Free phosphorus in medicine : with special reference to its use in neuralgia a contribution to materia medica and therapeutics / by J. Ashburton Thompson.

FREE PHOSPHORUS IN MEDICINE:

WITH SPECIAL REFERENCE TO

ITS USE IN NEURALGIA:

A CONTRIBUTION TO MATERIA MEDICA AND THERAPEUTICS.

BY

J. ASHBURTON THOMPSON,

Surgeon at King's Cross to the Great Northern Railway Company, Surgeon Accoucheur to the Royal Maternity Charity, &c.

LONDON:

H. K. LEWIS, 136, GOWER STREET, W.C.

1874.

LONDON:
PRINTED BY JUDD AND CO., PHŒNIX WORKS, DOCTORS' COMMONS, E.C.

TO

CHARLES MURCHISON, M.D., F.R.S., LL.D.

IN ADMIRATION OF

THE MINUTE OBSERVATION, DEEP RESEARCH, AND

FAITHFUL DELINEATION

CHARACTERISTIC OF HIS WORKS,

THIS BOOK

IS DEDICATED BY

THE AUTHOR.

PREFACE.

The following notes are offered to the Profession, not so much as constituting an original work, as containing a *résumé* of what is known of the use of Phosphorus in medicine, written in the light of a considerable clinical experience.

At a time when this drug, on account of its striking remedial powers, is beginning to make some progress in professional favour, and attention is therefore being again drawn to its poisonous properties, and the unexpected results which have sometimes ensued upon its use, it is probable that a work will be acceptable which points out the means of avoiding these accidents—not only by referring them to their true cause, but also by indi-

cating the purposes for which Phosphorus may be employed with just hopes of advantage.

It is desired that this work may be considered, not as endeavouring to set forth in an exhaustive manner the action and capabilities of Phosphorus in health and in disease, but as an attempt to render its employment safe, to make those results determinate and uniform which have hitherto been uncertain and variable, and as a step only towards further clinical investigation.

Considerable space is devoted to the pharmaceutical preparation of Phosphorus. This is a matter of the first importance; for the efficacy, stability, uniformity of effect, and, above all, the safety of the preparation, depend entirely upon the integrity of the active agent contained in it. The imperfect methods of exhibiting this remedy hitherto employed have contributed largely to the apprehension with which its internal administration has been regarded, and which, under those circumstances, was doubtless reasonable.

The author desires here especially to acknowledge the kindness of Mr. Messenger Bradley in forwarding for publication his notes of

eighteen cases of loco-motor ataxy, treated with Phosphorus. He believes that in the numerous instances in which the works of others have been consulted and quoted from, the obligation has been duly acknowledged, and the references given in the proper places.

ISLINGTON,

August 14th, 1874.

CONTENTS.

"NON FUMUM EX FULGORE, SED EX FUMO DARE LUCEM
COGITAT,——"

HORACE. *Ars Poetica*, l. 143-4.

FREE PHOSPHORUS IN MEDICINE.

A CONTRIBUTION

TO

MATERIA MEDICA AND THERAPEUTICS.

I.

ITS HISTORY.

Phosphorus was discovered by Brandt, a chemist, of Hamburg, in 1669. The name "phosphorus" (derived from φῶς "light," and φερω or φορεω "I bear") had been given by Galen and Paulus Æginetus to a dry application for the eye, and subsequently to any substance possessed of the power of emitting light in darkness. Naturally, therefore, the application of the term was extended to the element which possessed that quality in a characteristic degree as soon as it was discovered, although with a distinguishing prefix. Thus it was called at one time "*phosphorus fulgens*," and on the continent, "*phosphorus anglicanus*;" and other distinct appellations were also conferred on it: as, "*lumen constans*," and "the aërial, or liquid, noctiluca." But it very soon became known as "phosphorus" simply—the "light-bearer," *par excellence*; and under that term alone it is recognised at the present day.

The friends, Kraft and Kunkel, chemists, living in Saxony, quickly became aware of Brandt's discovery, and the former was despatched to Hamburgh to ascertain the process by which the new element was obtained. Brandt consented to impart his secret to Kraft only on condition that it should not be divulged to Kunkel; and this stipulation was so closely observed by him, that it led to a quarrel between them. Soon after this Kraft proceeded to England, where he showed specimens of phosphorus for money; he was called on to exhibit them at Court, and among other people they were seen by Boyle. That distinguished philosopher, having learned that the substance was obtained from urine, very quickly succeeded in making some for himself; and he published an account of its remarkable properties in a little work entitled "The Aërial Noctiluca." The process of manufacture was, however, still kept secret by the few to whom it was known; and it was not until after Boyle's death that a sealed paper containing an account of it, written by him, was opened and read before the Royal Society. It seems, nevertheless, that an English chemist, named Godfrey Hankwitz, had been privately instructed by Boyle in a method of extracting phosphorus; for he supplied all Europe with specimens for some years, and hence it acquired its name of "*Phosphorus anglicanus.*"

There is no doubt but that Kunkel, with similar ingenuity, succeeded about the same time in obtaining the element; and to him is assigned the credit of having first employed it in medicine.

Even so late as 1737, the method of extracting phosphorus from urine was not very widely known; for it was in that year that it was communicated to the Royal Academy of Sciences of Paris, and first published in France in the Transactions of the Society. The chemistry of the process was little understood until even a later date; for in 1743, Margraaf, of Berlin, first showed the compound from which it is directly obtained to be phosphoric acid.

Down to 1774, phosphorus had still been exclusively prepared from urine; but in that year Gahn and Scheele, the Swedish chemists, ascertained its presence in bone. Their process for extracting it was subsequently improved by Bertrand le Pelletier and by Fourcroy. It is from bone that phosphorus, which has of late years become possessed of so much commercial importance, is obtained at the present time.

The idea that the newly isolated element would possess medicinal properties was no doubt suggested by the source from which it was first procured; and so early as 1721, Kunkel published some observations upon its effects when administered internally. He gave it in what he called "luminous pills," in doses of three grains; and he praised it for its calmative powers. He was the first author who noticed the medicinal employment of phosphorus; but the eulogistic terms in which he spoke of its effects set other observers to work, and from 1731 down to 1820 every few years witnessed the appearance of some new book or tract recording its wonderful curative

powers in disease. Thus Sachs in 1731, Kramer in 1733, Abr. Vater and J. G. Mentz in 1751, P. E. Hartmann in 1752, Morgenstein in 1753, and very many other authors, found a great deal to publish on the subject during the earlier part of the period named. They dealt with it chiefly from a practical point of view, and noted such cases as appeared to them to show very marvellous therapeutic powers of the drug. In 1798 Alphonse Leroy, who had already in 1779 printed one case which he had treated with phosphorus, read a paper before the *Société Médicale d'Émulation de Paris*, in which the subject was handled in a manner a little more scientific than that of previous authors.

The first detailed cases with which we are acquainted are of fever of that kind called malignant, and it was in the exhaustion consequent upon that disease that the miraculous revivifying power of the new remedy was noted. Patients apparently at the point of death are repeatedly asserted by these earlier writers to have been reclaimed, almost from the grave, by a free use of phosphorus, given in quantities varying between three and twelve grains a day. Observers were not slow to attribute these results to a special power over the nervous system, and its use was soon extended from cases of general exhaustion by disease to those of paralysis. Here, again, most remarkable cures are recorded as having been effected—experience which the observation of later times does not very clearly corroborate. Although the aphrodisiac properties of phosphorus seem to have been well

known before Leroy's paper, yet he is the first author to take special notice of its use as a remedy for impotence. He extended its employment to this functional disorder and to the treatment of general failure of the vital powers, whether the result of natural decay or the premature exhaustion of the dissolute.

Notwithstanding the uniformly favourable testimony which all writers bore to its therapeutic powers, the internal use of phosphorus had, to the end of the 18th century, been somewhat limited. The difficulties attendant on its pharmaceutical preparation formed one obstacle to its more general employment, but the dangers attendant on its ingestion proved a still more formidable one. In fact, it may be asserted that no writer who has fairly recorded his experience of the internal use of this remedy in a large number of cases has failed to record some instances of its treacherous and very active poisonous power. Still, the advantages derived from its use in the treatment of certain disorders were undeniable, and far too valuable to allow of its unconditional exclusion from the Materia Medica; but its employment was, from the above-stated considerations, almost limited to extreme cases, in which the choice offered to the physician appeared to lie between its use at some possible risk, and the surrender of the patient to his still more certain fate.

Leroy continued his observations, and published other papers between 1799 and 1805, when Löbenstein von Löbel published in "Horn's Archiv.," and other places,

many examples of his successful use of this drug. Among other cases, he records his own cure of a neurosal headache, which had troubled him for some weeks. This is the first case of many noted about this period in which the remedial power of phosphorus in neuralgic affections is shown. Von Löbel employed ether as the vehicle for administration; and it is possible that the introduction of this solution, with which it is not easy to procure toxic effects, although it is a very active therapeutic preparation, may have served to encourage and spread the medicinal use of phosphorus. At all events, about this time, the fears which had interfered with its more general administration appear to have been dispelled; and the last-named author was very soon followed in his researches by a large number of other observers. Sorge, Bouttatz, Jacquemin, Boudet, De Lens, and Lobstein, all contributed to the literature of the medicinal use of phosphorus between 1800 and 1820, and all have much to say of its importance to therapeutics.

In the meantime, the employment of phosphorus in medicine was almost unknown in England, although the country from which the rest of Europe had been originally supplied with it. The first mention of it as a remedy in an English work occurs in the edition of "Bates' Dispensatory" for 1720; but the names of those who have been in any way associated with its employment in England to the present time may be counted almost on the fingers. The only authors

who have recorded any valuable observations on this subject are Dr. Cotton, who related, in 1867, the result of treatment with phosphorus in twenty-five cases; Dr. Hughes Bennett, his experience of seven cases; and Drs. Broadbent, Eames, and Thorowgood, who between them have recorded about thirty cases—all of similar diseases.

On the Continent, the medicinal use of phosphorus would appear to have fallen off about 1820, the recorded observations diminishing somewhat in frequency; and it remained for the employment of phosphorus in the arts again to attract attention to its powers over the human economy. Workpeople occupied in the manufacture of lucifer matches were soon observed to be affected in different ways by the fumes of the phosphorus used—to suffer from the necrosis peculiar to phosphorus-poisoning—to be specially liable to miscarry if they were pregnant—or, on the other hand, to enjoy remarkably good health and spirits (Ebel). Lorinser, in 1845, was the first observer to publish a scientific account of the necrosis from which these *employés* suffered; and his work was followed, in 1847, by Von Bibra and Geist's monograph on the same subject. This disease was also dealt with by several British authors, to whose papers references may be found in the List of References at the end of the volume.

But a circumstance other than this tended about the same time to attract attention to the action of phosphorus. In 1843 the Prussian Government, alarmed at the

frequency with which vermin poison containing arsenic was used for criminal purposes, decreed that phosphorus should be substituted for it in such preparations. They hoped that the unconcealable odour and taste of this substance would prevent the criminal use of a material known to be poisonous, but of which the sale could not very well be restricted. How far this measure was from effecting the expected purpose is shown by Chevallier, who ascertained that of 494 cases of criminal or suicidal poisoning which occurred in France during a period of five years, no less than 180 persons died from the effects of phosphorus alone.

Mainly, therefore, as the result of these two circumstances, a large mass of observations soon accumulated, illustrating the effect of phosphorus over the human economy in toxic or less than toxic doses, in health and in disease; and the more accurate knowledge of the physiological effects of the element explained by the wider physiological knowledge possessed in these later times naturally revived the interest which had formerly been taken in its therapeutic use. Not the least valuable outcome of these labours has been the discovery by M. Personne of an antidote to its poisonous power. It is, in fact, to continental chemists and physiologists that we are indebted for the chief part of what is known of the effect of phosphorus over the human economy; more especially to the labours of Ranvier, Personne, Dujardin-Beaumetz, Lecorché, and Mialhe; of Voit and Bauer, Köhler and Schimpf, and of Walser.

To these admirable authors it will be seen that much of the information which is contained in the following pages is owing; and I hasten to acknowledge my obligation to them.

From this brief, but sufficiently explicit, review of the history of the internal use of phosphorus, it will be seen that from the date of its first employment it has never entirely ceased to be used in medicine. On the other hand, the very copiousness of the literature appertaining to the subject (I refer to earlier times) points to the fact that its use, though wide-spread, was not universal; that each fresh author wrote as the exponent of a line of treatment, which, though wonderfully successful, he was aware but few of his *confrères* would have the courage or the temerity to pursue. No other consideration but the existence of a danger attendant on its use, as little understood as it was undeniably present, could account for the failure of phosphorus to establish itself in universal favour as a remedy. It is this element of danger, as Christison testifies in his work on poisons, which has stood in the way of its general employment even to a year or two ago. But it is among the objects of this treatise to point out that we are now in possession of certain preparations through which this drug may, with ordinary precaution, be safely employed, while we are also possessed of such accurate knowledge as to its dose and power as to be able to detect premonitory symptoms of poisoning in time to intermit the medication before any serious effects arise. Phosphorus can never be effectively

employed but in its free and most active state; but with this knowledge the physician may now use it to the infinite benefit of suffering humanity; nor, I venture to think, will it ever again be relegated to the obscurity from which it has recently been withdrawn.

II.

ITS PHARMACEUTICAL PREPARATION.

The internal administration of free phosphorus may be effected by three methods, viz. :—By the reduction of the element to a state of subdivision, by its solution, or by the decomposition of a chemical combination of it with a metal within the body.

Of these methods the first is the oldest. Kunckel gave it thus, in the "Luminous Pills;" and phosphorus was generally, if not invariably, administered in the solid state until the time of Leroy, or a little after, when solutions began to come into more general use. Many reasons then conduced to the entire rejection of preparations containing solid phosphorus, of which the chief was the difficulty experienced in reducing it to so fine a state of subdivision that the dose to be administered could be measured with accuracy. But no doubt, although it is not so specifically mentioned, the uncertainty of action which imperfectly divided phosphorus exhibits in different persons or at different times led also to the employment of formulæ which appeared to promise more precision and security. From these more remote times until the present, it has not

again been attempted to administer solid phosphorus internally. But this method, if it could be pursued with the precision which is essential in dealing with phosphorus, has appeared to me so desirable, for many reasons, that I have induced a pharmaceutical firm to attempt the manufacture of pills containing the drug in a condition of impalpable powder, and perfectly free or unoxidised; and they have, after many trials, succeeded in presenting a preparation which fulfils these conditions. As will be seen below, all other pills of phosphorus contain in effect a solution of the drug, with the exception of those made after Trousseau's prescription which are practically valueless.

The solvents of phosphorus which have been employed in medicine are: oils—as olive or almond oils, linseed oil, oil of turpentine, cod-liver oil, Dippel's animal oil or acroleine, and suet: white wax, beeswax, resin: ether, chloroform, alcohol, naphtha, and carbon bisulphide: aërated water, acetic acid, and sulphur. Of these bodies some are not adapted for internal use, and accordingly they are now employed in the manufacture of ointments only; such are acroleine and naphtha. Others, experience has shown to be not tolerated in the repeated doses which it is necessary to give; as bisulphide of carbon and chloroform, which last has had an extended trial at the hands of M. Beaumetz before its final rejection; while some, as sulphur and acetic acid, are said to be entirely unfit for the purpose. Further than this, oil in its usual state, turpentine, and aërated water are not

desirable media, for chemical reasons affecting the activity of the dissolved element which they seriously alter, impair, or destroy.

A means of administering phosphorus by the third method is presented in its low combination with zinc, as the phosphide of that metal. The manufacture of this compound in bulk has not until recently been practically perfected. It affords a safe and tolerably efficacious means of procuring the effects of free phosphorus.

From the foregoing remarks, it is evident that the pharmaceutical preparation of phosphorus presents an unusual number of difficulties. This fact, in conjunction on one hand with the danger, or, on the other, with the inactivity which appertains to imperfect formulæ, has hitherto prevented the universal employment of a medicine which, when judiciously administered, is capable of effecting results in the treatment of certain forms of disease, as remarkable as any other remedy with which we are acquainted. These difficulties may be summed up under the following heads: first, the remarkable aptitude for oxidation which phosphorus exhibits; secondly, the difficulty of dissolving it in vehicles which are at the same time comparatively inert and not intolerable to the stomach; thirdly, the difficulty of subdividing it to the necessary degree of fineness, yet without oxidising it.

Of these, the ease with which phosphorus combines with oxygen is undoubtedly the most embarrassing; for (as will be shown below) not only is the complete oxida

tion of phosphorus calculated to destroy its therapeutic power entirely, but, what is much more serious, its imperfect oxidation, or oxidation in the lower degrees, is calculated to confer an intensity of poisonous power upon it which it does not possess in the absolutely free state. In making a solution, these points have to be borne in mind. Olive oil, for example, has the property of absorbing from 600 to 800 times its volume of oxygen; and, if some of this solvent be employed which has been exposed to the air, and is therefore impregnated with this gas, a preparation is obtained which contains a mixture of free phosphorus and hypophosphorous and phosphoric acids. In addition, it has been shown by M. Beaumetz, that in such a solution as this, a white and insoluble precipitate is, after a time, formed at the expense of the element. This precipitate is inert; and hence arises another source of uncertainty in its active power. Oil of turpentine, again, has lately been discovered to enter into chemical combination with phosphorus, to form a crystalline cetaceous body, which has been named terebinthino-phosphorous acid, and which is insoluble and inactive. Probably this property of combining with phosphorus is shared by other essential oils in a greater or less degree. Hence the addition of any of them to a solution of phosphorus is to be deprecated as conveying an element of uncertainty into the strength of the preparation.

In the use of ether and chloroform as solvents, one characteristic is to be noticed which exists in each of

them, viz., the thinness of these bodies. This condition allows of their rapid evaporation, and a consequent condensation of the solution; and as in the case of alcohol also, even if the vessel containing them be well stopped, at least it permits the oxidation of the superior layer, unless care be taken to keep it quite full. The phosphoric acid thus formed sinks, a fresh layer of phosphorus is exposed and is oxidised in turn, and so a constant circulation throughout the fluid being kept up, in the end the whole becomes inert. But there is a special point to be noted with regard to alcohol, namely, the readiness with which it abstracts water from the air. In this case, too, the absorption of watery vapour will be attended by oxidation, and in addition by the precipitation of hydrated phosphorus. All these points show the care with which it is necessary to preserve such solutions as these when once they have been carefully made; and it is to be considered whether the care necessary is not so great as practically to debar us from the use of them. Experience of solutions in alcohol and ether has shown, however, that each affords a good practical means of dispensing, inasmuch as they retain their activity for sufficiently extended periods; and in the former case I have been successful in prolonging the time during which the solution may be kept in an efficacious condition, by adding to it a large proportion of glycerine. But even this plan requires care, on account of the great affinity for water which glycerine possesses.

The second obstacle to the therapeutic employment of free phosphorus is also no inconsiderable one. There are but three bodies in which it is soluble with any considerable degree of freedom, viz., oil, carbon bisulphide, and chloroform. Of these, olive or almond oil is that which has been most widely used. But there is an objection to the more general use of phosphorus in medicine, which we believe may be almost entirely traced to the employment of vegetable oil as a solvent—we mean the fact that cases of *accidental* poisoning may be found in the writings of nearly every author who has reported on any considerable experience of its use in this form. The frequent occurrence of such cases as these has naturally interfered with the wide adoption of phosphorus as a remedy, and they have been hitherto generally attributed to its intrinsic activity. But there is good reason to believe, and the point has indeed been almost demonstrated, that some of these cases of poisoning which occurred in the most abrupt manner, and after doses which had been often given before without harm, were owing to the partial conversion of the phosphorus into hypophosphorous acid. To this conversion, the solution of phosphorus in vegetable oil appears to be specially liable. It is in accordance with this view, that I have felt compelled at last to reject the use of solutions of phosphorus in olive oil, at least if they are prepared with oil in its usual condition; and it is to be regretted that this solution should have been introduced to the British Pharmacopœia

without proper directions for *super*-heating the solvent before using it. The necessity for this preliminary manipulation, in order to prevent the formation of the white material alluded to above, has long been recognised.

Apart from any question of toxic powers, this solution of phosphorus in olive oil is less easily tolerated by the stomach, whether it be given in capsules or in emulsion, than any other preparation; and this fact alone would justify its exclusion from the Pharmacopœia as an internal remedy, if any other preparation, acknowledged to be efficacious and easy to dispense, could be found to replace it. These conditions are fulfilled by the solution in cod-liver oil, and the alcoholic and etherial solutions. Of these, the first is perhaps the least palatable; but the odour of phosphorus dissolved in it is almost entirely lost, at the same time that the taste is very much lessened. It forms an active solution, and one which is quite free from the danger attendant on that in olive oil, so far as my experience of it has gone.

The solution in alcohol is capable of being rendered more palatable than any other solution of phosphorus. The means of effecting this are described below. The etherial solution can scarcely be effectually disguised; in whatever form it is dispensed, the solvent is very plainly perceptible, and the phosphorus is easily detected in the mouth and by eructation. Nevertheless, these are the only objections to its use; and they are not prohibitory. It is well tolerated by the stomach, and, like the alcoholic

solution, is an effective preparation. Carbon bisulphide and chloroform require no more than a passing notice in this place; they both dissolve the element freely, but it is evident that repeated doses of either of them cannot be administered without producing the peculiar effects of the solvent independent of those of the phosphorus. The former body has been retained in the manufacture of pills. Of the three best solvents of phosphorus, then—viz., vegetable oil, carbonic bisulphide, and chloroform—the two latter are generally allowed to be entirely inadmissible, while the first, well known to be most repugnant to the palate and offensive to the stomach, is, in my opinion, a preparation liable to become too actively poisonous to retain a place among remedies intended for internal administration. This reduces the choice of solvents to alcohol, ether, and cod-liver oil; and these, although they do not take up phosphorus very freely, do yet retain a sufficient proportion, and can be preserved in an active state for a period sufficiently long to render them convenient to the dispenser; while the freedom from danger which attends their use recommends them to the physician.

Acroleine or Dippel's animal oil has been employed by von Löbel (Hufeland's "Journal der Pract.: Heilk:" 1817), and I believe by him alone. Such a very active body is scarcely a good vehicle for phosphorus.

The solution of phosphorus in water is a preparation too feeble, too uncertain in composition, and too liable to change to be practically useful.

It has been proposed to subdivide phosphorus in a variety of ways. They all expose the element to oxidation, with the exception of the process referred to at the beginning of this section. The reduction of phosphorus is further described below.

From this general review of the various preparations of phosphorus I shall proceed to examine each of them separately, and to give such directions for their manufacture as it is necessary to know.

Of Solutions in Oil.

General Description.—Solutions of phosphorus in oil, which have been carefully filtered after preparation, present the usual appearance of the kind of oil employed. They exhale white vapours, which are luminous in the dark, and which have an alliaceous smell. They yield phosphuretted hydrogen gas by distillation. They are not acid, but they become so from exposure to light and air; the acidity is owing to oxidation of a part of the phosphorus, and the consequent formation of hypophosphorous, phosphorous, and phosphoric acids. They change eventually into a kind of phosphoric soap (De Lens). *Exceptions.*—Solutions in cod-liver oil have very little phosphoric odour. Solutions in essential oils are not phosphorescent. Oil of turpentine very soon combines with phosphorus to form terebinthino-phosphorous acid, a cetaceous body, which is not possessed of any active properties.

Olive Oil.—This fluid takes up phosphorus very freely. The proportion dissolved has been variously stated by different writers. Sorge places it at one part in forty-eight parts of oil, but it has been put so high as one in three or four. Concentrated solutions of phosphorus are not desirable preparations; and as it is certain that olive oil will take up a much larger quantity than is necessary for pharmaceutical purposes, this point is not of great importance. For making emulsions probably one grain of phosphorus in three drachms of oil will be found as convenient a proportion as any, since it gives a quantity of fluid which there is no difficulty in measuring, and which is sufficient to hold the drug in solution after it is diluted; while it is not too large to be well covered by the six or eight ounces of gum water which should be used in dispensing it. Should this solution be intended for enclosure in capsules, it would be necessary to employ it in a more concentrated form, since each capsule can contain but one dose of phosphorus, while its capacity is small. *Oleum Phosphoratum* has long held a place in the pharmacopœias of France and Prussia, and has lately been recognised as an officinal preparation in this country by its introduction in the Appendix to the "British Pharmacopœia" published during the present year. In the Prussian formulary the proportion of phosphorus to oil is as one to eighty; in the French codex as one to fifty. The following are the directions given in the codex of 1866 for making this solution :—

Formula No. 1.—*Phosphorated Oil.*

Take of Phosphorus, 2 grammes;
Oil of sweet almonds, 100 grammes.

Put the oil into a flask of such capacity that it shall be nearly filled with it. Introduce the phosphorus, and stand the flask in a water-bath for fifteen or twenty minutes with occasional agitation. Keep the flask closed, only, at starting, insert a piece of paper between it and the stopper, to allow an exit to the expanded air. Let it now grow cold; and, when the oil is quite cleared by precipitation, decant it from any phosphorus which may remain undissolved, and put into small flasks. The process described in the Appendix to the "British Pharmacopœia" differs in an important particular from the foregoing.

Formula No. 2.—*Phosphorated Oil.*

Take of Phosphorus;
Oil of almonds; of each a sufficiency.

Heat the oil in a porcelain dish to 300°, and keep it at this temperature for about fifteen minutes; then let it cool, and filter it through paper. Put four fluid ounces of the prepared oil into a stoppered bottle capable of holding four-and-a-half ounces, and add to it twelve grains of phosphorus. Immerse the bottle in hot water until the oil has acquired a temperature of 180°, removing the stopper two or three times to allow of the escape of expanded air; then shake the oil and the phosphorus together until the latter is entirely dissolved.

In the latter formula the most obvious objection to the French method of preparation—the uncertain strength of the resulting solution—is removed; but the directions are not such as are now known to be required for the proper and careful manufacture of this preparation.

It has been pointed out by M. Beaumetz that the solution of phosphorus in olive oil is followed after a time by a deposit of white insoluble matter, which is formed at the expense of the element, and which no care in preserving the fluid from the action of light and air is sufficient to prevent. This transformation was also observed by De Lens in his Essay on Phosphorus in the "Dic. des Sciences Médicales," published in 1820. Neither of these authors attempts to account for the formation of this body; but it is probably the result of a combination of phosphorus with oxygen, and the albumenoid matter which all vegetable oils contain. At all events, M. Beaumetz has ascertained that this transformation may be prevented if the oil used be first of all superheated. The effect of this process is to drive off the water and air which are contained in it in considerable quantity, and to destroy the albumenoid matter; and the result is, that whereas, in its normal or virgin state olive oil is possessed of the power of absorbing from six to eight hundred times its own volume of air, it is now in great measure deprived of it. M. Gubler thus describes the preparation of olive oil for the present purpose as performed by M. Méhu, of Paris. The oil is first of all

superheated to 250° Cent. This excessive heat drives out the aqueous vapour and air which are held by the oil, and it decolourises it and destroys the suspended fragments of vegetable tissue. On cooling, the requisite proportion of phosphorus is dissolved in the prepared oil, and a twentieth part of ether is added if it be intended for internal administration, or a similar quantity of oil of turpentine if it be for external use. These are said to be added "*afin d'êmpécher la phosphorescence.*"

The above fact, affecting the stability of the preparation under consideration, then, is well-known and recognised; and on this score alone no direction should be given for dissolving phosphorus in olive oil which does not include the preliminary process of preparation described. Any fault, however, which may result from this metamorphosis will be a fault on the right side—it will only *diminish* the activity of the preparation. But there is a far more serious and less known objection to this solution, which it has not been ascertained that any preparation of the solvent will obviate. This is the conversion of a portion of the element into hypophosphorous acid under the influence of light and air. That this conversion takes place in solutions of phosphorus in vegetable oils, and that these solutions thus altered acquire poisonous properties entirely out of proportion to the amount of the free element contained in them, was first pointed out by Devergie, and was further noted by Solon in his article on phosphorus in the "Dic. de Médicine et de Chirurgie Pratiques." I have not found

it noticed by any other author; but my own practical observation and careful consideration of the facts reported by others of the effects of this solution had led me to the conclusion that it is a dangerous preparation, and probably for the reason given by the authors last mentioned, before I became acquainted with their published observations. It is sufficient in this place to record the fact, since it is fully discussed and illustrated below, in the section on "Dose."

Oleum Phosphoratum may be administered in emulsion and in capsules; and it has also been employed in the manufacture of pills (*q.v.*). The following is a formula for an emulsion devised by Soubeiran:—

Formula No. 3.

Take of Phosphorised oil, 8 parts;
Gum arabic, 8 parts;
Syrup, 60 parts;
Peppermint water to 100 parts.

Formula No. 4.—*Tavignot.*

Oil of sweet almonds, 10 grammes;
Phosphorus, 10 centigrammes;
Syrup of gum, 90 grammes;
Gum, 2 grammes.

I have found it well to avoid the use of any sweet ingredient in this formula since it only increases the nauseousness of the mixture; but oil of peppermint is by far the best corrigent of the phosphoric taste aswell in other prescriptions as in this. The formula I haveused is

Formula No. 5.

Take of Phosphorised oil, 3 drachms;
Gum arabic, 6 drachms;
Water to 6 ounces;
Spirit of peppermint, half-a-drachm.

This mixture is disgustingly nauseous, most frequently giving rise to vomiting and diarrhœa, and always to so much offensive eructation that patients are only persuaded to take it with the greatest difficulty.

As I have stated above, I have finally rejected this preparation from the list of remedies; and so uncertain is it in its action, only never producing *less* than the expected effect, that I feel unable to suggest any definite quantity as a dose. It has also been administered in capsules, which are made with oil properly prepared by M. Méhu, of Paris; and possibly they may be procured thus made in other places.

Cod-liver Oil.—This oil takes up phosphorus freely enough for pharmaceutical purposes. The solution may be prepared without the assistance of heat. I have found the proportion of one grain of the drug to one ounce-and-a-half of the solvent to be the most convenient strength; of this, one drachm contains one-twelfth of a grain. This is a useful, but full dose.

Formula No. 6.

Take of Phosphorus, 1 grain;
Cod-liver oil, 1½ ounces;
Oil of peppermint, 1 minim.

The solution is almost free from phosphoric odour, but the peculiar taste, though much diminished, remains apparent. It does not give rise to a great deal of eructation, particularly if the dose be taken immediately after food. The taste of the oil is unaltered. The single drop of essential oil, which I am in the habit of adding, does not interfere appreciably with the action of the medicine. It is stable for considerable periods.

I have experienced no untoward result from the use of this solution in any case, nor any derangement of the digestive organs, during disorder of which (contrary to the rules laid down by von Löbel for the administration of phosphorus) I have ventured to prescribe it, and with good effect. To those who may desire to engage in an investigation of the therapeutic value of free phosphorus, unbiassed by the presence of any other active remedy, this preparation may be specially recommended.

Dr. Glover has reported in the *Lancet* his experience of good effects from the use of this solution, but he gives no cases. Dr. Radcliffe has also spoken of it; but he seems to have considered that the loss or diminution of phosphoric odour is presumptive evidence of impairment of the active power of the element. That this is not diminished, the following case, communicated to me by Dr. Arthur Edis, is sufficient proof. Three minims of a saturated solution of phosphorus in olive oil, with two drachms of cod-liver oil, had been prescribed for a female adult and taken for some time with benefit, when the treatment was discontinued. A considerable time after

wards, cod-liver oil was ordered for the same patient's baby, aged five months, and the mother began the treatment by administering a small teaspoonful of the phosphorised oil, which had remained after her recovery. The consequences of this single dose were most serious—sickness, abdominal tenderness, heightened temperature, and quickened pulse, with dangerous collapse, showed themselves within the next two days; and, as is usual in cases of phosphorus poisoning, the period of immediate danger was very long, and recovery was effected only after several weeks.*

Castor Oil does not dissolve phosphorus.

Dippel's Oil has been used by von Löbel, and, I believe, by him alone: it is unstable, very active, and quite unfit for the purpose. The same authority has employed

Oil of Savine in the following prescription:—

Formula No 7.

Take of Phosphorus, 5 centigrammes;
Oil of savine, 4 grammes.

As an essential oil it cannot be considered a good vehicle.

* The question often raised whether cod-liver oil normally contains phosphorus or not has been investigated by M. Personne, who gives the three following deductions as the result of twelve analyses of eleven specimens of oil.

1. All oils of cod-liver do not yield phosphorus.
2. It exists in some only in the form of earthy phosphates.
3. Its presence in this form is due to an imperfect method of preparation.—*Vide* "L'Union Médicale," 1853, p. 72.

Linseed Oil was used by Leroy in his phosphorised linctus. His formula was as follows:—

Formula No. 8.

Take of Phosphorus, 2 grains;
Linseed oil, 1 spoonful;
Linctus, 2 ounces.

It is to be supposed that the phosphorus was first dissolved in the linseed oil, although that is not stated. I do not know that linseed oil enjoys any advantages over olive oil for this purpose.

Some of these vehicles have been employed in the manufacture of pills (*q.v.*).

Of Solutions in Alcohol, Ether, and the Hydrocarbons.

General Description.—These solutions give off an alliaceous odour, more or less concealed by that proper to the solvent. On the addition of water they become milky, and eventually a white precipitate is thrown down which consists of hydrated phosphorus. They give a black precipitate with silver nitrate. They burn with their peculiar flames, a little whitened; and in some of them, when combustion is ceasing, small masses of precipitated phosphorus may be observed to take fire, and, throwing off the white vapour of phosphoric acid, to leave a residue of the red oxide of phosphorus. The solution in alcohol becomes luminous at the point of contact with water.

Alcohol.—One part of phosphorus is taken up by three hundred and twenty parts of absolute alcohol. The rather large proportion of solvent which must be given with each dose of the drug has been deemed an objection to the employment of this preparation in medicine, and I am not acquainted with any recorded instances of its use. I have found it a useful and convenient solution.

The best method of preparing it is as follows:—Take of absolute alcohol, a sufficiency; of phosphorus, an excess. Heat the alcohol to ebullition in a Florence flask; add the phosphorus, and keep the mixture at boiling point for a few minutes. Close the flask accurately, and set the solution aside to stand for twenty-four hours. Agitate until cool, and afterwards occasionally. Decant the solution from the excess of phosphorus with as little exposure to air as possible into small coloured glass bottles. Let each be quite filled, accurately stopped, and stored in the dark.

This is a saturated tincture of phosphorus; and it therefore contains one grain in three hundred and twenty grains, or six drachms and twenty minims by measure.* In preparing it great care should be taken to ascertain that the spirit is absolutely dehydrated, and that perfectly dry vessels are used during the process; the presence of a single drop of water is sufficient to

* I have received a sample of tincture of phosphorus from a well-known Bristol firm which is said to contain one grain in four drachms. These proportions are impossible.

throw down some of the element in its hydrated form, and thus to cast doubt on the actual strength of the solution.

Kept with the precautions indicated, this preparation will retain its active properties for several weeks at least. I have prescribed it, diluted with rectified spirit and water, with success in a large number of cases. The following was the formula employed :—

Formula No. 9.

Take of Tincture of phosphorus, 3 drachms 10 minims
Rectified spirit, 3 drachms ;
Peppermint water, to 6 ounces.

By the addition of an equal quantity of rectified spirit to the tincture before adding the water, precipitation of the hydrate is prevented to a great extent ; still the mixture is opalescent and very unstable. It should not be supplied to the patient in quantities calculated to last more than twenty-four hours. This formula yields a mixture which is readily taken, although it is not a very pleasant one, and it exhibits the power of free phosphorus with tolerable activity ; but although I have never seen it cause vomiting, it does cause a very great deal of unpleasant eructation. The chief objection to it, however, is the element of instability which the admixture of so large a proportion of water involves, and to obviate this fault I have tried many experiments. They have resulted in the following formula :—

Formula No. 10.

Take of Tincture of phosphorus, 3 drachms 10 minims;
Glycerine to 1½ ounces;
Spirit of peppermint, 5 minims.

This mixture should be perfectly clear and bright; but glycerine shares with absolute alcohol the property of absorbing aqueous vapour, and care must therefore be taken to ascertain its purity before using it, otherwise the result will be seen in opalescence of the mixture.

This combination possesses many advantages over any other with which I am acquainted. In the first place, it is very stable. Case No. 27, for example, shows this; the patient was cured with the remainder of a mixture of which part had been used two months previously in case No. 25. In the second place, it is free from any phosphoric odour, and almost free from any phosphoric taste; and, further, so far from causing unpleasant eructation, it appears to possess some power of dispelling flatulence, if that symptom be already present. This property is not the less important that it may be owing entirely to the spirit and essential oil. It is the most elegant fluid preparation of free phosphorus as yet at command; it is well received by the most delicate patient; and it is quite active. A sixth part of either of these formulæ is equivalent to one-twelfth of a grain of phosphorus which, in the case of the ninth prescription, is no doubt present partly in the form of hydrate; and I regard this dose *in these forms* as an average dose, suited to many cases but not as a full dose. I have

given much larger quantities to patients for some days together, without ever witnessing any untoward result, and in the dose specified three times daily to more than one patient for periods of from eight to thirteen weeks, without any intermission, and with no other than the best effect.

Sulphuric Ether.—This solvent was first employed in 1732 by Hoffmann, but it did not come into general use until von Löbel advocated it in 1805. It is stated by Beaumetz to be capable of taking up one part of phosphorus in fifty; but a long time, at least a month, is necessary to effect solution. Von Löbel used a proportion of eight grains of phosphorus in one ounce of ether, but this appears to be somewhat too concentrated for pharmaceutical purposes. The following are Bouchardat's directions for making phosphorised ether:—

Formula No. 11.—*Ether Phosphorée.—Bouchardat.*

Take of Phosphorus, 4 grammes;
Pure sulphuric ether, 200 grammes.

Put the phosphorus, divided into small pieces, into a well stopped bottle; cover with black paper, and allow to macerate, with occasional agitation, during one month.

I have found the chief objections to its use to consist in the taste of the solvent, which, after a few doses, becomes very repugnant, and in the great amount of phosphoric eructation to which it gives rise. The rapidity with which it evaporates is not a point of consideration.

