic phosphate.

Besides these, we have in more common use—*Bromide of iron :* dose, 1 to 5 gr. *Hypophosphite of iron syrup:* dose, 1 dr. (Pharm. Journ., v., vii.). *Parrish's syrup of phosphates* (compound), containing in each drachm 1 gr. phosphate of iron with soda and potash ; *Beef and iron wine ; Monsel's solution* (liq. ferri subsulphatis) ;' and many others. There are also granular effervescent forms in various combinations with arsenic, etc.

Organic compounds of iron are such as the *albuminate*, which has been made into a good lozenge with chocolate : dose, 10 gr. ; the *succinate :* dose, 10 to 15 gr. ; and the *chloro-peptonate.*

Iron is also used in the manufacture of filters for water, and acts in the same way as carbon. One variety is that of the spongy iron filters ; in another kind a mixture of carbon, iron and aluminium called Carferal is used.

Flitwick chalybeate spring, in Bedfordshire, is rich in iron and ought to be a good therapeutic agent ; it has an acid reaction and a clear orange-red colour, and keeps bright even when exposed to the atmosphere for an indefinite period. Analysis proves that it contains a large amount of iron (96·5 in 100,000) in the "ferric" state, with small amounts of alumina, lime and magnesia, combined with sulphuric acid as sulphates, and a large quantity of organic compounds derived from peat. It is said not to affect the teeth, nor to constipate (see also under chalybeate waters).

HYDRARGYRUM—MERCURY—QUICK-SILVER (Hg = 200).

Mercury is most frequently found in combination with sulphur as native sulphide or cinnabar, in mines in Almaden, Ydria, China, Peru, Japan and California. It is obtained from the ore by fusion with lime, which combines with the sulphur while the mercury distils over. It occurs also as a natural amalgam with silver—" argental mercury," and combined with chlorine in small grey crystals, known as " horn mercury " ; also more rarely as an iodide, and sometimes in a pure state—" virgin mercury."

CHARACTERS AND TESTS.—Mercury is a silver-white metal with bluish lustre, fluid at ordinary temperatures, and susceptible of such division that it may be squeezed in minute globules through chamois leather. When pure it has neither

taste nor smell; it readily oxidises on exposure to the air, but does not tarnish; should tarnishing occur, it implies the presence of other metals as lead, zinc, or bismuth; on agitation with alcohol, ether, or turpentine, or trituration with sulphur or unctuous substances, it loses its fluid character. With other metals and even with hydrogen, it forms soft compounds termed *amalgams*, and a mere trace of it will leave a white stain on silver or gold. It has a sp. gr. of 13·59, which is exceeded only by that of gold and platinum, is slightly volatile at ordinary temperatures, boils at 662° F. (350° C.), and freezes at – 39° F., becoming crystalline, tough, malleable and sonorous. Its specific heat is low but it is a good conductor, and has a regular rate of expansion and contraction, hence it is well suited for thermometric and barometric purposes: from its power of combining readily with silver and gold, and yet afterwards quickly volatilising on being heated, it is valuable in the arts of gilding and silvering, and alloyed with tinfoil it forms the reflecting surface of mirrors.

Hydrochloric acid has no action on mercury, and hence the chlorides cannot be prepared in a direct manner. Sulphuric acid when boiling, and nitric acid whether cold or hot, form respectively salts of different degrees of saturation—*proto-* or *sub-salts* which are known as *mercurous*, and *per-salts* known as *mercuric*, which have much more active powers than the former.

The per-salts of mercury are many of them (as the perchloride and red iodide) soluble in ether, while the proto-salts are not, so that by this agent they may be separated from each other.

If any salt of mercury be heated in a test tube with sodic carbonate the pure metal will sublime, and it may be obtained from its various combinations by distillation. With sulphuretted hydrogen in excess, mercurial compounds give a black precipitate of sulphide, but the best general test is the deposition of metallic mercury upon bright copper. It may be applied by heating any mercurial salt with a strip of copper and a few drops of hydrochloric acid, and if the copper be afterwards heated, small globules of quicksilver may be obtained as a sublimate.

Compounds of Mercury.

Hydrargyri Subchloridum—Subchloride of Mercury, or Mercurous Chloride—Calomelas—Calomel Mercurius Dulcis ($HgCl = 235{\cdot}5$).

Preparation.—(1) Ten parts of persulphate of mercury are triturated with seven of metallic mercury and a little water, so that a subsulphate is formed—thus

$$HgSO_4 + Hg = Hg_2SO_4.$$

(2) Chloride of sodium is then added with trituration, the mixture is heated, and the subchloride of mercury sublimes as vapour, while sulphate of sodium is left—thus

$$Hg_2SO_4 + 2NaCl = Na_2SO_4 + 2HgCl.$$

A large condensing chamber is required in order to obtain a *fine* powder, and this is washed with hot water in order to remove any perchloride that may be formed.

Characters and Tests.—Calomel usually occurs as a heavy, dull white powder, which is rendered yellow by trituration or by gentle heat: if sublimed in a small chamber, fibrous crystalline lumps are produced. The specific gravity is 7·2. It has no taste—hence the name of "mercurius dulcis." It is not acted upon by hot water, ether, alcohol or dilute acids, but potash or soda decomposes it with precipitation of the black oxide of mercury. Prussic acid also turns calomel black by causing the separation of metallic mercury. Pure calomel is entirely volatilised by heat, and warm ether shaken with it should leave no residue on evaporation (showing the absence of corrosive sublimate).

Hydrargyri Perchloridum—Perchloride of Mercury—Corrosive Sublimate

($HgCl_2 = 271$).

Preparation.—By subliming dry persulphate of mercury with four-fifths of its weight of dried sodium chloride, 2 or 3 per cent. of oxide of manganese being previously added to the mixture. The reaction is as follows:—

$$HgSO_4 + NaCl = HgCl_2 + Na_2SO_4,$$

sulphate of sodium being left, and corrosive sublimate condensing in the cooler part of the subliming apparatus. It will be noticed that the manganese has no share in the decomposition; it is introduced in order that it may set free from the excess of sodic chloride some free chlorine to combine with any calomel that may be formed, and convert it into corrosive sublimate: calomel

would be formed if the mercuric sulphate contained any mercurous salt, as it is apt to do. The fumes are extremely acrid and poisonous.

CHARACTERS AND TESTS.—Corrosive sublimate occurs in white crystalline heavy masses, of specific gravity 5·2; it is entirely volatilised by heat, is soluble in 16 parts of cold and 3 of boiling water, soluble also in alcohol, and still more so in ether. The strong mineral acids dissolve it without decomposition. Alkaline chlorides render it more soluble in water, and hence ammonium chloride is introduced into the official solution of the sublimate, and forms with it a double salt (sal alembroth). A simple solution in water readily decomposes, calomel being precipitated, and if exposed to light and to contact with organic substances, metallic mercury separates. Ammonia gives a white precipitate of ammonio-chloride, potassic iodide produces the red iodide, potash a precipitate of the yellow oxide, and nitrate of silver a curdy white silver chloride. Albumen also combines directly with corrosive sublimate and precipitates its solutions.

HYDRARGYRUM AMMONIATUM—AMMONIATED MERCURY—WHITE PRECIPITATE

(NH_2HgCl = 251).

PREPARATION.—By adding solution of corrosive sublimate to ammonia chloride of ammonium is formed, and an ammonio-chloride of mercury precipitated.

$$HgCl_2 + 2NH_3 = NH_2HgCl + NH_4Cl.$$

The ammonium salt is removed by washing after filtration.

CHARACTERS AND TESTS.—This compound occurs as a heavy white powder, or in small cones marked by the linen filters: it has a metallic taste; no odour; is insoluble in cold water, alcohol, and ether; soluble in warm acids; decomposed by caustic potash evolving ammonia, whilst yellow oxide of mercury is precipitated. Boiled with chloride of tin it gives a precipitate first grey and then black, from the presence first of subchloride and metallic mercury, and next of the metal wholly; this has been called the *magpie* test. Chlorine and bromine both act violently on white precipitate forming mercuric chloride or bromide, the action in many cases being attended with explosion. With iodine, an explosion almost invariably takes place after a few minutes, iodide of nitrogen being formed.

HYDRARGYRI IODIDUM VIRIDE—GREEN IODIDE OF MERCURY (non-off.)

(HgI = 327).

PREPARATION.—By triturating together mercury and iodine in proper atomic proportions: some rectified spirit is added in order to dissolve the iodine, and to lessen by evaporation, the heat evolved in the process.

CHARACTERS AND TESTS.—The pure mercurous iodide is a yellow powder, but according to the mode of preparation or degree of exposure to light, becomes greenish and olive-coloured or even black; it is insoluble in water or ether; entirely volatilises when rapidly heated, but if warmed slowly in a test tube, yields a yellow sublimate (pure mercurous iodide), metallic mercury being left: the yellow sublimate turns red on friction.

HYDRARGYRI IODIDUM RUBRUM— RED IODIDE OF MERCURY

(HgI_2 = 454).

PREPARATION.—By mixing together boiling solutions of iodide of potassium and corrosive sublimate: double decomposition ensues and the red iodide is precipitated.

$$HgCl_2 + 2KI = 2KCl + HgI_2.$$

CHARACTERS AND TESTS.—A crystalline red powder, which becomes yellow when gently heated and again red upon friction or after cooling: this change in colour is due to a change in crystalline form, the yellow crystals being rhomboidal,—the red, octahedral prisms. The salt is insoluble in water, soluble in ether and solutions of iodide of potassium. The presence of iodine may be verified by starch producing a blue colour in a solution which has been digested with soda and acidified with nitric acid.

HYDRARGYRI OXIDUM FLAVUM— YELLOW OXIDE OF MERCURY

(HgO = 216).

PREPARATION.—By adding solution of perchloride of mercury to excess of solution of soda: chloride of sodium and water are formed, and the yellow mercuric oxide is precipitated.

$$HgCl_2 + 2NaHO = 2NaCl + HgO + H_2O.$$

CHARACTERS AND TESTS.—A smooth yellow heavy powder, becoming grey on exposure to light; it is insoluble in

water, readily soluble in hydrochloric acid, entirely volatilised by heat, being resolved into oxygen and mercurial vapour. This oxide is an allotropic form of the red oxide; it is smoother and combines more readily with certain acids; it is better adapted for ointment used on delicate surfaces as the eyelids, and is preferred for the preparation of oleates.

HYDRARGYRI OXIDUM RUBRUM—
RED OXIDE OF MERCURY—RED PRECIPITATE

(HgO = 216).

PREPARATION.—By triturating and heating nitrate of mercury with an equivalent of metallic mercury: nitrous oxide gas is given off.

$$Hg(NO_3)_2 + Hg = 2HgO + 2NO_2.$$

CHARACTERS AND TESTS.—An orange-red crystalline powder almost insoluble in water, soluble in acids, the solution giving a yellow precipitate with caustic potash in excess, and a white one with ammonia; it is wholly volatilised by a heat below redness, and was the salt from which Priestley first disengaged oxygen (by means of a lens and sunlight).

LIQUOR HYDRARGYRI NITRATIS ACIDUS—
ACID SOLUTION OF NITRATE OF MERCURY

($Hg(NO_3)_2$ = 324).

PREPARATION.—By dissolving mercury in cold slightly diluted nitric acid, when mercurous nitrate is formed.

$$3Hg + 4HNO_3 = 3HgNO_3 + 2H_2O + NO.$$

By subsequent boiling this is changed into the mercuric nitrate.

$$3HgNO_3 + 4HNO_3 = 3Hg(NO_3)_2 + 2H_2O + NO.$$

Free nitric acid is also contained in the solution.

CHARACTERS AND TESTS.—A colourless strongly acid solution, from which excess of caustic potash precipitates the yellow oxide; water also decomposes the solution, precipitating oxynitrates. The presence of nitric acid is shown by the darkening of crystals of ferrous sulphate introduced into it.

Unguentum Hydrargyri Nitratis—Ointment of Nitrate of Mercury—Unguentum Citrinum, is prepared by dissolving mercury in nitric acid and then stirring it up with melted lard and olive oil; it is lemon-yellow in colour. A diluted form is also officinal.

HYDRARGYRI SULPHURATUM—SULPHURET OR SULPHIDE OF MERCURY—CINNABAR (HgS = 232) (*non-off.*).

PREPARATION.—By melting together with proper precautions, equivalents of mercury and sulphur, triturating the mixture and then subliming.

CHARACTERS AND TESTS.—It occurs in dark-scarlet crystalline masses which, when powdered, are known as vermilion; it volatilises on heating; on reduction with potash, metallic mercury separates out.

HYDRARGYRI PERSULPHAS—PERSULPHATE OF MERCURY ($HgSO_4$ = 296).

PREPARATION.—By heating mercury with sulphuric acid; sulphurous acid gas escapes, and mercuric sulphate and water are formed as represented in this formula:—

$$Hg + 2H_2SO_4 = HgSO_4 + SO_2 + 2H_2O.$$

The mixture is then evaporated to dryness.

CHARACTERS.—A heavy white crystalline powder, which is decomposed by water into a soluble acid sulphate and a yellow oxysulphate, known as turpeth mineral.

HYDRARGYRI CYANIDUM—CYANIDE OR BI-CYANIDE OF MERCURY $HgCy_2$ (*non-off.*).

PREPARATION.—By dissolving 1 part of ferro-cyanide of potassium in 15 of boiling water, adding 2 parts of mercuric sulphate, heating for ten minutes, filtering and cooling to crystallisation: besides the cyanide, mercury, ferric sulphate, and sulphate of potassium are formed in this process.

CHARACTERS AND TESTS.—Rectangular prisms sometimes transparent, generally opaque and white, taste metallic. It is stable in air, soluble in water, sparingly so in alcohol.

HYDRARGYRI CARBOLAS—CARBOLATE OF MERCURY, PHENOL MERCURY (*non-off.*).

PREPARATION.—By precipitating a dilute solution of corrosive sublimate with a concentrated alcoholic solution of carbolate of potassium. It is a neutral salt, occurring as a nearly white tasteless amorphous powder, sparingly soluble in cold, but readily soluble in boiling hydrochloric acid.

HYDRARGYRI TANNAS—TANNATE OF MERCURY (*non-off.*).

Occurs in dark-green powder or scales, odourless and tasteless: unaffected by dilute hydrochloric acid, but alkalies and their carbonates readily decompose it, separating minute particles of mercury, of which it contains 50 per cent.

OLEATUM HYDRARGYRI—OLEATE OF MERCURY.

PREPARATION.—By stirring and occasionally triturating oleic acid with the yellow oxide of mercury.

CHARACTERS.—It is a light-brown oleaginous semi-solid substance, composed of oleate of mercury and oleic acid, and having a slight odour of the latter. When warmed gently, no black precipitate separates. Heated with a piece of copper foil, the latter becomes coated with a film of metallic mercury.

ABSORPTION AND ELIMINATION.—*Metallic Mercury.*—The question whether mercury can be absorbed in its *metallic* state, either by the skin or the digestive tract, has been the subject of much debate and contradictory facts have been alleged concerning it. Von Hasselt found the metal in the blood of mercurialised persons, and Colson obtained a deposit of it from a brass plate placed for a time in contact with blood drawn from a patient who had taken the drug (Archives Gén., xii.). Claude Bernard filled the medullary cavity of a dog's femur with quicksilver, closed the perforation with wax and allowed the soft parts to heal; three months afterwards most of the metal had disappeared from the bone, and was found in small globules encysted on the surface of the lungs. In another dog the metal was injected into the jugular vein, and twenty-five days afterwards found "divisé à l'infini," in the cardiac tissue under the pericardium, so that it would not remain in the blood, though taken up by it. Oesterlen used mercurial frictions on cats, giving them also internally pills of blue ointment, and he reported the finding of mercurial globules not only in the skin, but in most of the organs. Overbeck confirmed these results on rabbits, and Blomberg detected mercurial globules in cats to which he had given pills of citrine ointment (Treatise on Absorption of Mercury, Helsingfors, 1868). The latter observer used mercurial friction

on the arm of a dead body, and found globules in the corium and mucous layers but not deeper.

Such observations would seem conclusive but that Bärensprung, Rindfleisch, and others find it impossible to verify them: they have made the frictions and given the pills, but they cannot find the metal in the blood, nor yet in the corium. Autenrieth could find no amalgam on plates of gold introduced into the subcutaneous tissue under the place of friction; and Gubler and Neumann, whilst they recognised the metal in the sweat-glands and hair-follicles, could trace it no further. Rindfleisch it is true, found mercury once in mesenteric glands after giving mercurial pills; but there were ulcerations in the intestinal mucous coat which might have permitted the passage of the metallic globules (Archiv für Dermatol., iii., 1870). More recent observations are those of Fleischer, who concludes from numerous experiments, that "frictions with mercurial ointment cause the penetration of metallic particles into the superficial layers of epidermis, but not deeper": and a consideration of the whole evidence warrants this negative conclusion, that although *metallic* mercury, when administered by the mouth in substance, or actually placed within the tissues, may circulate and be deposited, it does not seem to be absorbed in the ordinary sense, and when applied by friction it usually does not pass either into the deeper tissues or into the blood.

The physiological effects of mercurial frictions must be connected therefore, with its absorption in some other form: either mercurial vapour is inhaled during the process, or some compound of mercury enters through the skin. As to the former point, we know that sometimes salivation has occurred in a wife, six hours after a friction made by the husband upon himself only, both living in rather a small room (Samelsohn, quoted by Hallopeau); and additional evidence in favour of such an effect is furnished by the delicate observations of Merget. He demonstrated that mercury volatilised at all temperatures, and by means of iridium-paper (which showed a dark stain on contact with the vapour), he proved its presence on the hands or other parts of the body of persons who had spent only a few hours in a workshop where it had been used (Comptes Rendus, Dec., 1871). That the mercurial vapour is not absorbed *only* by the

lungs is evident from a carefully devised experiment by Fleischer (Erlangen): he caused frictions to be made upon an arm whilst the patient—with face covered by a mask—breathed only external air; the limb was then carefully wrapped in wool and oiled silk for sixty hours, and during that time the presence of mercury (in very small quantity) was verified in the urine. Pinner rubbed blue ointment into the skin of a rabbit—15 gr. thrice in four days—and covered up the anointed part so that no mercury could volatilise, but if absorbed at all, must be so through the skin; the animal died in thirty-two days. Twenty-four hours after the first inunction and up till death, mercury was detected in the fæces and urine, and hence he concludes that absorption through the skin must occur (Therap. Monatshefte, 1889).

We may state then that mercurial *vapour* is absorbed, not only by the lungs but also by the skin, and indeed the results of ordinary fumigations—when the head is external to the apparatus—would be sufficient to prove this. Gubler holds that the sweat-glands are the active agents in this absorption, and Röhrig admits that mercury in vapour can pass through the epidermis (Stricker's Jahrb., ii., 1873). It is probable also that some may be absorbed as *oxide* in combination with fatty or other acids contained in the secretions of the sebaceous and sweat-glands. Bärensprung and others have proved the presence of such oxide in "blue" ointment; Nevins calculated it at 1 part in 100, and Voit, analysing portions of skin which had been rubbed with it, found the oxide constantly present. A soluble double salt may be formed with the chlorides of the perspiration (Müller); and if mercurial oxides be given internally, Voit argues that the chlorides of the blood can change suboxide into calomel and peroxide into perchloride, which salts then combine with sodium chloride and albumen. Further researches on this point are those of Nega, who concludes (from fifty-five cases) that an ointment made with oxide is not more readily absorbed than one made with finely divided metal, and that the oleate is no better absorbed than grey ointment (French Ph.) or mercurial soap, but is less irritant (Rev. Gén., to. 28, 1886).

Metallic mercury, given by the mouth, usually passes off unchanged by the bowel; in the rare cases where it has given rise to constitutional effects, a portion has probably been oxidised or

changed into sublimate. In the very finely divided form, when the metal is "extinguished" by continued friction with chalk (grey powder), or with confection of roses (blue pill), Rabuteau thinks it may be directly absorbed from the intestine, but no doubt some oxidation occurs during trituration, and the oxide would be soluble more readily in the acid of the gastric juice: mercury in a volatile form would also be disengaged from such compounds as readily within the body as without, at the same temperature. Mercurial ointment or pill, introduced as a suppository into the rectum, produces physiological effects perhaps more quickly than by the stomach. In the various trades which require the handling of quicksilver—such as barometer- and mirror-making, gilding, and skin-dressing, and again, in miners at Almaden and elsewhere—the physiological effects produced are mainly traceable to inhalation of the vapour.

Calomel.—Calomel being insoluble, like metallic mercury, in ordinary liquids, there has been still more speculation as to how it could reach the current of the circulation.

According to the classic theory of Mialhe, it becomes, like other mercurial compounds, changed more or less into the soluble *perchloride* by the action of the gastric fluids, and is absorbed only to the extent of such change. Mialhe argued from the results obtained by heating together calomel and ammonium chloride in a test tube, but Buchheim and others failed to verify any formation of perchloride in such a mixture at the *temperature of the body*. Rutherford, experimenting more recently, digested 5 gr. of pure calomel in distilled water, with ·02 per cent. of free hydrochloric acid—(the same proportion as in gastric juice)—at 100° F. for seventeen hours, and obtained $\frac{1}{35}$ gr. of perchloride, but it is unlikely that even so much as this would be formed in the stomach; and the action of calomel so far differs from that of corrosive sublimate as to render it, clinically speaking, improbable, that it *only* depends upon some formation of the latter. Rabuteau maintains that calomel becomes changed into perchloride and *metallic* mercury; also that this perchloride combining with sodium salts forms chloride of sodium, and sets free more of the metal,—that under the influence of such changes the compounds are absorbed, acids and alkalies being afterwards eliminated, and the metallic mercury in part deposited.

In this view though complex, there seems some analogy with what is known of the behaviour of salts of gold, silver and some other metals, and calomel certainly resembles in action preparations of metallic mercury,—otherwise we have no *proofs* of such direct absorption of it, but rather the reverse. Observations of Fleischer confirm the view that calomel changes into perchloride under the action of chlorides, as also does the oxide of mercury (Rev. Gén., to. 28, 1886).

Various observers have directed attention to the possibility of calomel being rendered soluble in other combinations, *e.g.*, with albumen (Buchheim), or as a double salt formed with chlorides of the blood (Graham). Headland pointed out that *bile* exerts some solvent power on calomel (Lancet, i., 1858), and Gubler asserts that an excess of various organic materials—*albumen*, *mucus*, *epithelium*—acts similarly; some limit, however, must be placed to this observation, for the excess of mucin in the stomach of a dog entirely prevented the absorption of calomel that had been injected into the stomach (Rutherford, Exper. 38). An experiment of Tuson's is more to the point: he placed in one vessel calomel with dilute hydrochloric acid, and in another the same mixture with a proportion of *pepsin*: after digestion for an equal number of hours sulphuretted hydrogen was passed into the solutions and produced a black precipitate in that with pepsin, but none in the other, proving clearly the effect of the organic substance in promoting the solution of the calomel (Med. Times, i., 1872). Jeannel pointed out the importance of *fatty* matters for the solution of calomel: in the presence of an alkaline carbonate, it is readily decomposed with precipitation of black oxide; of this latter a *small* proportion is retained in solution by the water, but if a fatty oil be mixed with the alkaline solution, this proportion is very much increased: the same might readily occur in the intestine (Schmidt's Jahrb., 1869).

It is quite possible, as H. Wood remarks, that in consequence of the varying composition of the intestinal fluids and the complex chemical relations of calomel, its solution and ultimate absorption may be accomplished in several ways: when more chlorides are present some perchloride may be formed, and when sulphuretted hydrogen is in excess it may produce some amount of soluble sulphide.

The late Dr. Law, of Dublin, was the first to notice how much the absorption of calomel could be promoted, especially in severe illness, by minute subdivision of the dose, giving, *e.g.*, $\frac{1}{12}$ gr. every hour (Dub. Quart. Journ., vol. xiv.). Trousseau amply corroborated this observation, and it is, *a priori*, reasonable, for the smaller quantities more readily come into contact with the intestinal fluids to form the double salts or soluble compounds described.

Bellini indicated a difference in the mode of absorption of calomel according to the condition of the stomach: thus when taken fasting, only a small amount was at first dissolved, with formation of double chloride of mercury and sodium, and lactate of mercury; more was dissolved in the intestine under the influence of an alkaline carbonate, oxide of mercury being at first formed and then a double salt; in the large intestine a sulphide was formed (except in the case of infants). Introduced into the stomach during digestion, it was wholly, or almost wholly decomposed under the action of albuminous substances, metallic mercury being formed and a soluble albuminate.

From the cellular tissue some calomel may be absorbed, since constitutional effects have been produced by its *hypodermic* injection when simply suspended in liquid, but the major part remains unabsorbed, and is apt to cause suppuration.

Corrosive Sublimate.—The absorption of corrosive sublimate may be realised without difficulty, because it is soluble in ordinary fluids: an albuminate of mercury may be formed in the stomach, but is probably not absorbed as such: the formation of a double salt with sodium is more likely, and the same occurs with iodides and bromides of mercury. Blarez has published numerous observations on these points with chlorides and iodides given by the stomach: he always found a certain amount of finely divided free mercury in the intestinal tract, and this was susceptible of some absorption, whilst part passed out by the fæces. Soluble mercurial salts were formed with albuminoids and peptones, of which some were simple and some compound,—the latter did not join with serum or hæmoglobin, but remained soluble in plasma, were carried to the different tissues and produced their effects quickly: the former combined to form insoluble compounds and were deposited in blood-forming organs,

to be gradually re-dissolved more or less according to circumstances, *e.g.*, the administration of iodides (Rev. Gén., to. 23, Thèse, 1884).

Saline or albuminous solutions of perchloride and aqueous solutions of cyanide are also readily absorbed from the cellular tissue. The chlorides and iodides may also be absorbed from blistered surfaces (*endermic method*), and probably then also, double salts with albuminous and alkaline constituents of the plasma are formed. The tannate of mercury is said to be absorbed with special facility under the influence of the alkaline intestinal secretions, and with fewer drawbacks than other preparations; it is found in the urine within twenty-four hours after administration (Pract., 1891).

Elimination.—Although we cannot state positively the form in which mercury circulates or is deposited within the system, whether in a volatile form at first, or as very finely divided metal, or oxide, or as an albuminate, or (which is more probable) as a double chloride with sodium or ammonium and albumen, yet we can be satisfied of its detection under certain circumstances in every organ, and in every secretion. With the *blood* it seems so closely associated that destructive distillation is usually required for its detection, and in the *milk*, and even in the *urine*, there has been difficulty in finding it, so that some observers have reported against its presence (Köhler, Pract., xvii., etc.); but the more modern researches of Personne, Binz, Hamburger, and others can leave no reasonable doubt on the subject. Heller detected mercury in the fœtus borne by a salivated mother, and in the urine of an infant whose nurse was taking calomel. Sometimes however, it may not be discovered after inunction, though readily after the use of mercurial suppositories (Lancet, ii., 1877). Shuster made more than 100 examinations as to the elimination of mercury in syphilitic patients who were at the time under treatment by inunction, or had been so a varying time before. The metal was, in many but not in all cases, found in the urine during, and for three to four weeks after the course of treatment. In the fæces however, it was constantly found from a few days after commencing inunction up to about six months after ceasing; he concludes that it may be desirable to resume the treatment at the end of that time (Record, 1884, etc.). Certain Russian

observers have calculated the elimination of average doses of $\frac{1}{6}$ gr. of sublimate given by the skin or under the skin, and have, in most cases, found the drug in the urine five hours after administration; the amount thus eliminated gradually increased whilst under treatment and became more if stomatitis occurred. Elimination apparently ceased by this channel at least two or three weeks after the drug was last given (Lancet, ii., 1886). (The modern and accurate method of detecting mercury is by electrolysis.)

The question of its elimination by the *milk* is one of much importance, for large establishments have been formed in Paris for the treatment of syphilitic infants especially, through the milk of nurses or of goats that have taken mercury: such treatment is constantly adopted with good result, and there is abundant clinical evidence of its value.

With regard to the time during which mercury remains in the system, it is ascertained that elimination of a single dose is rapid, and is apparently completed within twenty-four hours; for $\frac{1}{6}$ gr. of perchloride having been taken, the urine contained traces for that period, but not afterwards; and 0·075 gramme (over 1 gr.) having been injected under the skin of a rabbit, none could be discovered in any part of the body four days afterwards (Lancet, i., 1873). M. Byasson injected $\frac{1}{3}$ gr. of sublimate under his own skin, and found mercury in the urine two hours afterwards, and at the end of four hours in the saliva, but after twenty-four hours he detected no more. If treatment has been continued for some time, mercury may be found in the urine for several days afterwards; thus, in the urine of two patients who took $\frac{1}{6}$ gr. daily for ten or twelve days, the drug was found for four or five days after treatment had been omitted.

During a mercurial course, the greater part of the drug is eliminated almost as soon as taken, but some remains in the tissues and passes out insensibly; and when the doses have been large and long-continued, some may be retained in the organism for months or even for years. It is in fact, impossible to recognise exactly when its elimination is complete, though it is probably so, sooner than that of gold, lead, or silver (Husemann). Years after its prolonged administration, unusual perspirations may develop dark mercurial stains on the linen, or a white

coating be given to a piece of copper on handling it. Salivation may reappear with apparently no cause but a chill; sometimes it has been traced to the use of sulphuretted mineral waters, and occurred in one patient ten years after taking the medicine (Hartung). I have myself seen five patients while under the influence of nitric acid, suffer from salivation and other physiological symptoms of mercury, and none of these had taken that drug for over eighteen months previously: I considered it clearly traceable to the mercury in the system, and not to the acid. The metal has been found in the liver of a workwoman who had not, for twelve months previously, been exposed to mercurial vapours, and in the liver and kidneys of another who died of phthisis six months after leaving her work at a mirror factory (Kussmaul, Gorup Besanez, Wien. med. Woch., 1862).

Melsens pointed out (1844) that iodide of potassium favoured the elimination of mercury as well as of lead, and in many cases it has been found that elimination which had ceased, has been renewed under the influence of the iodide; yet this is not always sufficient to complete the process, for Kussmaul found a quantity of mercury in the viscera of a patient who had taken none for four months, and who in the course of a month after ceasing it, had taken 2 oz. of the iodide.

Riederer has made experiments to ascertain the *quantity* of mercury that may be found in different organs or secretions: of about 10 gr. of calomel given to a dog in thirty-one days, he recovered four-fifths—the largest proportion from the fæces, the next from the urine, the liver, the thoracic viscera and brain, and the least from the muscles (quoted by Hallopeau). Other observers agree that on section of an animal subjected to the action of mercury, the largest amounts are found in the liver and kidneys (and not in consequence of their containing more blood than other viscera, for the blood contained a much less proportion of the drug): it must therefore be considered to have a special determination to the liver and kidneys, and it is eliminated mainly by the bile and the urine. During a continuous treatment by equal daily quantities of mercurial ointment (and also by injections) analysis of the urine showed that the amount eliminated gradually increased according to the length of time of the treatment, but became nearly constant after about a

month. After treatment for some months, and then cessation of it, elimination continued for six to nine months—the daily amount by the kidneys being about $\frac{1}{16}$ gr.—less than half this by the saliva, some by the bowel. Sweating by hot air baths was found to hasten elimination more than potassium iodide. A practical conclusion from these researches is that it is as well to stop the drug when the amount in the urine has reached its normal maximum (Abst. Pract., 1888).

PHYSIOLOGICAL ACTION.—*External.*—The local action of mercury varies according as to whether the metal itself is used, or one of its soluble or insoluble compounds, and of course according to the strength of the preparation; on account of the volatility and the ready absorption of the drug, its local use often induces systemic effects.

Metallic mercury produces upon the skin no other local effect than a sense of coldness. Mercurial ointment applied by friction is usually well borne, but sometimes excites a red or vesicular eruption (mercurial eczema), more or less intense; ointment of the red oxide is painful to sensitive parts, and that of the red iodide may irritate very severely, even to vesication: if not perfectly fresh an additional source of irritation is found in rancid lard: good calomel ointment is rather soothing than otherwise. Cases illustrative of how acute local dermatitis may result from the use of white precipitate ointment are recorded (B. M. J., i., 1884; ii., 1883).

Corrosive sublimate is one of the most powerful antiseptics known, and of late years it has come markedly into use on this account; a strength of 1 in 10,000 is stated to be sufficient to kill bacteria. Solutions stronger than 2 gr. to the ounce irritate the skin. Cloquet the distinguished anatomist, suffered from severe local and general symptoms after handling some preparations steeped in a strong solution. A proportion of 10 gr. to the drachm of alcohol vesicates, and when applied to the scalp has caused death in a child (Lancet, ii., 1871). In two other children the use to the scalp of an ointment containing 120 gr. to the ounce of tallow also caused death (Dub. Journ., 1854). The solution of the metal in nitric acid (liquor hydrargyri nitratis acidus) is a powerful and painful caustic, and its application has sometimes, though not frequently, been followed by severe general symptoms: it

combines with albumen and fibrin, producing a white eschar. A case of death from its injection into the vagina is on record (B. M. J., i., 1893).

On the mucous membrane of the intestinal tract mercurial compounds may exert a *local* action of the same nature as upon the skin, as seen especially in poisoning by the perchloride.

PHYSIOLOGICAL ACTION.—*Internal.*—In studying the action of this medicine, it is more than usually important to distinguish between the effects of *small* and of *large* doses. Modern observation shows us that the former are rather of tonic and constructive character, whilst older records have told us only too well the fatally destructive results of the "heroic" administration of the drug. I do not mean simply that one grain, *e.g.*, of calomel has a different effect from twenty: we must estimate the dose rather by what is absorbed of it, and by the results shown, especially by the state of the mouth and the secretions. Practically we can either give the medicine so as to cure without marked effect upon these, or so as to produce only moderate effects; and it is this "slight mercurialisation" which requires to be distinguished from the severe form which should be called rather mercurial poisoning, and is accompanied with stomatitis, salivation, diarrhœa, cachexia, etc. A similar difference of degree exists of course, in the action of all powerful medicines, but it requires more attention in the present instance, because our predecessors thought to give benefit only by what we consider a poisonous action of the drug, and it consequently fell into undeserved discredit. There is further, a chronic form of mercurial poisoning which may still be met with in various trades, and this differs in some respects from any condition produced by modern medication.

Circulatory System.—Recent observations as to the action of mercury on the blood illustrate well its different effects, since they show that in quite small doses, it increases the number of red corpuscles, and improves the condition of the circulating fluid. Grassi proved this by analyses, and Wilbouchewitz counted carefully under the microscope the average number contained in a cubic millimetre, and his patients (ten in number) then took either $\frac{2}{3}$ gr. of sublimate daily, or $\frac{1}{6}$ gr. of proto-iodide: during the

first fortnight of treatment the increase of corpuscles amounted to nearly one million per cubic millimetre.

These patients were syphilitic, and probably the anæmia of their malady was benefited by the antidotal action of the mercury, for the remedy being continued beyond a certain time (and thus allowed to accumulate in the blood), the red corpuscles diminished in number, so that by the end of the second fortnight, they numbered the same as before any treatment. Mercury being then omitted altogether, the corpuscles increased again within a week's time. The inference is clear,—*too much* of the drug impaired the condition of the blood, but a *little* improved it. When it was omitted, and when, after a few days' time, only a small proportion remained in the blood, the original improvement was again observed: the white corpuscles varied in an inverse ratio (Archives de Physiologie, 1874). Keyes repeated these observations, and concluded that small doses of mercury increased the number of blood corpuscles *in all subjects*, whether syphilitic or not, and further, that this increase is not temporary: he has never seen hypoglobulism—*i.e.*, a lessened average number of corpuscles, caused by small doses (Amer. Journ., Jan., 1876). Possibly the difference between these two observers may arise from difference in dosage, Wilbouchewitz giving the rather large quantity of "$\frac{2}{3}$ gr. of sublimate daily"; no doubt mercury in any form, continued long enough and absorbed, will produce a *destructive* effect on the corpuscles, and a condition of spanæmia. Long ago, Bretonneau and Dumont reported that either there was no clot formed in the blood removed from mercurialised animals, or, if any, it was soft and diffluent. Headland's expression is that mercury "disintegrates and decomposes the blood," and Wright's analysis showed it to be more fluid and less coagulable than normal, its proteids, fibrin and red discs being diminished, and a fœtid, fatty material being formed in it. Gubler has also corroborated this destructive effect, and yet Lemaire and Gelis found "mercurial treatment to increase the plasticity of blood." Autenrieth questions the analysis of Wright, and more lately Overbeck found in animals poisoned by mercury the venous blood dark and thick, the arterial blood clear and coagulating well, the fibrin being increased in amount: probably these results were connected with inflammatory reactions, but if

verified, they tell much against any available "aplastic power" of mercury in inflammation; still, the *ultimate* effect of the drug is destructive. Polotebnow, adding mercurial albuminate to the blood of dogs, found the corpuscles rapidly destroyed, with loss of their hæmoglobin (Schmidt's Jahrb., 1865). Wilbouchewitz, giving calomel to rabbits (and not in large doses), noted a rapid diminution of corpuscles. Recent researches on this subject are somewhat contradictory (B. M. J., ii., 1892, Epit.): certainly its value must be acknowledged in certain cases of anæmia, and may be traced to stimulation of glandular structures, and relief of glandular engorgement (Pract., 1889). Trousseau found that leech-bites which had ceased bleeding, bled again in patients submitted to mercurial treatment, but beyond any single facts is the general experience that too much of the drug induces—after a period of malaise and restlessness—a chlorotic pallor of the skin, with signs of enfeebled circulation, distress of breathing, intermittent pulse and palpitation; such a condition, known formerly as mercurial spanæmia or "erethismus," is difficult of cure; it may last long and end fatally.

Sir W. H. Broadbent has drawn attention to the value of calomel in reducing arterial tension, which effect Dr. Haig attributes to its lessening uric acid in the system (B. M. J., i., 1890), but his evidence is not conclusive. Fothergill includes mercury amongst his "cardiac depressants"; and G. Harley, having injected corrosive sublimate into the femoral vein of a dog, found that cardiac paralysis was produced before intestinal contractions ceased (Proc. Roy. Soc., 1864).

Nutrition.—Nutrition is so closely connected with hæmatosis that we shall be prepared for the modern observations that it also may be improved by *small* doses of mercury. Keyes found this to be the case—the weight of his subjects increased under their course, and the remedy acted "as a tonic." Hufeland had previously made a similar observation, and Basset, Liégeois and others corroborate it: the last-named observer considers corrosive sublimate in minute doses "comme un réconstituant des plus puissants" (Annales de Dermatol., 1870), and M. Clerc reports the same experience (Gaz. de Paris, 1872): it has been verified also, independently of syphilis, on animals and especially rabbits.

On the important question of *urinary excretion*, the principal

evidence is negative. We need more research in this direction, but so far the evidence does not favour the theory of mercury (in small doses) curing disease by *increase* of tissue-change—that it lowers the temperature in animals (except when "mercurial fever" occurs, and that it does the same in specific fevers (Wunderlich), I should take as evidence of its *lessening* change, rather than the contrary, as Husemann does. Mercury as a rule in ordinary doses produces no effect on the temperature of the body; but exceptional cases have been recorded in which the administration of the drug produced pyrexia (Pract., ii., 1882). Altogether, at least in the doses under consideration, mercury merits the name of "moderator of nutrition," rather than of alterative (Rabuteau); and in this rôle we can see its analogy with small doses of arsenic, antimony, etc., under which, as is well recognised, weight may be gained and nutrition improved. Under full or poisonous doses, when the blood corpuscles are destroyed, the secretions rendered profuse, and digestion impossible, nutrition is, of course, profoundly impaired, and waste of tissue progresses most rapidly.

Digestive System.—Small (therapeutical) doses of any preparation are usually well borne by the stomach. Rabuteau cites cases where many hundred pilules of the proto-iodide have been taken in the course of one to three years without any gastric disturbance: yet we must allow for some idiosyncrasy in this respect, and practically we find that those who have resided long in the tropics, and fair, delicate women and chronic dyspeptics are very sensitive. It is not however, possible to say beforehand what amount of mercury will produce the characteristic effects in any given case—a single friction or a few grains may produce in one patient what many weeks of treatment will not do in another.

Single doses of calomel—from 1 to 5, 10, or even more grains—produce thin and "bilious" stools without much griping. If the intestine of an animal be examined after such action, it will be found reddened especially in the upper part, and its glands stimulated. As a rule, ordinary care will early detect symptoms of constitutional action in the mouth, such as a sense of heat, metallic taste, sticky coating of the tongue, increased flow of saliva and perhaps slight tenderness of the gums. On continuance of the medicine, these latter symptoms increase and diarrhœa

occurs, with some nausea. The stools at first feculent, become thin and sometimes papescent with mucus, sometimes yellow, or dark or grass-green (the latter especially in children : they have been compared to "chopped spinach") : sometimes blood appears in the motions, and severe colic and tenesmus occur. The tongue is said to show a greenish coating with two longitudinal red stripes (Traube). In severe cases when the poisonous action of mercury has been induced, intense stomatitis appears, with swelling of the tongue and gums, a membranous deposit, fœtor, and loosening of the teeth, with severe pain and difficulty in mastication. The salivary glands become enlarged and tender, and a vast amount of secretion pours from the mouth—10 lbs. of saliva have been secreted in twenty-four hours : at first viscid as usual, it soon becomes thin and very watery, containing albumen, mucus, and alkaline chlorides. Children and the aged are seldom salivated—Graves suggests because their salivary glands are "inapt"—diarrhœa or prostration is with them the earliest symptom. Salivation is connected too, with local causes : it comes on more quickly when the mouth is unclean, and may be almost wholly prevented by great care with the teeth : dental caries will determine it ; it is said to commence by the last molar of the side on which the patient mostly sleeps (Ricord) : also the irritation of a wisdom tooth or of a pipe will influence it.

Such facts have led to the supposition that salivation is only *secondary* to buccal soreness, but this is incorrect : it may be induced by rubbing mercury over the parotid, and *before* any irritation is produced. Ricord detected the drug in saliva drawn from Stenson's duct by a catheter, in animals when calomel had been injected beneath the skin ; and salivation occurs as we know, independently of irritation of the mouth from the action, *e.g.*, of gold, iodine, various acids, etc., as well as during pregnancy and certain diseases. The safe test of a mercurial salivation is the detection of the metal in the secretion. Women seem to be more readily affected in this way than men, and the subjects of granular kidney, of scrofula and of scorbutus, are peculiarly susceptible. It occurs more frequently under fractional non-purgative doses of calomel, or inunction of blue ointment, than from fumigation, suppositories, or injections : it is markedly less under the use of sublimate, iodide, or cyanide, than of insoluble

preparations, either on account of the smaller dose of the former employed, or of some peculiarity in their elimination. Ulceration, or sloughing of the gums, hæmorrhage, periostitis and prostration of even fatal character have occasionally followed a profuse salivation, and necrosis, scars and contractions have accompanied recovery.

We have seen that a local action, irritant in character, is exerted by most compounds of mercury on the alimentary tract; but H. Wood speaks of calomel as "free from all irritant properties," and Lente argues that large doses (one teaspoonful) act in a sedative manner (New York Journ., 1870)—this was the argument of Annesley, but it is not a safe one to act upon. The irritation excited by corrosive sublimate in toxic doses is, however, the most severe: there is an acrid taste and a sense of burning and constriction in the mouth and fauces, with whitening and shrivelling of the mucous membrane if the dose be concentrated; vomiting and purging with tenesmus usually occur, with passage of blood, suppression of urine and general symptoms of gastro-enteritis: after death, signs of inflammation, contraction, or ulceration have been found, especially in the stomach and upper part of the intestine, and that this is not merely a local effect is proved by its occurrence when the drug has been administered by the skin. Profound depression is usually a symptom of sublimate poisoning, and is sometimes more marked than pain, vomiting, or purging; salivation is by no means constant in acute cases.

The iodides of mercury act much like corrosive sublimate, the red iodide being more actively irritant than the green one. The red oxide produces similar lesions of the intestinal canal; it is not given internally in medical practice, nor is the ammonio-chloride (white precipitate), but in a case when a large quantity of the latter compound caused death, the stomach was found contracted, and its lining membrane ecchymosed (Guy's Reports, 1874). A single dose of 20 grains dispensed by mistake for sal ammoniac, caused severe vomiting, purging and salivation—some albuminuria and illness for six weeks (B. M. J., i., 1889). The liquor hydrargyri nitratis acidus has produced intensely severe effects on the intestinal tract, and irritant poisoning has followed the accidental use of the sulphides and the cyanide of mercury.

Glandular System, Liver, etc.—Most of the glandular organs are liable to become congested and stimulated under the influence of mercury. This has been noted not only of the salivary glands as already described, but also of the pancreas and intestinal glands, the kidneys, the liver and the testis (C. H. Jones, Med.-Chir. Trans., vol. xxxv.). As illustrating the effect on the pancreas Dr. Copland recorded a case, where, in addition to salivation, deep-seated epigastric pain set in, with nausea and diarrhœa of thin fluid resembling saliva; after death the gland was found large and congested. Radziejewski found, on analyses of the stools after giving calomel, a large proportion of leucin, tyrosin and indol (the result of the action of the pancreatic ferment), which he did not find after other purgatives (Reichert's Archiv, 1870). That calomel also stimulates the intestinal glands has been demonstrated by Prof. Rutherford; the lymphatic glands are simultaneously affected.

The mode of its action on the liver is still a subject of discussion, and the conclusions of some physiologists on this subject are opposed to those of many practical physicians. Up to a recent period, mercury was universally regarded as a typical "cholagogue," in the sense of its stimulating both the secretion and the excretion of bile, and hence was commonly employed both in cases of deficient secretion to stimulate, and in cases of excessive secretion to "carry off" the excess.

The early experiments of Murray (1841) were taken to corroborate the theory of "cholagogue" action; for after giving purgative doses of calomel to dogs, he found the discharge of bile increased, and the stools contained excess of mucus and of serous effusion. Buchheim also reported an increase in the amount of bile discharged by dogs with biliary fistulæ. Still more important evidence was furnished by the analyses of Michéa, which were made first upon the normal stools of six healthy subjects without detecting bile; then, with nearly like result, upon the green stools of persons suffering from diarrhœa; then upon the greenish motions which occurred in eight healthy persons after taking calomel, and in all of which bile was clearly detected; and lastly, upon discharges produced by different saline and resinous purgatives and in which no bile was found (Lancet, i., 1849). Although these observations show an increased *discharge* of bile

under calomel, it is clear that they do not necessarily prove an increased *secretion* by the liver-cells, and therefore experiments on animals as to this point were undertaken. Kölliker and Müller, after giving calomel to dogs with biliary fistula and collecting the bile discharged, reported contradictory results—the secretion being in one instance increased, whilst in two others it was diminished (1855). Scott, experimenting with large doses of calomel on four dogs (also with fistulæ), recorded diminution of both fluid and solid biliary constituents in all the animals (Beale's Archives, i., 1858). Mosler, with two dogs, obtained a similar result (Virchow's Archiv, xxxii.); and the late Dr. Hughes Bennett, reasoning from the experiments of the Edinburgh committee, announced as a positive fact, that mercury really *lessened* the biliary secretion in man as well as in animals (1868). The experiments on which this physician founded his important conclusions require a brief consideration: they were made upon forty-one animals, and on account of difficulties in the operations, etc., results considered satisfactory were only obtained in nine instances—in four of these calomel was used: a permanent fistulous opening into the gall-bladder was very carefully effected, and about fourteen days afterwards the bile was collected on a sponge. The first dog, before taking any drug, secreted a daily average of 87 gr. of bile, which contained 5 gr. of solid constituents; after taking 4 to 12 gr. calomel daily, it secreted only a daily total average of 60 gr.; but it must be noted that the animal's condition was much impaired, it took little food, and soon afterwards died. Smaller doses ($\frac{1}{10}$ gr.) were given to the second dog; the general health became affected, and it soon died: the average bile-secretion was about the same, before and after giving the drug. The third dog received some blue pill in addition to the small doses of calomel, and the average amount of bile secreted was diminished one-half; the animal suffered much. The fourth dog got purgative doses, with an average diminution of bile whilst under their influence; on one day, however, when blue pill was given, the average was increased (B. M. J., i., 1869). Such results scarcely warranted Dr. Bennett's conclusions, which were indeed publicly controverted by Christison, Fraser, and other members of the same committee. Röhrig (of Kreuznach) reported that large doses of calomel slightly increased the biliary secretion

(Stricker's Jahrb., 1873), but we may take the more recent experiments of Rutherford and Vignal as showing, so far as experimental research can show, that the drug does not really do so. They proved (1) "that doses of 10 gr., 5 gr., or 2 gr., several times repeated, placed (without bile) in the duodenum of a fasting dog, produced a purgative effect varying with the dose, but so far from increasing the amount of bile secreted, usually diminished it: (2) that there is no difference in the result if the calomel be given in 1 gr. dose, several times repeated, mixed with bile and introduced into the duodenum" (B. M. J., ii., 1875-76; Pract., 1879). On the other hand, the same observers found that *corrosive sublimate* in doses of $\frac{1}{8}$ and $\frac{1}{16}$ gr. powerfully stimulated the secretion of bile, whilst it did not stimulate the intestinal glands (B. M. J., ii., 1877). (They further instituted experiments which showed that calomel does not become changed into *corrosive sublimate* to any appreciable amount under the influence of the organic secretions) (*v.*, p. 675). Rutherford himself notes that the experiments referred to above do not prove anything as to the action of mercury on the *bile-expelling* apparatus, and we may grant that they are correct without any denial of the clinical fact that a purgative dose of calomel will increase the amount of bile discharged by the bowel; it may do this, not necessarily by a previous stimulation of the liver, but either by irritating to unusual contraction the gall-bladder and gall-ducts, or by lessening a congested condition of these parts, through the discharge induced from intestinal glands.