Apart from these objections, I have found it an active preparation, and one which there is no difficulty in administering in combination with spirit and glycerine in some such formula as the tenth. The proportion of ether used need not be very large, and therefore no physiological action on its part need interfere with the treatment. The next formula is one of Soubeiran's for dispensing this solution.

Formula No. 12.—*Potion Phosphorée.—Soubeiran.*

Take of Phosphorated ether, 4 grammes ;
Peppermint water, 66 grammes ;
Syrup of gum, 64 grammes.

Phosphorised ether has also been given in capsules ; and after admixture with a little wine. The latter is not a good method to adopt. Probably the phosphorus is freely hydrated by the mixture ; but, above all, patients are not to be trusted to measure small quantities of fluid containing phosphorus for themselves.

Chloroform.—Chloroform will dissolve as much as one part of phosphorus in one hundred with convenient rapidity, and the solution has had an extended trial at the hands of M. Beaumetz. He usually administered it in capsules, each of which was made to contain one milligramme of free phosphorus in a gramme of chloroform. Eventually this preparation was rejected by him on account of the activity of the solvent. The following formula and method of dispensing have been employed by Glower :—

Formula No. 13.

Take of Phosphorus, 1 gramme;
Chloroform, 4 grammes.

Four or five drops to be taken with four grammes of ether in a glass of port or, better still, of Burgundy wine.

If there be any object in employing this form, while others more convenient are attainable, I do not see any reason why a smaller proportion of chloroform should not be employed; but this fluid adds very much to the nauseousness of phosphorus, and causes a great deal of eructation. It is, therefore, superfluous to give any further directions for making or administering it.

Carbon Bisulphide; Naphtha. — As has been stated above, phosphorus is soluble with more or less freedom in all the hydrocarbons; but carbon bisulphide takes up this metalloid in larger proportion and with greater rapidity than any other solvent. M. Beaumetz states that it is capable of taking up as much as one gramme in thirty-five drops; and the very small quantity of solvent which need be given with each dose of phosphorus in this form has led to its employment for therapeutic purposes, in spite of its intrinsic poisonous properties. But it has been found on this account to be quite unfit for use; and there is another objection to it, which M. Gubler has pointed out, viz., its power of notably counteracting the effect of free phosphorus. Bisulphide of carbon has been used in the manufacture of pills (*q.v.*) by Mandl, and lately

for the same purpose, but in a somewhat different manner, by Mr. Proctor.

Naphtha does not take up phosphorus so freely as the last-named body; it has never been used as a vehicle for internal administration. It enters into a formula devised by Tavignot for an ointment of phosphorus. (*Vide* External Applications.)

(For the solvents—suet, beeswax, white wax, and resin, see below, on "Pills of Phosphorus," in the composition of which alone they are employed.)

Of the Solution in Water.

Water does not dissolve phosphorus, but it is enabled to take up a small and uncertain proportion by means of the air which is contained in it. The ultimate result of the prolonged immersion of phosphorus in water is its oxidation, *i.e.*, its conversion into phosphoric acid; but before reaching this point it forms phosphuretted hydrogen, and it passes through the lower stages of oxidation, becoming hypophosphorous, phosphorous, and phosphoric acids successively. In the first of these oxides free phosphorus is soluble; and so a small and ever-changing proportion of the metalloid is always in solution in the water in contact with it, and in a form which, as in the case of olive oil solutions, is well calculated to intensify its activity as a poison. M. Tilley has observed that the water into which phosphorus had been received in the process of manufacture, which was fatal to some fowls

drank of it; and Charles le Pelletier observed a similar accident to some ducks, which drank water which had long contained a little phosphorus, from a copper basin. Leroy's attention was first attracted to the action of phosphorus over the human economy by accidentally giving a patient a placebo which he intended to consist of sugar and water, but which he made with sugar and phosphorised water. These facts go to prove that a solution of phosphorus possessing some active properties may be made with water; but the proportion which it can take up is known to be very small, and to be owing to the presence of air in the fluid; and these facts, combined with the rather well-marked power which it possesses, point to its presence in combination or in conjunction with the lower oxides of phosphorus. These, as stated above, very much intensify the poisonous action of free phosphorus.

M. Stanislas Martin has recommended this solution* as one way of procuring the effects of free phosphorus. His process for making it is to place two hundred and forty grammes of water in a large mattrass, and to suspend above it in a small dish four centigrammes of phosphorus. After twenty-four hours the upper part of the vessel is seen to be full of phosphoric acid, formed at the expense of the phosphorus, which has now disappeared. These vapours are to be dissolved by shaking them up with the water. M. Martin

* "Bulletin Générale de Thérapeutique." 1858. Page 360.

gives no directions for adding or keeping a piece of free phosphorus in the fluid; and, in consequence, the result obtained is only a very diluted solution of phosphoric acid, which may possibly contain, in addition, some vapour of phosphorus diffused through it.

Phosphorised water, however, is obviously a preparation too unstable and too uncertain in its composition to be employed in medicine. Nevertheless, M. Martin has used it, and he says that he has experienced the same results from it as from the ethereal solution or a phosphorised liniment.

Of Capsules and Pills.

Capsules are made to contain solutions of phosphorus in oil, in ether, or in chloroform. The latter solution has already been rejected by M. Beaumetz, who first proposed it. The former preparations must, at all events, be made with oil properly prepared. They are sold, thus manufactured by M. Méhu, of Paris, and possibly in other places. I no longer venture to prescribe a solution of phosphorus in vegetable oil, internally, under any conditions. The envelope should be coloured.

Pills.—Phosphorus pills may be made in three ways; with a solution of phosphorus, with reduced or pulverulent phosphorus, or with phosphide of zinc. The latter body will be treated of under a separate head.

Kunkel gave free phosphorus in the form of pills before 1721. He called them luminous pills, and their

preparation was, therefore, probably not very carefully carried out; but his process for making them was not published, and died with him. Leroy in 1798 believed that he had rediscovered Kunkel's method, and he entrusted the manufacture of pills after it to Charles le Pelletier—a brother of the celebrated Bertrand le Pelletier, and a Parisian apothecary. But in addressing the Société Médicale d'Émulation de Paris, Leroy says* that he is so impressed with the danger of giving unequally divided phosphorus, and the process in question is so difficult to carry out, that he declines to confide it to any other person; and we learn that very soon after this he gave up the use of it entirely on this score of danger. From that time until the present phosphorus pills have been made only with solutions so mixed with inert matter as to admit of their being dispensed in this form. Mandl, for example, has used carbon bisulphide for the purpose in the following manner:—

Formula No. 14.

Take of Phosphorus, 5 centigrammes;
Carbon bisulphide, 20 drops;
Oil of almonds, 18 grammes;
Carbonate of magnesia, a sufficiency.

Make fifty pills to be coated with gelatine. This seems to be scarcely a good prescription. The oil alone is sufficient to dissolve the phosphorus, and the

* "Mémoires de la Société Médicale d'Émulation de Paris." An VI., p. 170.

carbon bisulphide is therefore superfluous. As stated above this body is said to counteract the effect of free phosphorus, and it is very poisonous. On the last score Mandl was obliged to give up the use of this prescription, although the quantity contained in each pill is only two-fifths of a drop at most, and probably, from evaporation during manipulation, much less.

A process has been devised for making pills with a solution of phosphorus in carbon bisulphide in which the evaporation of the solvent is calculated upon. The prescription and directions of Mr. Proctor, the invento of it, are as follows :—

Formula No. 15.

Take of Phosphorus, 6 grains ;
Carbon bisulphide, 6 drops ;
Tragacanth powder, 12 grains ;
Soft soap, 24 grains ;
Liquorice powder,
Confection of roses, of each half-a-drachm.

Having all the materials weighed and ready for use, the tragacanth being in a mortar, put the phosphorus into a test tube, and add half the carbon bisulphide. On solution of the phosphorus pour the fluid into the mortar, rinse out the test tube with the rest of the solvent, and add it to the solution and gum. The carbon bisulphide almost immediately volatilises, and if it were not prevented the precipitated phosphorus would ignite ; at the right moment, therefore, the soft soap is to be added,

and the phosphorus to be hastily incorporated with it. The rest of the ingredients are then to be rubbed together, the mass divided into twenty-four pills, and coated with gelatine. This may be a useful preparation, but I am not aware that it has been tested clinically. The difficulty of the process, however, is a serious obstacle to its general employment. The pills would probably retain the very offensive smell of the solvent employed, and, unless they were very dexterously made, most likely some of the solvent itself.

Tavignot employed a pill made from an oily solution of phosphorus alone—avoiding the objectionable ingredient unnecessarily inserted in Mandl's formula given above. His prescription is—

Formula No. 16.

Take of Almond oil, 4 grammes ;
Phosphorus, 5 centigrammes ;
Almond soap, 4 grammes ;
Liquorice powder, 9·8 grammes.

Make fifty pills, to be covered with gelatine.

In 1849, Mr. Batten published in the *Lancet* an account of some cases of disease which he had successfully treated with pills, made by rubbing together white wax and phosphorus under hot water. The proportions he employed were one grain of phosphorus to three of wax. From his account of the doses he administered with the assistance of this formula, it must be concluded that it is not a very active one ; in one case he

gave three pills, each containing one grain of the remedy in the course of an hour and a-half; and in other cases, a grain every hour or every two hours, to three or four doses. The patients survived.

Dr. Radcliffe's method of making phosphorus pills is to melt together suet and phosphorus in a close vessel, to divide the mass, when cold, into pills of any desired dose, and to coat them with gelatine. Probably suet is not a very good solvent to employ, since the preparation has not been found very efficacious.

An ingenious formula for making pills with a solution of phosphorus has been devised by Mr. Gerrard, and published by him in the "Pharmaceutical Journal" of 1873. This gentleman has found that resin, that is to say, the residue of the distillation of turpentine, is capable of dissolving four or more parts per cent. of phosphorus. The directions which he gives for making phosphorised resin are as follows:—Take a stout, wide-mouthed, and well-stopped glass bottle, previously warmed, and nearly fill it with melted resin; weigh it, and add the proper proportion of phosphorus. Close the bottle and place it in a sand bath at a temperature of 200° Cent., and take care that it does not rise above 210° Cent. or red amorphous phosphorus will be formed. Two precautions are to be observed, viz.:—to see that the bottle is nearly full; and to add the phosphorus in one piece if possible, or, at all events, in pieces of such size as may be easily pushed at once below the surface of the solvent; otherwise it will inflame. The

mixture must be cautiously stirred during solution. To make pills with this solution, Mr. Gerrard directs that the following ingredients should be taken :—

Formula No. 17.

Take of Phosphorised resin (4 per cent.), 25 grains.
White sugar, 75 grains.
Tincture of tolu, *q. s.*

The resin being cold may be easily powdered with the assistance of a drop or two of the tincture, which further serves to bind the mass together. Mr. Gerrard is able to state that these pills retain their form well without the aid of any coating, and have but a very faint smell of phosphorus; and, further, that they have been used with results which speak for their activity, in the out-patient department of University College Hospital. The action of free phosphorus in disease is not so well understood, but that it would be satisfactory to have some more definite information as to the evidence which treatment with this prescription has afforded of its activity; but it appears to be an elegant and convenient form. Its efficacy must, however, depend primarily on the digestibility of the resin.

The coated pills made by Messrs. Kirby and Co. contain a solution of phosphorus combined with a resinous body. I have found them to be fairly active preparations.

The following method of making phosphorus pills is given in the Appendix to the British Pharmacopœia :—

Formula No. 18.

Take of Phosphorus, 2 grains.
Balsam of tolu, 120 grains.
Yellow wax, 60 grains.

Put the phosphorus and balsam of tolu into a Wedgwood mortar about half full of hot water, and when the phosphorus has melted, and the balsam has become sufficiently soft, rub them together beneath the surface of the water until no particles of phosphorus are visible, the temperature of the water being maintained at or near to 140°. Add now the wax, and as it softens mix it thoroughly with the other ingredients. Allow the mass to cool without being exposed to the air, and keep it in a bottle immersed in cold water. It may be softened with a few drops of rectified spirit when made into pills.

Perhaps it is intended that the mass should be kept in cold water in a bottle—not in a bottle kept in cold water: at all events, the former should be done. The water used should be deoxygenated, and, if possible, kept so.

These and all other pills of free phosphorus should be coated.

It is not improbable that the above formulæ, with one or two exceptions, may be practically found to be useful and active preparations of free phosphorus; but the dangers which beset the use of some preparations of phosphorus are subtle and serious enough to make it necessary to regard these forms, which to a certain extent are ex-

pected to stand the test of age, with some jealousy. I should hesitate to employ, therefore, except with great caution, any pill of phosphorus which has not already undergone ample clinical investigation; and this is the more necessary that the dose of phosphorus varies very greatly with the form in which it is administered; in other words, upon the solubility or digestibility of the menstruum employed, and the ease with which that separates from the phosphorus while in the stomach. For these reasons it has seemed to me eminently desirable that some method should be found of so minutely dividing phosphorus, without exposing it to oxidation, as would allow of the preparation of pills containing very small quantities of the element without any reasonable fear of its unequal distribution among a number of them; and accordingly I have been at some trouble to obtain pills of absolutely free reduced phosphorus in mechanical mixture with an inert vehicle.

Trousseau gives a prescription in which the metalloid and breadcrumb are the only ingredients, and pills may be prepared with this diluent in the following proportions:—

Formula No. 19.

Take of Breadcrumb, 1 drachm;
Distilled water, *q. s.*;
Phosphorus, 1 grain.

The bread is first of all to be worked into a mass of uniform consistence, and the phosphorus then incor-

porated with it. This is not at all a good prescription, both on account of the exposure to air which the phosphorus suffers, and the great difficulty of ensuring a uniform diffusion of it through the mass. M. Gubler has condemned pills made in this way, partly on account of the ease with which they undergo oxidation; and Dr. Druitt, from whose handbook the above prescription is taken, appends a note to the effect that they are of doubtful efficacy in just that form of disease in which authors are unanimous in praising the power of free phosphorus.

Many processes, essentially the same, have been proposed for reducing phosphorus to powder; and that devised by Leroy is to this day used for certain commercial purposes. The element to be reduced is placed in a long, narrow vessel, with water of a temperature to melt it; on violent agitation it is reduced to globules of great minuteness, and the rapid cooling of the water employed, by the sudden addition of a large quantity of cold water, solidifies these particles while they are yet suspended, and permits them to fall together at the bottom of the vessel without cohering. By this process a white powder is produced, which consists of particles of phosphorus of which each is coated with phosphoric acid; and it is scarcely at all luminous in the dark. This plan cannot, therefore, be employed in pharmacy. The employment of a fluid of somewhat higher specific gravity admits of a still finer subdivision of the metalloid than can be effected with water alone. Urine was long used

for this purpose; and solutions of salt or of sugar in water have been recommended as cleaner substitutes. There being, then, no other methods at command but these imperfect ones for reducing phosphorus, I requested Messrs. A. H. Cox and Co. to attempt such other processes as they might devise, and to supply me with specimens of the result. They eventually offered samples of reduced phosphorus, in which the metalloid appears as a perfectly homogeneous paste. It is produced by a simple process of reduction, which is well calculated to protect the phosphorus from oxidation from the time it goes under treatment to that in which it is dispensed in the form of pills. The very soluble coating with which these are covered is efficient in protecting them from oxidation while stored; and I have successfully employed some of them which had been made three or four months.

Of the Phosphide of Zinc.

Chiefly on account of the nauseous character of the fluid preparations, and the difficulty of preparing pills of free phosphorus, it has been sought at various times to obtain such a chemical combination of it as should be as therapeutically active as the free element. The desideratum is that the combination shall be such as may be easily decomposed, at some period of the process of its absorption, into its constituent parts, while it should at the same time be stable under ordinary circumstances. Most of the metallic combinations of phosphorus are

too stable to admit of decomposition by the rather feeble re-agents present in the human body; and a great many do not afford any evidence of the presence of phosphorus in them except under the action of complicated and powerful processes. The hypophosphites of lime and of soda have, however, been long known to present the more obvious qualities which appear to be desirable for the present purpose; for example, they may be preserved without change for indefinite periods with ordinary care, whilst it is only necessary to bring them into contact with flame to procure evidence of the presence of phosphorus in them. The ease with which they ignite, and the peculiar flame which they afford, together with their faintly alliaceous odour, are all tests which point plainly enough to the presence of phosphorus in them in a condition which admits of easy decomposition. Accordingly these combinations have been employed as means of exhibiting phosphorus; and they are supposed to afford the element, by their decomposition, on coming in contact with the acids present in the stomach. This is the process by which phosphide of zinc is made to yield phosphuretted hydrogen, and through it the effects of free phosphorus; but, practically, I have not found the hypophosphites of sodium and calcium to afford any analogous action.

I have tested these compounds and have not succeeded in obtaining any of those benefits from them which were subsequently derived immediately from small doses of the uncombined element. So far, then, as my ex-

perience has gone, I feel compelled to reject these compounds, if they are regarded as *media* for procuring the effects of free phosphorus. But results have been obtained with phosphide of zinc so different from those obtained with the hypophosphites, pointing so plainly to the evolution of free phosphorus in some part of the system, that it is certain that the exhibition of this body may be regarded as equivalent to the exhibition of free phosphorus. The decomposition of zinc phosphide is entered on in the section on "Dose;" it is proposed only to describe its chemical and pharmaceutical preparation in this place.

Zinc Phosphide.—In investigating the combining properties of phosphorus with metals, its union with zinc was attempted by Margraaf in 1740, and again in 1768 by Bertrand le Pelletier, but with only partial success. M. Vigier, in 1867*, first invented and published a process by which this combination could be effected. In 1868, he suggested to Dr. Curie the possibility of procuring the effects of free phosphorus by the decomposition of zinc phosphide within the body, and these two authors published the result of their investigations in the "Bulletin Générale de Thérapeutique" for the same year.

Zinc phosphide is made by passing the vapour of phosphorus over boiling zinc in an atmosphere of dry hydrogen; on mingling, the vapours unite with the evo-

* "Annales de Physique et de Chimie." August, 1867.

lution of light, and the product is condensed and deposited in a glass bulb to which it is conducted for the purpose.* This substance occurs in right-angled or oblique crystals with a rhombic base; it is of a grey colour and friable; the fracture is vitreous, and of a metallic lustre. At a high temperature, it vapourises and burns, becoming phosphate of zinc. Under ordinary circumstances it is stable, even if exposed to damp air; but it is easily acted on by weak acids, when it decomposes into phosphuretted hydrogen, and a salt of zinc. It is in this manner that it is decomposed in the stomach. Phosphuretted hydrogen is a dialysable gas, and is capable of affording the same results as free phosphorus. The composition of zinc phosphide is definite, and may be expressed by the formula PZn_3.

The atomic weights of these two elements being nearly equal, the formula which expresses this combination of them shows it to contain one-fourth part of its weight of phosphorus. But MM. Vigier and Curie have found that while a rabbit weighing three kilogrammes is killed by ·007 grammes of free phosphorus, it takes as much as ·06 grammes of zinc phosphide to produce the same effect. Hence it follows that zinc phosphide does not act in proportion to the whole weight of the combined phosphorus, but only in proportion to half of it; *i.e.*, the result of the decomposition of eight parts of phos-

* This process, which is attended by some danger of explosion, has been improved by M. Prevoust, who recommends the substitution of nitrogen gas for the hydrogen employed by M. Vigier.

phide of zinc is, in point of physiological power, equivalent to one part of free phosphorus. This test experiment is inserted here as given by the authors, and must be taken for what it is worth. Clinical experience of the preparation has led me to believe that these proportions are rather understated.

It is not necessary to point out the advantages which such a combination as this possesses over many of the preparations of free phosphorus; but it may be mentioned that it affords the only means of giving phosphorus in powder. This is sometimes of advantage in the case of children, although there is no difficulty in getting them to take formula No. 10. Dr. Curie's formula for powders of zinc phosphide is :—

Formula No. 20.

Take of Zinc phosphide, ·4 grammes;
Starch powder, 4·0 grammes;
Make fifty powders.

To some such formula as this, sugar and aromatic spices may be added, with the result of producing a preparation which is regarded as a sweetmeat by children, for the drug itself is tasteless. The addition of these ingredients is useful, too, in controlling the phosphoric eructation to which this medicine gives rise; but for that purpose nothing is more serviceable than the soluble coating which the firm named above has employed to cover pills made with it. These points are, however, more properly noticed below in the section on "Dose."

Of External Applications.

Phosphorus has been topically employed in the form of ointment, liniment, and collyrium, and for effecting the actual cautery. In the face of the facility with which it oxidises it is difficult to believe that any active properties can manifest themselves by its absorption through the skin. Cases are, however, recorded in which good results appear to have been obtained in this way. *Pommade phosphorée* holds a place in the French Codex; it is made in the following manner:—

Formula No. 21.—*Pommade Phosphorée.*

Take of Phosphorus, 1 gramme;
Axungia, 100 grammes.

Put the lard into a wide-mouthed, well-stopped bottle with the phosphorus. Place the bottle in a water-bath. When the phosphorus and lard are quite melted remove the bottle from the water-bath, shake the contents together, and keep shaking until they are cold.

The following are three formulæ for phosphorised pommade or liniment:—

Formula No. 22.—*Cruveilhier.*

Take of Phosphorus, ·05 grammes.
Camphor 5· grammes.
Axungia 80· grammes.

Formula No. 23.—*Tavignot.*

Take of Phosphorus, ·02 grammes.
Oil of nuts, 100· grammes.
Naphtha, 25· grammes.

Formula No. 24.—Gerdeesen.

Take of Phosphorus, ·03 grammes.
Acroleine, 10· grammes.

These formulæ contain a larger proportion of phosphorus than it is safe to apply by means of them to the skin. Fabre reports that ointments of phosphorus have been known to inflame on application to the skin, and in that case the resulting wounds are deep and serious; and that he has known them often enough to produce erysipelatous eruptions. He advises that no liniment or ointment should contain a greater proportion of phosphorus than one grain to the ounce. As to the possibility of its absorption by this channel in an active condition, De Lens affirms that he has been told by those who were in the habit of handling phosphorus frequently that they suffered from an amount of venereal excitation which could only be referred to their occupation. The third of the above formulæ is not a good one on account of the instability of the vehicle employed. Phosphorised oil has been employed by Tavignot as a collyrium. The proportion recommended by him is one part of phosphorus in one hundred and fifty parts of oil. He has employed it for the solution of cataract, a result which it is said to effect after some months of use. Lastly, phosphorus has been employed to produce actual cautery. De Lens thus describes the method of proceeding :—" Avec une parcelle de ce corps, grosse comme la moitié d'une lentille, à laquelle on met le feu, quelques

instants suffisent pour pratiquer une cauterisation profonde aussi entendue que celle qui resulte d'un moxa ordinaire." The number of points may be multiplied at will. The pain is extreme, but very brief, and for the latter reason, and on account of the rapidity with which the process is accomplished, adapted to those patients who are unable to bear prolonged discomfort.

There is an insuperable objection to this use of phosphorus in the bad character which burns from it always take on. Le Pelletier was burned in the thigh with a little phosphorus which he was carrying in his pocket; and although the wound was not very extensive, it did not heal for more than six months. But, further than this, it has been found that the inoculation of an ordinary and trifling sore with this body is sufficient to cause it to take on gangrenous action. Such a case is related by Mertens.

Of Allotropic Phosphorus (Red).

It would scarcely have been necessary to allude to this form of phosphorus if Bednar, of Vienna, had not recently reported excitement, trembling, and clonic spasm, as the result of its prolonged administration in small doses. It has generally been regarded as a perfectly inactive body. See Orfila and Rigaut, who made a dog swallow 200 grammes of allotropic phosphorus in the course of twelve days without observing any result; Bussy; De Vrij; and Lassaigne and Reynal, who con-

clude that it is not poisonous to dogs in doses of five grammes, nor to birds in doses of three centigrammes, and that it produces no action on mucous membranes with which it is left in contact. Other references to observations of a similar kind may be found in the List of References. Allotropic phosphorus of the red variety always contains some free phosphorus, and requires very careful washing with bisulphide of carbon in order to get rid of it. Perhaps the active properties apparently evinced by this form of phosphorus in the hands of some observers may have been owing to its imperfect isolation

III.

ITS DOSE.

Before proceeding to ascertain the dose of free phosphorus, and the comparative value of the various preparations described in the preceding section, it is necessary to consider the manner in which it is absorbed from the stomach or intestines, and in what form it manifests its peculiar powers. This section will therefore deal with the absorption, the form of action, and the dose of free phosphorus.

Absorption of Free Phosphorus.—The process of absorption will be regarded in the first place in relation to solid phosphorus both in the mass and reduced. It is proposed first to recite some of the ascertained properties of the metalloid under various conditions. Phosphorus is a transparent, almost colourless solid. Brittle at or below 32° degrees, it becomes waxy and ductile at higher temperatures.

It fuses at about 111° F., forming a viscid, oily liquid. Under conditions of molecular change, whereby on exposure to light its outermost layer becomes white, it melts at a temperature of less than 70°, and inflames

on being touched.* In air the heat of the hand or the slightest friction is sufficient to ignite it.

Exposed to air it exhales fumes which are luminous in the dark, and smell with an odour for convenience called alliaceous, but, in fact, *sui generis*; and it gradually becomes reddish yellow and opaque. If very small proportions of the vapours of olefiant gas, ether, naphtha, turpentine, or of some other bodies (but especially the essential oils) be present with the air, then the luminosity is prevented (Graham), and solutions of phosphorus in these bodies are not luminous. This is probably owing to some interference with oxidation (Taylor). Eventually it becomes coated with phosphoric acid, by which further change is prevented, and even its inflammability is diminished.

Phosphorus is soluble in the fixed and essential oils, and other hydrocarbons, in chloride of sulphur, sulphuret of phosphorus, chloride of phosphorus, and in hypophosphorous acid. In water it is not soluble, but it undergoes changes in it at ordinary temperatures which impart to this fluid some of the properties of phosphorus, together with those of phosphoric acid. These changes are the result of oxidation. Since no hydrogen escapes during the process, it is probably effected at the expense of the air suspended in the water.

In the presence of water phosphorus vaporises at a low temperature.

* Brande and Taylor, "Chemistry," p. 265.

If the temperature be raised to 95° or 104°, in contact with water phosphorus produces phosphuretted hydrogen and phosphorous acid; these bodies quickly pass into phosphoric acid.

If the water contain organic matter then the products named do not proceed to form phosphoric acid (Wöhler).

At the temperature named phosphuretted hydrogen and phosphorus vapours are dialysable (Wöhler).

In contact with oxygen phosphuretted hydrogen decomposes to form water and phosphoric acid.

Hypophosphorous acid is a powerful deoxidising agent; and Personne has ascertained that a solution of phosphorus in it diffuses itself most easily in the blood, and becomes extremely poisonous.*

In the stomach phosphorus may be exposed to air and to various gases, to the alcaline fluids proper to the organ when empty, and to a heightened temperature calculated to promote chemical changes. Under these circumstances the metalloid is acted upon in the following manner. In the first place it gives off its vapour, possessed of the properties of the mass from which it is derived; and the diffusion of this vapour in the fluids of the stomach affords one means of procuring the effects of free phosphorus. In the second place it forms phosphuretted hydrogen, which may also be diffused in a similar manner; but in addition, this gas and the vapour itself are dialysable. This point has been proved

* *Vide* Gubler, "Bulletin Général de Thérapeutique." 1873.

by Voit and Bamberger. Thirdly, the element undergoes oxidation. Hypophosphorous and phosphorous acids are formed; and, as phosphorus is soluble in the latter of these two products, there can be little doubt that a portion of it finds its way into the circulation in this manner. Hypophosphorous acid is a powerful deoxidising agent, and it has been ascertained to add greatly to the toxic powers of phosphorus; in what way I shall endeavour to show below. As before mentioned, it has been asserted that these results of the lower stages of oxidation do not in the presence of organic matter proceed to the higher stage, *i.e.*, to form phosphoric acid. There seems, however, to be some evidence to the contrary. From direct experiments conducted by M. Personne on starving dogs, it appears that a mass of phosphorus need not of necessity undergo any change of consequence to the subject in its passage through the body. The bolus has been found to traverse the intestinal canal, and to make its appearance coated with phosphoric acid, but otherwise unchanged; and the animals in that case have not seriously suffered. It has been stated that such a covering protects the element from further changes, and may even prevent its combustion. M. Tilley* has observed the same thing in the case of a cat; the dose was vomited. The occurrence of ulcerated or phagedænic spots in the stomach, in cases of poisoning with solid

* Quoted by Orfila and O'Henry in the "Annales d'Hygiéne." 1857.

phosphorus, has been cited by Lecorché,* in proof of the formation of this oxide. Except in so far as such portions of the element as may be thus oxidised are rendered innocuous, this point is not of consequence to therapeutics. The processes, then, by which phosphorus is absorbed from the empty intestinal tract are, so far as is known at present, by the diffusion in the gastric fluids of its vapour, and of the phosphuretted hydrogen which it forms, or by the direct passage of these gases into the blood by dialysis; and, I suggest in addition, by its solution in the hypophosphorous acid which is formed at its own expense.

But phosphorus is not often presented to the empty stomach; usually it will be associated with food in it. When this is the case the extreme solubility of phosphorus in fat, increased, no doubt, by the elevated temperature of the interior of the body, must be borne in mind. Experience shows that phosphorus is absorbed in no combination so rapidly, perfectly, and effectively as when dissolved in oil; and on the Continent such a solution, effected in the stomach, is regarded as the chief means by which solid phosphorus is absorbed from it. Some support of this view may be derived from certain cases of poisoning; and the evidence is the more valuable since it shows also that solid phosphorus, however it may yield eventually to the processes already described, is in reality attacked with difficulty by the matters at com-

* "Archives de Physiologie." 1868.

mand in the empty viscus. On this point, nineteen cases of poisoning reported by Dr. Tüngel* may be specially noted; since he states that in many the toxic symptoms became manifest only after the ingestion of food. The case of accidental poisoning related in the Appendix points also to absorption by this means. It will be observed that the patient, who had been unable to take food for many days, received two grains and eleven-sixteenths of solid phosphorus in the course of six days; that she derived signal benefit from the medicine, and that, therefore, some part of the metalloid was certainly absorbed from the empty intestines; but that some part also was retained, accumulating in the digestive tract; and that on eating freely of sprats, a fish which affords a large quantity of oil, toxic symptoms of the severest kind immediately appeared. Possibly in this case the unabsorbed portions of metalloid were preserved by such a coating of phosphoric acid as protected the larger masses given to animals by Personne and Tilley.

On due consideration, I see reason to believe that the above methods are those in which phosphorus is absorbed; but I entirely concur in the opinion that it is chiefly after solution in the fatty part of the contents of the digestive tract that it enters the circulation. It appears also that phosphorus may be presented to the economy strictly in a condition of freedom, either by its vapour, or by the decomposition in the blood of phosphuretted hydrogen, or, probably, by its solution in oil.

* "Clinical Report of the Hospital of Hamburgh." 1861.

Its Form of Action.—In what form does phosphorus manifest its peculiar powers? There seems good reason to believe that it is incapable of producing the symptoms and morbid changes which distinguish its action, except when it enters the circulation in the free state. The arguments in support of this view are derived from the toxicology of phosphorus. The presence of free phosphorus may be demonstrated in the tissues of persons who have died from poisoning with this element. Leroy cites a case in which the patient, who was suffering from malignant fever, took one grain of phosphorus the day before her death. On dissection the tissues were observed to be luminous, and the appearance of luminosity was even imparted to the hands of Rielle, who assisted at the examination. Leroy refers to this example in proof of the infinite divisibility of the element, and it may be an instance of it; but phosphorescence is a symptom often observed as a consequence of the rapid disintegration which goes on, not only after death, but even before it, in the bodies of those who have suffered from fever of the kind indicated. Luminosity of the tissues has, however, been observed as the direct result of the ingestion of phosphorus, both in men* and in animals. Tardieu records the fact that persons have been known to suffer from eating the flesh of animals which have died of phosphorus poisoning, although the smell of the meat while being dressed is

* Galtier. "Toxicologie," Tom. I.

generally enough to deter from its use as an article of food.* Evidence of the presence of free phosphorus in various parts of the bodies of animals or persons poisoned with it is afforded by chemical analysis. Professor Delarue,† on digesting portions of liver with sulphuric acid, has observed little flashes of light or scintillations in the charred tissue, due to the ignition of morsels of the metalloid. S. Passerini‡ has obtained, by the distillation of suspected organs with water, the evolution of white fumes from them, which were seen to be luminous in the dark. Herapath's process§ of analysis depends on the production of phosphuretted hydrogen gas, which can only be obtained with the assistance of free phosphorus.

The presence of phosphorus in the circulation during life is shown by the luminosity of the various excreta which is sometimes noticed. Thus the fæces are often seen to be luminous, though, since the appearance might be owing to the passage of unaltered phosphorus through the intestines, this fact is not of very great importance. But the urine has been observed to possess this property; Taylor vouches for this fact in his "Jurisprudence." In the same work it is asserted that in one case not only did the breath appear as a white vapour, but the hands were seen to be luminous in the dark.

* Tardieu et Roussin, "Sur l'Empoisonnement." Ed. 3me.

† "American Medical Monthly Journal." 1858.

‡ Quoted in the "Medical Times and Gazette," 1863, p. 287.

§ "Medical Times and Gazette," 1864.

The white vapour which accompanied expiration in that case was also noticed in a case reported in the "Glasgow Medical Journal;"* and the fact of its occurrence, which is not disputed, is also referred to by Professor Gubler in his essay, already quoted. The phenomenon has been observed by Magendie and Devergie† as the result of the injection of phosphorised oil into the jugular vein of dogs. The pulse rose, the respiration became quickened, and the breath loaded with phosphoric vapours so rapidly that there was scarcely time to finish the injection before they appeared, and the animals died in from fifteen to twenty minutes. The presence of phosphoric acid in the breath, and of the peculiar alliaceous odour which the latter affords in these circumstances, point to the presence of free phosphorus in the blood traversing the lungs.

One result of poisoning with phosphorus is seen in the deoxygenation and solution of the red corpuscles of the blood—their destruction as corpuscles.‡ Since it is by means of these bodies that oxygen is carried to the various parts of the system, it is probably by absorbing this gas that phosphorus commences its operations upon them. The production of phosphoric acid follows, and perhaps it is this acid which, brought in contact with

* "Glasgow Medical Journal," 1873, p. 407.

† "Dictionnaire de Médicine et de Chirurgie Pratiques." Article "Phosphorus," and in his "Médicine Légale."

‡ Lecorché, "Archives de Physiologie." 1868. Voit and Bauer, "Neues Repert. für Pharmac." xx., 340. Pepper, "American Journal of Medical Science," 1869.

the blood and tissues of the body in a nascent state, produces some of the lesions which are recognised as due to phosphorus. Almost certainly it is by the action of this acid that the corpuscles are *dissolved*—a process not effected by their simple deoxygenation. Other mineral acids when injected into the veins have this property of dissolving these bodies. But if the phosphorus were already fully oxidised—if it entered the circulation from the stomach as phosphoric acid—then it would have no further capacity for oxygen; and therefore a part of it enters the blood in one of the modes described above in the free state, while part may enter without having lost its affinity for this gas as hypophosphorous acid. An analogy which supports this view may be traced in the toxic action of pyrogallic acid—a body which in the presence of an alkali exhibits a remarkable affinity for and power of absorbing oxygen. M. Personne has proved that animals poisoned with it present precisely the same *post mortem* appearances as those which have been poisoned with phosphorus.*

The characteristic toxic effects of phosphorus are only to be attained with the element in a free state, or with the assistance of some chemical compound which is capable of evolving phosphuretted hydrogen in the intestines. The absorption of this gas affords a convenient and certain means of procuring the effects of free phos-

* "Gazette Médicale de Paris," 1869.

phorus, for on entering the blood and coming into contact with its oxygen it decomposes to form water and (theoretically setting the element free first) phosphoric acid (Mialhe*). This fact, too, affords some support to the opinion that to produce its characteristic effects phosphorus must enter the circulation in the free state.

Lecorché (*Loco citato*) has attempted to support the theory that free phosphorus taken into the stomach undergoes complete oxidation there, is absorbed as phosphoric acid, and in that form produces the lesions which are generally regarded as due to phosphorus. He points to the occurrence of ulcerations in the stomach alone, and the possibility of dissolving the red corpuscles of the blood by the injection of phosphoric acid into the veins, in support of this proposition. It seems to be almost a sufficient answer to this theory, to point to the harmless character of phosphoric acid as an internal remedy, since it may be given without producing any very marked effect, in as large doses as the other mineral acids. These latter, too, if they be injected into the veins, have a similar power of dissolving the red corpuscles. The argument derived from the observation of this phenomenon is fallacious therefore, since none of those acids, though they may be ingested of a strength sufficient to ulcerate the stomach, have any power after absorption through this organ of attacking the corpuscles; and it is in this way that the oxide of phosphorus must enter the blood, if it be produced in the stomach. But it is not

* "Union Médicale," 1868.

quite clear that gastric ulceration or inflammation is always a result of the local application of phosphorus or its compounds to it; in two cases reported in the *Lancet*,* *general* inflammation of the mucous membranes is noted; and perforation of the stomach has been observed in cases of poisoning with phosphorised oil.† There is no evidence to show that this solution admits of decomposition in the stomach. Indeed, the combination is that best calculated to protect the element from the action of the intestinal contents, and even for a time from oxidation in the general circulation.

To sum up, then, deoxygenation of the blood, the excretion of phosphoric acid by the lungs, luminosity of the urine during life and of the tissues after death, and the production by chemical processes of phosphorus-compounds from the organs of animals poisoned with this metalloid, point to the presence of free phosphorus in the blood and in the tissues. At the same time, the impossibility of procuring the characteristic effects of free phosphorus, except either with the element itself or with the assistance of such compounds as readily yield up their base in their free state, points to the latter as being that condition in which phosphorus exerts its powers over the living body.‡ It is, therefore, essential for therapeutic

* *Lancet*, Vol. I., 1869, p. 836. Vol. II., 1871, p. 189.

† Christison "On Poisons." Worbe, quoted by Taylor.