Dr. Lauder Brunton has further pointed out that the clinical fact of calomel relieving "bilious" conditions, receives from the experiments of Schiff and Lusana an explanation not at all inconsistent with Rutherford's conclusions (Pract., vol. xii.); these experiments go to prove that the liver not only *secretes* bile, but also *excretes* it, separating from the blood a part of that which normally circulates in it: for after effecting biliary fistulæ in animals, bile flowed at first freely—afterwards in much diminished amount, independently of any drugs. This diminution was accounted for by the passing away of bile so soon as formed, and the consequent impossibility of its being reabsorbed from the duodenum into the circulation to be again excreted, for if *fresh* bile were passed into the blood by intravenous or subcutaneous

injection, then the amount of excreted bile was again increased. Schiff further showed not only that bile can thus circulate without giving rise to jaundice, but that it probably always does so, passing from the liver to the duodenum, thence into the blood and so to the liver again, a portion only in a changed condition passing out by the fæces.

This tallies with the observation of Murchison, that "by increasing the elimination of bile and lessening the amount circulating in the portal blood, mercury is a true cholagogue, relieving the liver thus, more than by merely stimulating it to increased secretion" (Lancet, i., 1874). The green, liquid, spinach-like stools produced by calomel have been variously attributed to intestinal irritation, to altered hæmatin (Golding Bird, 1845), and to subsulphate of mercury (Thudichum); it is possible that they may contain sometimes mercurial compounds, but they certainly often contain bile,—Hoppe-Seyler showed this, and according to Simon's analysis of the fifth stool passed after a large dose of calomel, it was fluid, green, without fæcal odour, of acid reaction, and contained mucus and epithelial cells, fat, cholesterin, bilin and bile-pigments,—no mercury whatever (Animal Chemistry, vol. ii.). Wasilieff asserts, as a result of experiments on animals, that the special action of calomel is to prevent certain processes of retrogressive metamorphosis and putrefaction in the alimentary canal: also that it prevents normal change in the colouring matter of the bile, which remains therefore, giving to the fæces the characteristic colour referred to. It prevents, too, changes in the pancreatic secretion, so that no indol is formed in the intestine whilst under the influence of a few grain doses of calomel (Zeitschr. für physiol. Chemie, 1882).

Genito-Urinary System. — Women affected with mercurialism are liable to abort, yet it is equally proved that syphilitic women should be treated with medicinal doses, for thus given, mercury may save them from abortion. The influence on menstruation is not constant; generally this will be diminished, but sometimes much increased.

Lusana found that mercurialism in fowls prevented the laying of eggs, and Gaspard, that the vapour of quicksilver prevented eggs from coming to maturity.

Therapeutical doses exert a stimulating effect on the kidneys,

and we have seen that the drug is largely eliminated by those organs. Overbeck indeed, found leucin and evidence of disintegrated albumen in the urine of animals (Husemann); but E. R. Harvey experimenting on dogs, found the *quantity* of urine unaffected, the phosphates always diminished, the urea not increased beyond a normal variation (Brit. For. Rev., 1862). Von Böck could find no definite change in the excretion of nitrogen or uric acid (1869). Bouchard reported a diminution of urea, but his patient had uræmia (1874); and more recently, Conty, after observation on twelve syphilitics taking therapeutic doses of proto-iodide, could verify no definite alteration. Some careful experiments of Dr. Noel Paton on dogs seem conclusive as to the real increase in water, urea and uric acid excreted under moderate doses of perchloride and iodide. Boeck showed a similar result in man, but his patient was syphilitic (B. M. J., i., 1886). It has been plausibly said that the increase of urinary water—diuresis—is dependent on the increased amount of urea formed (Pract., ii., 1886).

During pronounced mercurialism, albuminuria may occur with or without hæmaturia (Pavy, Overbeck, Küssmaul). After death, congestion and fatty degeneration of the kidneys have been found (Balogh and others); and Ollivier has pointed out the analogy between such conditions and those produced by lead. The albuminuria does not necessarily imply altered renal structure, it may be dependent only upon general dyscrasia and loading of the blood with organic débris, but in severe or prolonged cases, steatosis is very probable. Bouchard has recorded two important illustrations; in one case of acute mercurialism, five days after salivation had commenced suppression of urine occurred, and on the ninth day the patient died comatose, and a very large amount of urea was found in the blood, implying that uræmia was the cause of death. We have not details of the second case, but in both the Malpighian bodies were found to contain, or to be changed into mineral matter, proved to be carbonate of lime (Hallopeau). This condition is very interesting when compared with Salkowski's results in rabbits; he injected fractional doses of sublimate, of iodide, and of calomel, and after death found constantly lime and soda deposits in the Malpighian bodies; the urine became pale and contained sugar, whilst the

bones became decalcified. More recent observations also report congestion, hæmorrhage, cloudy swelling and deposits of chalk in the kidneys of rabbits,—less deposit and more fatty degeneration in those of dogs (Lancet, ii., 1890). Cornil also found calcareous deposits, and Kletzinski reported diabetes.

Nervous System.—From the medicinal use of mercury we seldom see definite effects on the nervous system, beyond a temporary malaise, chilliness, depression, or hyper-sensitiveness; the severe symptoms of neuralgia, tremor, convulsion, or paralysis are met with only in persons exceptionally, or for a prolonged period exposed to its action, such as those who work with it and suffer from a "chronic mercurial poisoning." A grain of calomel or blue pill has been taken every night for more than forty years without other than good effects apparently, for one cannot argue much from fatty degeneration at the age of seventy-four (Med. Times, ii., 1867). On the other hand, tremor has developed in one night under the influence of strong mercurial fumes (Christison), but as a rule, the slow and continued absorption by the skin and the lungs of metallic quicksilver or its vapour is the cause of symptoms such as those we are now considering. Anstie pointed out that sensory nerves were sometimes affected by it, "a selective affinity" being shown for the fifth, whence an attack of severe and persistent facial neuralgia; but severe pain may also affect the head generally, or all the limbs (Lancet, ii., 1872); the pains are usually made worse by warmth; tingling or other alterations of sensibility may be experienced; there may be partial anæsthesia or analgesia, which either varies as in hysterical subjects, or may be permanent; abnormal sensations of cold are also described. Tremor is the most constant symptom of chronic mercurialism: all the workmen in mercurial mines suffer from it, and sometimes it is the only symptom apparent, there being neither salivation nor erethism: it commences usually in the lips and the tongue, and soon affects the upper extremities; it is most marked, like the tremor of sclerosis, under the influence of voluntary movements, or of fatigue; it may exist in all degrees up to severe convulsive movement affecting the whole body (called "calambres" at Almaden): slight cases of tremor are curable in a few weeks; more serious ones last for months or years, and yet the subjects continue to walk and to work. The tremors cease

during sleep, and also it is said, during intoxication; this is an interesting fact, as also is the transmission of the malady by inheritance, so that children are born in the state of tremor.

The phenomena of exaggerated action pass after a time, into those of paralysis, so that one or more muscles may cease to answer properly to the will; though muscular power is retained, co-ordination is lost, as in locomotor ataxy; the extensors are often affected: sometimes the paralysis is temporary, and of hemiplegic character; electro-muscular contractility is preserved, but atrophy of the muscles may occur.

It remains to note the *mental* condition in chronic mercurialism: emotional sensibility is generally heightened, the patient is timid and easily excited, intelligence is weakened, and a delirious condition (like that of delirium tremens) occurs in paroxysms; sleeplessness is marked. We cannot say that true epilepsy is produced, though the convulsive attacks may have been called by that name, but giddiness and noises in the ears, muscæ, nausea, and tendency to fall, constitute a condition resembling at least "petit mal." It is not likely that apoplexy can be directly connected with mercurial poisoning.

With regard to the *pathology* of the nervous symptoms described, Anstie suggested that the cortical grey matter was mainly affected. Ross in his able paper, seems to think that an effect on the connective tissue of the nerves would explain it (Pract., 1870). Mercury has been found by analysis in the brain, but we can scarcely consider its effects to be directly and locally poisonous to the nerve-cells: we may gain some light from the changes discovered in cases of alcoholic or saturnine saturation of the nervous centres, and those we find to be mainly chronic inflammation and fatty degeneration (Lancereaux, Vulpian). Dr. Popow has found that in animals, mostly dogs, mercury produces hyperæmia of the meninges and of the cord, followed by hæmorrhages and inflammatory exudation, similar to those produced by arsenic and lead. He found but few peripheral changes, and considers it proved that the nervous symptoms in mercurial poisoning are of central origin (Virchow's Archiv, vol. xciii.).

Cutaneous System.—We have spoken of the local irritation that may be excited by mercurial frictions. There may be merely

erythema with much itching, or an eczematous (vesicular) rash, or even erysipelas and gangrene (Stillé). The internal use of mercury may also, exceptionally, give rise to eruptions, of which Bazin has distinguished three forms, "hydrargyria mitis, febrilis, and maligna," showing either a simple efflorescence about the thighs, scrotum, abdomen and axillæ, or a more intense form with vesicles, or one still more severe with œdema and purpuric rash. The general symptoms in such cases may be serious: desquamation occurs in the milder forms about the eighth or tenth day; malignant forms (which I have never seen) may give rise to adenitis, abscess, or ulceration. Occasionally, owing to idiosyncrasy, a scarlatinoid rash may be excited by a single dose, as by $\frac{3}{4}$ gr. of proto-iodide in a case recorded by M. Fournier: one application of acid nitrate produced the same effect, as also did a few Dupuytren's pills ($\frac{1}{6}$ gr. sublimate). If cachectic ulceration be present, the action of mercury is likely to increase it, especially in the mouth: such ulcers are more irregular and less indurated than those of syphilis.

In exceptional cases the secretion of sweat has been increased, becoming of a clammy character and fœtid odour: a general brown colour of the skin or the occurrence of rupia and ecthyma has been sometimes noted, but it is not true that eruptions really equivalent to syphilitic eruptions are produced by mercury.

The hair and nails are said to have fallen off under its use. The teeth are said to show the effect of the drug, especially when administered in infancy, by a deficiency in the enamel, most marked in the first molars (Hutchinson, Med. Times, ii., 1876; Laycock, i., 1862); but I believe such deficiency may occur from rickets independently of mercury.

With regard to the tissues of the *eye*, we have evidence that iritis and retinitis may be produced by the continued employment of mercury, but a more usual condition is conjunctivitis, which occurs with the ordinary symptoms, such as suffused redness and injection, smarting, burning and some excoriation and purulent secretion.

Osseous System.—A form of periostitis occurs sometimes during a course of mercury, and it has been a question whether this is due to the remedy, or to the malady (syphilis) for which it is commonly prescribed. Pereira thinks the latter supposition

correct, but Graves states that he has seen periostitis occur in patients mercurialised for some other illness and who had never contracted syphilis, and to this I can add my own testimony, having witnessed such an occurrence several times. The tibia, the bones of the forearm, the clavicle, sternum and frontal bones are those more commonly affected, and the pains intermittent at first, are increased by warmth, or by changes of temperature, though sometimes relieved by a low temperature. The articular ends of the bones are liable to be affected, and even caries may be produced.

SYNERGISTS.—Agents such as alkalies, which fluidify the blood and secretions, favour a similar action of mercury. Oxygen, dilute acids and alkaline chlorides favour the transformation and absorption of metallic mercury, and hence assist its action. Bellini however, concluded that these agents *lessened* the effect of mercurial chlorides and iodides by preventing the action of carbonated alkalies upon those salts in the intestine, and impairing the formation of double salts: *magnesia* he found distinctly adjuvant, it giving rise to a double chloride with mercury. Carbonate of sodium has been found to increase its purgative effect (Hunt, Brit. For. Rev., 1852), and rhubarb, colocynth, jalap, or other purgatives are used to aid its action on the liver or intestine.

The cholagogue properties of calomel are naturally much increased by combination with a little perchloride, and also it is said by the simultaneous use of alkaline salicylates,—there should be several hours interval between the giving of these drugs.

Alkaline iodides markedly increase the constitutional action of mercury. A skin rubbed with *blue ointment*, and then after an interval and after cleansing, rubbed with *iodine ointment*, becomes much inflamed, evidently from a chemical combination (biniodide of mercury). Milk, bromides, sulphites and prussic acid are also said to increase the effect of mercurial compounds (Bellini), and the good effects of mercurial treatment in syphilis are specially aided by the concurrent use of the sulphurous waters of Aix-la-Chapelle (B. M. J., i., 1874).

ANTAGONISTS AND INCOMPATIBLES.—Sulphur especially in the form of sulphuretted hydrogen, antagonises the *physiological* action of mercurial compounds, whatever their therapeutical relations may be (see above). Chlorate of potassium

controls, to some extent, its salivating powers; a mouth-wash containing boracic acid is useful for tender gums resulting from mercury; astringents such as alum and tannin, lessen fluxes, and tonics and stimulants oppose mercurial cachexia.

Finely divided iron, or zinc, or gold acts as a mechanical antidote in cases of mercurial poisoning (Johnston, Amer. Journ., 1863), but albumen is perhaps more efficient: the white of one egg is calculated to form an insoluble compound with 25 centigrammes (about $3\frac{1}{2}$ gr.) of the sublimate (Peschier).

Treatment of Mercurial Poisoning (*Acute*).—By an emetic dose of ipecacuanha, if necessary, the poison should be as far as possible removed, and then albuminous demulcent drinks freely administered. The white and yolk of raw eggs with milk are very suitable, or gluten may be prepared by washing flour in a muslin bag under a stream of water, or the flour itself may be given in a paste (Tanner). Opium may be required for the pain and purging, and gargles of alum and borax for the corrosion produced on the mucous membrane of the mouth and fauces. For salivation sulphur has been strongly commended, and to promote elimination when the acute symptoms have subsided, the iodide of potassium is to be advised. The symptoms of poisoning by corrosive sublimate are sometimes insidious, and after evacuating the stomach a principal indication is to sustain the strength. In a man under Dr. Mackey's observation, who had taken sublimate with suicidal intent and in large quantity, there were at first no symptoms, so that doubt was thrown on the history given with him when first brought to the Queen's Hospital. The stomach-pump was used, and for some days afterwards he complained of nothing but slight abdominal pain and weakness. Milk and beef-tea were given,—perhaps not in sufficient quantity,—and stimulants were not ordered: he died in about a week, apparently more from asthenia than from irritant poisoning, but an inflammatory condition of the large intestine was found.

THERAPEUTICAL ACTION.—*External.*—The power of corrosive sublimate to destroy bacteria has led to its very general use as an antiseptic in surgical and gynecological practice. Over carbolic acid it has the advantage of being odourless, of not numbing the hands, and of being effective in much weaker solu-

tion, 1 in 10,000, though the strength usually ordered is 1 in 1000. This is well prepared according to the formula of Sir J. Lister, by making first a glycerine solution containing 1 part of mercuric chloride in $1\frac{1}{2}$ (by weight), and then adding 1 fl. dr. of this to 4 pints of water (B. M. J., i., 1884). In surgical operations the hands of the operator, the instruments, the skin of the affected part and all tissues exposed to the action of atmospheric germs, are washed with such a solution—just as with carbolic preparations. There is a large amount of evidence in favour of sublimate dressings preventing suppuration and septicæmia, and promoting union by the first intention (Kümmel, De la Croix, Schede, Bergmann, Weir and others). Weighty surgical opinions in the same direction were expressed in a discussion at the Glasgow Society, though some drawbacks, such as local eczema were referred to (B. M. J., ii., 1886). Sublimate lotions are largely used also for wounds, sinuses, and inflammatory and septic conditions of skin, mucous membrane, and internal viscera such as the bladder and uterus.

Kehrer was one of the first to advocate such injections for the vagina and uterus after delivery, and especially when metritis occurred (Med. Press, i., 1884), and a large number of cases have been thus treated with much success, so that injections of sublimate became almost matters of routine in several large lying-in hospitals. Still we must recognise that such applications are by no means free from risks of their own. One of the earliest illustrations was reported by Stadfeldt in a healthy primipara irrigated with solution of 1 in 1500, and dying a few days afterwards with exhaustion, diarrhœa, sore mouth, pain, etc. The case was considered by some to be doubtful, but since that time further evidence has accumulated. Fraenkel has reported fourteen cases of toxic enteritis following such injections in the course of two and a half years' practice at Hamburg Hospital; in those that ended fatally, inflammation of the large and small intestine was found. He advises only the weakest effective solutions and a not too frequent use of them (Centralb. f. klin. Med., 1885). Reporting on some surgical cases, M. Lucien Butte notes that when a toxic amount has been absorbed, diarrhœa comes on a few hours after dressing the wound: it is at first watery, afterwards sanguinolent and with pain. Salivation is rare, but

albuminuria and headache occur, and death may follow from exhaustion; the principal lesions are found in the digestive tract and the kidneys. A fatal case of Keller's is also reported, and a case of Murray's with severe diarrhœa,—and there are observations on animals to the same effect (Royer Charrière, B. M. J., ii., 1886). The cases of Richet and of Prévost show a large amount of success with some drawbacks, and one serious case from the surgical use of 1 in 1000 solution. Müllen reports a case of death after sublimate dressing of an operation for cancer uteri (Record, 1886). Szaléo reports serious results short of death (Record, 1886), and Braun states as to vaginal injections that absorption is rapid, especially if the exit of fluid be delayed, and that mercury is soon found in the fæces: an injection should be used only for one minute, and followed at once by one of clean water (B. M. J., i., 1887). He thinks that a strength of 4 in 1000 may be thus used in septic endometritis, but not when there is an open wound. At a debate at the Obstetrical Society on the subject, Dr. Dakin reported two serious cases, one fatal, but the general opinion was favourable —with the qualification that sublimate should be reserved for occasional use, and a less dangerous drug, *e.g.*, carbolic or permanganate be employed for ordinary daily injection (Lancet, ii., 1886). Dr. Playfair has formulated excellent detailed directions for the use of such solutions by the nurse (B. M. J., ii., 1887). Good authorities hold that not even a dilution of 1 in 5000 is safe for an *intra-uterine* injection (Internat. Journ., 1889).

The perchloride has also been used successfully in the disinfection of rooms, in much the same manner as sulphur,—50 to 60 gr. being placed on a shovel over a firepan in a room with doors and windows closed.

The biniodide has also been much commended by some observers as even a more effective and convenient antiseptic: Miguel states that a strength of 1 in 40,000 is fatal to micro-organisms, and a vaginal injection of 1 in 4400 is reported as safe and satisfactory (Internat. Journ., i., 1886, and B. M. J., i., 1887). Cheifetz supports the favourable account as regards surgical practice in sixty cases, including ovariotomy, lithotomy, herniotomy, resection of joint and removal of breast, all dressed

with solution of biniodide. Another Russian observer speaks well of the bromide of mercury (B. M. J., i., 1887).

The destructive effect of mercurial compounds upon the lower forms of animal and vegetable life is extensively utilised in the treatment of *parasitic diseases*.

Phtheiriasis.—When pediculi infest the head or the clothing, ointments containing the red oxide or the ammonio-chloride will often suffice to cure, and have the advantage of being free from unpleasant colour or odour: mercurial fumigations may sometimes be required for the body. For the pediculus pubis, blue ointment is commonly prescribed, but it is not a pleasant application and I have seen it produce much irritation. As in all cases when the hair is affected, destruction of the eggs or "nits" which are closely attached to the hair, is important for cure, and for this purpose weak lotions of sublimate are good (2 to 3 gr. to 1 pint water), or strong lotions of vinegar, followed by the use of a dusting powder or ointment containing calomel or white precipitate. M. Vigier recommends that a mixture of perchloride of mercury and glycerine (1½ dr. of perchloride in 8 oz.) should be employed as a parasiticide in these cases, the admixture with glycerine hindering absorption through the skin, and so preventing the general effect of mercury from taking place (Gaz. Hebd. de Méd., 1882).

Tinea Tonsurans — Pityriasis — Favus. — The parasitic growths upon which these unsightly maladies depend are destroyed by lotions containing 1 or 2 gr. of corrosive sublimate in the ounce, which should be applied once or twice daily after cleansing: ointments containing the same, or the ammonio-chloride, are also useful. Their curative effect, like that of all similar remedies, is often somewhat slow in ringworm of the scalp and in favus, but in ordinary ringworm of the body (tinea circinata), and in pityriasis versicolor, a few applications will suffice for cure.

Dr. Alder Smith has recommended the oleates of mercury as having more penetrating power, and records their proving curative in chronic and obstinate cases not amenable to lotions and blisters: for children under eight he uses a strength of 5 per cent., and for others who can bear it, 10 per cent., mixed with acetic

ether 1 part to 7; after cutting the hair close, thorough washing and drying, this is rubbed into the whole scalp regularly night and morning, a cap or turban being worn to keep any of the preparation off the face: it is important that the head should not be washed more than once a fortnight.

Mercurial remedies should not be used too concentrated, or over too large a surface, for fear of producing severe constitutional effects; and it is well to remember that blistering increases the absorptive power of the skin (New York Med. Journ., 1858). Under the heading of "absorption" we have mentioned cases in which death followed inunction of the scalp for ringworm, and would refer again to one in which a single painting with a vesicating solution of sublimate (gr. x. ad ʒi.), caused salivation and death from mercurial poisoning (B. M. J., 1871). I have myself seen a case in which death resulted from the local use of a strong sublimate ointment, and more than one case with serious symptoms.

Other Skin Diseases.—In many non-parasitic forms of skin disease mercurials are useful locally: sometimes by an absorbent action or quickening of the functions of the lymphatics, sometimes by stimulating the epithelial and other tissues also, sometimes by exciting irritation of "substitutive character," and in some cases by a powerful caustic effect. In syphilitic affections they exert a "specific" power, and in many cases their local effect is supplemented by a varying amount of general action consequent on absorption. The late Mr. Startin perhaps an empirical, but certainly a successful practitioner in his speciality, and Mr. Naylor who followed him, were accustomed to introduce mercury in some form into the treatment of almost all their cases; and if we do not use it so much, it is only that we have become more cautious than our predecessors as to doing harm by remedies.

M. Gubler has specially drawn attention to the cure sometimes obtained by general mercurial treatment in very chronic inflammations of the skin, such as psoriasis (*v.* p. 702) and eczema, and observes that it is a last resource not to be neglected, even if it be not easy to explain its action. Unna and some others would include these under parasitic disorders.

Eczema—Herpes.—In the acute inflammatory stages of

eczema mercurials are usually unsuitable as being irritant, but Dr. Spender speaks highly of the use of lotio hydrarg. nigra in eczema rubrum: he adds glycerine and applies it fresh three times in twenty-four hours, without oiled silk (B. M. J., i., 1878). Salivation from the local use of such a lotion has, however, occurred (B. M. J., ii., 1891). In sub-acute and chronic stages with thickening from infiltration of the cellular tissue, moderate crusting, scaling and dryness of skin, mercurial ointments are very serviceable: that of the red oxide often irritates even at this stage, and that of the ammonio-chloride, diluted 1 in 4 or 8, is more generally suitable; Niemeyer specially commends it for chronic eczematous patches on the face. When there is more than average secretion or irritation, better results are obtained by a combination with equal parts of lead or of zinc ointment, and a formula much used for eczema capitis at the Skin Hospital is the following: R. Plumbi acet. gr. x.; zinci oxidi, hydrarg. subchlor., ung. hydrarg. nitrat., āā gr. xx.; olei palmæ purif. ʒss.; adipis recentis ʒss., misce: such ointments are useful in the chronic general eczema of childhood especially.

For eczema mammæ, which is often very obstinate, Hebra uses sublimate lotions (1 in 120), but they require great care if any lactation is continued. For eczema of the genitals, Devergie recommended a very much weaker solution of the same; Guéneau de Mussey prefers calomel (15 gr. to ½ oz. of lard). For eczema about the hands, and especially for "cracks" about the fingers and nails, an oleate of 5 per cent. strength is said to be very efficacious (Pract., vol. x.). I have found an ointment of hydrarg. ammoniatum gr. v. to ʒj. very useful for eczema capitis et aurium after thorough removal of the crusts, also for all cases of chronic eczema. In sycosis, parasitic or not, mercurial ointments combined with sulphur give the best results. In herpes preputialis, calomel is a useful dusting powder.

Impetigo Contagiosa.—The ointment of the "white precipitate" diluted to an equal amount acts almost as a specific in this affection. As in eczema, the crusts must first be removed thoroughly; this may be painlessly done by softening them with a little carbolised olive oil. In obstinate *pemphigus*, frictions with the oleate of mercury—5 per cent. and upwards—may be useful (B. M. J., i., 1887).

Erythema—Ephelides (Freckles).—Many cosmetic waters owe their efficacy to a minute proportion of sublimate, or to an albuminate of mercury. M. Hardy's formula for the treatment of freckles contains lead acetate and zinc sulphate of each 40 gr., sublimate 8 gr., with alcohol 2 oz., and distilled water 4 oz.; it acts by slightly irritating the epidermis, so that this exfoliates quickly. For a more decided effect Hebra uses a stronger solution (about 4 gr. of sublimate to 1 oz.), applying it for four hours till the skin grows red, or even is blistered, and then under soothing applications it peels off, leaving a new surface. For ordinary erythema of the face, a lotion containing 1 to 2 gr. in 4 oz. of almond mixture, with or without bismuth or zinc oxide, and spirits of wine, is very useful.

Acne.—The last formula is suitable for many cases of acne when sulphur would not be well borne; but the pustules of this disorder may often be aborted with still more satisfactory results by means of the acid nitrate of mercury. The apex of the pustules should be lightly touched with this, on a glass brush or a match point, and the drop of liquid should be soon removed by blotting-paper or sponge; some temporary irritation may be expected, and strong carbolic paint has almost superseded this, as being less liable to scar.

Psoriasis.—The application just described (of acid nitrate) has been recommended also for chronic patches of psoriasis, and especially for such as occur along the forehead at the roots of the hair, but it should be used with great caution. The ointments of white and of red precipitate have a certain value for psoriasis of the face, or scalp, or hands, because they have no unpleasant colour or smell, but they are seldom so efficacious as tarry or chrysophanic preparations. The iodides, with iodide of potassium, are also recommended (Rochard, Lailler). Mapother recommends not only ammoniated mercurial ointment locally, but the iodide or blue pill internally (B. M. J., i., 1891), and Shoemaker uses injections of perchloride.

The carbolate of mercury is useful in macular and tubercular syphilides and in syphilitic psoriasis of the palms and soles of the feet, also in syphilitic rash and specific affections of the mucous membranes, and in papular and pustular eruptions, in doses of $\frac{1}{16}$ to $\frac{1}{4}$ gr. three or four times daily; it is also used *hypodermic-*

ally with success in the form of a mucilage containing 2 per cent. (Lancet, i., 1887).

Prurigo — Chronic Lichen — Pruritus.—In all itching papular eruptions, hot dilute solutions of the perchloride are likely to give relief. Trousseau recommends a strength of 12 gr. to the pint, and justly lays stress upon the importance of its being used hot.

In *prurigo* the ointment of ammoniated mercury either alone or combined with hydrocyanic acid, or with lead compounds, often gives relief, and *calomel ointment* is a good remedy for pruritus ani, and for pruritus of the scalp connected with chronic eczema or pityriasis.

Erysipelas—Eruption of Small-pox.—Evidence may be found both for and against the use of mercurial ointment (ung. hydrarg.) in these conditions. The application cannot be depended on for the arrest of erysipelas, but it has some power to relieve the burning pain, and to lessen the chances of pitting in small-pox : it certainly can prevent the maturation of a vaccine vesicle. The late Dr. Hughes Bennett thought highly of this treatment, and Mr. J. F. Marson says that a mercurial plaster in use at the Children's Hospital, in Paris, answers well : it is a modification of the emplastrum Vigo c. mercurio, and contains 25 parts of mercurial ointment with 10 of yellow wax and 6 of black pitch ; it is most suitable for semi-confluent cases, where the patient can use a little care, for in severely confluent attacks the application would soon be rubbed off by the restless movements. There is also some risk of salivation, and other forms of ointment answer equally well, so that although I have tried mercurial preparations in such cases, I have latterly abandoned their use. A spray however, containing 2 per cent. of perchloride with ether, is a more suitable application, and is said to lessen pustulation (Pract., 1890).

Inflamed Lymphatics—Adenitis, etc.—When the parotid, the testis, or the mammary gland is inflamed, gentle frictions with mercurial ointment or applications of it on lint, are suitable : in chronic superficial glandular swellings resulting from inflammation, or especially from syphilis, and also to procure absorption of inflammatory products in an early stage before suppuration has occurred, the same treatment is useful. The

5 to 10 per cent. solution of the oleate painted on night and morning is excellent, and I have known it succeed quickly in some cases where ordinary blue ointment had failed.

For inflammatory and congestive conditions of the *uterus*, but more particularly of the *ovaries*, a combination of mercurial and belladonna ointments in equal parts applied externally is sometimes useful; it has been recommended even in fibroid growths.

Serous Effusions—Pleurisy—Hydrocele.—I have not been able to satisfy myself of distinct benefit from mercurial frictions in pleuritic or pericardial effusions, though they have been considered useful by others: in hydrocele in children, Kock uses an ointment of the cyanide (1 part in 4), rubbing a very small quantity into the scrotum daily for three to six weeks unless erythema supervene: in such cases I have sometimes successfully employed as a paint, a 2 to 10 per cent. solution of the oleate.

Goître (Cysto-Adenoma of the Thyroid Gland).—In true goître as distinguished from fibroid or purely cystic enlargements, an ointment of the red iodide of mercury succeeds, according to the large Indian experience of Mr. Macnamara, better than any other remedy. The strength he recommends is 15 gr. to the ounce of cerate, more than this causing unnecessary pain and soreness. A thin coating of such an ointment should be smeared over the goître, which should then be exposed to the full rays of the sun, or at least to bright light: artificial heat is not so effective (Frodsham, Lancet, i., 1860). Within half an hour, smarting and burning are felt, and in another hour a blister forms, which is treated in the usual way. The good effects of the red iodide continue long after this blister has healed, the tumour decreasing day by day for several weeks. One application of the ointment every two months is sufficient for the most extreme cases. Mr. Macnamara has often seen tumours which extended from the chin to the breasts disappear after two or three applications; from ordinary blisters he has never seen benefit in such cases, and the expensive iodine ointment was found to act very slowly, compared to the mercurial preparation: he has never seen salivation produced by the red iodide, though it is said to have occurred in some exceptional cases.

Splenic and Glandular Enlargements.—Mr. Macnamara has also found the ointment of red iodide of mercury useful in the treatment of "spleen," meaning the chronic enlargement resulting from ague or malaria (ague cake): he gives at the same time "ague powders" (quinine). At Netley this ointment forms part of the accepted treatment for such cases, phosphates of iron, quinine, and strychnine being given internally (Murchison, B. M. J., i., 1867). Dr. Andrew reports advantage from the same ointment at St. Bartholomew's Hospital (Lancet, i., 1869). Of course, in the enlarged spleen consequent on mechanical impediments to the circulation and heart disease, or on blood poisoning as in typhoid, or on waxy or other structural degenerations, mercurial ointments are useless, and even in malarial enlargements harm may be done by them, because splenic disease seems to render the system peculiarly liable to salivation and other ill-effects of mercury. Sir Joseph Fayrer has observed serious results from its use in splenic cachexia, with tenderness of the organ and much debility (Med. Times, i., 1874). Mr. Macnamara however, as above remarked, has never seen salivation from a judicious use of the iodide ointment, and in all chronic cases it ought to receive a fair trial.

The ointment is equally applicable in strumous enlargement of lymphatic glands.

Inflamed Joints.—In any persistent articular inflammations, whether traumatic, gouty or rheumatic, mercurial ointments or oleates are useful applied with friction two or three times daily. Mr. Scott (Bromley) earned a high reputation by his successful treatment of "white swelling," chronic synovitis, etc., with a mixture of mercurial ointment, camphor, soap, and cerate, applied on strips of lint firmly covered with plaster strapping. Although this method is useful I commonly prefer gentle friction with an ointment of the ammonio-chloride, beginning with a strength of 1 part of the official ointment to 4 of simple cerate, and using afterwards 1 part in 8 two or three times daily. Under this simple treatment, with rest, I have known good results occur which other remedies had failed to procure: thus in one case of chronic inflammation of the wrist-joint, where able surgical and hydropathic treatment had been fairly tried, this ointment relieved more than any other means, and in several

cases of chronic disease of the knee-joint already condemned to amputation, the limb has been saved (though with a stiffened joint) by this application.

Ulcerations—Whitlow.—In chronic indolent or suppurating sores even when non-specific, the "black or yellow" lotions containing the respective oxides are very good applications, and the ointment of the red oxide is a valuable stimulant. Martin has strongly recommended blue ointment in *whitlow*, rubbing it in every hour in intervals of poulticing. I have also used this treatment with some advantage, but the frictions need not be so frequent. Chronic indolent ulcers of the leg whether syphilitic or not, often heal quickly with small doses of mercury, and lotions or ointment of the same when applied to a similar condition, hasten cicatrisation.

Syphilitic Ulcerations and Eruptions.—It is in these forms of disease that the efficacy of mercurial lotions and ointments is the most marked. For *condylomata*, calomel with astringents is a good dusting powder, but the acid nitrate lightly applied, is still more effective: one application will sometimes destroy the growths when nitric acid alone, and other caustics have failed (Pract., Aug., 1874). The injection of 15 m. of a 1 per cent. solution of formamide of mercury, at intervals of three to four days is said to be very successful (Lancet, ii., 1890). The acid nitrate is also the best agent to employ in the rare cases when it is desired to destroy a chancre by caustic in its early stages. As a dressing for hard chancre and for squamous and ulcerative forms of cutaneous syphilide, the "emplastrum mercuriale" (Prussian form) is recommended by Dr. Liveing; it contains metallic mercury (3 oz.), turpentine ($1\frac{1}{2}$ oz.), and lead plaster (12 oz.).

For generalised syphilitic eruptions especially those of papular or scaly character, baths of corrosive sublimate have been recommended by Baumé, Trousseau and others; but their proportion of $\frac{1}{2}$ oz. to each bath I think too large: headache, drowsiness and sometimes colic and diarrhœa were produced, and the skin irritated by them. Baths containing only 10 to 15 gr. have been found very useful for syphilitic infants (*cf.* Pract., 1891).

Gonorrhœa, etc.—Weak injections of sublimate (1 or 2 gr. in 8 oz.—Black; 1 part in 20,000 and 30,000—Leistikoff) have

been found very effective in this disorder (Record, 1883-85), also in cystitis from prostatic retention (B. M. J., i., 1884).

Epithelioma—Lupus.—A similar injection, $\frac{1}{4}$ gr. in a pint of water with glycerine, has given much relief in painful uterine epithelioma: it was used twice daily, and presumed to act by lessening infiltration, as well as by disinfection (B. M. J., i., 1885). Cases of epithelioma have been cured by repeated painting with the acid nitrate of mercury, the morbid growth being destroyed in layers (Gay, B. M. J., i., 1862), and this mode of treatment is applicable with due care in instances where operation is not desirable; it has been used to the *cervix uteri*, but has sometimes caused salivation.

Extending patches of lupus are often controlled by the nitrate, but it is not so useful in the *erythematous*, as in the *ulcerative* and *discharging* forms: its application is very painful and should not be repeated more than once or twice weekly, and should be followed by soothing remedies. This method of treatment is however, specially applicable to small nodules remaining or recurring at the edges of a large patch after scraping, and may be carried out by means of a pointed splinter of wood, which should be well pressed into the growth. In chronic torpid ulcerative conditions, M. Lailler recommends an ointment containing the red iodide with iodide of potassium (about 7 gr. of each in 3 oz.), which is useful but irritant: it may be applied stronger to non-ulcerative forms. Cinnabar is combined with arsenic in "Cosme's paste," which is very useful for superficial lupus patches about the face: three applications are usually made, for twenty-four hours each time (*v.* p. 487). Calomel dusted on after the application of creasote has been found effective in some cases (Rev. Gén., 1885). Local injection of 5 to 6 min. of a 1 per cent. aqueous solution of perchloride sometimes gives good results, though there may be much reaction, with swelling and even abscess (B. M. J., ii., 1892). The perchloride, together with zinc chloride, carbolic acid, iodol, and sedatives forms the paste of M. Félix (Brussels) for destroying lupus, nævi, and malignant growths.

Diseases of Mucous Membrane—Syphilitic Throat, Tongue, etc.—In ulcerative conditions due to syphilis, gargles of "black-wash" or applications of calomel in substance are most

useful: more active effects are, however, to be obtained from painting with dilute acid nitrate—1 part in 8 or in 16: 1 min. to 1 oz. of water is sufficient for a spray (Lyster, Liverpool Hosp. Rep., 1870). Trousseau used cigarettes for these and for laryngeal affections. A gargle of bicyanide of mercury (½ gr. to 1 oz.) is most useful when black-wash and other preparations fail.

For syphilitic and other ulcerations of the Schneiderian membrane, an ointment of the grey oxide is preferred (℥ss. ad ʒss.): a powder containing cyanide of mercury and camphor may be cautiously used.

In *Ozæna*, injections of black or yellow mercurial lotion are of some service, with powders for insufflation containing calomel, bismuth and white sugar: a spray 1 in 4000 of biniodide is recommended by Dr. Illingworth.

In *Chronic Angina*, good results have been obtained from the local use of the diluted acid nitrate of mercury (1 part to 6). It has relieved "nervous cough," and also, it is said, spasmodic asthma (Bull. de Thérap., xxiii., 1842); this action would be of reflex character. In *Diphtheria*, solutions of perchloride (1 in 1000) have been found valuable, applied locally. For *Chronic Laryngitis* and *Eustachian Catarrh*, Dr. Nevins has written in favour of mercurial vapour; it may be obtained from cigarettes made with blotting-paper soaked in a solution of the nitrate (Trousseau). A curious application of *metallic* mercury is for the removing of solid lead from the ear (Lancet, i., 1892).

In **Strumous** and **Catarrhal Ophthalmia** a lotion of corrosive sublimate is one of the best remedies, especially in conjunction with the internal use of the same preparation, or of calomel: 1 or 2 grs. of the sublimate are to be dissolved in 6 oz. of water, and of this, 2 drs. with an equal part of hot water applied three times daily. Under this lotion the conjunctival redness is lessened, the corneal pustules and ulcerations of the lids heal, whilst the discharge, lachrymation, photophobia and irritability of the adjacent mucous membrane all diminish; in this affection is well seen the special power of mercury to check threatening suppuration and to heal ulceration. Irrigations of sublimate, 1 in 2000, are effective in contagious conjunctivitis (Record, 1885).

In **Blepharitis,** when the sebaceous glands near the ciliæ become inflamed or obstructed, causing redness, crusting and

irritation, mercurial lotions or ointments applied at bedtime after due cleansing, are very serviceable. Calomel ointment is the mildest, that of the red oxide the most energetic (B. Carter), but that of the freshly-precipitated yellow oxide, introduced by Pagenstecher, is now the most generally used (Ophthalm. Rev., v. ii.). I have been well satisfied with the effect of white precipitate ointment diluted with three or four parts of lard, and Haltenhoff (Geneva) prefers this.

Hordeolum (or "stye") is often best treated by applications of the same three or four times daily.

Phlyctenular Ophthalmia and **Keratitis** of scrofulous character have been cured by insufflations of calomel. In opacities and nebulæ of the cornea, thickening of the tissue is somewhat diminished by the use of a small fragment about the size of a pin's head, of the ointment of the red oxide, every night for some months; this is placed under the lid, and then gently rubbed over the cornea by means of the finger outside the lid. Sometimes this application excites much irritation and even deposit of false membrane, which is presumed to be from formation of perchloride.

THERAPEUTICAL ACTION.—*Internal.*—A *general* effect may be obtained as we have already seen, from *local* applications made in several ways—by inunction, by endermic painting or hypodermic injection, as well as by suppository or fumigation. These methods which will be more fully described afterwards, are utilised for mercury more than for other drugs, yet the ordinary mode of administration is simpler, and with due attention to the mouth and the digestion, is more satisfactory when the conditions of the illness admit of it.

Inflammatory Diseases.—From the time that Robert Hamilton described his successful treatment of inflammation by calomel and opium (Duncan's Commentaries, 1764) down to perhaps twenty or thirty years ago, mercury in some form was, in English practice at least, the almost universal remedy both for acute inflammations and for their results, such as effusions, adhesions and indurations. Trousseau described mercurials as "les antiphlogistiques les plus puissants"—more active, perhaps, than blood-letting,—and Nothnagel remarks that at one time the name of any malady ending in "itis" seemed sufficient to indi-

cate their use. Sir Thomas Watson, in the later editions of his classic Lectures, quotes his own earlier opinion that "mercury is a very powerful agent in controlling inflammation, especially when acute and 'adhesive' in character, also in preventing exudation," but owns that this can be said no longer—"it requires much qualification" (5th ed., 1871). This is perhaps the most important point in which modern experience and opinion would discredit the therapeutical power of mercury. It is not denied that full doses can act destructively on the blood and the tissues, though we have given some evidence against its aplastic energy, but modern clinical experience affirms that it has not *great*, but comparatively *little* power over *acute* inflammatory disorders, that these often run a natural course towards recovery independent of mercurial or other medicinal treatment, and that when it is pressed to a full effect convalescence is protracted by greater anæmia and debility. (The unquestioned good results recorded from the treatment of Hamilton, which led to its general adoption, have been plausibly attributed to the *opium* rather than to the *mercury*.) Sufficient account of the evils that followed was not made by our predecessors, who knowing too little of the natural history of disease, attributed all bad sequelæ to *it* rather than to the medicines, and considered themselves successful if, when "the disease was subdued," life at least was saved.

We cannot on the other hand, agree with the assertion that mercury is never useful but always injurious in inflammation. There is evidence of its advantage in certain conditions, though this evidence is not so consistent nor so general as of its value in syphilis. It will certainly remedy some of the *results* of inflammation, as chronic effusions in joints or lungs, and as Dr. Stephenson remarks when narrating such cases, no number of instances in which the medicine has been abused, or even has failed, can contradict the cases in which it has conferred evident benefit (Edin. Med. Journ., 1871). Dr. Habershon allows that it has value in cases of retained secretion, dropsy, and gastric disorder, as a purgative and as an anti-syphilitic, but objects to its use in all degenerations and passive congestions, in fevers and exhausted conditions, in diseases of mucous membranes, in rheumatism and *all inflammations* of the lung and brain (Pamphlet on Mercury, Brit. and For. Rev., ii., 1860). For my own part, I still hold it

useful in many chronic inflammations whether syphilitic or not, affecting mucous membranes and parenchymatous tissues, and having a general tendency to suppuration and ulceration—but I am satisfied that it should never be pushed to salivation.

Meningitis and Cerebral Disorders.—The principal difficulty in judging of the effects of mercury in meningitis, and of the relative value of recorded cases, lies in the uncertainty of diagnosis. Cases of cerebral congestion, in children especially, present at first symptoms very similar to those of simple meningitis, such as pain in the head, vomiting, injection of the eyes, excitement followed by semi-coma, pyrexia and even convulsions. Many years ago I usually treated such cases with minute doses of perchloride or iodide of mercury, and as I thought, with moderately good results, but further experience has not satisfied me on this point. Many surgeons prescribe it in *traumatic* cases and believe it relieves the fulness of the cerebral vessels, and although Dr. Ramskill (Reynolds' System), Stromeyer, and some other authorities might be quoted as still commending mercurial influence in meningitis, the general tendency of modern opinion is decidedly against its value. In many recent text-books, in Dr. Bristowe's for instance, it is not even mentioned. When the malady follows on febrile or eruptive diseases, or spreads from caries—*e.g.*, in the ear-bones—mercury is not likely to relieve it, and in other idiopathic, or at least non-tubercular cases, I think aconite, belladonna and bromides are of more importance in the early stages, and nourishment and perhaps iodides in the later ones. In cases presumed to be tuberculous I use iodide of potassium, generally with cinchona. Dr. Copeman, when narrating several cases of apoplexy and cerebral disorder in illustration of the beneficial action of mercury, fully adopts the proposition that it cannot prevent inflammation, but may cause absorption of its results, such as effusions and adhesions; he strongly advises its use therefore, in all inflammations of *vital* organs, after the acute stage is passed (Med.-Chir. Rev., i., 1872). I have seen it of some service in such cases, but many remain quite unaffected by it.

Chronic Hydrocephalus.—Of this disease, Gölis recorded a large number of cures under $\frac{1}{4}$ to $\frac{1}{2}$ gr. doses of calomel twice daily and mercurial inunctions of the scalp, but his results were

not confirmed by other observers. Sir T. Watson refers to two remarkable cases cured by a mixture of metallic mercury 10 gr., fresh squill 5 gr., and manna, taken three times daily for three weeks: it caused weakness, emaciation and diuresis, but not ptyalism. I have not myself seen any good result in this condition from mercury.

Pericarditis.—To treat this inflammation without mercury would, a generation ago, have been reckoned almost criminal, and men no less eminent than Graves and Stokes have left their emphatic testimony in its favour—the latter gave 20 gr. of calomel once or twice daily. Yet soon afterwards, Markham and Walshe began to doubt its value, and Todd denied it wholly. Watson says: "I am obliged to recant my advice as to giving mercury in acute pericarditis" (Lectures, 1871), and Hayden is almost alone amongst modern writers in still recommending calomel and antimony (Diseases of Heart, 1876). Waters, Austin Flint, and Loomis have discarded mercurials, and Sibson, in his able monograph, does not even mention them (Reynolds' System, vol. iv.). Sir A. Garrod states that full mercurial treatment of the joint-affection in rheumatism will not prevent pericarditis, and it would seem, therefore, scarcely likely to arrest it after its commencement: further, as it is almost always connected with, or dependent upon rheumatism, its treatment should naturally be conducted on the same principles, and as we do not now give mercury for the main disease, why should we do so for one of its local manifestations? I have myself carefully watched its effects several times, and although the bruit and other physical signs have varied during the attack, I have never been able to satisfy myself of a definite influence of the drug upon the malady; on the contrary, I have seen this prolonged to more than an ordinary duration whilst the gums have been sore. In sub-acute or chronic cases where effusion has occurred and is persistent, I have seen benefit from small doses of sublimate or grey powder and mercurial applications locally, but when the effusion is very large, the pulse feeble and cardiac paralysis threatening, any excess of mercury must be carefully avoided (Nothnagel).

High-Tensioned Pulse.—In cases of contracted kidney where there is high-tensioned pulse and consequent sleeplessness, Sir W. H. Broadbent finds that only venesection or a dose of

calomel will relieve the condition. In many other cases of sleeplessness accompanied by a similar condition of the pulse, but without the underlying renal disorder, he believes that blue pill is the only trustworthy hypnotic (B. M. J., ii., 1883). Dr. Tyson refers to a similar effect in "bilious attacks" (B. M. J., i., 1891).

Endocarditis.—In rheumatic endocarditis, on account of the still more serious issues involved in exudation and adhesion, more advocates are to be found for the use of mercury in the hope at least, of controlling such results. I myself treat this affection on the principle recommended in a previous paragraph, viz., that treatment of the rheumatism, the cause of the cardiac mischief, with salicylates, iodides and alkalies is the most effective for its complications: this should in all cases be combined with rest, and in certain instances opium also may be indicated.

Pleuritis.—Fuller and Walshe may be named amongst modern advocates of mercurial treatment in pleurisy, but for the acute stage I cannot see its advantage, since aconite, salines, belladonna, or morphine, with suitable local applications, give usually all the good results that can be expected from medicines. When effusion has occurred however, I believe that mercury may be of considerable service in stimulating the absorbents; and in some cases, when hectic has set in and there have been signs of commencing suppuration, small doses of corrosive sublimate have seemed to me advantageous. I have also noted benefit from this medicine in pleuritis occurring in puerperal women; a similar observation is recorded by Nothnagel, and in a patient æt. 40 with extreme prostration and much effusion, not improving after paracentesis, much benefit followed mercurial inunction (M'Dougall, Pract., i., 1884; *cf. ib.*, i., 1878). In no case should it be pushed to the production of salivation or anæmia.

Peritonitis.—Velpeau was the great advocate for a thorough mercurial treatment of this inflammation, and by enormous doses of calomel used concurrently with inunctions, he expected so to alter the blood in a few hours as "to prevent its furnishing the elements of a severe inflammation." Trousseau adopted for some time a similar method, for which he substituted later that of Dr. Law, giving minute doses frequently. Without accepting

Velpeau's theory, it may be said that mercurial treatment—or rather calomel with opium—has been less completely abandoned in this inflammation than in many others. Watson certainly says "he is doubtful if it has ever done good, whilst if it purge it must do harm," but I believe that small doses of calomel or of sublimate ($\frac{1}{100}$ to $\frac{1}{50}$ gr.) have conduced to the recovery of some of my cases of acute and "idiopathic" peritonitis. I have generally given them every one to three hours alternately with aconite, and used opium as required for relief of pain. In localised forms of peritonitis, occurring for instance, after perforation, or from peri-typhlitis, opium is the most important remedy and mercurials should never be given.