‡ The opinion that phosphorus produces its peculiar effects only when introduced to the economy in the free state is also held by MM. Tardieu and Roussin. See their "Études sur l'Empoisonnement."

purposes, that phosphorus should be presented to the circulation in the free state. Further, the following more general deductions may be drawn from the foregoing observations:—1st, that the more perfect the state of reduction in which phosphorus is ingested, the more actively will it exert its powers; and 2nd, that the better adapted the solvent is to protect the phosphorus from chemical action in the intestines the more readily free phosphorus will enter the circulation;* always provided that the solvent itself is easy of absorption. Finally, as corollaries to the two latter deductions, the most perfect reduction is effected by solution; and oil is the solvent best calculated to protect the element from premature oxidation.

It will be expedient before entering on the question of dose to compare the various formulæ already described. The remarks upon them will take an almost entirely practical form, and will show that the evil reputation phosphorus has hitherto borne, as a drug treacherously poisonous and of uncertain action, is entirely owing to an imperfect knowledge of its special qualities and properties under various conditions. I trust that a due consideration of the points advanced in the pages immediately ensuing will remove this stigma from a remedy which is at least as valuable as any other in the Materia Medica.

* Devergie holds that the more volatile is the vehicle the more actively will the phosphorus operate ("Dictionnaire des Sciences Médicales"). I am not able to agree with this opinion.

Critical Remarks on the various Pharmaceutical Preparations.—From the concluding remarks of the last paragraph but one, it will be judged that a solution of phosphorus in oil is that which best fulfils the physical conditions necessary to its efficient exhibition. This preparation has been employed more generally than any other. During the 18th century the solid form was most usually chosen for administration. The etherial solution was discovered, indeed, in 1732, by Hoffmann, but it did not come into general employment until the beginning of the present century, when the writings of Löbstein and von Löbel, who preferred this form to any other, and who reported its excellent therapeutical properties, brought it more prominently into notice. Phosphorised oil is almost the only preparation of phosphorus which has been used in England; and when I began the investigations of which I now relate the result, I employed the element in this form. The first case in which I used phosphorus received an emulsion of olive oil and gum water, containing one twenty-fourth of a grain of phosphorus, every four hours. The patient took six doses. At the fourth or fifth, violent vomiting and purging set in, and she was very shortly reduced to such a state of debility that for three days the symptoms were most alarming.

I was a little surprised by this action of a remedy of which I had then had but little experience. However, since the patient was relieved, even before the sixth draught, of the sciatica for which she was placed under

treatment, the dose of phosphorus was reduced to one-fortieth of a grain, occasionally advanced to one-twenty-fourth, and in a similar mixture given to eight other patients. The medicine in this form is disgustingly nauseous; and when everyone of these persons was observed to suffer from vomiting, the symptom was at first set down to this quality. But it was further observed that in five of these patients the sickness was attended by diarrhœa; in two, there was considerable epigastric pain; while in two, flatulent dyspepsia was set up, and persisted for many weeks. These last had not previously suffered from dyspepsia. I have since found reason to believe that this experience was unfortunate—even exceptional; but it made a further inquiry into the administration of free phosphorus necessary, since evidently it could never have been carried to any considerable extent if it were frequently attended by such results as these.

In the course of further investigations, with a view of ascertaining the best form in which to administer this drug, the reports of Drs. Hughes Bennett, Cotton, Broadbent, and Eames, came under notice. These writers had employed phosphorised oil in doses varying between a fortieth and an eighth of a grain; and three of them observed the frequent occurrence during its exhibition of dyspeptic and other toxic symptoms of greater or less severity. Dr. Broadbent reported on twelve, Dr. Bennett on seven, Dr. Cotton on twenty-five, and Dr. Eames on eight cases. All these authors, who are the only English authors who have hitherto reported on the

treatment of any considerable series of cases with phosphorus, concur in speaking of its use as being attended with more or less danger and much inconvenience, and to be undertaken only with the greatest caution. One other very remarkable case also appears to throw some light upon the internal use of phosphorus. In the *Lancet* for 1844, Mr. Reedale reported very fully a case of death after the treatment of the patient with this drug by a quack. The nature of the illness is not stated; but the attendant began his treatment by administering to the patient—a little boy of ten years of age—one-fourth of a grain of phosphorus in a pill two or three times a day. On the eighteenth day of this treatment a saturated solution in ether was substituted for the pills in doses of ten or fifteen drops, given thrice a day. This quantity may have been equivalent to from a fifth to three-tenths of a grain. On the twenty-third day a solution in oil replaced the etherial tincture, and the quantity given in each dose in this form is said to have equalled five-sixths of a grain. Serious symptoms immediately appeared, and on the twenty-sixth day the child died with what we now know to be the symptoms of phosphorus poisoning, although they were not then distinctly recognised as such. It will be observed that although this child received daily from about three-fourths to possibly nine-tenths of a grain of phosphorus per diem in the solid form or in the etherial solution, he did not suffer from it, at all events in any marked manner; but that a very

few doses of phosphorised oil were sufficient to throw him at once into a dangerous condition, and to cause death. A consideration of these reports and of other contemporaneous writings made it apparent that the administration of phosphorus was generally regarded as unsafe on the ground of its liability to cause *unexpected* symptoms of poisoning; symptoms which, although absent in some cases yet suddenly arose in others, without any essential difference being perceptible in them, either in constitution, disease, or treatment, from those which derived nothing but advantage from the medication. It is especially noteworthy that the authors whose works led to this conclusion had chiefly employed phosphorised oil.

Not less remarkable than the last described case, and more valuable on the ground of its greater accuracy, is that reported by Solon,* in which the patient yielded to less than one grain of phosphorus, under the following circumstances. The case was that of a male adult who was suffering from saturnine paralysis, and had been under Solon's care in hospital for a long period without receiving any benefit, when he discharged himself. In a fortnight, finding himself getting worse, he returned for further treatment; and other remedies having already failed, Solon determined to try the effect of phosphorus. Accordingly, a mixture was prescribed containing one-fourth of a grain of phosphorus in one drachm of ether,

* Martin Solon, "Dictionnaire de Médicine et de Chirurgie Pratiques."

two ounces of distilled water, and two ounces of peppermint water. The whole to be taken by spoonfuls in the course of twenty-four hours. This and other mixtures employed in this case were prepared by Soubeiran—a sufficient guarantee of accuracy. Some signs of improvement appearing, on the third day a similar mixture, containing twice the quantity of phosphorus, and, therefore, of ether, was substituted, to be taken as before. This mixture was continued till the ninth day. The improvement was now so well marked, that Solon thought it advisable to increase the dose of phosphorus still further; but he was unwilling to vitiate the experiment by increasing also the daily dose of so active a drug as ether, the vehicle hitherto employed, and he therefore gave the patient on this, the ninth day, an emulsion, containing in four ounces one grain of phosphorus dissolved in almond oil. The patient did not complain of the taste of this mixture, of which, however, he only took a part in the first twenty-four hours, instead of the whole as was intended. The next morning he began to take the remainder of it as before, by spoonfuls. He complained very much of the burning in the throat and stomach which each dose caused; and the third spoonful was speedily followed by vomiting, tenderness of the abdomen, small quick pulse, coldness of the surface, and by death on the third or fourth day. The post-mortem examination revealed the usual appearances of phosphorus poisoning. This patient, then, who had taken half-a-grain of phosphorus in another form every

twenty-four hours for six days, succumbed to some quantity less than a grain taken during thirty-six hours so soon as it was given in solution with oil. No wonder Solon appends to his account of this case the remark that, "this, then, is one of those medicines of which we must be most jealous, and the use of which, when once it has been decided to employ it, must be attended by the greatest possible caution." And this remark fairly expresses the spirit, a little intensified in this case by the unfortunate accident described, in which the internal administration of phosphorus has generally been regarded. At the same time it is to be observed that it has generally been given either in the solid form or in the oily solution, and the reflection is almost forced upon us that the ill effects were due, not to the drug itself, but to the form in which it was administered.

On becoming acquainted with the alcoholic and etherial solutions, I found that the doses of phosphorus which had proved poisonous when dissolved in oil might be very far exceeded in these vehicles without harm. At the same time the excellent results obtained with them afforded sufficient evidence of their therapeutic activity. I was thus prepared to find that Löbstein and von Löbel, while they are enthusiastic in their praises of the therapeutic power of phosphorus, are less hampered in their recommendations by cautions and restrictions than any other writers. They employ on almost every occasion the etherial solution, and that in very large doses; von Löbel himself taking as large a quantity as twenty-

five drops of a solution in ether of eight grains to the ounce (the equivalent of five-twelfths of a grain) every two hours, for many days. Bouttatz also took one grain of phosphorus dissolved in ether in the course of twelve hours; he says, that although he experienced some of the physiological effects of the drug, he suffered no inconvenience.

To sum up, the result of an examination of the recorded cases amounted to this: that phosphorised vegetable oils had been used in England almost exclusively, and on the Continent most generally, in preference to other solutions; that whenever an author, English or foreign, had used phosphorised oil, he spoke more cautiously of the use of phosphorus than those who had employed other solutions; that the dose of phosphorus which proved harmful when dissolved in oil might be far exceeded with impunity, while affording the best therapeutic results, if dissolved in ether; finally, that although many cases of fatal and unexpected poisoning with phosphorised oil have been recorded, no case of poisoning in any degree has yet been recorded from the employment of phosphorised ether. I have now, as far as possible, verified these conclusions by direct clinical observation, and find that they apply equally to the alcoholic tincture. It thus becomes evident that phosphorised vegetable oil possesses properties which are not shared by the etherial and alcoholic solutions.

Since the results yielded by these two preparations (for those last named may for the present purpose be

considered as one) differ more in degree than in kind, the toxic symptoms yielded by small doses of phosphorised oil and by poisonous doses of the solid element being the same, it may be suggested that oil, after all, only affords a *better* means of exhibiting free phosphorus; a means which, by protecting it from premature oxidation in the stomach, ensures the utilisation of all the element administered. I am inclined to admit in part that this may be so. But this point granted, the unexpectedly poisonous effect of medicinal doses of phosphorus thus exhibited is not explained by it; because the same dose may be given in solution with cod-liver oil as in the etherial tincture, with the same benign result, and without the occurrence of the least gastric derangement, even when continued for considerable periods. This fact, which, for the reasons presently to be given, is most important, I have ascertained by special observation; and it is the more valuable that I have employed what is generally regarded as a large and unsafe dose of the metalloid, *i.e.*, one-twelfth of a grain repeated three or even four times in the day. It is necessary to add, that there is no reason to think that this fish oil in any way impairs the active powers of phosphorus dissolved in it, or is less able to protect it from such premature oxidation in the stomach as might alter it.

Idiosyncrasy has been appealed to for the purpose of explaining the apparently greater activity of phosphorus in some persons than in others. Experience alone can answer this question; in the meantime, I may say that,

for my own part, having carefully watched the action of various preparations of this drug in long series of cases, I am not yet satisfied that any idiosyncrasy with regard to it exists. A careful observation of those cases in which the unexpected results so often referred to have occurred, will show that they were all treated either with phosphorised vegetable oil or with solid phosphorus. A consideration of the immunity enjoyed by patients treated with the tinctures leads me to suspect the form in which the drug was administered, rather than any peculiarity in the constitutions of the subjects.

The third explanation of the facts recorded which suggests itself, is that the element and a vegetable oil may enter into combination to form a new chemical compound. They are not, however, capable of thus combining; for, from a solution of phosphorus in olive oil, all the metalloid may be recovered by crystallisation, if the temperature of the fluid be properly reduced. But as phosphorus, which is not soluble in water, yet undergoes changes in it which confer some of its properties upon the liquid, at the expense of the air suspended in the latter, so phosphorus, which is soluble in, but cannot combine with, olive oil, may yet undergo certain chemical changes in it, by means of the oxygen which that body is capable of absorbing. The extreme avidity for oxygen which phosphorus exhibits has already been dwelt upon, and contributes the chief difficulty in the way of its pharmaceutical preparation. It is very difficult to preserve phosphorus, either in solution or in a

purely divided state, without its becoming oxidised. Oil, as has been stated above, is one of the best solvents of phosphorus, at least, for pharmaceutical purposes; it dissolves a sufficient proportion with certainty and rapidity; it best protects the drug from the premature action of the gaseous or liquid contents of the stomach and intestines; and it therefore best ensures the condition essential to the therapeutic action of phosphorus—its entry into the circulation in a perfectly free or uncombined state. But the vegetable oils have hitherto been almost exclusively used as vehicles for phosphorus, and they possess the quality of absorbing large proportions of air —olive oil being able to take up as many as six hundred times its volume.

Now the ultimate result of the free exposure of phosphorus to air is the formation of phosphoric acid, the highest oxide of the element. To produce this compound it passes through the lower combinations, forming hypophosphorous and phosphorous acids; but the successive transformations occur with so much rapidity, that a mass of the element appears on exposure to throw off fumes of the highest combination at once. But if the metalloid be kept under water, these transformations proceed more slowly, and evidence of the presence of the lower oxides in the fluid may be obtained after an interval. After a still longer immersion, phosphoric acid alone is found present. It seems to me plausible to imagine that the density of oil, together with the peculiar manner in which it presents

oxygen to the element dissolved in it, is well calculated to retard the process of oxidation, and to detain it in the lower combinations named.

These, then, being the only changes to which phosphorus dissolved in a vegetable oil is liable, it remains to inquire into the properties of the oxides of phosphorus. Phosphoric acid, it has already been stated, we know to be a harmless body when absorbed in the usual manner from the stomach; any poisonous result which might be produced by it would be analogous to that of any mineral acid. It could not be present in any medicinal dose of phosphorised olive oil in sufficient proportion to produce an appreciable effect. But it is very different with hypophosphorous acid, of which the following are the chief properties. It is easily obtained by submitting the element to the action of a *limited* body of air. It is solid when anhydrous; liquid when hydrated; colourless, inodorous, and very caustic. Heated in the dark, it gives off phosphuretted hydrogen, and becomes luminous in passing into phosphoric acid. It is a powerful deoxidising agent, reducing the metals from solutions of the salts of gold and silver, and decolorising a solution of potassium permanganate. Finally, it dissolves phosphorus. Thus it appears that this compound possesses some of those properties on which phosphorus depends for its action. It will abstract oxygen, so great is its affinity for that gas, from metallic salts; much more, therefore, will it abstract it from the blood corpuscles, which may be deprived of this gas even by the feebler

pyrogallic acid; and at a certain stage of decomposition it yields phosphuretted hydrogen, a gas which, as has been shown, affords the same physiological effects as free phosphorus. It also becomes luminous in the dark, showing that it does not exist without the presence of a certain amount of the free element in it, and perhaps in a peculiar condition. Some physiological experiments have been performed with this acid by Tardieu,* from which he argues its perfect harmlessness. "It has been asserted," says he, "that the poisonous properties of phosphorus are owing to its conversion into phosphorous acid. It is not thus; direct experiments conducted by us in our laboratory at Val-de-Grâce have shown us that one can administer to dogs considerable quantities of the alcaline phosphites or hypophosphites with impunity. Specially, in one of these experiments a dog received twelve grammes of hypophosphorous acid dissolved in water without dying, when the twentieth part of phosphorus (necessary to kill a dog?) dissolved in this acid, and administered in the pure state, sufficed to kill it in a few hours." The fallacy of the deduction drawn from these experiments is obvious. It need scarcely be remarked that the new body formed by the chemical combination of two other bodies may be possessed of properties entirely different from those of its constituents; and it is almost equally apparent that so unstable a compound as hypophosphorous acid can

* Tardieu et Roussin, "Étude Medico-Légale sur l'Empoisonnement." Ed. 1867, p. 432.

scarcely survive admixture with water. It is first by that means deprived of its caustic properties, and then very rapidly oxidised. At the same time it must be observed that the latter part of the paragraph quoted contains a corroboration of the experiments already performed by Personne, which have shown that phosphorus dissolved in hypophosphorous acid is most easily absorbed, and, further, is endowed with toxic powers quite out of proportion to those enjoyed by a similar quantity of the free element.

By experience and by research, I had thus been brought to the conclusion that the uncertain effects of phosphorised vegetable oil are owing to the partial conversion of the metalloid into hypophosphorous acid, when I became acquainted with the following remark, which shows that the opinion had been entertained by Devergie* before. "It results from an observation reported by Martin Solon,† that phosphorus exercises a much greater action when it has been transformed into hypophosphorous acid by contact with air. The fact is that in hypophosphorous acid the phosphorus is present in a state of extreme tenuity. This acid is not only corrosive; it is easily absorbed, and acts upon the nervous system almost like phosphorus itself."

Thus theory and practice concur in conferring on phosphorised vegetable oils a reputation for uncertainty of action, a quality which is in all cases undesirable, and,

* "Médicine Legale." 3me Edition. Tome 3, pp. 165—168.

† The observation already briefly recounted at p. 71.

in that of the drug under consideration, hazardous to life. I have, therefore, entirely rejected these preparations as internal remedies.

Experience of the use of phosphorised superheated oil is not yet sufficiently wide to warrant the assertion that it does not share the dangers of phosphorised virgin oil. These will, however, certainly be very much diminished by the preparative process; and if the oil be effectually purified, it may be enabled to retain phosphorus in the free state for considerable periods at least. Pure oleine is not liable to the same changes as virgin oil. Probably exposure for fifteen minutes to the comparatively low temperature of 300° F., prescribed in the Appendix to the British Pharmacopœia, is not sufficient to destroy the fragments of cellular tissue—the albumenoid impurities of this oil, although it will serve to drive off the whole of the air and water suspended in it. The process was not devised with any view of preventing the formation of hypophosphorous acid, but in order to prevent the production of white, insoluble, allotropic (Beaumetz) phosphorus, which had been observed by De Lens, and subsequently by Beaumetz. The results of administering partially altered phosphorus are so serious, entailing prolonged discomfort or illness on the patient, even when they do not endanger life, that I do not feel inclined to test solutions of phosphorus in vegetable oil clinically, even when properly made; and the less so, that we are possessed of many other efficacious and practically useful means of exhibiting the

drug in the free state. I shall, therefore, for reasons deduced from the foregoing observations, not venture to suggest any dose of phosphorus in this form.

It has been above stated that free phosphorus may be administered in solution with cod-liver oil in full doses and for long periods without the occurrence of any untoward symptoms. Oils of this kind are liable, but not equally with vegetable oils, to become rancid, and for a similar reason, viz., the presence in them of small fragments of the tissues from which they have been obtained. The finest kind of oil of this sort does not easily putrefy, and does not contain a considerable proportion of these tissues. Neither is it possessed in any similar degree of the power of absorbing oxygen. It further possesses the property, pharmaceutically very valuable, of concealing the taste and odour of the element almost completely; and, by the judicious addition of some essential oil, the solution may be made as palatable as any oily fluid can be. The chief difficulty of administration—and it is a very trifling one—practically consists in the well-known taste of the solvent. It does not give rise to any great amount of eructation. I have not found it to disagree with the stomach in any instance, although I have preferred this form for administration in some cases of phthisis attended by flatulent dyspepsia. In point of activity, I see reason to regard this as the most efficacious preparation of phosphorus at command, at the same time that it is perfectly safe. To those who desire to

investigate the therapeutic or physiological powers of this drug, unbiassed by the presence of any other active body, phosphorised cod-liver oil may be specially recommended. There is good ground for the abstract opinion that oil is the best vehicle for the exhibition of phosphorus; but, having regard to the special qualities which *vegetable* oils appear to possess, it is doubtful whether they should ever be employed for that purpose, whatever process of preparation they may first be submitted to. Animal oils are not possessed of these properties, and, of them, cod-liver oil at all events is an eminently suitable vehicle.

A careful consideration of what has been stated of the mode of absorption of phosphorus will render it superfluous to point out how far preferable for medicinal purposes are solutions of phosphorus to the solid element, or that, theoretically, oily solutions are preferable to those made with more volatile fluids. Nevertheless, the alcoholic and etherial tinctures are *practically* as useful as the oily solutions, being powerful enough to effect the desired result in most cases. Since they are possessed of pharmaceutical advantages over phosphorised oils, I now generally begin treatment with one of them; because, if the effect anticipated does not ensue, it is easy then to have recourse to the more active, but less palatable, phosphorised fish-oil. For theoretical reasons, it seems probable that phosphorised ether should be inferior in power to phosphorised oil, and I think that clinical experience warrants

the deduction. But I have not ventured to give the same doses of phosphorus in oil as I have given, or as have accidentally been taken, in the more volatile solutions, nor, indeed, has it ever seemed necessary. One-twelfth of a grain, repeated every four hours, is the largest quantity which I have ever found occasion to exhibit in cod-liver oil; while of phosphorised alcohol (as in the 10th formula), I have frequently exhibited one-eighth of a grain at a similar interval for many days together, while one patient took as much as the equivalent of one-sixth of a grain every four hours for three days without any but a beneficial result. Probably, on entering the stomach, these solutions admit of the separation of the element from the solvent to a certain extent, and in that case, no doubt, the former is partially oxidised before it can be absorbed. Oxidation under these circumstances need not, however, be expected to be otherwise than perfectly effected; the state of tenuity in which the precipitated element will be presented to the contents of the stomach being probably sufficient to ensure its complete, and almost instantaneous conversion, into phosphoric acid. Possibly the large proportion of glycerine in which I am in the habit of giving these solutions may protect the element from separation a little; but this adjuvant mingles so easily with water that this use of it is better seen before than after ingestion. Devergie has asserted that not only is phosphorus more active the more it is divided, but that the more volatile is its solvent, the greater effect will it produce. This is certainly

not the case, nor is it necessary to repeat the reasons for this opinion here; but I may add that although ether is very much more volatile than alcohol, I cannot say that I have been able to detect any difference in the amount of activity displayed by similar doses of these two solutions.

Of the fluid preparations of phosphorus, then, the solutions in cod-liver oil, alcohol, and ether may be taken as those best adapted for internal administration. Of these the solution in cod-liver oil is the most active, but that in alcohol admits of being made the most palatable. I have said before that the volatility of ether is not a serious obstacle to its employment for the present purpose; but alcohol has this advantage over it, that its evaporation, whether much or little, cannot alter the strength of the remaining tincture. Alcohol will only take up one part of phosphorus in three hundred and twenty, and to avoid the use of an inconvenient quantity of the solvent, a saturated solution must be made in the first place, and it can become no stronger. Ether will dissolve a much larger proportion of the element than is convenient for pharmaceutical purposes; if, therefore, this solvent be allowed to evaporate from a comparatively weak solution, the strength of the preparation will be increased. This is, perhaps, not a very practical objection to the employment of phosphorised ether, which is in other respects a useful vehicle, but it requires notice in this place.*

* The contents of this section show that the form in which phos-

Several preparations are now at command, by which phosphorus may be administered in the solid form. These "phosphorus pills" may be divided into two classes, of which one offers the element in the solid form, only very finely pulverised or reduced, while the other contains, in fact, a solution of phosphorus, made into a pill mass with some inert material. These two classes are represented by the coated pills manufactured by Messrs. A. H. Cox and Co., and Messrs. H. T. Kirby and Co. respectively. The former firm offers a pill containing phosphorus which has been reduced to an impalpable powder by a process which well preserves the element from oxidation; the powder is mixed with a sufficient proportion of dextrine, and coated. On entering the stomach, the pill, owing to a peculiarity of the diluent, swells a little, and falls to powder. Thus solid phosphorus, in a condition favourable to absorption, is presented to the digestive organs. I have used this pre-

phorus is exhibited is a matter of the first importance. It is, therefore, necessary to remark here upon two preparations lately introduced to the profession under the names of "Syrup of Phosphorus" and "*Sol. Phosph. Medicat.*" Of the first, it is only necessary to point out, that in it finely divided phosphorus is kept in contact with water. The result is obvious. The second is prepared according to a formula by Dr. Hammond, and is nothing more than an emulsion of phosphorised almond oil, in which the proportion of mucilage is very small. The effects of it as reported by Dr. Routh, who gave it the above name, bear out my conclusions with regard to such an emulsion; and he now proposes to substitute an animal oil for the solvent first used. But the addition of water, essential to the manufacture of an emulsion, will probably be found to render this solution as dangerous as the original formula.

paration rather extensively, and it seems to me to be the best pill of phosphorus at command.

Messrs. Kirby and Co.'s pills contain the element in combination with an oily body and a resin; it is, therefore, really in a state of solution. This I believe to be a very valuable point in these preparations; but the diluent is open to some objections. It is not probable—for the point has never received any special attention—that resins and wax are digested, and absorbed by the intestinal canal, very readily. At the same time some resins and balsams do undergo absorption—Chian turpentine and Canada balsam, for example. As to wax, it is very doubtful whether more than a fractional part, if any, of a mass of it is capable of undergoing digestion. To put this point to a practical test, I shall refer the reader, with regard to the last-named body, to the cases alluded to at p. 40. Here, without doubt, very little indeed, if any, of the pills administered was absorbed. One grain of phosphorus absorbed at one dose would cause serious, if not fatal, symptoms. At a recent meeting of the Pharmaceutical Society, it was asserted, as the result of direct experiment, that the pills of phosphorus as prescribed in the British Pharmacopœia, pass through the digestive tract, and may be recovered unaltered, save in respect of form. Wax, then, seems to be an unfit vehicle for phosphorus. As to resin, Mr. Gerrard is able to say that his pills (Formula No. 17) have been used with such clinical results as prove their activity, in

the out-patient department of the hospital to which he is attached. Messrs. Kirby and Co. inform me that they receive similar evidence from day to day of the efficacy of their resinous preparation, and thus it would seem that resin is a fit vehicle for phosphorus. For my own part, however, I cannot help feeling that some clinical report of the cases treated with either of the two preparations last named is most desirable, before the statements made concerning them are received as conclusive. The fact is that the powers of phosphorus—the results which should be at command with it, are not yet sufficiently well-known to render an *ex cathedrâ* statement concerning a particular formula acceptable. Under these circumstances, the result of a small part of a dose of phosphorus exhibited in a difficultly digestible form may readily be taken for the effect of the whole of that dose. I have been of late in the habit of testing preparations of phosphorus according to their action in uncomplicated cases of neuralgia. I believe, and have endeavoured to show, that phosphorus has almost specific powers over some forms of that disease; and it has appeared to me that the results obtained in a short series of cases of neuralgia may be taken as a fair test of the efficacy of a given preparation. This test may be demurred to, for I have reason to know that the treatment of neuralgia with this drug has not been generally so successfully pursued as I believe it may be. That is chiefly on account of reasons more fully entered upon below; and a due regard for the rules of treatment there laid down will dispel the

dissatisfaction with which this treatment is at present regarded, and will show it to be possessed of the special powers which I have claimed for it. Tested, then, in this way, all resinous and waxy preparations of phosphorus have been found wanting. They may serve well enough (for the former, at all events, yields a mild result) in those cases in which it is deemed advisable to give phosphorus as a tonic (if it possess any such property) or for a protracted period. Judged in the same way, I find that Messrs. Cox and Co.'s pills of reduced phosphorus are fairly efficacious. They are a little more active than zinc phosphide, and I prefer them for general use. The rules laid down for the administration of solid phosphorus must, however, be carefully borne in mind in using these preparations. I have hitherto found no difficulty in getting patients to take Formula No. 10, and that being the case I cannot help being chary of administering solid phosphorus, the conditions necessary to its absorption being only partially under control.

I conclude, with regard to pills of phosphorus, that the element must be reduced to the finest powder imaginable, and by a process which not only does not expose it to oxidation, but which shall actually protect it from any such risk. That this powder must be equably diffused through the inert mass necessary to dilute it. That this mass must not be a wax, and had probably better not be a resin. That the pills when made must be coated. That when administered they must be given with the

strictest regard for what is known of the absorption of phosphorus; the chief condition being its association with food in the stomach. That if all these conditions be observed, pills of phosphorus may be given as safely as solutions of phosphorus. For ordinary purposes they will be found efficacious; but neuralgia cannot be treated in the best manner but with a solution.

I think it wise to be careful of administering solid phosphorus, so far as experience goes at present, for the following reasons. There is but little chance that the whole dose will not be absorbed, provided it meet with a sufficient quantity of fatty matter in the gastric organs. Solid phosphorus may be absorbed in part without its solution in this way, but the quantity taken up by this means is uncertain. The whole dose is never utilised in this way; the time necessary to effect the essential changes being probably longer than that occupied by the passage of a comparatively insoluble body through the intestines. Two elements of uncertainty, then, attend the ingestion of solid phosphorus; first, it may not meet with the matters necessary to ensure its absorption; and secondly, a portion of it is probably, in any case, converted into phosphoric acid. There is a third consideration of more consequence than these two; that the exposure of this element in the solid form to the mixed gases of the stomach, containing a *limited* proportion of oxygen, may admit of the formation of hypophosphorous acid. The suggestion that particles of the element may actually take fire seems

to be improbable; phosphorus does not inflame without friction at a temperature of 100° or 102° Fahrenheit, nor is it likely that it could be made to burn under these conditions in contact with moisture. It is, therefore, probable that the ulcerations or perforations so frequently observed in cases of poisoning with solid phosphorus are caused by the formation of hypophosphorous acid. Perhaps phosphoric acid produced *in contact* with a mucuous membrane might be possessed of similar power, as has been suggested by Lecorché,* who, in the same place, has denied the caustic properties of the lower oxides. These, I believe, are undisputed; and it is difficult to account for the death of a man from a single dose of one-eighth of a grain of solid phosphorus (as in the case reported by von Löbel), on any other hypothesis, than the partial conversion of the mass into hypophosphorous acid, and the solution of the remainder in it, with the effect of producing toxic results not attainable with a similar quantity of free phosphorus. In the case alluded to, the patient (a lunatic) complained in twenty-five minutes after taking the dose of extraordinary heat in the stomach and thirst; anxiety, violent trembling, and convulsions of the muscles of the face and limbs soon followed; the extremities then grew cold, the lips pale, and death very shortly ensued. It will observed that in the case related in the Appendix, the symptoms succeeded one another with much less rapi-

* "Archives de Physiologie." 1868.

dity than in this one; and that has generally been noted in similar instances. Such a case as the latter should, I think, be regarded, therefore, strictly as one of poisoning with free phosphorus. The administration of solid phosphorus seems to be inseparable from certain elements of uncertainty. I do not think that these remarks altogether apply to phosphorus, which, though accurately speaking solid, has been reduced to an impalpable powder.

I have found the phosphide of zinc* to afford a convenient, safe, and efficacious means of procuring the effects of free phosphorus. In full doses it exhibits an undoubted and active emetic power; I therefore give it in half doses, repeated twice as often as if the full dose were being taken. In this way the necessary quantity may be taken in twenty-four hours without causing any sickness. This compound gives rise to a considerable amount of eructation if taken in the form of powder, or in an uncoated pill. Messrs. Cox and Co. manufacture this material into coated pills, and the envelope is specially useful in this case in obviating the eructation to a very considerable extent.

Zinc phosphide has the advantage of admitting of combination with other drugs, not acid, without the slightest suspicion of change attaching to it, and I

* The reader is reminded that the exhibition of zinc phosphide is equivalent to the exhibition of free phosphorus, and, pharmaceutically speaking, is included under that term. The reasons for this view may be found at page 46.

should be inclined to prefer this form if it appeared desirable to employ any such combination. I now most frequently commence treatment with zinc phosphide, and if given in full doses I find that it is sufficiently active to cure four cases of neuralgia out of five; should its action not be prompt or decided enough, recourse is then had to a fluid preparation. For administration to children this preparation is invaluable. As has been already pointed out, it affords the only means of exhibiting phosphorus in powder; and, since it is itself tasteless, it may be made, with the assistance of some aromatic spice, into a dose which will be readily taken by the little patient. M. Gubler, in his article already quoted, has recorded the occurrence of one case of poisoning with zinc phosphide. The medicine was administered in a moderate dose for twenty consecutive days without any effect, but it then became evident that the doses had accumulated in the intestines to some extent under circumstances unfavourable to its decomposition. A change occurred in the character of the intestinal secretions, and toxic symptoms at once evinced themselves. The patient did not die. Zinc phosphide decomposes only under the action of an acid; and it is easy to imagine circumstances under which the contents of the intestinal tract might exist in an alcaline state. The means of preventing the recurrence of such an accident is, therefore, obvious. The patient should either take, during a course of this compound, an acidulated tonic, or be recommended to follow each dose with a draught of lemonade. A very

weak acid effectually decomposes zinc phosphide. From the foregoing remarks the three following suggestions for the safer administration of free phosphorus may be deduced :—

That solutions of phosphorus in virgin vegetable oils are not safe, and should therefore be entirely rejected.

That the solid form is not a perfectly safe mode of exhibiting phosphorus ; it may, however, be employed, but should never be presented to the empty stomach.

That the administration of zinc phosphide should be attended by the use of an acid at the same time.

I trust that it has been shown in these pages that there is reason to believe that want of attention to the facts upon which these rules are founded has materially contributed to retard the more general employment of free phosphorus in medicine, and that a due observance of them will tend to remove the distrust with which it has hitherto been looked upon.

Dose.—The proper subject of this section may be now discussed with the assistance of the information contained in the former part. This is sufficient to show the reader first of all that the dose of phosphorus may vary between very wide extremes, according to the form in which it is exhibited; and hence, I imagine, has arisen the difficulty which has been experienced in fixing any definite quantity as an average dose hitherto.

When phosphorus was first employed as a medicine, it was administered for a long time exclusively in the solid form, and the dose employed seldom fell below three grains, while it occasionally rose as high as twelve. Even Leroy, who had only the older works to guide him, and who found these immense doses familiarly handled by the authors, instituted his experiments by taking a bolus of three grains, and he did not very seriously suffer from it. Epigastric burning pain and great thirst are the only toxic symptoms which he described, and these lasted during only twelve or eighteen hours. It is at first sight hard to understand how the persons who received these large quantities ever survived them. But no doubt the element was exhibited either in one mass, or but coarsely divided, and in that case probably became quickly covered with the coating of phosphoric acid alluded to above, and which has been shown to be sufficient to protect the drug from further changes. Fatal accidents, however, are noted not rarely by these older authors, and if the use of this medicine had not been greatly limited to cases of severe illness (in which the abdominal organs were probably free from food) would no doubt have been more frequent. The best known case of poisoning with the large doses referred to is recorded to have occurred in a case of sudden illness—of apoplexy. The patient took five or six grains immediately after the hæmorrhage, and the next day five or six grains more. The symptoms, both before and after death, pointed,

as they well might, to the fatal effects of phosphorus rather than of apoplexy.* The circumstances of this case render it probable that the stomach contained food. Smaller doses of solid phosphorus than this have been known to cause death. That noticed above, recorded by von Löbel, is the only one in which so minute a quantity as one-eighth of a grain has proved fatal. Of death from somewhat larger quantities many examples might be quoted; one or two, however, will be sufficient. Worbe† notes a case in which a healthy young man of twenty-seven years took half a grain of solid phosphorus, and in three days a grain and a half more; death ensued in twelve days. Hartcop‡ records the case of an apothecary who took first one grain, on the next day two, and on the third day three grains of phosphorus; when he died. Another case in which two or three grains proved fatal may be found in the "Revue Médicale" (1829, III., p. 429). Much smaller quantities than these have caused death when the drug has been exhibited in solution. Solon's case has already been detailed above. Galtier‖ relates that a woman took a solution (in oil) of 0·06 grammes of phosphorus, made into an emulsion, in divided doses during four days. Death ensued three days after the last dose. These latter examples go to show that phosphorus dissolved acts more energetically

* Weickard. "Vermischte medicinische Schriften." 1780.

† "Mémoires de la Société Médicale d'Émulation de Paris." 1825.

‡ Casper's "Wochenschrift," 1846, p. 117.

‖ "Toxicologie. Vol. I., p. 87.

than phosphorus solid, or even reduced to powder. The reasons for believing that solutions made with vegetable oils may possess unduly poisonous properties have been entered on already, and my own experience (which is corroborated by that of many other practitioners who have lately used phosphorised oil) alluded to. This preparation is that which until quite recently has been exclusively employed, and the doses of phosphorus given in this way have varied between one-fortieth and one-eighth of a grain, repeated three times daily. Dr. Hughes Bennett* employed these doses in seven cases, and he concluded that the larger quantities very soon occasion abdominal derangement. He thinks the smaller quantity named the proper dose for administration, and that even this cannot be taken for many days without causing abdominal symptoms. He considers one twenty-fourth of a grain to be the full dose of phosphorus when given in oil. Very similar to this experience of phosphorised oil is that of Drs. Eames† and Cotton.‡ Not to multiply references on a point which need not detain attention long, if the view taken of the dangers of phosphorised vegetable oil be accepted, the doses usually employed in England have varied between one-fortieth and one-eighth of a grain. On the Continent, it is usual to administer one milligramme of phosphorus in

* "Edinburgh Monthly Medical Review." 1855.

† "Transactions of the College of Physicians of Ireland Medical Society." "British Medical Journal," Vol. II., 1871.

‡ "Medical Times and Gazette," Vol. II., 1861, p. 7.

this form five or six times daily, the dose being gradually increased to five or six milligrammes as often repeated. Every seven days the medication is intermitted for a like period.

Although a formula for the manufacture of phosphorised cod-liver oil has been published by Glower, it does not appear that it has ever been much used; and that, for the reasons given above, is remarkable. Of English authors, Dr. Glover* reports that he has employed this form with success; and as he is not particular to enjoin caution in the use of it, it may, therefore, be inferred that he found it a safe preparation. I have used it very extensively, and believe that a solution in this oil is the best preparation. I have given the equivalent of one-twelfth of a grain of phosphorus three times a day for eleven days to a delicate phthisical girl, suffering, moreover, from flatulent dyspepsia, without the least ill result and with much benefit. On the twelfth day a slight diarrhœa set in; but she had often suffered before—once in three weeks or once a month—from similar attacks, and it is not at all clear that it was caused by the medicine. Caution led to an intermission of treatment, however, and the patient has not since had occasion to come under my care. I have not observed any similar symptoms in other patients. This may be considered a test case of some of the properties of phosphorised cod oil; and it is much in

* "Lancet," Vol. I., 1853.

favour of this preparation that no increase in the dyspeptic symptoms occurred during the use of it. I have found from one-twentieth to one-twelfth of a grain of phosphorus dissolved in this vehicle to be a useful range of dose. One-twelfth of a grain I consider to be a full but perfectly safe dose in this form, and the smallest quantity to be employed in cases where a speedy effect is desired. For administration in phthisis, or in chronic diseases, a much smaller quantity will probably be found sufficient—about one-fiftieth of a grain.