Pneumonia.—In the early stages of acute pneumonia formerly treated by calomel and antimony, I cannot recommend mercurials, but the time for using them with advantage is when secondary fever arises, and there is reason to fear purulent formation. So far as I can judge, they have seemed to exert some power in preventing this, for certain cases of the kind have improved on commencing the use of sublimate, and others have relapsed on its omission. In pleuro-pneumonia with copious effusion, the same remedy is still more clearly indicated, and in chronic interstitial pneumonia it sometimes has excellent effects. Sher advocates the treatment of croupous pneumonia by local applications of cold and by rubbing in grey ointment (2 drs. daily); this appears very effective and is said to shorten the duration of the disease considerably (Voënno-Sanitarnoë Delo, No. 26, 1885). Sometimes a syphilitic or strumous deposit occurs in the lung, rendering it partially solid and giving the physical signs of a pneumonia, and these deposits, especially when of the former nature, seem to "melt away" under the moderate action of mercury: but careful diagnosis of such cases is required, for in true tubercular deposit the drug is injurious. A bold method of treatment injects perchloride directly into the lung and claims thus to shorten pneumonia and benefit phthisis (B. M. J., ii., 1885; i., 1886).

Bronchitis.—In acute cases with much congestion of the mucous membrane and scanty expectoration, small doses of perchloride are often useful. In certain cases narrated by Thorowgood, blue pill with squill was given with apparent

advantage, when there were "severe cough at night, pyrexia with loaded urine, dyspnœa, some lividity of lips, difficult scanty expectoration, with râles and perhaps impaired resonance" (Pract., i., 1878): this treatment is more suitable for robust adults than for the aged. In catarrhal bronchitis passing into pneumonia, frictions of the chest with oleate of mercury are said to be useful.

Coryza.—In ordinary coryza especially when there is much sneezing, I have often found small doses of grey powder cure more quickly than any other remedy. Catarrh affecting the Eustachian tube is also well treated in the same manner.

Diphtheria—Croup (Laryngeal Diphtheria).—Stillé, after giving many authorities in favour of the mercurial treatment of diphtheritic disease, says himself, "that it appears urgent that the system should be brought under mercurial influence as speedily as possible," and following Albers, he recommends $\frac{1}{4}$ gr. of calomel every hour, and a scruple of mercurial ointment to be rubbed at intervals into the thighs. Trousseau, finding that the direct application of calomel to external diphtheritic surfaces modified favourably their condition, recommended its use by insufflation, or by allowing it to mingle slowly with the saliva; this has not, however, given much result. Bretonneau used mercurials freely, but his mortality was great and contributed to induce a general distrust of the treatment. West, however (ed. 1859), still considered calomel useful for "counteracting the tendency to formation of false membrane and preventing lung-inflammation." I have been myself much disappointed with the action of calomel in these respects, but the red iodide and the cyanide of mercury, in doses of $\frac{1}{50}$ to $\frac{1}{30}$ gr. every two to four hours, have exerted a more favourable influence in some severe cases. It is very important to watch their action carefully and not to induce salivation, for according to general experience this promotes rather than checks the spread of exudation, and certainly as a general rule, other remedies of a tonic or antiseptic character are to be preferred to mercurials.

The treatment by mercury has been again advocated of late years. Schutz recommends the cyanide, but most of his confrères object to such treatment for fear of collapse (Rec., 1884). Thallon, Lange, Linn and others however, support it (Med. Times, 1884;

N. Y. Journ., 1884). A series of sixty cases without one fatal issue under perchloride is given by Mr. Coward. Drachm doses of the liquor hydrarg. perchlor. were given every hour for several hours to both adults and children—less frequently after the first few hours; the tr. fer. perchlor. was sometimes added (B.M. J., i., 1891). Dr. Illingworth is an enthusiastic advocate of the biniodide, and my experience of many years back is in its favour. Calomel vapour has been of service in croup (Lancet, i., 1889).

Tonsillitis.—In ordinary tonsillitis, and even in suppuration about the fauces, I have seen advantage from small doses of hydrarg. c. cretâ. In early stages of quinsy, in ulcerated sore throat and even in the "putrid" form (cynanche maligna), $\frac{1}{2}$ gr. given every two to four hours has induced rapid improvement; it does not exclude the use of aconite or belladonna if indicated by high temperature or much pain. In parotitis, also in glossitis, "cancrum oris," and cracks and ulcerations about the mouth and lips, the same treatment is effective. For relaxed congested conditions of the faucial mucous membrane the value of dilute solutions of mercurial nitrate has been already indicated.

Scarlatina.—The small doses of hydrarg. c. cretâ just mentioned I have found equally useful in the severe specific sore throat of scarlatina, especially when the cervical glands and adjacent cellular tissue are inflamed and swollen, and when there is ulceration or even a tendency to gangrene.

The biniodide is advocated, as in diphtheria, according to the following form: Liq. hyd. perchlor ʒi., potas. iod. ʒss., syrup ʒviii.—ʒss. every two or three hours. Some observers, however, have thought nephritis more frequent after it (B. M. J., i., 1889). It is also used as spray—1 part in 2000: or the perchloride may be employed double that strength.

Morbilli.—Half-grain or quarter-grain doses of grey powder given every four hours will also control the catarrhal symptoms of measles: when the conjunctivæ and mucous lining of the nose, mouth, and throat are inflamed, and even when ulceration is present, they render excellent service.

Variola.—When the eruption is passing into the pustular stage and secondary fever is setting in, I can recommend $\frac{1}{2}$ gr. doses of hydrarg. c. cretâ every three to four hours, for a few days. Unless the gums show signs of tenderness, this treatment

tends to check and limit suppuration, and consequently to lessen in some degree the chances of pitting. The local use of mercurial ointment has been already mentioned.

Anthrax.—The remarkable observations of Dr. T. Cash showing that small doses of sublimate are prophylactic against anthrax in animals may here be referred to (B. M. J., i., 1886 and 1887). The bacilli exposed for ten minutes to solution of only 1 in 25,000 are rendered innocuous (Klein). A number of cases in men have been reported in which, after excision of the affected part, powdered sublimate—3j.—3ii.—has been sprinkled over the wound with excellent result,—a slough formed, and in a few days separated,—there were no toxic symptoms (Record, 1886). Remarkable improvement in Indian cases of anthrax is reported from dressing with a lotion of sublimate 1 in 1000, 2 dr. of the same being injected near the sore (B. M. J., ii., 1890). The ung. hydrarg. nitratis has special repute for aborting boils (Edin. Journ., 1888).

Enteric Fever.—We need not here refer to the older method of treating this fever by repeated purgative doses of calomel (*v.* Stillé), a method not now advocated, but several eminent physicians abroad—Traube, Wunderlich, Liebermeister and others—have recently recommended a "specific" treatment for the first nine days of this fever by calomel, giving 10 gr. in a single dose the first day, and 8 gr. (in divided doses) daily for three or four days afterwards. They claim for these doses an antipyretic effect, and a power of lessening both the duration and the mortality of the disease (Med. Times, ii., 1876). I have not had much experience of this treatment, nor, although foreign statistics show good results, has it made way in this country. An early moderate purgative dose is however, often advisable, and Black has written to recommend one or two 5 gr. doses of calomel during the first week, as "antiseptic" (Lancet, i., 1875). Corrosive sublimate in minute quantities has also proved valuable in typhoid diarrhœa (B. M. J., i., 1874), this being in accord with my experience, and $\frac{1}{3}$ gr. of biniodide thrice daily disinfects the stools (*ib.*, ii., 1891), but with these exceptions mercury is not indicated in the treatment of this fever. Kalb, however, and others claim advantage from mercurial inunction (B. M. J., i., 1885; i., 1889).

Puerperal Fever.—Traube has also revived mercurial treat-

ment in some cases of this disease—not for the general blood poisoning—but at the commencement, when phlegmonous inflammation is spreading from the uterus and involving other parts, *e.g.*, the peritoneum or pleura. He considers that a rapid and energetic mercurialising by calomel and inunction gives the best results, that such cases bear large doses, and that improvement generally coincides with the first signs of salivation. Spiegelberg especially observed the good influence of corrosive sublimate in similar conditions—he gave $\frac{1}{6}$ gr. at a time (Nothnagel). Concerning this treatment, I can only say that I have not had occasion to adopt it, aconite, opium, quinine, etc., seeming to be much more desirable remedies. Sublimate is, however, much used as injection, etc. (*v.* p. 697).

Erysipelas. — In many cases of phlegmonous erysipelas, especially when occurring in strumous subjects, I have found the internal administration of corrosive sublimate distinctly useful (*v.* p. 703).

Syphilis.—In 1497, Gilinus first employed mercury in the treatment of the then epidemic of syphilis, borrowing his practice from that of the Arabians in skin diseases, and using only external applications by friction, bath, or fumigation. Several serious accidents that occurred from the remedy as used by empirics contributed to discredit it, and in 1517 it was almost entirely superseded by guaiacum. Not long afterwards however, the internal administration of corrosive sublimate, red precipitate and calomel became general, and by the time of Boerhaave was carried to such excess that mercurial treatment was not considered thorough and satisfactory till it secured the ejection of three or four pounds of saliva in twenty-four hours. Protest against such abuse was not wanting, and between mercurialists and anti-mercurialists sprung up a controversy which has lasted to our own time. In the early part of this century a reaction of opinion against the extravagant use of the drug in syphilis became general — thanks mainly to Rose, Guthrie, Thomson and Abernethy—and it was proved that syphilis sometimes tended to spontaneous cure, and yielded to non-mercurial treatment. Later on, an important distinction was made out between the soft or non-infective, and the hard infective sore, and professional opinion pronounced strongly in favour of mercury

for the latter, whilst allowing it unnecessary in the former, and in gonorrhœa. This was clearly evidenced in the report of the Admiralty Commission on the subject, which records the opinions of forty eminent practitioners (1864). Amongst others, Sir James Paget called mercury "a specific—if the patient could take it well; in favourable cases it would prevent secondary symptoms, and at least it would shorten their duration." Mr. Hutchinson speaks of it as a "true vital antidote and if given early, as really stopping the development of symptoms, and absolutely curing the disease." Whilst agreeing with this conclusion, I do not discard wholly the use of mercury in soft chancre, for I find that small doses cause the sore to heal more quickly than any other medicine.

Constitutional syphilis is commonly divided into three stages, fairly well distinguished as primary, secondary and tertiary, and the best period for giving the remedy has been much discussed. Some have maintained that its early exhibition only *defers* the appearance of secondaries, and it is better for these to appear and then to give mercury till they disappear; but the best authorities favour early commencement. Mr. Alfred Cooper has however, objected to too early use, as liable to obscure the diagnosis (Lancet, i., 1892). Ricord gave mercury—generally the iodide—so soon as the hard chancre was distinctly diagnosed, and insisting on a year's continuance of treatment, was satisfied that he prevented secondary symptoms. Barallier supported the same conclusion after much experience amongst sailors. The majority of British surgeons follow this practice at present, and it seems to me the right one.

On the other hand, most are agreed that in tertiary stages of syphilis mercury is not a desirable remedy, and Dr. Wilks finds a reason for this in the different processes which occur at different periods of the malady. In the primary and secondary periods plastic lymph is being effused, but in later stages degeneration is going on; mercury causes absorption of the effused products, but its *further* action can only assist degeneration, induce cachexia and be thus injurious (Guy's Rep., vol. ix.). As clinical evidence of this if any were needed, reference might be made to the cases recorded by Mr. Hutchinson, where phagedænic ulceration in delicate subjects distinctly increased under the influence of mercury (Lond. Hosp. Rep., vol. ii.). Also, if any syphilitic

sore be much inflamed, or if aggravated dyspepsia, anæmia, phthisis, or albuminuria be present, special treatment for these conditions must be instituted independently of mercury. Pregnancy has been by some, considered a bar to due mercurial treatment, but in my opinion, the danger of miscarriage in the mother and of injury to the infant, are greater from syphilis than from mercury.

In any case a *moderate* use of the drug must be the rule. It is true that Trousseau and Pidoux blame a relaxation of the old methods for what they consider the present gravity of the disorder, but the large majority of the best authorities, including Ricord, Sigmund and Hutchinson, deprecate full mercurialisation, and find the best effects from small doses continued for a long time. Mr. Hutchinson uses grey powder almost exclusively in 1 gr. doses from three to six times a day, and seldom for a shorter time than six months (B. M. J., i., 1886). Sigmund stated that of nearly 9000 patients treated in the Vienna Hospital, 8500 showed no sign of salivation, but were cured as permanently as those salivated (Med.-Chir. Rev., July, 1858). Slight tenderness of the gums may be safely and properly produced as evidence of systemic influence, and a method sometimes successful, is to give fractional doses ($\frac{1}{12}$ gr.) of calomel every hour; given in this manner, 3 gr. may suffice for the purpose (Law). In all forms of *tertiary* syphilis, in rupia and deep ulcerations especially of the mucous membranes, tongue and fauces, in cases of gummata, visceral syphilis and most syphilitic nervous affections, the great remedy is not mercury, but iodide of potassium, though in hereditary syphilis mercury is still to be preferred. For late secondary and early tertiary symptoms a favourite combination is that of small doses of corrosive sublimate with iodide of potassium. Professor Bartholow, however, considers the administration of the two drugs in the same mixture a mistake, and gives them separately and alternately, so allowing the iodide to be diffused through the system before the mercury is given (B. M. J., i., 1884). Dr. MacNaughten Jones speaks highly of the bicyanide of mercury in doses of $\frac{1}{12}$ grain combined with quinine and arsenic in the form of pill, for delicate patients especially women (Pract., i., 1885). The late Mr. Berkeley Hill is quoted for the statement that iodides are not

curative in tertiary syphilis, and that mercurial inunction is preferable. After a hot bath, one drachm (or less) of a lanolin preparation is rubbed in thoroughly over the whole body for six days in the week till forty-two baths are taken (unless special symptoms require modification), then after a rest, a second similar course may be required. Care is prescribed as to clothing, and astringents are used to the gums. Cases of serpiginous ulceration, necrosis and gummata are said to yield to this, after failure of other treatment; any resulting anæmia is treated by iron (Lancet, i., 1893).

In *syphilitic iritis* and *retinitis*, the early and sufficient use of mercury is perhaps more clearly indicated than in any other inflammation, and they are the only conditions in which Ricord held salivation justified. Watson has graphically described how effused lymph in the anterior chamber may be seen to "melt away," under the influence of the drug. I often combine with its internal use, collyria of corrosive sublimate, 1 to 2 gr. in 6 oz. of water with opium, or an ointment of ammonio-chloride with belladonna for frictions round the orbit, with good success; but the same treatment cannot be depended upon in rheumatic or traumatic cases. Landolt has protested against the routine use of mercury in such cases, quoting instances of optic neuritis that got well without any (B. M. J., i., 1892).

In *keratitis*, an ointment of mercurialised lanolin is good, applied locally (Pract., 1889). In "*serous iritis*" (chronic), Mr. B. Carter objects to the rapid administration of mercury, but gives $\frac{1}{16}$ gr. of perchloride thrice daily, with local application of discs containing $\frac{1}{2500}$ gr., which may be placed on the conjunctiva night and morning, ten minutes after a cocaine disc (Lancet, i., 1893).

In *syphilitic laryngitis* also, mercury must be promptly and freely used, for in acute cases life is rapidly endangered by the disease. Syphilitic infants as a rule, develop only a sub-acute form of this disease, which may be treated less actively by moderate frictions with very satisfactory result. A good general treatment for congenital syphilis is to rub a piece of blue ointment about the size of a pea into the side of the abdomen or chest every day.

A germ theory to account for the action of mercury in syphilis has been advanced, and the benefit of mercurials, whether applied

locally or given internally, is supposed to be due to their germicidal action. The general likeness of syphilis to the acute exanthemata would suggest a similar bacterial origin; Dr. Lustgarten of Leipsic found in fact, small groups of slightly curved bacilli very like tubercle bacilli, while M. Briçon and others have described a micrococcus as the cause of the disease.

Scrofula.—Not only in syphilitic, but also in scrofulous diseases, small doses of mercury are useful. I know that this is not so commonly recognised, but ½ or 1 gr. doses of hydrarg. c. cretâ twice daily, will often be found of great advantage in purulent discharges from the eye, ear etc., as also in chronic glandular swellings. Dr. Douglas Powell considers that in the early stages of miliary tuberculosis of the pia mater or peritoneum, the treatment by small doses of mercuric with potassic iodide should be tried, and he has recorded cases in which such treatment produced good results; this should be done even if there be no syphilitic taint (Lancet, i., 1882).

Phthisis.—Dr. Andrew believes that cases of phthisis which are originated by syphilis are more numerous than is usually supposed, and has recorded a case in which there were signs at both apices, but which rapidly recovered under treatment with corrosive sublimate (Lancet, i., 1884). Ananiin however gave corrosive sublimate hypodermically and by inhalation in numerous cases of phthisis, but without any good resulting.

Hepatitis.—Annesley recommended in this inflammation, large doses of calomel to the production of salivation which he looked upon as "derivative," and no doubt at one time, as Maclean observes, "faith in calomel may be said to have attained in India to the dignity of a dogma." He himself strongly objects to any systematic use of mercury, and suggests that if it has gained credit for preventing suppuration, this has been in cases which were really of "*peri-hepatitis*," and not likely to end in abscess; in a large experience he has never seen it arrest suppuration and "disbelieves in any such power" (Reynolds' System, vol. iii.). Morehead and Waring agree in this opinion, and Massy reports serious impairment of health after its free exhibition. These authors may be taken as representing the present state of general opinion, but I think they have been too strongly prejudiced against the remedy by its

excessive use or abuse, and that small continued doses, stopping short of any full physiological effect, may still be found of advantage in commencing hepatitis; occasionally, larger (purgative) doses act well. In chronic forms of inflammation of the liver when the viscus is large and tender, mercury is also suitable, though if marked cachexia be present, or suppuration be fully developed, the drug is better avoided.

Cirrhosis.—Monneret has strongly recommended moderate doses of blue pill in cirrhosis with dropsy (Archives Gén., 1851), stating that after the numerous stools and copious sweatings induced, effusions are often absorbed without any ill-effects from salivation. Barallier corroborated this experience, and further reported a case, not far advanced, which was cured by this treatment (Dictionnaire). I have certainly had the best effects from mercury in cirrhotic dropsy, but have generally used purgative doses of blue pill, or calomel followed by salines, and in the intervals of purgation have given nux vomica and other tonics. Under such treatment large abdominal effusions have passed away six times in one case, at different intervals, so that the patient was restored to comparative health for some time, and this without any ill-effects from the mercury. The diagnosis was verified post mortem, but I cannot say that I have seen the malady permanently cured by this or any other treatment. In a recent case, diagnosed as hypertrophic cirrhosis from catarrh, in a man æt. thirty, jaundiced for nine months in spite of treatment (including potassic iodide), and who had enlarged liver, but no ascites, calomel was given in about $\frac{3}{4}$ gr. doses six times a day for three days, and then omitted for three days; he began to improve at once and was free from all symptoms in three months (B. M. J., i., 1893, Epit., *cf. ib.*, ii., 1888).

Cardiac Dropsy.—Jendrässik has drawn attention again to the value of calomel, especially in cardiac dropsy: he gave it with jalap, but says the latter alone was ineffective; from 1 to 4 grs. given two or three times daily soon provoked active diuresis, with relief of symptoms,—this gradually lessened and could not be secured again from the same remedy, unless after an interval; some systemic action was usual. Similar diuresis did not occur in the healthy, nor in pleuritic effusions, nor in Bright's disease (Pract., ii., 1886). In another case (hepatic) diuresis occurred

under a 5 gr. dose. In a later communication he records the most brilliant results in dropsy with cardiac asystole: in a few cases of ascites from *hepatic* disease, diuresis (due to calomel) removed the effusion, but very seldom in *renal* dropsy; in pleural effusion it was worthless. In health there occurs occasionally only a very slight increase in the amount of urine. He attributes the diuresis neither to a stimulation of the heart nor of the kidneys, but to re-absorption of the effused fluid into the blood. The calomel according to Jendrässik forms an albuminate of mercury in the blood, and this encourages osmosis into it. The less albumen the effused fluid contains, the more readily is it absorbed, hence the difference in results in different diseases. He recommends a small dose eight or ten times during only one day at a time (Deutsch Arch. f. klin. Med., Bd. xlvii.).

Weinstein (Wien. med. Blätter, 1887) and Rosenheim (Deutsch med. Wochenschr., 1887) while admitting the diuretic action of mercury in dropsy from various causes, point out that in an undue proportion of these cases there is risk of mercurial poisoning. Bieganski got a diuretic action after giving calomel by the mouth, corrosive sublimate and mercurous oxide subcutaneously, and blue ointment by inunction; it was most marked after subcutaneous administration. Changes in the kidney can limit or annul the diuretic effect. The results are most satisfactory in cardiac dropsy (Deutsch Archiv f. klin. Med., xliii.). Rosenheim as the result of perfusion experiments on the excised kidney comes to the conclusion that the diuresis results from direct stimulation of the renal epithelium (Ztschr. f. klin. Med., xiv., 1888), while Locke attributes it to the increased formation of urea caused by the action of mercury on the liver (Pract., ii., 1886).

Hepatic Congestion—Constipation.—In torpor, or subacute congestion of the liver, marked by a coated tongue, yellowish countenance, headache, nausea, depression, and light-coloured stools, a moderate mercurial purge, especially with a saline, will commonly relieve more quickly than any other medication (unless it be sometimes podophyllum), and no amount of experiment on animals can alter this clinical fact. The experience and authority of Murchison quite corroborate this (Lancet, 1874), and Sir D. Duckworth has drawn renewed attention to the good results of calomel in acute gastric catarrh and "biliousness"

(Pract., July, 1876). In chronic cases of this kind it is however, advisable not to resort frequently to this remedy, but to depend rather upon diet, hygiene, and saline or vegetable aperients, though small doses—$\frac{1}{50}$ to $\frac{1}{20}$ grain of corrosive sublimate at bedtime—have a good effect. Dr. Lauder Brunton considers that the action of blue pill or a few grains of calomel in relieving "biliousness" may be due to the *antiseptic* power of mercurials. So far as relates to calomel, this view has been supported experimentally by Vassilieff, who finds that calomel will prevent the growth of putrefactive organisms in the digestive tract or in artificial digestions, although it has no destructive action on the unorganised ferments which bring about digestion (Zeits. f. physiol. Chem., 1882).

The use of *metallic* mercury as a purgative might be thought obsolete, but instances of its value when obstinate obstruction and vomiting are present are still recorded; thus 1 oz. of quicksilver given in two doses at half an hour's interval soon acted, and recovery followed (Lancet, i., 1874). I have myself used it in two cases lately: one was that of a boy aged eight, who had had obstruction for five days, and although under active and competent treatment, continued to get worse, with vomiting, pain and accumulation over the ilio-cæcal valve, and distension. Surgical interference was desired by the parents, but in consultation it was agreed to try mercury first, and 1 oz. was given in the manner just described. It was readily taken, and some of it soon passed, but without producing a motion; the symptoms improved, and on the following morning we gave castor oil which acted well, and the child soon recovered. The whole of the quicksilver passed was collected and weighed and found to amount exactly to the ounce taken. In a second case, a girl aged between five and six, the obstruction had lasted several days, and the vomiting and other symptoms were persistent in spite of croton oil and other drastic purges. I recommended at first, treatment by opium, which was steadily continued for three days, but without benefit; castor oil was then given but was rejected; we then gave 2 dr. of quicksilver, in five minutes afterwards another 2 dr., and in half an hour a third and similar dose. It made its appearance from the rectum in about two hours, bringing wind but not much fæcal matter; we followed

up the mineral with castor oil which was retained and acted, and the child gradually got well. Cases illustrating the value of the metal in obstruction are reported from German practice (Pract., i., 1883). Five ounces were successful in a recent case, after a period of collapse (Lancet, i., 1892).

Vomiting.—In some forms of obstinate vomiting dependent upon a disordered condition of stomach with hepatic congestion, 3 to 5 gr. of calomel in pill or powder, have a most beneficial effect; the dose should be followed after a few hours by a saline purge.

Diarrhœa (Infantile). — When the motions are green, curdled, watery and offensive, small doses ($\frac{1}{4}$ gr.) of grey powder act very well, especially when combined with bismuth, and the same powders are useful when curdled milk is frequently rejected from the stomach. When there is a simple diarrhœa with whitish stools, Dr. Stephenson thinks that rhubarb and soda should replace the mercurial, for fear the latter should depress the strength (Edin. Med. Journ., 1871), and certainly, if it be continued unwisely, it may do so by irritating the mucous membrane, etc., but I have never seen ill-effects from the minute doses above recommended. For infantile watery diarrhœa $\frac{1}{100}$ gr. of corrosive sublimate given with due care after each motion acts well. I think this is now a common experience; I have acted upon it for twenty-five years. In the acute diarrhœa and colic of adults, one of the best methods of treatment is the use of a pill of calomel (3 gr.) with opium (1 gr. or $\frac{1}{2}$ gr.), followed, after three or four hours, by castor oil or other laxatives.

Dysentery.—In acute dysentery, with violent pain, severe prostration and frequent muco-sanguineous stools, small doses of corrosive sublimate, given at short intervals, commonly relieve in a few hours, and almost in a "specific" manner—certainly better than any other remedy I have known. Sublimate is equally useful in the "white dysentery" of Ceylon and India. I have seen the best results from it when opium, lead and other astringents had proved useless. I thus agree with Wood, who asserts that in this malady "no remedial influence is more effective than that of mercury," rather than with Maclean, who deprecates its use in all forms and stages. I can only suppose that the injurious effects traced by him and by others to calomel and other mercurials, resulted from doses that were too large.

Cholera.—Dr. Maclean equally objects to any preparation of mercury in cholera, as "useless in collapse and dangerous when reviving" (Lancet, 1866), but although I am not myself an advocate for the calomel treatment, the results obtained by Dr. Ayre, of Hull, deserve attention. He gave $\frac{1}{4}$ to $\frac{1}{2}$ gr. of calomel every ten minutes or every four hours, according to circumstances; it rarely salivated, but produced apparently good results in a majority of cases. Bloxam and some other observers have followed the same plan with advantage, and Niemeyer speaks well of calomel treatment.[1] What is desired is to stimulate by this means a secretion of bile and to promote elimination, for we know that the reappearance of bile in choleraic stools is a favourable sign; besides this, large doses of calomel ($\frac{1}{2}$ dr.) have been said "to restore warmth" (Brit. and For. Rev., i., 1870). Köhler thinks that its good effects are owing to the disinfecting property of the drug when brought into contact with the contents of the intestines. Of fifty-six cases some of which received 200 gr. in two days, twenty-one died, but the reporter seems to think the results favourable to the treatment by calomel (Lancet, i., 1874). The general experience of the profession has not however, adopted it, and it is clearly not free from danger, for under certain conditions a quantity of the medicine may remain for a time unabsorbed, and afterwards produce serious toxic effects. Still there exists in favour of its use an undercurrent of opinion, which may be supported by much clinical experience (*cf.* Ewing Whittle, and others, B. M. J., ii., 1884).

Intestinal Worms.—Calomel is a very suitable vermifuge in cases of ascarides. Both the round and the thread worms are expelled under the influence of 2 to 5 gr., which may be given early in the morning and followed in a few hours by a purgative draught. It is usual to combine the dose with powdered jalap, but I have found the mercurial alone sufficient and it is more readily taken. Dr. Stillé speaks well of the effect of a small portion of mercurial ointment placed in the rectum daily at bed-

[1] A pill containing $\frac{1}{6}$ gr. with $\frac{1}{4}$ gr. piperine every ten to twenty minutes till feculent matter appeared in the stools, is said to have acted so well in cholera that "not a patient was lost after its adoption unless previously saturated with opium, or too far gone for medication" (Lancet, i., 1893).

time for destroying ascarides, also of the injection of $\frac{1}{4}$ to 1 gr. of corrosive sublimate dissolved in water, but I doubt the wisdom of this latter treatment.

Hypodermic Injection of Mercury.—The subcutaneous administration of mercury has been a good deal used in recent years in the treatment of syphilis. According to Dr. Cullingworth (Lancet, i., 1874) this method was first adopted by Charles Hunter (1858) who injected perchloride of mercury in watery solution to a girl twice weekly until 25 gr. had been given; the strength of solution was 1 gr. in each dr. and no salivation occurred. In 1860 Hebra and Neumann reported on the method, but did not consider it superior to others. Scarinzi used calomel in glycerine and in water, being in the habit of injecting about 3 gr. each time; he praises it very highly. Lewin (Berlin, 1869) used a solution of mercuric chloride, giving $\frac{1}{8}$ gr. daily, and found that fifteen injections usually sufficed for cure. Since then the hypodermic method has had an extensive trial, and has on the whole given satisfactory results as regards cure, though we may doubt whether it is more efficacious than mercury given by the mouth, or by inunction. It is claimed that it cures syphilis more rapidly, and that relapses are less frequent than when mercury is given in other ways, that it ensures precision of dosage, does not disturb digestion and is easily given. On the other hand, most of the preparations hitherto used cause a good deal of pain locally, and not infrequently abscesses. In many cases the metal or insoluble salts, such as calomel suspended in oil, vaseline, mucilage, or glycerine have been given in about 3 gr. doses once weekly; or yellow oxide of mercury in the same menstrua about $\frac{1}{2}$ gr. weekly; 2 or 3 gr. doses have been given with success every ten days into the cellular tissue (Lancet, ii., 1889), but are not so safe as the smaller dose; the insoluble salts are presumed to be more permanent in their effects. "Grey oil" consists of mercury, lanolin and olive oil, and was at one time in vogue in Vienna, while the salicylate, yellow iodide and cyanide were employed in Russia, and the formamide (Liebreich) in Germany. The benzoate has also been used (Lancet, ii., 1891), as well as albuminates and peptonates made with corrosive sublimate. It has been claimed that organic soluble compounds act better, are more quickly

absorbed and eliminated, and cause less risk of poisoning. Thus v. Mering has recommended mercury-glycocol (Archiv f. expt. Path., 1880), Wolff, mercury-asparagin (Strassburg, 1883), while Hüfler speaks very highly of a peptonate made with gelatine, hydrochloric acid and corrosive sublimate (Therap. Monatsheft, 1890). Vollert (Therap. Monatsh., 1888 and 1890), has used mercury succinimide in a large number of cases. He uses a 2 per cent. solution, giving an amount equal to about $\frac{1}{6}$ gr. of metallic mercury daily; and states that twenty-four injections usually suffice for cure, and that his results are uniformly good.

The hypodermic method does not lessen the risk of mercurialisation, a large number of cases have been reported and even several deaths (Cullingworth, *lac. cit.*). Kraus gave $\frac{1}{6}$ grain of calomel subcutaneously to a labourer aged thirty, suffering from recent syphilis, and seven days afterwards a similar dose; on the eighth day stomatitis was observed, and on the thirteenth day death occurred after typical symptoms of mercurial poisoning which were confirmed post mortem (Deut. med. Wochenschr., 1888). Kuneberg has collected seven fatal cases under *larger* doses (*ib.*, 1889) and Watraszewski considers that up to $\frac{2}{3}$ gr. is practically safe. With the "grey oil," stomatitis and also several cases of fat-embolism in the lungs are on record, and he finds yellow oxide ($\frac{2}{3}$ to 1 gr.) the best, and has given it "thousands of times" without ill-effect; mucilage is the safest vehicle, 1 part to 120 water; with oily vehicles there is risk of embolism or pneumonia, if a vein be pierced in intra-muscular injection (Lancet, i., 1890). Mr. J. A. Bloxam recommends in syphilis the *intra-muscular* injection of sal alembroth, which should not contain an excess of chloride of ammonium. The solution is made by dissolving 32 gr. of perchloride of mercury with 16 gr. of pure chloride of ammonium, in water sufficient to yield 2 fluid ounces of product; 10 minims of this equal $\frac{1}{3}$ gr. of the salt. It keeps well, is clear and not liable to fungoid growths or precipitation. The injection should be made deeply into the muscles of the buttock, changing sides alternately; the quantity should be 10 minims, and the patient should be injected once a week. He used this injection upwards of 900 times; it caused little or no pain and no induration at the seat of puncture unless blood was extravasated. In only four of these cases slight mercurialism was produced: in none had abscess

followed. The primary lesion usually healed after a few injections, and the sequelæ, in some cases extremely severe, were at once arrested. The effect on the eruptions had been most marked; in seven to eight weeks the most obstinate skin manifestations melted away, the throat and glands alone remaining as evidence of the disease. From this period the injection was only used once a fortnight until nearly all the symptoms had disappeared; then the patient was injected only once a month, the treatment being continued for twelve to eighteen months (Lancet, i., 1888).

Inunction.—The patient should be prepared for a course of mercurial inunction by simple dieting and by warm baths: and during it should be clothed in flannel and avoid exposure. When making the frictions himself, he should rub thoroughly in his hand the prescribed quantity of ointment, and then slowly and forcibly anoint certain parts of the body in a definite order: it is usual to choose the axillæ and the groins, but practically it is better to avoid parts with abundant hair-follicles. According to the German method of Zeissl, the inner side of both upper arms is first treated, on the next night the inner side of the thighs, then of the forearms, then of the legs, afterwards of the groin and of the back, so that an interval of several days is allowed between the friction of any one part, in order to avoid local soreness. The evening is the best time for the application, and warmth promotes its effect: the part should be kept covered during the night, and be cleansed on the following morning. When the patient is too ill, or for any reason is unable to apply the ointment himself, the attendant who uses it should protect his own hand with a leather or caoutchouc glove. In young children frictions are often made on the inner side of the soles of the feet, or a piece of ointment is simply placed on the inner side of a thin flannel binder. For adults, ½ dr. up to 2 dr. represents an average amount of mercurial ointment for daily use, but sometimes, as in peritonitis, 1 dr. has been ordered every hour: it is important that no rancid ointment be used, or severe irritation may be induced by it.

This method of treatment has theadvantage of saving the digestive tract from any direct irritation by the drug, and, according to Sir B. Brodie, "it cures better and injures

the constitution less." This however, scarcely holds true in view of the modern cautious administration of mercury, and the method of inunction is less often adopted than formerly, since it is at the best, troublesome and uncleanly. Blue ointment is the one usually chosen for inunction, but the oleate is now often used. Dr. Shoemaker considers it to be the best mercurial ointment for other purposes as well. Dr. Detmold recommends that a solution of corrosive sublimate should be used instead of ointment; it is made with water (1 gr. in 1½ oz.), and this is rubbed on the extremities in turn, every night and morning; except for occasional griping pain he obtained good results (Boston Med. Surg. Journ., 1884). Schuster finds Oberlander's soap (made with mercury and potash) the best form, since less friction is required, but Nega points out that it is not always well made and on the whole prefers the "grey ointment" of the French Pharmacopœia (Rev. Gén., xxviii., 1886).

The *endermic* application of mercury is effected by dressing a blistered surface with blue ointment, or sometimes with calomel. From the latter, purging has resulted, but as a rule the endermic method is employed for a local stimulating action on the absorbents, as in pleuritic, pericardial, or joint effusion, rather than to affect the general system.

The **Mercurial Vapour Bath** is the best method of application for some cases especially of syphilitic cutaneous disease. In it calomel or sulphide of mercury is vaporised in conjunction with steam, and becomes deposited as finely divided powder on the body of the patient, as he is seated unclothed over the lamp. Care should be taken that the vapour be not inhaled, or profuse salivation may occur.

PREPARATIONS AND DOSE.—*Hydrargyrum cum cretâ* (contains 1 part of the metal to 2 of prepared chalk, rubbed together until globules cease to be visible): dose for children, ½ to 2 gr., less or more; for adults, 3 to 8 gr., or less. Several observers have drawn attention to the fact that in warm climates grey powder is rapidly oxidised, red oxide of mercury being formed, and this has sometimes led to dangerous symptoms of poisoning. Surgeon-Major Cookson recommends either heavy or light magnesia as a better admixture than chalk with the mercury, in these countries (Lancet, ii., 1884). Dr. F. Macnamara recommends that the grey powder should be mixed with an equal amount of white sugar to prevent such

oxidation (Med. Times, i., 1885). *Pilula hydrargyri* (contains 2 parts of the metal with 3 of confection of roses, and 1 of powdered liquorice root): dose, as a purgative, 3 to 8 gr.; for constitutional effects, 2 to 3 gr. three times daily—may be well combined with quinine. *Emplastrum hydrargyri* (made with mercury, olive oil, sulphur, and lead plaster). *Emplastrum ammoniaci cum hydrargyro* (contains gum ammoniac in place of lead plaster, or in other words, ammoniacum and mercury plaster). *Unguentum hydrargyri* (mercury rubbed up with prepared lard and suet). *Unguentum hydrargyri compositum* (contains mercurial ointment, yellow wax, and olive oil and camphor): this combines the medicinal properties of mercurial ointment and camphor, to which wax and oil are added to give a suitable consistence; it is used as a stimulant to swollen glands, and for chronic inflammation of joints, and represents "Scott's ointment". Mercurial plasters and salve "mulls" are also prepared from German formulæ. Mr. Atthill recommends "geoline," a patent product of petroleum, and which is very stable, as a basis for mercurial and other ointments (B. M. J., i., 1886). *Linimentum hydrargyri* (contains equal parts of blue ointment, solution of ammonia, and camphor liniment): it should be a lead-coloured cream; this readily produces salivation. *Suppositorium hydrargyri* (contains mercurial ointment, and oil of theobroma): there are 5 gr. of blue ointment in each suppository.

Hydrargyri cyanidum (not official): dose, $\frac{1}{10}$-$\frac{1}{12}$ gr., twice daily, used also in lotion. *Hydrargyri subchloridum:* dose as a purgative, for children, $\frac{1}{2}$ to 2 gr.; for adults, 2 to 5 gr.; for constitutional effects, $\frac{1}{2}$ to 1 gr. or more, frequently repeated, or $\frac{1}{12}$ gr. may be given every hour (3 to 4 gr. in this manner sometimes produce mercurial action), or $\frac{1}{4}$ to $\frac{1}{2}$ gr. or more may be given night and morning combined with a fractional quantity of opium. *Lotio hydrargyri nigra* (contains 3 gr. of calomel to the ounce of lime-water). *Pilula hydrargyri subchloridi composita—Plummer's pill* (contains calomel, sulphurated antimony, guaiac resin and castor oil): each 5 gr. of the pill mass contains 1 gr. of calomel and 1 gr. of sulphurated antimony; calomel should not be given with alkaline carbonates, as corrosive sublimate is liable to be formed. *Unguentum hydrargyri subchloridi* (6½ gr. of this ointment contain 1 gr. of calomel). *Hydrargyri perchloridum:* dose, $\frac{1}{16}$ to $\frac{1}{8}$ gr. in solution or in pill: but very much smaller doses are used. *Liquor hydrargyri perchloridi* (contains $\frac{1}{2}$ gr. of perchloride and $\frac{1}{2}$ gr. of ammonium chloride to each fluid ounce, or $\frac{1}{16}$ gr. of each to the drachm): dose, $\frac{1}{2}$ to 2 dr., *i.e.*, $\frac{1}{32}$ to $\frac{1}{8}$ gr., but I prefer smaller doses, as mentioned above. *Lotio hydrargyri flava* (contains 18 gr. of corrosive sublimate in 10 oz. of lime-water).

Hydrargyrum ammoniatum ("white precipitate"): not used internally. *Unguentum hydrargyri ammoniati:* 1 part of ammoniated mercury in 8 of ointment.

Hydrargyri iodidum viride (not official): dose, $\frac{1}{2}$ to 3 gr. *Hydrargyri iodidum rubrum:* dose, $\frac{1}{32}$ to $\frac{1}{8}$ gr. *Unguentum hydrargyri iodidi rubri:* 1 part in 28 of ointment.

Hydrargyri oxidum flavum: used in the preparation of the oleate of mercury, and for an eye ointment (non-off.).. *Hydrargyri oxidum rubrum:* for

external use. *Unguentum hydrargyri oxidi rubri* (contains red oxide of mercury, yellow wax, and oil of almonds): there is about 1 gr. of red oxide in 8 gr. of the ointment.

Hydrargyri nitratis liquor acidus: used externally. *Unguentum hydrargyri nitratis* (citrine ointment): 1 part in 15½. *Unguentum hydrargyri nitratis dilutum* (1 part citrine ointment to 2 parts soft paraffin).

Hydrargyri sulphuratum—"artificial cinnabar" (not official): not used internally. Its fumes are used in syphilitic skin diseases, as ecthyma; also, in syphilitic sore throat by inhalation, 30 gr. being heated on an iron plate and placed under the patient, who should be wrapped in a blanket; or the vapour may be inhaled through a funnel. *Hydrargyri persulphas:* not given as a remedy, but used in the preparation of corrosive sublimate and calomel.

Of non-official preparations *hydrargyri tannas* is well spoken of as an antisyphilitic; it contains 50 per cent. of mercury which is set free by alkalies: dose, 1 gr. (B. M. J., ii., 1886). *Hydrargyri salicylas* is given internally as an antisyphilitic, and is used also as a dusting powder or ointment in specific sores. *Hydrargyri succinimidum.* In syphilis it is used as a hypodermic injection—2 per cent. solution. A 1 per cent. solution of cocaine may be added to prevent pain. *Hydrargyri naphtholactas:* used for healing wounds and as antisyphilitic: dose, ½ to 1 gr. *Hydrargyri thymolacetas:* used as an intra-muscular injection (1 in 10 of liquid paraffin in syphilis); also in pills: ¾ to 1 grain. *Double cyanide of mercury and zinc* (solubility in water 1 in 1200); kept corpuscles and blood serum permanently free from putrefaction. Although an inhibitor of putrefaction, is not a powerful germicide; it is quite unirritating (B. M. J., ii., 1889).

Sal alembroth—(*Syn. double chloride of mercury and ammonium—Ammonio-mercuric chloride*). A salt of mercury in which one molecule of mercuric chloride is combined with two molecules of chloride of ammonium: it contains two-thirds of its weight of the former, is soluble in less than its own weight of water, and is a powerful antiseptic. It is used to prepare—

Alembroth gauze (blue), containing 1 per cent. The gauze should be damped with a lotion of 1 in 40 of carbolic acid before application as a dressing. *Alembroth wool* (blue), containing 2 per cent. *Alembroth gauze and cotton wool tissue* (blue), containing 2 per cent. (Chiefly used for eye cases.)

LITHIUM (L = 7 (*non-off.*).

This metal has not been found native. It occurs in the mineral kingdom as an oxide, chloride, silicate, or fluoride with potassium and aluminium (the lepidolite or rose mica of Bohemia). Bunsen and Matthiessen isolated it by means of electricity (1855).

Supposed at one time to be found in minerals only, it was named λιθος, stony, but it is now recognised not only in many

mineral waters, but in seas and rivers, vines and many fruits, the ashes of plants, and in most of our vegetable food. The "Buffalo" water is said to contain $2\frac{1}{4}$ gr. in each gallon (Record, 1885).

CHARACTERS.—It is soft, silvery-white and easily oxidises: it floats upon water, and is the lightest known metal, the specific gravity being 0·5936.

COMPOUNDS OF LITHIUM.

LITHIA—OXIDE OF LITHIUM ($L_2O = 30$) (*non-off.*).

CHARACTERS AND TESTS.—It occurs in white granules, forms salts with acids, and has a high power of saturation, 15 parts neutralising as much acid as 41 of soda or 47 of potash. For uric acid it has a special affinity, and will abstract it from portions of gouty bone and cartilage placed in warm solutions of the drug (Garrod).

The most characteristic tests for lithium are the carmine red colour it imparts to flame, and its characteristic spectrum, which consists of two bright lines, one in the red, about midway between the B and C lines, and one in the yellow, on the red side of the D line. Of substances that resemble it, potassium has its red line coincident with A, sodium its yellow line coincident with D, and strontium, besides several lines in the red and yellow, has one also in the blue, between the F and G lines.

LITHII CARBONAS—CARBONATE OF LITHIUM ($L_2CO_3 = 74$).

PREPARATION.—It is obtained by treating a solution of sulphate or chloride of lithium with one of carbonate of ammonium.

CHARACTERS.—It occurs in the form of a white powder or crystalline grains, having an alkaline taste and reaction: it is insoluble in alcohol, but slightly soluble in water (1 part in 150, or about 4 gr. to the ounce): carbonic acid increases the solubility to 5 parts per 100. Hoffman has published some exact observations as to the solubility of and tests for carbonate of lithia (Lond. Record, 1886).

LITHII CITRAS—CITRATE OF LITHIUM

($L_3C_6H_5O_7$, $4H_2O$ = 282).

PREPARATION.—It is prepared by dissolving the carbonate in citric acid, evaporating the liquid and drying and pulverising the residue.

CHARACTERS.—A white amorphous powder, anhydrous, deliquescing on exposure, entirely soluble in two and a half times its weight of water: it is somewhat unstable in composition and requires to be carefully kept from the air.

The *urate* occurs in small white crystals which are very soluble. The *guaiacate* is prepared by digesting guaiacum resin with a watery solution of lithia, and evaporating. The *benzoate*, which is prepared from the carbonate by adding benzoic acid to the hot solution (Pharm. Journ., July, 1875), occurs in glistening pearly scales, of soapy feel, acid reaction and cool sweetish taste: it is soluble in three and a half parts of cold water, and ten of alcohol—it is thus more soluble than the carbonate whilst it is more stable than the citrate, and has the advantage of containing an acid itself valuable in the treatment of urinary deposits.

A *ferruginous benzoate* of lithium has been prepared by M. Tréhyon (Progrès Médicale, 1874) and is recommended both as a non-irritant form of benzoic acid, and as a tonic and preventive of the anæmia produced more or less by all alkalies.

The *bromide* may be prepared by direct combination, and obtained in transparent crystals which are deliquescent. It contains a large proportion of bromine (92 per cent.), whilst the analogous salt of potassium contains only 66, and of sodium 78 per cent.

The *salicylate* is a white deliquescent powder of sweetish taste and acid reaction, it is soluble in water and alcohol. It is presumed to unite the properties of salicylic acid and lithia in the treatment of gout and rheumatism.

ABSORPTION AND ELIMINATION.—Lithium salts are rapidly absorbed: thus, from the experiments of Dr. Bence Jones, it appears that if 3 gr. of the chloride be given to an animal on an empty stomach, it may be detected even in the cartilage of the hip-joint, and the aqueous humour of the eye in a quarter of an hour: 7 gr. having been given to a parturient woman eight hours before delivery, lithia was afterwards detected in every part of the umbilical cord, and 20 gr. of the carbonate

having been taken three and a half hours before an operation for cataract, ample traces of lithia were detected in the lens when removed: four days afterwards lithia could still be detected in the secretions, and was not wholly eliminated till the end of seven days. It is excreted chiefly by the kidneys.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Lithium salts act much like the alkalies potassium and sodium upon the gastric secretions,—the carbonate especially is a direct antacid. Small doses are readily borne, but doses of 30 to 50 grains of the carbonate—such as were used by Charcot—give rise after a few days, to cardialgia and dyspepsia. Rabuteau also states that, though he at one time recommended 15 to 30 gr. per diem, his later experience proved that dyspepsia and even vomiting were caused by these quantities. Climent records similar results in his own person (Traitement de la Gravelle, Thèse, Paris, 1874), and although lithiated waters—*e.g.*, at Baden-Baden—at first improve the appetite and digestion, they quickly give rise to sickness and diarrhœa if taken in excess.

Circulatory System.—Carbonate of lithium increases the alkalinity of the blood more quickly than compounds of potassium or sodium. The same salt given in large doses (80 gr.), rapidly diminishes the number of red blood corpuscles and induces anæmia, like the alkaline carbonates. A much less quantity than 80 gr. seems to exert a depressant effect on the heart in weakly subjects—lithia in this respect again, resembling potash in its action—but it does not depress so much as that salt. Several observers agree in the conclusion that bromide of lithium, a salt with especially sedative powers, exerts a less lowering effect upon the heart than bromide of potassium (Roubaud, Archives Gén., i., 1875; Lévy, Gaz. Méd. de Paris, 1875), but frogs and some warm-blooded animals may die under toxic doses of lithia, with cardiac arrest in diastole (Husemann, Hesse). Dr. Nikanoroff has investigated the action of lithium salts on animals. In frogs the heart is stopped in diastole, but not so readily as by potassium compounds, and its excitability remains intact for some time after it has been stopped; division of the vagi or of the spinal cord does not alter this result; there is also dilatation of blood vessels. In mammals the effects are somewhat different; the heart is but little affected and there is a rise of arterial pressure,

diuresis, and after large doses, albumen and hæmoglobin occur in the urine. He concludes that the drug is more allied to soda than to potash (Record, 1884).

Nervous System.—Lithia is said to depress the general nervous power, and a slight degree of tremor or twitching has been sometimes noticed under its continued use, but I am not aware of any serious effects of this kind. The action of lithium upon muscles, nerves and nerve centres, is very much like that of potassium, but is more powerful.

Urinary System.—The quantity of urine is generally increased by lithia, but analyses are not uniform as regards solid urinary products. Thus M. Levy, using the bromide of lithium in gouty subjects, found the excretion of urea and uric acid rather lessened. In healthy subjects however, Moss found both liquid and solid constituents of the urine much increased (Amer. Journ., April, 1861). Diuresis is usually a marked effect of lithia; one or two doses of 1 to 4 gr. may not produce it, but if continued they do so, and commonly render soluble any deposit of urates. In some persons one bottle of lithia water (about 4 gr.) will cause copious secretion, but the effect varies somewhat, possibly according to the amount of acid in the system. Sir A. Garrod found lithia more active in this respect than potash, 20 to 30 gr. of the former citrate equalling 2 to 3 dr. of the latter. Moss corroborated this (*loc. cit.*). Nikanoroff found the chloride more diuretic than the acetates, but the amount of uric acid excreted under it was unchanged.