Phosphorised ether was first used extensively by von Löbel in 1805. He employed very large doses of phosphorus in this form, taking himself twenty-five drops of a solution of eight grains to the ounce every two hours for eleven days. Bouttatz, as observed above, took one grain in this vehicle during twelve hours. Beaumetz has used it in doses equivalent to one milligramme, gradually increased to six, repeated five times daily. These facts show that phosphorised ether is not possessed of actively toxic powers, nor am I acquainted with any case of poisoning with it. I have employed it in various doses, using a solution of two grains to the ounce. I believe that to produce a rapid effect, as in acute neuralgic pain, or in the last stages of exhaustion from disease, it is necessary to give the equivalent of not less than one-twelfth of a grain of phosphorus every four hours; while, if it seem advisable, the dose of the element in this form may be increased with advantage. It will be better, however, to give the dose named every three or

every two hours, rather than to increase the amount of each dose. This formula, on account of the stimulant properties of the solvent, recommends itself for use in such cases as those in which the stimulant effects of phosphorus are chiefly desired.

I am not acquainted with any noteworthy report of the use of the solution in alcohol. I have found it (in Formula No. 10) an elegant and useful preparation. I have never seen any ill result even from very large doses of it. In one case the patient took the equivalent of one-fourth of a grain of phosphorus every four hours for three days, without suffering. The medicine was given in Formula No. 9, and it is probable, therefore, that part of the drug, at all events, was oxidised in or before entering the stomach. In Formula No. 10, which is calculated to protect the drug from oxidation, however, I have given as much as one-eighth of a grain every four hours for several successive days without observing any untoward result, and I consider that one-twelfth of a grain in this formula is a full dose; not a full one, if that is to be judged by the quantity which *may* be given without harm, but the *maximum* dose under ordinary circumstances. The rule, very necessary in administering phosphorised oil, or solid phosphorus, of intermitting the medication every seven or fourteen days, is not necessary in the case of this preparation. I have given one-twelfth of a grain three times a day to one patient for thirteen weeks, with the greatest regularity, and to another for seven weeks, without harm.

With regard to zinc phosphide I have already remarked that clinical experience of this compound warrants the opinion that its therapeutic power, as measured by an equivalent of free phosphorus, has been a little overstated. That is to say, that instead of obtaining the therapeutic effect of one part of free phosphorus with eight parts of zinc phosphide, I have found it necessary to give more than the latter quantity to obtain the same result. The emetic action of zinc phosphide has also been alluded to. For some time I was in the habit of giving one-third of a grain of zinc phosphide every two hours, which, theoretically, was the same thing as giving one-twelfth of a grain of free phosphorus every four hours. The therapeutic results obtained, however, fell short of those which could be obtained from the latter dose of the free element, and it became necessary to ascertain whether the compound was actually less active than it, or whether the administration of a larger proportionate quantity would rectify the difference. In a considerable number of cases of neuralgia, therefore, in which the specific action of phosphorus might be fairly expected to exhibit itself with rapidity, half a grain of zinc phosphide was given every two hours. The result was observed in a decided increase in the powers shown by the smaller doses. It was not deemed advisable to give any larger quantity than this, so that I cannot say that a larger proportion may not be absolutely equal in power and rapidity of action to a given quantity of the free metalloid. But I do not think it would be possible to exhibit

any larger dose than half a grain every two hours, for it was occasionally necessary to reduce even that dose on account of the vomiting to which it gave rise. It may be noted here that on two occasions I have seen a very small dose indeed of this compound—one sixth of a grain—occasion the most violent vomiting, which lasted several hours. This symptom following on this small dose is not evidence of poisoning, but is attributable to the emetic power of zinc phosphide acting on an unusually sensitive stomach.

This compound affords a useful and efficacious means of procuring the effects of free phosphorus, and since I have employed it in the form of a coated pill I have not observed any sickness or eructation to ensue on its ingestion. The advantages which it presents have been pointed out above. The dose should be, for an adult, not less than one-third of a grain, repeated every two hours, and taken with the precaution already prescribed. I have given one-sixth of a grain in powder to children of from six months to three years of age, in states of exhaustion from acute disease, with good results.

Of other preparations of phosphorus it is not necessary to say much in addition to what has already been written. It may be added, however, with regard to the pills prepared by Messrs. Cox and Co., that in this form I regard one-twelfth of a grain as quite a full dose. One-twentieth is the dose which will be found to give good results in neuralgia. For other purposes, as an

occasional stimulant for example, one thirty-second of a grain is sufficient.

In concluding this section, the contents of it and the preceding one may be reviewed together. It will be seen that for many reasons solutions of phosphorus are much to be preferred to any other preparations, while an oily solution is preferable to the alcoholic or etherial. The solutions in vegetable oils as made in England appear to be not safe preparations; possibly if made in the French manner they may be administered without risk. Having other formulæ at command which I know to be safe, I shall not venture to test them clinically. The solution in cod-liver oil may be regarded as one of the safest and, at the same time, the most active of the preparations of free phosphorus at command. It admits of being made reasonably palatable, and, if it were enclosed in capsules, forming what are known as "*perles*," might obviate the necessity of seeking any other means of exhibiting phosphorus. In the absence of these preparations it is necessary, for the sake of some patients, to find a more elegant preparation than this. It is presented in the combination of glycerine and the alcoholic tincture of phosphorus, which affords a mixture almost tasteless as far as the active ingredient is concerned, and not unpleasant in other respects. It is active enough for most purposes, and may be given without intermission for very long periods and in considerable doses. It is perfectly stable. Similar remarks may be made on the etherial tincture, which, however, never loses the somewhat offensive taste of the solvent.

The pills of reduced phosphorus already described afford an efficient, convenient, and agreeable means of exhibiting free phosphorus; and they have the further advantage of a very soluble covering, essential to all pills of phosphorus, which well protects them from the external air. But pills made with a solution would be at once safer and more active than these if the menstruum employed were easy of digestion. By the decomposition of zinc phosphide in the stomach, the same results may be commanded as with free phosphorus, only somewhat less in degree. The salt of zinc which results from its decomposition, recommends it for administration as a tonic in cases where the use of phosphorus for a long period is considered advisable, and specially in cases of epilepsy.

The dose of phosphorus seems to vary very considerably with the formula employed. I do not venture to suggest a dose for solutions in vegetable oils. Of the solution in cod-liver oil I regard the equivalent of one-twelfth of a grain as the quantity which will yield whatever benefit is to be derived from the drug. That is the dose which will be found to give the most uniform results in a series of cases of neuralgia. If it be intended to continue a course of treatment for any period beyond ten days, the dose should be much reduced. Probably, if it be given as a tonic, one-fiftieth of a grain in half-an-ounce of the oil will yield the best results. Of the alcoholic and etherial tinctures I believe the equivalent of one-twelfth of a grain to be an average dose; an increase may be allowed to one-eighth of a grain if it be

thought desirable. I prefer to increase the quantity taken by repeating the original dose every three hours, for example, as compared with intervals of four hours. I think the minimum dose of these preparations is one-twentieth of a grain.

The dose to be given in the pills of reduced phosphorus ranges between one-fiftieth and one thirty-second of a grain. For ordinary cases one-fortieth may be considered as a sufficient quantity. For prolonged use, one-fiftieth will be sufficient.

Of the phosphide of zinc the full dose probably is about three-fourths of a grain. That quantity would invariably cause vomiting, and on this account I have never given more than one-third of a grain every two hours. If the drug be presented in a coated pill sickness will very rarely be witnessed. Except where otherwise stated, these doses are calculated for repetition every four hours, and for adult persons.

IV.

ITS INTERNAL ADMINISTRATION.

The introduction of phosphorus as an internal remedy among the drugs and formulæ of the collection known as "Bates' Dispensatory," shows, probably, that it had been thus used for some years previous to 1720, although I have not been able to find any earlier reference than this. Nothing is more likely, however, than that its extraction from a product of the body, albeit that product is an excretion, was regarded as sufficient evidence of its fitness for medicinal use, at a time when urine, in its native condition, was occasionally employed in a like manner. Kunkel has the credit of being the first to employ it in medicine, his remarks in the "Chemische Anmerkungen," published in 1721, being the earliest printed clinical observations at present known; and the fact that he was also one of the discoverers of the element, or, at least, one of the first to become acquainted with a method of extracting it, points also to a still earlier medicinal employment of it. From that date to the end of the eighteenth century, treatises or papers on the medicinal uses of phosphorus

were published with remarkable frequency; but the subject can scarcely be said to have received the attention of a scientific discussion until the very end of that period, when it was examined by Alphonse Leroy. In 1769, that physician, called suddenly to see a patient who was suffering from phthisis and apparently moribund, accidentally dispensed for her, with his own hands, a mixture of sugar, and water in which some phosphorus had been kept for a long time, instead of the *placebo* of *eau sucrée* which he intended to administer. On going the next day to visit his patient again, he found her, to his surprise, not only not dead, but apparently better, and she survived fifteen days longer under a further use of phosphorised water. This case attracted Leroy's attention to the virtues of phosphorus as a medicine, and in the year 1798 he published the first of a series of three or four papers describing the results which he had attained with it. From that date to the present, phosphorus has received a considerable amount of attention; that is to say, papers, or even works, continued to be published during the next thirty years with the same frequency as had marked the progress of the element during the previous century, but treating the subject in a more scientific manner, and illustrating it with clinical observations, both greater in number and more accurately noted. From that time until about 1860, very little that was novel was added to the existing knowledge of the therapeutic powers of phosphorus. Its poisonous effects, however, had in the

meantime received considerable attention, for the opportunities of observing them became more and more frequent as the use of phosphorus in manufactures caused a knowledge of its toxic powers to become more common. But from the last-named date to the present time many observers in different countries have been occupied in ascertaining the mode of action and the effects of phosphorus upon the organism, and I have endeavoured to embody in the following pages the result of their investigations, gathered from numerous and widely scattered sources.

Phosphorus is found in various combinations in the animal, vegetable, and mineral kingdoms. In the two latter it exists in one or other of the better known chemical combinations—as phosphate or subphosphate of lime, for example; but in the animal body it is found to exist in another form as well, neither as an acid nor as a salt, but in a peculiar combination with C, H, N, and O (Fourcroy and Vauquelin). This compound has been isolated by MM. Liebreich and Bayer, who have named it "Protagon," and who give C_{232}, H_{240}, N_4, PO_{44}, as its formula. It is by the disintegration of this compound that the various phosphorus-holding fats may be obtained. Phosphorus has also been asserted to exist in a particular combination with an animal oil in the liver, by Braconnot; and Pasquier has discovered it to exist in oysters in combination with an animal juice peculiar to those molluscs. This fact is interesting in relation to the aphrodisiac power with which this fish,

I know not with what reason, is vulgarly credited. The human brain contains from 1·352 to 1·790 *per centum* of phosphorus, the amount gradually increasing from infancy to adult age, and then again decreasing in old age. The brain contains the largest proportion of phosphorus of any organ; the muscles and the stomach in that order contain the next largest quantities (Borsarelli). Bone, however, which contains eighty *per centum* of subphosphate of lime, is the source from which the largest amounts of this element may be extracted, and it is thence that the large quantities required for commercial purposes are now procured. Phosphorus is also an important ingredient in the blood, which in anœmia is found to be deficient in it.

The Physiological Effects of free phosphorus have been examined by personal experiment by several authors. The earliest experience of this kind is recorded by Leroy. Before employing the element as a medicine (with the exception of the accidental administration referred to above), he instituted a personal experiment, by taking a bolus containing three grains of solid phosphorus. He felt at first a little epigastric pain; the pulse then rose, and some feverishness and general excitement set in, followed by great thirst, which was easily allayed by small quantities of cold water. Towards the evening these symptoms passed off. The next day he found himself feeling unusually well; his muscular power and general activity appeared to be redoubled; and he felt a painful amount of venereal ex-

citation. Another personal experience is related by Bouttatz. Having made an etherial solution of eight grains of phosphorus to the ounce, he took twenty-four drops, and repeated that quantity every two hours. The first dose produced a little nausea; the second, a ravenous appetite, accompanied by a general sensation of what he calls *bien-être*, and a heightened pulse. By the evening he had taken about a grain, and he experienced no inconvenience. His powers, muscular and mental, were increased; there was an excessive secretion of urine, and he felt a little venereal ardour. These two briefly related experiments convey a general idea of the effect of phosphorus on the human body, in a medicinal but full dose. I shall now relate its action, as gathered from various authors, and trace its effects as they progress from those which may be called physiological, to those which are toxic.

Applied externally, phosphorus may inflame. In that case it produces injuries which are always very slow of healing. For example, Bertrand le Pelletier, carrying some of this body wrapped in paper in his pocket, was burned by it in the thigh. Although the wound was a slight one, it was scarcely healed in six months. Applied in the form of an ointment, it has been known to inflame and to produce similar injuries (Devergie). Used in this way it may produce erysipelatous eruptions without inflaming (Fabre). It has been reported by those whose business leads them to handle phosphorus constantly that they experience an amount of sexual

irritation, which is attributable to its absorption through the skin (Solon). A wound inoculated with phosphorus has been known to become gangrenous. A man having an injured finger, inoculated the sore by frequently bringing it in contact with some matches, which he carried loose in his waistcoat pocket. It took on an unhealthy action, and gangrene ensued (Mertens). The following results were obtained by Ranvier, by putting masses of solid phosphorus under the skins of various animals. If inserted in the subcutaneous cellular tissue of dogs, the animals died of phosphorus poisoning in two or three weeks, although the metalloid retained its transparency, and had not visibly diminished in bulk. On examination, the wound presented no evidence of inflammation, no redness, suppuration, or even simple thickening of the subcutaneous cellular tissue. Rabbits and guinea-pigs thus treated did not die. The wounds cicatrised rapidly, and around them was seen neither redness nor swelling; nor was there any evidence of pain. On killing these animals in ten or fifteen days, no sign of inflammation, but a very slight and circumscribed swelling of the connective tissue was found. These experiments are considered by the author to afford sufficient evidence that phosphorus is a contra-stimulant to the histological elements, since masses of absolutely inert material, placed in a similar position in the same animals, caused the usual inflammation and suppuration.

Taken internally, the action of phosphorus differs somewhat according to the dose and form in which it is

administered. Some of these differences depend, as has been already explained, on changes to which the particular mode of preparation employed has exposed the element. Others probably depend upon the greater or less freedom with which the element is absorbed. It will, therefore, be supposed that the dose is administered in solution in an oil which protects it from change. This is the typical method of exhibition; *cæteris paribus*, the nearer to it that other methods approach, the more perfect will they prove. But the effects of phosphorus on the human body differ almost entirely as the dose is therapeutic or toxic; and the subject will therefore be considered under these two heads, of which the second need not long detain attention.

In a Therapeutic Dose of one-twentieth to one-twelfth of a grain, a little nausea may be observed soon after its ingestion. This symptom is not constant. At some time about the second hour, sensations of exhilaration begin to make themselves felt. The capacity for exertion, both mental and physical, is increased, and that condition which the French describe as one of *bien-être* is experienced. If the subject have taken the dose while in a state of fatigue, then he feels his strength renewed; if while in a state of despondency, he takes a more cheerful view of things. The pulse becomes firmer and a little more frequent. These effects pass off gradually in the course of a few hours, the period probably differing in different individuals. A state of depression does not ensue; in this respect, therefore, phosphorus,

while acting as a stimulant, differs from other stimulants, and has probably some other properties in addition. My own experience, clinical and personal, agrees with the above description.

If the dose be repeated at regular intervals, so that from half a grain to a grain is taken during the twenty-four hours, some other symptoms may be observed in addition. The pulse and temperature rise, the former becoming fuller but not firmer; there are signs of peripheric capillary expansion; and, subsequently to the first few days the temperature is reduced by 3 or 4 degrees (Gubler). Some notes have recently been published by Dr. Willis E. Ford,* of the effect of reduced phosphorus on the pulse, temperature, and respiration. The observations were made on fifteen persons, who, after an attack of acute mania, were becoming demented; and the results gathered from three daily observations in each case during one month were compared with similar notes, made during a like period, when they were not under the influence of this drug. One-thirtieth of a grain of reduced phosphorus was given to each patient three times a day, with the following result:—The temperature, one hour after the dose, was raised from one-half to three-fourths of a degree; towards the end of the month it was observed to remain steady at 98° or 98·5°, instead of fluctuating at different times of day, as

* "American Journal of Insanity." January, 1874.

it did before treatment, from one-half to one-and-a-half degrees. The pulse was at first raised ten or fifteen beats after each dose; but towards the end of the month it became fuller and more regular, the sphygmograph showing a deeper and less tremulous down-stroke.

In some of these cases there were also observed symptoms of transient intoxication. I have noticed these in my own person only, and after taking solid phosphorus alone—not from any other preparation of phosphorus. They come on about forty-five minutes after taking one-twelfth of a grain, and are shown by giddiness, and a tendency to roll in walking. They last about half-a-minute, and are not accompanied by any confusion of intellect.

The skin may become the seat of great irritation and itching (Löbel); it becomes moist, or perspires freely; and the urine is secreted in larger quantity than usual. It is found to be reddish and loaded, and it may smell of violets, or of sulphur (Pilger). It has sometimes been seen to be phosphorescent. The sensations of increased muscular power, intellectual activity, and lightness of heart, before mentioned, appear and are sustained. At the same time tactile sensibility becomes more acute (Gubler). As a rule, the appetite at first becomes ravenous; subsequently it diminishes somewhat, but remains much improved. Occasionally, digestion seems to be interfered with. The process becomes difficult, and is accompanied by flatulence, abdominal distension, and colic;

these symptoms may be followed by diarrhœa (Gubler). The author named attributes this effect of phosphorus to the production of phosphuretted hydrogen gas; for, having placed two similar masses of food in two separate portions of a digestive mixture, he observed that digestion was delayed in that vessel to which he had added some phosphide of zinc, from which phosphuretted hydrogen was disengaging. I have not found this kind of gastric derangement to attend the use of phosphorus, except in those cases in which it was given in a vegetable oil; I have already indicated the true cause of the symptoms in those cases. They were not owing to free phosphorus. I have seen zinc phosphide produce actual vomiting in two or three cases; the drug acted simply as an emetic. It very often causes nausea, for the first few doses at least; the stomach has then seemed to become accustomed to it, and the symptom has disappeared. I have given phosphorus in different formulæ to persons already suffering from dyspepsia of various kinds; this disorder has not been aggravated by it. In many cases improvement in this respect has advanced *pari passu* with the general improvement. My own experience does not, therefore, warrant a general assertion that phosphorus is a cause of flatulent dyspepsia; yet it may operate thus in some cases. If it do so, however, I should be inclined to consider closely the formula employed, in which it is possible that the cause may be found. The tongue has been noted by Dr. Eames to assume that silvery-white appearance which may be

observed in those who have been under treatment with arsenic, in the course of a few days. Dr. S. W. D. Williams has also noted this phenomenon in every one of six patients under his care. Symptoms of venereal excitement may also supervene (Gubler and others). If phosphorus be given in not more than the quantity premised, this symptom is at least very rare. The aphrodisiac power of this drug will be discussed at length, under the head "Impotence." The gums have been known to suffer; they may become inflamed and retract from the teeth—more especially from the incisors (A. Voisin). I have, perhaps, observed these symptoms in the two cases, Nos. 38 and 41. In one of them, the patient, who was possessed of a set of teeth in fair condition, complained that they had become loose after a few days of treatment with the Formula No. 10. The other patient was an old woman, with few teeth, but a great many stumps. She complained of tenderness of the gums and teeth after the use of Formula No. 9. Cautious inquiry appeared to elicit the fact, that she had never, or, at least, not for many years, suffered from such symptoms. The condition named has been more frequently observed in cases of acute poisoning with phosphorus.

During the prolonged use of zinc phosphide I have frequently observed tremor of the muscles to supervene —sometimes to such a degree as prevents the subject from carrying a moderately full glass, for example, without spilling the fluid. This symptom comes on

earlier in some persons than in others. Generally it does not appear before ten days at the soonest; but in some subjects it comes on earlier, and specially in the writer himself. One grain taken in divided doses during the day for three days produces in him a state of trembling which is not only disagreeable but inconvenient.

It has also lately been asserted that repeated medicinal doses of phosphorus "clog up" the liver. I have not been able to trace any such effect as this, except in one or two of those cases which had been treated with Formula No. 5. In these persons it seemed probable that the vomiting which occurred in the use of this mixture, although directly caused in the first place by altered phosphorus, was kept up by, and was eventually perhaps entirely owing to, hepatic derangement. But even in these cases no jaundice-tint appeared; and the occurrence of such a symptom during treatment with phosphorus would, in my opinion, constitute *primâ facie* evidence that poisoning had occurred. Further observation is necessary to confirm the opinion that such a symptom can occur, as the result of the administration of this drug, without the previous appearance of indications of poisoning, which should already have led to a suspension of the remedy. These, then, are the more immediate results of a repetition of medicinal doses of phosphorus; an increased rate of circulation, a heightened temperature, perspirations, irritation of the skin, and abundant urine, sometimes loaded with deposit,

sometimes possessing a peculiar odour, sometimes phosphorescent. In the nervous system a sharpening of the faculties, relief from fatigue, and increase of muscular power; sensations of well-being; sometimes nervous excitement, evidenced by hesitation and trembling, or even slight clonic convulsions of the muscles; occasionally some venereal ardour, and, still less frequently, a more acute tactile sensibility. In the digestive tract, increase of appetite and relief from indigestion; possibly under some circumstances free phosphorus may cause symptoms which are recognised under the general term of dyspepsia.

A Cumulative Action of phosphorus is said to exist by Vigier and by Gubler. On this point, further and wider observation than exists at present is wanting. The conclusions already drawn have the disadvantage of being chiefly based on the use of solutions in unprepared vegetable oils, or of solid phosphorus. In the section on "Dose," reasons may be found for rejecting observations on this head made with the metalloid in these forms. The fact in favour of a cumulative action is the constant recommendation of those who have employed phosphorised virgin vegetable oil, and solid phosphorus, to intermit the administration every week to allow the symptoms of gastric derangement, caused by a seven days' medication, to abate. Against it, is the negative evidence of those who have employed other preparations of phosphorus, and who do not think it necessary to recommend this precaution. I have myself

given tincture of phosphorus three times a day, in one case for thirteen weeks, in another for seven weeks, and in many for four weeks, in a dose of one-twelfth of a grain, without intermission or harm. I have also given phosphorised cod-liver oil in a similar dose for twenty-seven days, for twelve days, and for ten days; and phosphide of zinc for periods of five weeks, four weeks, and three weeks in many cases. I have, therefore, good grounds for saying that I am not yet satisfied that phosphorus is possessed of cumulative action; but further observation with other preparations than those already objected to is desirable. It is to be noted, however, that there is undeniable evidence that phosphorus absorbed need not of necessity at once undergo change; its presence in the tissues of subjects poisoned with it having been frequently observed. It is thus possible that a regular repetition of large doses of phosphorus may allow of a storing up in the tissues of a part of each dose, under circumstances which are not at present defined; and in that case, some change in those circumstances may bring the whole store into action at once, with a poisonous effect. This seems to me specially liable to occur when the drug is ingested in solution with oil, which certainly protects it from premature change in the stomach, and *may* continue to protect it for a time in the tissues. I conclude that in the present state of our knowledge too great caution in administering phosphorus cannot be observed, and that, therefore, it will be wise to intermit the use of it every ten days, for a

period of four or five days. Although it is not yet ascertained that phosphorus is possessed of cumulative powers, I believe I have observed that toleration of this drug is easily established; a point which it is not less necessary to know, although for a contrary reason. Thus, if the treatment of a case be commenced with a dose which, after a few days, proves inefficient, and the quantity be therefore increased, the larger amount will not then produce the same effect as if it had been used in the first place. In the treatment of neuralgia at least (in which disease it is necessary to procure the full medicinal effect speedily), I have had many opportunities of observing this; in some cases in which I had used too small a dose at first I have been obliged to intermit the treatment for a week or two, and then to resume it in a full dose, the patient not having derived the least benefit from the small dose used at first, nor even from the larger dose which immediately followed it. After the interval the larger dose has, in such cases, produced its usual striking effect.

In a Toxic Dose phosphorus causes symptoms which very much differ from those last described. There are, as a rule, some warning signs which make themselves known before any grave injury has been inflicted, and it is these alone which call for notice in this place. They appear in certain derangements of the digestive tract and the organs appended thereto. But it is equally certain that these premonitory signs are occasionally either entirely wanting, or occur in so slight

a degree as to attract no special attention; and in that case the first symptom of poisoning is, in fact, the first glimpse obtained of a condition already set up.* In administering phosphorus medicinally, more especially if the treatment is being long continued, the slightest symptom of dyspepsia should lead to its instant intermission; and if on examination of the abdomen, the indigestion is found to be attended by marked tenderness in the epigastrium or in the right hypochondrium, there is little doubt but that it and the last-named pains are due to an excessive effect of the drug. On carefully examining the liver in such cases as these, corroborative evidence may be obtained by detecting a distinct increase of volume; this is due to congestion. Should the administration, or, as it may be called under these circumstances, mild poisoning, now be persisted in, the conjunctivæ and skin will assume an icteric tint. Occasionally this has appeared without the concurrence of other well-marked symptoms of poisoning, but in that case they ensue shortly. In the absence of these symptoms the effect of this drug upon the nervous system should be very carefully watched, and, if it produce excitement, nervousness, or spasmodic muscular action, a continuation of the treatment will soon be followed by the graver signs of poisoning. The issue

* This remark applies chiefly to cases in which poisoning has been effected and concealed, or ignorantly induced. Of course no symptom will be allowed to escape the attention of the physician whose patient is taking phosphorus medicinally.

of a case of acute phosphorus poisoning appears to bear some relation to the amount of the element absorbed; death, however, follows in all cases far more frequently than recovery. It should be understood, once for all, that no antidote to phosphorus is yet known, unless the poison can be reached while still in the digestive tract; that palliative, or so-called eliminative, treatment is of the smallest possible, or even of only hypothetical use; that the result of slight poisoning even is seen in conditions of debility, dyspepsia, and melancholia, which persist for many weeks or months; and that, therefore, too great a caution in the use of this body as a medicine cannot be enjoined. Nor should it be trusted at all to the hands of the inexperienced.*

While the result of an excessive dose of phosphorus is seen in an increase in the volume of the liver, which is due first of all to congestion, and then to fatty disease of it; animals which have been slowly poisoned by the repeated administration of slightly toxic doses have been found to have livers very much diminished in size, and in a state which cannot be anatomically distinguished from that of acute yellow atrophy (Lebert and Wyss). It is not probable that this result could be brought about by long continued medicinal employment of phosphorus, without the occurrence of more easily recognisable symptoms. Lebert and Wyss, and A. Voisin have recorded the occurrence of gingivitis with

* The efficacy of transfusion is not here questioned, since it seems a probable means of relief, but has never yet been tested.

hæmorrhage in cases of acute phosphorus poisoning, both in men and animals; any symptoms, therefore, such as has been above described of tenderness of the teeth or gums, should lead to extra vigilance, or even an intermission of the remedy.

Dr. Anstie has noted a case in which pills containing one-thirtieth of a grain of phosphorus dissolved in suet, taken three times a day, were followed at the end of a week by epigastric burning pain, some dyspepsia, and hæmaturia. By the former symptoms, a fault in the preparation employed is indicated, unless it be conceded, as is suggested *àpropos* of the case related in the Appendix, that phosphorus, like arsenic, need not be brought into contact with the mucous membrane of the stomach in order to cause irritation of it. I have found no record of experiment which tends to confirm this view, although some cases of poisoning have suggested its probability. But the cause of the hæmorrhage in this case is not so evident as it appears at first sight. The administration of phosphorus to persons predisposed to hæmorrhages is disapproved of by some of the older writers—von Löbel for example; not because hæmorrhages occur in plethoric subjects who are not deficient in phosphorus—not because the excitement which phosphorus sets up may be followed by hæmorrhage in persons with weakened or diseased vessels; but because acute poisoning with phosphorus is attended by hæmorrhage in various structures of the body. This reason, almost homœopathic in

its obliviousness of pathological anatomy, renders it necessary to inquire into the nature of the hæmorrhage referred to. Two opinions have been held on this subject. One set of observers affirms that in phosphorus poisoning the blood corpuscles are destroyed—disintegrated; that the colouring matter of the corpuscles is thus set free, that it stains the serum, and that it exudes without any anatomatical lesion into the subcutaneous, submucous, or subserous tissues. Part of the icteric tint observed, or the icteric tint observed in some cases is, by these writers, attributed to this exudation of the hæmoglobin, which colours the surface of the body just as a limited area is coloured by a simple bruise. These writers divide the jaundice, therefore, into two kinds—one owing to the colouring matter of the blood, the other to the colouring matter of the bile. But another set of observers denies that this disintegration takes place; and they assert that these ecchymoses, or hæmorrhages, are due, not to an exudation of blood, but to a distinct anatomical lesion; that is to say, to rupture of the capillary vessels, subsequent to a fatty degeneration of their coats, and a consequent weakening of their walls. Notable among those who hold this view are MM. Lebert and Wyss, from whose carefully minute description and analysis of fifteen fatal cases, it appears that in every instance in which the blood forming an ecchymosis was examined by them, the corpuscles were found intact. This is not the place, nor for the present purpose is it necessary, to discuss the merits of these two

views comparatively, since on either of them it is scarcely possible to account for the hæmorrhage observed in Dr. Anstie's case. Whichever view be adopted, the condition which would attend on hæmorrhage from phosphorus poisoning must be attended also by other symptoms, and those of an acute kind. If, then, the hæmaturia in this case is to be attributed to the use of phosphorus, some other explanation of the manner in which it was caused must be sought. Three hypotheses present themselves—the case may have been one of poisoning with an oxide or unsuspected combination of phosphorus; it may have been the result of hyperæmia in a diseased kidney, attendant on the diuretic action of phosphorus; or, lastly, the case is one which shows that hæmaturia may occur as a symptom of slight poisoning, and is not necessarily an indication of any grave mischief. The first hypothesis appears to me to be reasonable, so far at least as the *presence* of altered phosphorus in the pills employed goes.

I have not yet met with symptoms of gastric irritation of the kind described following on any solution or preparation of phosphorus, except in the case of the solutions in vegetable oil already condemned, or, as in one instance, on the use of solid phosphorus. In the latter instance, the patient simply got too much of the remedy; but in the former instances no reasonable doubt remains but that the peculiar burning pain described was an effect, not of free phosphorus, but of hypophosphorous acid. It may be suggested that the

small dose used in the present case was too much for the individual; but that implies an idiosyncracy with regard to the remedy of the existence of which there is as yet no proof. (1.) The symptom may, then, have ensued on the presence of altered phosphorus; in that case, altered phosphorus differs in action from free phosphorus. That this is the case is very probable, but no experimental evidence of it is yet forthcoming. (2.) A diseased condition of this patient's kidney is not noted by Dr. Anstie. (3.) This, on the third hypothesis, is a solitary example of the power of phosphorus to cause hæmaturia as a result of *slight* poisoning.

To sum up, the following are the symptoms, the occurrence of any of which during the administration of phosphorus should lead to extra vigilance, or a total suspension of the treatment.

Dyspeptic Symptoms are said to occur sometimes as the result of the administration of phosphorus, not as symptoms of poisoning. I believe them to occur, most frequently at least, from the ingestion of altered phosphorus. After acute poisoning, they are constantly observed for other reasons.

Burning Pain in the Epigastrium may occur either immediately or after many doses. In the former case, *i.e.*, if it ensue on the first and each subsequent dose, it indicates the presence of an oxide of phosphorus in the preparation used. Treatment may be continued with another formula. In the second case it indicates poisoning established or, perhaps, commencing.

Vomiting may be regarded in a similar light. *Diarrhœa* attends more especially upon the ingestion of altered phosphorus. It sometimes occurs during acute poisoning with free phosphorus.

Hepatic Pain may occur in either, or both lobes. During a long continued course of phosphorus, the liver should be occasionally examined by pressure; this should be made not only in the right hypochondrium, but also in the epigastric region. If tenderness be found, first of all suspend the treatment. Further examination by percussion, according to the time during which the liver-pain has persisted, may or may not show enlargement.

The Teeth and Gums become loose or tender in acute poisoning. The occurrence of such a symptom during medicinal treatment should lead to extra caution.

The Urine, if the remedy be given in full doses, will become muddy and deposit a red sediment. Probably this symptom may be taken to show either that the patient does not require phosphorus, or that the dose given is larger than necessary. It is not a constant symptom. *Hæmaturia* attends frequently on acute poisoning. Whether it occurs or not as a symptom of slight poisoning has just been discussed.

In the Nervous System, should trembling of the muscles or clonic convulsion occur, or the condition recognised as one of nervousness supervene, the medicine should be intermitted, either as unsuited to the case, or as excessive in dose,

Venereal Excitement (except in such cases as suffer from special debility in this respect, or from impotence), if it occur, is a sign that the dose in use is excessive, and probably poisonous. (The data on which this opinion is founded are given below.)

Hygienic Rules to be observed during treatment with phosphorus were laid down by von Löbel. These have been endorsed by Lobstein, and are therefore repeated here. The diet, says von Löbel, is to be carefully regulated, and chiefly confined to meat, with mucilaginous drinks containing a little Hungarian or Burgundy wine. Acid articles of diet, salads, cabbages, onions, horseradish, and peas, are to be specially avoided, since they may cause anxiety, vomiting, and diarrhœa; and no fruit or milk-diet is to be allowed. The same author further notes that phosphorus is contra-indicated in the cases of young persons; of those with a hæmorrhagic tendency; of the plethoric; of the dyspeptic; or of those with a tendency to phthisis. He also remarks that this drug may be taken in larger quantities when the weather is dry than when it is moist and dull; that persons undergoing treatment with it should be specially careful not to expose themselves to cold, and should wear flannel next the skin; and that warm baths should be used frequently. He had often seen the therapeutic effects of phosphorus to manifest themselves after the warm bath, in patients who had before that apparently experienced no result from the treatment.

Without doubt, a great many of these directions are

fanciful and unnecessary. With regard to the diet, for example, it has not in any case seemed necessary to me to prescribe any particular rules. The prohibition of this drug in cases of dyspepsia, too, need not be obeyed without discrimination at all events; for my own part I have not yet met with that kind of indigestion in which phosphorus is inadmissible. The part which it may play in causing dyspepsia has been alluded to. Of the diseases in which von Löbel believes this drug to be contra-indicated, in phthisis, at all events, it has been vaunted by some as specially useful, and at least it is as well tolerated by patients suffering from that disease as by others. Phosphorus is, however, wisely forbidden in plethoric cases ; in these the element is probably not deficient. There is another reason to be found against its use in that condition, in the excitement of the circulation to which it gives rise in full doses, and which might probably conduce to apoplexy. This reason may also hold good of some persons inclined to hæmorrhage—that is, first, if the hæmorrhage is attendant on plethora, or secondly, if it occur in consequence of a diseased condition of the vessels, which are thereby unfitted to stand the extra strain thrown on them by agitation of the circulation. This latter, perhaps, affords one reason why von Löbel forbids phosphorus in cases of phthisis, nor should I venture to administer it, in a stimulant dose, to persons in whom hæmoptysis has occurred or may be anticipated. But from what is known of the action of this remedy, which differs con-

siderably according as the dose is small or full, it may be given even in those cases without apprehension, in such small quantities as may be regarded simply as nutritive or tonic. The same remarks which were made on the alleged power of phosphorus to *cause* hepatic obstruction, may be applied to its use during that disorder, which might be considered as a contra-indication. I have found it of signal benefit in the commencing convalescence of those cases of hepatic congestion and slight jaundice, which occur pretty frequently at the beginning of every summer, especially if the heat set in abruptly. Young persons I have found to take phosphorus as well as adults.

There is, however, a precaution which should certainly be always observed, but more especially during the use of phosphorised pills of whatever kind, viz., that the bowels be kept in action. If an easily digestible formula be employed, there need be little apprehension of a storing up of doses in the intestinal canal; but to avoid all risk, an occasional purgative should be prescribed. So, too, theoretically, persons under the influence of phosphorus should avoid exposure to cold, in consideration of the peripheric expansion of the capillary vessels described by M. Gubler. Practically, it has not happened to the writer to observe any special necessity for taking this precaution.

The General Effects of Free Phosphorus are thus seen to be those of a stimulant possessed of special powers over the nervous system; evanescent in

its effects, but not followed by any marked stage of depression. Almost all the symptoms to which phosphorus is capable of giving rise in medicinal doses may be traced to its power of stimulating, or of modifying, the nerve functions. Beyond this immediate power, there seems no reason to doubt that phosphorus taken in small repeated doses may supply the nerve matter with those phosphorus compounds which are wanting in certain diseases in which this element is found serviceable.

But, while acting as a general nerve stimulant, phosphorus probably possesses a special power over the vasomotor nervous system ; and to such a power as this may be ascribed its remarkable remedial properties in many diseases, apparently of somewhat diverse kinds. Reasons deduced from the analogical positions held by phosphorus and arsenic in chemical classification, led Dr. Broadbent to anticipate that the therapeutic action of these two elements might be found to be similar, and thus it has proved. Especially this is noticeable in the case of many skin diseases, in which phosphorus has been found to be a remedy superior to arsenic in the rapidity of its action. Many of these disorders are attributable to a disorder which probably consists in a paresis of the neighbouring capillary walls. Such a condition is the proximate cause of herpes-zoster, for example ; and, in one case at least, in which phosphorus was exhibited at the beginning of the disease, I have seen its course to be shortened, some vesicles even aborting. Such is, perhaps, the cause

of, but is at all events a condition in, pneumonia; and in this disease also phosphorus is a valuable aid, although I am not able to say that I have certainly witnessed any effect from it which could be considered distinctly remedial. The remarkably rapid and lasting effect of this drug in some cases of neuralgia, is perhaps among its most striking therapeutic powers. Probably in this case, as in that of some other diseases, phosphorus exerts a double power; in some instances, merely regulating the blood supply to the affected nerves—in others, acting in addition as a tonic, or nourisher, of the diseased spinal nerves, or of the affected nerves themselves. The action of free phosphorus may, then, be more closely defined as that of a stimulant possessed of special powers over the nervous system, and particularly over that part of it which controls the circulation of the blood; while, in repeated doses, it acts also as a tonic, in virtue of its capacity for supplying the nerve matter with compounds, the want of which attends on the morbid conditions which it remedies.