Benzoate of lithium seems to have special powers in this respect, for it is very soluble, and the benzoic acid, changing in the system into hippuric acid, combines with alkalies to form hippurates which are more soluble and more readily eliminated than urates: benzoic acid has also a direct solvent action on urates. The diuretic action of any salt of lithium is much increased by free dilution.

Synergists.—Lithia is akin to potash, soda and alkaline earths generally, but the characters of some of its salts indicate a special chemical analogy with magnesia. Thus, the carbonate is decomposed by heat, requires 100 parts of water for solution, but is more soluble in presence of carbonic acid: the phosphate is insoluble, the chloride and nitrate are deliquescent; there is

no alum or bisulphate of lithia. Agents promoting waste, such as mercury and the iodides, also favour the constitutional action of this and allied medicines.

ANTAGONISTS AND INCOMPATIBLES.—Acids, acidulous and metallic salts.

THERAPEUTICAL ACTION.—*External.*—**Gouty Concretions—Stiff Joints.**—These may often be well treated by a lotion containing about 5 gr. of any soluble lithium salt in the ounce of rose-water, kept constantly applied on lint, covered with oiled silk. I have generally combined this application with the occasional local use of iodine and the internal administration of lithia, and have known the concretions and the stiffness to be removed. A pomade containing oleo-stearate of lithium has been recommended for friction in similar cases (Duquesnel). Lithia lotions are useful also if the skin be broken near gouty joints. Such sores do not readily heal, because the urate of sodium permeates the connective tissue near them, and an alkaline salt neutralises the acid and promotes healing.

THERAPEUTICAL ACTION. — *Internal.* — **Gout.** — The treatment of gout varies somewhat, according as to whether the attack is acute or otherwise. During acute gout, lithia is often useful as an adjuvant or an alternative to alkalies or colchicum, but it is during the intervals, when the urine is loaded and the joints obscurely painful, that the habitual use of small quantities is most advantageous. According to Sir A. Garrod it lessens the frequency of the attacks, diminishes uric acid deposits, sometimes causes the absorption of concretions, and even wholly removes the gouty dyscrasia. Reasoning from the power of lithia in warm solution to dissolve uric compounds out of gouty bone external to the body, he presumes that it can exert an analogous effect within the system, and favour the elimination of the *materies morbi* in the form of urate of lithium. Wagner found, after ample experience, that treatment by lithia shortened the duration of acute attacks, and prolonged the intervals of freedom: it relieved pain and promoted elimination by diuresis. He gave from $\frac{1}{2}$ to 5 gr. doses of the carbonate in an aromatic bitter, continuing them during the interval between the attacks for many weeks (Schmidt's Jahrb., i., 1875). Stricker reports a case in which gouty concretions on the finger-joints disappeared in a

few weeks under a course of lithia (quoted by Garrod). Ditterich, whilst estimating the remedy highly, would restrict its use to chronic forms of gout or chronic illness of any kind, if dependent upon excess of uric acid. He found that doses of 5 to 10 gr. were liable to induce dyspepsia, and recommended not more than 1½ gr. for a single dose, or 15 gr. in twenty-four hours: he generally observed relief in seven to fourteen days without drawback (Schmidt's Jahrb., 1870). When acidity of the stomach is present the carbonate should be given, because it is a more direct antacid than the other salts; if, however, there is no marked gastric derangement, the neutral citrate is to be preferred; it is decomposed within the system, and eliminated as carbonate in the urine. The ferruginous benzoate of lithia is much recommended by Dalkiewicz in his essay (Sur la Goutte, 1873), by Malley, and other French physicians (Record, 1874).

The Baden-Baden waters, though valuable in gout and in gouty headache, concretions, etc., are said to increase the joint pains during their early use (Althaus). There is only one spring, the Murquelle at Baden-Baden, which is distinguished for a considerable quantity of lithia, viz., 0·4 gr. of the chloride of lithium in 16 oz. Next to the Murquelle is the Fettquelle, in the same place, with 0·23 gr. of chloride of lithium, and a spring in Elster, with 0·76 of carbonate of lithium.

With the exception of Sir A. Garrod's writings, there are but few English observations on the treatment of gout by lithia, though the remedy must be largely used. It does not always give the satisfactory results that have been claimed for it, and some practitioners are still sceptical as to its real value.

Siebold denies that lithium salts are superior to potassium in the treatment of uric acid diathesis. He points out that it follows as a matter of course from the relative atomic weights of lithium and potassium that the former is capable of saturating nearly twice as much uric acid as the latter, further than this it has no specific action, and he argues that one has only to administer twice as much of the potash salt to get equally good results. He holds that mineral waters containing mere traces of lithium can have no special efficacy in gout, and points out that the lithium is present in them as chloride or sulphate, salts which

neither directly nor indirectly act as alkalies and possess no solvent action on uric acid (Year-book of Pharmacy, 1889).

Uric Acid Gravel—Calculus.—When this occurs independently of distinct gouty attacks, lithium salts amply diluted often act well, rendering the "gravel" soluble and the urine clear. According to the observations of G. de Mussy and others, the bromide of lithium exerts a high degree of solvent or lithontriptic power (Roubaud, Archives Gén., 1875).

Lithiated injections into the bladder for direct solution of uric concretions were proposed by A. Ure and Aschenbrennen. The former observer ascertained that an oxaluric calculus placed in a 4 gr. warm solution of a lithium salt lost 5 gr. in weight in five hours, but his practical application of this knowledge to the treatment of calculus within the living bladder has not proved very satisfactory. The patient got some temporary relief from the lithiated injections, and they were presumed to have softened the calculus, but did not reduce its size; lithotrity was performed, but ultimately the man died (Lancet, ii., 1860). Mr. Ure directs attention to the necessity of avoiding lithia when phosphate of sodium is present in the urine, otherwise an insoluble triple phosphate is formed.

Gouty and other Neuroses.—In the forms of irritative or melancholic nervous disorders which sometimes accompany the uric acid diathesis, and in some forms of hysteria, the bromide of lithium promises to be extremely useful. The observers already quoted agree in attributing to it a marked sedative effect on the sensory nerves and upon the spinal cord and reflex sensibility, without much depression of the circulation: its action, in short, is more that of bromine than of lithia.

Epilepsy.—In true epilepsy, bromide of lithium was used by M. Lévy and by Dr. Weir Mitchell. The latter physician found that it was excreted by the skin much like other bromides, but it proved a better hypnotic, and in moderate doses of 10 to 20 gr. relieved or cured epilepsy after larger doses of other bromides had lost their effect (Amer. Quart. Journ., 1870).

Croup and Diphtheria.—Foerster of Dresden, has recommended inhalation of a vaporised solution of carbonate of lithium as a solvent of the false membranes in these diseases.

PREPARATIONS AND DOSE.—*Lithii carbonas:* dose, 3 to 6 gr.

(B.P.). The diuretic effect is increased by free dilution, and the *liquor lithiæ effervescens*, B.P., which contains ½ gr. to the ounce, is a good form: dose, 5 to 10 oz. *Lithii citras:* dose, 5 to 10 gr. (B.P.). I recommend less than these doses. *Bromo-citrate of lithium* in an effervescent water containing also potash and soda is prepared by some London chemists (Lancet, i., 1874); also a "granular effervescent citrate," which is a convenient and portable form, and contains 4 or 5 gr. in each drachm. *Urate and Benzoate of lithium:* dose, 1 to 4 gr. *Bromide of lithium* (as a nerve sedative): dose, 10 to 20 gr. *Salicylate of lithium:* dose, 20 to 40 gr. *Guaiacate of lithium:* dose, 5 gr. *A lotion* should contain 4 or 5 gr. of any soluble salt in each ounce; *a vesical injection*, 20 or 60 gr. of a soluble lithium salt in 4 oz. of water.

MAGNESIUM (Mg = 24) (*non-off.*).

This metal is not found native, but may be isolated by decomposing its chloride with potassium or sodium. In combination it is widely diffused, a carbonate occurring in magnesite and limestone rocks, a sulphate and chloride in sea-water, in many mineral waters and in almost all spring-water: a silicate forms talc, meerschaum, etc., and is present in small quantity in all soils, whence it passes (mainly as a phosphate) into plants and animals.

CHARACTERS.—Magnesium is white, lustrous, hard and very light, its specific gravity being 1·74. It readily oxidises, and when ignited burns with intense brilliancy.

COMPOUNDS OF MAGNESIUM.

MAGNESIUM OXIDE—MAGNESIA—MAGNESIA LEVIS—LIGHT MAGNESIA—MAGNESIA PONDEROSA—HEAVY MAGNESIA

(MgO = 40).

The two oxides, identical in composition, differ in one of their physical properties, namely their specific gravity.

PREPARATION.—They are prepared by strongly heating the heavy and light carbonates respectively, until all carbonic acid is driven off: hence the name "calcined magnesia."

CHARACTERS.—Magnesia and light magnesia occur as white powders, almost tasteless: the heavier form is called "magnesia ponderosa" and is smoother than "magnesia levis," and more readily miscible with water. A given weight of the

light variety occupies three and a half times the bulk of the same weight of the heavy magnesia. Both forms are almost insoluble in water, but their solubility is increased by heat; they absorb water, and if kept long in it may form a concrete mass of hydrate; they are soluble in acids.

MAGNESII CARBONAS PONDEROSA—HEAVY CARBONATE OF MAGNESIUM—MAGNESII CARBONAS LEVIS—LIGHT CARBONATE OF MAGNESIUM

$((MgCO_3)_3\ Mg(HO)_2\ 4H_2O = 382)$.

PREPARATION.—The *heavy* carbonate is prepared by dissolving in boiling water and then mixing, sulphate of magnesium and carbonate of sodium, evaporating, then washing and drying the precipitate. To prepare the *light* variety, the first solution is effected in a *large* quantity of *cold* water which is afterwards boiled. The result of the decomposition is an oxycarbonate which is hydrated, and sulphate of sodium is removed by washing. Thus:—

$$4MgSO_4 + 4Na_2CO_3 + 5H_2O = (MgCO_3)_3Mg(HO)_24H_2O + 4Na_2SO_4 + CO_2.$$

CHARACTERS.—The carbonates are white powders, soluble in acids with effervescence. The light form appears under the microscope partly amorphous, with slender prisms intermixed. Their solubility in plain water is slight, but it is much increased by carbonic acid which converts them into bicarbonates.

MAGNESII SULPHAS—SULPHATE OF MAGNESIUM—EPSOM SALTS ($MgSO_4\ 7H_2O = 246$).

PREPARATION.—It is prepared by evaporating sea-water or saline springs, or by treating dolomite or mountain limestone with sulphuric acid: the soluble sulphate of magnesium is dissolved out and crystallised, insoluble calcium sulphate is left.

CHARACTERS AND TESTS.—It occurs usually in small acicular opaque or whitish crystals, but may be obtained in large, transparent, rhombic prisms. The pure crystals are somewhat efflorescent, but if they contain chloride of magnesium they are moist or deliquescent. Iron is an occasional impurity and gives a reddish tint to the solution.

The small acicular crystals resemble those of *zinc sulphate*,

with which indeed, they are isomorphous: they may be distinguished (1) by the taste, magnesium sulphate being bitter and nauseous, zinc sulphate astringent; (2) ammonium sulphide gives with magnesium salts no precipitate, but with zinc a white one of sulphide (ZnS); (3) caustic potash gives with magnesium salts a white precipitate insoluble in excess, with zinc, a white precipitate soluble in excess. The rhombic prisms resemble those of *oxalic acid*: the latter are markedly acid to the taste and are coloured a purplish brown by common ink; magnesium sulphate is not affected by it except blackened where touched. The characteristic test for magnesium salts is the formation of a precipitate of triple phosphate on the addition of ammonia and any soluble phosphate. The precipitate of magnesia which would be produced by adding ammonia in this test, is prevented by the previous addition of ammonium chloride in which it is soluble. The usual method of applying the test is to add first ammonium chloride, then ammonia, and lastly sodium phosphate.

ABSORPTION AND ELIMINATION.—Magnesia and the carbonates and neutral salts, such as the citrate and tartrate of magnesium, are changed partially into chloride in the stomach, and absorbed either wholly or in part according to the amount taken and the condition of the gastric fluids: not more than 15 gr. at a time is changed (Rabuteau); the unabsorbed portion passes on into the intestine, and under the influence of intestinal secretions or of carbonic or other acids, especially in the large intestine, an additional amount becomes absorbed, and any residue passes unchanged with the fæces, or under certain circumstances accumulates in the bowel, and forms concretions. Absorption varies with the degree of acidity of the intestinal tract, and if this be not marked, lemonade or other acidulous drinks will be required to secure solution. When large doses are given the absorbed portion is comparatively small, the remainder absorbs carbonic acid, becomes converted into the bicarbonate of magnesium which is a very indiffusible salt, and acts as a saline purgative. Part of the absorbed magnesia appears in the urine as a triple phosphate.

The sulphate of magnesium given in *small* doses, is wholly absorbed without producing definite physiological effects. Of large and purgative doses part only is absorbed, and passes out

by the urine or other emunctories. Part of the sulphuric acid of the sulphate is withdrawn by potassium and sodium salts met with in the bowel, and the magnesia or its bicarbonate is almost wholly excreted with the motions.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Magnesia and magnesium carbonate act as direct antacids and local sedatives; also when given in the form of powder, as mechanical absorbents. A dose of 30 gr. and upwards given to an adult, produces after eight or ten hours moderate semi-solid motions of less than normal odour. It has been stated that the effect of these preparations, though less quickly produced, lasts longer than that of stronger cathartics, and is often more copious, 1 dr. of magnesia causing more evacuation than 1 oz. of Glauber's salt (Trousseau)—also that their effect increases with continuous use so that sanguineous and mucous stools may occur after some time. On the other hand if the drug accumulates in the intestine mechanical obstruction may be caused by it, and concretions of ammonio-magnesium phosphate mixed with mucus and débris of food, have sometimes formed when large quantities of magnesia or the carbonate of magnesium in solid form have been taken; as much as 2 pints (Gubler) and "several pounds" (Brodie) of such concretions have been found in the colon, and Dr. G. de Mussy required a mallet and chisel to remove one from the rectum (Med. Times, ii. 1879).

Peritonitis and even perforation have followed from such obstruction, and I have myself seen one fatal case of the kind. The patient was an actor accustomed to hurried, irregular meals, and to consuming large quantities of magnesia (for constipation), and on making a post-mortem examination, the large intestine was found blocked up by magnesian concretions.

When a moderate degree only of such a condition is suspected, full doses of vinegar deserve a trial. The citrate of magnesium acts as a mild, but efficient and somewhat quicker laxative, and being more soluble than the oxide or carbonate, is free from the risk of concretion.

The sulphate in small doses, acts as a gastric sedative, and if not sufficient to purge, often exerts a diuretic effect, especially if the skin be kept cool: 1 to 2 dr. freely diluted, and taken on an empty stomach, will usually produce several watery stools

without colic but with some distension, rumbling and sense of chilliness. The bitter, unpleasant taste, if uncorrected by carminatives, may induce nausea, but this subsides when the purgative effect commences. The pulse and temperature are lowered by the action, and some malaise may be felt from it; more or less subsequent constipation will also be noticed: the biliary secretion is not increased by it.

Much larger quantities (1 to 2 oz.) are sometimes taken by ignorant or careless persons, and if given to the weakly may cause serious depression amounting to syncope, with or without severe purging: Christison refers to a fatal issue from a dose of 2 oz. On the other hand, it has been stated that minute quantities (1½ gr.), given by hypodermic injection, will induce characteristic serous motions (Luton, Gaz. Hebdom., 1874), but Caville could not verify this result on dogs, and Professor Gubler's trials resulted only in local abscess. When even large doses are injected into the veins no purgation is caused (Moreau, Rabuteau) but rather constipation, and this fact bears upon an explanation of its action.

Theory of Action.—Poiseuille and also Liebig, taught that the purgative action of salines when taken by the mouth was due to osmosis of certain constituents of blood plasma *from* the vessels *into* the intestine, and in support of this view Moreau found that on including a portion of intestine (of an animal) between two ligatures and injecting into it a drachm of Epsom salts dissolved in a little water, afterwards returning the intestine to the abdominal cavity, a large quantity of fluid was poured into the ligatured portion within twenty-four hours (Archives Gén., 1872). Vulpian corroborated these observations, but noted also intestinal catarrh, which others have not done (Gaz. Hebdom., May, 1873). Dr. Lauder Brunton has recorded in an interesting paper, results similar to those of Moreau (Pract., vol. xii.). By means of ligatures he made three loops of intestine, and injecting into the middle one a measured quantity of water with a few grains of magnesium sulphate, and into the others the same amount of water only, found after a few hours, that the middle one contained treble the quantity of fluid injected, whilst the others were empty. He experimented also with *concentrated* solutions passed into the middle loop, always with similar result, and suggests

that it is produced by a *direct stimulation* of the intestinal mucous membrane. Rutherford and Vignal also consider the drug a pure stimulant to the same membrane; this view has been more recently supported by the experiments of Dr. Matthew Hay (Journ. of Anat. and Physiol., vol. xvi.). Dr. Brunton showed that the osmotic theory was not tenable, arguing from the structure of the intestine, and Dr. Hay regards the increased secretion as a true *succus entericus*, such as was obtained by Moreau after the division of the nerves of the intestine. The increase of fluid is also partially due to diminished absorption. The salt does not purge when injected into the circulation, nor does it purge when injected subcutaneously, unless in virtue of its causing local irritation of the abdominal subcutaneous tissue, which acts reflexly on the intestines dilating their blood vessels, and perhaps stimulating their muscular movements.

Some eminent writers, chiefly German, have offered other explanations which require a brief notice. Radziejewski observed in experiments on animals that the fæces were quite liquid when passing from the small to the large intestine, and argued that saline purgatives simply hurried them through in this liquid state, and that the larger quantity of fluid in stools procured by purgatives could not come from the blood, or even the glands, because on analysis the proportion of albumen in them was found too little for such a source (Reichert's Archiv, 1870, 39, 77). Thiry, experimenting with the peculiar form of intestinal fistula devised by himself, and formed by a separated portion of bowel communicating with the external surface of the abdomen, found that although local irritation would excite secretion in it, saline purgatives such as sodium sulphate would not do so, and concluded with Radziejewski that they simply *increased peristalsis*. Buchheim taught that besides this, on account of their low diffusion-power, they did not readily pass through the intestinal membrane, but remaining in the canal retained the water in which they were given and also much of the natural watery secretion from the liver, pancreas and glands (a very large quantity, according to Kühne), and so carried from the intestine a large quantity of fluid without necessarily drawing it from the blood by endosmosis, or from the glands by stimulation. These reasonings, although ingenious, seem to me answered or qualified by the later experiments

of Moreau and of Brunton. Thiry's fistula disarranges normal structure too much to furnish a strong basis for hypothesis, whilst Legros and Onimus have satisfied us that peristalsis *per se* is but little increased by sulphate of magnesium (Journ. d'Anat., 1869).

Urinary System.—Magnesia has sometimes caused the solution of uric acid deposits when alkalies have failed to do so, and Mr. Brande pointed out that it could render the urine alkaline more permanently if more slowly, than potash or soda. Thus 2 dr. of soda gave a maximum of alkalinity in a quarter of an hour, 1 dr. of magnesia only at the end of six hours, and ½ dr. in twelve hours (Philos. Trans., 1810). A deposit of triple phosphate occurred, but since earthy salts can be passed in only limited quantities in the urine it is of interest to know precisely how magnesia rendered the secretion alkaline. Caulet concluded from recent researches that both it and lime do so only *indirectly* through the digestive organs—*i.e.*, they neutralise a part of the acid of the gastric juice, and consequently more soda is excreted with the urine and becomes the direct agent in determining its alkalinity. In support of this he finds on analysis no increase in the amount of earthy salts in the urine (rendered alkaline under administration of magnesia), but marked excess of soda (Bull. de Thérap., 1878). In further support of this observation, we have the fact that during normal digestion, when the acid of gastric juice is being neutralised and withdrawn from the system, the acidity of urine becomes less, and in some disorders of the stomach is even replaced by alkalinity.

Glandular System.—Some observers have attributed to magnesia an alterative action, and Grange, Bouchardat and others state that its habitual use, as in drinking water, will cause goître. Some support is given to this idea by the fact that enlargement of the thyroid gland in mice has followed after mixing magnesia with their food (Gubler), but on the other hand many waters from goîtrous districts have been analysed without finding in them a trace of magnesia (Med.-Chir. Rev., i., 1862). The latest conclusions are that the presence of magnesia in drinking water is not of much importance (Lancet, ii., 1891).

Toxic Action.—Jolyet and Cahours report magnesium sulphate to be the most toxic of neutral purgative salts, 30 to 90 gr. having caused sudden death in dogs when injected into the veins.

Vulpian noted abolition of voluntary and reflex movements in a frog poisoned by the salt, and its effect has been compared to that of curare, but this comparison requires further support before it can be accepted (Archives de Physiol., 1869). Dr. Hay found that in cats and other animals, doses of 5 gr. per pound of body weight, produced death by paralysing the heart and the respiration. When administered by the mouth in such animals, the difference between absorption and excretion is not sufficiently great to allow magnesium salts to accumulate in the blood so as to produce toxic effects.

SYNERGISTS.—Absorbent substances such as charcoal and black oxide of manganese aid the mechanical effect of magnesia in powder. Its purgative effects are aided by acids, by the sulphate and citrate of magnesium, and other neutral salts. It is usual to combine the sulphate and carbonate in a mixture, but unless care be exercised they are liable to form lumps which are not readily soluble. The analogues of sulphate of magnesium are the sulphates, phosphates, tartrates, sulphovinates of potassium and sodium, and the chloride of magnesium. Water, cold and refrigerants generally are other adjuvants of its action. Dr. Laycock found quinine aid the purgative effect of magnesium sulphate, 1 gr. of quinine with only 1 scruple of the salt given every three or four hours, acting as well as much larger doses given without the tonic; he supposed this to depend upon improvement of nervous power (Med. Times, i., 1863).

ANTAGONISTS AND INCOMPATIBLES.—Acids given with magnesia destroy its absorbent, but increase its purgative powers; on the other hand, alkalies antagonise its purgative effects. Alcohol, aromatics, and opium lessen its anti-febrile and depletory effects. With regard to opium, Buchheim and Wagner observed that if it be brought in contact with the mucous membrane before the saline no increased flow of liquid occurs, but liquid is absorbed from the membrane: they concluded that opium favoured the absorption of the salt, but in my opinion it acted by paralysing the terminations of the nerves and thus dulling the sense of irritation.

Magnesia forms a rather insoluble salt with arsenious acid, and is ordered in the German Pharmacopœia as part of the official "antidotum arsenici." Schroff proved magnesia to possess

antidotal powers in cases of poisoning by arsenic and cobalt, if given early (Med.-Chir. Rev., 1859). Sugar and magnesia mixed together have been found useful (Lancet, ii., 1873). Orfila proposed it as an antidote to phosphorus, and there is some but not exclusive evidence in its favour (Med.-Chir. Rev., 1857). It has seemed of use in carbolic poisoning.

THERAPEUTICAL ACTION.—*External.*—Magnesia being smooth, light, non-irritant and antacid, makes a good absorbent dusting powder. It has been used for erythema, erysipelas and similar inflammatory conditions of the skin, and also for atonic ulcers, exposed surfaces and inflamed wounds.

THERAPEUTICAL ACTION.—*Internal.*—**Dyspepsia.**—In acidity, pyrosis, and allied symptoms of irritative dyspepsia such as heartburn, flatulence, colic or constipation, magnesia and its carbonate are very useful, and their efficacy may be increased by the addition of bismuth or of carminatives: such symptoms are often brought on by food containing too much fat, and this point should be attended to. Headache accompanied with nausea and mental depression often occurs in the conditions described and may be relieved by magnesia. When vomiting is a troublesome symptom in the dyspepsia either of children or adults, and in the vomiting of pregnancy, magnesia often acts well. An effervescent solution of the carbonate or citrate is a good form, but 5 to 10 gr. doses of the sulphate will sometimes act better. I have known this succeed in the vomiting of albuminuria and in cases where hepatic derangement was more marked than acidity.

Acidity and Diarrhœa of Children.—The mild antacid and laxative action of magnesia and its slight taste, render it a very suitable remedy for the acidity of the stomach which so readily occurs in children; it is valuable both when constipation is present, and when unwholesome food has caused irritative diarrhœa marked by a red furred tongue and greenish, sour and liquid motions: 2 to 10 gr. of the carbonate may be given thrice daily, its antacid action only being desired and its purgative effect avoided, unless with the first dose. On several occasions I have known 4 grs. severely purge an infant at the breast. When the attack is clearly traceable to unsuitable food, "Gregory's powder," containing rhubarb and ginger with the magnesia, is a popular and very useful combination.

Constipation.—In the constipation of delicate persons, especially of pregnant women, also of those subject to gout or rheumatism, hæmorrhoids, or other rectal affections, magnesia is a valuable mild laxative; if required frequently it should be taken in solution (fluid magnesia), and with lemon-juice if the system be free from acidity. The citrate or the sulphate are useful aperients at the commencement of a febrile attack of almost any kind, their action being rapid and more or less depletory; the former may be given effervescing in mild cases, but when a full and decided effect is desired, 1 or 2 dr. or more of the sulphate should be used; sometimes it is given in lemonade or acid infusion of roses, but general experience has proved that it acts best with tincture and infusion of senna. In habitual constipation ½ to 1 dr. given in a glass of lemonade or aromatic water in the early morning will often answer every purpose. Dr. Fleming found the addition of small quantities of atropine advantageous (B. M. J., ii., 1865): it is more usual now, and I believe better, to make use of the magnesium salts in *combination* with others as they are found in many natural mineral waters, such as Seidlitz, Pullna, Friedrichshall, or Hunyadi Janos, half a glass or a glass of such waters being ordered with warm water in the early morning. To obviate constipation and headache during the use of astringent tonics, moderate doses of the sulphate may be usefully added to medicines containing sulphate of quinine, iron, acids, etc.

Obstruction.—In cases of intestinal obstruction dependent upon hardened fæces, full doses of the sulphate freely diluted and given every four hours often succeed well; sometimes the action may be favourably assisted by belladonna. Dr. Strahan has recorded their value in obstruction and colic caused by iron.

Plumbism.—In cases of colic and constipation dependent upon lead poisoning, sulphate of magnesium is a valuable agent; it should be used in conjunction with iodide of potassium, and Dr. Lauder Brunton has well shown that if the latter remedy removes from the tissues the metal in soluble combination yet it is readily reabsorbed unless the bowels be freely and regularly moved (Pract., vol. xii.): ½ oz. doses may be required. Dr. Copland and others used the sulphate with sulphuric acid before the special value of the iodide was known.

Jaundice.—Although the sulphate has no specific cholagogue action, it is a very suitable aperient in cases of jaundice. Dr. Budd recommends it in combination with the carbonate and aromatics, but I generally prefer one of the mineral waters before mentioned.

Diarrhœa.—In intestinal irritation and diarrhœa dependent upon unwholesome food, and especially stone-fruit, sulphate of magnesium is a good evacuant, because it produces so little irritation. In cases of severe dysenteric diarrhœa from this cause I have often given drachm doses at intervals of six hours, for three or four doses, with the best results. Similar treatment has recently been again advocated with illustrative cases of cure from "large doses." Dr. Bradbury finds they cause less griping than small ones owing to more copious discharge of fluid with less affection of the muscular coat (New York Med. Record, 1892).

Enteritis—Dysentery.—Dr. H. Wood speaks of the sulphate of magnesium as the best aperient in enteritis and colitis when one is required: (usually treatment by opium is to be preferred). In true dysentery there is much evidence as to the value of the same salt although it is not generally known. Trousseau called attention to it in 1826 (Archives Gén., v. xiv.), Giacomini recognised it (Treatise on Mat. Med.), and Stillé confirmed their observations; he gave about 60 gr. freely diluted every two hours, with the result of at once diminishing tenesmus and bloody discharges and inducing watery feculent stools; the treatment should be commenced early, and is best suited for sthenic cases; an occasional opiate at night may be given during the treatment. That the same method is equally available for chronic and debilitated cases is shown by the experience of Mr. Ford in Melbourne, when dysentery was for a long time epidemic and more severe in character than he had ever seen it in this country. Some of his patients (medical men and others) had suffered for many months with only temporary relief from chalk mixture, laudanum, etc., when he gave them drachm doses of the sulphate with 20 min. of sulphuric acid every four hours, and a blue pill with opium (1 gr.) at night; mustard was applied over the abdomen and farinaceous diet ordered. In the course of twenty-four to thirty-six hours the dejections became feculent with less blood, and in

about nine days all irritation had usually subsided. Mr. Ford adopted this method on the hypothesis that excessive action prevailed in one part of the intestine (the colon), while the rest of it was inactive; and he hoped to "restore unity of action," and also to "eliminate morbid material." However this may be he is able to report that, in seven years of extensive practice, he did not lose one case of dysentery in the adult (Australian Journ. and Ranking's Abst., 1859). This treatment was adopted by Dr. Leahy in ninety-five cases of acute dysentery with only two deaths—he gave ʒi. of a saturated solution with acid every hour or two till normal stools were passed—then opium or astringents (Lancet, ii., 1890).

Peritonitis.—Similar treatment, viz., by saline purgatives—of which magnesia is one of the chief—has been by some advocated in this disorder, and there is clinical evidence that in *commencing* peritonitis after laparatomy this treatment is good, if not best (B. M. J., i., 1886; ii., 1892). It is not so clear that the same treatment is safe in the *developed* malady especially when independent of surgical cause, but Dr. Baldy claims that by active peristaltic action adhesions are prevented, products of inflammation drained away and inflamed surfaces relieved of engorgement, whilst pain and pyrexia are lessened:—if relief be not given, he concludes that surgical interference is required (Philad. Med. News, Dec., 1888). At present the more accepted treatment is by opium, rest, etc., but the question of aperients must be carefully considered at every point of the case.

Hæmorrhage.—Sulphate of magnesium is a valuable adjunct to astringent remedies for hæmorrhage, because it helps to lessen arterial tension and capillary congestion at the same time that it obviates constipation. In *menorrhagia* it may be given with sulphuric acid; in *hæmoptysis*, with ergot, acid and digitalis; and in *hæmatemesis*, with alum and opium.

Dysmenorrhœa.—In delayed and obstructed menstruation, when the discharge is scanty, dark and of glutinous character I have long prescribed the carbonate of magnesium with beneficial results and especially when the irregularity is attended with sick headache and mental depression; it is most indicated in rheumatic subjects. Five to sixty or ninety grains may be given according as to whether the constitutional, the laxative, or fully purgative

action is required. The small dose should be given each night for the first fortnight after the cessation of the menses, and the larger doses during the latter fortnight, or especially before or during the period, or when headache and depression are present.

Lithiasis—Uric Acid Diathesis.—The power of magnesia to dissolve uric acid and to lessen its formation, whether directly or indirectly, has already been mentioned. Amongst other instances Mr. Brande records that of a man aged sixty, accustomed to pass much uric acid and even calculi, and who had taken daily either 9 dr. of "subcarbonate" of sodium, or 3 of that of potassium for more than a year without good effect, yet under the use of 60 gr. of magnesia thrice a day the acid soon diminished in amount, and after three weeks of continuous treatment it seldom recurred. Since Mr. Brande's memoir (1810) the remedy has been often used in similar cases. Sir B. Brodie combined 6 gr. of magnesia with 12 of potassium bicarbonate and 15 of bitartrate, and it often acted well.

Chronic Gout.—Magnesia in combination with magnesium sulphate, and sometimes with colchicum in addition was largely used by Sir Charles Scudamore, and with satisfactory result. It is especially adapted for the gastric derangements to which gouty patients are liable. In rheumatism its value is not so evident.

Serous Effusions.—Dr. Matthew Hay advocates large doses of the sulphate—one or two ounces—for pleural and other effusions, the taking of fluids by the mouth being much limited during the treatment.

Irritant Poisoning.—As already mentioned, magnesium carbonate forms nearly insoluble compounds with arsenic and cobalt, and besides being used as an antidote to those poisons it has been given with more or less success in cases of poisoning by corrosive sublimate, mercurial oxide and salts of copper. It is perhaps best suited to neutralise the action of the strong acids, whether mineral or vegetable, and acts well when mixed with charcoal. When used for *oxalic* acid poisoning, large quantities must be given to form a basic insoluble salt (Husemann). In the case of a lady, where nearly a tablespoonful of *carbolic* acid was given and unconsciousness came on in twenty minutes, three ounces of sulphate of magnesium were given with the albumen of three eggs, and the patient recovered after vomiting; the bowels were moved only once (Pract., i., 1888).

PREPARATIONS AND DOSE.—*Magnesia ponderosa—magnesia levis:* dose, as an antacid, 10 to 20 gr.; as a purgative or adjunct, 20 to 60 gr. or more—4 to 8 gr. will purge an infant at the breast; children of about ten years require 30 to 40 gr. The *pulvis rhei compositus* (Gregory's powder) contains 6 parts with every 2 of rhubarb and 1 of ginger. *Magnesii carbonas ponderosa—magnesii carbonas levis:* dose, 10 to 60 gr.; 10 to 20 gr. as antacid, 20 to 60 gr. or more as a purgative. *Liquor magnesii carbonatis* contains 10 gr. of the official carbonate in the ounce, or about 2 per cent. The bismuth lozenges B.P. contain about 2 gr. of the carbonate of magnesium. *Liquor magnesii citratis*, the "limonade purgative" of the French codex, may be taken in doses of 5 to 10 fl. oz. A "granular effervescent citrate of magnesia" is in popular demand, but was proved at a trial under the Adulteration Act to be in reality a citro-tartrate of sodium (Pharm. Journ., 1873). I believe that an article containing at least some citrate of magnesium is now supplied. *Magnesilyne* is another form of the same remedy. Rochelle salt has also been found as an adulteration of it (Pharm. Journ., Feb., 1873). In consequence of the high price of citric acid, a formula for producing a meta-tartrate of magnesium has been published (Bulletin, i., 1873). In the same journal, M. Martin records the rather important observation that even carefully prepared citrate, which is perfectly soluble when fresh, is apt to change with age into a subsalt, and to become insoluble. The *acetate* of magnesium is said to have several advantages of solubility, etc. (Record, 1884). A "*boro-citrate*," made by dissolving a borate of magnesium in citric acid, has been recommended by Köhler for acid urinary deposits (Med. Times, ii., 1879). *Magnesii sulphas:* dose, 10 to 20 gr. for irritable conditions of the stomach, or in combination with astringents or tonics; when given with senna or other purgatives 30 to 60 or 120 gr., according to the frequency of repetition. For diuretic effects 20 to 60 gr., as a purgative in a single dose 2 dr. to ½ oz., according to the habit of the patient. Coffee and infusions containing tannin disguise the nauseous taste. A *double sulphate of iron and magnesia* forms a crystalline greenish-white powder, soluble in water and stable without marked astringent or aperient properties (B. M. J., i., 1891). *Enema magnesii sulphatis* (contains 1 oz. of the salt with 1 of olive oil, and 15 of mucilage of starch). The *mistura sennæ composita* contains somewhat more than a drachm in each fluid ounce combined with senna and aromatics.

MANGANESIUM—MANGANESE (Mn = 55)

(*non-off.*).

Manganese is found in many ores, and generally associated with iron; the most common one is the black oxide, or peroxide (pyrolusite), which is found abundantly in Great Britain and in various parts of Europe.

CHARACTERS.—Manganese is a greyish-white metal, hard and brittle, of specific gravity 8. It emits a peculiar odour in a moist atmosphere, or if handled. When pure it oxidises readily in the air, and hence is kept under naphtha, or in sealed glass tubes; it is dissolved by dilute sulphuric acid.

COMPOUNDS OF MANGANESE.

MANGANESII OXIDUM NIGRUM—BLACK OXIDE OF MANGANESE ($MnO_2 = 87$).

CHARACTERS AND TESTS.—It occurs in brilliant needle-shaped crystals or in compact masses, but is usually met with commercially as a dull, earthy, dark-brown or black powder, which contains iron and other impurities. Treated with hydrochloric acid it causes evolution of chlorine, thus—

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2.$$

When heated to redness, it gives off oxygen and leaves a residue of red oxide of manganese—

$$3MnO_2 = Mn_3O_4 + O_2.$$

Sulphuretted hydrogen causes in solutions of manganese salts a flesh-coloured precipitate of sulphide.

Manganesii Oxidum Præparatum (*non-off.*). — The prepared oxide is obtained by digesting the powdered black oxide in dilute hydrochloric acid for twenty-four hours, then levigating and drying.

MANGANESII SULPHAS—SULPHATE OF MANGANESE ($MnSO_4 4H_2O = 223$) (*non-off.*).

CHARACTERS.—It occurs in colourless, or pale rose-coloured, transparent crystals, freely soluble in water.

The *double sulphate*, the *double carbonate* and the double *iodide with iron*, are sometimes prescribed; less frequently such compounds as the *lactate*, *phosphate*, *citrate*, and *valerianate of manganese*. None of them are official.

Permanganate of Potassium (*v.* p. 788).

ABSORPTION AND ELIMINATION.—Kobert found that manganese salts given by the mouth were not absorbed, and con-

sequently no elimination could take place in the urine or otherwise. When injected subcutaneously, manganese is eliminated from the blood into the stomach and bowel, and by the kidneys (Archiv f. expt. Path., xvi., 1883). Cahn has also come to the same conclusions (*ib.*, xviii., 1884). W. Turner found distinct evidence of manganese in the urine of a diabetic patient who had been taking permanganate of potash freely for three weeks, showing that that salt is absorbed to some extent, and partly eliminated by the kidneys (Edin. Med. Journ., 1861). Traces have been found in the urine of man, and more than traces in the urine of herbivora; these are derived from vegetable food, hence there must be some absorption (Ber. d. deutsch. chem. Gesellsch., xiv., 1881).

PHYSIOLOGICAL ACTION. — *Internal.* — **Circulatory System.**—The presence of manganese as an essential element of the corpuscles has been relied upon as a guide to its action, but it seems to be rather an accidental than a normal constituent of the blood. Wurzer, in 1830, first announced its presence, and Millon, Hannon and Burin-Dubuisson corroborated this, whilst Melsens, Bonnewyn and others, could find no manganese on repeated analysis; Melsens operated on 7 kilogrammes of blood from twenty-one different persons. M. Glénard analysed in various ways, blood from forty subjects of varying age and sex, and found the metal in one case only. He concluded "that manganese is not an essential element of human blood; it may be found accidentally, but only in minute amount; it does not enter by the lungs or skin, as proved in the case of a miner" (Gaz. Méd. de Lyon, 1854). M. Riche, who finds the galvanic test to be exceedingly delicate, has detected minute quantities in the blood of bullocks, etc., and a mere trace in human blood (Bull. Acad. de Méd., 1877). Manganese in certain of its chemical properties resembles iron, and that it has a similar therapeutical action has been often stated, but must be considered problematical.

According to Laschkewitz, the organic salts of manganese in moderate doses (subcutaneously) slow the pulse and the heart-action, and cause lowering of blood-pressure and paralysis of muscles and nerves, which iron, he says, certainly does not; after death from manganese poisoning the heart is found dilated, and

does not respond to electrical stimulation (Cbl. f. med. Wiss., 1866). Kobert finds that the intravenous injection of manganese salts first transiently stimulates the vaso-motor centre, then paralyses it; later the heart itself is depressed and finally paralysed; the cardiac nervous centres suffer first and later the muscle. He finds, contrary to Laschkewitz, that the action is analogous to that of iron.

Nervous System.—Certain nervous phenomena are determined by manganese salts. Toxic doses cause death with convulsions, and ½ to 1 gramme injected into the veins of rabbits or dogs produces cramp and death from heart-palsy, or else faintness and weakness and slower death with fatty degeneration (Laschkewitz). The pupils are dilated, the temperature unaffected. Rabuteau injected a little more than 1 gramme into a vein of the hind leg of a bitch, and at first there were no symptoms, but on the following day tetanic convulsions set in with trismus and opisthotonos, and death followed shortly afterwards: the white substance of the spinal cord was shrunken, the grey matter congested. Kobert states that rabbits after large doses subcutaneously, die in epileptiform convulsions; after non-lethal doses they suffer from diarrhœa, loss of appetite, and great depression of the function of the spinal cord, the transverse conducting power being destroyed. In dogs excessive vomiting and great nervous depression are seen after hypodermic injection; there are no convulsions, but jaundice and renal inflammation are striking symptoms always present. It must be remembered that rabbits cannot vomit, hence the difference in symptoms.

Large doses given for a long period induce effects analogous to those of zinc—progressive wasting and feebleness, a staggering gait, and paraplegia (Bartholow). (Kobert states that chronic poisoning can only be induced if the salt is administered by subcutaneous or intravenous injection.) The only cases of chronic poisoning observed in man have been reported by Couper in workers in manganese. The symptoms were muscular wasting and paralysis, and may have been due to other metallic admixtures (Brit. Annals of Med., 1837).

Digestive System.—The saccharated carbonate of manganese has no peculiar taste, the sulphate is styptic, metallic and disagreeable. Small doses (5 to 10 gr.) of these salts are

said to promote appetite and digestion, but larger quantities are apt to irritate and cause vomiting and purging. The oxide, which is gritty on the tongue, is said to exert a sedative action on the gastric mucous membrane.

The sulphate of manganese has been especially credited with the power of stimulating the secretion of bile since the observations of C. G. Gmelin, who found in animals poisoned by large doses, inflammation of the stomach and intestines, and "so large an amount of bile poured out that the whole tract was coloured like yellow wax." He reported a less degree of the same effect in man, and Mr. Ure also found that 60 to 120 gr. acted as a cholagogue purgative. Dr. Goolden took various doses, from 1 up to 30 gr., before any vomiting occurred, but states that as a rule 10 to 20 gr. will cause some nausea and free purging with a copious secretion of bile (Lancet, 1840, and i., 1878). Dr. Rutherford, however, failed to corroborate this experience, at least in animals, for after giving 60 gr. to a dog, the biliary secretion was at once lessened, and severe diarrhœa occurred. After death the mucous membrane of the small intestine was found pulpy, "as if the epithelium had been dissolved by caustic." In another dog a dose of 20 gr. equally caused lessening of bile, although benzoate of sodium given afterwards had power to stimulate its secretion. Dr. Rutherford concludes that the drug is a powerful intestinal, but not an hepatic stimulant, acting very like sulphate of magnesium (B. M. J., i., 1879). Nitrogenous excretion is increased by it. Poisonous doses induce acute fatty degeneration of the liver, like phosphorus.

SYNERGISTS.—Iron may be considered as allied in action to manganese within the limits of the preceding observations; the two substances are constantly associated in nature. Copper, silver, and zinc have allied effects on the nervous system. Goolden speaks of sulphate of manganese as substitutive for mercury as regards the action on the liver, but this is doubtful. He says also that it aids the action of sulphate of magnesium. Luchsinger and others associate molybdenum and tungsten with manganese, asserting that all three produce paralysis in frogs, and inflammation of the digestive tract in warm-blooded animals (Rev. Gén., xxiii., 1884).

ANTAGONISTS AND INCOMPATIBLES.—Caustic alkalies

and salts of lead, silver, and mercury are *chemically* (not therapeutically) incompatible with manganese. Tannic acid and vegetable astringents are not incompatible, as they are with iron.

THERAPEUTICAL ACTION.—*External.*—**Hæmorrhage, etc.**—The chloride of manganese and iron has been used by M. Pétrequin, in preference to the simple perchloride of iron, as a local hæmostatic; in Italy it has been applied to necrosed bone, and injected into fistulous tracts and hydroceles (Pract., vol. v.), but it has no proved advantage over other well-known remedies.

Skin Disease.—The same remark applies to the use of an ointment made with the oxide of manganese (℥ij. to ℥j. of lard), which has been recommended in *scabies* and *ringworm*, and, combined with sulphur, in *porrigo*.

Snake Poisoning.—Wynter Blyth showed that admixture of permanganate of potassium with snake poison rendered it inert. Dr. Vincent Richards finds that if the permanganate be injected into a wound sufficiently soon after the bite, ill-effects are avoided (Indian Med. Gaz., 1882) (*v.* p. 814).

Disinfectant.—Free chlorine is readily and cheaply generated by acting on peroxide of manganese with hydrochloric acid, or by heating a mixture of common salt and peroxide with sulphuric acid and water (equal parts). The former process is recommended in the Swedish Pharmacopœia, 1 part of peroxide (pyrolusite) and 4 of acid being ordered; the latter process is that known by the name of Guyton Morveau: a mixture of manganese oxide 7½ grammes, and 10 grammes of salt, with sulphuric acid and water, of each 20 parts, will disinfect a space of 30 cubic metres.

THERAPEUTICAL ACTION. — *Internal.* — **Anæmia — Chlorosis.**—Manganese was introduced into practice mainly by M. Hannon, of Brussels, with special reference to the treatment of these conditions. He argued that during digestion, sulphuretted hydrogen is formed, and reacts on the ferrous and manganic compounds contained in the intestine, changing them into insoluble sulphides, and thus removing essential elements of hæmoglobin. This happens especially (he supposes) in chlorosis, and the remedy is to supply more of a metal which can form

such sulphides, and prevent the removal of essential elements of the organism. Hence, bismuth, lead and copper are said to prove as serviceable as iron or manganese, though the latter are better assimilated (Presse Médicale Belge, 1850, and Guibert). M. Hannon goes even further than this, and describes three forms of chlorosis, according as there is a deficiency in the blood of iron only, of manganese only, or of both metals. His statements are largely theoretical, and apart from the fact that even the necessary presence of manganese in the blood of healthy persons is doubtful, an appeal to clinical results does not bear out the suggestion of its great importance as a hæmatinic remedy, but rather the contrary. He himself reported very good effects from it, and Dr. Steer reported benefit in chlorotic anæmia, traumatic anæmia, phthisis, and the anæmia of children; but he used saccharated carbonate of manganese with iron, not manganese alone. In uterine leucorrhœa of pale weakly subjects, he gave it with ergot; for constipation, with aloes; for dyspepsia, with soda and rhubarb (Med. Times, ii., 1853). Sir J. Simpson found the phosphate sometimes useful in amenorrhœa, given either with or without iron, but says very little about it (Med. Times, i., 1861). Sir W. H. Broadbent, using the chloride and sulphate, reported some favourable, some negative results, and Mr. Carter used it with no good effect (Clin. Soc. Trans.; see also B. M. J., ii., 1885); the observations of Sir A. Garrod who failed to cure every case of anæmia in which he used manganese alone, whilst the same cases rapidly improved under iron—have been recently repeated by Dr. Ralph Stockman (B. M. J., i., 1893). It is true that M. Pétrequin was an enthusiastic advocate for the remedy in all forms of impaired blood-condition, and also in intermittent fever, phthisis and cancer, but the general experience of the profession is not with him or M. Hannon. All we can at present say is, that in obstinate cases of chlorosis not cured by iron, the conjunction with manganese should receive further trial.

Amenorrhœa.—Drs. Ringer and Murrell first brought the permanganate of potassium into prominent notice as a remedy for this condition, and there seems little doubt that the good effect is due to the manganese, not to the potassium; they recommend 1 to 2 gr. three or four times daily for a few days before the

expected period. Dr. MacDonald however, who reports good results in several cases of amenorrhœa with mental disease, advocates the same dose of permanganate for three months at least (Pract., 1888). Dr. Braithwaite (Leeds) obtained no good effects (B. M. J., i., 1887), and anæmic cases generally require other treatment in addition, but in the fairly healthy with accidental suppression from such a cause as a sea voyage or change of climate, the effect seems good (Edin. Med. Journ., 1887, abstract)—1 gr. thrice daily was given up to a week before the period, then 2 grs. In a careful paper by Dr. W. Stephenson (Aberdeen) relief is recorded not only to the amenorrhœa, but to headache, leucorrhea, and sometimes menorrhagia "mainly through a vaso-motor effect." He gave 2 gr. pills of permanganate with kaolin after food, and found them less likely to cause irritation than the crystals in capsules on an empty stomach (B. M. J., ii., 1889). As Dr. Leffmann points out, the drug, especially given in pill form, is found to be decomposed, with the formation of manganese dioxide; he therefore recommends that pills of the manganese dioxide should be given instead. This has been done by Dr. F. Martin of Chicago (Med. Times, ii., 1885), who states that doses of 2 to 2½ grains every four hours promptly cure amenorrhœa and menorrhagia, especially if these are the result of anæmia.

Hepatic Disorder.—I have already mentioned that Mr. Ure found 1 to 2 dr. of the sulphate act as a cholagogue purgative, and Dr. Goolden gave it in cases of enlarged liver with dark or pale stools and jaundice, when no abscess or acute symptoms were present. Most of the patients (at the Dreadnought Hospital) were in a weak condition, having returned from India, and he sought for a non-mercurial remedy to stimulate the liver. He says that 10 or 20 gr. of sulphate of manganese, though at first it excited nausea or vomiting, soon acted on the bowels to the marked relief of the patient, and with rapid clearing away of the jaundice (Lancet, 1840). This favourable result has, however, not been corroborated by the experience of others, but recently Dr. Goolden has written to direct attention again to the subject, stating that he has continued to use the remedy with success in hepatic dropsy, hæmorrhoids, bronchial congestion, hypochon-

driasis, etc. : he usually combines it with Epsom salts, in a glass of effervescent water (Lancet, i., 1878).