V.

ITS THERAPEUTIC USES.

The remedial powers of free phosphorus have been tested in the following diseases:—General brain and nerve exhaustion, melancholia, softening of the brain, apoplectic paralysis; sclerosis of the spinal cord; impotence; migraine, neuralgia, hysteria, epilepsy; some cutaneous diseases; pneumonia; alcoholism; phthisis; cholera; amaurosis, cataract, and glaucoma. Of the successful treatment of cases of nearly all of these diseases more than one example is to be found, but each kind is generally dealt with by one author only. The evidence in favour of the remedy in these instances is, therefore, not so good as in those in which different authors have been successful in the same disease; and, indeed, in some of those morbid states in which certain observers have considered phosphorus to be eminently useful, and have given cases in support of their opinion, the experience of others has been found to be unfavourable, or negative. These diseases are, therefore, considered but briefly; and greater space is devoted to those in which several authors concur in

finding phosphorus specially useful, or in which the writer has himself had special experience. In one instance—that of the treatment of impotence—a great deal of evidence is at command; and although this is not uniformly agreeable to the efficacy of the remedy under consideration, it is treated of at greater length both on account of the general acceptation of the view that phosphorus is possessed of special aphrodisiac properties, and because the information from which an opinion on this point may be formed, is both more extensive and more varied than in some other forms of disease. Locomotor ataxy, again, is a disease in which no drug has yet been found to afford any considerable benefit; the experience of M. Beaumetz, therefore, of the remarkable power of phosphorus over it in four cases, has attracted considerable attention. His observations have not been altogether confirmed by other continental physicians who have at various times published a few cases, exemplifying the same treatment. In preference to recording their isolated cases here, I have devoted considerable space to a recapitulation of a valuable series of eighteen cases of posterior sclerosis of the cord, treated with this drug by Mr. Messenger Bradley. Most space of all is given to a longer detail of the use of phosphorus in neuralgia than has yet appeared, for it is over this disease especially that it appears to possess powers which subsequent experience may perhaps recognise as specific.

Before entering on the clinical part of this section,

I propose, first, to take a general review of the therapeutic powers of phosphorus.

Apart from any specific power which it may possess, it may subserve two distinct ends at least, according to the manner in which it is administered. It may stimulate, and it may nourish.

Phosphorus acts as a stimulant when it is given in a full dose, and in a form easily absorbed. This action may be increased by its combination with an adjuvant; and for this reason, the etherial tincture should be selected, of such a strength that with each dose of the basis an effective proportion of the adjuvant vehicle may be administered. The dose, too, with this object should be a full dose—that is to say, not less than one-twelfth of a grain; and it should be repeated, not at regular intervals, but whenever the patient appears to be about to relapse into that condition of which the first dose has relieved him. Given in this manner, phosphorus may be employed with the greatest success in all typhoid states, whether they ensue upon a specific fever, or upon other kinds of disease. It was the almost miraculous power of phosphorus over this condition which first of all attracted attention to its therapeutic uses; and the desuetude into which the remedy has fallen requires a brief, but special explanation with regard to this state. It must be premised, then, that if success is to be attained with phosphorus in such a desperate case, for example, as the muttering delirium or incipient coma of typhus fever, no caution must be allowed to limit the

quantity given; the only limit which may be recognised is the improved state of the patient. If this be admitted, it is easy to imagine that while the oldest authors remained in ignorance of the toxic powers of phosphorus, they gave immense doses of it in these cases without apprehension; and their patients recovered. But the immediate effect of the bare discovery that phosphorus is an element possessed of violent poisonous powers would be felt in such a reduction of the dose, as in these cases would deprive it of its just value. But I believe, for reasons already given, that with phosphorised ether, which is the best formula for the present purpose, there is great difficulty in producing any poisonous effect. In addition, while many of the premonitory symptoms of poisoning are now ascertained clearly enough, it has already been noted that in those cases in which phosphorus is the remedy indicated, much larger doses may be given with impunity than under other conditions. That it is indicated in diseases attended by rapid waste, the observations made in subsequent paragraphs show to be probable. The more accurate knowledge which we now possess, of the conditions under which phosphorus may be internally administered, warrants a fresh and more intelligent investigation of its therapeutic powers; and, as in the special example now being treated of, success may attend the judicious use of doses which, in less-instructed times, could only be considered heroic, or simply rash.

But it may be desirable to use this remedy as an oc-

casional stimulant only, and for this purpose it may be given not only in a different dose, but in a different and more agreeable form; for the bodily conditions under which it may be wished to employ it for this purpose differ entirely from those of the state just alluded to. The digestive processes, the absorbent powers, and the contents of the intestinal canal, may all be in a perfectly normal state, and the subject suffering merely from a temporary exhaustion of mind or body. In this case, the stimulant generally resorted to is alcoholic. Its effect may be regarded as local and general: local, as exciting the stomach to a secretion of its juices, and a consequent return of appetite; general, as accelerating the circulation, and deadening the exalted sensitiveness of the overwrought nervous system. By this means an apparent recovery is effected in a few minutes; that it is entirely fallacious, the subsequent indigestion, depression, brain congestion, and sleeplessness, which most often ensue on this ready but ill-reasoned treatment, stand in evidence. If half-an-hour or an hour, of rest in the recumbent posture were adopted instead of the usual glass of wine, the body, getting exactly what its then condition requires, would be fitted to undertake the new exertions of the digestive process; but there is "no time to spare" for such a rational expedient as this.

It is in these cases that phosphorus is an invaluable agent, acting not as a stimulant simply, but as a substitute to some extent for rest. A moderate dose

taken three-quarters of an hour or an hour before the cessation of the day's work is found to remove sensations of fatigue; to produce appetite and a healthy digestion; and to conduce subsequently to the quiet sleep of which overwork so constantly deprives those whose occupation is mental. For such a purpose as this, phosphide of zinc, in a half-grain dose, may be used with advantage; and it may be judiciously combined with some other of those ingredients which enter into the composition of dinner pills. It should be remembered that frequent use of this stimulant will be found to beget a tolerance of it; and that it is not yet ascertained to what extent the dose may be increased without danger, in order to sustain its usual effect. Probably, phosphorus does not act in this condition purely as a nerve stimulant; it *supplies* something which restores the balance of the nervous system, which the acuteness of sensibility to slight impressions shows to be depressed, in a manner not entirely temporary. It will be observed that these remarks are applied to cases of occasional exhaustion—not to those of chronic exhaustion of nerve power, or the climax of long-continued overwork.

The last sentence introduces to notice that other property of phosphorus in virtue of which it acts as a special food; for it is in those cases in which the brain is exhausted by long-continued and excessive occupation, whether attended by a specific morbid condition (softening) or not, that it confers some of its most signal benefits. That phosphorus may be regarded as a remedy

in some cases of softening is attested, among others, by Dr. Hammond, in his work "On Diseases of the Nervous System." For such a purpose, or if it be employed in an uncomplicated case of nervous depression from overwork, whether mental or physical, or in the simple debility consequent on acute or attendant on chronic disease, a *minimum* dose should be employed, and the administration continued for long periods. One-fiftieth of a grain of reduced phosphorus, one-tenth of a grain of zinc phosphide (Hammond), or from one-hundredth to one-fiftieth of a grain of phosphorus in cod-liver oil, repeated thrice daily, are sufficient quantities; and they may and should be as steadily administered as iron is administered for a similar purpose. Here, it will be observed, no rapid impression is sought to be made upon the nervous system, which would probably ill bear the effect of this powerful remedy administered in a stimulant dose; it is given entirely on the supposition that the nerve tissues are deficient in phosphorus, and that the want may be supplied in this manner, just, as it is said, iron is supplied to the blood of a spanæmic person, by the long-continued use of small doses of that metal. Whatever may be the value of these theories of the mode of action, which are perhaps a trifle physical, it is now ascertained by observation that phosphorus is as much more valuable in such nerve disorders than any other drug, as that iron is more valuable than any other drug in spanæmia. The use of phosphorus in nervous exhaustion, or in some nerve diseases, exhibits its special

powers, which even appear in some instances worthy to be called specific. The aid of this drug has almost always been invoked in cases of derangement or lesion of the organs of innervation; or, if it have been called in as a remedy in the treatment of diseases apparently of other kinds, a special connection between them and disordered functions of the nervous system has generally been recognised in later times. But having indicated its sphere of action, it is not possible in any other way than by clinical observation to define more closely in what particular diseases it will be of most signal benefit. That it would not avail in the treatment of apoplexy, in which disease it has been given by the older authors, even while the hæmorrhage was probably continuing, is no more than might be predicted by the merest tyro in the art of healing; but who would venture to anticipate that, without acting as an anodyne or an anæsthetic, phosphorus would be found to remove a neuralgia dependent on mechanical irritation, while the cause continued? Yet it undoubtedly possesses such a power over the neuralgias dependent on decayed teeth, and on cancer; and, further, over that attendant on states of extreme debility, which it removes in a space of time so short that the general condition cannot possibly be modified in any material degree by the treatment. For this reason I have endeavoured here, as elsewhere, to register facts, so far as the names appended to them guarantee their accuracy; and, having done this, although I have in some places recorded my own in-

ferences, yet (if they be not found agreeable) from the *data* the reader may draw such others as seem, to his better judgment, more warrantable.

Contra-indications to the use of phosphorus afforded by morbid conditions are thus laid down by Professor Gubler (*loc. cit.*). Affections characterised by nervous excitement, as tonic or clonic convulsion, hypersthenic neuroses, general paralysis with peri-encephalitis, inflammations, all kinds of fever, and the febrile exanthemata. Indications for its employment are afforded in maladies without inflammation, fever, or nervous excitement; local or general depressions of the circulation with coldness, malarial fevers, retarded convalescence, tabes dorsalis, old cerebral paralyses, hemiplegia, paraplegia, and other local or partial paralyses. It is sometimes used to call forth the eruption in febrile diseases when it is tardy or imperfectly developed, or when it has retrograded. Above all, it is indicated in impotence, although its effects often disappoint both physician and patient. Finally, the author concludes that its use will be found practically confined to paralysis and analogous affections; and he does not regard it as anything but a stimulant—certainly not at all as a tonic. These opinions are introduced here as being the only recent attempt by an author of eminence at defining the morbid conditions in which phosphorus may be prohibited or found useful, with which I am acquainted; not because they seem to me either exact enough to guide, or correct even in their more general tenour.

In the first place, as will be seen hereafter, the writer

has ventured to deduce from his observations a fundamentally different opinion of the therapeutic powers of this drug, in that he has seen reason to regard it not only as a stimulant, but very decidedly as a tonic as well. Obviously, upon this view, a different enumeration of the indications for or against its administration to the foregoing, must be drawn up. No attempt is made in this work to present any such table, first of all because it seems quite premature to attempt to define the therapeutic powers of a drug of the physiological action of which little is at present exactly known; but, secondly, because the most perfect knowledge at present attainable of the physiological action of medicaments, yet leaves us entirely in the dark as to their specific action. It is in this that the process for ascertaining the value of drugs by their action on the healthy body, the employment of which as an infallible guide to treatment is characteristically homœopathic, entirely fails. Thus far, at all events, it is necessary first to procure the *corpus vilum* before speculating upon the powers of a new or untried remedy over it. Looked at with these views, the above tables are imperfect in detail and loose in expression; I shall not proceed, therefore, to criticise them. When it has been said that phosphorus is—

1stly. A stimulant, possessed of special powers over the nervous system (which it perhaps affects primarily through the capillary circulation in closest relation to it); and

2ndly. A tonic; special, as nourishing or rebuilding

used-up or even altered nerve matter ; general, as affecting the body at large through the renovated functional nerve power—

all, in the writer's opinion, has been said that present knowledge warrants. Even accepting these opinions, general indications only are afforded by them of the direction in which the drug may be probably employed with benefit, and, after all, any specific power which it may possess is still a matter for experimental observation to be made, not in health, but in disease.

I propose to examine at most length, and practically, the power of phosphorus as a remedy in posterior sclerosis of the spinal cord, impotence, neuralgia, migraine, and hysteria, and in some cutaneous disorders ; first reviewing the treatment of the other diseases in the list which heads this section. As yet there is not sufficient evidence that phosphorus is of special value in any of them, those conditions which are known to depend upon functional disorders of the nervous system, and perhaps brain-softening, being excepted.

Melancholia.—Of the treatment of melancholia with phosphorus, Dr. S. W. D. Williams has published* a short series of six cases. The patients were treated with one-thirtieth of a grain, repeated twice and occasionally four times daily, in Messrs. Kirby & Co.'s pills. The results attained were as follows :—

Case 1.—M., æt. 51. No hereditary taint, but his

* "Journal of Mental Science." 1874.

father given to drinking. The attack was one of pure melancholia without delusions, which had been coming on twelve months. In a few days from the beginning of treatment the depression became less, and in one month had quite left him. No after history.

Case 2.—M., æt. 39. Had been very intemperate, both in smoking and drinking. He first suffered from locomotor ataxy, on which acute mania supervened; the latter passed off, and he remained sane for some months, when he began to suffer from melancholia, the ataxy continuing. Phosphorus was given and the melancholia disappeared; the ataxy progressed. No after history.

Case 3.—F., æt. 30. Had recovered from two attacks of melancholia relapsing almost immediately. The first attack lasted seventy days, the interval eleven days; the first relapse lasted sixty days; after an intermission of three days, she again relapsed under excitement, and she was put on phosphorus. The third attack lasted only twenty-seven days. Two months afterwards she remained well.

Case 4.—F., æt. 54. Hereditary taint; suicidal tendency; no delusions. Ill five months. Phosphorus given for seven weeks without benefit; speedy recovery with opium.

Case 5.—F., æt. 33. Suicidal and homicidal impulses. Phosphorus, after a course of tonics, was prescribed with advantage. She relapsed during treatment, and refused her medicine; she continued to grow worse.

Case 6.—F., æt. 33. Attack said to have lasted ten

days. Improvement was noted after a week's treatment with phosphorus, and every success anticipated. No further history.

The result attained in these cases can scarcely be regarded as satisfactory. The last must be excluded from the series, in the absence of further information concerning it. Of the remaining five, Case 4 was treated absolutely without benefit, and Case 5, although apparently relieved at first, very soon relapsed. Cases 1 and 3 appear to have been treated with most success, although some further account than is given of the former would be necessary before regarding it as a cure. In Case 2 it may be noted that the ataxy remained unrelieved. As examples of the use of special treatment in melancholia, these would in any case be unsatisfactory on account of the absence of any after history of most of them. But exception may justly be taken to the form in which the phosphorus was exhibited. Provided the difficulty of administering medicines to these patients was overcome, the cod-liver oil solution would appear to be specially indicated for them. In this form it may be suggested that one-fiftieth of a grain given three times a day, or one thirty-second of a grain given twice a day, would be a useful dose; and the investigation, conducted with this solution, would be the more valuable that there is every reason for believing that the whole dose thus administered is absorbed in the free state.

Dr. Willis E. Ford has lately spoken of the satis-

factory result afforded by the employment of phosphorus in fifteen cases of dementia, ensuing on attacks of acute mania.* The observations are related with special reference to certain physiological effects of this drug. It was exhibited in the reduced form.

Of the use of phosphorus in various kinds of paralysis many observations are recorded. I am not acquainted, however, with any series or collection of cases thus treated; the notes at command refer, in each author, to one, or at most two examples; and the results are so variable, while the cases themselves are not often reported with much exactness, that it is impossible to draw any conclusions from them.

Cerebral Hæmorrhage.—One is surprised in the first place to find that any remedy could ever have been employed with a hope of obviating the immediate symptoms attendant on cerebral hæmorrhage, since it was perfectly understood that the cause of them was mechanical. Yet phosphorus has been thus used by Weickard among others. One example has been already cited; in another, the patient received two grains of phosphorus in oil immediately after the fit, two grains more the next day, and two on the third day. He died then, but the record does not say whether of phosphorus or of apoplexy. Not only must any *remedy* be useless at this stage of the disease, but on account of its marked power of accelerating the circulation, phosphorus, of all

* "American Journal of Insanity," Jan., 1874.

drugs, is distinctly contra-indicated. Nevertheless, the same writer, in conjunction with Coindet, of Geneva, has related the following case, of the nature of which the reader may form his own opinion, as one of recovery from apoplexy under the use of this drug. An old man, aged seventy, had been subject for a twelvemonth to repeated and frequent attacks of vertigo and migraine, which were always aggravated by bleeding, but relieved by stimulants. This person was suddenly seized with a severer vertigo than usual, which was attended by imperfect articulation and somnolence; these symptoms speedily progressed to perfect insensibility. He was bled, and became worse. The next morning, the patient continuing in the same state, Weickard gave him two grains of phosphorus dissolved in oil. He speedily showed signs of amendment, and the same evening was able to get up and walk about his room. He shortly recovered entirely. Of the use of this remedy in the paralysis consequent on hæmorrhage, it will be convevient to treat along with other forms of paralysis; I will, therefore, briefly relate what is known of its use in diseases of the brain. Of these conditions I can offer but two examples from my own casebook, and am chiefly indebted to Dr. Hammond's "Diseases of the Nervous System," for the following paragraphs.

Cerebral Congestion.—In the active stage of cerebral congestion, this drug, it has been pointed out, is expressly contra-indicated. But in the subsequent debility and depression which attend convalescence from this

disease, and which is often very protracted, there is every reason to look to phosphorus for valuable aid to recovery. Without referring to it particularly, Dr. Hammond says he has found it a useful remedy; and, since he looks upon the oxide of zinc as a tonic specially suitable in such cases, probably the union of the latter body with a small dose of zinc phosphide, in the form of a pill, would offer a happy combination for the purpose. But I apprehend that the dose should be quite small and carefully watched; rather repeating it daily for a long period, than attempting any rapid effect which might prove precisely contrary to the one desired.

Cerebral Anæmia.—In cerebral anæmia, however, where this remedy is, in my opinion, distinctly indicated, perhaps a little less caution might be used; and a combination of the drug with cod-liver oil, the latter being in large proportion, would be the most suitable form. In the former disease I should be inclined to limit the dose employed to that used by Dr. Hammond, viz., one-tenth of a grain of zinc phosphide, the equivalent of about one-hundredth of a grain of phosphorus, repeated three times daily; but in the latter case one-fortieth or one-fiftieth of a grain, would perhaps be found a more suitable quantity.

Apoplectic Paralysis.—The author already quoted regards phosphorus as a useful remedy in cases of apoplectic paralysis, but it is not to be employed until all danger of further hæmorrhage is clearly at an end. This stage is not reached in the most favourable instance

before the tenth day from the fit. I would suggest, with much diffidence, that a considerably longer period should be allowed to elapse before attempting this treatment, for which there can be no particular urgency unless it be ascertained to possess the power of averting the subsequent processes of softening. Its too early employment, apart from any apprehended hæmorrhage, might, I opine, by inducing a condition of nervous excitement, do much harm. In a comparatively recent case I should prefer for exhibition either the Formula No. 10 (one-twentieth of a grain) or phosphorised cod-liver oil one (seventy-fifth); or, if the appetite were pretty good, a pill of reduced phosphorus might be exhibited (one-fiftieth). The dose should in any case be small; nor should the medication be commenced until the local disturbances are quieted, and the processes which go on around the clot subsequent to that period well advanced. Of the use of phosphorus in this condition I offer the following example: A man, aged forty, experienced a cerebral hæmorrhage, which left him with left hemiplegia. From the third to the twentieth day subsequent to the effusion, the mind showed both delusions and illusions. These symptoms were transitory. At seven weeks his condition was as follows:—Paresis of the left facial and lingual muscles, and complete paralysis of the left arm; paralysis of the left leg, which was, however, subject to reflex and to slight convulsive movements. Sensibility gone in the two extremities, good in the trunk, imperfect in the

face ; articulation, at first imperfect, is now normal. This statement shows a good deal of improvement in his general and mental condition as it stood at the end of a fortnight ; none, as regards the paralysis. He now began to take one-third of a grain of zinc phosphide every twelfth hour ; it was continued for five weeks. At the end of that time there was so much improvement in the sensibility of the leg only, that the position of two fingers laid on the affected limb could be pretty readily distinguished, and there appeared at times to be a very slight return of voluntary power in it. The mental state was also very much better. I concluded that no result distinctly attributable to the remedy was observed. Lauth cites* a case of apoplectic paralysis of long standing which was much aggravated by phosphorus. Gaultier de Claubry gives two cases in which there was perhaps some benefit afforded. It is in these cases that phosphorised liniments are said to have shown active and useful properties. Solon, indeed, says that on one occasion the inunction of a liniment, containing one grain to the ounce, was followed by so much excitement that a fresh hæmorrhage was apprehended ; and Tozzetti gives one in which the inunction of a similar liniment was attended by very great improvement, although the case had previously resisted the drug internally administered. In the case of so easily altered a body as phosphorus one

* "Bulletin de Pharmacie." 1812.

can scarcely anticipate any marked effect to ensue upon the external use of a liniment containing it; nor is it plain in what way its topical application can be expected to possess advantages over its internal administration. There is evidence, however, that such applications are possessed of active properties, and these are worthy of some further investigation.

Cerebral Softening.—In softening of the brain, Dr. Hammond has found phosphorus of distinct and great advantage; but, as it is reasonable to expect, its effects are more marked in those cases in which the softening is insidious and gradual in its attack, than in those in which it results from thrombus, embolism, or hæmorrhage. The author gives two examples in which the illness supervened on much excessive mental application, and in which perfect recovery was noted. The treatment consisted in the use of one-tenth of a grain of zinc phosphide thrice daily; but the medicinal treatment was of course supplemented by absolute cessation from the usual duties, and by change of scene. In this class of cases, too, it is necessary to give phosphorus in carefully watched doses, such as those just named. While the patient still remains under immediate observation, probably the phosphorised cod-liver oil would better answer the indications. Convenience, as well as other reasons, would lead to the substitution of a pill after a time.

I present one case of brain softening, which occurred in a clerk, aged fifty. He had rheumatic fever at the

age of twenty-five, but, he alleges, without any cardiac complication. Since then he has been subject to attacks, sometimes of gout and sometimes of muscular rheumatism, recurring two or three times a year. The heart sounds are normal, and the health in other respects good. After the attack of acute rheumatism, his hair fell off; and what remained of it, or grew subsequently, is quite white. He is a tall, stout man, but looks much older than his years. The illness began with a little difficulty in writing, which seemed to consist in loss of free movement of the fingers simply. On the second day this symptom had increased, and was accompanied by tingling which affected the whole of the lower half of the right hand, but was more intense in the ring and little fingers, and the ulnar side of it. On the third day there was numbness of the same parts, and the tingling was also felt in the right side of the trunk. Neither the leg nor the arm suffered, nor was any other symptom of illness detected. On the fifth day, the other symptoms remaining *in statu quo*, a distinct loss of directing power was observed in the right extremity, but indefinite movements of the limb were performed readily. There was also loss of muscular power, as indicated by the grasp. After five weeks of treatment with alterative and tonic medicines, all the symptoms related were present as at first. There was no improvement. During that time there had been a little depression of spirits, but no other symptom. He was then directed to take one-third of a grain of zinc phosphide

three times a day, with a little acidulated vegetable tonic. Improvement was at once observed ; in a week the tingling disappeared from the side, and then it began to leave the fingers ; at the same time the power of direction was recovered. The numbness next left, so that he was able to pick a pin off a hard table ; and at the end of a month he was again able to write—not with his usual freedom, nor without effort, but fairly well. The muscular power had improved, but remained lessened. He was then removed to the country, and reported at the end of another month (during part of which the treatment was pursued), that there was still further improvement, which was more marked on some days than on others. In this case I think the improvement noted may be distinctly traced to the remedy employed.

Hysterical Paralysis.—In hysterical paralysis Dr. Hammond has found phosphide of zinc, in conjunction with strychnine or nux-vomica, a most useful medicine. Its employment in hysteria is specially adverted to below.

I am not aware of any observation of its use in infantile paralysis, in writer's cramp, or in facial paralysis ; and it is not easy to reason on the probability of its proving serviceable, save in the last-named affection. That kind of facial paralysis which appears to result from the local application of cold might be expected to yield rapidly to this drug, because of its close connection with the trifacial neuralgia which occurs under similar

circumstances. It appears to be a symptom of a more advanced stage of the condition which is sometimes evidenced by pain alone, and which is among those neuralgias which yield with most rapidity to free phosphorus properly administered. Probably, the cause of both these stages, of pain or of paralysis, is the result of interference with the local blood supply of the nerve; on this hypothesis an analogy is at once perceived between the specific power to remove the symptoms possessed by two so widely differing drugs as phosphorus and croton-oil.

Cerebral Exhaustion.—That phosphorus is an invaluable agent in the treatment of brain exhaustion, whether it be attended by distinct evidence of softening or not, is now a fact pretty well ascertained. But it yet remains to be observed in what manner precisely it is most useful in this condition; whether it will enable the failing brain to resume those excessive duties which have already injured it, whether it best operates in a stimulant dose, or whether in a small dose persistently used as a tonic or nourishment for the nerve matter. It remains, too, to be inquired whether the habitual or the intermittent use of this drug can be long pursued with impunity in such cases, the exertion continuing. I shall specially point out that as yet there is little or no evidence either one way or the other on this point, since, in these days of high-pressure work, any drug which can be put forward as at once a stimulant and a special food is likely to meet with much popular favour.

Apart from the necessity for cautious supervision during the administration of phosphorus, which must at all times render it impossible to place it as a remedy in uninstructed hands, I think there is reason to believe that its too long-continued use may be productive of serious injury, in addition to some serious accidents. This must, for the present, be regarded as a speculation only, based upon probabilities, since I am not yet prepared to publish the facts which are presumed to warrant it. As an occasional stimulant, as a preparation for an unusual mental effort, or as a safeguard against such nervousness, for example, as that to which a first appearance before the public lays a novice open, a large stimulant dose of phosphorus may be taken an hour or two before the trial is to begin with the greatest possible advantage. It appears to give coolness, and clearness, or dexterity of mind; and this is, in fact, the essential on the occasions referred to, when, having a clear conscience, it is only necessary to view the circumstances in their just relation, to act with the greatest *nonchalance*. Phosphorus in a similar dose is useful, again, to those who are occupied in such brain work as may be presumed by the careless to be not only interesting but even exciting, on account of its apparent variety, but which is indeed intensely monotonous to the worker; and, if it necessitate any sort of originality of thought, more laborious than any other occupation. In this case the drug enables the writer to pursue his task *con amore;* and I do not doubt but that the same variation might

be perceived in a work written, now under ordinary circumstances, now under the influence of phosphorus, as are perceptible in most other writings, and which the authors themselves can generally refer directly to varying conditions of bodily and mental health. The increased excretion of phosphorus compounds in the urine during a period of hard intellectual occupation, seems to point to the transformation of the phosphorus compounds of the body as a necessary concomitant of the exertion. If it could be shown, first, that the proportion of this element in the brain is actually reduced by such exertion, and secondly, that the just proportion may be restored by the ingestion of free phosphorus, then the use of it in cases of brain exhaustion would be indicated with mathematical precision. But it is not yet possible to ascertain these points by practical experiment, and it is, therefore, from a consideration of known facts that the indication is inferred. These are, briefly, the increased excretion of phosphates during extra exertion of the mental powers, whether from well-directed work or from anxiety; the result of over-work, as seen in some cases in consequent brain-softening; and, finally, the deficient proportion of phosphorus which such softened brain-matter contains. Analogous facts are, a similar deficiency in the undeveloped brain of childhood, the degenerating brain of old age, and the brain of persons of imperfect intellectual development; and the debility or destruction of brain power, which ensues on continued spermatorrhœa; semen containing

a large proportion of phosphorus, which is thus evacuated from the body in undue proportion. Conversely, it is known by experiment that a short course of phosphorus renovates the failing brain power in overwork; conferring freshness, originality, and energy on the mental processes; that it is eminently useful in the treatment of cases of brain-softening; and, above all, that, apart from any power which it may or may not possess over functional impotence, it is the remedy *par excellence* for the mental as well as the physical debility, resulting from sexual excess or from spermatorrhœa.

Long-continued hyperæmia of the brain tends eventually to anæmia; and the power of phosphorus to impart tone to, as well as to accelerate the circulation, must not be omitted from consideration along with the above facts in support of its nutritive powers, any more than its action in favouring the processes of secretion. I think a due consideration of the facts at command will, when duly elaborated, tend to establish the hypothesis that by the ingestion of free phosphorus the formation of those phosphorus compounds peculiar to nerve-matter is favoured.

The dose to be given in cases of cerebral exhaustion should obviously vary with the stage of exhaustion, or rather with the object in view. For single efforts a large dose once or twice repeated recommends itself; in that stage in which the exhaustion amounts to a disease, the smallest doses, long continued at regular intervals, are to be recommended. As in other instances of disease,

the formula should be so varied as to fulfil any collateral indication which may be observed.

Amaurosis.—Amaurosis appears to have been successfully treated with phosphorus on a few occasions; the reader may refer for accounts of this disease and of glaucoma, thus treated, to von Löbel's writings. For negative observations, reference may be made to the writings of Gosselin and Maisonneuve.

Epilepsy.—The remedy under consideration has, on more than one occasion, been vaunted as powerful against epilepsy, but, as in the case of so many other disorders, the results obtained are far from uniform. In my own practice I have had the opportunity of exhibiting it, during a sufficiently long time, in four cases. Three of these occurred in adults, and one in a child four years of age. In the former the attacks were well developed and frequent; in the last, the disease was incipient. Of the adults, one was a female aged twenty-one, married, and subject to epileptic fits from the age of eighteen. She took Formula No. 10, one-twelfth of a grain, for five months, during and after which time no modification in her condition was ascertained. The second was a male, aged twenty-nine years, unmarried, subject to attacks since many years. They then recurred not less than once in two days, and at the end of every lunar month at the rate of three or four a day for a week. His temper was uncertain, but good on the whole, so long as the fits were frequent; but if the number of attacks diminished, he fell into fits of passion with-

out provocation, in which he was unmanageable and dangerous.

Bromide of potassium, in controlling the number of fits, aggravated the irritability of temper. He took one-third of a grain of zinc phosphide three times a day for six weeks with the following result: there was no modification in the number or character of the convulsive attacks; they were infrequent at the beginning, and very numerous at the end of the lunar month. But the temper was decidedly improved; and it was reported that the improvement was shown, not so much in a greater equability, but in the fact that if irritated and apparently about to become uncontrollably enraged, he was capable of being led to control himself to a considerable extent, and in an unusual manner. In a third case of very long standing, occurring in a male adult, aged forty-five, no alteration whatever was observed after a seven weeks' treatment with zinc phosphide in the dose last named. In this case the temper was good.

The following account of the case occurring in childhood presents some remarkable points. The patient is a female aged four years; father and mother healthy. I have attended three brothers of from one to three years of age in fatal attacks of meningitis. In one case this was ascertained by post-mortem examination to be tubercular. She is a stout, well-grown, red-faced child, with coarse hair, of the appearance which Londoners consider that of a "country child." To the educated eye she shows at once many evidences of peculiarity of

nerve constitution. She talks fairly well. Was born with one tooth. Is considered to be a sharp child. In November, 1872, she had two long and severe epileptiform convulsions; in the second she presented the usual appearances. I could not detect any other evidence of disease; there had been no premonitory symptom; and she was very soon quite well again. On March 29th, 1873, she had one similar fit, which lasted fifteen minutes. As before, no warning was observed, and when the attack had passed over she seemed quite well. Twenty-five days after this she was observed to become very irritable; crying at the least provocation; picking quarrels with her brothers and sisters; sometimes sitting for ten minutes at a time, if undisturbed, staring at nothing, quite lost to what was going on around her, and flushing or turning pale at frequent intervals. On the twenty-sixth day, April 24th, she had another fit, lasting fifteen minutes. This time a little peevishness was observed to remain for a day or two afterwards. From that time to the present date, on every twenty-eighth day precisely, a return of these symptoms has been observed, with the variations herinafter described. On May 22nd, the same sequence of events last detailed was observed. On June 17th, two days before the next fit was expected, she was brought for treatment. The premonitory flushings and absence of mind were well marked. She was, however, at the time of inspection, apparently in good health. There were no objective symptoms noticeable; but these generally disappeared under the excite-

ment of seeing a stranger, or any other small occasion. To take Formula No. 10, one thirty-sixth of a grain, every four hours. She should have had a fit on the 19th inst., but there was none; and, indeed, by that time she was quite well again. At the next period, July 17th, the treatment having been regularly persisted in in the meantime, there was again no fit; and the usual symptoms of nerve-disturbance lasted only two days, instead of five or six. On August 14th, September 11th, and October 9th, similar very slight symptoms were observed; the treatment had been intermitted on the 25th of July. On October 1st, she fell ill with measles, and experienced a severe but uncomplicated attack, which left her very weak. The November period came round before she had recovered strength; and on the 6th of that month, without so much warning as usual, she became insensible, and was convulsed in a more violent manner than on any previous occasion. The insensibility persisted until the 11th inst., when she began to recover a little. During this time she continued in a state of clonic convulsion. The insensibility was complete—the temperature two degrees above the standard. The pulse ranged between 140 and 180, but it was at no time observed to be intermittent; and the pupils about the third day of the attack failed to answer to the stimulus of light. There were symptoms then of meningitis, and death was very confidently predicted. However, on the 12th she showed some signs of return-

ing sensibility, and on the 13th she was quite recovered in that respect. Another week saw her as well as usual, with the exception of a pain in the nape of the neck, which always attends the monthly manifestations. From that time to the present the usual symptoms of disturbance have recurred every twenty-eighth day, but in a degree distinctly greater than during and immediately after the time she was under treatment with phosphorus.

During May of the present year, the usual neurosal disturbance having manifested itself four weeks previously, it was determined to test the effect of the phosphide of zinc. Accordingly, two days before the attack should have appeared, one-sixth of a grain was prescribed, to be taken four times daily. No symptoms of any kind occurred; nor, the period having passed by, and the medicine being intermitted, did they show themselves again before the next month.

With regard to the effect of phosphorus in this case, the remarkably regular return of the symptoms every twenty-eight days, and their omission or abatement during such time as the patient was under treatment, first attracts attention.

The attack of March 29th may be regarded as the commencement of the series, although the next attack occurred on Thursday, April 24th—*i.e.*, two days short of twenty-eight. But this is the only exception to a manifestation of some neurosal disturbance on every fourth Thursday up to the present time. Since she had already had three consecutive monthly convulsions when

placed under treatment, it is fair to attribute the intermission which then took place to the treatment commenced just before the fourth period, and the justness of this opinion is corroborated by the experimental observation last related. Notwithstanding the occurrence of the attack commencing November 6th, on precisely the right day, from which it might be inferred that it was of the usual epileptic kind, there was no room for doubt that it was, in fact, an attack of meningitis. Acting on this diagnosis, the patient was treated with bromide of potassium and tincture of aconite, in grain and half-minim doses respectively, repeated hourly. The excellent results which Dr. Brunton has shown* to attend on this treatment in acute hydrocephalus, led to its employment in this case.

Chronic Alcoholism.—The use of phosphorus in this condition has been recommended by Dr. Anstie. The following case, in which an attack of delirium tremens was attended by severe neuralgic pain, occurred in my own practice.

M., æt. 50.—Single. A clerk. Drinks spirits. The present illness began with severe left cranial neuralgia, soon followed by vomiting. On the second day he was observed to have much tremor of the muscles, and he began to experience illusions, which chiefly took the form of faces of men and children. Towards the evening of this day he appeared to lose his

* "Glasgow Medical Journal." 1873.

power of sight and speech without becoming at all insensible ; this would last about half-a-minute, during which he appeared to make futile efforts at speaking. These attacks recurred frequently. In the evening of this day, on examination, he presented all the above symptoms, with white, furred tongue, tremor, and sleeplessness. Constipation. P. 120. No sleep for several nights. To take thirty grains of hydrate of chloral. One-third of a grain of zinc phosphide every two hours.

Third day, 3 p.m.—The neuralgia is reduced in severity. There was some sleep last night, but very broken. He is quite rational, but complains of the illusions (which he recognises as such) above named. To continue the phosphide every three hours.

Fourth day, 2 p.m.—Is sitting up, but very tremulous still. Has not yet eaten anything. The pain is still lessened, and the illusions very rare. No sleep last night. Continue.

Fifth day, 3 p.m.—Says he is well. Is eating a second chop. There is no tremor; the tongue clean; pulse 70. Has had one or two stabs of pain only during the last twenty-four hours; but he says he did not sleep. To take a cathartic draught shortly; to repeat the chloral to-night. Continue the phosphide every four hours.

Seventh day.—Called on me, previous to resuming his duties. Quinine.

Of the treatment of the remaining diseases in the list it is not necessary to say much. *Phthisis* has been

treated by Dr. Cotton with phosphorised oil. The observations were made during a sufficient period on twenty-five patients in various stages of the disease. It was concluded that no result was observed traceable to the remedy used. The great success in the treatment of this disease which Dr. Churchill has reported, and which has been to some extent corroborated by the experience of Dr. Thorowgood, Dr. Achille Vintras, and Dr. Holsbeck, of Brussels, attends on the administration of the hypophosphites of lime and soda. These compounds have not, according to my observation, the therapeutic powers of free phosphorus.

In the latter stages of ataxic fevers free phosphorus has been found specially useful. Numerous examples of its restorative power in persons moribund from the fevers called putrid, petechial, malignant, ataxic, bilious, or typhoid, may be gathered from the works of Kramer, Wolff, Mentz, Barchewitz, Gaultier de Claubry *père*, Leroy, Lobstein, Remer, and Coindet, besides many others. The unanimity of these authors invites a renewed employment of this drug, which should be given in the form and with the precautions which I have already described. I have myself used it in the ataxic state ensuing on various acute diseases with success; not with any view of offering a remedy for the disease, but simply as a special stimulant. Given with this view of the action to be expected of it, the dose should not be limited by any predefined rule, but should be proportioned to the effect produced. Only it should never fall

below one-twelfth of a grain, should be repeated every two hours, and should be exhibited in ether.

As a collyrium, Tavignot recommends the use of a solution of one part of phosphorus in one hundred and fifty parts of oil to dispel the opacity in cataract. It is said that the application requires to be made during many months. I am not aware of any detailed observations of this use of phosphorus.

Posterior Sclerosis of the Spinal Cord.

The treatment of this disease with phosphorus was tested in 1867-8 by M. Beaumetz, in the absence of any other method which afforded the least benefit in it. He has reported four cases, of which the following are the essentials very briefly epitomised.

Case 1.—M., æt. 52. The symptoms dated back eight months. The sense of touch and general sensation is scarcely altered; motility and sensibility unaltered in the upper limbs; walking or standing is impossible; there is frequent neuralgic pain, originating in the gluteal region, and shooting down to the toes. This pain was a prominent symptom at the beginning of illness, when it lasted two or three days at a time, the attacks recurring every few days; gradually, the intervals grew longer and the attacks shorter. There is complete amaurosis. This patient was treated with phosphorised oil from September 20th to December 15th. On his discharge—sensation unaltered: amaurosis unaltered. Yet, it is said, he could walk not only on a level

surface, but up and down stairs with the aid of a stick. No after history.

Case 2.—F., æt. 43. Disease of eight years' standing. Sensation in inferior limbs very much diminished. She had not left her bed for a long time. She was treated with phosphorised oil from October 1st to December 1st. On her discharge at the latter date she walked with the assistance of a stick. No after history.

Case 3.—M., æt. 35. Disease of two years' standing. He was carried into hospital, and had not stood upright for some months. He was under treatment from January 1st to February 8th. On his discharge, sensation remained unimproved; but with a stick he was able to walk—always stumbling and oscillating it is true; but, repeats M. Beaumetz, *he walks*. No after history.

Case 4.—M., æt. 54. Disease of three years' standing. Sensation in lower limbs much altered; unable to walk; partial amaurosis. Treatment from January 20th to February 14th. On discharge, sensation improved; amaurosis unaltered; but is now able to walk up and down stairs. No after history.

Phosphorised oil was employed in all these cases in a dose gradually increased from one to eight milligrammes, repeated two or three times a day. The result recorded in them, however far from cure, is sufficiently remarkable; and M. Beaumetz augurs from it, that under more favourable circumstances phosphorus may be found to yield even more favourable effects in this disease. Of this experience, however, it has been

well remarked by M. Gubler, that the disease is one of which intermissions are a characteristic feature; and it needs little reflection to see that these cases, without subsequent histories, are comparatively valueless. In juxtaposition to these four observations, I am enabled, by the great kindness of Mr. Messenger Bradley, to record his trial of phosphorus in no less than eighteen consecutive cases of the same disease. The result in all these was unfavourable to the medicine employed; the only case in which there was apparently some recovery remained under the same treatment long enough to show that the improvement was due to an intermission of the disease, and not to the phosphorus. Had she been discharged at that time the latter might have been credited with the benefit.

Case 1.—F., æt. 28. Single. Schoolmistress. Two years since began to stagger while out walking, and has never quite regained the use of her limbs, though still able to walk short distances with fatigue and stumbling. Full control of sphincters and no pain, nor is any elicited by pressure along the spine. With perfect rest, and the application of tincture of iodine to the spine, she improved so that she could walk a mile without much difficulty. Three months since she began to relapse, and has got worse and worse ever since. *Present condition.*—Is able to stand, and can walk, but with characteristic gait. She falls if the eyes are closed. The eyes are healthy. There is no history of neurosis in the family, but she is herself evidently highly nervous and excit-

able. *Treatment.*—First, tonics and galvanism. Then phosphorus in pills (Kirby and Co.) for a month, without any benefit. She was then lost sight of.

Case 2.—M., æt 25. Married. Discharged soldier. Has lived loosely, and drank much beer but no spirits. Eight months since began to suffer from severe flying pains in the back and legs. Six months since was seized with violent trembling, palpitation of the heart, numbness of the feet, &c. Got weaker to present time, and lately began to drag the right foot. *Present condition.*—Walks with a halting gait, dragging right foot. *Can* stand with his eyes shut, and even walk, but very badly. Trembling, and neuralgic pain, of lower extremities; incontinence of urine; spermatorrhœa; obstinate constipation; pain in back increased on pressure, and worst at junction of dorsal and lumbar-vertebræ. Eyes clear, but sight imperfect. *Treatment.*—Phosphorised oil in capsules taken regularly during two months without any benefit whatever. There was no traceable loss of motor power in this case; nevertheless, I am convinced, says Mr. Bradley, that it was a genuine case of progressive loco-motor ataxy.

Case 3.—F., æt 25. Married. Three months since fell and broke her arm. Afterwards was frequently seized with violent trembling, and suffered from violent neuralgic pain in the back. No loss of sensation, and no tenderness on pressure. Two months since began to suffer from incontinence of urine, which has continued. Mind clear. Walks with a marked ataxic gait. *Treat-*

ment.—Alcoholic tincture, one-fiftieth of a grain twice a day for fourteen days. No change for the better. No subsequent history.

Case 4.—M., æt 52. A porter. Married. One year since began to lose power in legs, especially the right; no atrophy. Sensation diminished. Occasional pains of the most excruciating kind. No spinal tenderness. *Present condition.*—The slightest obstruction upsets him whilst walking; rolls from side to side as soon as the eyes are shut, and would fall. Impotence, seminal emissions, incontinence of urine, and pain in micturating. *Treatment.*—One-fiftieth to one twenty-fifth of a grain of phosphorus three times a day for two months. No relief; gait more markedly ataxic than at the beginning of treatment.

Case 5.—F., æt. 55. Widow. Mill-hand. Has had five children, all deceased. Good health until four years since, when she fell from a table and was confined to bed two months, with much pain in the back. She completely recovered, and walked quite well until eleven months since. She then began to stumble and fall if she did not keep her attention fixed on her legs, and suffered from severe lancinating pains in the back. Two months ago ptosis occurred, which has persisted. Constipation. Mind clear but weak. If told to close her eyes she instantly reels and topples over. *Treatment.*—This patient was under observation for six months, during which a variety of means were tried. Nitrate of silver, galvanism, &c.; and then phosphorus in

alcoholic tincture, one-fiftieth to one twenty-fifth of a grain three times a day. At first it seemed that the last-named drug was doing good; there was less uncertainty in walking. But after a time she relapsed, and died thoroughly ataxic.

Case 6.—M., æt. 46. Spinner. Single. Symptoms began eighteen months since, and have progressed to present date. Father died of epilepsy: brother insane. *Present condition.*—Cannot stand unless looking at his legs. There is no apparent loss of muscular power, and no atrophy. Violent pains in back and legs. Intense conjunctival injection. Spermatorrhœa. Much excitement of manner. *Treatment.*—Alcoholic tincture, one-fiftieth to one twenty-fifth of a grain three times a day, continued during two months. No benefit.

Case 7.—M., æt. 16. Striker. Eighteen months since began to feel a cold sensation in the neck and dimness of sight; became nervous and irritable, and got severe shooting pains in the legs. Soon after, the legs felt too heavy, and he tottered in walking. *Present condition.*—No spinal tenderness. Falls if the eyes are closed, but manages to walk with a strong effort if they are kept open. No atrophy or loss of muscular power. Frequent emissions." I gave this patient phosphorus for a month, and, at first, with apparent benefit; he certainly walked better, and the pains recurred less frequently. After the first fortnight, however, he relapsed, and passed from my observation without my being able to come to any satisfactory conclusion as to the value of

the drug. This case, more than any other, seemed to derive benefit from it which may have been real; I regret that in it, as in so many others, I was and am unable to trace the subsequent history of it."

Case 8.—M., æt. 53. Married. No history of any marked neurosis in the family. Has led a very dissolute life, and has many scars on the penis. Has drunk much, and suffered much exposure to wet. Fifteen months since he first found difficulty in walking; from this he recovered, and remained well for a month, when he fell down in the street, and on regaining his legs, staggered, as if drunk. The arms as well as the legs were affected, and he felt as if he had gloves and socks on, when the extremities were, in reality, uncovered. These symptoms increased to present date. *Treatment.*—Nitrate of silver; then phosphorus, continued for some weeks. His condition was in no wise altered by treatment.

The remaining ten cases occurred in men of ages between 38 and 59 years, all of whom took phosphorus, either in oil or alcohol, in the doses used in the above detailed cases, and for some weeks. No improvement was noted in any of them. Mr. Bradley concludes his report by adding—"Indeed, I cannot say that it is easy in true cases of progressive loco-motor ataxia to understand how this drug can act beneficially. It may supply pabulum to a hungry nerve, or a certain *quid* to the blood, which may relieve the neuralgic pains; but how it is to arrest the hypertrophy of the neuroglia, and the consequent atrophy of the nerve tubes, is quite another

matter. After all, this seems to be the desideratum in treating this disease. At the same time, I can quite safely say that, in prescribing phosphorus, I held my observation perfectly free from any bias, and looked simply to results, without the slightest heed whether they told for or against any theory I might hold."

Upon these observations I shall take the liberty to remark, that therapeutics is no more than an art; that the special powers of drugs can be ascertained only by experiment in disease; and lastly, that it is not necessary to know *how* a remedy acts in order to use it with success.

Thus, of the utility of phosphorus in sclerosis of the posterior columns of the cord the evidence is conflicting. In addition to the two series of observations above recorded, the experience of Professor Hammond may be added. He gives no special examples, but in his work on "Diseases of the Nervous System," in the chapter devoted to this affection, he says:—"In several cases I have obtained amelioration by the use of phosphoric acid, phosphorus, and chloride of barium." This does not read as though phosphorus had been found possessed of any special powers by him; but the remark which I am about to make on Mr. Bradley's mode of treatment applies equally to Professor Hammond's. The former gentleman does not appear to have pushed the drug beyond one twenty-fifth of a grain of phosphorus given three times a day, in oil, in alcohol, or in ether. I believe that in the latter vehicles such a dose is too

small to warrant a reasonable expectation of marked effect; but, in addition, the alcoholic solution used is said to have contained one per cent. of phosphorus. This is not possible; and the dose actually administered in that form was, not one twenty-fifth of a grain, but one-eightieth of a grain at most. This dose of the alcoholic or etherial tincture is almost, if not quite, inert; and I should regard the larger quantity, which it is supposed was given, as of doubtful value in such cases as these. In point of fact, I consider the last-named solutions as unfitted for the purpose under consideration. The oily solution is better adapted to it; but, even in that form, probably one twenty-fifth of a grain is a moderate dose, if positive evidence is to be gained with it. Professor Hammond usually employed zinc phosphide in a dose of one-tenth of a grain, the equivalent at most of one-eightieth of a grain of phosphorus, and, as I believe, probably of one-hundredth only. In other diseases, brain softening, brain anæmia, and such like, good results were obtained from the use of this dose for long periods; and, if phosphorus is to be used for weeks, no doubt it is a sufficient dose. But I have no hesitation in saying that a negative result obtained in a given disease with such a dose as this is no argument against the efficacy of phosphorus in it. It is in this point, that the remedy was not pushed, that Mr. Bradley's otherwise valuable cases seem to me to fail. Several other cases, attended by differing results, may be found reported in the French journals for 1868-9. In

the case of this disease, as in that of some others, further observations may be undertaken with advantage; and, with a different mode of administering phosphorus, possibly with different results.

In connection with this disease, a case of sclerosis of the liver of eighteen months' standing, may be mentioned, in which the daily administration of at first three-fourths of a grain, and subsequently of half a grain, of zinc phosphide, was followed by remarkable improvement, which persisted during three months of this treatment, and has maintained itself during six or seven months subsequent to it. In the diagnosis of this case I had the benefit of Dr. Murchison's opinion. I prescribed the drug in combination with aloes, rhubarb, and one-thirtieth of a grain of ipecacuanha, to remedy the dyspeptic symptoms, which were very severe. They were accompanied by much vomiting, and by diarrhœa. The result, in two months, was seen in the almost complete departure of the dyspepsia and diarrhœa, and in an increase of strength almost equivalent to a renewal of it. At first the patient, a female aged 38, walked with difficulty and exhaustion from one room to another on the same floor; but after treatment, she was able to walk without much fatigue for three-quarters of an hour at a time, and to take a short journey (fifteen miles) to London, occasionally, to consult me. I was not able to ascertain any physical alteration in the state of the liver, after treatment.

Here, too, seems the proper place to mention a case

of cancer, which seems to me to have comported itself in a somewhat unusual manner. It is treated of below with reference to the neuralgic pains accompanying the disease, and their treatment with zinc phosphide. The patient began to suffer from symptoms of a vague kind, which were referred to the rectum a month or two after confinement, three years since. At the time of delivery, nothing abnormal was observed in the state of the uterus or rectum. These symptoms, probably entirely hæmorrhoidal, were prescribed for and relieved, and the patient did not again present herself for about fifteen months. She then complained that the trouble suffered immediately after delivery, although relieved at the time of treatment, had never really left her; that it had continued to increase in severity to the present consultation; and that she should certainly have sought advice before this, but for her aversion to the examination of the bowel which she felt would be necessary. The chief symptoms now related were difficulty in defæcation, pain then and frequently at other times, hæmorrhage, and sanious discharge from the rectum and vagina. She was emaciated and already a little cachectic in appearance. Examination of the rectum and vagina showed the former canal to be very much narrowed, and its walls infiltrated and hardened equally in every direction as far as the finger could reach. In the vagina it was found that the os uteri was thick, hard, and lumpy; the recto-vaginal septum thickened

and quite hard; and the vault of the vagina towards the posterior part of it similarly affected. The patient now took to her bed, rising not more than twice a week at first, for an hour or two daily. At about the third month of my attendance it occurred to me to try the effect of phosphorus on the paroxysms of neuralgic pain, which recurred two or three times a day. The treatment is described below, and was continued for three months. During this period a tumour made its appearance on the right buttock. It pointed and broke while away from home, and it discharged a great deal of watery matter which is not described as being purulent. This subsequently healed, and could not be said to have influenced the case in any material way. She continued to get worse and weaker, after this abscess had long been well. At about the seventh month of attendance she entered a hospital. She remained there four or five weeks, and came out in much the same condition as she entered, only she was far weaker; and on arriving home took to her bed entirely. The zinc phosphide was now resumed, from one-third of a grain to a grain being taken daily, according to the frequency with which the nerve-pain recurred. She took, in addition, not more than forty minims of laudanum and half-a-drachm of chloral in each twenty-four hours. Until the end of May of the present year she continued to grow weaker, and more and more emaciated, being almost unable to bear the exertion of changing her linen and so forth; but about the beginning of June a remarkable

change took place. Her appearance improved, the skin assuming a somewhat healthier tint; she suffered far less pain; her strength gradually increased; and, having for several days sat up an hour or two, on the 15th of June she dressed and remained about her room for no less than eight hours, and without suffering excessively from fatigue. The improvement in every way, even in gaining flesh, was so marked and so steadily maintained during six or seven weeks, *i.e.*, until the last observation, that it seemed to throw doubt on the diagnosis first made. An examination of the rectum now showed, however, that the canal was so narrowed that the forefinger would scarcely pass through the stricture, and that the deformity resulted from the deposit around the bowel, of the nature of which there was no room for doubt. The pain caused by this examination appeared to be excessive and lasted many hours. Since the beginning of the year diarrhœa had persisted; and there had, therefore, never been any of the usual trouble, owing to distention of the bowel.

Impotence.

Phosphorus had long been noted for its aphrodisiac properties when it was employed as a remedy for impotence by Leroy. Most recently, Mr. Acton, in his work on "The Functional Disorders of the Reproductive Organs," says, "Phosphorus is, in my opinion, one of those pharmaceutical preparations which the modern

surgeon should most frequently employ in the treatment of impotence. . . . . Practice, as well as theory, seems to sanction this treatment; and I must admit that phosphoric acid, in combination with syrup of oranges and syrup of ginger, is a favourite formula with me in all those cases where there seems reason to suppose the semen is not secreted in abundance, or where too rapid ejaculation attends the act, or where connection is followed by serious nervous depression." Without offering any opinion as to the efficacy of phosphoric acid, it is necessary to remark upon this confusion between phosphorus and its compounds, which is so often apparent in writings on this drug. As Dr. Broadbent has very well remarked, to give phosphoric acid is no more to give phosphorus than to give sulphuric acid is to give sulphur. Mr. Acton does, however, append a formula containing free phosphorus, and his remarks may be taken to apply to it. Phosphorus is, then, recommended as a specially useful remedy in impotence; and it is generally believed to be the only drug which can be depended on to exhibit aphrodisiac properties. This power, if it were exercised in the use of a medicinal dose of the drug, and under all circumstances, would form a serious obstacle to its employment; it is the object of this section, therefore, to consider the general subject of the aphrodisiac power of phosphorus, rather than its special relation to impotence. The treatment of that disease will be referred to incidentally. First of all, chiefly the older writers refer to this aphrodisiac

power. But, as has already been observed many times, the doses then usually administered were excessive and poisonous doses, which only failed to kill on account of the difficult digestibility of a mass of solid phosphorus. A well-authenticated case of this kind is Leroy's personal experience. He took three grains, with the result of some symptoms of poisoning, and an almost unbearable feeling of sexual irritation. But no argument deduced from the effect of such a dose as this can be employed to anticipate the effect of a medicinal dose. The quantity absorbed was not a fatal quantity; but the other symptoms show that it was an excessive quantity. A little better adapted to the present purpose is the personal experience of Bouttatz. He took one grain of phosphorus, dissolved in ether, in divided doses during twelve hours. No toxic effects were noted, but some venereal excitement ensued. Here again the dose, although not poisonous, was very large; and it was given in that combination and in that manner which is best calculated to exhibit the stimulant powers of this drug. De Lens says, "M. Boudet à rapporté qu'un veillard, a qui l'on avait fait prendre quelque gouttes d'éther phosphorée, éprouva impericusement et plusieurs fois le besoin de sacrifier à Vénus." In this case the quantity given is not stated; but a few drops, according to the doses generally employed at that time, were equivalent to half a grain, or probably more. Charles le Pelletier, having a flock of ducks and a drake, incautiously placed a copper basin

containing phosphorus and water where they could get at it. Presently those which drank of the water fell ill and died; but the drake died first, exhausted by repeatedly covering the ducks, to which he was so impelled that he continued to attempt it to the last moment of life. The works on toxicology generally concur in assigning sexual irritation a place among the symptoms of poisoning by phosphorus, though apparently without special evidence; and Christison says that it is not a symptom which has ever come under his notice in any case of poisoning. Perhaps it occurred in the case of accidental poisoning related in the Appendix; in which the catamenia had appeared at the usual time, and in the usual manner, from the fifth to the seventh day of the illness, or November 7th, the lochial discharge subsequent to miscarriage having ceased on October 15th. This interval of three weeks was also the usual interval. Ninety-three days from the cessation of the menses the patient believed herself to be three months pregnant, and her condition two hundred and seventy days subsequent to the same date showed the calculation to be pretty accurate. Possibly, therefore, she conceived when she was in a state of the greatest mental and bodily prostration and pain.

Evidence of the usual effect of a medicinal dose of phosphorus in this respect is not so copious. The observations have been conducted in health, in general disease, and in special disorder of the reproductive organs. The observations in health were conducted by

the writer on three expert persons. The forms employed were zinc phosphide and solid phosphorus. The doses taken were, in two cases, from one grain to a grain and a half of zinc phosphide each day for eight or nine days; of solid phosphorus, from one-eighth to one-sixth of a grain for four days, and on another occasion for five days. The latter observation was made by the writer on himself; he found it impossible, on account of warnings of incipient poisoning, to continue the experiment beyond the periods named. In all three cases the result was negative. Special observations on this point, in cases in which the drug was given for some indifferent complaint, have been made by Dr. Eames in seven cases. The remedy was given in oil and in full doses. Direct inquiry failed to elicit any evidence in favour of this action of a medicinal dose, in any of them. My own experience has yielded a similar negative result. I have made direct inquiry on the point in a large number of instances in which the drug was being given in a full dose, and in various forms. In no case did I obtain any positive evidence. Observations on the power of a medicinal dose of phosphorus over the impotence which attends on loco-motor ataxy have been made by M. Beaumetz and by Mr. Messenger Bradley. In two cases treated by the former writer, the patients experienced erections while under treatment—in one instance they are called "violent." The remedy was given in an average dose, in oil. Mr. Bradley's experience in such cases, on the other hand, does not afford any example in which the

impotence was removed, even temporarily. Nor has the latter writer met with any success with phosphorus in the treatment of any case of impotence alone. It was for this purpose employed by Leroy; but, in affirming its usefulness, he adds that unless the strictest continence be observed after treatment, the relapse will be serious. This opinion points as plainly as the cases of Bouttatz and Boudet do, to the conclusion that phosphorus acts as an aphrodisiac only in virtue of its stimulating properties; its power in this respect is evanescent, and, naturally, the patient relapses, after the unusual exertion for which the stimulant has fitted him for a time, into a condition even worse than before. My experience of two cases of impotence corrobates Leroy's observation last quoted more closely than that of Mr. Bradley, who has not been able to trace any result from the use of phosphorus in this disorder. But I must here again draw attention to my opinion that the doses generally employed by Mr. Bradley are too small to allow of any but negative evidence being deduced from their use. In the two cases to which I refer it was not easy to fix on the cause of illness. One patient was a man, evidently of feeble constitution, who affirmed that he had led a life in every way steady and sober. When he applied to me he had just been married, but had never consummated the ceremony. This a few large doses of the drug in the etherial tincture enabled him to do; but in a few days he returned, saying that

without the medicine he failed to get even the imperfect erection which he had had before treatment. I did not consider it advisable to continue to administer the large doses I had given in the first place, and after a time the patient removed himself from my care. The other patient was a man of five-and-thirty years of age, who had been married ten years. He had never been very active in performing the duties of his condition; and within the last twelve months had lost all desire, as well as all power, to fulfil them. In this case again, a large dose in the same form—as much as from three-fourths of a grain to a grain taken daily for two or three days, had the desired effect; but the result was as in the case last named. In this instance also, the dose was almost a dangerous one; and on diminishing it, this patient, too, disappeared.

I think it is reasonable to conclude, from the brief *resumé* of facts given here, that phosphorus is not an aphrodisiac, unless given in a larger dose than it is safe to employ for remedial purposes; that if this dose be increased until it verges upon a poisonous quantity, and specially if it be given in combination with ether, it will very certainly manifest aphrodisiac properties; and, finally, that in a toxic dose it may, or it may not, show this particular action, the difference in different cases probably depending on the degree of poisoning caused. It is thus quite possible that the symptom of sexual irritation has not been uniformly observed in such cases,

because it is a transitory symptom, occurring at an early stage of poisoning only, and disappearing on the further development of the toxic powers of the drug. The latter are, indeed, of a kind to deprive the patient of every sort of energy. The aphrodisiac power is therefore a special power of phosphorus; but, equally with other reputed aphrodisiacs, which are not known to possess any special claim to the title, this effect cannot be produced but with such a dose as is dangerous to life. Finally, it is most likely that over the female, in whom the sexual inclination is fortunately by nature not strongly developed, this power is much less actively exerted, if it exist at all.

From these conclusions such cases are always to be excepted as those in which the impotence depends upon brain disorder or even lesion, or on general nerve exhaustion. There is no reason why this drug, given as a tonic or special nerve-food, should not, along with other paralyses and symptoms of nervous exhaustion, remove this one. Probably, too, cases in which the impotence depends upon spermatorrhœa, resulting from other causes than debauchery, are to be excepted.

Neuralgia.

That free phosphorus is a remedy for certain neuralgic conditions is not a recent discovery. The first observation on disease of this kind with which I have become acquainted is recorded by von Löbel of himself. He

was a nervous and delicate subject, and had experienced an attack of gout in the beginning of 1805. From the date of his recovery from this illness, he became subject to frequently recurring headache, for which no cause could be discovered. The pain was circumscribed, attacking different spots successively; and when it was most severe, the part affected swelled, and became tender. In addition, repeated attacks of pain began to affect the sight of one eye, although there was no organic disease of it; and the intellectual powers began to fail. The attacks returned once or twice a week. To remedy this state of things, von Löbel took a variety of medicines, and made a number of different applications to the head; he also ceased his intellectual labours, and, in great measure, his bodily exertion too. The treatment appeared for a time to afford a little relief; but soon the attacks began to return oftener, and increased in duration from one to two or three days. He had endured this condition for two years, when it became serious. He grew melancholy, irritable, anxious, and depressed; he lost his hair; and got so weak as to be unfit for the least exertion. The pulse fell to 45; the urine was pale, and of a peculiarly disagreeable sweetish odour; and after the attacks he felt a violent pain in the loins. Having exhausted the advice of his friends, and every suggested remedy, he determined to try the effect of phosphorus, taking an etherial solution, in a dose equivalent to about one-fourth of grain, repeated every two hours. After a few doses he experienced those symptoms already de-

scribed as resulting from a free use of this drug; and, in addition, the sharp pain from which he was suffering at the beginning of the treatment was exchanged for a dull headache. The next day he was quite well, and remained so for six weeks, when, after a severe rigor, the headache returned with much of its former severity. He took half a grain of phosphorus in the same form, and in half an hour repeated the dose. He soon fell asleep and awoke quite recovered; but he continued to take five-twelfths of a grain every two hours for eleven days, with the result of entirely curing his disease.

Another instance is related, ten years later, by Lobstein. In this case a female adult suffered from attacks of hemicrania, which returned with regularity every ten days. After undergoing various kinds of treatment without success, Lobstein prescribed twenty-five drops of an etherial solution (one grain to a drachm) of phosphorus. The first dose was taken shortly before the occurrence of an attack, and it passed off in three-quarters of an hour instead of lasting a day or more. No further doses were taken until just before the next paroxysm, when a similar quantity was used; this attack was very slight, and was entirely dispelled in about fifteen minutes. From that time there was no return of the illness, which had lasted for many months. These are typical, but not solitary examples of the use of phosphorus in neuralgia between 1805 and 1820. In 1828, or twenty-three years after the publication of the former of these cases, phosphorus was first 'proved' by Hahnemann,

Hartlaub, and Trinks (Sorge's "Phosphor," &c.), and from these provings, says the "British Homœopathic Review," "its action in neuralgia was deduced, and it is, in consequence, regularly used by the homœopathic school in facial and visceral neuralgia, and neuralgia of the trunk and sciatica." The drug is to be found in Jahr's work (1838) in which it takes an unconspicuous place among one-and-thirty other 'remedies' for the same disease. Its use is specially indicated in those cases which offer the list of symptoms, appended to each drug, under the head 'Phosphorus.' To the ordinary mind, unaccustomed to the delicate orthographical distinctions of homœopathy, the symptoms detailed are not distinguishable from those appended to many of the other thirty-one drugs. Notwithstanding, however, the regular use by the homœopath for nearly fifty years, of a remedy for this very common and distressing disease, which, in *ordinary* doses, operates in neuralgia with a rapidity, a certainty, and a permanency unequalled by the action of any other medicine in this or any other disorder, its merits remained unheeded or forgotten along with the works of von Löbel and Lobstein until two years ago; and it is even yet generally believed that for neuralgia, as for rheumatism, no remedy, in the proper acceptation of the word, is known. In the "British Medical Journal" for 1872, Mr. Messenger Bradley reported that he had exhausted the Pharmacopœia in treating a patient who suffered from acute and long-continued neuralgia of the chest walls, without the least success, when, after an in-

terval, the patient called on him, saying that he had been very speedily cured of his pain by a homœopath. On inquiry, it was ascertained that the remedy employed was tincture of phosphorus. Mr. Bradley accordingly proceeded to test the value of this preparation in other cases of the same disease, and reported favourably of some of the trials. In April of the next year, Dr. Slade-King communicated a short note to the "Medical Times and Gazette," in which he stated that he had successfully treated a few selected cases of neuralgia with it.

It appeared to me that these records of isolated cases did but little towards establishing a fact which had already been recognised in the same manner—*i.e.*, with regard to special cases, nearly seventy years previously. The success which I met with, unprecedented in my experience in the use of any other drug except that of mercury in syphilis, seemed to render it expedient to collect the particulars of a considerable number of consecutive cases, and to analyse the result. Accordingly, I published in "The Practitioner" for 1873 two articles in which the result of treatment in forty-one consecutive cases of neuralgia was given. These, with nine selected cases in addition, are reproduced here. It appears to me that this series of consecutive cases goes far to establish as a fact that phosphorus, if it have not a specific action in neuralgia, at least finds in that disease a special sphere of action in which it is not surpassed by any other remedy. But I have reason to believe, both from private communications and a consideration of

published notes, that the success here indicated has not been attained by other observers; a few words, therefore, on the mode of treatment employed may not be out of place.

It is scarcely necessary to premise that in order to avoid disappointment both to physician and patient it is essential to ascertain, first, that the latter is really suffering from neuralgia, and not from one of the many disorders which simulate it; and, secondly, that there is no mechanical cause for it. The chief precaution to be observed in the treatment of neuralgia with free phosphorus—and I believe that to obtain the greatest amount of success in a large series of cases it is a *sine quâ non*—is to administer a full dose of the remedy in the first place. Although a small dose of phosphorus—one-twentieth to one-thirtieth of a grain, repeated three times a day, may be enough to cure some cases, I believe that I have sufficient evidence to warrant the assertion that unless half a grain or more be given in the course of each twenty-four hours, frequent failures, or only partial successes in treatment, will be met with, even in the course of a tolerably small experience. But the remedy must be given in not less than this dose—*i.e.*, one-twelfth of a grain repeated every four hours *from the beginning* of treatment; for I have undoubtedly ascertained that, after a few small doses of phosphorus, should they be found inefficient, the same result is not to be attained with an increased quantity as might have been attained had that been administered in the first place.

The formula to be employed is of no less importance than the dose to be administered. This point has already been sufficiently discussed, and it will be enough to say here that, although the alcoholic and etherial solutions, reduced phosphorus or even zinc phosphide may be used with almost perfect success; as a general rule I have found the best results of all to follow on the administration of one-twelfth of a grain of phosphorus, dissolved in cod-liver oil, every four hours.

In such cases of facial neuralgia as those in which the nerve-pain can be distinctly traced to a decayed tooth, the medicinal treatment here referred to is not so hopeless as might be expected. Considerable relief is most often afforded by it, and I have witnessed cure of pain in a few instances; but, as a rule, a return of it may be expected. In these cases the extraction of the tooth is the obvious remedy; but it is interesting to note that in some cases, apparently precisely similar to those in which the operation is followed by instant relief, cure may be effected by this treatment although the presumed cause of the disease is not removed. Somewhat similar to such examples as these (in the cure of pain effected in a few hours of treatment without the removal of the presumed cause), are those cases of nerve-pain attendant on conditions of debility, whether arising from general causes or from hæmorrhage. In them, nothing may be more confidently predicted than a cessation of the neuralgia after a few full doses of phosphorus, which need not be continued after

relief has been procured in order to secure a permanent recovery. Case No. 45 is a notable example in which frequent and not slight hæmorrhage from the rectum was combined with pregnancy in the causation of a most severe trigeminal neuralgia. It will be seen, on perusing the notes of this case, that not only did a few doses dispel the longstanding pain, but that with a continuance of the presumed causes, or, at least, predisposing conditions, it did not return. I do not know of any other remedy which is capable of effecting similar results in a similarly short space of time and under the like adverse conditions; and the example is not an exceptional one. It is indeed in those cases in which neuralgia concurs with, or is the result of, extreme general debility, whether arising from over-lactation, hæmorrhage, or simple asthenia, that phosphorus exhibits its most remarkable powers; but the treatment of these cases is generally better conducted with a stimulant dose of the remedy dissolved in ether, than in the manner indicated above. If it be desired to remedy the general state, the medicines which are necessary for that purpose have to be continued for some weeks before any appreciable result is attained, and for very many before recovery is effected. Yet half-a-dozen doses of free phosphorus will permanently remove the most distressing complication which accompanies it. This points to a specific power of phosphorus over these forms of neuralgia.

Such is the power of phosphorus over neuralgias, the

result of general depression of the vital powers; and I have found it to be no less efficacious in those local depressions in which the pain follows on exposure to cold. The particular kind of experience for which my practice affords special opportunities has offered many examples of neuralgia, which, occurring in persons not hitherto subject to the disease, has been decidedly attributed by them to the effect of cold locally applied. In one or two of the detailed cases this will be recognised simply as the exciting cause. Taking the power of this drug over the vaso-motor system as a basis, it may be fairly argued that in these cases phosphorus exerts some regulating force over that part of it which is in connection with the affected nerve; and since the paresis is but local, the permanency of a rapidly procured relief is not surprising. Such experience I have chiefly had in the cases of men apparently in good health and suffering from this symptom of trigeminal pain only.

In connection with the speedy relief of pain observed in the cases last treated of, it may be noted that, whatever the kind of neuralgia from which the patient is suffering, relief always follows the first few doses of the remedy in those in which cure will ultimately be effected. The following instances, which are selected from the first few cases in the Table, exemplify this; but it holds good of the whole series:—

Case No. 1 obtained relief in 28 hours.

„ 2 „ 12 „

Case No.	4	obtained relief in	8	hours.
„	6	„	32	„
„	9	„	20	„
„	13	„	40	„
„	14	„	8	„
„	17	„	24	„

I think that if marked relief does not ensue in seventy-two hours, as a rule it is useless to persevere with this treatment; nor am I clear that any good is to be anticipated from an increase of the dose already indicated in case that is found to fail. A notable exception to this rule is seen in those cases in which the local nerve-pain accompanies a condition of general nervous —or brain-exhaustion. Case No. 48 is an instance of this, in which treatment had to be prolonged for three weeks before recovery was effected, while, as the pain departed, the efficiency of the nervous system became restored. Perhaps Case No. 49 may be placed in the same category of exceptions. In this instance, too, the hysteria, which may be taken as evidence of a state of general nervous depression, failed to yield to a four weeks' treatment with zinc phosphide; the special symptom of migraine being also but slightly modified. Simultaneously, it is true, with a change of formula, but still in continuation of the same kind of treatment, the special symptom and the general condition disappeared. But in many instances a resumption of the phosphorus treatment in cases in which it has at first failed may be found effective, if the interval

have been employed in using those kinds of general treatment which the circumstances of the particular case seem to render advisable. Although the remedy may not have produced any appreciable effect upon the pain in the first place that may now generally be removed on resuming it. It need scarcely be said that the general rules of treatment, so admirably laid down by Dr. Anstie, should be followed in conjunction with, after, or as last indicated, in preparation for treatment with phosphorus. These it is not necessary to recapitulate here.

I have now had experience enough to enable me to express the opinion with confidence that phosphorus is a remedy apparently specific in neuralgias occurring in states of asthenia, whether the cause of the general debility be removed or not; and that it is equally efficacious in those cases in which the pain is either caused in healthy subjects or excited in predisposed subjects by cold locally applied. I believe that this drug will also be found very valuable in cases in which the pain is due to other causes, either more occult, or more plainly conditions of special disease, whether cerebral, or such as are commonly described as local. Of the latter class the already cited causation of nerve-pain by a decayed tooth is an example; but the neuralgia which very frequently accompanies cancer comes more clearly under that head, and was seen, in the only example which I have yet had the opportunity of observing, to yield with rapidity and certainty to small doses of zinc phosphide.

The pain recurred from day to day, as might have been anticipated; but the attacks, instead of persisting for six hours, were usually cut short in from thirty to sixty minutes.

Migraine, or sick-headache, is a neurosis which, in the cases hitherto under my observation, yields as readily to phosphorus as the neuralgias already alluded to. Two or three examples are given below, and the result attained in them is such as to warrant an anticipation that in this drug will be found the remedy, lately so eagerly inquired for, for this distressing and obstinate disorder. As to other remedies for sick-headache, I believe that I have procured better results with aconite, repeated in minim doses every ten minutes to a slight degree of poisoning than with any other; and, possibly, some light may be thrown on the action of phosphorus in this disorder by comparison with the action of this medicine (which has also long been a favourite remedy for neuralgia) in its power over the circulatory system. The power of phosphorus, however, to nourish, as well as stimulate, the nerve matter, must not be lost sight of, in case it is administered for a long time, although that can scarcely be referred to for the purpose of explaining the instances of most rapid cure.

Among the fifty cases which are presented below in a tabular form are found examples of neuralgia, the result in persons disposed to this neurosis, of irritation of the uterus (pregnancy, cancer), of the bladder, of the teeth; of debility attendant on recent delivery with

and without hæmorrhage, on over-lactation, phthisis, the decay of nature; of depression of nerve power either from overwork, mental causes, or the effect of cold locally applied; and three cases of neuralgia concurrent with hysteria are related last with special reference to the use of phosphorus in the latter condition. These cases are arbitrarily divided into three classes, viz., acute, acute recurrent, and chronic cases. This arrangement is convenient in considering the efficacy of the remedy employed. The more remarkable or specially illustrative cases are noted at length; all that it is necessary to know of the remainder may be gathered from the table. It may be once more observed here, that the cases Nos. 1 to 41 inclusive are consecutive, every instance of neuralgia occurring in my practice from about January, 1873, to July of the same year, having been treated empirically with phosphorus. In this way a number of facts about a given remedy may be ascertained which cannot (but exceptionally) be predicted of it by a process of reasoning. Thus, as I have already pointed out, it has been ascertained as a fact that phosphorus will relieve pain in a nerve suffering from mechanical irritation, without the removal of the cause.

I will now relate the prominent symptoms of the more remarkable cases which have occurred in my practice, or are comprised in the table; they include examples of neuralgia accompanying the various conditions just enumerated.

FORTY-ONE CONSECUTIVE AND NINE SELECTED CASES OF NEURALGIA TREATED WITH FREE PHOSPHORUS.

Primary Acute Cases.