Gastrodynia—Pyrosis.—Dr. Leared found that purified oxide of manganese had decided power in relieving these disorders: in the cases in which he describes benefit, epigastric pain severe and radiating, coming on not immediately but soon after food, especially after albuminous food, were the prominent symptoms. Pyrosis and vomiting were sometimes present. In these cases the tongue was generally red and patchy, and the malady connected with a too rapid shedding of the epithelium and the exposure of a hyper-sensitive mucous surface. Bismuth is a usual and excellent remedy for such a condition, but Dr. Leared found manganese relieve it often more quickly, with the advantage of not causing constipation, and states that he has treated several hundred such cases with satisfaction, before venturing to recommend it (Ranking, i., 1864). He reports two cases of gastralgia, "severe pain with occasional vomiting," one case of derangement of the stomach sympathetic with that of the uterus, and one of pyrosis, with "irritable mucous membrane":—all these got well rather quickly with 10 gr. doses of the oxide (Lancet, i., 1864; ii., 1865). We have not, however, heard much of this remedy from other observers, and Dr. Goddard Rogers states that his patients found the medicine so gritty and unpleasant that they could scarcely continue it.

PREPARATIONS AND DOSE.—*Manganesii oxidum nigrum:* dose, 5 to 10 gr. *Manganesii sulphas:* dose, 10 to 20 gr. as a purgative. *Ferri et manganesii carbonas saccharata:* dose, 5 to 10 gr. as a hæmatinic. *Potassii permanganas:* dose, 1 to 5 gr. Solutions of manganese salts are apt to change colour on exposure to the air. The administration of the *oxide* is more convenient, as it is difficult to make pills of the permanganate; with the usual excipients, it bursts into flame—glycerine smokes. Martindale considers that the best excipient is a mixture of vaseline, paraffin, wax and kaolin (Lancet, i., 1883), while Dr. Bampton finds unguentum resinæ useful for the same purpose (B. M. J., i., 1885). A *phosphate* and *hypophosphate* are sometimes used, and there is a liquor ferri *manganesii peptonatis*. *Permanganate of sodium* is a cheap disinfectant. *Permanganate of zinc* is suitable for astringent lotions, and *permanganate of calcium* for a mouth wash. Mineral waters containing manganese are at Luxeuil and at Crausac (L'Aveyron).

NICKEL (Ni = 58·6) (*non-off.*).

This is a white malleable metal (of specific gravity 8·8), which occurs in nature combined with arsenic (Kupfernickel **NiAs**). It forms two oxides, the monoxide, **NiO**, and the sesquioxide, Ni_2O_3. The compounds of this metal are hardly ever used medicinally, but a few observations have been made on their physiological action.

PHYSIOLOGICAL ACTION.—Schutz gave as much as 10·5 gr. of the acetate to a dog without any result, he therefore concludes that there is no danger in using nickel-plated vessels for cooking, especially as so little enters into solution under such circumstances. Anderson Stuart found that large doses administered to frogs hypodermically, affected the spinal cord and caused tetanic spasms, and in short, that the physiological action of nickel is identical with that of cobalt (*q. v.*). Drs. M'Kendrick and Snodgrass have experimented with the carbon monoxide of nickel, $Ni(CO)_4$, which is a clear liquid, soluble in alcohol, etc., and so volatile as to require to be kept in sealed tubes; they found it a respiratory poison which depressed temperature and reported it as not yet available for therapeutics (B. M. J., i., 1891). Prof. Ch. Richet found it displace the oxygen of hæmoglobin: the vapour caused headache (Rev. des Sc. Méd., 1892). Dr. Blake classes nickel with cobalt, iron, manganese and other metals with which it is isomorphous, and says that all cause death in the same way, viz., by arresting the heart. Nickel like cobalt also causes slight contraction of vessels. Prof. Da Costa of Philadelphia (Med. Times, 1883), has investigated various salts of nickel, and he found that the sulphate and bromide are best, and are tolerated in small doses, but any amount over 5 gr. causes nausea and giddiness.

THERAPEUTICAL ACTION.—*External.*—The oleate of nickel has a local astringent action.

THERAPEUTICAL ACTION.—*Internal.*—The sulphate and chloride in small doses (1 to 3 gr.) are stated by Prof. Da Costa to be serviceable in obstinate diarrhœa; they are sedative in their action, but the bromide is more trustworthy. Speaking generally, it acts on the nervous system like the other bromides in epilepsy and congestive nervous disorders, but careful observation

of eight cases by Mr. Bourneville at the Bicêtre showed its use to be followed by continuance or increase of attacks (Pract., 1889). Dr. Broadbent used nickel chloride in 2 gr. doses given thrice daily in anæmia and chlorosis; some of the cases improved, others did not (Clin. Soc. Trans., ii., 1869). On the whole it seems to be inefficacious.

PLUMBUM—LEAD (Pb = 207) (*non-off.*).

This metal, which does not occur in the native state, is found often combined with sulphur or oxygen. Its commonest ore is galena, a glistening grey sulphide, **PbS**, from which the metal is obtained by roasting it in a current of air; it is not used in medicine.

Compounds of Lead.

PLUMBI OXIDUM—OXIDE OF LEAD—LITHARGE (**PbO** = 223).

Preparation.—It is prepared by roasting lead ores with access of air, when the oxide is formed in a melted state and separates on cooling.

Characters and Tests.—It occurs in small glistening red or yellowish-red scales, which should dissolve without effervescence in dilute acids, but after exposure for some time to the air, the scales slowly absorb carbonic acid and may then give some effervescence; they are soluble also in excess of potash.

The following *tests* are applicable to this, and to all soluble salts of lead: (1) Sulphuric acid and soluble sulphates give a white precipitate (sulphate of lead) insoluble in dilute acids; (2) Iodide or chromate of potassium gives a yellow precipitate of iodide or chromate of lead respectively; (3) Sulphuretted hydrogen or sulphide of ammonium gives a black precipitate of sulphide of lead, but if the proportion of lead be minute, the colour is brown rather than black.

PLUMBI ACETAS—ACETATE OF LEAD—"SUGAR OF LEAD" ($Pb(C_2H_3O_2)_2 3H_2O$ = 379).

Preparation.—It is prepared by dissolving lead oxide in slight excess of acetic acid by aid of gentle heat, then crystallising.

Characters.—It occurs in white crystalline lumps not

unlike sugar, or in large four-sided prisms. The odour is somewhat acetous and the taste at first sweet, afterwards astringent. It effloresces in air, and is soluble in water; with distilled water the solution is clear, but with ordinary water it is turbid, from the formation of carbonate of lead with the alkaline carbonates always contained in such water; a few drops of acetic acid will dissolve the carbonate and clear the solution.

LIQUOR PLUMBI SUBACETATIS—SOLUTION OF SUBACETATE OF LEAD—"GOULARD EXTRACT" ($Pb_2O(C_2H_3O_2)_2 = 548$).

PREPARATION.—It is prepared by boiling acetate of lead with two-thirds of its weight of oxide of lead in water, then filtering, and adding distilled water: a basic or subacetate of lead remains in solution.

CHARACTERS.—A colourless liquid of alkaline reaction and sweetish astringent taste. It quickly absorbs carbonic acid from the air, and becomes turbid from formation of carbonate. It gives precipitates with most vegetable colouring matters, with tannin, and with many animal substances, especially albumen. With gum acacia it forms an opaque white jelly, which the acetate of lead does not. Its specific gravity is 1·275. It answers to the other tests of lead already mentioned.

Liquor plumbi subacetatis dilutus contains one part of the foregoing, mixed with 79 parts of water.

PLUMBI CARBONAS—CARBONATE OF LEAD—"WHITE LEAD" ($(PbCO_3)_2Pb(HO)_2 = 775$).

PREPARATION.—No process is given in the Pharmacopœia, but the carbonate is prepared on a large scale by exposing thin sheets or gratings of lead, placed in earthen pots, to the combined action of acetic acid, air, and carbonic acid gas.

CHARACTERS.—A heavy white powder, insoluble in water, but readily soluble in dilute acids, with effervescence.

PLUMBI IODIDUM—IODIDE OF LEAD ($PbI_2 = 461$).

PREPARATION.—It is prepared by precipitating a clear solution of nitrate of lead with iodide of potassium, washing and drying.

CHARACTERS.—A bright yellow powder, darkened by heat, almost insoluble in cold water, soluble in boiling water, from

which it is deposited in golden crystalline scales; soluble in solution of acetate of sodium. It fuses and sublimes yellow, but soon gives off violet vapour.

PLUMBI NITRAS—NITRATE OF LEAD ($Pb(NO_3)_2 = 331$).

PREPARATION.—It is prepared by dissolving lead, or its oxide or carbonate, in boiling nitric acid slightly diluted, then crystallising out.

CHARACTERS.—Octahedral crystals of white waxy appearance, and sweetish, astringent taste, soluble in water and alcohol, not efflorescent.

ABSORPTION AND ELIMINATION.—Soluble lead compounds when introduced into the stomach are transformed probably into chloride, but in any case are readily absorbed, as shown by clinical results; it is presumed that they circulate mainly as albuminates.

Workers in lead, such as compositors, plumbers and painters, absorb the metal in part by the skin, in part by the lungs, and sometimes directly with the food (from eating with unwashed hands), and injurious effects are not uncommon from the application of cosmetics and dyes containing lead to the skin and hair. Once within the system lead remains for a long time, in small quantities at least, and may be deposited in different organs. It has been found not only in the blood and the liver, spleen and kidney, but also in the muscles and bones, and Chatin recovered 3 milligrammes of lead sulphide from 150 grammes of the upper cervical cord—the tissue was dark grey in colour (Comptes Rendus Soc. de Biol., 1862). Mr. Wynter Blyth found in two cases of lead poisoning which occurred at a lead factory in East London, that the brain contained large quantities of lead, in one case as much as 117·1 milligrammes of sulphate. He considers that this large amount may account for the profound nervous effects that absorption of the metal produces (Proc. Chem. Soc., London, 1887). Lead is *eliminated* chiefly in the form of chloride through the liver, kidneys, skin and mucous membranes, especially those of the urinary tract; the process is markedly promoted by iodide of potassium,—iodide of lead, which is excreted with comparative ease, being formed.

PHYSIOLOGICAL ACTION.—*External.*—Solutions of ace-

tate and nitrate of lead, if not too strong, exert a local astringent and sedative action, coagulating albumen, contracting the vessels, blanching the tissue, and controlling congestion if it be present; on the other hand, if the solution be too strong, and be applied to a delicate part such as the conjunctiva, it excites severe irritation. The carbonate of lead applied in fine powder, is sedative and slightly astringent. The iodide is slightly stimulant and absorbent. The nitrate and chloride decompose sulphuretted hydrogen combining with the sulphur, and hence they act as deodorants.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—The acetate of lead is the only salt of this metal given internally, and the effect of moderate medicinal doses upon the intestinal tract is to diminish its secretions and to occasion sometimes slight colic. The more pronounced effects of poisonous doses vary with the mode of receiving them, and may be acute, sub-acute, or chronic in character.

Acute poisoning.—After a dose of from 1 to 2 oz. the symptoms begin quickly with the characteristic taste of the drug, followed perhaps, in a quarter of an hour by burning and pricking in the gullet, nausea and vomiting, but the vomiting caused by the poison alone is not usually severe; there is uneasiness in the stomach sometimes followed by violent colic, but the pain intermits, and it may be relieved by pressure. There is usually constipation, but sometimes an attack of purging, the fæces being dark and containing lead sulphide; sometimes there is extreme collapse. If recovery ensues, there may occur afterwards symptoms of chronic lead poisoning caused by the absorbed metal.

Sub-acute poisoning may be illustrated by cases which occurred at Stourbridge in 1849, when acetate of lead was mixed by accident with flour at a miller's. Upwards of 500 persons were attacked, a few days after eating the bread, with a sense of constriction about the throat and stomach, cramping pain near the umbilicus, and rigidity of the abdominal muscles; sickness occurred only in a minority of the cases, and did not last long; there was obstinate constipation and a general lessening of secretion; a dark-blue line on the gums was noted. No cases were fatal, but severe symptoms continued for a long time, and sometimes recurred after apparent convalescence.

The subject of *chronic lead poisoning* is exceedingly interesting to the practical physician, but concerns us at present only as illustrating the physiological action of the drug. Some of its symptoms have occurred from the medicinal use of the acetate, and from the continued use of minute quantities rather than from massive doses. Thus Sir R. Christison gave 18 gr. in two days without injurious effects, whilst $\frac{1}{15}$ gr. given two or three times daily for two months caused fatal poisoning in a child (Letheby, Taylor). As a rule it may be said that the worst effects of any medicinal use of lead limit themselves to an attack of colic, and the severe symptoms about to be described need not be feared from it: 5 gr. doses of acetate are largely used at Brompton Hospital without bad results.

The ordinary "lead colic," or plumbism, is traceable most frequently either to the mechanical use of metallic lead, its oxides or carbonates, or to the solution of these salts in drinking water, etc. After some general malaise, disordered taste, dryness of mouth, fœtid breath, anorexia and constipation, abdominal pain will usually be the most marked symptom, but is not so invariably; Sir A. Garrod finds it absent in 2 to 3 per cent. of cases. When fully developed it is much more intense than ordinary colic; it is referred mainly to the region of the navel (the colon), but severe cramp-like or neuralgic pains dart in many directions, towards the loins, the scrotum, the chest, and the thighs: it has a twisting, tearing character, so that German miners name it commonly "Hütten Katze" ("cat of mines"). It comes on in paroxysms, remaining constant but dull in the intervals, and the whole attack lasting from a few minutes to several hours; it is often worse at night, but its recurrence is irregular. Relief is found from firm pressure and altered position, and the sufferer either lies flat on his face pressing the abdomen, or is doubled up, bending his legs, or rises suddenly, still pressing the painful part with his hands, till a violent paroxysm again sends him to bed. Restlessness is extreme, and the whole attention is concentrated on the pain. The abdominal walls are rigid, knotty, and drawn in, there is commonly tenesmus, and the rectum has been felt to contract and relax spasmodically. The liver is retracted (Potain) or actually lessened in size; the intestines also are drawn into less space from contraction of their muscular coat, and in prolonged

cases, after the abdominal fat has been absorbed, the retraction of the belly becomes very striking.

Tanquerel (Traité des Maladies de Plomb, Paris, 1839) and Burton (Med.-Chir. Trans., 1840) were the first to describe as common in plumbism a dark-blue or grey line along the free edge of the gum, together with a brownish coloration of the teeth. Though a valuable sign and often present it is not always so, nor does it necessarily imply saturation of the system with the mineral; it varies in its time of appearance according to the dose, but has been seen within twenty-four hours of administration of one large quantity (Burton): 20 to 30 gr. in divided doses may develop it, and when once seen it is very persistent, lasting twelve months at least after its cause (Oliver); similar coloured patches may often be found on the buccal mucous membrane. The colouring depends on formation and deposition of lead sulphide from the sulphuretted hydrogen evolved from particles of food left about the teeth (Tomes), and by perfect cleanliness it may be prevented. According to Dr. Hilton Fagge it is distributed in rounded loops corresponding with the vascular papillæ of the mucous membrane, and depends on small pigmented granules, some of which are external to, others within the small vessels. He concludes that the gas from food-particles diffuses into the textures of the gum, and then combines with lead circulating in the blood or lymph, so that particles of lead sulphide are really precipitated—a similar condition may be present in the intestinal membrane. Iodide of potassium sometimes induces its rapid development (Lancet, i., 1876).

We cannot so readily explain the pathology of the colic. It is in part dependent on constipation, for it is relieved when purgation is secured; yet Briquet claims to have relieved it more quickly by faradism of the abdominal wall without any aperient effect. It is dependent partly also on irregular muscular contraction of the intestinal tube, following on partial paralysis and spasmodic peristalsis; other characters again show it connected with an enteric neuralgia. Harnack using the triethylate of lead, which can be injected directly into the blood, found that the nervous ganglia in the intestinal wall were stimulated, in consequence of which sometimes diarrhœa results from increase of

peristalsis, but more usually there is firm contraction of the intestine leading to severe constipation; the former is more often seen in animals, the latter in man; the contraction of the bowel explains the colic (Archiv f. expt. Path., ix.).

In acute poisoning, the gastro-intestinal mucous membrane has been found coated with a whitish-grey layer of coagulated mucus containing the poison, and there have been patches of abrasion, congestion, or inflammation. In chronic cases the mucous membrane is congested, softened and discoloured, the walls are thickened and the canal irregularly contracted; sometimes intussusceptions are found; the coils of intestine are closely packed together. In chronic plumbism emaciation is notable, especially about the face.

Nervo-muscular System.—Ordinary medicinal doses do not usually produce definite effects on the nerve or muscles, but in acute poisoning from large quantities, besides the pain and cramp already mentioned, general prostration is a marked symptom. There may be also giddiness or stupor, numbness, paralysis, or epileptiform attacks, and in fatal cases convulsions and tremor generally occur. In the sub-acute cases at Stourbridge the nervo-muscular symptoms were cramp and rigidity of muscles, numbness, with partial palsy of the lower extremities, and collapse: the mental faculties were unimpaired.

But it is in chronic plumbism that affections of the nerves and muscles become marked and significant, various forms of neuritis and paralysis almost always appearing. The most common is a paralysis of the extensors and supinators of the forearm, leading to a condition known as "wrist drop," from the peculiar manner in which the hand hangs down when the limb is extended. This occurs more often on the right side than the left—the fingers and wrists are flexed and the hand prone, the elbow stands out from the side, and the forearm bends on the arm—wasting of the affected muscles quickly follows, and especially of the small muscles of the thumb.

A special plastic or fungoid form of synovitis in the sheath of the extensor tendons has been described (Gubler, B. M. J., ii., 1878).

Sometimes other muscles are affected—thus, strabismus has been noted from paralysis of the ocular recti, and aphonia from laryngeal palsy. Occasionally hemiplegia occurs, more rarely still

paraplegia, and in advanced cases the extensors, at least of the lower limbs, are more or less affected. Death has resulted from paralysis of the respiratory muscles; in a case where this was imminent, recovery occurred under atropine which was presumed to stimulate the respiratory centre (Lancet, i., 1889). Of the special senses sight is the most often affected, amblyopia occurring, or amaurosis from anæsthesia of the optic nerve; in such cases the pupil is dilated. Optic neuritis has been connected with the special effect of lead on the optic nerve, but Jeaffreson in an able essay, offers evidence to show that when occurring in plumbism it is not primary, but secondary to increased intra-cranial pressure, probably from effusion, and he further suggests that in some of the recorded cases this was more likely connected with uterine congestions (B. M. J., i., 1886). Dr. Oliver, however, gives instances of optic neuritis apparently primary (Lancet, ii., 1889). It is not uncommon for the hearing to suffer, and common sensibility is often altered. There is usually partial anæsthesia, though sometimes, as in the Claremont cases, excessive hyperæsthesia is developed. From experiments on animals, Curci concludes that lead specially irritates the vagus, and he thus explains the slowing of the heart-action (Record, 1883).

During an attack of lead colic the intellect is, as a rule, clear, but in long-continued cases the moral courage and the spirits give way, and sometimes in the course of the illness distinct delirium occurs, generally of the form "delirium of dread," not unlike delirium tremens. The patient is extremely fearful of being alone, especially at night, and has visions of black and creeping things. Three remarkable illustrations occurring in women-workers at a lead-factory are furnished from the London Hospital (Med. Times, i., 1869). Other cerebral symptoms, such as haedache, delirium, epileptiform convulsions and coma, have been recorded; insomnia is usual. A comparison may be drawn between the effects of alcohol and of lead, both upon the nervous system and the kidneys (Lancet, i., 1889).

Theories of Plumbism.—Whether the muscles or nerves are primarily affected, and in the latter case whether the peripheral branches or the centres are most at fault, has been much debated. Giacomini attributed the *colic* to direct muscular irritation from deposition of the metal in the abdominal muscles

and the diaphragm, pointing out that superficial pressure often gives pain, even over the iliac crests, whilst firm supporting pressure relieves. Briquet acting upon this theory, faradised the skin of the abdomen with a metallic brush, and thus relieved the pain by counter-irritation. That the *paralysis* also depends on deposition of the metal in the muscles is suggested by the frequency with which the right arm is affected in lead-workers, it being more exposed to the poison than the left.

Tanquerel maintained that the colic was due to irritation of the great ganglionic centres, though signs of this could only be found in one out of forty post-mortem examinations. It may be noted, however, that galvanism of the sympathetic nerve-centres has been said to cause elimination of the poison quickly, and to cure palsy of the forearm without direct local treatment (Med. Times, i., 1877).

Eulenburg considers lead colic "a mixed neurosis of motor-sensory nature, in which the splanchnic nerves and vaso-motor branches from the aortic plexus are affected" (Med. Times, i., 1870). He points out the special determination of lead to the muscular system and its powerful local effect in causing contraction of involuntary muscles.

Heubel argues that the peripheral intra-muscular extremities of nerves are at fault rather than the main trunks (Bleivergiftung, Berlin, 1871), and Althaus apparently takes the same view (Med. Times, i., 1874). On the other hand, Bernhardt asserts that the real lesion is in the grey matter of the cord (Med. Record, 1878), and most modern observations point to the same conclusion, at least in chronic conditions; lead has been found in its substance in some cases, and a granular partly atrophic state of spinal cells has been verified in one instance by Lancereaux. Popow finds that lead, like arsenic and mercury, produces a central myelitis of the spinal cord (Virchow's Archiv, 1893). The affected muscles and corresponding nerve-trunks are much atrophied, so that sometimes scarcely one normal fibre can be found. The view that the nerve-centres are the seats of the lesion is also supported by the observation of Wynter Blyth, who found large quantities of lead in both cerebrum and cerebellum. In animals choreic movements occur and even convulsions, without impairment of sensation or conscious-

ness; it would thus seem that the motor areas of the central nervous system are more affected than the sensory.

Harnack, as previously stated, explains the colic by an action on the intestinal ganglia. He holds that the action on the muscles is a primary one, although certain observers have stated it to be secondary to degeneration in the spinal cord. In acute poisoning, before any affection of the cord has had time to affect the muscles, he describes the latter as being easily fatigued so that they cannot be tetanised by repeated electric stimulation.

Circulatory System.—Full medicinal doses of the acetate slightly lower the force and frequency of the pulse (Laidlaw). In hæmorrhagic cases and in pneumonia this effect is often marked. Strohl found a diminution of ten to fifteen beats per minute after daily doses of 25 to 50 centigrammes, and Rabuteau verified a pulse-rate below that of health; it has been explained by a direct action on the muscular structure of the heart. In cases of *acute* lead poisoning, the pulse has been sometimes quickened, but has become slow in the stage of collapse. In *sub-acute* cases it is markedly slow and feeble. During a paroxysm of colic in the course of plumbism the pulse is of characteristic wiry hardness, and generally lowered in frequency, while the heart's action is so weakened as to be scarcely perceptible. In half the large number of cases recorded by Tanquerel, the pulse-rate was from 30 to 60 per minute, the hardness and slowness being usually proportional to the amount of pain; exceptionally the frequency was increased. The peripheral circulation is commonly impeded, and arterial anæmia leads to pallor and chilliness, though in two cases recorded by Murchison a rise of temperature (102°) was found (Lancet, i., 1868). In *chronic* conditions of lead poisoning the pulse is small, hard and usually slow, and the sallow, bloodless skin has an icteric tint, anæmia is commonly marked, and there is more than normal water in the blood as well as fewer red corpuscles; Malassez states, however, that these are increased in size (Archives de Physiol., 1874). Cardiac murmurs are common in lead-workers, and it is said that the heart and great vessels have been found smaller than usual after death. Henle considers that the vessels are contracted (during life) by direct irritation of their muscular coat by lead circulating with the blood; certainly

vascular tension is much increased in plumbism, as clearly shown by the sphygmograms of Dr. A. Frank (Deut. Arch. klin. Med., Bd. xvi.). German observers, besides corroborating this, have demonstrated the antagonistic effect of pilocarpine during attacks of colic: very soon after its hypodermic injection the tracing shows greatly lessened tension, and simultaneously the pain is relieved. Nitrite of amyl acts similarly (Med. Record, 1876).

Genito-urinary System.—Chronic lead poisoning often leads to abortion, and if this does not occur, the children born are delicate. Of 123 conceptions amongst lead-workers, 50 children only were born alive, and of these but 14 survived infancy. Dr. Swan records three cases in which abortion occurred (B. M. J., 1889). It would seem that the influence of one parent only affected by lead is enough to produce these results (M. Paul, Archives de Méd., 1860). Amenorrhœa has been clearly traced by Dr. Dowse to working in lead.

The influence exerted by this drug upon the kidney is of great practical importance; albuminuria is not uncommon in acute plumbism, and is then connected probably with an altered condition of the blood, but in chronic cases a directly injurious action is exerted on the kidney structure, leading to fatty or albuminoid degeneration. Dr. Shearman has recorded two remarkable instances of albuminuria in one family, clearly traceable to the use of drinking water impregnated with lead; characteristic palsy was also present. The cases recovered for a time after removing the cause, but later one died of apoplexy, the other of Bright's disease (Pract., vol. xii.). In a valuable clinical lecture on the subject Dr. Thomas Oliver concluded lead to be a "special poison to the renal cells" (B. M. J., ii., 1885); but all metals, if absorbed, affect the kidneys more or less severely.

During a paroxysm of colic the amount of urine is diminished, and it is passed with difficulty. It is proved also, that the excretion of urates and of uric acid from the blood in its passage through the kidneys is lessened under the influence of lead, hence a larger than normal amount remains in the blood and the patient becomes exposed to gouty attacks. Indeed, Sir A. Garrod has developed acute gout in susceptible subjects by the administration of lead salts, and has calculated that 33 per cent. of gouty patients had been exposed in some manner to the action of lead.

Pains about the joints and deposits of urates are not uncommon in saturnine cachexia.

Glandular System.—By the ordinary medicinal use of the drug all secretions are diminished. Heubel attributes the icteric condition frequent in plumbism to contraction of the muscular fibres of the bile-ducts. During an attack of colic all the secretions are diminished except that of the skin (Alderson, Lumleian Lectures, 1852).

Modes of Chronic Lead Poisoning.—Of the different workers in lead, oxide of lead, or "white lead" (carbonate), those who grind it in factories are most liable to suffer, though less so now that the powder is ground with water (Taylor); but house-painters and coach-painters, plumbers, pewterers and compositors, makers of certain white glazed cards, hat pressers, bleachers of Brussels lace and glazers of pottery are often affected. Severe symptoms have sometimes arisen from sleeping in a newly-painted room, or from breathing the smoke of burning painted wood. Amongst exceptional and little suspected causes of plumbism are the handling of vulcanised rubber and black horse-hair coloured by lead sulphide, the use of hair washes, dyes and cosmetics containing lead salts, breathing dust from "American cloth" whitened with lead salts, and in the process of making yellow cord fusees (chromate of lead). Poisonous symptoms have followed in an infant after the application of strong lead lotions to the mother's nipples, and in children from yellow confectionery (chromate); the chewing of "tea lead" (in which tea is wrapt), the using of snuff that had been wrapt in similar "foil," the use of soda water from lead "syphons" (B. M. J., 1874-75)—(free tartaric acid is said to help in this case)—bathing in water impregnated from a leaden pipe, the drinking of wine from bottles which had been cleansed with shot—have all caused plumbism.

Two curious epidemics have occurred—one at Taunton, another in France—from flour ground between mill-stones that had been mended with lead (B. M. J., 1877; Med. Times, i., 1878), and even the handling of lead machines, as in ice-cream making, or cameo polishing, or cleaning "beer engines" or brass handles (as engineers do), has induced colic.

There is some reason to think that the "dry colic," or enteric neuralgia of tropical countries is connected with lead. Gubler

gives instructive instances of its development from the use of lead cosmetics in creoles (Med. Record, 1876), and it is said to have become more common since steam-boats have been more used (Med. Record, 1876). Mialhe and other French physicians also speak of lead colic being frequent on ship-board, and connect it with the action of a saline atmosphere on lead. It is especially frequent in Newcastle, "the home of the lead trade."

But excepting the trades first mentioned, the most frequent source of lead poisoning is the use of drinking water impregnated with the metal or some of its compounds. Bad symptoms have resulted from so small an amount as $\frac{1}{10}$ gr. per gallon, and 1 gr. per gallon is a surely dangerous dose. It is to be noted that the freer the water from saline ingredients, the more readily it takes up a soluble carbonate formed on the metal pipe or cistern. The formation and solubility of this are also favoured by much organic impurity, free access of oxygen, a little nitric or other acid or the presence of a second metal (iron as well as lead). Carbonic acid in pure water also favours solubility, although in certain circumstances it may act differently. Lime and other saline constituents will, on the other hand, if present in the water *lessen* the liability to contamination by forming insoluble coatings on the metal: otherwise, no doubt, plumbism would be still more common than it is.

Epidemics have occurred within recent years at Huddersfield, Bradford, Sheffield, Keighley, etc., and in several of these the public water supply was found acid (B. M. J., i., 1889).

Idiosyncrasy.—There is a great difference in the susceptibility of different individuals to the poisonous action of lead,—as may be verified in any large factory,—and it is comparable to what has been noticed with arsenical wall papers. One attack of colic predisposes to another, which may follow after a long interval from a comparatively slight cause—thus a man who had suffered as a house-painter turned gamekeeper and got an attack long afterwards from stirring shot in water with his hands (B. M. J., i., 1877).

SYNERGISTS.—The depressing influence of lead upon the *circulation* is assisted by full doses of digitalis, ergot, veratrum, prolonged cold, etc. (Gubler); its astringent action by metallic salts of

copper and zinc particularly. The other metals, especially mercury, antimony and copper, have a similar effect in lessening nutrition.

ANTAGONISTS AND INCOMPATIBLES.—Sulphate and carbonate of calcium, carbonic acid, mineral acids, alkalies, iodide of potassium, albuminous solutions and most vegetable astringents are chemically incompatible, and most of these may be used in the treatment of lead poisoning. In acute cases, when the drug has been taken by the mouth, emetics or the stomach-pump should be used, and sulphate of sodium or magnesium given in milk or mucilage. In chronic cases alkaline iodide should be given internally, and sulphur baths should be used containing about 7 oz. of sulphuret of potassium. During half an hour of bathing, frictions should be employed, and soap should be freely used afterwards (Eulenburg). Electricity should be applied to the affected muscles—faradism if it causes contraction, if not, the continuous current three or four times weekly for about a quarter of an hour, whether it induces contraction or no: in curable cases it will ultimately do so. Purgatives should be freely given. Castor oil will remove the lead excreted into the intestine: the best results are obtained, however, from magnesium sulphate given with potassium iodide: under the influence of the latter drug the lead is excreted by the bile and intestinal juice and is then immediately removed by the Epsom salts, and thus reabsorption of the poison prevented. Fatty food is said to antagonise the development of plumbism in lead-workers, and a long prevalent colic in large lead-works in Birmingham was stopped by the free use of a "treacle-beer" containing sulphuric acid (Lancet, i., 1860). Washing the hands before eating etc., is important, and washing with petroleum is said to be prophylactic (B. M. J., ii., 1877).

Pilocarpine and amyl nitrite antagonise the increased arterial tension which occurs in chronic cases.

THERAPEUTICAL ACTION.—*External.*—**Disinfectant Power.**—A solution of lead nitrate (Ledoyen's disinfectant) has been in use for many years, and acts by decomposing sulphuretted hydrogen and as an antiseptic and germicide; it is comparatively expensive, and its black precipitate is sometimes objectionable: Dr. Goolden has, however, recommended as applicable to many cases solution of *chloride* of lead. He prepares it by dissolving

½ dr. of powdered nitrate of lead in one pint of boiling water, and mixing this with 2 dr. of common salt in 2 gallons of water. The precipitate which falls is in part carbonate of lime, in part carbonate of lead, and the clear supernatant fluid is a saturated solution of lead chloride. This quickly removes the smell of foul drains, ship-holds, etc., and cloths wrung out of it and placed about a room neutralise organic emanations such as from crowded assemblies and fœtid suppuration. It was used with much advantage on board the *Thunderer* after a gun-explosion (Lancet, ii., 1875-76; B. M. J., ii., 1876).

Inflamed Surfaces.—A solution of subacetate of lead is still, perhaps, the most frequently used of all remedies in the external inflammatory conditions for which it was introduced by Goulard, of Montpelier, more than 100 years ago.

In *erysipelas* it proves cooling and astringent, and a good formula for its use is that given by Christison, Murchison, and others (Med. Times, i., 1867), viz., 4 gr. each of lead acetate and of powdered opium in an ounce of warm water. The meconate of lead is formed and is precipitated but gives an effective therapeutical result; a more elegant form combines the lead salt with acetic acid and acetate of morphine. Dr. Lawson speaks well of a solution of acetate, 10 to 20 gr. in ½ oz. each of plain water and lime-water, for all kinds of *burns*, *wounds* and *ulcers* (Lancet, ii., 1875). Mr. Freer, from much practical experience, recommends the carbonate of lead with linseed oil (white paint) in preference to the acetate, or indeed to any other application; it has the advantage over nitrate of silver of being painless, and it often relieves very quickly (Lancet, i., 1859). It is good not only in erysipelas, but in burns, carbuncles and eczema, since it excludes the air and exerts a sedative effect; it may be applied with a feather, and a fresh coat put on every two hours or so and left to peel off in a few days. A more elegant mode of using the carbonate is with glycerine, 1 dr. to 4 gr. of the powder, and 1 oz. of cerate; this is useful for erythema.

Conjunctivitis.—Warm lead lotions, with or without opium, are very serviceable in ordinary catarrhal cases, but it is important they should not be ordered if the corneal surface be abraded, or else an opaque white deposit may be left.

Eczema.—In cases of moist discharging eczema, lead lotions

are often soothing and sometimes curative ; a combination of the liquor plumbi subacetatis 1 oz., with glycerine ½ oz., and cherry laurel water 3½ oz., is very good for sub-acute cases, but may require dilution. Mr. B. Squire gives the preference to a *glycerole* of subacetate of lead, in the preparation of which glycerine is used instead of the water of the official liquor (Med. Times, i., 1876) : 1 part of this in 4 of glycerine or of vaseline is a useful strength. Such a preparation under the name glycerinum plumbi subacetatis has since become official (B. P., 1885). The lactate of lead is also a good soluble form, but care must be taken that it is not unduly acid from long keeping, as then it is apt to irritate. The liq. plumbi with fresh milk or cream, 1 part in 8, is sometimes a good resource and better borne than the same strength with water. Equal parts of the liquor plumbi and glycerine have given me as good results in chronic eczematous conditions, and more especially in mentagra. In some cases the iodide of lead ointment will be found useful.

The unguentum diachylon is an excellent soothing application where ointment of any kind can be borne, if made properly and according to the following formula (Hebra) : Ol. olivæ opt ℥xv., Pulv. lithargyri ℥iii. ℥vi., Aquæ. q. s. Coque. Heat the oil with a pint of water by steam-bath to boiling, the finely powdered litharge being sifted in and stirred continually until the particles disappear ; add a few more ounces of water as required and stir till cool. The result should be like butter of a light yellow colour ; it is difficult to prepare properly and is apt to decompose.

Wounds.—Mr. Hutchinson has strongly recommended the continuous use of lead lotions in operative surgery. Within about six hours of any serious amputation he applies over and near the part, compresses soaked in a lotion containing ½ oz. of liquor plumbi subacetatis and 1½ oz. of spirit of wine in a pint of water, and kept constantly moistened every half-hour for several days and nights. This constant attention is essential to success, and is the only troublesome part of the treatment, which seems to prevent inflammation, to have some antiseptic power, and certainly to promote union by first intention—no poisonous symptoms have been observed from it (Lancet, i., 1875) ; this method is, however, now but seldom used. Zeissl advocated a similar dressing for bubo, after observing the unfavourable results of

routine treatment by incision, etc., as carried out in certain German hospitals; he kept the surface constantly covered with linen soaked in solution of basic acetate of lead, and found that inflammation and suppuration were much controlled, and convalescence hastened (Med. Times, i., 1872).

Onychia.—Powdered nitrate of lead I have found a remarkably good resource in cases of onychia, and it has quickly benefited when ordinary treatment had failed.

Sore Nipples.—Dr. Fordyce Barker speaks highly of the nitrate of lead (10 to 15 gr. in the ounce of glycerine) as an application to sore nipples (Med. Times, ii., 1873).

Enlarged Glands, etc.—The ointment of lead iodide is often useful in chronic adenitis and splenic enlargements, also in chronic synovitis. It has been found specially useful in acute mastitis when abscess is threatened: steady friction with it relieves pain, enables the milk to be withdrawn, and lessens its secretion. Lead lotion should be applied between the frictions.

Leucorrhœa, etc.—In cases of purulent and muco-purulent discharge from the vagina, the urethra, the ear, or the nose, lead lotion is very useful at any stage, since, if sufficiently dilute, it does not irritate like alum and some other astringents. If, however, improvement is not obtained from weak dilutions the full strength should be tried, and zinc sulphate may be added in the proportion of 1 or 2 gr. to the ounce of lead lotion.

THERAPEUTICAL ACTION.—*Internal.*—**Hæmorrhage.**—The acetate of lead has decided power over many forms of internal hæmorrhage, and is still in frequent use, though not so much so as formerly. Dr. Elliotson often prescribed it in 2 to 3 gr. doses; Dr. Stokes says "nothing can be more striking than its power to arrest the discharge in chronic *bronchial* hæmorrhage," and I have more than once verified this. Dr. C. J. B. Williams recommends 3 gr. with opium every hour or half-hour in cases of *hæmoptysis*, taking care to give a daily dose of purgative salts (Lancet, i., 1862). In the hæmorrhage of *enteric fever*, acetate of lead is often valuable.

In an obstinate case of *hæmaturia*, after failure of tannin, iron and other remedies, grain doses of lead acetate with $\frac{1}{2}$ gr. of opium, given every six hours, soon arrested all bleeding; a blue line appeared on the gums within a week of this treatment

(Gull, Lancet, i., 1866). In *uterine hæmorrhage*, acetate of lead with opium is often suitable. Dr. Dewees used it largely in plethoric menorrhagia and in hæmorrhage occurring during pregnancy.

Dr. Workman has written to advocate a novel prescription, which theory would scarcely seem to justify, though the practice is said to be advantageous; he gives the acetate in ½ to 1 dr. doses without any opium; this causes diarrhœa but no other bad symptoms, and produces he says, the best results in hæmoptysis and also in uterine hæmorrhage, causing contraction of the uterus (Med. Record, 1878).

Phthisis—Chronic Bronchitis.—At one time acetate of lead was thought valuable in consumption, and it may relieve some of the symptoms, such as profuse sweating, expectoration and diarrhœa, but the cases said to be cured by it were probably of chronic bronchitis with excessive secretion. M. Beau has, however, written comparatively lately to advocate again the advantages of lead treatment in phthisis, recommending the carbonate in gradually increasing doses (Lancet, ii., 1861). He founded his practice upon some cases of phthisis which recovered after working in lead-factories, and concludes that a moderate degree of lead poisoning is antagonistic to the malady—but such an opinion is not generally accepted. Nearly all physicians condemn the use of lead salts in phthisis, and with these I fully agree; if only for the impairment of appetite produced, this method of treatment must be objectionable.

Pneumonia.—Under the use of lead acetate a good proportion of success in the treatment of pneumonia has been reported by Brandes, Strohl, Leudet and others (B. M. J., i., 1863). I only mention this fact as historically interesting, pneumonia not being so treated at the present day.

Aneurism.—Since the observations of Dupuytren, who reported three cases of aortic aneurism relieved by lead acetate (together with small bleedings and rest), this remedy has been tried by many physicians. Dr. Owen Rees reported a case of acute popliteal aneurism (Lancet, i., 1865), with thin walls, and no coagula in the sac, which did not improve under pressure, and was thought incurable without operation; on October 29th 3 gr. of acetate with opium were ordered thrice daily, the diet was not

restricted nor rest enforced: on November 1st there was a slight blue line on the gums: on November 5th the dose was increased to 5 gr., and this was continued for twenty-six days when the remedy was stopped on account of colic: aneurismal pulsation had ceased. On December 31st the man was at work, and on January 17th reported cured. This rather striking instance I have not found supported by the results of others, though Sir A. Clark reports a case of thoracic aneurism in which 2 gr. of acetate with opium were given thrice daily for two months, and the patient got better; he was kept constantly at rest (Med. Times, ii., 1867). Stillé remarks that the sacculated form of aneurism can only be cured by coagulation of blood in the sac, and in so far as acetate of lead promotes this it assists a cure, but in the fusiform aneurism with symmetrical distension no mere astringent can exert a salutary power. Bellingham objects to the use of lead in any case, and Mr. T. Holmes, who has known aneurism develop during the course of a lead colic, asserts that the acetate is of no real value in the treatment of the malady (Lancet, i., 1872). Dr. Bristowe points out that it may help to quiet the circulation, but cannot really coagulate blood within the vessels, otherwise its administration would lead to danger from thrombosis or embolism. From a general review of the evidence at present before us, I should conclude that although individual cases of apparent benefit may be cited, as a rule very little can be expected in aneurism from the use of lead.

Diarrhœa—Dysentery.—Stillé has collected a large amount of evidence, American and foreign, in favour of lead acetate as a remedy in many forms of these disorders. Graves and others have recommended it in cholera. It certainly exerts a powerful astringent effect, but should not be used without due regard to the elimination of irritating material by previous purgation if necessary. In some cases of obstinate diarrhœa amongst the ill-fed children of the poor, I have found it exceedingly useful.

PREPARATIONS AND DOSE.—*Plumbi acetas:* dose, 1 to 4 gr. *Pilula plumbi cum opio:* dose, 4 to 8 gr. (1 gr. of opium and 6 gr. of lead acetate in 8 gr. of the pill mass); *suppositoria plumbi composita* (1 gr. of opium and 3 gr. of acetate in each); *plumbi iodidum:* dose, ¼ to 1 gr. The following are for external use only: *Plumbi oxidum; emplastrum plumbi* (diachylon); *emplastrum plumbi iodidi; unguentum plumbi acetatis* (12 gr. of acetate of lead in 1 oz. of benzoated lard; a good ointment is also made by using

vaseline instead); *unguentum glycerini plumbi subacetatis* (contains 4½ oz. of glycerinum plumbi subacetatis in 24 oz. of a mixture of hard and soft paraffin); *liquor plumbi subacetatis* (Goulard extract); *liquor plumbi subacetatis dilutus* (Goulard water); *glycerinum plumbi subacetatis; plumbi carbonas; unguentum plumbi carbonatis; unguentum plumbi iodidi; plumbi nitras.* The following plasters also contain lead: *Emplastra belladonnæ, saponis, calefaciens, plumbi, plumbi iodidi, saponis fuscum, ferri, galbani, hydrargyri, opii, resinæ.*

PLATINUM (Pt = 196).

This heavy whitish metal is official in the form of "foil," which is used in the analysis by heat of salts of organic acids, etc.

PERCHLORIDE OF PLATINUM SOLUTION ($PtCl_4$).

PREPARATION.—By dissolving the foil in nitro-hydrochloric acid and diluting. It is used as a test to distinguish potassium from sodium and to precipitate ammonium salts.

PHYSIOLOGICAL ACTION. — According to Dr. Lauder Brunton, soluble salts of platinum given to frogs paralyse the cerebral centres for voluntary motion, but irritate the intermediate motor centres between the brain and cord, so that although voluntary motion is diminished, reflex convulsions still occur.

In mammals the peripheral ends of vaso-motor nerves are paralysed, causing diarrhœa with hyperæmia and hæmorrhage from the mucous membranes and abdominal viscera. The excitability of the heart muscle is not affected—that of voluntary muscle is lessened.

PLATINUM BLACK.

PREPARATION AND CHARACTERS.—By adding excess of carbonate of soda and some sugar to solution of the perchloride and boiling till the metal is reduced and precipitated in the form of fine black powder which is washed and dried. This has great power of condensing gases, especially oxygen; it is used as a test for amylic alcohol, which it oxidises into valerianic acid.

POTASSIUM—KALIUM (K = 39) (*non-off.*).

This metal has not been found native, but its compounds are very widely diffused. The nitrate occurs in various soils and the chloride in mines, the tartrate in the juice of the grape and

other fruits, and carbonate and chloride are found in the ashes of all woods and plants; chloride of potassium abounds especially in the seeds of leguminosæ. From vegetables this salt passes into the animal organism, and hence the milk and the urine of herbivora contain much more of it than the same secretions of carnivora; the blood corpuscles and the contractile substance of muscle contain a comparatively large proportion of it.

CHARACTERS.—The metal itself is soft and silvery-white, so light (its specific gravity being ·865) that it floats on water, and with such affinity for oxygen that it decomposes water, thus setting free hydrogen which ignites and burns with a violet purple flame, characteristic of the presence of potassium. Some liquid devoid of oxygen—like benzene—is therefore required in which to keep the metal; if exposed to the air it rapidly oxidises to potash.

COMPOUNDS OF POTASH.

Potassii iodidum (*v.* p. 81). *Potassii bromidum* (*v.* p. 139).

LIQUOR POTASSÆ—SOLUTION OF POTASH.

PREPARATION.—It is obtained by adding slaked lime to a boiling solution of about twice its weight of carbonate of potassium; carbonate of calcium subsides, and the clear solution of potash is transferred by means of a syphon to a bottle, which should be of green glass.

$$K_2CO_3 + CaH_2O_2 = 2KHO + CaCO_3.$$

(The solution would corrode wool or other organic filters, and would dissolve the lead in white glass.)

CHARACTERS AND TESTS.—A colourless liquid of acrid taste and strongly alkaline reaction; its specific gravity is 1·058; it contains nearly 6 per cent. of caustic potash, or 27 gr. in the fl. oz.; it feels soapy when rubbed between the fingers on account of its solvent action on the cuticle; it corrodes animal and vegetable substances, and forms soluble soaps with oily and fatty bodies. It is liable to contain carbonate of potassium, lime, sulphates, chlorides and alumina. The best general test for potash salts in solution is perchloride of platinum, which precipitates a yellow double chloride; they communicate a purple colour to a Bunsen or spirit-lamp flame.

POTASSA CAUSTICA—CAUSTIC POTASH—HYDRATE OF POTASH—POTASSIC HYDRATE (KHO = 56).

PREPARATION.—It is prepared by rapidly evaporating the *liquor* to dryness in a clean silver or iron vessel, then fusing and pouring into suitable moulds.

CHARACTERS AND TESTS.—It occurs in hard pencils, which should be white, but which are often bluish in colour; of peculiar odour, and acrid taste. It has a strong affinity for water and carbonic acid, and readily deliquesces if exposed to the air: is soluble also in alcohol. Heat is evolved during its solution in water.

POTASSII CARBONAS—CARBONATE OF POTASSIUM ($K_2CO_3 = 138$).

PREPARATION. — It is prepared from the ashes of plants which consist of a soluble carbonate and insoluble salts of calcium, silicon, etc. The carbonate is dissolved out by frequent washing with water, which is then evaporated, and the residue fused to a brown stony mass—the crude potashes of commerce (black potash). This is purified by calcination in a furnace, the dull white residue being termed "pearl-ash," and this again is further purified by dissolving it in its own weight of water, filtering and evaporating to dryness while it is kept briskly agitated. The carbonate may also be obtained by heating the bicarbonate to redness.

CHARACTERS AND TESTS.—It occurs in small white opaque crystalline grains, having a strong alkaline taste and reaction; it is distinguished from the bicarbonate and from sodium salts by its great affinity for water, for on exposure it soon deliquesces into a thick liquid.

POTASSII BICARBONAS—BICARBONATE OF POTASSIUM ($KHCO_3 = 100$).

PREPARATION.—It is prepared by passing carbonic acid gas through a strong solution of carbonate of potassium; the stream of gas should be disengaged slowly but continuously for a week: crystals of bicarbonate are gradually deposited.

$$K_2CO_3 + H_2O + CO_2 = 2KHCO_3.$$

CHARACTERS AND TESTS.—These crystals are large, transparent, colourless, rhombic prisms, which are not deliquescent and not caustic: they are soluble in four parts of cold,

and less than their own weight of boiling water, insoluble in alcohol: alkaline to test paper.

POTASSII ACETAS—ACETATE OF POTASSIUM

($KC_2H_3O_2 = 98$).

PREPARATION.—It is prepared by neutralising acetic acid with carbonate of potassium; the acetic takes the place of carbonic acid, which is liberated with effervescence.

$$K_2CO_3 + 2HC_2H_3O_2 = 2KC_2H_3O_2 + H_2O + CO_2.$$

The liquid is evaporated, and the salt dried, melted, and crystallised.

CHARACTERS AND TESTS.—It occurs in long masses of white, smooth, glistening crystals, which are soft, fibrous in texture and unctuous to the touch: neutral in reaction, very deliquescent, and soluble in alcohol as well as in water.

POTASSII CITRAS—CITRATE OF POTASSIUM ($K_3C_6H_5O_7 = 306$).

PREPARATION.—It is obtained by neutralising carbonate of potassium with citric acid; a reaction similar to the last-mentioned occurs.

$$3K_2CO_3 + 2H_3C_6H_5O_7 = 2K_3C_6H_5O_7 + 3H_2O + 3CO_2.$$

CHARACTERS AND TESTS.—Citrate of potash is a white, granular, crystalline powder, deliquescent, soluble in water, insoluble in alcohol. It is charred by hot sulphuric acid, and its solution gives a precipitate with chloride of calcium only when boiled—a test which distinguishes it from tartrate of potassium.

POTASSII TARTRAS—TARTRATE OF POTASSIUM

($K_2C_4H_4O_6H_2O = 244$).

PREPARATION.—It is obtained by boiling the acid tartrate with carbonate of potassium and water, when an atom of hydrogen in the acid salt is replaced by one of potassium, and carbonic acid given off.

$$2KHC_4H_4O_6 + K_2CO_3 = 2K_2C_4H_4O_6 + H_2O + CO_2.$$

The liquid is then concentrated to crystallisation.

CHARACTERS.—It occurs in small granular crystals, deliquescent, soluble, neutral in reaction, and somewhat bitter in taste.

POTASSII TARTRAS ACIDA—ACID TARTRATE OF POTASSIUM —CREAM OF TARTAR ($KHC_4H_4O_6 = 188$).

PREPARATION.—Grape juice contains a large quantity of this salt

in solution. When the grape sugar is converted into alcohol by fermentation. the acid tartrate is gradually deposited inside the wine casks, and is known as "crude tartar," or "argol," and this, when purified by recrystallisation, constitutes "cream of tartar," a name originally given to the fine crystals which were "skimmed off" the evaporating liquid.

CHARACTERS AND TESTS.—It occurs as a gritty white powder, or in fragments of cakes. It is distinguished from the neutral tartrate by its very sparing solubility in water, viz., 1 in 180 parts: in spirit it is insoluble, like other tartrates. It chars on exposure to heat, giving off inflammable gas and an odour of burnt sugar.

POTASSII SULPHAS—SULPHATE OF POTASSIUM ($K_2SO_4 = 174$).

PREPARATION.—There is no process directed in the Pharmacopœia, but the salt may be prepared from the residue left in the manufacture of nitric acid, this residue being an impure acid sulphate which is converted into the neutral salt by treatment with lime, and afterwards with carbonate of potassium and sulphuric acid.

CHARACTERS AND TESTS.—A very hard crystalline salt, sparingly soluble in cold water; it decrepitates on heating, and has a bitter rather nauseous taste.

POTASSA SULPHURATA—SULPHURATED POTASH (HEPAR SULPHURIS).

PREPARATION.—By fusing together carbonate of potassium and sublimed sulphur.

CHARACTERS AND TESTS.—From its liver colour when fresh it was formerly called "liver of sulphur," but it rapidly absorbs oxygen from the air and becomes green and ultimately dull white, sulphate of potassium being formed. It evolves sulphuretted hydrogen on the addition of any acid.

POTASSII NITRAS—NITRATE OF POTASSIUM—NITRE—SALTPETRE ($KNO_3 = 101$).

PREPARATION.—Nitrates occur naturally in many waters, soils and plants, but are mainly obtained either from certain soils in India by solution in water, or from artificial "nitre beds," *i.e.*, heaps of manure and vegetable refuse, wood ashes and calcareous earth, which are exposed to the action of air and sun. The nitrogen of the organic matter is slowly oxidised

into nitric acid, which combines with the bases present (potash, etc.), and the nitrates so formed are removed by washing. The agents chiefly concerned in this process of "nitrification" are bacteria.

CHARACTERS AND TESTS.—It occurs in white crystalline fragments, or in striated, long, six-sided prisms which are transparent. It is soluble in water and has a cooling taste; at a red heat it deflagrates. When fused and cast into round moulds it is known as "sal prunelle"; abroad, these are often coloured purple (like a plum: *prunelle*—a *sloe*).

POTASSII CHLORAS—CHLORATE OF POTASSIUM ($KClO_3 = 122{\cdot}5$).

PREPARATION.—By passing chlorine gas through a mixture of potassium carbonate and excess of slaked lime; chlorinated lime and chlorinated potash are first formed, and the latter is then converted into chlorate of potash on boiling; but the reaction may be simply expressed thus—

$$6Cl_2 + K_2CO_3 + 6Ca(HO)_2 = 2KClO_3 + CaCO_3 + 5CaCl_2 + 6H_2O.$$

CHARACTERS AND TESTS.—Chlorate of potash occurs in pearly-white, hard, crystalline plates which are slightly soluble in water and have a cooling taste. Rubbed with sulphur, or phosphorus, tannic acid, or catechu, etc., the salt explodes; treated with sulphuric acid it becomes red, and gives off vapours of chlorine peroxide.

POTASSII PERMANGANAS—PERMANGANATE OF POTASSIUM ($KMnO_4 = 158$).

PREPARATION.—The principal steps of the process are—(1) to prepare manganate of potassium (K_2MnO_4); (2) to convert this into permanganate ($KMnO_4$) by boiling. Black oxide of manganese, caustic potash and potassic chlorate are fused together, and a dark-green mass of manganate of potash obtained.

$$3MnO_2 + 6KHO + KClO_3 = 3K_2MnO_4 + KCl + 3H_2O.$$

This manganate when boiled, filtered and saturated with carbonic acid yields a purple solution of the permanganate.

$$3K_2MnO_4 + 2H_2O = 2KMnO_4 + 4KHO + MnO_2.$$

The green manganate when turning into the purple permanganate undergoes several changes of colour, and hence has received the name, "mineral chameleon": finally the solution is evaporated and the crystals purified.

CHARACTERS AND TESTS.—It occurs in dark-purple acicular crystals, one of which will impart its colour to a large quantity of water. It yields up most of its oxygen (five-eighths)

very readily; and if only a little spirit be boiled with its solution, it changes to yellowish-brown on account of its reduction to the state of peroxide. A similar brown stain is left on the hands when washed in it, on account of its oxidation from contact with organic substance. In distilled water the purple colour may remain two years without change. (Manganese stains are removed by oxalic acid—"salts of lemon.")

POTASSII BICHROMAS—BICHROMATE OF POTASSIUM ($K_2Cr_2O_7 = 295$).

PREPARATION.—It is prepared by roasting chrome iron-ore with a mixture of carbonate of potassium and chalk; yellow chromate of potash is formed, and yields the red bichromate when treated with sulphuric acid.

CHARACTERS AND TESTS.—It occurs in large, red, transparent, four-sided tables, soluble in ten times their weight of water. The solution readily gives up part of its oxygen, and when acidified with sulphuric acid, turns green from reduction of the chromic acid and formation of the sulphate of chromium.

POTASSII CYANIDUM—CYANIDE OF POTASSIUM (KCN = 65).

PREPARATION.—It is obtained by heating the ferrocyanide of potassium at a red heat till gas is no longer evolved, allowing the sediment to settle in the still molten mass and pouring off the clear fluid. It may be purified if necessary, by solution in and recrystallisation from spirit.

CHARACTERS AND TESTS.—It occurs in white, opaque, deliquescent crystalline masses, which have the odour of prussic acid, and are soluble in water and in spirit. The aqueous solution has an alkaline reaction.

POTASSII FERROCYANIDUM—FERROCYANIDE OF POTASSIUM ($K_4FeC_6N_63H_2O = 422$).

CHARACTERS AND TESTS.—It occurs in large, yellow crystals, permanent in the air, soluble in water, insoluble in alcohol. It is used in the preparation of dilute hydrocyanic acid and of potassium cyanide, and forms a test solution for ferric salts.

Ferricyanide of Potassium ($K_6Fe_2C_{12}N_{12}$) is included in the appendix to the B. P. as a test for ferrous salts.

ABSORPTION AND ELIMINATION. — *Liquor potassæ* taken on an empty stomach, is quickly absorbed; it then combines probably, with carbonic acid in the blood and is eliminated by the kidneys, mainly in combination with sulphuric acid (Parkes, Med.-Chir. Rev., 1853). When taken with food, or in very small doses at any time, it forms with the gastric acid a chloride, and as such is absorbed.

The *carbonates* when taken in small doses, are absorbed as chlorides; of large doses, the greater part passes out by the kidneys unchanged: a single large dose (2 dr.) is eliminated more quickly than the same amount given in divided doses (Thompson, Med.-Chir. Rev., ii., 1864). The *acetate*, *citrate* and *tartrate* are reduced in the system to carbonate, and eliminated as such. The *chloride*, *chlorate* and *nitrate* are absorbed very rapidly, and have been detected in the urine, the saliva, etc., within five minutes after being taken.

Much interest attaches to the chemical changes which the *chlorate* undergoes in the system; it was believed to become a chloride, parting with its oxygen to the blood and tissues (Fourcroy), and even the proportion of oxygen furnished was calculated (Garnett). Gubler and some other modern observers also think it possible that a partial reduction of the salt may occur within the body, but it is difficult to reconcile this with the chemical fact of its being found *unchanged* in the urine passed after its administration (Wöhler, 1824), as also in the saliva, milk, tears, bronchial mucus, etc. (Isambert). Rabuteau, taking himself small doses, also found the drug *unchanged* in the secretions, and of one large dose of 5 grammes, recovered 4·873 grammes from the urine within thirty-six hours (Gaz. Méd. de Paris, 1868). Hence it seems improbable that the chlorate should decompose and give up oxygen at the temperature of the body, and yet there is some clinical evidence of its improving oxygenation in whatever mode this may be effected (*v.* pp. 810-814). Dr. H. Leffmann has shown the improbability of the theory of *direct* oxygenation by means of potassium chlorate, pointing out that although it yields oxygen in the laboratory at a red heat, yet at the temperature of the body in contact with artificial gastric juice it does not yield oxygen

sufficient to combine with 1·50 gr. of phosphorus (Pract., ii., 1884). Potassium permanganate also, which is a good oxidising agent outside the body, is of no avail for that purpose after being swallowed, as it is decomposed and reduced to oxide the moment it comes in contact with the organic substances in the mouth.

When *nitrate* of potassium has been taken in large doses (270 gr. in twenty-four hours) the greater part has been found unchanged in the urine—the rest probably passing as sulphate by the intestines (Taylor, Guy's Reports, 1863); that a certain amount of potassium salt passes off in this manner has been shown by Kramer (Annales d'Hygiène, i., 1843).

PHYSIOLOGICAL ACTION.—*External.*—Caustic potash locally applied, has a marked destructive effect. It forms a soft eschar by dissolving albumen, saponifying fats, and splitting up salts. Weaker solutions are simply irritant, but communicate to the skin a greasy saponaceous feeling from their action on the fatty secretions. The carbonate is much less active, but is also markedly irritant in strong solution. In the bicarbonate, the irritant action has become completely neutralised.

PHYSIOLOGICAL ACTION.—*Internal.*—*The sulphate and acid tartrate* if given in small doses, are absorbed from the bowel, and excreted from the blood by the kidneys. In larger doses they act as purgatives, and probably only very minute quantities are then absorbed; they are less diffusible and less easily absorbed than the other salts.

Oxidation and Nutrition.—How far alkalies as such, contribute to oxidation, has long been a question of interest, and it is one of great practical importance. Organic substances, such as bile and hæmoglobin, when exposed to air outside the body, certainly oxidise more quickly when in contact with potash (Chevreul, 1825); olein again, is not acted on by ozone alone, but if potash be added, oxidation sets in at once.

Physiological chemists did not fail to trace a similar action within the body. Lehmann and Mialhe taught that alkalies were powerful promoters of systemic oxidation, and augmented the excretion of urea and carbonic acid. Liebig fully adopted the same view, teaching that they promoted the combustion of what he termed "respiratory foods," and pointing out that if organic acids (gallic, citric, etc.) were taken alone they passed off

almost wholly unchanged, but if in combination with alkalies, *e.g.*, as citrate of potassium, the acid was "burnt off" in the system, and the alkali passed as a carbonate.

Bence Jones concluded that alkalies, though they could not themselves give up oxygen, decidedly assisted oxidation of organic substances within the body by promoting the formation of acids (Lectures, and Lancet, i., 1867), and Parkes found, in a series of analyses, that the organic material and sulphuric acid excreted in the urine were markedly increased under the use of liquor potassæ, which acted, he considered, by increasing the oxidation of albuminous tissues; for this effect it had to be given at least eight hours after food (Med.-Chir. Rev., 1853). Similar results did not follow the use of acetate or nitrate of potassium in Parkes's experiments, but Dr. Golding Bird reported a considerable increase of urea and other urinary solids in the case of a dog submitted to the action of 3 dr. of the acetate (On Urinary Deposits). Dr. Reginald Thompson proved by several series of observations that the amount of phosphoric acid in the urine was increased by the administration of carbonate of potassium (Med.-Chir. Rev., ii., 1864).

On the other hand, Rabuteau recorded different results obtained on himself, on Constant (of Smyrna), and on a third person (a woman). Each took 5 to 6 grammes of bicarbonate of sodium or potassium for five to ten days: the full dose of bicarbonate of potassium produced a slight diuretic effect, but 5 grammes none at all; urea was markedly and progressively *diminished*, and depression and anæmia were induced. Analogous results were obtained by Ritter of Nancy.

The explanation of contradictory results obtained by different observers turns largely upon the question of dosage, as with many other medicines. Large quantities like those last referred to will pass out unchanged and quickly, and in their passage so far deteriorate the conditions of the blood and impair the function of the alimentary tract, as to induce asthenia and diminish nutrition; (Dr. Ringer regards potassium as a protoplasmic poison); evidently Dr. Parkes's supposition that increasing the dose of potash will proportionately increase oxidation cannot be sustained. Small doses, on the other hand, not only help to saponify fatty food, but aid its oxidation and that of

carbonaceous material generally, improve the digestion and raise the temperature.

Rabuteau himself confirms these statements, and explains such effects of small doses by their change into *chloride* in the stomach, and their acting as chlorides rather than as alkalies; under the influence of 5 gramme doses of chloride of potassium, he found the excretion of urea increased by 20 per cent.

That potassium salts are essential for the development of the animal tissues is shown by the fact, that food which in itself is not sufficiently nutritious, such as over-stewed meat, recovers its properties on the addition of these salts and of a little sodium chloride (Binz), whilst the absence of potash salts seems to be at least one cause of scurvy (Garrod). If on the other hand we give meat broth, which is very rich in potash salts, without adding any other nutrient, tissue-change becomes so accelerated that animals thus fed die earlier than others kept without food.

Circulatory System.—A certain amount of potassium salt is essential, as we have seen, for the proper constitution and action of the corpuscles, and the chloride seems to be the best suited for this purpose (Rabuteau); but the prolonged use of the remedy in any combination has an unfavourable effect. Loffler has reported the results in five of his students who took doses of from 1 to 5 dr. of alkaline carbonates for several days, and then allowed blood to be taken from a vein. It was found to be like "cherry juice" in colour and density, the red corpuscles were paler and the white ones more numerous than normal; there was excess of water and of fatty material, and the clot was less firm and elastic than it ought to be (Schmidt's Jahrb., 1848). A curious illustration of the diminished coagulating power of the blood under the influence of nitrate of potash is furnished by Dr. Stevens, who had occasion to bleed a man who had lately taken an ounce of that salt, and was surprised to find the venous blood red and not at all coagulable (Lancet, ii., 1862, quoted by Dr. Basham). In animals after injection of nitrate the result is similar (Rabuteau).

Martin Solon, having analysed blood drawn from the vein of a robust man suffering from acute rheumatism and treated by nitre, found the fibrin diminished, though the inflammatory process was still at its height; ten days afterwards when the remedy

was no longer being taken, the blood-clot was dense and buffed (Bull. de Thérap., 1843). That the drug cannot, however, be depended upon for antagonising the effects of disease, is shown by the fact of fibrinous deposits having been found on the valves of the heart in patients dying during its free administration (Med. Times, i., 1863).

Both this salt and the chlorate have the power of rendering venous blood bright red, and much stress was laid upon this change by the early advocates of the direct oxygenation theory (Stevens, O'Shaughnessy, Lancet, ii., 1831), but Isambert after making fresh experiments asserts that their statements on this point are incorrect (Gaz. Med., 1874), and although the change does occur it varies with physical conditions and is dependent rather on altered osmosis than on difference in oxygenation.

Several cases of poisoning by potassium chlorate have been recorded (Berlin. klin. Wochenschrift, Med. Times, and Deut. med. Woch., 1883). The symptoms are those of irritant poisoning—choleraic in character—usually with either suppression of urine or the presence of hæmoglobin or methæmoglobin in the urine. Considerable light has been thrown on these cases by the researches of Dr. J. von Mering who finds that the chlorate is decomposed in the system with the formation of chloric acid, by the action of carbonic acid upon it. In acute cases of poisoning, death results from the conversion of hæmoglobin into methæmoglobin in the blood by the chloric acid; in sub-acute cases, the products of the decomposition of the blood produce occlusion of the renal tubules and death from uræmia. The viscera contain brown masses of altered corpuscles. D'Espine has even argued that the phenomena known as uræmia are really due to accumulation of potash in the blood and its non-elimination by the urine, and he supports this view by analyses in two cases of eclampsia (Record, 1884). An instructive case has been recently reported in which a man who received nearly one ounce of chlorate for use as a gargle, drank the whole dissolved in hot water. In half an hour he became faint and thirsty, vomited, and next day had headache and jaundice; the urine was very scanty and albuminous with sediment of altered blood corpuscles; blood from the finger also showed altered discs; death occurred six days afterwards, suppression of urine continuing; lesions were

found in the intestinal tract, liver, spleen and kidney, dependent mainly on excessive blood destruction (Landerer, quoted by Shoemaker).

Small doses of the potassium salts (excepting the permanganate) cause a fall in the pulse-rate and in the arterial pressure, probably through the vaso-motor nerves; this effect is usually only temporary, and is followed by a rise of both. *Full* doses lower both pulse-rate and blood-pressure; the lowered pressure may or may not be followed by a rise according to the dose employed. Parkes found a full dose of *liquor potassæ* render the pulse small and slow, but a copious secretion of urine explained this effect. Under the *nitrate* the frequency of the pulse came down in a few days from 76 to 64 (Rabuteau), and the *chlorate*, according to Socquet, has a similar sedative action. Some observers report a *quickened* circulation, especially after venous injection of chlorate (Gubler); Jacobi speaks of this salt congesting the kidney (Med. Times, i., 1876), and Osborn of its congesting the brain (Lancet, ii., 1859); but such effects must be exceptional. The observations of Black (1839), and of Bouchardat (1844), and the experiments of Podcopæw (Virchow's Archiv, Bd. xxxiii.), of Guttman, Aubert, Dehn and others agree in assigning to potash salts a distinctively *depressing* effect on the heart-action. Their injection in frogs quickly lessens the force of the blood-current, and finally arrests the heart in diastole; 10 gr. of chloride injected into the jugular vein of the smaller animals cause instant cardiac death, and since the heart-muscle in such cases is found insensitive to electricity (Traube), and since previous section of the vagi has no influence on the result, we conclude that the cardiac arrest is due to a direct paralysis of the muscular substance. This paralysis is commonly preceded by increased activity, but finally it becomes complete, so that the heart-muscle ceases to react to any ordinary stimulus. If, however, the potassium chloride be introduced *gradually* into the system through the stomach, then cardiac contractility is not entirely destroyed by it. Drs. Ringer and Sainsbury in comparing the effect of salts of potassium, sodium and ammonium on the frog's heart, found that the potassium salts are the most poisonous, both as regards excitability and contractility (Lancet, i., 1882). Dr. Ringer has also found that the addition

of a small quantity of a potassium salt is necessary in order to make an artificial saline circulating fluid for keeping the heart going after its removal from the body. Sodium and calcium salts must also be present in such a fluid (Pract., ii., 1883).

The bitartrate of potassium has some power of arresting hæmorrhage, especially from the kidney (Ramskill and others, Ranking, i., 1867); it possibly lessens congestion by diuresis or purgation. Albuminuria has occurred under the influence of the nitrate.

Nervo-muscular System.—Large doses of potassium salts lower the reflex irritability of certain parts of the spinal cord (Binz), but many observers consider this to be only secondary to depression of the circulation; the fall of temperature induced is attributed to the same cause. In warm-blooded animals motor power is weakened, probably from a direct alteration in the *chemical* constitution of muscular elements; the *electrical* reactions are however unchanged. On the other hand, Dr. Ramskill finds baths of *sulphuret* of potassium to be the most effective stimulant to muscular action during such diseases as wasting palsy (Med. Times, ii., 1860); this however is probably the stimulating action on the skin acting reflexly on the nervous centres. Petrone applied potash salts to exposed intestine and found them excite peristaltic movements upwards and downwards (Record, 1883). In healthy men a sense of weight and fatigue is often felt in the limbs after absorption of the more easily diffusible salts, as the nitrate, oxalate, chloride, iodide or bromide; local anæsthesia of various parts of the body has been described as a result of drachm doses of the bicarbonate (B. M. J., ii., 1876). There seems, however, to be some idiosyncrasy with regard to such effects, and although full doses usually depress the nervous functions, Dr. Prout refers to pronounced nervous excitement and even convulsions in some cases, as connected with an excess of alkali, and the chlorate of potassium is said to have caused headache and cerebral congestion (*v.* p. 795). Isambert considered it a nervine sedative, but "this action was not evident in healthy persons" (Med. Times, ii., 1856). Rabuteau finds the "perchlorate" to produce giddiness and other symptoms like those of quinine. Liquor potassæ has been used to quiet the spasms of tetanus (Lancet, i., 1861). Dr. Thompson

traces the nervous depression commonly caused by alkalies to an increased excretion of phosphoric acid under their use (*v.* p. 792).

Death produced by large doses in animals is preceded by convulsions, and is caused by stoppage of the heart (the animal can however be restored by the use of artificial respiration and mechanical irritations of the heart); the nerve-centres are also paralysed, but when on recovery reflex irritability returns, it is found to be much exaggerated.

Glandular System—Mucous Membranes.—Dilute alkaline solutions taken into the stomach *before* meals augment the secretion of gastric juice (Blondlot, C. Bernard), for if digestion is to continue, fresh secretion must occur to compensate for what is neutralised; also the chlorides that are formed augment the secretion (Rabuteau). But alkalies given in too large or too concentrated a dose, arrest the secretion, and if given soon *after* a meal, neutralise the acid which has been already formed. Dr. Ringer formulates a general proposition thus: "Alkalies applied to the orifices of glands with acid secretions increase their secreting power, while alkalies applied in a corresponding way to glands with alkaline secretion lessen or check this secretion;" and I think that, as a general rule, and with due regard to the strength of solution, this may be held true.

The increased secretion of saliva caused by direct application of alkalies is thick, whitish and cloudy; it is not large in amount, and there is some doubt as to whether it is true secretion or (as Kühne thinks) the result of a rapid degeneration of the gland. A similar fluid results from irritation of the sympathetic nerves of the submaxillary gland, and hence the alkali has been thought to act through the sympathetic. The chlorate of potassium sometimes acts so as to produce a degree of salivation.

Under the influence of alkalies taken internally, the bile and pancreatic juice are rendered more fluid, and thereby increased in amount. The bronchial secretions are also increased and fluidified by alkalies, and the movements of cilia are rendered more active by them.

Secretion from the intestinal glands is augmented, especially by full doses of the potassium salts of mineral acids: 2 or 3 dr. of the sulphate cause watery purging; larger quantities sometimes irritate much: ½ oz. doses have been used in France as aborti-

facient with serious effects (Mowbray), and 2 oz. have caused death (Taylor).

The nitrate in small doses is absorbed and produces some constipation, but in full doses and well diluted, causes diarrhœa (Martin Solon, 1843). Orfila reported violent irritation of the mucous membrane from its use, and an ounce has caused death with irritant symptoms and depression, though this is exceptional. The experiments of Rognetta indicated only a moderate degree of congestion—no inflammation ; and ounce doses, when well diluted, have been given medicinally without serious result.

The chlorate may also irritate mucous membranes, and in large doses has sometimes, though rarely, caused death through this effect, *e.g.*, in a patient with phthisis, who took 300 gr. daily for four days, and in the case of Dr. Fountain, who unfortunately took an ounce in order to prove his conviction of its innocent character (Stillé) ; 1 dr. every two hours until 2 oz. were taken, proved fatal with choleraic symptoms.

The bichromate in small doses increases all the secretions, and in large doses acts as an irritant poison, causing vomiting, purging and collapse, with suppression of urine.

The urine is often markedly increased in quantity by liquor potassæ (Parkes), by the bicarbonate and the chlorate, but still more by the bitartrate, nitrate, acetate, and citrate ; the increase is not always decided, unless the urine is rendered alkaline. There is a marked difference in different compounds as to their production of alkalinity : thus, a single dose of 40 gr. of acetate alkalinised the urine in a few hours, and then was not all changed, but of the bicarbonate several drachm doses were required. In febrile diseases, salines, such as nitrate of potash, may cause at first marked lessening of excretion, afterwards increase (Parkes, Med. Times, i., 1855). In cases of irritant poisoning by the potassium salts of the mineral acids, suppression of urine has occurred, probably reflex in character.

The observations of Sir Wm. Roberts with serous solutions of uric acid, showed that whilst soda salts hastened its precipitation, those of potassium sensibly retarded it, and the carbonate and phosphate, which are alkaline, produced the same effects as the chloride, iodide and bromide, which are neutral, the results being

entirely dominated by the nature and quantity of the base, not by the combined acid radicle (B. M. J., ii., 1892).

SYNERGISTS AND ANTAGONISTS.—The other alkalies are allied in chemical action to the salts of potassium, and acids are the chemical antagonists of those which are alkaline. Drs. Lauder Brunton and Cash found that by feeding animals with potassium salts the poisonous action of barium might be lessened. Dr. Ringer showed that the prolongation of the cardiac diastole, produced in frogs by calcium salts or by veratrine, can be prevented by potassium salts (Pract., i., 1883).

THERAPEUTICAL ACTION.—*External.*—Caustic potash has been used in surgery for the same purpose as other powerful caustics, and has the special characteristics of being deliquescent, and of dissolving and deeply penetrating the tissues; parts near the seat of its application should therefore be protected by plaster or by oil, and the cauterised place should be sponged with dilute vinegar to prevent undue action. The slough caused by it is leathery, soft, dark-coloured and moist, not dry like that of nitrate of silver; it separates after a variable time, according to its thickness.

Issues—Abscess—Bubo, etc.—For the purpose of making an issue, or of opening a large collection of matter, such as a chronic or "cold" abscess, caustic potash was formerly often, and for the latter purpose is still occasionally, used. Macnamara found better results from it than from the knife in opening bubo (Ranking, i., 1872), and others recommend it in carbuncle. It causes pain but no hæmorrhage, and makes a free opening for the escape of the slough, but antiseptic surgery has practically abolished this treatment.

Caries—Necrosis, etc.—Caustic potash and concentrated solutions of the carbonate have been recommended in these conditions, but sulphuric acid and other substances are to be preferred (Med. Times, ii., 1860; Lancet, i., 1870).

Varix—Nævus.—Caustic potash is said to have the power of obliterating the trunk of a varicose vein (Bonnet), and also of destroying superficial nævi (Wardrop); but the application is painful, and is apt to leave a very evident cicatrix. Powdered nitrate of potassium kept in contact with the nævus, has given a better result in slight cases. Half an ounce of a saturated solution of

the chlorate with a little opium, is a good injection in painful hæmorrhoids.

In **Hospital Gangrene,** the part may be first dressed with the solid caustic, and afterwards with a lotion containing it in gradually diminishing proportion—400 cases are said to have been treated successfully by this means (Restelle, Brit. For. Rev., 1850).

Strumous Ulceration.—In strumous ulceration of a superficial indolent character, with livid undermined edges, and affecting extensive surfaces on the trunk or extremities, caustic potash lightly applied to the margin often stimulates to satisfactory healing.

Lupus.—For cases of ulcerative lupus in which the strumous character is most marked, caustic potash is sometimes a good agent; we do not apply it generally for lupus about the face, because of the unsightly cicatrix which is apt to follow its use, but in Vienna it is in frequent request, and is found to succeed when other remedies have failed. Dr. Robert Liveing recommends it with an equal part of water, and this is a very usual application for lupus exedens even of the face, and has given me excellent results.

Epithelioma.—The disadvantage of the deliquescent character of potash may be obviated, and its efficacy rather increased by combination with caustic lime, two parts of the latter to one of the former constituting "Vienna Paste"; it should be kept dry, and moistened only with a little spirit as required. Epithelioma affecting the lip has been sometimes cured by successive applications of this caustic, but it is painful and tedious. The *chlorate*, given internally and applied locally, has also been said to arrest and cure epithelioma, and certain Paris surgeons especially have reported well of the local use of concentrated solutions. I have observed several cases treated in this manner, but without substantial benefit.

Uterine Ulceration.—Pure caustic potash has been applied to ulcerations and hyperplasiæ of the cervix uteri, and although disastrous results such as contraction and cicatrix have occasionally followed, it may be of decided service in skilled hands, not only for irregular ulcerative conditions, but also in chronic cervicitis with induration (areolar hyperplasia); in such cases it may be applied about every ten days for several times, and free

injections of vinegar and water should be used afterwards. Dr. Henry Bennet recommended it or the lime compound "as a last resource," and the Vienna paste is sometimes serviceable. French surgeons use the same remedy, with an additional quantity of lime, carefully prepared in lead or iron tubes (caustic of Filhos, of Robiquet). Dr. Herbert Snow has brought forward illustrations of its value, but the balance of opinion on discussion was rather against it (B. M. J., i., 1885).

Primary Syphilitic Ulcers, Warts, etc., have been sometimes destroyed by caustic potash. The bichromate is very useful for this purpose.

Urethral Stricture has been treated by the application of caustic potash to the affected part, and in some cases of cartilaginous hardness and of unusual irritability, it apparently proved useful—with due precautions—but the majority of modern surgeons rightly, I think, object to any direct caustic application in such cases.

Leucorrhœa—Gonorrhœa.—In the former affection, when the discharge is profuse and strongly alkaline and either transparent or white, coming probably from the glands of the cervix uteri, a weak alkaline injection (1 dr. of bicarbonate to the pint) thoroughly applied will often relieve; but injections of chlorate (2 dr. to the pint) act better, especially if the discharge be at all purulent (Amer. Med.-Chir. Rev., Nov., 1858). The permanganate should be used if there be a disagreeable odour.

In gonorrhœa, injections of the permanganate (1 to 5 gr. to the ounce) have been highly praised, especially in the second stage (Med. Times, ii., 1862; Lancet, i., 1883). In many cases they certainly act well, but care should be taken to begin with a weak solution, for I have known pain and irritation produced by such injections. The scalding and burning pain in micturition may also be much relieved by the bicarbonate, or perhaps better by the acetate and nitrate given *internally* with mucilage; it is said even that the attack may be cured by them (Lancet, ii., 1850). In chronic cystitis with fœtid urine, injections containing chloride (4 gr. to 1 oz.) are recommended by Dr. Braxton Hicks and by Dr. Shoemaker. Dr. Boegorold recommends internally $\frac{1}{2}$ dr. of potassium chlorate every two hours in this affection; it soon renders the urine acid (Pract., i., 1884).

In-growing Nail, etc.—This troublesome affection may be well treated by means of dilute liquor potassæ (2 dr. to the ounce of water) constantly applied on lint, between the nail and the soft tissues, so as to thin the nail and render it flexible, when it can be rubbed or pared away (Norton, Lancet, i., 1869).

Unhealthy Wounds.—Several compounds of potash have valuable disinfectant and also alterative properties, especially the permanganate and the chlorate, and when used in the form of lotion prove of the greatest service in removing fœtor and promoting healthy action. For the *bites of rabid animals* its penetrating and alkaline powers render liquor potassæ valuable; in *snake bite* especially it should be applied locally. If solution of permanganate of potassium can be applied locally to snake bites before the poison has had time to be absorbed it destroys the virulence of the poison and acts as a very efficient local antidote (*v.* p. 814); a lotion containing 5 gr. of chlorate to the ounce is good in burns, especially in the second stage (Brown, B. M. J., ii., 1884).

Stomatitis—Diphtheria.—In aphthous conditions and unhealthy ulcerations about the gums, palate or tonsils, gargles containing the chlorate or permanganate are very good (*v.* p. 811). In diphtheria both these salts have proved of great service. A useful proportion of the permanganate for local application is about 10 gr. to the pint of water.

Eczema.—A weak lotion of bicarbonate of potassium (or of sodium), 30 to 60 gr. in the pint, will often relieve the early discharging stages of eczema, and a stronger application (caustic potash, 5 to 20 gr. in the ounce) is a useful stimulant to patches in the chronic stage; although painful, it markedly relieves the itching, which is often worse than pain. The German school especially have reduced to a system the application of potash in the form of their sapo viridis ("Schmier-seife"), which is made by boiling oil with potash and potassium carbonate; it forms a soft amber-green compound, more elegant than our "soft soap." Of this a general bath is prepared with 1 dr. to the pint, a second strength (1 dr. to ½ ounce of water) is used for infiltrated sub-acute patches, and a third (1 dr. to 2 dr. of water) acts as a caustic for very chronic cases; besides these the German codex contains a "spirit of soap" and other similar preparations. The solution of selected strength should be thoroughly

brushed in and the irritation quickly relieved by a stream of cold water. The use of such remedies is painful and causes profuse serous effusion from the part; before commencing a course of them, vascular irritation should be subdued by cold water, etc., and afterwards it will be found desirable to use some emollient such as glycerine or oil, otherwise the skin becomes harsh and dry. There can be no doubt that in some chronic forms, and especially in chronic eczema of the scalp, the soft soap treatment gives remarkably good results (Med. Times, i., 1860). Dr. Unna and others have introduced "fatted" soaps medicated in various ways, which are very useful in eczema, psoriasis, etc.

Sebaceous Disorder—Acne, etc.—In cases of greasy skin and of obstructed follicles, soft soap is a good remedy. In the former it cleanses and tends to lessen secretion; in the latter it dissolves obstruction, but it should be used cautiously if much inflammation be present. Alkaline drops or injections are useful for softening and evacuating hardened cerumen in the meatus.

Boils and Carbuncles.—Dr. Shoemaker recommends potassium chlorate both internally and as a dusting powder in these affections (Med. Times, ii., 1882).

Scabies—Ringworm.—Preparations of potash (soft soap, etc.) are indirectly useful in parasitic disorders by softening the epidermis and removing secretion, and thus allowing the more direct contact of sulphur or similar remedies, hence the carbonate is a frequent ingredient in pomades for scabies. The sulphocyanide of potassium is a direct parasiticide, and has been commended by Dr. Gee in ringworm ($\frac{1}{2}$ oz. in 8 oz. water).

Psoriasis.—The diffused forms of this disease may be much relieved by alkaline baths (potassium and sodium carbonates together, of each about 3 oz. in the bath), and thickly accumulated scales may be removed by frictions with soft soap. Oil of cade may be usefully combined with the same remedy (soft soap, rectified spirit, oil of cade, equal parts). Hebra applied to severe cases a daily friction with soft soap for many days, not using a bath during the course but keeping the patient in blankets. This is, however, a painful process on account of the great tension of the skin which is induced whenever strong applications of potash are made to the general surface.

Lichen—Urticaria, etc.—Weak solutions of potassium salts

or liquor potassæ relieve the itching and irritation of these disorders, also of general pruritus, and to some extent of pruritus vulvæ. A lotion made by boiling ½ oz. of potassa sulphurata in 1 pint of water is very useful.

Rheumatism, etc.—The carbonate of potassium dissolved in a bath of warm water, is often useful to relieve pain in the joints and irritable eruptions, in rheumatic and gouty subjects. The sulphuret of potassium on the other hand furnishes a bath which stimulates especially the muscular system, and has proved useful in plumbism, in locomotor ataxy and other forms of paralysis; it has the distinctive properties of sulphur. The silicate of potassium or "liquid glass" applied on saturated bandages makes an excellent splint for fractures (Darby, Med. Times, ii., 1870).

THERAPEUTICAL ACTION.—*Internal.*—**Dyspepsia.**—In cases of irritative dyspepsia, especially when occurring in stout and rheumatic or gouty persons, and marked by a red tongue, acid eructations or pyrosis, with nausea and discomfort after meals, the liquor potassæ or bicarbonate of potassium taken at that time (*after* meals) often gives relief; in gouty subjects and when the urine is loaded, they are to be preferred to soda; in such cases the alkali acts chiefly by neutralising excess of acid. In atonic dyspepsia however, with a pale coated tongue and much weight after food small doses of alkali are best given *before* a meal, and if continued for some time should be combined with a bitter infusion;—the alkali stimulates the gastric glands to secrete more abundantly. In "biliousness" with yellowish complexion and conjunctivæ, headache and nausea, and even in actual catarrhal jaundice, salts of potassium are good adjuvants.

In *vomiting* connected with the condition just described, or with other functional or even organic gastric disorder, or occurring at the commencement of inflammatory fevers, the bicarbonate of potassium is advantageously given in effervescence with citric acid.

Acid Poisoning.—In cases of poisoning by the mineral acids, bicarbonate of potassium may be employed not only to neutralise the acid but as an emetic, by giving first a large dose of the alkali, and a suitable quantity of citric acid some minutes afterwards. The amount of carbonic acid evolved distends the

stomach so as to assist the discharge of its contents (but if the stomach wall has been much corroded by the acid, the sudden distension caused by the evolution of carbonic acid may induce rupture).

Lithiasis—Calculus.—In cases of excessive formation of uric acid, potassium salts are useful by assisting oxidation of the acid to some extent, and also by furnishing a base with which it is readily eliminated in a soluble form; they should be considered however, rather palliative than curative, and attention should be equally directed to diet and hygiene during their use.

The continued administration of potash had at one time much reputation in the treatment of uric acid calculus, and Sir William Roberts has shown by careful experiments that benefit may be expected from it under certain conditions. It is specially adapted for renal calculi which cannot be reached in any other way, and for small vesical calculi consisting either of uric acid or of cystine. The acetate and citrate of potassium are the best to use, and in order to secure a sufficient and continuous alkalescence of the urine, 30 gr. for children, 40 gr. for adults, of either salt must be taken at intervals of about three hours. This quantity will give to the urine an alkalinity equal to 3 or 4 gr. of carbonate in the pint, which may be kept up for several weeks without injury to the general health, but the urine must be frequently examined, and if it become ammoniacal the treatment should be omitted.

As an illustration of its occasional value may be cited the case of the Rev. V. Harcourt, who at the age of eighty continued for three months, rendering the urine alkaline to the extent of 20 to 25 gr. per pint, with relief to many painful symptoms and with much advantage (Med. Times, ii., 1869). For phosphatic calculi, potash is of course unsuitable.

The use of large doses for continued alkalescence of the urine is not now often prescribed, but in cases of uric acid gravel, as the urine becomes markedly more acid during fasting, and the flow slower during rest and sleep, the tendency to precipitation in the kidney is greatest in the early morning, and may be obviated by one full dose, say a drachm of citrate of potash at bedtime, and for a limited period another dose in the early morning if necessary (Roberts). I have seen much advantage from this proceeding.

Skin Disease.—Several varieties of cutaneous disease are

connected with a gouty or rheumatic diathesis, especially forms of eczema and psoriasis; in such cases the urine is often scanty and loaded, and then alkaline diuretics are of service. Mr. Easton has shown the advantages of the acetate (Edin. Month. Journ., 1850); the liquor potassæ is also given successfully.

Acute Rheumatism.—Up to comparatively recent times, alkaline treatment, by potash especially, was accepted as the best for rheumatic fever. Amongst its principal supporters, Dr. Fuller claimed that it would prevent cardiac lesions, for such lesions did not occur in any of a large number of cases thoroughly brought under the influence of alkalies (Lancet, ii., 1862). He argued that these remedies did not simply neutralise abnormal acidity, but restored normal alkaline conditions, held the fibrin in solution, exerted a sedative influence on the circulation, and favoured complete metamorphosis of tissue; he pointed out also that for a fair trial correct diagnosis was essential, and that true rheumatism should not be confounded with the gonorrhœal affection, with rheumatic gout or pyæmia, and such a mistake would account for failures; he approved of a prescription containing ammonium, potassium and sodium salts in combination, with citric acid in effervescence.

Sir Thomas Watson recommended liquor potassæ, and Dr. Parkes made use of it (Med.-Chir. Rev., 1864), but it is not really so suitable as the neutral salts. Todd preferred the bicarbonate or acetate in $\frac{1}{2}$ dr. doses every three hours (Ranking, i., 1869). Dickinson has written in favour of the same method, and Golding Bird in favour of the acetate specially, whilst Dr. Basham was a constant advocate of the nitrate (Lancet, 1848, and ii., 1862); he used large doses, from 1 to 3 oz. daily in 4 pints of barley water. Dr. Wade found the best results from a combination of these two salts in moderate doses, 15 to 20 gr. of acetate with 8 to 10 of nitrate, and other observers have corroborated his experience (Fleischman, Lancet, i., 1869, etc.). On the other hand, Dr. Sutton concluded that none of these remedies could influence the course of rheumatic fever or prevent heart-complications, though they might allay pain (Med.-Chir. Trans., vol. lii.). Dr. Ringer from his own observations came to a similar conclusion, whilst Dr. Ridge and others have argued that they are injurious (Med. Times, ii., 1871). No doubt the continued use of large

doses may induce depressing anæmia, and consequent tedious convalescence, and now that salicin, the salicylates and other remedies are better known, we are not so dependent on alkaline medication; it must however, be held a valuable resource in cases marked by high degree of acidity and loaded urine, and its judicious use may greatly relieve. In my own practice I commonly combine iodide of potassium with bicarbonate in effervescence.

Ague.—Nitrate of potash has been given successfully in ague—10 gr. every two or three hours (in brandy); it increases the secretions, notably the perspiration and urine, and is said to be as sure a specific as quinine, leaving even less tendency to relapse (Ranking, i., 1869).

Specific Fevers.—Alkalies, especially in effervescence, greatly relieve the thirst and other distressing symptoms in various fevers, and they promote elimination by the skin and the kidneys. The chlorate has been recommended in *enteric* fever by Chomel, but has not been largely given; in *scarlet* fever, I with others have found it of much advantage: even in *yellow* fever in the later stages it is said to do good (Med. Times, i., 1875).

Diphtheria.—Chlorate of potassium in full doses either alone or combined with iodide has seemed very useful to many observers (Squire, Hillier, Perrin, Henoch, Vogel). I quite agree with them; I have for twenty years used it more or less with advantage. In America it is commonly given with chloride of ammonium. Dr. Ciattaglia has recorded his very successful results with doses of 10 to 15 grammes daily; but in addition he thoroughly applied to the affected part a wash of chloral—1 dr. in 5 of glycerine (Lancet, i., 1876). Since the record of fatal results from over-doses of the salt, some fear has been entertained of its harmful effect in diphtheria and other fevers when the alkalinity of the blood is subnormal, and in two fatal cases of diphtheria the post-mortem appearances have been connected with the use of large doses. The maximum is put at 2 dr. per diem for adults, 1 dr. for children, ½ dr. below ten years, 15 gr. for infants (Record, 1884).

The permanganate of potassium has also proved useful in diphtheria, as well internally as locally (Lancet, ii., 1863; Ranking, 1865). I can add my testimony to its value, though it is

right to recognise the statements of Dr. H. C. Wood that he "has never seen the chlorate do a particle of good in such maladies as scarlet fever, diphtheria, etc.," and with regard to the permanganate, "as immediate decomposition of it must occur in the stomach the absurdity of its internal use needs only to be pointed out" (Treatise on Therapeutics).

Croup.—Liquor potassæ has been used in croup both locally and internally. Certainly it will dissolve fibrinous membrane outside the body, and to some but not to a great extent may be available in the form of spray ($\frac{1}{2}$ or 1 dr. to 1 oz. of water). It has been compared to mercury in its constitutional effect of promoting absorption, but it acts too slowly to be depended upon for so acute a malady as croup. Iodide of potassium is more effective, and the acetate seems to have sometimes acted well. The bichromate I have occasionally used locally and internally with excellent effect in true membranous croup.

Cardiac Disorder, etc.—Dr. V. N. Sirotinin has drawn attention to the remarkably good effects of potash salts—the nitrate and the acetate in 30-90 gr. doses per diem—in cases where cardiac compensation is disturbed as well as in inflammatory lung conditions, such as pneumonia and pleurisy and in ascites; the cardiac tone was improved, the arterial tension increased, the pulse slowed and palpitation relieved: the urine was increased and albuminuria lessened where these effects were produced (St. Petersb. Inaug. Diss., 1884).

Bronchitis — Catarrh. — When expectoration is scanty, viscid and brought up with difficulty, either in early or later stages of bronchitis, alkalies often relieve and may be taken with other expectorants. The liquor potassæ in doses of 10 to 15 min. is one of the most suitable forms: the nitrate is also useful, and is commonly combined with Dover's powder or with antimony and tinct. camph. co. (Graves, Clin. Lect.). Laborde has found the chlorate very serviceable both in acute and chronic catarrhal bronchitis; it modifies the expectoration, lessening its viscid character and gradually its amount; the respiratory sounds become normal, the cough is relieved and the appetite improved (Bulletin, Oct., 1864). In ordinary catarrh I have found the chlorate a very good remedy; it is recommended also by Dr. Sedgwick (B. M. J., i., 1873).

Asthma.—The inhalation of fumes of "nitre paper" is often valuable in this malady, and I with others strongly recommend it, especially for spasmodic asthma, though it is available also in the bronchitic form, if congestion is not very acute. The paper may be made with thick blotting-paper, saturating it in a hot solution of nitrate of potassium (4 oz. to ½ pint), then drying and dividing it as required. In some cases a little of this is sufficient, and a less strength of solution is desirable, but in others, relief is not obtained till the room is filled with the vapour (Times, i., 1874). Nitrous acid fumes are given off and exert the anti-spasmodic action of nitrites. "Ozone" papers are said to be prepared with nitrate and chlorate which form also ingredients in Himrod and other "cures." Dr. Murrell has recently reported much relief from thick strong papers covered with crystals of nitrate or chlorate; when lighted they give out "dense volumes of smoke" (B. M. J., i., 1881). Sometimes however, especially if there be extensive or active congestion, such treatment proves irritant, and its first use therefore requires watching.

The cobalto-nitrite of potassium has been used like other nitrites with advantage for the relief of dyspnœa, whether uræmic or emphysematous. It is said to be easily prepared, cheap, stable and safe in doses of ½ gr. every two or three hours or oftener; the effects begin within an hour and last two or three hours (Roosevelt, N. Y. Journ., 1888).

Pertussis.—The carbonate of potassium was at one time in good repute in the treatment of whooping-cough, but we cannot expect more from it than the thinning of tracheal and bronchial secretion, and a slight sedative effect on the mucous membrane. The acetate has been especially recommended (Pract., vol. ii.), also the sulphuret; the latter is given in doses of 1 gr. per year up to four years, after that age in the proportion of ½ gr. per year. It is important that its solution should be freshly prepared; it is rather nauseous, and acts sometimes as an emetic, but if continued for four or five days will usually do good (Ranking, i., 1869).

Phthisis.—The value of chlorate of potassium in phthisis has been much disputed; by some it has been esteemed a specific, and though it really cannot be called so, it has the power of

relieving at least some of the symptoms. Dr. Fountain introduced it on the hypothesis that it gave up oxygen to the blood (*v.* Physiological Action), and seems to have found benefit from the salt, not only in consumption but in various disorders with impeded respiration (Med. Times, ii., 1859 ; Amer. Journ., 1860).[1] Dr. Harkin records that in the first or second stages of phthisis doses of 5 to 20 gr. improved colour and strength, and diminished cough and diarrhœa (Dub. Quart., 1861). Dr. Symonds considered it of service in promoting the healing of vomicæ (B. M. J., i., 1868), and Spender, pointing out that full doses may readily be given because of its great solubility in boiling water, "regrets that its value in phthisis is not better known" (Brit. For. Rev., i., 1872). On the other hand, Dr. Flint's observations satisfied him of benefit from the drug in only one out of fourteen cases, mostly advanced (Amer. Quart. Rev. and Med. Times, ii., 1861). Dr. Cotton could trace no definite effects to it, though it seemed to improve the vigour of cachectic individuals generally.

I have myself known the carbonate as well as the chlorate relieve pleuritic stitches, diminish profuse purulent expectoration, and check copious perspiration. The tellurate has proved of service in profuse sweating, one dose being given in twenty-four hours—of about $\frac{1}{2}$ gr. per day or $\frac{1}{3}$ per night in pill—but the garlic odour given to the breath is an objection to its use ; it will also control the sweating of healthy subjects when due to hot weather, etc.

Chronic Hoarseness—Aphonia.—In these conditions, whether connected with chronic chest-disorder (not laryngeal phthisis) or with over-exertion in talking or singing, I have frequently prescribed from 5 to 15 min. of liquor potassæ with advantage ; in fact this simple remedy, given every four hours for a few days, has quickly relieved and sometimes quite cured the symptoms.

Struma—Asthenia.—Many observers agree in attributing benefit to the chlorate in strumous asthenic conditions, more or less allied to phthisis. Dr. Harkin used it in all forms of scrofulous glandular ulcerations. Mr. Weeden Cooke praised it in

[1] Mr. Whymper has reported its good effects in relieving headache and other symptoms induced by highly rarefied air, at an altitude of 16,500 feet on Chimborazo ; it was recommended to him by Dr. Marcet.

"scrofula," and in the generally impaired condition which follows exanthematous disease (Lancet, ii., 1869). It has also acted well in improving the general state during pregnancy, and even in preventing the recurrence of abortion (Edin. Med. Journ., 1866). The early reputation of potash in struma was founded mainly on the success of Brandish with liquor potassæ, but good air and hygiene were essential elements in his cures. This medicine will sometimes induce the absorption of glandular tumours, but cannot be considered curative of the constitutional taint; it is now practically replaced by iodide of iron and cod-liver oil. The chloride is commended in anæmia, as well as in neuralgia and "inflammatory exudations" (Pract., 1886).