No.	Sex.	Age.	Nerves Affected.	Duration of Attack.	Extreme Duration of Treatment.	Complication.	Result.	Formula and Dose Employed.
1	M.	40	R. Trigeminal.	4 days.	4 days.	Catarrh.	Recovery.	F. 9, gr. 1-24, 4tis. h.
2	F.	26	L. ,,	14 ,,	10 ,,	Anæmia.	,,	F. 9, gr. 1-33. 2dis. h.
3	F.	25	L. ,,	21 ,,	24 hours.	None.	,,	F. 9, gr. 1-50, 2dis. h.
4	M.	46	Cervico-occipital.	12 hours.	12 ,,	General derangement.	,,	F. 9, gr. 1-50, 2dis. h.
5	F.	28	L. Trigeminal.	14 days.	48 ,,	Lactation.	,,	F. 9, gr. 1-50, 2dis. h.
6	F.	26	L. ,,	6 ,,	12 days.	Catarrh.	,,	F. 5, gr. 1-20, 3tis.; F. 9, 1-100, omni horâ.
7	M.	21	L. ,,	21 ,,	5 ,,	None.	,,	Z. P., gr. 2-3, 4tis. h.
8	M.	32	L. ,,	48 hours.	3 ,,	Catarrh.	,,	F. 10, gr. 1-12, 3tiis.
9	M.	38	R. ,,	4 days.	36 hours.	None.	,,	F. 10, gr. 1-12, 4tis. h.
10	F.	33	R. and L. Trigemnl.	7 ,,	10 ,,	,,	,,	F. 10, gr. 1-12, 3tiis. h.
11	M.	30	L. Hemicrania.	21 ,,	4 days.	,,	,,	Z P., gr. 2-3, 4tis. h.
12	M.	33	R. Supra-orbital.	6 ,,	84 hours.	,,	,,	Z. P., gr. 2-3, 4tis. and F. 5.
13	M.	69	Cranial.	21 ,,	5 days.	Ague, Stricture.	,,	F. 10, gr. 1-12, 4tis. h.
14	M.	24	L. Trigeminal.	10 ,,	20 hours.	Caries of teeth.	,,	F. 5, gr. 1-12, 4tis. h.
15	F.	40	Cranial.	9 ,,	12 ,,	General debility.	,,	F. 10, gr. 1-12, 4tis. h.
16	F.	15	L. Trigeminal.	7 ,,	48 ,,	Hysteria.	,,	F. 10, gr 1-12, 4tis h.
42	F.	22	L. Clavus - hysterious.	3 ,,	8 days.	Recent delivery.	,,	Z. P. gr. 2-3, 3tiis.; F. 10, gr. 1-12, 4tis.
43	M.	30	R. Occipito-cervical.	9 ,,	4 ,,	None.	,,	Reduced Phosphorus, gr. 1-20, ter die (Cox.)
44	F.	18	R. Intercostal.	12 ,,	7 ,,	Menorrhagia.	,,	,, ,, ,, ,,

Recurrent Acute Cases.

17	F.	60	R. Sciatic.	15 days.	36 hours.	Decay of Nature.	Recovery.	F. 5. gr. 1-24, 4tis. h.
18	F.	33	L. Trigeminal.	5 ,,	6 days.	None.	,,	F. 9, gr. 1-100, om. horâ.; F. 5, gr. 1-32, 3tiis.
19	F.	32	L. ,,	21 ,,	24 hours.	,,	,,	F. 9, gr. 1-12, 3tiis. h.
20	F.	35	R. ,,	10 ,,	4 days.	Lactation.	,,	F. 9, gr. 1-18, 4tis. h.
21	F	30	R. ,,	14 ,,	5 ,,	Phthisis.	,,	F. 9, gr. 1-10—1-5, 4tis. h.
22	F.	30	R. ,,	7 ,,	48 hours.	Debility.	,,	F. 9, gr. 1-33, 2dis. h.

Recurrent Acute Cases—(continued).

No.	Sex.	Age.	Nerves Affected.	Duration of Attack.	Extreme Duration of Treatment.	Complication.	Result.	Formula and Dose Employed.
23	F.	25	Occipito-cervical.	7 weeks.	17 days.	None.	Relief.	F. 10, gr. 1-12, 3tiis.
24	F.	42	R. Trigeminal.	7 days.	12 ,,	,,	Recovery.	F. 9, gr. 1-12, 2dis. h.
25	F.	36	L. ,,	5 weeks.	6 ,,	,,	,,	F. 9, gr. 1-12, 4tis. h.
26	F.	38	Cranial.	8 ,,	8 ,,	Phthisis.	,,	F. 10, gr. 1-12, 4tis. h.
27	F.	30	R. Trigeminal.	8 days.	3 ,,	None.	,,	F. 10, gr. 1-12, 4tis. h.
28	M.	28	L. ,,	14 ,,	20 hours.	,,	,,	F. 9, gr. 1-12, 4tis. h.
29	M.	28	L. ,,	5 ,,	30 ,,	,,	,,	F. 10, gr 1-12, 4tis. h.
30	F.	26	R. ,,	28 ,,	4 days.	,,	,,	Z. P. gr. 2-3, 4tis.; F. 10, gr. 1-12, 4tis.
45	F.	36	R. ,, & Occipital.	4 weeks.	48 hours.	Pregnancy, &c.	,,	F. 6, gr. 1-12, 4tis. h.
46	M.	50	R. Temporal.	14 days.	6 days.	None.	,,	Reduced Phosphorus, gr. 1-20, 4tis. (Cox.)
47	F.	28	L. Intercostal.	23 ,,	4 ,,	,,	Relief.	,, ,, ,, ter die ,,
					Chronic Cases.			
31	F.	28	R. & L. Trigmnl. Cervico-brachial	18 months.	5 weeks.	Phthisis.	Relief.	F. 5, gr. 1-40, F. 9, gr. 1-12, 4tis.
32	F.	24	R. & L. Trigeminal	4 weeks.	9 days.	,,	,,	F. 5, gr. 1-12, 4tis. h.
33	M.	35	R. & L. Trigmnl. Occipital	12 months	12 ,,	Nervous Debility.	Recovery.	F. 9, gr. 1-33—1-12, 4tis. h.
34	F.	36	Cervico-brachial.	2 ,,	14 ,,	Pregnancy.	,,	F. 9, gr. 1-40—1-18, 4tis. h.
35	F.	26	R. & L. Trigeminal.	16 years.	18 ,,	None.	,,	F. 9, gr. 1-12—¼, 4tis.
36	F.	40	R. ,,	4 months.	15 ,,	Caries of Teeth.	None.	F. 5, F. 9, gr. 1-12, 4tis. et 2dis.
37	F.	33	Cervico occipital R. Trigeminal.	6 ,,	5 ,,	Over-lactation, &c.	Relief.	Z. P., gr. 2-3, 4tis. h.
38	F.	20	Migraine.	5 years.	6 ,,	None.	,,	,, ,, ,, ,,
39	F.	50	Sciatica.	Chronic.	5 ,,	Debility.	Recovery.	F. 9, gr. 1-18, 3tiis. h.
40	M.	27	R. Trigeminal.	4 months.	3 ,,	,,	,,	F. 10, gr. 1-12, 4tis. h.
41	F.	43	Cranial & Sciatic.	21 days.	3 ,,	None.	,,	F. 10, gr. 1-12, 4tis. h.
48	M.	43	R. Trifacial.	22 months.	21 ,,	Cerebral softening.	,,	F. 10, gr. 1-12, 4tis.; Z. P., gr. 1-3, 3tiis.
49	F.	20	Migraine.	4 ,,	41 ,,	Hysteria.	,,	Z. P., gr. ¼, 4tis. h; F. 6, gr. 1-12, ter die.
50	F.	37	R. Trigeminal.	7 weeks.	12 ,,	Pregnancy.	,,	Reduced Phosphorus, gr. 1-20, t. d. (Cox.)

Case No. 1 (45 in table).

Right occipito-cervical and facial neuralgia recurring with successive pregnancies. Dyspepsia and severe hæmorrhage from the rectum. Pregnancy.

F., æt. 36, married; is in good circumstances, but is a tall, thin, miserable-looking subject. She suffers from enormous varicosity of the veins of the lower part of the abdomen, the vulva, vagina, and thighs. This condition is much aggravated during pregnancy, and at her last confinement she was in great danger from hæmorrhage proceeding from one of the vaginal varicosities ruptured during delivery. As that happened only six months ago she still shows evidence of anæmia, which is kept up by frequent and severe hæmorrhage from the rectum; and she is in a generally debilitated condition. The teeth are very defective, and partly in conquence of this she suffers much from dyspepsia. She is now pregnant for the sixth time, and about two-and-a-half months advanced. At the sixth week she began to suffer from neuralgia affecting the right facial and the right occipital nerves; the pain now extends into the neck also, but it occupies various positions at various times. During the day she is tolerably free from active pain, although the *points douloureux* remain; about ten in the evening the acute attack commences, and persists until she leaves her bed next morning. The pain is so severe

that she seldom sleeps during the night; moreover it is instantly aggravated, if by chance there is any intermission, on laying down. It is not brought on by laying down during the day. This affection has returned with unfailing regularity during each successive pregnancy; but she had never suffered from it before marriage nor has it occurred under any circumstances of illness or debility during the intervals of pregnancy. She has frequently been under treatment without obtaining the least relief.

First day.—One-twelfth of a grain of phosphorus in one drachm of cod-liver oil, taken at 9 p.m. A bad night, as usual.

Second day.—Three doses were taken. Great relief of pain during the night, and a little sleep.

Third day.—Four doses were taken. She slept the whole of this night, and on the

Fourth day—the *points douloureux* were not distinguishable. To omit the medicine after to-day. Five months from treatment premature labour was induced, with a view of avoiding the dangers which had attended her last delivery, and to remedy the now almost constant hæmorrhage from rectum. Notwithstanding that she had daily been becoming weaker and more anæmic, there had been no return of neuralgia even in the slightest degree, up to the date of operation. Five or six days after delivery she had slight recurrence of pain; it was at once checked by a few doses of zinc phosphide, and has not returned.

Case No. 2*

General cranial and cervico-brachial neuralgia, recurring with successive pregnancies.

F., æt. 23, married; a tall, dark-haired, sallow woman, of an excitable temperament. Her family history records many cases of phthisis and insanity among her near relations, the one disease on the maternal the other on the paternal side. She has three decayed teeth on the right side, two lower molars and one upper bicuspid. She has always been hysterical, but had never suffered from neuralgia until her first pregnancy, when she was attacked with it about the eighth week, and did not recover until after delivery. When five months pregnant for the second time she came under my care suffering from general cranial neuralgia, for which she was treated with Formula No. 10. She was much relieved, when on the sixth day of treatment she sustained a fall, in consequence of which she miscarried. On her recovery from the delivery, which was not attended by any particular circumstance, the cranial neuralgia returned with unprecedented violence. After passing five nights without sleep, and being reduced to a condition of very great exhaustion by the pain, she again came under treatment. On this occasion she took one-sixteenth of a grain of solid phosphorus every three hours

* This case is related at length in the Appendix; but such part of it as illustrates the point under consideration is recapitulated here.

during eight days. On the seventh day she was almost, and on the eighth quite, free from pain. Owing to circumstances which are fully described elsewhere, symptoms of phosphorus poisoning now appeared. During her recovery, on the fifty-third day of treatment, the neuralgia returned with moderate severity, and she was directed to take Formula No. 10, in a dose of one-thirtieth of a grain twice a day. On the fifty-fifth day there was no relief from pain; and, symptoms of poisoning distinctly reappearing, the treatment was relinquished. On the fifty-sixth day the neuralgia ceased, and on the fifty-eighth day the acuter symptoms of recurrent poisoning departed, leaving the patient in a greatly improved condition. On the fifty-ninth day there was a slight return of pain; and on this day, for other reasons than that, she began to take one-fiftieth of a grain of phosphorus, twice daily, in glycerine. On the sixty-third day she was so far improved in general condition that the extraction of one of the molar teeth was sanctioned; the pain left in twenty-four hours. On the ninety-sixth day it returned in precisely the old localities, viz., in the right side of the head and the right arm and neck. Occasionally, as before, the left side would suffer, or sometimes both together. On the ninety-ninth day she told me that she believed herself to be three months pregnant; she was in extreme pain and had had no sleep for three nights. To take one-third of a grain of zinc phosphide every two hours. In forty-eight hours the pain had disappeared, and the

treatment was discontinued. Two or three days afterwards it returned in a slight degree, but yielded to two doses of the remedy in the same form. From that date until now (four months) there has been no return. The peculiar circumstances of this case prevented the administration of such a quantity of phosphorus as I deem necessary for the effectual removal of neuralgia, until this last occasion of treatment.

Case No. 3 (13).

Left trigeminal neuralgia. Chronic bronchitis and stricture of the urethra.

M., æt. 69; a man of active and temperate habits. Many years ago in Italy he contracted a tertian ague; he has also suffered for some years from periodical attacks of bronchitis, during which aguish symptoms generally manifest themselves. Ten years ago he began to suffer from stricture of the urethra which has frequently but not regularly necessitated catheterisation. He has never suffered from neuralgia. The present illness began with an attack of bronchitis, attended as usual by some aguish symptoms; and when he had been ill about three weeks the stricture became so troublesome that it was necessary to pass the catheter, and eventually to wash out the bladder daily. After the bladder complication had persisted about a week, and the whole illness about four weeks, he began to suffer from neuralgia, affecting the left trigeminal

nerve. This continued about three weeks almost without cessation; and, as the pain was severe enough during most nights to deprive him of sleep, he seemed in a fair way to sink under this complication of disorders. Under these circumstances I was desired to prescribe for him. He took, in Formula No. 10, one-twelfth of a grain of phosphorus every four hours. After the fourth dose he got five hours' sleep, and in five days was entirely recovered of the neuralgia, which has not returned (twelve months).

Case No. 4.

Paroxysms of neuralgic pain attendant on cancer of the uterus and rectum.

F., æt. 40, married; has suffered from cancer of the rectum for more than seventeen months. She did not present herself for treatment until the recto-vaginal septum had become deeply involved. Subsequently the neck of the uterus began to suffer, and a large abscess formed which broke through the skin of the left buttock. The pain usual in cancer is, as far as can be judged, not more severe than it most generally is; but, in addition to it, the patient describes the occurrence of paroxysms of shooting pain, which far outrun the constant pain in severity. The paroxysms recur at least once in every twenty-four hours, the pain appearing to begin in the rectum, and thence to dart in every direction through the pelvic organs. The attack lasts not less than five or six

hours. To take one-third of a grain of zinc phosphide every three hours. The first dose being taken at the beginning of a paroxysm very great relief was experienced in half-an-hour, and it was quite removed shortly after the second dose. The medicine, therefore, was not continued regularly, but the next day one dose appeared to cut the paroxysm short. During three months subsequent to this observation no more than from half-an-hour's to an hour's pain of this kind was experienced at a time, except on one or two occasions when the remedy was not at hand. The pain then showed every symptom of persisting as usual, but was, nevertheless, allayed by the usual dose. This case shows an exceptionally active power of the phosphide of zinc.

Case No. 5 (14).

Right trigeminal neuralgia. Caries of right upper molar and one bicuspid.

M., æt. 26; in good health; teeth sound, with the above exception, and two or three teeth in the left upper jaw. The molar tooth had been the seat of ordinary odontalgia for a week, when that pain ceased and was replaced by neuralgia of the right auriculo-temporal and supra-orbital nerve branches. Although the tooth itself no longer ached, a trifling pressure on it during an intermission was sufficient to produce a recurrence of the neuralgic pain in the nerves named. Five days' treatment with Formula No. 5 removed the neuralgia, which has not since returned (three months).

Case No. 6 (36).

Neuralgia of the left side of the body. Extensive caries of the teeth.

F., æt. 40, married; generally enjoys good health. Has never suffered from neuralgia until the present attack. Almost all the teeth of both jaws are carious, the exceptions being one or two of the incisors; the rest are little better than stumps. She had been suffering from the most acute neuralgic pain, which affected the whole of the left side of the body, and was occasionally attended by vomiting, for three months and a half, when she came under treatment; she was then reduced to a dangerous state of debility. She had been treated with various remedies, and on various assumptions; for, with the exception of the state of the teeth, there seemed no clue to the exciting cause. Fourteen of the stumps were extracted at one sitting. No relief was afforded. She was then directed to take Formula No. 5—one-twelfth of a grain every four hours; about seven doses were taken, when the stomach refused to tolerate the remedy in that form any longer. Recourse was then had to Formula No. 9, and subsequently to No. 10, given in a corresponding dose; but, although the medicine was taken with almost unfailing regularity for a fortnight, no improvement resulted. The patient living in a damp house in a dull place, her removal was recommended; and accordingly she was taken to Brighton. Here she got a

little better; and when she returned to town, occupied a house in a healthier situation. She then gradually improved, and after six months suffered only occasional attacks of pain—a few hours twice a week; a few weeks after this, however, she had another severe and persistent attack. One-third of a grain of zinc phosphide every three hours seemed to afford some relief after four days. It could not have been very considerable, for the patient refused to take any more medicine for a disease which, she said, was incurable.

These six cases exemplify the power of phosphorus in removing nerve-pain, the result of mechanical irritation, without removing the cause. Exceptions may fairly be taken to Nos. 3 and 6, as illustrating this point. It may be observed of the first, however, that while neuralgia does attend on irritation of the genito-urinary organs, this patient, although he had often suffered from bronchitis and ague before, and on this occasion had been seriously ill from those diseases for three weeks, had yet never had an attack of neuralgia. He had suffered slightly from his stricture on former occasions, but never to the extent nor with the complications which were present on this occasion, and the nerve-pain set in one week after the occurrence of symptoms requiring daily catheterisation. In Case No. 6 the true cause of the disease was never ascertained. But if caries of the teeth can cause such a neuralgia as this patient suffered, then its removal upon the extraction of the fourteen stumps need not necessarily have been expected, for she

still had a large number left. The symptoms in some respects seemed to point to cerebral disease; but no distinct evidence of it was obtained; and with the exception of frequently-recurring attacks of a severe kind, she is still (twenty months) in average health. This is the only case of a very large number in which phosphorus has not afforded some relief. The other four cases are typical examples of this peculiar power of phosphorus, and No. 4 is a most remarkable one. I have never observed a manifestation of such active power on the part of zinc phosphide on any other occasion. Should further experience of the use of phosphorus in cancer confirm the experience which is recorded in this instance, a most valuable palliative will be added to our means of combating the disease, which is so often complicated by a neuralgic, as distinguished from its proper, pain.

The next series of cases is illustrative of the use of phosphorus in neuralgia occurring in states of general debility, the result of recent delivery, over-lactation, phthisis, or the decay of nature. Of some of these it will be seen that I have chosen to relate the less successfully treated examples. They are exceptional in that respect, and may, perhaps, prove more profitable than a long-drawn list of more favourable instances.

Case No. 7 (31).

Cranial and thoracic neuralgia. Phthisis.

F., æt. 28, married; seven pregnancies. Is subjected to a good deal of domestic trouble. Is in the

second stage of phthisis, the apices of both lungs being affected. Is the daughter of Case No. 13. Has suffered neuralgia affecting the facial and superficial thoracic nerves for eighteen months. The pain is always present, but is asserted to be distinctly worse every other day. It attacks sometimes one side and sometimes the other. She has now been under general treatment for six weeks without any relief. She is in a debilitated condition.

First day.—To take one-fiftieth of a grain in alcohol every hour. This was continued with great regularity for five days, and then omitted.

Eighth day.—Thinks there was a little improvement during the treatment. To take Formula No. 9, one-sixteenth every four hours.

Fourteenth day.—Was purged five times during last night. Was as bad as ever on the eleventh and thirteenth days, which were usual days of recurrence.

Eighteenth day.—Has now taken the tincture for eighteen days, two days only being omitted, and without benefit. To take one-fortieth of a grain, Formula No. 10, every two hours.

Twenty-second day.—No improvement. One-hundredth of a grain every hour.

Twenty-seventh day.—No improvement. To take Formula No. 5, one-twelfth of a grain every four hours. On the whole, she considers that she has been better under treatment than before.

Twenty-ninth day.—Was quite as bad as usual on the

bad days, yesterday. Formula No. 10, one-eighteenth of a grain every three hours.

Thirty-first day.—The attack on the last bad day was slighter than heretofore. Continue.

Thirty-eighth day.—Is considerably better than she has been for many months. She was not cured, however, and now removed to a distant part of town. I have since been informed that she continues to suffer, although not very severely.

Case No. 8 (32).

Right and left trigeminal neuralgia. Phthisis.

F., æt. 24, married ; two pregnancies. Is suffering from phthisis, first stage. Apex of the left lung affected. Has lost flesh lately rather rapidly, but is not in a very feeble state. Has been subject to neuralgia for some years, the pain having always been confined to the trigeminal nerves. Sometimes the right and sometimes the left side suffers, but never both together. Duration of present attack, four weeks. Has had 'no sleep' for nine nights. To take Formula No. 9, one thirty-third of a grain every four hours.

Third day.—Much relief of pain.

Sixth day.—Pain as on third day.

Eighth day.—As bad as ever again. To take Formula No. 5, one-twelfth of a grain.

Tenth day.—Is a good deal relieved, but not cured. She now removed to the country, where she improved considerably.

Case No. 9 (26).

General cranial neuralgia two months. Phthisis.

F., æt. 38, married; six pregnancies. Two years ago this patient had small-pox, and during convalescence, a short but severe attack of neuralgia. One year ago she miscarried, with much hæmorrhage, and afterwards had another and longer attack. She is now suffering from general cranial neuralgia, both sides being affected. It has persisted for two months without intermission, and recently, for many consecutive nights, she has had no sleep. She is suffering from phthisis, and has had two sharp attacks of hæmoptysis; but the disease now appears to be quiescent.

First day, 10 *p.m.*—Formula No. 10, one-twelfth of a grain every three hours.

Second day, 3 *p.m.*—The pain is very much deadened.

Third day.—Is still better; a feeling of weight at the top of the head replaces acute pain. She says she is better than she has been at any time for two months. Formula No. 10, one-twelfth of a grain every two hours.

Sixth day.—Is now quite free from all pain, or the sensation last described. There is still, however, a little tenderness of the scalp.

Ninth day.—Is perfectly well. The treatment was now discontinued, and a simple tonic prescribed. There has been no return of neuralgia during twelve months.

Case No. 10.

Right and left trigeminal and cervico-brachial neuralgia. Recent delivery.

F., æt. 36, married; eight pregnancies. Shortly after her seventh confinement was laid up with severe cranial neuralgia. She was treated with quinine, muriate of ammonia, and other remedies, without any immediate good effect. The attack ceased at the third week. She had never before suffered from neuralgia, her health during pregnancy had been good, and delivery had been attended by no unusual occurrence. Similar circumstances obtained with regard to the eighth delivery; but fourteen days afterwards she was attacked with general cranial neuralgia, the pain affecting both sides. At the time of treatment had been suffering for two months with very trifling intermissions. The pain sometimes affects the arms. Formula No. 10, one-hundredth of a grain every hour.

Second day.—After taking four doses she felt a peculiar sensation in the parts affected, and from that time was almost free from pain.

Third day.—Is not quite so well as yesterday. Formula No. 10, one-fortieth every four hours.

Sixth day.—Has a severe headache, with sickness and neuralgia, as on the third day. On the fourth and fifth days she was all but well.

Eighth day.—Again better.

Eleventh day.—Still has only very slight pain. Formula No. 10, one twenty-fourth every four hours.

Sixteenth day.—Has had a very slight attack since the last note. She is now perfectly well. There has been no return during twelve months.

Case No. 11 (42).

Left "clavus hystericus." Recent delivery without complication.

F., æt. 22, married; second delivery; labour normal, rapid; no flooding. Trifling hæmorrhage continued for several days after delivery. General health fair; no history of previous neuralgia. Eight days from delivery complained of severe sharp pain confined to one spot in the left temporal region. The pain is intra-cranial, and unattended by any tenderness of the scalp. It comes on about six in the evening, and lasts all night, interfering with sleep. On the third day of illness, to take one-third of a grain of zinc phosphide every three hours.

The medicine was taken with great regularity day and night for five days. A little improvement was noted on the third day of treatment, but it was not considerable, nor did it persist; and on the sixth day the etherial tincture, as in Formula No. 10, was prescribed. One-twelfth of a grain in this form taken on the sixth night of treatment was followed by better rest than heretofore; and four-twelfths, taken during the next day, by a night free from pain. The medicine was now intermitted. Four months afterwards it was

ascertained that this patient still experienced occasional attacks of pain, which one dose of the mixture was sufficient to dispel. As she had obtained no fresh supply it appears that this formula remained active nearly four months after preparation.

I have notes of seven or eight other cases of neuralgia occurring under similar circumstances, all of which recovered in from two to seven days. Beyond this fact they present no specially noteworthy feature, and are, therefore, not detailed.

Case No. 12 (37).

Cervico-occipital and right trigeminal neuralgia. Over-lactation and poverty.

F., æt. 33; has borne seven children in as many years, and is still suckling the youngest at fourteen months. The patient is in an indigent condition, and very imperfectly clad and fed. She has suffered from profuse leucorrhæa and dyspepsia for the last six months. During this period she has also suffered from cervico-occipital and right trigeminal neuralgia, of medium severity, with very slight intermissions. She is now, therefore, in a condition from which long treatment, under favourable circumstances, can alone retrieve her. To take-two thirds of a grain of zinc phosphide three times a day. On the sixth day she reported that she was considerably relieved, and had found means to go into the country. As it was not considered advisable to allow her to continue to take phosphorus unless under

supervision, the treatment was discontinued. When she returned to town her strength was much improved, and the neuralgia had disappeared.

Case No. 13 (3).

General cranial neuralgia. Over-lactation.

F., æt 25; in good circumstances; is anæmic looking, and still suckling her youngest child at thirteen months. For the last three weeks has suffered from general cranial neuralgia, of which she can recall no intermission of longer duration than one hour. Sleep has in consequence been much interrupted.

First day, 10 *a.m.*—To take Formula No. 10, one-fiftieth of a grain every two hours.

Second day, 11 *p.m.*—Has taken the medicine with perfect regularity during these thirty-seven hours and is now quite well. She experienced a return about six months after this treatment; on the fourth day the same remedy was used, and the pain yielded in a similarly rapid manner. This has been the only return during twelve months.

Case No. 14.

Left facial neuralgia, lactation, anæmia, &c.

F., æt. 33; is nursing her fifth child at eleven months. This patient is very anæmic and feeble. She is in fair circumstances, and well fed. During the present lactation she has suffered from facial neuralgia of medium severity, recurring at short intervals. The pre-

sent attack is worse than usual, and has prevented sleep for five nights. To take Formula No. 9, one-eighteenth of a grain every two hours.

Twenty-third hour.—She has taken her medicine regularly, and in a dose rather more than twice as large as was prescribed. She has taken two-thirds of a grain of phosphorus in twenty hours. She says she is worse. Continue.

Thirty-seventh hour.—Is quite well. Twelve months from treatment she reported that she had had no return of pain. In connection with this case the proclivity of patients of all classes for measuring their medicines carelessly or for purposely increasing the dose if relief does not follow the remedy employed as speedily as they consider it should do, may be noticed. The point is of importance in the use of this drug.

Case No. 15 (17).

Sciatica. Poverty and general decay.

F., æt. 60; is in indigent circumstances, and enfeebled by privation and trouble. She looks much older than her years. Six years ago she was attacked suddenly by sciatica on the right side; she was quite incapacitated by it for two years. She has now been suffering excruciating pain in the same nerve for three weeks. During two more weeks she was treated with various remedies, but without benefit, and I then determined to employ phosphorus. Accordingly, she was supplied with

Formula No. 5, one twenty-fourth of a grain every four hours. The pain at this time was continuous, excruciating, and accompanied by some trigeminal pain.

Fourteen hours.—Is a trifle better.

Twenty-four hours.—She has taken six doses, or one-fourth of a grain. Before the seventh dose, violent vomiting and purging set in; notwithstanding this, she took two more doses in the course of the night, which were retained; a third dose was immediately vomited. The pain about this time got much better.

Thirty-six hours.—All pain has gone. She is extremely weak, still purging and vomiting, and scarcely able to move in bed. This condition of debility, which was out of all comparison with her state before treatment, lasted for some weeks, and was accompanied by flatulent dyspepsia, which persisted for several months. The sciatica, however, did not return, nor, during eighteen months, has there been any re-appearance of it. This was the first case which I treated with phosphorus, and I now recognise the gastric disturbance, the extreme and long-continued debility, and the chronic dyspepsia, to be the result of slight poisoning. Probably, had these symptoms been referred to their true cause, this unfortunate first experience would have also been the last of so active a medicine. They were owing, not to the dose of phosphorus administered, which is, indeed, a moderate and reasonable dose, but, as in so many other cases of unexpected poisoning, to *altered* phosphorus. Such cases may be expected to recur, if unprepared vegetable oils

continue in use as solvents of this drug, or even if emulsions of *prepared* oil with water are employed.

The nine foregoing cases include three examples of the use of phosphorus in neuralgia concurrent with phthisis. In case No. 26 the latter disease was not in an active state, and an examination of the patient's chest fourteen months afterwards yielded no evidence of progress. Of the other two in No. 31 the disease was progressing with rapidity; and in this one it is worthy of remark that no alteration in the patient's general condition was effected, although she was taking free phosphorus in one form or another for several weeks. Although amelioration of the neuralgia is reported in this example I should hesitate to say that the improvement was in consequence of the treatment. As remarked elsewhere, experience has shown me that all those cases which will eventually derive signal benefit from phosphorus, manifest some marked signs of improvement within a very few hours. Such was not the case with this patient, and the total improvement was, after all, very slight. In No. 32 the lung disease was quiescent. The period during which the patient was under observation was a short one, and in any other kind of treatment the case would, for that reason, have been scarcely worthy of insertion. I have inserted it here because I think the time of treatment long enough to show that it would be of little service. Thus it is seen that the remedy was of use only in that case in which the phthisis was trifling and quiescent. Further

observation will be necessary to determine whether phthisis operates as an unfavourable element in the treatment of neuralgia with phosphorus. Of the remaining six cases it is only necessary to observe that recovery was effected in periods far too short to have allowed of the general condition of debility becoming ameliorated; while in Case No. 17 the remedy employed was actually productive of a condition of extreme weakness, and yet the disease did not return. In those attacks which have occurred soon after recent delivery, recovery has always been effected with rapidity, and has remained permanent. I have treated a considerable number of persons under these circumstances with uniform success.

Case No. 16.

Right supra-orbital neuralgia without complication. Exposure to cold.

M., æt. 36; enjoys good health, and even now offers no other sign of derangement but neuralgia of the right supra-orbital nerve branch. The pain is severe and has entirely prevented sleep for three nights. He has had three previous attacks, each of which lasted about fourteen days; and on other occasions, as on this, they followed on prolonged exposure of the face to a cold draught of air. The teeth are in fairly good condition. Formula No. 10, one-twelfth of a grain every four hours. He returned quite well in thirty-six hours. There has been no return during fifteen months.

Case No. 17 (28).

Left trigeminal neuralgia, periodicallg recurring without complication. Exposure to cold.

M., æt. 28. This patient is a carpenter; he enjoys good health. The teeth are in fair condition. For several years he has experienced three or four attacks of neuralgia each year; the pain always occupies the left facial nerve and is generally severe, lasting three weeks at a time, more or less. He attributes these attacks to cold, and observes that they almost invariably follow on his working in partially completed houses, and the consequent exposure to draughts and damp air. He has now been ill with pain of medium severity for seven or eight days. Formula No. 9, one-eighth of a grain every four hours. He was quite cured in five doses. Three months later, and after a period of exposure of the kind alluded to he returned with pain in the same nerve branches. He recovered after seven doses of the same formula, and has not since had any return (ten months).

Case No. 18 (8).

Right temporal neuralgia, recurring on exposure to cold, without complication.

M., æt. 32. This patient, as in the two previous examples, is a strong, healthy-looking man, who is exposed by his occupation to cold and damp. At frequent intervals —*i.e.*, after most occasions of exposure,

during the last year, he has suffered from neuralgic pain occupying the right temporal or supra-orbital nerve branches. He has now suffered for forty-eight hours and has had no sleep. Formula No. 10, one-twelfth of a grain every four hours. He recovered in seventy-two hours, and has had no return (ten months).

Case No. 19.

Right trigeminal neuralgia. Mental shock.

F., æt. 40 ; in fair general health. After three days' confinement to the house for some trifling ailment, the patient paid a visit to a sister who lived some distance away. On enquiring for her, she was told that she had died suddenly the same morning. The patient was much shocked by the news, and nearly fainted at the time; shortly afterwards she was seized with neuralgia in the right trigeminal nerve. The pain was general; there was one *point douloureux* at the side of the nose. The pain has now continued one week with much severity, and trifling intermissions. To take Formula No. 10, one-twelfth of a grain every four hours. She quite recovered after the third dose, and has had no return (fourteen months).

Case No. 20.

Left occipito-cervical neuralgia. General nervous exhaustion; hysterical tendency; overwork.

M., æt. 25. This patient is a cashier, and has lately been much overworked. He is not strong, but has en-

joyed fair health hitherto. On leaving his business at ten o'clock at night on the present occasion of illness, he felt ill, and, arriving at home, fainted. He was found on the floor an hour afterwards, still faint, apprehensive of death, and hysterical. During the night, very severe neuralgia, affecting the left occipito-cervical nerve came on; he had never suffered from this disorder before. The pain continued during the night. The next day he said that he had felt his strength and energy to be leaving him for some time past; and that recently he so easily got confused over his accounts as to be almost unfit for business. He had also had some occasional twinges of pain in the nerves now affected. Similar treatment to that employed in the last case served to dispel the neuralgia in eight-and-forty hours. It was continued, however, with a view of remedying the general nervous debility; and in a week he said he felt as well as ever.

Case No. 21 (48).

Right trifacial neuralgia. Old softening of the brain from overwork.

M., æt. 43; for some years has been subject to occasional attacks of facial neuralgia. The patient is engaged in commercial pursuits involving scientific knowledge; and two and a half years ago, after a long period of unusually close mental occupation, he broke down. There were some symptoms of paralysis at that time; but from these, and from the general mental

exhaustion, he so far recovered, after several months of perfect rest, as to be able to resume his duties. As soon as he began to recover his mental powers he became subject to frequent attacks of very severe neuralgic pain, chiefly in the right trifacial nerve; and he has now, for nearly two years, suffered such an attack daily for several hours. The time of recurrence is not regular. For a few months he has been at work again; but he is liable to become confused on any undue pressure of business, and does not feel that mental clearness and capacity for which he used to consider himself distinguished. There is now no paralysis. To take Formula No. 10, one-twelfth every four hours.

Fourth day.—Has had no attack until this day. He has had no such interval of freedom from pain since the commencement of it after his illness. To take zinc phosphide, one-third of a grain every three hours. He finds the fluid preparation inconvenient.

Twelfth day.—Has had an attack of pain of modified severity about every second day. He begins to feel more vigour both of mind and body than for months. Continue.

Twentieth day.—Has had no pain at all for four days. The treatment was continued for a few days longer, and the neuralgia has not since returned (four months). In addition, the patient says that, he 'feels his life renewed.' This case is referred to above as an example of the use of phosphorus in brain-softening.

These six cases show neuralgia following on depres-

sion of nerve power, whether local, as the result of cold, or general, as the result of mental influences or of overwork. Of the first class, the results attained in them may be predicted of this treatment with as much certainty as of those in which neuralgia occurs as a result of an asthenic or debilitated condition. Three examples only are given, but I could multiply analogous instances almost *ad infinitum*.

Hysteria.

The three following cases of hysteria, the treatment of which was undertaken with a view of remedying the concurrent neuralgia, show such a remarkable improvement in the former neurosis, that they are related rather with regard to it than to the nerve-pain.

Without attempting any definition of hysteria, I shall merely observe that in most instances, at all events, it appears to consist essentially in a depression of nerve power. That is to say, hysteric persons, while they have lost control over their emotions, most frequently offer some other and more direct evidence of loss of nerve power—as neuralgia, anæsthesia, hyperæsthesia or paralysis, migraine, or a condition of general mental depression; or they may suffer from violent and irregular—that is to say, uncontrolled—explosions of nerve force. As in some cerebral conditions—epilepsy, for example (to which hysteria seems nearly akin), a period of debility is followed by convulsive movements, to control which the powers of two or three strong

persons are occasionally necessary. There is a further point of resemblance between epilepsy and hysteria, although it is generally taken as a distinction between those diseases—that the attacks are at first, or in some cases, under the control of the patient. Not unfrequently patients are met with who are able, by changing their position—by adopting some simple mechanical expedient, such as grasping the limb in which the aura is felt—by diverting the attention, in fact, to put off an epileptic fit; and hysteric fits are sometimes similarly under the control of the subject. Epilepsy, then, which is acknowledged to be a disease, is sometimes under the control of the sufferer; that hysteric fits are also under control is not, therefore, an argument against the claim of this condition to be also considered as a disease. The locality of hysteria has been fixed by some in the cerebro-spinal system—if that can properly be called *localising* it—and I think with reason; although Mr. Brudenell Carter has argued, from the uniform absence of pathological lesions in these parts of the body, that the evidence in favour of it is but theoretical. The same writer infers that hysteria cannot depend upon any morbid condition of a particular part of the *body*, since a person may be suddenly seized with a hysteric paroxysm, or with some of the less common forms, as paralysis, who, two minutes before, would have been pronounced healthy, after the application of every known test. The argument is deficient. When *the* test is applied, the patient yields evidence of hysteria.