Suppuration—Ulceration of Mouth.—In cases of suppuration, such as carbuncle or continued eruption of boils, or discharging wounded surfaces, also in sloughing or gangrene, the chlorate and permanganate have been found useful internally as well as locally, but it is especially in ulceration about the mouth, the gums and the fauces that chlorate of potassium is most valuable. Mr. Hutchinson has recorded many cases occurring in unhealthy children, and very obstinate until this remedy was given in full doses of from 10 to 30 gr. (Med. Times, ii., 1856). Mr. Hunt introduced it as a specific in ulcerative and gangrenous stomatitis (Med.-Chir. Trans., xxvi.), and I consider it a most valuable remedy when used internally and locally in these affections. In relaxed sore throat and catarrhal pharyngitis the chlorate is often serviceable, and is commonly prescribed in the form of lozenge.

In *mercurial stomatitis* it is very useful, and Ricord administered it with mercury to obviate injurious effects from the latter. Sir T. Watson quotes a formula containing the chlorate, 10 gr., with an equal quantity of sulphur, as "almost a specific," but my own experience is that the chlorate does not give in mercurial maladies the same good results as in ordinary stomatitis.

Diarrhœa.—The chlorate of potassium has been recommended in dysentery and even in inflammatory diarrhœa (Amisy, Lancet, ii., 1872). Marotti considers the acetate valuable in gastro-intestinal disorder connected with chronic catarrhal conditions and increased secretion of mucus in the alimentary canal, and marked by a coated tongue and anorexia (Pract., vol. ii., 1869), but I think we have more trustworthy

remedies. I should rather avoid it in acute conditions of this kind, but in the form connected with advanced stages of chronic nervous disorder and cachexia, or "vaso-paralytic" diarrhœa, its use is more indicated. The chlorate is an ingredient in the "saline treatment" of cholera.

Constipation.—The sulphate of potassium acts as a mild aperient, and is suitable for cases of dyspepsia with deficient biliary secretion or hæmorrhoids; it is often combined with rhubarb, especially for children (West, Hillier). Dr. Dickinson recommends it in doses of 10 to 20 gr. as a good laxative in albuminuria (Lancet, i., 1876); in larger doses it is apt to cause griping. The acid tartrate is also used as an aperient, especially in cases of hæmorrhoids and of dropsy, since it produces a copious watery secretion into the intestinal canal, but it should be combined with some more active agent to secure efficient expulsive effect; thus it is ordered with sulphur in the confectio sulphuris, and with jalap in the pulvis jalapæ compositus.

Purpura—Scorbutus—Hæmorrhage.—In purpura simplex, 10 gr. doses of nitrate of potassium have been sometimes useful, and even in hæmorrhagic purpura the same remedy in large doses (10 to 60 gr.) has been recommended. The advantage of potassium salts in true scurvy is not clear, but for the special ulceration of the gums the chlorate is certainly good (Lancet, ii., 1860, etc.). Both the nitrate and tartrate are of service in the treatment of capillary hæmorrhage; the former has been used especially in hæmoptysis accompanied with febrile excitement, and the latter and also the succinate, in hæmorrhage from the kidney, bladder, and rectum. Half-drachm doses of the acid tartrate quickly arrested a hæmorrhage connected with a malignant growth of the bladder, and 2 dr. is an efficient dose for relieving the loss of blood from piles (Ramskill, B. M. J., i., 1867).

Cirrhosis of the Liver.—The acid tartrate of potassium is said to be "of singular value in alcoholic cirrhosis" (Gull, Lancet, i., 1866), and this observation has been corroborated for other forms of cirrhosis and chronic peritonitis (B. M. J., ii., 1892, and Semaine Méd., 1892). In the latter, benefit is recorded in a case that had been tapped twenty-eight times: from ʒii. to i. may be given daily.

Obesity.—There are on record some remarkable cases in

which the use of potassium salts and especially of liquor potassæ, has reduced the amount of fat deposited, but these remedies are by no means always effective for this purpose, nor should they be employed without real necessity and due care, for fear of inducing an anæmic condition: they probably act by bringing on a state of general malnutrition. In a case of *local* excessive deposit of fat round the neck of a girl, which was very unsightly and for which no available treatment could be at first suggested, the use of 15 to 20 min. doses of liquor potassæ thrice daily led to marked improvement, and so quickly as to be clearly traceable to the remedy (Lancet, i., 1873). In some other cases of fatty tumour liquor potassæ has also been given with supposed success as regards diminution of the growth, but this is not within my experience.

Diabetes.—The use of alkalies in this malady was at one time largely adopted in the hope that their property of assisting oxidation would be of direct service, but this hope has been in the main disappointed. The permanganate especially was recommended by Sampson (Lancet, i., 1853), and also by Ramskill (Med. Times, ii., 1867), but has not proved trustworthy (Bence Jones, Basham and others); it seems, however, to have the power of relieving the intense thirst of the malady. The compound alkaline waters of Vichy, Carlsbad, etc., really ameliorate many cases. The nitrate, chlorate and tartrate are also serviceable in polydipsia, and are given dissolved in water or lemonade; the citrate in effervescence may give much temporary relief.

Albuminuria—Dropsy.—The use of alkaline diuretics is advantageous in the early stages of this malady, the citrate of potassium or the acetate being the most suitable: they are presumed to act directly on the kidney, washing away débris and epithelium, which obstruct the tubules. In later stages when dropsy is present, and indeed in all forms of dropsy, 20 gr. doses of the acetate, or half that quantity of nitrate, given in conjunction with digitalis, squill, or other vegetable diuretics, often secure a copious secretion from the kidneys. The phosphate has recently been recommended.

Cyanosis.—Although, as before remarked, the theory of oxidation of the blood by means of chlorate of potassium cannot be maintained, yet I have certainly seen benefit from that salt in

cases of congenital cyanosis ; the colour and the temperature have both improved under its continued use. Sir Walter Foster has recorded two remarkable cases in which he obtained similar results (Clin. Medicine). Mr. Harding found the chlorate useful " in cases with lividity and coldness of lips and extremities, and symptoms of obstructed circulation " (Med. Times, ii., 1861), and Dr. Fountain and others have had the same experience.

Tetanus—Chorea.—The power of potash to alter and diminish the contractility of muscular tissue, furnishes some theoretical ground for an old method of treatment of tetanus by means of potash baths and the internal administration of the carbonate, " the method of Stütz " ; practically this is not often employed, but some cases in which it was successful may be found recorded (Lancet, i., 1861). In chorea also, baths of the same kind have been found beneficial by G. Sée and by Hillier. The internal administration of potash may be desirable, for a time at least, in cases with rheumatic taint, but must not be pushed to the production of anæmia.

Blood Poisoning—Pyæmia.—The influence of potash upon oxidation and upon the condition of the blood, have led to its employment in cases of absorption of poisonous material.

Savory has found it of distinct value, not in acute but in chronic pyæmia (Lancet, i., 1867), and Sir James Paget records the disappearance of a chronic pyæmic abscess under the use of liquor potassæ (Barth. Hosp. Rep., vol. i.).

Snake Bite.—Dr. Shortt, of Madras, has recorded indisputable evidence of the value of liquor potassæ when quickly and largely used after the bite of venomous snakes. He gives it in several ways in order to saturate the blood as soon as possible; thus internally 20 min. are ordered with 1 oz. of brandy and $\frac{1}{2}$ oz. of water ; 1 dr. is injected into the veins every hour, and general and local bathing with a strong solution (4 oz. to the bath) is constantly practised (Med. Times, ii., 1873). M. de Lacerda has reported that intravenous injection of a 1 per cent. solution of permanganate, soon after an injection of snake venom, has proved antidotal in dogs (Oct., 1881). Dr. Vincent Richards writes in favour of the permanganate locally applied (*v.* p. 759).

Syphilis.—By those who decry or discourage the use of mercury in syphilis, the chlorate of potassium is much depended

upon as a substitute, especially in infantile forms of the disorder (Drysdale, Dub. Press, Dec., 1862). I believe that it may contribute to the healing of ulceration in this as in other cachexiæ, but I cannot attribute to it special anti-syphilitic power. More has been claimed for the bichromate, and it seems to have proved sometimes useful, especially in ulcerated throat and in iritis; a pill containing $\frac{1}{10}$ to $\frac{1}{6}$ gr. with opium, is the best way of giving it, for its solution is apt to nauseate. In large doses it is an irritant poison, and its action as a remedy has not been well proved nor extensively tried. I have myself been greatly disappointed with its effects in some obstinate cases of syphilitic disease.

PREPARATIONS AND DOSE.—*Potassii bromidum* (*v.* p. 168). *Potassii iodidum* and its preparations (*v.* p. 124). *Liquor potassæ:* dose, 15 to 60 min., freely diluted. *Potassa caustica. Potassii carbonas:* dose, 10 to 30 gr., freely diluted. *Potassii bicarbonas:* dose, 10 to 40 gr. as an antacid, etc.; in acute rheumatism, 30 to 60 gr. every four hours, freely diluted with water. *Liquor potassæ effervescens:* "potash water" (contains 30 grains in the pint). *Potassii acetas:* dose, 10 to 60 gr. as a diuretic; 120 gr. and upwards as a purgative. *Potassii citras:* dose, 20 to 60 gr. *Potassii tartras:* dose, 20 to 60 gr. as a diuretic and alterative; 120 gr. to $\frac{1}{2}$ oz. as a purgative. *Potassii tartras acida:* dose, 20 to 60 gr. as a refrigerant or diuretic; 120 to 300 gr. as a hydragogue purgative (contained in confect. sulphuris). *Potassii sulphas:* dose, 20 to 120 gr. as a purgative; 15 to 60 gr. as an alterative. *Potassii nitras:* dose, 10 to 20 gr. as a refrigerant and diuretic; 20 to 30 gr. as a vascular sedative. *Potassii cobalto-nitris:* (non-off.) dose, $\frac{1}{2}$ gr. as often as necessary. *Potassii chloras:* dose, 10 to 30 gr. *Trochisci potassii chloratis:* 5 gr. in each lozenge. *Potassii permanganas:* dose, 1 to 5 gr. *Liquor potassii permanganatis* (contains 4 gr. to the ounce—for external use, 1 fl. dr. to 5 or 10 oz. of water). *Potassii cyanidum* is used in the preparation of Bismuthum purificatum. *Potassii ferrocyanidum* is used for the preparation of hydrocyanic acid and of cyanide of potassium, in addition to being used as a test solution. *Potassii phosphas (deliquescent):* (non-off.) dose, 1 to 10 gr. *Potassii succinas (deliquescent):* (non-off.) dose, 5 to 10 gr. *Potassii telluras:* (non-off.) dose, $\frac{1}{8}$ gr. in pill, once daily. *Potassa sulphurata:* dose, 3 to 6 gr. in pill (often used in much smaller doses in pill or in water—$\frac{1}{10}$ gr. or even less for children). *Unguentum potassæ sulphuratæ* (should be recently prepared). *Sapo mollis.*

SODIUM—NATRIUM (Na = 23).

This metal does not occur native, but in various combinations is found extensively throughout all the kingdoms of nature; the chloride especially is abundant in the animal organism, also in

sea-water, in many mineral springs and marine plants, as well as in mineral formations. The nitrate of sodium (Chili saltpetre) occurs as an efflorescence on the soil in some countries.

CHARACTERS AND TESTS.—Sodium, the metallic base of soda and its compounds, is of waxy consistence, and silver-white colour. It has a great affinity for oxygen, and when placed upon water floats like potassium, producing effervescence from escape of hydrogen, and combining with the oxygen of the water to form soda; it is therefore necessary to keep it under mineral naphtha; the specific gravity is 0·972. Sodium is the only metal of which the ordinary salts are all soluble in water, and therefore do not furnish precipitation tests; we have, however, an excellent reaction in the flame-test, *i.e.*, the communication of an intensely yellow colour to a clear flame; so delicate is this test, and so universally diffused are the compounds of sodium, that it is difficult to obtain a flame perfectly free from all traces of them. The metal is used to make the following preparation.

LIQUOR SODII ETHYLATIS—SOLUTION OF ETHYLATE OF SODIUM.

PREPARATION.—It is prepared by dissolving 1 part of metallic sodium in 20 parts of ethylic alcohol, the flask being kept cool in a stream of water.

CHARACTERS.—It is a colourless syrupy caustic liquid, becoming brown on keeping, of specific gravity 0·867. It contains 19 per cent. of ethylate of sodium (NaC_2H_5O) and when heated a white residue consisting of this salt remains, the alcohol having been all driven off. It should be freshly prepared for use.

COMPOUNDS OF SODIUM.

SODA CAUSTICA—CAUSTIC SODA—HYDRATE OF SODIUM (NaHO = 40).

PREPARATION.—It is obtained by evaporating liquor sodæ to dryness in a silver, or clean iron vessel; the process is conducted as rapidly as possible to prevent absorption of carbonic acid, and platinum, glass, or porcelain vessels are not admissible because the alkali would act upon them. A pure hydrate may be prepared by decomposing water with metallic sodium.

CHARACTERS.—It occurs in whitish cakes or pencils which are highly alkaline and corrosive; it is not so deliquescent as potash.

LIQUOR SODÆ—SOLUTION OF SODA.

PREPARATION.—It is prepared by adding slaked lime to hot solution of carbonate of sodium, $Na_2CO_3 + Ca(HO)_2 = CaCO_3 + 2NaHO$.

CHARACTERS.—A colourless liquid, of intensely caustic taste, containing 18·8 gr. of caustic soda to the ounce.

SODII CARBONAS—CARBONATE OF SODIUM
($Na_2CO_3 10H_2O$ = 286).

PREPARATION.—The combustion of sea plants formerly furnished us with crude soda-ash, or "barilla," from which the carbonate was prepared, but it is now generally obtained from common salt (chloride of sodium) on a large manufacturing scale.

CHARACTERS.—It occurs in large rhombic crystals, colourless and transparent when fresh, but readily effloresing on exposure to air; of nauseous alkaline taste, very soluble in water, not at all in alcohol; they contain 63 per cent. of water of crystallisation, which they lose at a sufficient heat. Twenty grains of carbonate of sodium neutralise 9·8 gr. of citric, and 10·5 of tartaric acid.

Sodii Carbonas exsiccata, or dried carbonate of sodium, being the same salt deprived of water and powdered, is introduced as a separate preparation for convenience in dispensing; 1 gr. = about 2½ gr. of the crystallised salt.

SODII BICARBONAS—BICARBONATE OF SODIUM
($NaHCO_3$ = 84).

PREPARATION.—It is prepared by passing a stream of carbonic acid gas into a mixture containing two parts of the crystallised and three parts of the dried carbonate, until the gas ceases to be absorbed (if the ordinary carbonate only were used, the mass would become too moist and the crystals too large). By a special arrangement of vessels, the delivery of the carbonic acid is made continuous, as in the case of bicarbonate of potassium. The salt may also be prepared by acting upon chloride of sodium with bicarbonate of ammonium.

CHARACTERS.—It occurs in small snow-white grains or scales, or in opaque white powder, slightly alkaline and somewhat unpleasant to the taste, permanent in the air, and soluble in water. Good commercial bicarbonate commonly contains 2 or 3 per cent. of carbonate. Twenty grains of the former salt neutralise 16·7 gr. of citric and 17·8 of tartaric acid.

Liquor Sodæ Effervescens is a solution of the bicarbonate in water, 30 gr. to the pint, saturated with carbonic acid gas.

Sodii Arsenias (*v.* p. 459). *Sodii Bromidum* (*v.* p. 140).
Sodii Iodidum (*v.* p. 81). *Sodii Salicylas* (under *Salicin*).

SODII SULPHAS—SULPHATE OF SODIUM—GLAUBER'S SALT ($Na_2SO_4 10H_2O$ = 322).

Preparation.—In the process for making hydrochloric acid, an acid sulphate of sodium is formed by the action of sulphuric acid on common salt, and if this *acid* sulphate be neutralised with carbonate of sodium, the *neutral* sulphate may be crystallised out.

Characters.—It occurs in transparent colourless six-sided prisms, which are deeply channelled; they are efflorescent in the air, and have a saline bitter taste and neutral reaction. Arsenic is a frequent impurity.

SODII SULPHAS EFFERVESCENS—EFFERVESCENT SULPHATE OF SODIUM.

Preparation.—It is prepared by drying crystals of sulphate of sodium (100 parts) until they have lost 56 per cent. of weight, and then mixing with bicarbonate of sodium (100 parts), tartaric acid (54 parts), and citric acid (36 parts). The whole is powdered, and being placed in a suitable dish or pan, is heated to between 200° and 220° F., and granulated by stirring.

SODII SULPHIS—SULPHITE OF SODIUM ($Na_2SO_3 7_2H_2O$ = 251·56).

Preparation.—It is obtained by the action of sulphurous acid on carbonate of sodium, or on caustic soda.

Characters.—It occurs in colourless, transparent, monoclinic prisms, efflorescent in dry air; it is inodorous and has a cooling, saline, and sulphurous taste. It is readily soluble in water and spirit. The aqueous solution has a neutral or faintly alkaline reaction, and if treated with hydrochloric acid evolves sulphurous acid.

SODII HYPOSULPHIS—HYPOSULPHITE OF SODIUM (SODIC THIOSULPHATE) ($Na_2H_2S_2O_4 4H_2O$).

Preparation, etc.—It is obtained by warming a solution of the sulphite with powdered sulphur; it occurs in large colourless oblique prisms,

which are very soluble in water, but not in alcohol. This substance is an antiseptic like the sulphite and is sometimes used like it, but is only placed in the B. P. as a test solution for the estimation of iodine.

SODII NITRAS—NITRATE OF SODIUM ($NaNO_3$ = 85).

PREPARATION, etc.—This salt is found native in Peru and Chili, and is purified by crystallisation from water. It occurs in the form of obtuse rhomboids resembling cubes, deliquescent, and very soluble.

Sodii Nitris (*v.* p. 841).

SODII PHOSPHAS—PHOSPHATE OF SODIUM ($Na_2HPO_4 12H_2O$ = 358).

PREPARATION.—It is obtained from bone-ash, which is mainly phosphate of calcium, by rather a complex process, of which the essential steps are two, viz.: (1) The bone-ash is digested with sulphuric acid, when an acid phosphate is formed and remains in solution, and an insoluble sulphate precipitates. (2) The filtered solution containing the acid phosphate of calcium is then treated with carbonate of sodium to slight alkalinity, when phosphate of sodium is formed, filtered, and re-crystallised.

CHARACTERS.—It occurs in large, transparent, rhombic prisms, which quickly effloresce in the air; they are faintly alkaline, very soluble in water, and have a mild saline taste.

SODII PHOSPHAS EFFERVESCENS—EFFERVESCENT PHOSPHATE OF SODIUM.

PREPARATION.—This is made in the same proportions and in the same way as the effervescent sulphate.

SODII HYPOPHOSPHIS—HYPOPHOSPHITE OF SODIUM ($NaPH_2O_2$ = 88).

PREPARATION.—It is prepared by adding carbonate of sodium to solution of hypophosphite of calcium, so long as a precipitate (carbonate of calcium) is formed; this is filtered off, and the solution evaporated cautiously.

CHARACTERS.—A white, crystalline, bitter salt, deliquescent, and very soluble in water and spirit. It readily decomposes so that explosions occur with it on mixture, for instance, with chlorate of potash, and friction; when heated to redness it ignites, and gives off phosphuretted hydrogen.

SODII BENZOAS—BENZOATE OF SODIUM ($NaC_7H_5O_2$ = 144).

PREPARATION.—It may be obtained by neutralising benzoic acid with solution of carbonate of sodium, and evaporating to dryness.

CHARACTERS AND TESTS.—A white, obscurely crystalline or amorphous powder, without smell or with faint benzoic odour, of sweetish taste and slight alkaline reaction; very soluble in water and in spirit. When heated it melts, emitting a faint benzoic odour, and then chars. An aqueous solution gives a yellowish or flesh-coloured precipitate with solution of persulphate of iron.

SODII BIBORAS—BORAX ($Na_2B_4O_7 10H_2O = 382$).

PREPARATION.—It is found native in a crude form in Thibet, India, California, etc.; it is also prepared by neutralising boric acid with carbonate of sodium.

CHARACTERS.—It occurs in flattened semi-transparent prisms, of slightly alkaline reaction and saline taste, soluble in water, and effloresecing in the air. Its solubility is increased by glycerine and by cream of tartar, and from its solutions boric acid is precipitated by any mineral acid; it gives a green colour to flame. When heated it dissolves in its water of crystallisation, and at red heat forms a transparent glass much used as a flux for mineral substances in blow-pipe operations.

LIQUOR SODÆ CHLORINATÆ—SOLUTION OF CHLORINATED SODA.

PREPARATION.—By passing washed chlorine gas through a solution of carbonate of soda till a specific gravity of 1·06 is reached. The resulting solution contains hypochlorite of soda, with some chloride and bicarbonate of the same.

CHARACTERS.—A colourless alkaline liquid, with the odour of chlorine, and a pungent taste; its specific gravity is 1·054; it bleaches vegetable colours, effervesces with acids, and readily evolves chlorine.

SODII CHLORIDUM—CHLORIDE OF SODIUM—COMMON SALT ($NaCl = 58·5$).

It is found native in "rock-salt" and saline waters.

CHARACTERS.—It occurs in transparent cubes or small white grains, soluble in water, and if pure, permanent in air; deliquescent, if containing chloride of calcium or magnesium.

SODA TARTARATA—TARTARATED SODA—TARTRATE OF SODIUM AND POTASSIUM—ROCHELLE SALT ($NaKC_4H_4O_6 4H_2O$ = 282).

PREPARATION.—It is obtained by adding cream of tartar to a hot strong solution of carbonate of sodium, so long as effervescence continues, then filtering and crystallising.

CHARACTERS.— It occurs in large, colourless, rhombic prisms, or halves of prisms, which have been compared to tombstones; they are neutral in reaction, soluble in water, and of saline rather bitter taste.

PULVIS SODÆ TARTARATÆ EFFERVESCENS—EFFERVESCENT TARTARATED SODA POWDER—SEIDLITZ POWDER.

PREPARATION.—Contains in the blue paper, tartarated soda 120 grains, and bicarbonate of sodium 40 grains; in the white paper, tartaric acid 38 grains. On dissolving the former powder in about half a pint of water, and then adding the latter powder, an effervescent saline purgative is obtained.

SODII CITRO-TARTRAS EFFERVESCENS—EFFERVESCENT CITRO-TARTRATE OF SODIUM.

PREPARATION, etc.—It is prepared by mixing bicarbonate of sodium with citric and tartaric acids, at considerable heat (200° F.); with constant stirring, this salt is obtained as a granular powder, which effervesces on contact with water.

SODII SULPHOCARBOLAS ($NaC_6H_5SO_4 2H_2O$).

PREPARATION.—Is obtained by dissolving carbolic acid in excess of sulphuric acid, supersaturating the liquid with barium carbonate, filtering and treating the filtrate with sodium carbonate till no further precipitate forms. The filtrate from this mixture yields crystals of sulphocarbolate of sodium on evaporating.

CHARACTERS.—It occurs in colourless, transparent, rhombic prisms, nearly inodorous, with a cooling, saline, and somewhat bitter taste. It is readily soluble in water, the solution being neutral to litmus. On ignition it gives off carbolic acid.

SODII VALERIANAS ($NaC_5H_9O_2$).

PREPARATION.—Is prepared by mixing sulphuric acid, potassium bichromate solution, and amylic alcohol in a retort and distilling: the acid distillate is then accurately neutralised with soda; on cooling, the valerianate of sodium solidifies.

CHARACTERS.—It occurs in dry, white masses without alkaline reaction; is entirely soluble in rectified spirit and gives off a powerful odour of valerian on the addition of sulphuric acid.

Other compounds of sodium used medicinally but which are not official are the following: *Sodii chloras*, *sodii pyrophosphas*, *sodii santoninas*, *sodii bisulphis*.

ABSORPTION AND ELIMINATION.—The salts of sodium though highly diffusible, are not so much so, nor so readily absorbed as those of potassium. Small doses become changed in the stomach into chloride, but large quantities undergo this change only in part, the rest being absorbed unchanged; from the rectum also, sodium salts are absorbed without chemical decomposition. In the blood they circulate as chlorides, carbonates, phosphates, etc., and are eliminated mainly by the urine: the carbonates, nitrates, and other salts of *mineral* acids in their natural state, but citrates and other salts of *vegetable* acids pass out as carbonates.

The time that elapses between absorption and some elimination is not precisely known but is short, for the nitrate and an excess of chloride have been found in the saliva and urine within a few minutes after the taking of those salts; also, a very large quantity (60 grammes) of nitrate has been taken in divided doses during a day without injury, whilst half the amount in *one* dose has proved poisonous.

The chloride taken into or formed in the stomach, is said to decompose into hydrochloric acid and soda, the former passing into the blood to combine again there with soda (bicarbonate), whilst the latter is eliminated, not only by the kidneys but also by the salivary glands, the liver, the pancreas, etc. (Bidder and Schmidt). The chloride is never completely eliminated from the system even if it be excluded from the diet; on the other hand, if an excessive quantity be taken most of it is rapidly got rid of; thus Lehmann, analysing his blood before and during the action of a salt-dose or salted diet, found the proportion of salt in the blood to be very similar, the excess being passed out by the kidneys almost as soon as taken.

Chloride of sodium in the air or in the form of a finely-divided spray, is absorbed from the pulmonary mucous membrane even more quickly than from the stomach. It is not absorbed through

the unbroken skin. Sodium salts like alkalies generally are eliminated to a slight extent by the mucous membranes, especially by those of the respiratory tract, the secretion of which they tend to increase and make thinner ; they exercise a remarkable stimulant effect upon the vibratile movements of ciliated epithelium, which they revivify after apparent extinction.

PHYSIOLOGICAL ACTION.—*External.*—The *hydrate* of sodium exerts a local caustic effect, consequent upon its great affinity for water and its power of dissolving nitrogenous tissues. The *carbonate*, applied in solution, dissolves sebaceous and fatty secretions, and if concentrated acts as an irritant. Solutions of *chloride* redden and stimulate the skin, and if applied to a surface denuded of epithelium, excite much smarting and flow of lymph ; redness is then masked by whitish opacity of the albuminous secretion, and the same whitish appearance may be observed on the inner aspect of the buccal mucous membrane after eating much salted food. Strong saline baths may cause cutaneous eruptions.

Salt has a local stimulant or irritant effect on nervous tissue, and for some physiological experiments C. Bernard considered it more effective than galvanism. If the exposed sciatic nerve of a frog be dipped in salt and water, immediate spasmodic contraction of muscles occurs in the limb ; if the tympanic nerve be so treated saliva is secreted. This however is no special peculiarity of sodium chloride ; most strong chemical reagents behave in a similar way, but salt is a convenient substance to use in order to demonstrate that nervous impulses can be set going by chemical stimuli.

PHYSIOLOGICAL ACTION.—*Internal.*—**Oxidation and Nutrition.**—Under potassium has been summarised evidence as to the action of alkalies on oxidation, and with regard to the carbonates of sodium we may equally conclude, that whilst large and continued doses induce anæmia and asthenia, small quantities given for a moderate time help to saponify fatty food, to aid its oxidation and that of carbonaceous material generally, to improve digestion, and to raise temperature. This is especially the case with the chloride of sodium, and indeed Rabuteau teaches that it is by conversion into this salt that the other sodium compounds produce the good effects mentioned. Confirming conclusions

already published by Voit (Brit. and For. Rev., ii., 1862), he showed that the chloride increased "vital combustion," for whilst taking an extra daily dose of 10 grammes of salt, his excretion of urea was 20 per cent. more, and his temperature was half a degree higher, than when under a dietary from which salt was excluded. Similarly Kaupp found that when taking 1 gramme of salt, the amount of urea excreted was increased 4 centigrammes, the other soluble constituents of the urine being diminished. According to Zabelin, salt favours absorption of phosphates specially, and rather hinders their excretion, which effect would to some extent favour nutrition.

Falck found also increased excretion of urea after giving salt to fasting animals (1872), whilst Münch reported from large doses, continued for a few days, at first diminished excretion and gain in weight, afterwards a contrary effect.

Our present knowledge of the influence of alkalies on human metabolism has been summed up by Stadelmann in a paper read at the Ninth Congress of Internal Medicine (B. M. J., i., 1890). The observations were made on the experimenters themselves while in a condition of nitrogenous balance, that is, on fixed diet with a constant excretion of nitrogen. The effects of large doses and also of smaller doses given for a long period were studied. The alkalies used were the carbonate, bicarbonate, and citrate of sodium. The citrate showed itself better adapted than the other salts for introducing an alkali into the system. It is converted into carbonate in the blood and does not therefore combine with the acids of the stomach as the others do, thereby injuring primary digestion and so affecting metabolism; it is also more readily absorbed. All the substances found in the urine and also the nitrogen of the fæces were carefully estimated. In the urine the uric acid and ammonia were both greatly diminished; the urea usually fell at first and then underwent great daily variations, but on the whole the average did not differ from the normal; in every case there was a more or less pronounced diuretic effect. The lime and magnesia salts of the urine remained unaffected as did also the phosphoric and sulphuric acids. After giving citrate of sodium the amount of soda excreted in the urine remains high for about four days, showing that its excretion takes some little time. In the fæces the amount of

nitrogen was nearly doubled. An increased oxidation of fat, although probable, was not proved. No dyspeptic symptoms were observed with the citrate even after about 20 oz. had been administered during a prolonged experiment.

In another series of experiments it was found that moderate doses of alkalies (many salts were tried) neither increase the total amount of bile nor the quantity of colouring matters, acids, or fats in it. Large doses on the other hand, decreased the total amount (probably by removing water from the system) but left the biliary constituents unaltered. The use of alkalies as *cholagogues* is therefore improper, and like the present therapeutical application of most so-called cholagogues is based on incorrect physiological experiments. The favourable action of alkalies in dyspeptic affections depends rather on their influence on catarrhal conditions of the gastro-intestinal tract and biliary passages. During their administration the bile becomes more alkaline, and thus mucus and biliary constituents are dissolved so that they more easily pass along the common bile duct.

The carbonate, according to the majority of observers, diminishes the excretion of uric acid, and as this acid results from insufficient oxidation, its diminished excretion implies improvement in oxidation. According to some recent experiments under Salkowski, the addition of alkalies to the diet diminishes the formation and therefore the excretion of uric acid in man, but increases the same in dogs (Therap. Gaz., 1890). The reported increase of excretion of carbonic acid requires proof, but is rendered probable by the increase which follows injection of lactate of sodium into the veins (Husemann). Animals improve under a ration of salt—their coat becomes smoother, their vigour greater, their flesh more healthy, and if at the same time their weight is not increased, it is because the vital processes and combustions all go on with greater energy. We have negative evidence to the same effect in the sufferings consequent on deprivation of salt, as in the American War of Independence, and more lately during the siege of Metz, and Barbier records that certain Russian serfs, deprived for a time of salt (from motives of economy), suffered so much (becoming albuminuric and dropsical), that their lords were forced to supply them with it again (Gaz. Méd., 1838). On the other hand, it is curious that the Tlascalans are said to have

lived for half a century without salt (Prescott), and certain Aryan tribes never use it (Fick), or else their ordinary food contains sufficient to supply the needs of the economy.

Whether the sodium chloride contained in our food is sufficient or whether additional small quantities should be used, as is our custom, has been a much discussed question. Bunge says that purely herbivorous animals require salt, while the carnivorous do not; mixed eaters require a small amount. The fact is well known that wild herbivora travel long distances to procure it, while carnivora never touch it and dislike salted meats. Bunge's explanation of these facts is, that in the food of herbivora potassium salts are from two to four times more abundant than sodium salts. If potassium phosphate for instance be absorbed into the blood it decomposes the sodium chloride there, and potassium chloride and sodium phosphate are formed. Both of these salts being foreign to the blood are soon excreted, and more sodium chloride must be taken to make up the loss. In the food of carnivora however, there is no excess of potassium salts, and thus the sodium chloride of the blood remains uninterfered with. Mixed eaters therefore, such as man, require a small amount of salt as an addition to their dietary, but certain tribes which live entirely on flesh are in the position of carnivorous animals with regard to the consumption of salt.

We must repeat that the above-mentioned good effects of ordinary salt and of alkaline compounds are obtained only within certain limits of dose—an excess of the former causes not only thirst and disordered digestion, but an impaired condition of the blood, and under daily 5 gramme doses of bicarbonate the excretion of urea is diminished and anæmia and prostration induced (Rabuteau); the nitrate and sulphate also diminish urea (Jovitzo and others), lower temperature, and slow the circulation; it is probably from alteration of the blood that these effects arise.

Digestive System.—What has been stated under potassium as to the influence of alkalies upon digestion and secretion, applies equally to the alkaline salts of sodium, but the chloride of sodium has a special value, because it furnishes in part the gastric acid; it aids the solution of albuminous substances and increases the amount of saliva and gastric juice. Bardeleben

proved this by observations on dogs with gastric fistula, though indeed, many other salts and even mechanical irritants, will provoke a temporary increase in the gastric secretion. Rabuteau found that salted diet increased also the degree of its acidity. Observations on the gastric juice of dogs fed on meat washed free from chloride, showed that not only did the chlorides disappear from the urine, but also hydrochloric acid from the gastric juice. If chlorides were then administered, an abundant secretion of hydrochloric acid began almost immediately (Cahn, Zeitsch. physiol. Chem., x.). The question has arisen how the chlorides give rise to a secretion of free hydrochloric acid, and there seems to be no doubt that although the salt may act in some measure as a simple stimulant, it is chiefly by means of a chemical reaction that the formation of free acid takes place. Landwehr has advanced the following theory, that lactic acid is formed by fermentation from the mucus of the stomach, and reacting on the sodium chloride liberates the free acid (Chem. Centralblatt., 1886). This reaction certainly occurs in experiments performed outside the body, but it will not account for the formation of the acid in all cases, for often no lactic acid is discoverable; and E. Frerichs has demonstrated that in fifteen minutes after the introduction of distilled water into the stomach of men and dogs, traces of hydrochloric acid are discoverable (Biol. Centralb., 1886). (This does not agree with the observations of van der Velden that the acid is not perceptible until one and a half to two hours after a meal.) Maly suggests that as free hydrochloric acid is formed outside the body as the result of a reaction between sodium or calcium chloride, sodium dihydrogen phosphate and disodium hydrogen phosphate, a similar reaction between these salts in the blood may also occur (Sitzungsber k. Akad. d. Wissensch., Bd. 76). In connection with this question it is interesting to note that E. Kulz (Zeitschr. Biol., Bd. 23) has found that after the administration of iodides and bromides, free hydriodic and hydrobromic acids respectively are formed in the gastric juice.

The good effects of sodium chloride are shown clinically by small doses of 15 to 60 gr. Large quantities precipitate proteids of the globulin class, whilst very large and concentrated doses cause vomiting, watery purging, and even gastritis; in China they are said to be used for suicidal purposes. Injection of much salt

into the crural vein of dogs causes ptyalism, intestinal gurgling, and temporary lessening of the size of the spleen (Podkaepow).

The action on secretion of bile is not certainly known; Nasse, experimenting with animals, found it lessened, but observations made after the use of alkaline waters show an increase (Grossmann), and this would be in accord with analogy. Rutherford has stated that sulphate of sodium has marked cholagogue properties, but the good effects of alkalies in so-called bilious states are attributable rather to an influence on the catarrhal conditions than to any supposed influence on the secretion of bile. According to Dr. Pavy, the carbonate not only increases the bile but also the percentage of fat in the liver (Guy's Reports, 1861; Proc. Roy. Soc., vol. x.-xi.; Med. Times, i., 1865); also the saccharine urine which commonly follows certain traumatic lesions of the sympathetic, does not occur if much soda be previously introduced into the blood; these are curious facts, of which we do not at present see the full bearing (*cf.* p. 825).

Circulatory System.—It is an important difference between potash and soda, that the former is an active cardiac depressant and poison, whilst the latter has little effect on the heart-muscle or the circulation. Frogs die, but only slowly, after the injection of very large quantities (Podkaepow, Guttmann), whilst upwards of 100 gr. of sodium carbonate have been introduced into the vein of a dog with but slight and temporary malaise and muscular weakness (Grandeau, Robin's Journ., 1864). Sodium is, like the other alkalies a cardiac poison, though to a less extent than potassium and ammonium; the contractility of the heart is chiefly affected, the excitability being but little influenced. Its action upon other involuntary muscles is also not so marked as that of potassium salts (Pract., i., 1882). A small amount of sodium chloride is necessary in a saline fluid used to keep a heart beating, but unless it is mixed with traces of a potassium and a calcium salt, the heart is soon brought to a standstill in systole (Pract., ii,, 1883).

These differences are only observable when the different alkalies are *injected* directly into the blood. If given by the stomach, potassium seems to exert no very depressant effect in man, possibly because it is rapidly excreted and only a small amount is present in the circulation at any one time.

The chloride of sodium in small or moderate doses *increases*

the number of corpuscles; thus Plouviez had analyses made of his own blood before and after a course of salt, lasting two months, during which he took daily 150 grs. besides his ordinary allowance, and at the end of the time the red corpuscles were augmented 10 per cent., the fibrin was increased, and the albumen diminished (Comptes Rendus, 1847, t. xxv.).

Rabuteau states that blood-corpuscles placed under the microscope disintegrate much less rapidly when salt is added than with simple water, and from this and general physiological results, concludes that any influence of salt in apparently increasing the number of globules, is exerted by *conserving* them rather than by supplying food for fresh ones as iron does. The saline solution used in histology and in physiological experiments, generally has a strength of 0·6 per cent. This preserves not only blood-corpuscles but also other tissues in a normal state for some time, and is a good substitute for blood serum. Ordinary water is now well recognised as a protoplasmic poison.

According to Bergeret, *omission* of salt from a dietary leads to pallor, languor, œdema, and a chlorotic condition, the corpuscles are dissolved, and fibrin deposited (Abstract, Ranking, i., 1871).

Whether the excessive use of highly salted food is the main cause of scorbutic conditions, such as occur in sailors, must be considered doubtful; they may arise from the hardships of such life, from deficiency of *potash*, of vegetables, etc., but it would almost seem as if either great (relative) *excess* or *deficiency* of the element led to equally injurious consequences. Prussac found that when frogs were placed in concentrated salt solutions, or had them injected into the lymph sacs, copious "wandering" of red corpuscles took place from uninjured vessels, and also capillary hæmorrhage. (This however, like the action upon nerve, is not peculiar to sodium chloride,—almost any other chemical reagent will set up similar inflammatory conditions.)

Outside the body, salt reddens and liquefies blood-clot. The change in colour is attributed by Gubler to liberation of carbonic acid and absorption of oxygen by the hæmoglobin. It is permanent, but I do not think it more than a physical change due to altered osmosis; it may be produced by many other saline compounds.

Soda is more abundant in the blood plasma, whilst potash occurs most in the red corpuscles, and excessive doses of the

former alkali may alter this normal relationship, and thus interfere with respiratory combustion and with nutrition.

The proportion of sodium chloride in normal blood has been variously estimated at from 3 to 5 per 1000. It is diminished in various morbid states, such as cholera, diabetes (Nasse), jaundice, chlorosis; in pneumonia, on the contrary, its elimination is checked, and hence an excess remains in the blood.

Nervous and Muscular Systems.—There is some (not cogent) clinical evidence that excess of soda in the blood leads to convulsive action of the nervous system (Laycock, Med. Times, i., 1863; Hunt, Med. Times, 1856); most observers think an excess of little import. In large doses sodium salts lengthen the time of contraction of voluntary muscles, instead of shortening it like potassium salts. Their action on involuntary muscle has already been considered (*v.* p. 828). Dr. Ringer finds that the bicarbonate and the rhombic phosphate of sodium produce a prolongation of the muscle-curve, like veratrine. These salts also produce fibrillar twitchings in frogs' muscles very like those of progressive muscular atrophy. Such effects are produced after the section of nerves and so they are not central.

Urinary System.—With regard to the influence of soda salts on diuresis, opinions are divided, partly perhaps because of the different doses employed. Usually some increase in the quantity of urine is observed in patients taking carbonates, especially in those with acid dyspepsia, but it is not always the same with healthy persons. Münch found in five subjects, when perspiration or diarrhœa did not occur, *increased excretion of water* as the principal effect of 3 to 6 or 9 gramme doses of carbonate, but Rabuteau and Constant could not verify any increase with 5 gramme doses given daily. A continued weak alkalescence of the urine may be secured from about 3 gramme doses of bicarbonate of sodium taken thrice daily at meal-times, whilst one daily dose of 5 gr. will give alkalinity only for two or three hours —even 1 gramme will do this if taken fasting. Much dilution or warmth of the liquid in which the drug is taken promotes the alkalescence of urine, and it lasts longer in weak or elderly persons.

The chloride will produce the same effect, though not so quickly as the carbonate, and under its use earthy phosphates replace free acids.

Glandular System.—Milk is secreted in increased quantity under the influence of salt. This fact, indicated by Saive but denied by Boussingault, has been confirmed recently (Rabuteau). In Brazil and some other countries there is a popular custom of watering the food of milch cows with salt water to increase their milk, but the animals also may simply drink more, and thus secrete more watery milk. Large doses of borax (50 grains) induce copious secretion of saliva, and occasionally sickness and dyspepsia; more rarely a scaly eruption on the skin (*v.* p. 841).

SYNERGISTS.—The chemical action of the alkaline salts of sodium is shared by other alkalies, the physiological action of the chloride of sodium by other chlorides, both as stimulant of hæmatosis and as irritant in large doses; as a *digestive* stimulant, condiments assist its power.

ANTAGONISTS—INCOMPATIBLES.—Acids antagonise the chemical effects of alkaline salts of sodium, though the vegetable acids are often added to them to secure liberation of carbonic acid gas and formation of neutral salts. Mucilaginous substances lessen the local irritant effects of excessive doses of chloride or nitrate, and the chloride itself is a suitable antidote for nitrate of silver.

Sulphate of sodium acts as an antidote to carbolic acid by forming the almost innocuous sulpho-carbolate of sodium in the blood; in cases of poisoning 2 or 3 drachms dissolved in warm water should be given by the mouth at intervals. Sulphates do not *directly* antagonise carbolic acid. The matter stands thus:—so long as sulphates are present in the blood in sufficient amount carbolic acid forms with them sulpho-carbolates (of sodium, potassium, etc.), which are very slightly toxic; as soon as the sulphates are exhausted the carbolic acid circulates free and is highly toxic.

THERAPEUTICAL ACTION. — *External.* — **Strumous Ulceration, etc.**—For destroying unhealthy growths, the edges of strumous ulceration, etc., caustic soda has been sometimes used. It is less deliquescent than potash, but yet it is very diffusible, and readily extends its action; it therefore requires the precaution of protecting adjacent parts, and of neutralising with weak vinegar or oil after application.

Glandular Scrofulosis.—A strong solution of salt locally

applied is a good resolvent of enlarged and hard glands ; sea-bathing is useful for the same purpose.

Frictions with a pomade containing salt cause a pustular eruption, and have been used over the chest in phthisis (Med. Times, ii., 1859).

Hoarseness—Catarrh.—A piece of borax allowed to dissolve slowly in the mouth sometimes cures these conditions. A spray containing salt (gr. iv.-v. ad ʒj.) is also useful.

A simple mode of stimulating the external surface in some chronic catarrhs and relaxed throat conditions, is sponging or bathing of the neck and chest in salt water night and morning, following this with friction.

Unhealthy Wounds.—Solution of chlorinated soda mixed with water in various strengths, makes an excellent detergent and disinfectant gargle, lotion, or injection, but is rather a preparation of chlorine than of soda.

Hæmorrhage.—Much evidence has recently accumulated as to the value of warm saline injections in conditions of collapse, especially when this is due to loss of blood or serous fluid whether in cholera, dysentery, operations, childbirth, etc. ; it seems to replace in many cases transfusion of blood. The strength now used is less than formerly, about 1 dr. of salt to the pint of water (boiled) at 100° F. = $\frac{3}{4}$ per cent. During the recent epidemic at Hamburg such intravenous injection was part of the routine treatment of severe cases, and often with good effect, but in non-choleraic cases it has many times seemed to save life by stimulating the circulation, and this as well by injection into the bowel, or even the peritoneal cavity, or the cellular tissue, as into the vein (Lancet, B. M. J., 1891-2-3). We cannot suppose that the salt is a very active agent in the good result—it simply supplies one constituent of the normal circulating fluid ; a more scientific substitute is in the formula known as that of Jennings, viz., sodium chloride, gr. 50 ; sodium sulphate, gr. $2\frac{1}{2}$; sodium carbonate, gr. $2\frac{1}{2}$; sodium phosphate, gr. 2 ; potassium chloride, gr. 3 ; dissolve in a pint of hot water (sterilised), and at 100° F. add of absolute alcohol 2 drachms.

Pruritus—Eczema, etc.—In several forms of skin disease attended with itching, lotions containing a small proportion of carbonate or bi-borate of sodium, 1 to 2 dr. in $\frac{1}{2}$ pint, are often

serviceable. In *urticaria*, *lichen*, and the early inflammatory stages of eczema when alkaline oozing occurs, the same lotion will give relief, but in the last case it should be made weaker still—20 to 30 gr. in the ½ pint; or again, 20 gr. of the carbonate of sodium may be usefully combined with an ounce of zinc ointment. In several forms of papular and scaly eruptions, such as *lichen* and *psoriasis*, baths containing about 4 to 6 oz. of carbonate of sodium are very useful, being sedative as well as detergent. For common *chilblains* a strong solution of salt in water is a good domestic remedy; borax with glycerine is also good.

A weak lotion of borax is also often useful in cases of ordinary *sore nipple;* Sir Astley Cooper commonly prescribed it with spirit of wine. For slight cases of fissured *sore tongue* or buccal irritation, the glycerine of borax is pleasant and efficient.

Tinea Versicolor and even mild cases of tinea tonsurans may be cured by the same remedy. For the irritation and scaling connected with so-called *pityriasis capitis*, a lotion containing borax, camphor, and rosemary is a good application.

Aphthæ, etc.—Aphthous conditions affecting the mouth and fauces, are often treated with borax mixed with honey or dissolved in glycerine; a solution of chloride will also succeed sometimes. Aphthous conditions affecting the vulva and the very irritating "pruritus pudendi" in either sex, may be much relieved by warm lotions or by paints containing borax. Laycock has spoken well of the use of borax in *diphtheria* (Med. Times, i., 1858), but we have more trustworthy remedies. The chlorate of sodium is equal if not superior to the chlorate of potassium in such cases, and in ulcerations.

Tonsillitis.—Dr. Armangué has reported a large number of cases of tonsillitis cured within twenty-four hours by the local application of the bicarbonate of sodium (L'Union Médicale de Canada, Dec., 1881). Dr. Giné states that the predisposition to this disease is also thereby lessened,—a statement which has since been confirmed by others (Lancet, i., 1884).

Acne Simplex.—A liberal use of soap with hot water is often necessary in this disorder, and a borax lotion is of service.

Burns.—In burns and scalds, especially of the first degree, a saturated solution of the bicarbonate applied constantly on moistened cloth quickly relieves the burning pain.

Dental Caries.—Toothache connected with open carious teeth may often be relieved by the local use of carbonate of sodium (½ dr. in the ounce of warm water); it probably acts by neutralising acid or irritant secretions (Duckworth, Pract., 1875).

Rheumatism—Gout.—Soda baths are also useful in relieving pains of rheumatic character in the joints and muscles. Basham recommended basic phosphate of sodium in powder as a good application for enlarged and painful gouty joints (Med. Times, ii., 1848), and it has some advantage over liquid applications; it may be applied on moistened spongio-piline. Hot salt in flannel is often a convenient mode of applying warmth to rheumatic or painful parts: in similar cases Dr. H. Bennett used "soda poultices" (Times, ii., 1853).

Leucorrhœa—Cystitis.—Injections containing carbonate of sodium (1 to 2 dr. in the pint) form a simple and often efficacious remedy in cases of vaginal leucorrhœa with white, alkaline discharge, and in chronic cystitis an injection of borax, glycerine, and warm water is very soothing. The silicate of sodium has been lately recommended for the same purpose; it coagulates albuminous material, and is antiseptic (Ranking, i., 1873).

Ascarides, etc.—A strong injection of salt into the rectum is a popular cure for these parasites, and is best given with quassia or other bitter. (Rectal injections are however of little use in those numerous cases in which the cæcum is the habitat of the worms.) Salt is also taken internally to prevent recurrence of thread or round worms, and so strong at one time was the belief in its efficacy that an ancient law in Holland deprived certain criminals of salt in their diet, in order to allow intestinal worms to develop and devour the victims!

Leeches are very sensitive to the action of salt; it will make them disgorge blood they have swallowed, and a saline injection will dislodge them from the rectum or vagina. It is advisable to administer the same remedy freely should they by accident have passed from the nose or mouth to the stomach.

Fractures, etc.—The silicate of sodium (water-glass) is used like the analogous salt of potassium. Bandages soaked in the fluid harden into a light firm support in twenty-four to forty-eight hours. The plaster of Paris bandages dry more rapidly and have in a measure replaced those made with the silicates.

THERAPEUTICAL ACTION. — *Internal.* — Comparing sodium with potassium we find the former more indicated in disorders of the stomach, the primæ viæ, and the liver, whilst the latter, acting better as a diuretic and a solvent of uric acid, is more appropriate in renal congestions and lithiasis.

Dyspepsia.—Sodium salts are very useful in several forms of indigestion, but the dose and mode of administration vary somewhat according to the conditions present. In cases of *atonic* dyspepsia connected with deficient secretion of gastric juice, the bicarbonate in small doses of 5 to 10 gr. should be given, and shortly *before* a meal, on the principle already alluded to, viz., that an alkali causes increase of an acid secretion, for though on first contact it neutralises the acid it meets with, additional acid is very quickly poured out so as to leave an excess. The alkali may in some cases be very suitably combined with an aromatic as in "Gregory's powder," with ginger only, or with a bitter, like tincture of orange or infusion of gentian. On the other hand, in cases of *acid* dyspepsia, with thickly coated or red shining tongue, sour eructations, heartburn, and flatulence, larger doses of the bicarbonate (15 to 20 gr.) should be given an hour or more *after* a meal, according to the time at which the symptoms come on; in this case also, the remedy may be well combined with an aromatic or stimulant, as ammonia or peppermint. Soda is especially useful for the dyspepsia of those who live in towns, eating and drinking freely, and taking little exercise. If the urine be scanty and irritating, nitre may be given at the same time, and according to Dr. Budd, an occasional blue pill. The taurocholate of sodium, which may be obtained in powder form from bile, has been found useful in the dyspepsia of gouty and "bilious" subjects; 2 to 5 gr. are given in pill, which should be coated with keratin. A dry skin and very furred tongue are other indications for soda, whilst for those who live in the country, take more vegetable food, and perspire freely, acids usually agree better (Med. Times, i., 1854).

The familiar use of salt is of no small importance in stimulating appetite and digestion. Dr. Symonds states that "duodenal dyspepsia" with its attendant "bilious headache" may often be relieved for a long period by the daily taking of a tumblerful of "salt and water" before breakfast (Med. Times, i., 1858). An

effervescent mixture containing sodium carbonate or sulphate is often efficacious in such headaches.

Lientery.—In this species of diarrhœa of young children, Rabuteau has found salt curative after other remedies had failed.

In **Vomiting** or **Diarrhœa** connected with acidity or with incomplete digestion of fatty food, the bicarbonate of sodium with an aromatic such as cinnamon, is very good. In children with coated, irritable or aphthous tongue, it may be combined with a little grey powder, and for adults, especially if colic is present, it may be given in effervescence with opium. In cases of dyspepsia, etc., in weakly subjects, the use of alkalies must not be too long continued.

Hepatic Disorders.—For congestion of the liver with deficient excretion of bile, soda is of proved value in several combinations, and it relieves such symptoms as have been already described under dyspepsia.

Phosphate of sodium especially is said to promote the flow of bile, and acting in full doses as a gentle laxative it is useful in "bilious or sick headache," and in catarrhal jaundice. It has some value also in preventing biliary calculus, which condition arises generally from continued catarrh of the bile-duct and inspissation of mucus and bile. (Vichy water presents a good natural combination for such cases, and for chronic hepatic congestion.) The salt cannot be expected to control fully developed attacks of biliary colic, but if a dose of 20 or 30 gr. be taken regularly before meals for some months, it seems to have the power of lessening the calculi, or preventing fresh formations; from larger doses (1 to 2 dr.) of the carbonate in copious draughts of hot water, Dr. Prout has often seen immediate relief even during the attack of colic. The salicylate is still more effective in 10 to 15 gr. doses two or three times daily.

In *fatty degeneration of the liver* we have the authority of Dr. Murchison for saying that large quantities of common salt eaten with the food have proved useful, and there is at least encouragement to try saline waters in this condition. In the case of ill-conditioned children passing pale and pasty stools 5 or 10 gr. of the phosphate taken with meals will often serve to regulate digestion and improve nutrition (Stephenson).

Renal Diseases.—In cases of calculous (uric acid) diathesis,

if it be desired to keep the system under the continued influence of alkalies, the salts of sodium have sometimes been preferred in weakly dyspeptic subjects, being less depressing than those of potassium commonly used. The waters of Vichy have a special reputation in such conditions, and under their influence a urate of sodium replaces uric acid in the urine, and is more readily eliminated. The phosphate was especially commended by Liebig and by Golding Bird as a solvent of lithic deposit. Sir A. B. Garrod regards sodium salts as less valuable than those of potassium, and still less than those of lithium; sodium urate being the least, and lithium urate the most soluble of the three.

Gout.—Although it is true that Vichy water relieves some symptoms of gout, there is evidence that in many cases salts of soda act unfavourably. The theoretical explanation is that normally uric acid circulates as a quadri-urate which is readily eliminated, but under certain conditions and in presence of an extra amount of sodium carbonate an additional atom of the base is taken up, the less soluble bi-urate is formed, and ultimately precipitated in joints and elsewhere.

In **Albuminuria** it has been recommended to supply alkalies freely to the blood, in order to lessen the liability to inflammation, and to dissolve fibrinous deposits. It has been taught also that they further the oxidation which is deficient in this dyscrasia, but they can only do so in a slight degree, if at all. Soda, like other alkalies, may be occasionally useful in relieving the dyspeptic symptoms, but is no cure for albuminuria, and its prolonged use is contra-indicated by the tendency to anæmia.

Diabetes.—Speaking not of the temporary and accidental passage of sugar into the urine, but of the more permanent malady, diabetes, we find that small doses of bicarbonate or of chloride of sodium often lessen the amount of sugar passed (Clarke of New York and others).

The citrate, ½ to 1 dr., used instead of common salt with the food, is said "to cure saccharine urine" (Ranking, ii., 1866), and alkaline waters have been largely used in the treatment of this condition. At Vichy and similar springs it is found that stout diabetics derive advantage from the waters, when thin and pale patients do not. Transitory cases such as have arisen from temporary nervous causes, from carbuncle, etc., often do well at

Vichy, and even old-standing cases have been relieved, but those with marked lesion of the pulmonary or digestive organs are not suitable for this treatment.

Ebstein reports favourably of Carlsbad and other alkaline waters, especially for mild cases (Med. Times, i., 1875), also Kraus (Monograph on Carlsbad, 1891). According to the theory of Mialhe they should help to oxidise sugar in the system, but their use cannot be based on this hypothesis. Poggiale fed dogs with non-nitrogenous food—starch and sugar—to which he added enough soda to render the urine alkaline, but their blood contained as much glucose as that of dogs fed without any soda; also he injected glucose into the blood of rabbits, and again injected it mixed with soda, in each case finding sugar in the urine, whilst under tartaric acid the sugar disappeared (Bull. de l'Acad., 1866). Bouchardat on the other hand, points out that alkalies may act dangerously in increasing both the fluidity of the blood and the tendency to apoplexy or pulmonary congestion, and Rabuteau cites several cases that died soon after commencing Vichy treatment. He suggests that whatever benefit is derived from sodium salts is really due to the chloride, and according to Nasse and others this salt is deficient in the blood of diabetic patients. Martin Solon (Bull. Gén., 1842-43), Constant (Thèse, 1844), and Bouchardat have reported some clinical illustrations of the good effects of salt given as medicine to such subjects.

Struma—Phthisis.—Some writers have much insisted on the therapeutical virtues of salt in these diseases. Durand Fardel reported instances of benefit, and Amedée Latour reduced its administration to a system; he gave it to well-fed goats, and then used the goats' saline milk largely in the diet of his patients; he employed also all hygienic means, and obtained good results (Union Méd., 1851-56; Brochure, 1857). Piétra Santa is another advocate for the systematic use of salt in phthisis, recommending a "syrupus natrii chlorati." Dr. Cotton however, could not trace any definite effects from salt in his treatment at Brompton Hospital. The saline baths of Soden, in Nassau, have a reputation in similar cases, and in *obstinate bronchial catarrh* the waters of Ems, etc., are often prescribed with advantage: they may be given diluted with warm milk, especially in the early morning.

Intermittent Fever.—There is evidence of a favourable influence being exerted by salt in ague and some of its complications. Piorry used it, and Gintrac gave 30 grammes daily with success, except in quartans; he did not verify reduction of the spleen (Bordeaux, 1850), but Herschel and Rondelet have done so after a more prolonged use of the remedy. At Bruges forty-eight cases were reported, and all of them, except the quartans, were convalescent in three to four days, after taking from 30 to 45 grammes of salt daily, freely diluted; it cleansed the furred tongue and improved appetite. Out of fifty-two cases reported from Africa the greater number were cured with 15 gramme doses of salt (Union Méd., 1851), and Villemin states that, according to his experience at Damascus, common salt stopped attacks of ague six times out of every seven, ½ oz. doses being given two, three, or four times (Gaz. Hebdom. de Méd., March, 1854). Mareschkin, a Russian physician, has given further evidence to the same effect (Bull. Gén. de Thérap., vol. li.).

Cholera.—The carbonate of sodium has been used both by the stomach and by injection in cases of cholera, but the chloride has been more depended upon.

A reasonable argument may be given for its employment, for a main fact in the disease is profuse discharge from the vessels of the intestinal tract into the alimentary canal; this by itself can determine the cyanosis, shrunk features, blood stasis, etc. It depends upon a change in the albuminous constituents of the blood, and is increased by desquamation of intestinal epithelium, whilst by saline injections the loss of fluid may be compensated. Both rectal and venous injections have been used (*v.* p. 832).

During an epidemic at St. Petersburg (1830), salt water and salt milk relieved as much as any other remedies. In 1835, at Paris, Bracton reported fifty cases of Asiatic cholera treated with common salt, and only one was fatal; two table-spoonfuls were given dissolved in 6 oz. of water. Chomel, Aran, Richard and others reported good results from the same treatment in the epidemic of 1865. On the other hand Husemann concludes that the use of salt has no really good effect, and states that its intravenous injection has sometimes caused asphyxia.

For **Dysentery,** the sulphate of sodium has been much commended by American writers: 1 dr. is given with ⅛ gr. of mor-

phine every two hours, until natural though loose evacuations occur; this treatment is said to control the malady in two or three days (Med. Record, 1872).

Typhoid Fever.—It is the experience of Dr. J. S. Peatson that the liquor sodæ chlorinatæ, if given sufficiently early, will cause abortion of this fever (Lancet, ii., 1885):—another illustration of the value of antiseptic treatment.

Constipation.—On the other hand sodium sulphate, when given in larger doses of ½ oz., is a useful saline purge in inflammatory conditions, and is an ingredient in several natural aperient waters: if given with sulphate of magnesium or acid tartrate of potassium, smaller doses (1 to 2 dr.) may be used. The phosphate of sodium acts in the same manner on the intestinal tract, and has a more decided diuretic action; it renders the urine alkaline. Tartarated soda is an ingredient in Seidlitz powders.

Epistaxis—Embolism.—Common salt is an ordinary domestic remedy for bleeding at the nose, and even for hæmoptysis, and cases of the former are sometimes favourably influenced by it when given in drachm doses. Some attribute the benefit from salt in hæmorrhage to the nausea excited, but it is more likely that it results from a reflex contraction of vessels consequent on the irritation of gastric nerves. It has been stated that in *embolism* the collateral circulation becomes better established under the influence of an alkali (sodium carbonate) though the thrombus itself is not affected (Brit. For. Rev., ii., 1861).

Uterine Inertia.—Borax has some stimulating effect upon the uterus, as shown by its increasing the contractions during labour; it has been used in lingering cases, though generally combined with ergot and cinnamon. It has been given also in *amenorrhœa*, with or without aloes, and in *dysmenorrhœa* with belladonna, but is not in general use. Since this is the only sodium salt that acts upon the uterine system, it probably does so through the boracic acid.

Epilepsy.—Borax is an old remedy for this disorder, and still finds a useful place in its treatment, *e.g.*, 15 grains thrice daily were effective in a case of four years' duration—the only drawbacks were some sickness if taken fasting and some sleeplessness (B. M. J., ii., 1882).

Drs. Russell and Taylor report good results from borax, but

find it apt to cause a scaly skin eruption (Lancet, i., 1890). Gowers has found borax useful in some cases of inveterate epilepsy in which bromide had no influence, and has given it in 15 to 30 grain doses thrice daily for years, without any ill-effects beyond an occasional eruption of psoriasis (Diseases of the Nervous System). (See also Therap. Gazette, 1890.) I find 10 grain doses as much as can usually be borne, and have seen much benefit from them, but dyspepsia sometimes follows.

PREPARATIONS AND DOSE.—*Soda caustica* (used externally as a caustic). *Sodæ liquor:* 10 to 60 min., freely diluted. *Sodæ chlorinatæ liquor:* 10 to 20 m.; 2 to 6 dr. in 10 oz. water as gargle, etc. *Cataplasma sodæ chlorinatæ* (1 part to 2 of linseed meal and 4 of boiling water). *Sodii arsenias:* $\frac{1}{10}$ to $\frac{1}{8}$ gr. *Sodii arseniatis liquor* (gr. 1 in 107 m.): 3 to 10 m. *Sodii benzoas:* 10 to 30 gr. or upwards (in spray, 5 per cent.). *Sodii biboras:* 5 to 40 gr. (*glycerinum boracis—mel boracis*, each *about* 1 in 7, by measure). *Boroglyceride* (non-off.), made by treating 92 parts glycerine with 62 boric acid. *Sodii bicarbonas:* 10 to 60 gr. *Sodæ liquor effervescens* (soda water, contains about 30 gr. of bicarbonate to the pint). *Trochisci sodii bicarbonatis:* 5 gr. in each. *Sodii bromidum:* 10 to 30 gr. and upwards. *Sodii carbonas:* 5 to 30 gr. *Ib. exsiccata:* 3 to 10 gr. *Sodii chloras* (non-off.): 10 to 30 gr. *Sodii chloridum:* as emetic $\frac{1}{2}$ oz. or upwards. *Sodii citras* (non-off.): 10 to 60 gr. *Sodii citro-tartras effervescens:* 60 to 120 gr. and upwards. *Sodii ethylatis liquor* (caustic). *Sodii hippuras* (non-off.): 5 to 30 gr. *Sodii hypophosphis:* 1 to 10 gr. *Sodii hyposulphis* (*thiosulphas*) (non-off.): 10 to 60 gr.; as lotion 1 in 10. *Sodii iodidum:* 3 to 20 gr. *Sodii nitras* (to prepare the arseniate). *Sodii nitris:* 2 to 5 gr. *Sodii permanganas* (non-off.) (disinfectant, green in colour). *Sodii phosphas:* 20 gr. to 1 oz. *Sodii phosphas effervescens:* $\frac{1}{4}$ to $\frac{1}{2}$ oz. *Sodii salicylas:* 10 to 30 gr. (this combined with *Theobromin* = "Diuretin": 15 gr.). *Sodii santonas* (non-off.): 5 to 10 gr. *Sodium silicate* ("soluble glass") (non-off.). *Sodii sulphas* ("Glauber's salt"): $\frac{1}{4}$ to 1 oz. *Sodii sulphas effervescens:* $\frac{1}{4}$ to $\frac{1}{2}$ oz. *Sodii sulphis:* 10 to 60 gr. *Sodii sulphocarbolas:* 10 to 15 gr. *Sodii sulphoichthyolas* (non-off.): 3 to 10 gr. *Sodii sulphovinas* (*sulphethylas*) (non-off.): $\frac{1}{2}$ to 1 oz. as aperient. *Soda tartarata* ("Rochelle salt"): 1 to 4 dr. *Soda tartarata effervescens* (Seidlitz powder): 120 gr. with 40 gr. bicarbonate in blue; tartaric acid, 37 gr. in white paper. *Sodii taurocholas* (non-off.): 2 to 6 gr. *Sodii telluras* (non-off.): $\frac{1}{3}$ to $\frac{2}{3}$ gr. in pill. *Sodii valerianas:* 1 to 5 gr. "Carlsbad salt," artificial, contains of dried sulphate of sodium, 44 parts; bicarbonate, 36; chloride, 18; potassium sulphate, 2; mixed and finely powdered: 20 to 60 gr. and upwards.

NITRITE OF SODIUM ($NaNo_2 = 69$).

This salt differs so much in its physiological action and therapeutical applications from the other sodium salts that it will be more convenient to take it separately.

Its action resembles that of the other nitrites, and depends upon the nitrous acid rather than on its metallic constituent.

It is prepared by heating the nitrate of sodium (**Na No_3**) which parts with an atom of oxygen when so treated.

PHYSIOLOGICAL ACTION.—Barth was the first to recognise that the poisonous effects of the nitrates of sodium and potassium, as occasionally observed, were due to admixture of these salts with the corresponding nitrites (Toxicolog. Untersuch. ueber Chili-salpeter, Inaug. Diss. Bonn, 1879). Reichert and Weir Mitchell found that sodium and potassium nitrites had physiological actions almost identical with that of amyl nitrite (Am. J. Sc., 1880). Gamgee pointed out that its action on the blood resembled that of nitrite of amyl (Proc. Roy. Soc., Ed., 1867), and various authors as Drs. Hay (Pract., 1882) and Leech (B. M. J., ii., 1885; i., ii., 1893) have found clinically that it closely resembles other nitrites in action. It is decomposed by the acids of the stomach, and though the nitrous acid set free is in part absorbed, there is considerable loss by escape and decomposition of the acid vapour. Dr. G. A. Atkinson gives a very complete description of its action on man and animals (J. Anat. and Physiol., 1888). In frogs it causes progressive enfeeblement of the muscular and nervous systems, with depression of the heart and respiration. It is a very powerful muscle poison, the gastrocnemius muscle of the frog losing its contractility in thirty to forty minutes in a 1 per cent. solution, and in three or four hours in a 1 per 1000 solution. The blood becomes chocolate-coloured from formation of methæmoglobin.

In mammals there was general depression, dilatation of blood-vessels, quick and shallow respiration, and very rapid action of the heart. The blood-vessels wherever visible were chocolate-coloured, and voluntary and reflex movements gradually ceased. After death the venous system was found to be greatly engorged, blood chocolate-coloured, muscles inexcitable to electric stimulation, the right ventricle in full diastole, the left in moderate systole. Dr. Atkinson, after taking 8 grains by the mouth felt very faint, the pulse was accelerated, but there was no flushing of the face such as occurs after amyl nitrite. No sickness was produced, but the eructations of oxides of nitrogen continued for some time. In rabbits the blood-pressure was very much diminished, while after large doses the temperature also fell.

Excretion.—The greater part is excreted in the urine as nitrate of sodium, but much is found unchanged, while traces of nitrite may be detected in the saliva and perspiration.

Nitrite of sodium closely resembles in action amyl nitrite (*q. v.* for greater details) but being less volatile it is much more slowly excreted and maintains its action longer. Its action is, moreover, purely that of nitrous acid, which is not the case with ethyl or amyl nitrite: it is less likely than nitro-glycerine to cause headache (Leech).

THERAPEUTICAL ACTION.—*Internal.*—**Epilepsy.**—Dr. W. T. Law treated a case of epilepsy with the salt, giving doses of 20 gr., and the result was exceedingly favourable (Pract., i., 1882).

Dr. C. H. Ralfe also found that the drug was sometimes useful in epilepsy, where potassium bromide produced no improvement (Lancet, ii., 1882).

The papers of Drs. Ringer and Murrell brought the drug prominently before the notice of the profession, whilst it showed the danger of giving the pure drug in such large doses as Dr. Law had previously used. The latter obtained no ill-effects from 20 gr. doses because the salt he used was largely adulterated with the nitrate. Drs. Ringer and Murrell however found that doses of 10 gr. may produce dangerous symptoms, of which the most prominent are giddiness and sickness (Lancet, i., 1883).

This paper caused many practitioners to abandon the use of the drug altogether as dangerous, but there can be no doubt that in doses of 2 to 3 grains it is worthy of trial in cases where bromides are of no avail. (It has been stated by several good observers that this salt and nitrite of amyl increase the elimination of uric acid.)

Angina pectoris.—As Dr. Hay has shown the similarity between nitro-glycerine and the nitrites of amyl and of sodium in physiological action, so also he has demonstrated that the nitrite of sodium may be employed in angina pectoris like the other two drugs mentioned; the effects are less quickly produced, but continue for several hours longer, and Dr. Fraser has shown a similar result in cases of dyspnœa connected with asthma, etc. (Internat. Journ., Oct., 1887). Dr. Hay has proved that the nitrous acid is the main element that affords relief and independently of the base with which it is conjoined, though amyl

has also some influence. Dr. Lauder Brunton's observations tend in the same direction (Pract., i., 1883). Dr. Pearse also has recorded cases of asthma relieved by 3 to 4 gr. doses of nitrite of sodium (Pract., 1891). In nine cases of bronchitic asthma, in neurotic subjects, I tried it, but in none was definite relief experienced.

STANNUM—TIN (Sn = 118).

This metal is known to occur only in the mineral kingdom, and in minute quantity in the water of Saidschütz.

CHARACTERS AND TESTS.—Silver-white in colour, with a tinge of yellow and high metallic lustre, unaffected by moisture or exposure, inelastic, but flexible; when rubbed it imparts to the fingers a peculiar odour. It is a good conductor of heat and electricity, has a specific gravity of 7·292, melts at 442° F., and at a higher temperature burns with a brilliant white light; at ordinary temperatures it is not brittle, but when heated to near the fusing point may be easily powdered. Nitric acid does not act upon it, except in presence of water; hydrochloric acid dissolves it with evolution of hydrogen. *Granulated tin* (B.P.) is the metal reduced to small fragments by pouring it when fused into cold water.

Solution of *chloride of tin*, $SnCl_2$ (Appendix, B.P.), absorbs oxygen readily, and hence is a powerful deoxidising agent. It reduces to the metallic state the salts of mercury, silver, gold, etc., and is made use of for this purpose; also as a test for ammoniated mercury.

PHYSIOLOGICAL ACTION.—*Internal.*—The metal itself is inert, but if taken into the stomach may be so far acted on by acids or saline substances as to be rendered soluble in the form of chloride, and may then produce some irritant effects. The fact of such a change sometimes occurring and sometimes not, may explain the disagreement between the results of Orfila, who considered oxide of tin to be a poison, and Schubarth, who considered it inert. Patenho, of St. Petersburg, gave to dogs 3 gr. of finely powdered tin daily for six weeks without any effect; he could detect none in the urine—it seemed all to pass by the fæces. Worms were not expelled under its use, as they were found in the

intestines on section (Lancet, i., 1886). Dr. T. P. White attributes to tin a direct irritant action on the intestine, as well as tremor and weakening of functions such as the respiratory, which depend on the cord and the medulla (Phar. J., 1887).

It has been said that fatty, or acid, or simply albuminous articles of food, after having been kept in tinned vessels (free from lead) have sometimes occasioned colic and vomiting, but this must be exceptional. We may note that arsenic is a usual constituent of tin-ores, and in small quantity it is generally present in all tin that has not been carefully purified, and irritant effects may have occurred from it. The resemblance in physiological action between lead and tin has been already mentioned.

The *chloride* or "*butter of tin*," is stated to exert a tonic, antispasmodic effect when given in small quantities, but in large doses it causes muscular twitching, convulsion, and paralysis; also some gastro-intestinal irritation, with dryness of the mouth and throat. Patenho found the bichloride given subcutaneously cause local anæsthesia, and if in strong solution, gangrene: in the veins less than $\frac{3}{4}$ gr. proved fatal—by the stomach it only caused some indigestion (*loc. cit.*).

THERAPEUTICAL ACTION.—**Intestinal Worms.**—The powder of tin (tin filings) has been used as a vermifuge in cases of lumbricus and tænia.

Trousseau remarks that of all metals after mercury, tin has been in the highest repute as anthelmintic, and many secret vermifuges contain either the finely-powdered metal or its sulphide: from 30 gr. to $\frac{1}{2}$ oz. have been given in electuary. Alston gave 1 oz. at a time, but severely irritant effects sometimes followed. Professor Stillé quotes several authorities in favour of the remedy, and Dr. Graves speaks well of it (Lectures), but it is not now much used, because more trustworthy medicines have been found. It is supposed to act either mechanically or by disengagement of hydrogen or other chemical effects. Salts of di-stann-ethyl have a strong purgative action (Jolyet and Cahours).

In **Epilepsy, Chorea,** and allied forms of nervous disorder, the chloride of tin has been given with benefit, according to the observations of Dr. Schlessinger (Med.-Chir. Rev., Oct., 1838, and April, 1846).

In **Chronic Skin Diseases,** the same physician recommends it both internally and in lotion, but its real value is not ascertained.

PREPARATIONS AND DOSE.—*Pulvis stanni* (non-off.): dose 20 to 40 gr. as a vermifuge—it may be given in honey or treacle three or four times daily for several days, and should then be followed by a cathartic. *Stanni chloridum*: dose, $\frac{1}{10}$ to $\frac{1}{2}$ gr. two or three times daily in pill or in chloric ether—*a lotion* may be made with 1 gr. to the ounce.

ZINCUM—ZINC (Zn = 65).

This mineral is obtained for commercial purposes, mainly from two ores—the carbonate (calamine) and the sulphide (blende) —by distillation with carbon. It has been found also in plants which grow on the calamine hills of Rhenish Prussia. It is liable to contain admixtures of arsenic, iron, copper, and sulphur. Alloyed with copper, zinc forms brass, with nckel, man silver." It is extensively used in galvanic combinations, and forms the positive plate of many voltaic batteries; as a coating on iron (galvanised iron) it protects that metal from oxidation. *Granulated zinc* is prepared by pouring the molten metal into cold water.

CHARACTERS AND TESTS.—Zinc is a brittle bluish-white metal, which at a red heat burns with a brilliant flame and emits white fumes of oxide; its specific gravity varies from 6·8 to 7·2. It is the only metal which yields a white sulphide with sulphide of ammonium, and hence this reaction is the characteristic test for it. Fixed and volatile alkalies also give with zinc white precipitates, soluble in excess of the reagents.

COMPOUNDS OF ZINC.

ZINCI OXIDUM—OXIDE OF ZINC (ZnO = 81).

PREPARATION.—It is obtained by exposing the carbonate to a dull red heat until all the carbonic acid is driven off.

CHARACTERS AND TESTS.—A white heavy powder, without taste or odour, insoluble in water, soluble in acids; moderate heat renders it yellow. Commercial specimens are often impure from presence of carbonates, sulphates, chlorides, iron, etc.

ZINCI CHLORIDUM—CHLORIDE OF ZINC ($ZnCl_2 = 136$).

PREPARATION.—It is prepared by dissolving zinc in hydrochloric acid and evaporating the solution ; chlorine water is then added (to combine as chloride with the iron usually present), and afterwards zinc carbonate, which forms more zinc chloride and precipitates ferric oxide.

CHARACTERS.—Chloride of zinc is soft, white or semi-transparent, crystalline or waxy, and is met with either in opaque tablets, or in pencils like nitrate of silver. It is very soluble and deliquescent, but if mixed with an equal part of oxide (oxychloride), may be kept dry for a long time.

Liquor zinci chloridi.

ZINCI SULPHAS—SULPHATE OF ZINC—WHITE VITRIOL

($ZnSO_47H_2O = 287$).

PREPARATION.—It is prepared by dissolving zinc in dilute sulphuric acid : chlorine water and carbonate of zinc are added, as in the last preparation, and for the same purpose, viz., to remove any iron that may be present.

CHARACTERS.—It occurs in prismatic crystals, which may be large or small. The latter much resemble in appearance those of sulphate of magnesium, but their strong styptic taste will distinguish them from the bitter magnesium salt; they redden litmus and effloresce in air.

CALAMINA PRAEPARATA—PREPARED CALAMINE.

PREPARATION, etc.—This is the native carbonate calcined in a covered earthen crucible at a moderate temperature, powdered and freed from gritty particles by elutriation. It is a pale, pinkish brown powder, almost entirely soluble, with effervescence, in acids.

Unguentum calaminæ.

ZINCI CARBONAS—CARBONATE OF ZINC

($ZnCO_3(Zn2HO)_2H_2O = 309$).

PREPARATION.—It is obtained by adding carbonate of sodium to a boiling solution of sulphate of zinc, and drying the precipitate ; if cold solutions be used, the precipitate is gelatinous (the compound formed is really a hydrated oxycarbonate, as in the formula).

CHARACTERS.—A soft, white powder, resembling magnesia, insoluble in water, tasteless and inodorous.

ZINCI ACETAS—ACETATE OF ZINC ($Zn(C_2H_3O_2)_2\ 2H_2O = 219$).

PREPARATION, etc.—By dissolving the carbonate in acetic acid. It occurs in thin, lustrous, micaceous plates, having a sharp astringent taste.

ZINCI VALERIANAS—VALERIANATE OF ZINC

$(Zn(C_5H_9O_2)_2 = 267)$.

PREPARATION.—It is obtained by mixing concentrated solutions of sulphate of zinc and valerianate of sodium.

CHARACTERS.—It occurs in brilliant scaly crystals, which have an odour of valerian, and a metallic taste; they are soluble slightly in cold water or ether, freely in hot water and in alcohol. It is liable to be contaminated with butyrate of zinc.

ZINCI SULPHOCARBOLAS—SULPHOCARBOLATE OF ZINC

$(Zn(C_6H_5SO_4)_2H_2O = 429)$.

PREPARATION.—It is obtained by heating a mixture of carbolic and sulphuric acids, saturating the product with oxide of zinc, and crystallising.

CHARACTERS.—It occurs in colourless, transparent, tabular, efflorescent crystals, which are soluble in about twice their weight of rectified spirit or of water.

OLEATUM ZINCI—OLEATE OF ZINC.

PREPARATION.—It is prepared by stirring oxide of zinc with oleic acid and allowing the mixture to stand for two hours; it is then heated on a water bath till the oxide is dissolved. It forms a fine pearl-coloured powder, smooth to the feel like "French Chalk."

Other compounds of zinc which are used medicinally, but which are not official, are the *bromide*, the *iodide*, and the *phosphide*.

ABSORPTION AND ELIMINATION.—Soluble salts of zinc, such as the *chloride*, *sulphate*, and *acetate*, are readily absorbed, and pass into the blood probably as albuminates. The *oxide* and the *carbonate* are also dissolved to some extent by the acids of the gastric juice, and then slowly absorbed; independently of clinical evidence of this, the oxide has been detected by Schlossberger in the urine, and by Michaelis in venous blood.

Zinc does not seem to be deposited in the tissues in the same manner, or for so long a period, as mercury, lead, or copper, although Lechartier and Bellamy have detected it in the bodies of animals to whom the metal had been previously administered (Med. Record, i., 1877). The soluble salts are eliminated soon after being taken, but the insoluble ones are not found in the excretions until four or five days afterwards (Michaelis). The

metal passes out mainly by the bile and the intestinal secretions; in smaller amount by the urine.

PHYSIOLOGICAL ACTION.—*External.*—The oxide and the carbonate of zinc in powder, act mechanically as absorbents and sedatives. The sulphate and the acetate in the solid state, act as efficient, but not very severe caustics, if the epidermis be removed; in dilute solution they act as astringents. The chloride and nitrate exert a strongly caustic effect by virtue of their affinity for water, and their power of coagulating albuminous material; the former especially, being deliquescent, penetrates deeply into the tissues, and causes severe burning pain; the eschar produced is white and hard, and separates in five or six days; when formed from deep tissues it is of a spongy character, but dry on exposed surfaces. Zinc chloride is a powerful disinfectant, and even in dilute solution proves fatal to bacteria, etc.; according to Calvert's experiments, it is only equalled in efficacy by mercurial chlorides and the tar acids (Lancet, ii., 1873; Med. Times, ii., 1852).

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—The oxide and carbonate in doses of a grain and less, exert an astringent and somewhat sedative action on the gastro-intestinal tract, markedly lessening its secretions. The sulphate in small non-irritant doses, is still more astringent. All zinc compounds have a tendency to excite nausea and irritation of the stomach; the oxide and the carbonate, though tasteless, show this effect when given in doses of from 1 to 5 gr. and upwards. The soluble salts have a styptic metallic taste, and the sulphate, in doses of 10 gr. and upwards, acts as a prompt and thorough emetic without much nausea or prostration, though often with diarrhœa; this action is not purely a local one, because it is equally produced by intravenous injection of the salt. Emesis however, is not a constant effect, for if the drug be taken at first in small doses and continued regularly, a certain tolerance is established, and then 10 to 20 gr. doses may be taken without disorder of the stomach. Caution is required in the continuance even of small doses, since they have been said to cause ulceration of the mucous membrane, and ultimately symptoms like those of lead poisoning, such as emaciation, anæmia, debility, fœtor of breath, constipation and colic, also tremor and paralysis. Symp-

toms of acute irritant poisoning, such as pain, vomiting, convulsions and collapse, have followed doses of 30 to 60 gr. and sometimes concentrated solutions have caused death (Med. Times, ii., 1862), but the salt has rarely proved fatal, because of its being so soon rejected; persons have recovered after taking an ounce or more.

The chloride is much more corrosive in character, and is unsuited for internal use—5 to 10 gr. have produced severe irritant symptoms. It has been a not infrequent source of fatal poisoning in the form of Sir W. Burnett's disinfecting fluid, which is an impure solution of it, somewhat oily in character, and either colourless or of yellowish tinge, from the presence of some ferric oxide; it has been mistaken for fluid magnesia, for mineral waters, and for pale ale, the fact of its frothing up when shaken contributing to its resemblance to the last-mentioned; one fl. oz. has been found to contain from 100 to 372 gr. of solid chloride, and less than that quantity has proved fatal, though not invariably.

Nervous System.—The oxide of zinc has been credited with a special action on the nervous system, of tonic character in small, but depressant in large doses. Dr. Marcet traced drowsiness to its use, and others have recorded giddiness after taking it, and generally depressed nervous and mental conditions from the prolonged continuance of large doses (Med. Times, 1858; Med.-Chir. Rev., ii., 1861). In cases of ultimate recovery from the effects of large doses of zinc salts there have been, besides the gastric symptoms, signs of impaired nervous power, with perversion of taste and smell, tremor, or partial paralysis. Exposure to fumes of the molten metal, as in the course of certain metallic castings, gives rise to a curious train of symptoms, mainly nervous, and commonly known as "brassfounders' ague," including general malaise, tightness of chest, a cold stage with rigors, followed by a hot stage with profuse sweating. These symptoms may recur periodically for several days.

Cutaneous and Renal Systems.—The internal administration of the oxide or other astringent zinc salts, checks the secretions of the skin.

Helpup made a large number of experiments on rabbits and cats with zinc salts, given subcutaneously and by the mouth, for several days or weeks. In 79 per cent. of these, parenchymatous nephritis was induced (Deuts. med. Woch., 1889).

SYNERGISTS.—The oxides of silver and of bismuth are much allied in action with oxide of zinc : henbane and belladonna assist its power of controlling perspiration. The chloride of zinc resembles in corrosive and disinfectant properties the chloride of mercury, and both the chloride and nitrate are allied in action with other mineral caustics.

ANTAGONISTS.—The chemical antidotes in cases of poisoning by the corrosive compounds of zinc are lime-water, alkaline carbonates and tannic acid ; these should be given in mucilage or milk. Valerianate of zinc is decomposed by acids and by most metallic salts. Purgatives and diaphoretics interfere with the action of zinc salts.

THERAPEUTICAL ACTION.—*External.*—**Lupus, Cancer, etc.**—The chloride of zinc was first introduced as a secret remedy for cancer by Canquoin in Paris in 1837, and was combined with sanguinaria in the paste of Dr. Fell, which had a temporary popularity (Med. Times, i., 1858). Veiel recorded excellent results from its use in lupus (Med.-Chir. Rev., ii., 1860), and it is certainly a trustworthy escharotic. I have seen immediate improvement from it in some very severe cases, especially of facial lupus and rodent ulcer. It has disadvantages in being deliquescent, and hence readily penetrating adjacent healthy tissues and disposing to hæmorrhage, but when mixed with flour, zinc oxide, or better still with calcium sulphate or gutta-percha, it becomes quite manageable. The nitrate of zinc, though not in such frequent use, has, perhaps, advantages over the chloride ; according to Mr. Marshall it penetrates deeper and causes less pain : in lupus it was commended by the late Dr. Tilbury Fox, and I have had successful results with it, generally using a paste made with equal parts of nitrate, flour, and mucilage spread on lint.

In *lupus erythematosus* a lotion of zinc sulphide is sometimes useful.

Both nitrate and chloride are equally applicable to all forms of strumous and syphilitic ulceration. Franchi reports arrest in some very severe cases of this kind, when acid nitrate of mercury and iodine had been tried without success (Gaz. Méd. de Paris, Feb., 1876). Maisonneuve used the chloride made into a firm paste with flour in the form of flèches (" arrowheads ") which he thrust into incisions all round a morbid growth, thus destroying a zone

of tissue and separating the tumour; but this process is more painful and prolonged than the use of the knife, and does not prevent recurrence better than an equally extensive incision.

Sir J. Y. Simpson advocated sulphate of zinc in powder as the best caustic for these maladies, whether affecting the uterus or other parts: it is simple, easily applied and managed, safe, efficient, fairly rapid in action (five or six days), and does not deliquesce. In cases where the epithelium was destroyed, he applied the anhydrous salt in fine powder or mixed with glycerine into a paste (1 oz. of sulphate to 1 dr. of glycerine). In other cases, *e.g.*, of cancer of the breast, he mixed the salt with sulphuric acid and scored the part with a quill at successive applications (Med. Times, i., 1857 and 1859); he records many good results, which were to some extent corroborated, but his practice has not been largely followed. Mr. Erichsen found it very painful (*ib.*).

Warts—Nævi.—The strong chloride is useful for destroying warts and superficial nævi. Mr. Weeden Cooke has suggested a convenient mode of applying it, viz., by soaking lint in the deliquescent salt, drying it, and cutting off suitable pieces when required: if covered it will preserve its power for many weeks (Med.-Chir. Rev., Jan., 1866).

Wounds.—Mr. C. de Morgan and others recommended the sponging of recent wounds, whether from accident or operation, with strong solutions of zinc chloride (20 to 40 gr. in the ounce) on disinfectant principles, *i.e*, to destroy "germs" (Lancet, i., 1866; Med.-Chir. Rev., Jan., 1866). This seems to have good effect in lessening risk of septicæmia, etc., but has in a measure been superseded by the more detailed and exact method of Lister. It is, however, still largely used, and is valuable in many cases: it cleanses the wound and any old sinuses, and lessens and prevents suppuration. Some surgeons employ it specially after excision of malignant tumours.

Eczema—Erythema.—The oxide and the carbonate of zinc and calamine form useful sedative, absorbent, and protective powders for inflamed surfaces, and sometimes are indicated when serous discharge is present: they are generally mixed with $\frac{1}{4}$ to $\frac{1}{2}$ part of a neutral powder, such as that of orris-root, starch, or magnesia. They may be used also suspended in mucilaginous

liquids as a good lotion, *e.g.*, for erythematous acne of the face, or in the form of ointment of oleate of zinc (Crocker, B. M. J., i., 1879), or with vaseline or benzoated lard: benzoated zinc ointment, when properly made, is an excellent application for irritative and eczematous conditions. The "paste" of Lassar is made with zinc oxide and finely powdered starch of each 25 parts, vaseline, 50 parts, and salicylic acid, 2 parts. A lotion containing 5 gr. of sulphate in the ounce relieves the itching of eczema and other skin diseases, but is liable at first to cause some smarting: a strength however of 15 gr. to the ounce with the same of sulphuret of potassium mixed with glycerine and rose-water is useful in acne vulgaris (W. A. Jamieson).

Relaxed or Discharging Mucous Surfaces.—For ordinary relaxed or discharging surfaces, when astringents are indicated, the sulphate of zinc is one of the best: from 1 to 2 gr. in the ounce of distilled water is a usual strength, and combined with a stimulant such as spirit of rosemary or lavender, this forms the ordinary "red lotion" of many hospitals, and is suitable for any indolent atonic ulcerations: sulphocarbolate of zinc also makes a good detergent lotion.

For catarrhal *throat-affections* accompanied with deafness, Dr. Druitt finds zinc sulphate in solution act better than ordinary acid gargles, and Mr. Nunn reports similarly as to the chloride (Med. Times, i., 1857): a spray containing this is excellent for relaxed pharynx and congested vocal chords.

In catarrhal *conjunctivitis* and *otorrhœa*, collyria and weak warm injections of the same salts (2 gr. to the ounce of water) are useful, and 4 gr. to the ounce is a good strength for injection in *ozæna*; morphine, atropine or carbolic acid may be combined with the astringent.

The chloride lotion is also valuable in *gonorrhœal* and *purulent ophthalmia*, and Mr. Hutchinson reports it as less painful than silver nitrate, and sometimes completing the cure when that remedy failed (Lond. Hosp. Rep., 1867-68).

In *leucorrhœa* and *gonorrhœa*, injections containing 1 to 2 grs. (or more) of zinc sulphate or sulphocarbolate to the ounce are very suitable after the early acute stage has subsided (Med. Times, ii., 1870); they are sometimes better combined with an equal quantity of lead acetate. As a general rule, the more acute the condition,

the more frequently should a weak solution (½ gr. or less in the ounce) be applied, and as the inflammation becomes less or passes into a chronic stage, one or two applications daily of a double or treble strength are best. Some time ago I recommended to Dr. Ringer's notice the prescription of a very dilute injection of sulphate (1 to 2 gr. in the *pint* of water) to be used every hour or half-hour from the commencement of a gonorrhœal attack, and his experience supports mine, that this can arrest the disorder in twenty-four to forty-eight hours; care is required so as to avoid risk of pain and swelling of the testicles, *i.e.*, the injection must be used less often or left off, if any such symptoms set in. A stronger solution (1 to 10 gr. in the ounce) is advisable, but used less frequently, in more chronic cases. The chloride, and indeed many other astringent salts, may be used in a similar manner with advantage.

THERAPEUTICAL ACTION.—*Internal.*—**Narcotic and other Poisoning.**—Zinc sulphate is a good emetic for cases of this kind: 10 gr. in warm water is an average dose, but 20 gr. is the amount preferred by many practitioners; if the mouth be firmly closed it may be administered by a tube passed through the nose to the gullet, or by the stomach pump through a gag, and if the larger dose be used, its after-rejection must be secured. When an emetic is given by the stomach, its bulk has an effect in securing the result: thus, the greater quantity of warm water that can be given with the zinc sulphate, the better it will act: time also makes a difference, for smaller doses given slowly have acted better than large ones quickly swallowed. In some cases a few grains have been given by intravenous injection, and have produced emesis.

Gastralgia—Diarrhœa.—Professor Gubler, having remarked the analogous effects of the oxides of zinc and of bismuth, suggested the substitution of the former when expense was an object, and experience has proved that the zinc compound will often act in an extremely satisfactory manner in relieving gastric pain especially when this is followed by diarrhœa from undigested food; it has, however, more tendency to nauseate than the bismuth salt. The dose should commence at 1 gr. and not exceed 3 gr., and should not, as a rule, be given on an empty stomach.

In *dyspepsia* connected with oxaluria, Bartholow has found the sulphate useful, and Gillespie also recommends it (Boston Journ., May, 1868).

Dr. Brakenridge, of Edinburgh, was one of the first to draw attention to the value of zinc oxide in *infantile diarrhœa* (Med. Times, i., 1873), and I have, in common with many others, found it an efficient and non-irritant astringent, especially so in unstable nerve-conditions as during dentition or pertussis.

In *chronic* diarrhœa, and even in *dysentery*, the oxide has acted very favourably, but the sulphate has more decided powers.

Bronchorrhœa.—Excessive secretion from the bronchial tubes is controlled by the oxide and by the sulphate of zinc.

Hyperidrosis.—I can entertain no doubt of the power of zinc oxide to control excessive sweating in phthisis and other exhausting diseases, although it has been denied by some observers. Dr. T. Thompson, one of the first to record this effect, found it increased, as we should expect, by conjunction of the zinc with henbane extract—he prescribed 4 gr. of each substance (Med. Times, i., 1854); and W. Curran and others have corroborated his observations (Lancet, i., 1854; ii., 1868). I generally order 1 or 2 gr. of the oxide with the same quantity of extract of henbane, to be taken at bed-time, and again in the course of the night if necessary. The local application of the oleate in powder is often good, especially in osmidrosis. Thymol, 1 in 500 parts, may be added.

Epilepsy.—The value of zinc salts in disorders of the nervous system has been much disputed, some physicians, as M. Herpin, recording extraordinary results from them, and others, as M. Gubler, denying to them any power.

There can be little doubt that the high estimate formed by M. Herpin of the efficacy of the oxide, and later of the lactate of zinc, in epilepsy, is unfounded—no other observer has verified his results—at the same time we cannot deny altogether their power in some cases. Dr. Wilks has seen benefit from the oxide (Med. Times, i., 1869), and Sir E. Sieveking records successful results, though he does not value it highly. Dr. Russell Reynolds has known it serviceable, and Dr. Radcliff, noting its effect in causing anæmia, suggested that it might best be tried in markedly congestive cases (Lancet, i., 1863). Others have thought it more

applicable when the epilepsy was complicated with gastric disorder, and others again have seen the best results from it when used in conjunction with digitalis (Lancet, ii., 1868; Med. Times, ii., 1874).

Charcot observed benefit from the bromide of zinc (B. M. J., ii., 1877), and others have advised it in hystero-epilepsy, as having a special action on the medulla; but Dr. Gowers in his lectures, considers that salt of little value, and has found it badly borne. The oxide, however, in his experience, proved sometimes useful, relieving three cases out of ten submitted to it (Lancet, i., 1880).

Chorea.—There is much evidence, as to the value both of the oxide and sulphate of zinc in this malady, more, perhaps in favour of the latter; it requires to be given in gradually increasing doses up to 15 to 20 gr. (Barlow). In recording many cases, all of which derived some benefit, Mr. Marsh found that no definite indication for the sulphate could be verified, but that a harsh, dry skin became soft during its administration (Lancet, ii., 1871); it was well borne. In chorea affecting *strumous* children, I can speak well of the iodide of zinc. In a case of traumatic tetanus, zinc sulphate internally was an element in successful treatment, but opium and antiseptics were also given (Lancet, ii., 1892).

Chronic Alcoholism.—Dr. Marcet made many observations on the treatment of this condition, and published a special essay to illustrate the value of zinc oxide in controlling the unsteadiness and the tremor which are its usual accompaniments (Chronic Alcoholic Intoxication, London, 1860; Lancet, i., 1859). Dr. Anstie accorded some, but not so much, value to the drug in the same conditions.

In **Hysteria** and **Debility,** if anæmia be not extreme, zinc salts often prove useful, but more especially when combined with other nerve tonics; thus, Dr. Barnes speaks very favourably of zinc with phosphoric acid (phosphate of zinc) (Lancet, i., 1858), and has more recently re-stated his opinion as to its value in convulsive diseases of women (Lancet, i., 1873). Vigier finds the phosphide of zinc acts more quickly than phosphorus itself (Bulletin, Jan., 1876), and the valerianate, although decried by many observers, certainly relieves in some cases. Five gr. doses

thrice daily have relieved *diabetes insipidus* (Lancet, ii., 1883). Zinc oxide may be well combined with such drugs as camphor, galbanum, and sumbul.

Spasmodic Cough—Asthma.—Both the oxide and the sulphate of zinc, especially in conjunction with belladonna, have been found to relieve spasmodic cough, such as whooping cough. In the intervals of spasmodic asthma, they are given as prophylactics (Symonds, B. M. J., i., 1868). The valerianate has been successfully used for obstinate hiccough and for hysterical cough (G. Harley, Med. Times, ii., 1863), but although of some value, is uncertain in its action. In laryngeal spasm, sometimes, 5 to 6 gr. doses will succeed when smaller ones fail (Med. Times, i., 1858).

Nervous Headache—Neuralgia.—The valerianate is valuable in nervous headache, and it is especially useful for cases of neuralgia connected with uterine derangement.

Tremor.—In tremor connected with mercurial and arsenical poisoning, Guéneau de Mussy found phosphide of zinc effective (Lancet, i., 1876). I have tried it in the tremor of sclerosis, but without result.

Rheumatism.—Amongst the rarer uses of zinc salts may be mentioned that of the cyanide in articular rheumatism : it was strongly commended by Luton, as relieving pain and lowering vascular excitement (Bulletin, Jan., 1875). Other observers find it also of some, but not definite, value ; it is apt to cause headache (Med. Record, i., 1877).

PREPARATIONS AND DOSE.—*Zinci bromidum* (non-off.): dose, 3 to 10 gr. *Zinci citras* (non-off.) : dose, 3 to 10 gr. *Zinci lactas* (non-off.) : dose, 3 to 30 gr. *Zinci oxidum :* dose, 2 to 10 gr. or more. *Unguentum zinci :* made with oxide of zinc and benzoated lard. *Gelatum zinci :* made with gelatine and glycerine (non-off.). *Zinci carbonas :* dose, 1 to 8 gr. *Zinci sulphas :* dose, as a tonic or astringent, 1 to 3 gr. or upwards ; as an emetic, 10 to 30 gr. ; for an injection or lotion from 1 to 10 gr. in the ounce of water. *Zinci acetas :* dose, 1 to 2 gr. as a tonic, 10 to 20 gr. as an emetic ; as an injection or lotion, 1 to 10 gr. to the ounce of water. *Zinci valerianas :* dose, 1 to 3 gr. and upwards. *Zinci chloridum :* dose, ½ to 2 gr. : the same in spray or lotion. *Pasta zinci chloridi* (non-off.) : made with flour and mucilage. *Liquor zinci chloridi*, B.P. (containing about 36 gr. in the fluid ounce, not used internally). *Zinci nitras* (not official : used as a caustic in paste). *Zinci sulphocarbolas :* 2 to 3 gr. to the ounce as lotion. *Oleatum zinci*,

unguentum zinci oleati, calamina praeparata, unguentum calaminæ, unguentum zinci borici.

Zinci sulphis is used for antiseptic dressings (B. M. J., ii., 1891). A double cyanide of zinc and mercury has proved an efficient antiseptic for external use, not so irritant as corrosive sublimate (Lancet, i., 1892).

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