It is only on some extraordinary occasion, such as is sufficient to produce a violent revolution in the nervous system, that apparently healthy subjects really suddenly reveal their hysteric state; in most cases, at all events, in which the attack is said to have occurred suddenly, evidence of predisposition—or, rather, of initiatory symptoms—may be elicited. Considering, then, the relation which hysteria bears to epilepsy, and to insanity, and the fact that it is accompanied by symptoms of depressed nerve power, at one time evidenced by the neuroses named, at another by an unusual nerve tension and absence of control over the purely emotional functions of the mind, I think it may fairly be considered as a nerve disease. If this be so, it admits of remedial drug treatment. Conversely, any drug treatment which can be shown to be distinctly remedial of hysteria affords an argument in favour of its claim to be considered as a disease. Hitherto, no drug has been found which can be depended on, *per se*, as a remedy for the disease, although many are effective in removing concomitant symptoms. There may be collateral indications to be dealt with; and treatment not special may be successfully employed to meet them. These being remedied, the patient may or may not get well. If she do not, treatment, as far as the Materia Medica goes, at least, is at an end. Then, if not before, moral treatment is employed, and generally with advantage. But I will observe here that cases of hysteria differ materially as they are of

old or recent standing. I have no doubt but that in old standing cases the symptoms are more often than not perpetuated by habit: it is in these that moral influences are so effective. Such a case is one which I have recently published, and in which the simple treatment employed was corporal punishment—not administered as such, but apparently directed against special symptoms; such, too, are those cases in which recovery ensues on the occurrence of a fire, or, potent remedy, the excitement of curiosity to gratify which the bedridden patient must get up and walk. But if these moral influences are tried in recent or acute cases they fail. They may succeed for the time, but the patient relapses. I would divide hysteric patients into two classes, then: an acute and a chronic—or, as I prefer to call it, an "habitual" class. It is not necessary to recapitulate reasons here for denying that a cure or alleviation, however transient, procured simply by the mental power which one person possesses over another is not an argument against the existence of disease. Probably when there is functional disease of the nervous system, were the mode of using it better understood; the mental powers of the patient, excited by those of another person, would be found far more speedy and efficacious than any purely drug treatment. It is but fair to infer this, when the power of the mind over actual lesion of structure, as set forth by Mesmer, Braidwood, and Dr. Tuke, is considered. Hysteria may thus be regarded as

a disease of the nervous system, and, probably, it is more amenable to moral treatment than to any other. By moral treatment, I mean the power which one mind has over another, to excite in the latter its full and healthy influence over the body, through which it is manifested. But it is not generally known how to exert this power, nor is it probable that it would be found to exist in all instructed individuals; and it remains, therefore, to discover a medicine possessed of special influence over this condition. Phosphorus is a nerve stimulant, and, more than this, a nerve food. It is reasonable to look to it.

Apart from all theory, and indeed accidentally, as far as the disease under consideration goes, I have made the three following observations.

Case No. 22.

Cranial and occipito-cervical neuralgia. Hysteria.

F., æt. 37; married, three children; is in a state of debility. For some months has been lapsing into a condition of chronic hysteria. Within six months has had two 'attacks' of hysteria, and, in addition, is always in a low, despondent condition. Six weeks ago she began to suffer from short and infrequent attacks of pain, sometimes in the right and sometimes in the left trigeminal nerves. Three weeks since pain of a neuralgic character occurred in the cranial nerves, darting from one to the other with rapidity, but apparently not confined to any particular set. For seven nights she

has had 'no' sleep. To take Formula No. 10, one-twelfth of a grain, repeated every four hours.

Seventy-two hours.—Slept well last night, and is now free from pain. Began to cry during consultation. To continue.

Fifth day.—Has had a few twinges during the day.

Tenth day.—There is marked improvement in her general condition. She has had no neuralgia to speak of since about the forty-eighth hour of treatment, and has been quite well since the fifth day. She is evidently in the condition described by the French as that of *bien-être.* At her own request the treatment was continued, although the neuralgia was gone.

Case No. 23 (16).

Left temporal neuralgia. Hysteria.

F., æt. 15; is a fairly well-developed girl. The menses appeared first about a year and a half ago, and the function has since been performed with regularity. She is somewhat pallid; and while she is at all times very excitable, for the last two or three months she has had a violent hysteric paroxysm once or twice a week. Her general health being pretty good, it was considered that these symptoms were due to debility consequent upon rapid growth, and advice was not sought until an attack of neuralgia supervened. It did not appear from the general information received that the pain was very severe, although the patient made a great deal of it; and it had lasted at the time of treatment about ten

days, with only slight and imperfect intermissions. It affected the temporal and supra-orbital nerve branches on the left side of the head. One-twelfth of a grain of phosphorus in alcohol and glycerine was prescribed to be taken three times daily. At the third or fourth day the neuralgia disappeared and did not return ; but in addition a striking change became manifest in her general condition. She had an attack of hysterics of the usual description on the second day of treatment; but from that time these fits ceased to occur. Her spirits began to be more equable, and her emotions more under control; she was neither depressed at times nor boisterously merry at others. The treatment, on these signs of improvement being manifested, was continued for a fortnight, and ten weeks afterwards her mother stated that there had been no return of the old symptoms. Three months after this, or about six months from the commencement of treatment, she again complained of the hysteric feelings; the same remedy as before was given, and the result was equally satisfactory.

Case No. 24 (49).

Migraine. Hysteria.

Is a well-grown, fresh-coloured girl of twenty, but it is obvious at a glance that she is hysterical. She has that fulness of the upper eyelid, and that entreating look about the eye which serve to diagnose hysteria, without any further inquiry. Five months since, her mother entered upon her fatal illness; it lasted for two

months, and during that time the patient had a great deal of very arduous duty to perform, often passing two consecutive nights without putting off her clothes. Before she was released from this occupation she began to suffer from migraine. The pain always occupied the left temporal region exclusively, and would come on suddenly. For a few minutes previous to the attack vision would be disturbed, surrounding objects became indistinct, and while large things appeared to have green spots on them, print appeared to be surrounded with red lines; in a short time these sensations were followed by sickness, and the whole attack usually lasted some hours, only passing off after a little sleep. These attacks, which had persisted for three months at the time of treatment returned with tolerable regularity every other day; and, in addition, during the latter eight or ten weeks she had a hysteric paroxysm at least once a week. She became listless and dull, being able to talk of little but her own health; and, having to take the position of mother to her younger brothers and sisters as far as might be, felt herself incapable of performing the duties entailed upon her. In addition to the above-named symptoms the menses returned every eighth day, and she suffered very much from flatulent dyspepsia, with irregularity of the bowels. A diet of lentil meal with milk and eggs, and abstinence from meat, with an alkaline mixture containing infusion of gentian and bismuth soon corrected the last-named symptom; but the other trouble continued. She was

therefore directed to take one-third of a grain of zinc phosphide in the form of a pill and coated (Cox) every four hours.

Fifth day.—A bad headache.

Thirteenth day.—Has had no headache until this morning, when, having sat up very late last night, she had what she calls 'half a headache.'

Fifteenth day.—Was much upset yesterday by some domestic affair, and has quite a bad headache to-day. Menstruation.

Seventeenth day.—'Half a headache.'

Twenty-fourth day.—A bad headache. Menstruation.

Twenty-fifth day.—With the exception of the seven days between the fifth and thirteenth days, she can scarcely be said to show much improvement in respect of the sick headache, and she is very little better as regards the hysteria. The treatment with zinc phosphide was therefore exchanged for three doses daily of one-twelfth of a grain of phosphorus dissolved in cod-liver oil.

Thirtieth day.—There having been no headache, she was directed to intermit the medicine.

Thirty-first day.—Slight pain occurring the mixture was resumed, and continued for another ten days. There was no headache during this period, nor has any been experienced since—now three months. In addition, all the hysteric symptoms have disappeared, and she says that she is so well that she scarcely knows herself. It should be observed that as the headache failed to yield to the zinc phosphide so the hysteric symptoms

persisted unabated during its use; no sooner, however, was phosphorus exhibited in another form than her appearance at once altered. Her manner became cheerful; she no longer occupied the day searching out a new symptom to inform me of on the morrow; she began to interest herself again in her domestic duties, and she very shortly lost the peculiar physiognomy which I have alluded to above. In a word, in this case, as in the previous, in curing the special nerve-pain the general nerve condition was removed. In the last case it is not easy to estimate the importance of this happy result, for the patient came of a family in which consumption and insanity had occurred in many instances. The mother died of the former disease; the father, maniacal.

Case No. 25 (38).

Migraine.

F., æt. 20; domestic servant. Every two or three weeks since the commencement of menstruation has suffered an attack of sick headache. The pain chiefly occupies the right temple, but is sometimes felt in all the right side of the brain. The attacks begin on rising, with dimness of vision. In half-an-hour sickness sets in, and she is incapacitated for that day. She gets better towards night, but does not recover until the next morning. The attacks recur irrespective of the menstrual periods, which are observed with regularity. To take zinc phosphide, two-thirds of a grain three times a day.

Seventh day.—The medicine has been taken regularly, *i.e.*, about two grains *per diem.* According to her expectation, she should have had an attack about this time, but there was none.

Three months from this date she returned. She reported that the headaches continued to occur, but "not half as often." Nor did they now prostrate her; coming on at rising they would be quite gone at twelve o'clock in the day. She underwent further treatment, somewhat irregularly pursued, during six weeks. She has since reported herself well (six months).

Cutaneous Disorders.

Cazenave has recommended phosphorus as a remedy in certain skin disorders, and he appends to his book a formula for its exhibition, which is, however, a very imperfect and dangerous one. In 1850, Dr. Burgess stated that he regarded this drug as a most valuable medicine in the treatment of lupus, psoriasis, and lepra. From that date until 1868 no further observation on this subject was published; but in that year Dr. Broadbent, in a paper entitled "An attempt to apply chemical principles in explanation of the action of remedies," read before the Royal Medico-Chirurgical Society of London, referred to the cure of old-standing cases of skin disease with phosphorus in support of his theory — phosphorus and arsenic belonging to the same chemical group. In 1871, the same author read before the Clinical Society of London another paper on the

same subject. In it, the treatment of six cases of eczema and six cases of psoriasis was described. Of the cases of eczema, three got perfectly well, two nearly well, and one only was not benefited. Of those which were cured, the most striking case was that of a girl aged twelve years, who had had eczema of the scalp, reaching over the forehead, for three months. She took phosphorus for three months, and had nearly recovered, when she was obliged to intermit the medicine on account of the occurrence of dyspeptic symptoms. After an interval of three weeks, during which some return of the disease was observed, the remedy was resumed; and after taking it for another two weeks she was discharged, quite cured. Of the six cases of psoriasis, two were uninfluenced by the remedy.

In the same year Dr. Eames treated the same subject in a paper read before the College of Physicians of Ireland Medical Society. His experience extended over a greater variety of diseases, and appears to have been somewhat more successful than Dr. Broadbent's. Thus a case of acne indurata of four years' standing was cured in six weeks; three cases of lupus were treated "with similarly satisfactory results;" that is to say, in one, marked improvement was noted in fourteen days, and cure was effected in nine months; in the other two cicatrisation was complete in five months, and there was no return of the disease at the eighteenth month subsequent to treatment. In two cases of scrofulo-derma the swellings disappeared, in one instance in six weeks,

in the other in three weeks. Psoriasis, pemphigus, and eczema yielded readily.

Probably, since many of these cases were of old standing, and had already resisted other kinds of treatment, some other matter than the difficulty of its pharmaceutical preparation has interfered with a more general trial of phosphorus in skin disease. It is in such diseases as these that phosphorus is likely to be misapplied, and therefore to fall into disfavour. All those remedies which have not a specific power, and many of those which have such a power in one disease only, are liable to abuse in their general application to diseases for which they are unfitted, and are thus overlooked in many instances in which a more accurate knowledge of their mode of action would suggest their value. At the same time something is to be said for the trial of a new remedy in various disorders in which there is no contra-indication to its known effects, with the object of ascertaining any specific power of which it may be possessed; but such investigations must be conducted philosophically, and unfavourable results must not be allowed to detract from the value of the drug in cases in which it has either already been ascertained to be useful, or in which indications for its use, collateral to the special disease, exist.

According to Mr. Erasmus Wilson,* phosphorus being a useful remedy in all those diseases which are

* "Journal of Cutaneous Medicine." 1868.

due to debility of nerve power, it should also be useful in those cutaneous disorders which are called nutritive, and in many of those which are called congestive. These conditions are probably the result of a paresis of the neighbouring capillary vessels; and quite lately Dr. Colomiatti, of Turin, has ascertained in two cases of chronic psoriasis that a varicose condition of the vessels supplying the papillæ is a prominent pathological condition in that disease. Taking this paresis of the cutaneous capillaries as a proximate cause of many skin diseases, a wide field of usefulness is at once opened for phosphorus, for its power over this part of the circulation is evidenced by many facts which are mentioned in former parts of this work. A cutaneous disorder co-existent with general nerve debility, will very probably then be benefited by phosphorus, for it depends upon a partial paralysis of nerves, over which phosphorus has special power. But this latter condition may exist without any particular evidence of nerve exhaustion forthcoming; it exists thus in some of the febrile exanthemata; other indications for the use of phosphorus must therefore be sought. They will be found either in the mere existence of certain skin diseases, in which cases the action of this drug may probably be called specific, or in a clearer definition of the circumstances under which to remove the capillary paresis is enough to remove the disease, without regard to the remote cause of it. Thus, as an example of the first proposition, herpes-zoster and intercostal neuralgia so constantly concur that the rash is

taken to be a symptom of the nerve disorder, which is primarily recognised by pain; and, as I have said elsewhere, I believe I have observed this rash to be cut short in a case in which phosphorus was given to remedy the pain. Thus, the mere appearance of herpes-zoster may be taken as an indication for phosphorus. But, to exemplify the second proposition, I apprehend that a disease which finds its exciting cause in syphilis might fail to yield to phosphorus alone, although the proximate cause of the rash in that case may be the same capillary paresis which is the only tangible pathological condition in cutaneous eruptions excited by more occult morbid states, which are found amenable to this drug.

The indications for the use of phosphorus in skin diseases have yet to be defined. Speaking in general terms, the drug will be found serviceable for two contrary purposes—to remedy a cutaneous disorder, and to promote the rash in exanthematous diseases. For the former purpose, it must be used in the small or tonic dose; for the latter, in the large or stimulant dose. Used in the former manner, phosphorus will be a useful remedy in those eruptions which accompany general nervous exhaustion, or which can be traced to a local nerve derangement; in those which result from anutrition of the skin, or in which a state of chronic congestion (or varicosity) of the capillaries is a prominent pathological condition. Used in the latter manner, it is useful to promote those eruptions which depend for their development upon an expanded condition of the

capillaries—that is to say, in the rashes of the exanthematous fevers. It is interesting in this relation to recall the itching and irritation of the skin which, according to von Löbel, occasionally attends on the use of this drug, and the occurrence of phagedænic spots on the surface of the body in some cases of poisoning with it, as recorded by Weickard.

Thus, it will be seen, that that drug which causes An eruption may also cure An eruption; but (if it be worth noting for the thousandth time) this is a favourable opportunity for observing that the trifling amount of pathological knowledge which governs this use of phosphorus, entirely deprives it of any superficial resemblance it may be supposed to bear to the superstitious practices of homœopathy, and of any support it may at first sight be deemed to afford to the notorious hypothesis upon which that system (if the expression can be justly used) is based.

APPENDIX A.

A Case of Accidental Poisoning with Solid Phosphorus.

F., æt. 23; married. Father and brother insane. Phthisis in father's family; mother neuralgic. Is a woman of middle height, dark coarse hair, dark eyes, large irregular features, sallow complexion. With the exception of generally deficient action of the liver, and occasional attacks of flatulent indigestion, has hitherto enjoyed fair health. The menses first appeared at sixteen, and have recurred every twenty-one days with regularity. Has been married three years, and has had one labour at full term; this was followed by a severe attack of neuralgia, lasting six weeks. Is of a highly excitable temperament, very cheerful, and remarkably loquacious.

On October 1st, 1873, being five months pregnant, she applied for advice, suffering from general cranial neuralgia. Treatment was begun with Formula No. 10, one-twelfth of a grain every three hours, and she was relieved; when, on October 7th, having had a fall, she miscarried. On her recovery from this accident, which was not attended by any unusual circumstance, the hæmorrhage in particular being

slight, the cranial neuralgia returned, and, after passing five nights without sleep, and more than a week almost absolutely without food, she again applied for assistance on

November 2nd, 9 p.m.—Is suffering excruciating pain in left trigeminal and cervico-brachial nerves; occasionally the pain affects the tongue. To take one-sixteenth of a grain of reduced phosphorus every three hours. The pills were taken with perfect regularity from this date to the 8th inst., day and night, for no relief was experienced until the evening of the 6th, when she passed a sleepless night, but one comparatively free from pain. On the 7th she was almost, and on the 8th quite, free from neuralgia; she expressed herself as feeling better and stronger; her appetite had returned, and she had had some broken sleep on the night of the 7th. During the evening of the 8th she ate a large supper of sprats. In the night she began to feel sick, pain in the abdomen and epigastrium set in, and towards morning she vomited many times. She had taken forty-three sixteenths of a grain, or nearly two-and-three-quarter grains of phosphorus in one hundred and forty-four hours, or six days, the intervals having been strictly observed.

First day.—Pulse 100. Complains of intense pain across the abdomen and in the epigastrium. It is not described as a burning pain, nor is it constant; on the contrary, it is colicky, is relieved by pressure, comes and goes, and tends to draw her double. She still vomits frequently, but with more violence after attempting to swallow a little food, or even milk. These symptoms being ascribed to indigestion, caused by a heavy meal taken after a long period of almost total abstinence, a purge was

prescribed, and a draught of thirty grains of chloral to be taken at night. Both these doses were immediately vomited.

Second day.— Pulse 80, temperature 98·5. The pulse rather weak. The vomiting continues as before. There is a great deal of flatulence ; and the epigastrium is extremely tender ; the bowels have acted once. She has no neuralgia, and is quite cheerful.

Third day.—Pulse 140, temperature 98·75. She now vomits frequently, whether on taking food or not. There is a great deal of flatulence still, with eructation of a peculiarly disagreeable kind ; but it is not described as phosphoric in taste or odour. The abdominal pain is violent and now constant. The retching is a little moderated ; but each effort is followed by a sharp pain in the palate, which is perhaps neuralgic. During the night the cranial neuralgia returned, and to-day three circular red spots are visible on the affected side of the face ; one on the left side of the nose, one to the left of the median line of the forehead, and one on the left temple. They do not correspond to *points douloureux*. To-day there are the following fresh symptoms —nervousness, and excessive weakness. To illustrate the latter, she says that having stumbled in walking across the room (for she is not confined to bed), she could not make the least effort to save herself ; and wishing to wash her hands, she could do no more than dip them into the water, and was not able even to dry them. Her sensation is one of being tired to aching, and, in addition, of perfect exhaustion, not of power only, but of will. The action of the heart is a little inclined to hesitation or irregularity, and its sounds very feeble ; the pulse is very weak and compressible.

Although these symptoms began by the thirty-sixth hour they were, when considered together, judged to be due to fatty degeneration, or possibly to a stage preceding that; and the patient's condition was now attributed to phosphorus poisoning. She was, therefore, ordered to keep her bed, and the recumbent posture; to take five minims of spirit of turpentine every two hours; and, with some hesitation, five minims of tincture of digitalis was added to a mixture of bismuth and potash which she had been taking every four hours.

Fourth day.—Pulse 80, temperature 98·5. She seems a little stronger to-day, and gets up in the bed with ease. Nevertheless, she says that she lay this morning from six o'clock to eleven unattended, and quite incapable of raising herself or of calling for assistance. To-day she is observed to be slightly jaundiced. The area of liver dulness is distinctly, though not much, enlarged; the right hypochondriac, as well as the epigastric, region is intensely tender, and in addition there is constant pain, described as aching. The sickness continues, and the vomit, consisting of a little mucus simply, is now streaked with blood. The bowels have acted once, but slightly. She experiences marked alternations of heat and cold. The cranial neuralgia is severe. *Evening.*—Pulse 80. In quality not improved In a violent fit of retching, some blood escaped by the rectum. She has no hæmorrhoids. She is quite rational in conversation, and still cheerful, notwithstanding the pain and prostration. But during the day she has been wandering a good deal; fancying that her father, who is dead, had been to see her, and that she had seen rabbits running about

the bed. She volunteers that these appearances were illusive ; but she gives me this information in a whisper, and I am told that she persisted for a long time that her father had been speaking with her. There is no nervousness to-day.

Fifth day.—Pulse 70, temperature 98·5. The heart sounds are very distant, and the pulse quite feeble. The epigastric pain and tenderness continue unabated. She vomited three times last night after swallowing a little milk. The bowels have not acted. The tongue is, and has been throughout, clean and moist. The jaundice is to-day quite bright. The catamenia appeared (three weeks after the cessation of the lochia). The neuralgia is better. She has wandered a little both last night and to-day, and she says she is forgetful, but I can obtain no other evidence of the latter symptom. *Evening.*—Pulse 70, temperature 98. She has not vomited during the day, although she has taken about a teacupful of milk and arrowroot, by teaspoonfuls at a time. As each was followed by increased epigastric pain, all attempts at feeding are interdicted for the present ; brandy, soda-water, and ice, which does not cause pain if taken in small quantities, to be given only. The hepatic tenderness is better ; the neuralgia a little worse again. Has wandered a good deal during the day, but is quite rational in conversation, only hurried and excited. The bowels have acted once, the evacuation being normal in colour and consistence. No hæmorrhage has been noted. To-day the patient dwells upon a remarkable feature in the weakness. About every hour-and-a-half she becomes excessively prostrated, and remains in this condition twenty minutes ; then a reaction sets in and she speedily recovers her strength, and the voice,

which sinks to a whisper during the attack, returns again. Concurrent with these attacks, which are said to be not at all like fainting fits, in that the senses remain perfectly clear, she experiences a præcordial pain which she herself calls "heart-ache." The urine, which was withdrawn for examination on the third day, contained no blood and no albumen, but a very large amount of phosphates. This was so great as to be taken by the analyst to imply the presence originally of free phosphoric acid, which had entered into combinations during the four-and-twenty hours which had been allowed to elapse before it was chemically examined.

Sixth day.—Pulse 78, temperature 98·5. Hepatic and epigastric pain, as at first; the latter at times very severe The pulse is extremely weak and difficult to count. Complains of a slight degree of formication. The disturbance of the circulation still very marked. Jaundice as yesterday. The urine very turbid and yellow, but normal in quantity; no albumen. The bowels unopened. Is reported to have wandered a little in the night; but she is quite conscious of this herself, and her mental condition is such that her own account of it may be trusted. *Evening.*—Pulse 84, and even yet more feeble if possible; the heart sounds are heard with difficulty. She says she feels worse to-night. In spite of the strictest injunctions to the contrary, she took half a teacupful of beef-tea to-day. She was immediately seized with violent epigastric pain and retching, but she did not vomit. The bowels then acted twice, the stools being liquid and without blood. The paroxysms of epigastric pain continue to recur with unprecedented violence; and she now complains of a feeling of constriction in the œsophagus,

which delays the passage of the morsel of bread on which the turpentine is taken. She nearly or quite fainted on getting out to stool; the injunction to maintain the recumbent posture at all times is therefore repeated. Notwithstanding that her condition is calculated to raise the gravest apprehension, her appearance does not at all corroborate it. Looked at by artificial light, when the jaundiced complexion is not very apparent, her appearance seems nearly normal; the lips maintain their colour, the eyes are bright and attentive, and she is conversing much in her usual manner, although the voice is very weak. Yet the muscular debility is so great that at this consultation she absolutely could not get her hand to the top of her head; and the grasp of it, though the exertion causes her to complain of great pain in the muscles, and in the head too, would scarcely crush a fly. To take half a grain of solid opium.

Seventh day, 10 *a.m.*—Pulse 84, temperature normal. The pulse is, if possible, still weaker, but the heart-sounds seem to be a trifle louder. She has not wandered at all during the night, but complains again to-day of extreme nervousness. A cinder falling on the hearth, a similarly trifling noise below stairs, or the entry of her nurse to the room is sufficient to throw her into a state of distressing tremor. She now has, for the first time, dryness of the throat, but still no thirst; this symptom disappeared in a few hours, and was probably caused by the opium. The catamenia have ceased to flow, having been as usual with her. Has vomited a little mucus three times since six this morning, with much epigastric pain; the latter has gone,

but leaves increased tenderness. 3 *p.m.*—Much the same. To substitute for her mixture ten grains of ammonio-citrate of iron, half a drachm of spirit of ammonia, and two minims of tincture of digitalis to be taken every two hours. 10 *p.m.*—Having overheard her husband deploring her dangerous condition, she has been in a state of hysterical excitement. Her countenance is now anxious, or rather apprehensive, betraying her mental condition. Pulse 104, very small, but a trifle more distinct; temperature 98·6.

Eighth day.—Pulse 100, temperature 98. The pulse is improved in quality. Tongue clean and moist; no vomiting; the bowels have acted once, the stool being tarry in consistence and appearance. Her mental condition is to-day perfectly serene. She belongs to a sect which believes in instantaneous and conscious conversion, a member of which was introduced to pray with her yesterday. She is now under the impression that she was so converted during the night, and related a kind of vision to me in which the details were transacted. Her mind is clear during conversation. She took three teaspoonfuls of gruel this morning during three hours, according to direction; she then felt sick. She did not vomit.

Ninth day. — Pulse 100, temperature normal. No action of the bowels. Urine still loaded with bile and phosphates. To try the gruel again to-day cautiously. *Evening.*—I was summoned in haste, and found the patient collapsed. The surface was cold and damp, pulse imperceptible, respiration shallow; the voice, when she became a little conscious after a time, scarcely articulate. The heart sounds were barely audible with the stethoscope. The lips

are now, for the first time, colourless. Hitherto, even at the worst, they have retained their usual tint. She complained only of feeling very tired; there is no pain; the mind is clear. This condition lasted two hours; she then recovered very gradually, and without evincing any new symptom. Nothing unusual had occurred during the day to account for the collapse.

Tenth day.—Pulse 84. Is reported to have slept six hours during the night in short naps of about an hour-and-a-half. She has taken about twelve teaspoonfuls of gruel in as many hours, but feels a little sick after each, though she has not vomited; the gastric and hepatic tenderness are much worse to-day; the jaundice continues as before. The bowels have acted once, the stool being natural in appearance, and formed. There is much flatulence. The intellect is quite clear. She now sees things yellow, and vision is a little interfered with. She complains very much of feeling sore all over, and she cannot bear the least pressure on any part of the body, but there seems to be special tenderness along the course of the larger nerves. The muscles feel quite soft.

Eleventh day.—Pulse 84 and irregular, but in quality smaller and firmer. Yesterday some roseolous patches appeared on the palms of the hands, which were hot and burning; they have disappeared to-day. She has been able to eat a little to-day without getting any pain or vomiting; a poached egg with a small piece of toast, two ounces of sago pudding, and four ounces of brandy. These things have made her feel a little sick, but have caused no pain. The mind now continues quite clear, and she gets a good deal of sleep; before dozing off she becomes hysterical. Has complained

much to-day of the præcordial pain which she calls "heart-ache;" the contraction of the muscles (hands) is extremely feeble, and the exertion causes pain. The urine is still deeply coloured, but the jaundice is fading. To omit the digitalis and turpentine, but continue the iron and ammonia.

Twelfth day.—Pulse 80 and regular, but very soft and indistinct. No abdominal pain, but tenderness as before. Has taken half-a-pint of beef-tea, an egg, toast, and milk and water without suffering from pain or sickness. Has had a good night, and is evidently much better. The grasp of the hand is a little firmer.

Thirteenth to nineteenth days.—Pulse averages 80, always very soft and weak. The temperature remains normal, or within half a degree more or less. She has continued on the whole to gain strength, although she still has frequent attacks of extra debility, accompanied by "heart-ache." She has herself made these two observations: that the epigastric *tenderness* is very much increased at such times as she feels weaker; and that at all times the right side is weaker than the left. I observe nothing which approaches paralysis of the right side; it seems rather to get tired first, then to be materially less strong than the other. The jaundice has disappeared, the urine being now clear and normal (fifteenth day). On the eighteenth day, having perhaps eaten a little too freely (for the appetite is now good), she began again to vomit after food. The same day the neuralgia returned with more severity than it has done since treatment. On the nineteenth day the pulse is feebler and more irregular than it has been for many days; at the same there is a general tired feeling which amounts to aching of the limbs, always worse

on the right side. There is a slight degree of fever this morning, dry throat, furred tongue, headache, the pulse 105. There is a slight cough, and the lower half of each lung yields soft *râles;* respiration is a little hurried.

Twentieth day.—Pulse 105, compressible, indistinct and irregular. Is better in many respects. The cough and auscultatory signs, and the febrile symptoms, have disappeared. The neuralgia has been very severe, and has now also attacked the right arm. Five minims of *liquor strychniæ* are added to the iron and ammonia, which she has continued to take until now.

Twenty-first to fifty-third days.—During this period of about a month her condition has appeared to remain almost stationary. About the thirtieth day she began to sit up for about fifteen minutes in the afternoon; and now, three weeks afterwards, she can sit up just so long and no longer. The right side is still the first to get tired, and the sensations in the limbs sometimes amount to pain: this, and the general weakness, are both distinctly worse every other day. A great change has taken place in her mental condition. Whereas before this illness, whatever pain she might be suffering, she was almost always lively, cheerful, and very loquacious; now her aspect is sour and her temper always irritable, and she has become silent or even sullenly taciturn. Occasionally her spirits are very much depressed. On the *fifty-first* day, the neuralgia being excruciating, and her progress towards recovery being *nil*, Formula No. 10, in a dose containing one-thirtieth of a grain of phosphorus, to be taken twice a day, was prescribed.

Fifty-fifth day.—Pulse 120, and small. Neuralgia un-

abated. In addition she complains of a tearing and burning pain which begins in the region of the stomach, and gradually rises as far as the throat, where it interferes with respiration. It comes on occasionally. Her description of it, excepting the pain, sounds somewhat like a description of the *globus hystericus*. The spirits are very much depressed, and the eyes are restless and suspicious-looking. She dislikes her husband, and accuses him of inattention and neglect. He is in fact kind and careful of her. The urine, which has long been normal in appearance, is again very turbid and rather scanty. The bowels have acted five times without pain. The stools are normal. The conjunctivæ have assumed a distinct yellow colour, such as has not been noticeable since the jaundice passed off early in the illness. It was not present yesterday. The heart sounds are feebler than they have been for three or four weeks; the general strength is much reduced, and she again complains of the severe aching of the limbs, noted before. Omit the phosphorus.

Fifty-sixth day.—Pulse 120. Is very much as yesterday, except that there is no neuralgia. Gastric pain continues. Had some sleep last night. To confine herself to a diet of lentil meal and eggs and milk. To substitute for the iron and ammonia, chloric ether, spirit of ammonia, and ten grains of bicarbonate of potash every two hours.

Fifty-seventh day.—Same.

Fifty-eighth day.—To-day there is a most remarkable change in her condition. The jaundice and the gastric pain have disappeared; the spirits are quite cheerful; not the appetite only, but the digestion too, is very much improved;

and there is a great accession of strength. Up to the fifty-fifth day the exertion of sitting in a chair, wrapped up in blankets for a quarter of an hour, was as much as she could bear; and during the last three days she has been again quite prostrate. But to-day I find her already sitting out of bed; and she gets up, and manages to walk round the room. The pulse, too, appears to be to-day of average quality, and it can now, for the first time almost, be counted without difficulty. To resume the phosphorus, as in Formula No. 10, but made with the etherial tincture, one-fiftieth of a grain twice a day.

Fifty-ninth day.—The improvement is maintained. The pulse not quite so good as yesterday, but fair in quality.

Sixtieth day.—Same. Having taken a dose of phosphorus before, instead of after food, she got a great deal of gastric pain. It came on ten minutes after swallowing the medicine, and lasted forty minutes. With the exception of a little tenderness of the teeth she has now no neuralgia, for the first time for many days.

Sixty-second day.—Yesterday the neuralgia returned with great severity and in the usual situation; it continues to-day. The last molar tooth is much decayed, and it was long since decided to extract it as soon as the state of the heart rendered it probable the operation could be performed with safety. To-day I sanctioned the extraction, and the tooth was accordingly removed. She stood the pain well.

Sixty-ninth day.—No pain since the sixty-third day. She continues to progress in strength, and has ascended one flight of stairs. On the sixty-seventh day she had a little fresh epigastric pain, which she attributed to some cheese

she had eaten. She was, nevertheless, directed to omit the phosphorus.

Eightieth day.—The phosphorus was resumed on the seventy-third day. There has been a slight but steady increase of strength, and about this date she went out of doors for the first time. She walked about two hundred yards and returned home exhausted; she did not leave her bed for two days afterwards. From this time she continued to improve much more rapidly than heretofore, going out every day, until the

Ninety-sixth day—when she experienced a return of the neuralgia in the old places. She had had no sleep for three nights, and was in a condition of great exhaustion when she applied for relief. It should have been stated that all treatment was omitted a week since.

Ninety-ninth day.—To take one-third of a grain of zinc phosphide every two hours. In forty-eight hours the pain had disappeared, and she remained free for two or three days, when it returned slightly. Two or three doses again removed it, and a similar quantity answered the same purpose on two shortly subsequent occasions. In trying to account for these fresh attacks, she told me that she believed herself to be now three months pregnant; during the other two pregnancies she had suffered in the same way.

Two hundred and seventh day.—She is now in fair health. The digestion is as good as ever it was; sometimes, it is true, it is attended by a little pain and flatulence, but not more markedly than before this illness. The strength I believe to be not quite so good as before; still, she does not *complain* of debility, only admitting it on cross-examination. The change

in her mental character continues. She shows no sign now of melancholia, or of any condition which can be taken to indicate any sort of mental aberration. But from being one of the most talkative women I have ever met—not only possessed of a great flow of words, but of a lively imagination and some originality of thought and expression, she is now not more remarkable in these respects than most other women of her station and education.

This case presents many points which call for remark and investigation. Instead, therefore, of merely repeating Solon's observation on a like experience, which he termed 'unfortunate,' and considered only to point the 'care with which phosphorus should be administered,' I shall endeavour to indicate what these are; first of all assigning the occurrence of the case to its proper cause—not misfortune, but ignorance.

The amount of phosphorus which this patient took *per diem* was not excessive. Supposing each dose to have been taken punctually—and I have seldom met a patient so particular with regard to medicine in this respect—she took half a grain of phosphorus every twenty-four hours. This quantity I have often much exceeded in the alcoholic and etherial tinctures, without harm. I regard such a quantity as a full, but not an excessive, dose, if the metalloid be exhibited in that form which is agreed to offer the most certainty of absorption in the free, and therefore most active, state, viz., in solution with cod-liver oil; and I have given this dose in this form for long and short periods to a variety of persons, without harm.

The form in which it was given is not answerable for the result which ensued. Provided it be associated with food in

the stomach, solid phosphorus may be given with perfect safety, although I believe that a smaller dose than that under consideration would, in that form, answer every useful purpose. It is, therefore, to the state of

The stomach that the untoward result must be attributed. After what has been said of the absorption of solid phosphorus, it will be enough to remind the reader that the patient had taken almost no food for a week previous to treatment, to make it plain that the solid form is that which, of all others, should have been avoided in this case. Some part of the element was absorbed from each dose; the recovery from pain, and the great improvement in health, noted on the fifth and sixth days of treatment, evidence this. But the sudden appearance of toxic symptoms after the ingestion of a heavy meal of a kind of fish which affords a large quantity of oil points to several conclusions. As—that phosphorus is imperfectly absorbed from the empty intestine or stomach; that the greater part of each of the doses remained in the intestinal tract (probably not in the form of a pill, but smeared over the surface of it); that solid phosphorus is chiefly absorbed after its solution in the fatty parts of the food. Further, that solid phosphorus is not a form of administration to be recommended in case the patient is not eating the usual diet in something like the usual quantity; that it will be a wise precaution, whenever solid phosphorus is being given, to administer an occasional purge; lastly, that the statement that one-sixteenth of a grain of phosphorus every three hours is not an excessive dose, must be qualified by the provision that each dose shall be absorbed before the next is taken. In relation to cases of poi-

soning of another kind, it suggests the caution with which the question of feeding the patient should be considered, for some days after the poison has been swallowed, and the desirability, should the case be seen early, of administering emetics and purgatives of the most active kinds, and without delay. Here it may be observed, that under all circumstances the administration of oil of turpentine as an antidote appears to the writer to be worthy only of a second place in comparison with purges and emetics, for the following reasons:—The experiments of Köhler and Schimpf have proved, not only that turpentine acts as an antidote to phosphorus merely by the chemical combination of the two bodies, which cannot be effected but by actual contact, but also that this combination can be effected only in the stomach. It is equally, therefore, a question of time whether either of the expedients named shall be adopted; neither is of use after the absorption of the element. Under these circumstances, the mechanical remedy, as it may be called, is (as being more direct) preferable to the chemical remedy, with the operation of which it is conceivable that many accidental circumstances might interfere.

Another interesting point, not hitherto discussed, is raised by the suggestion that the eliminative process is better adapted for the *immediate* treatment of these cases than the more ingenious chemical process. An objection to the former, it may be suggested, is found in the gastric irritation which is sometimes amongst the earliest symptoms of this kind of poisoning; and the frequent discovery of perforation of the intestinal tract after death by it may give ground for apprehension that, by purging, this fatal lesion may be hastened or even determined.

The symptoms of irritation may occur either immediately or after an interval of hours or days. They occur equally after the use of an oily solution and of solid phosphorus. They may prove to be the result of circumscribed ulceration, having a fragment of phosphorus for its centre, or of general inflammation; or they may accompany *general* injection and inflammation of the mucous membrane. They do not seem, in fact, to bear any well marked relation to the form in which the drug is taken. From a consideration of very many careful reports of cases of poisoning with phosphorus, I believe that there is good ground for supposing that this body, like arsenic, is possessed of the property of causing irritation of the gastro-intestinal tract after its absorption—that is to say, that contact, in the usual sense of the word, is not essential. To establish this proposition satisfactorily would involve a consideration of the whole of that most interesting subject of phosphorus poisoning, for which the present opportunity is not fitted; I propose, therefore, to make a few general remarks only upon this special point, and to give such conclusions as I believe may be supported. There is no doubt that this condition of irritation may be caused by the contact of phosphorus with the mucous membrane. But it is probably to oxidised and not to free phosphorus that the symptoms are owing. This is confirmed by the immediate occurrence of vomiting and diarrhœa on the introduction of already altered phosphorus, as in some faulty preparations. Conversely, Ranvier's experiments (page 111) appear to prove that free phosphorus is not an irritant, at all events. Taking these as the modes in which the symptoms of irritation may be caused—immediately by contact, or more

remotely after absorption, it is obviously a question of time in a particular case, whether they are owing to local contact or not. If the symptoms arise immediately, probably the metalloid was altered before it was swallowed, and, supposing assistance to be at once sought, it would be proper on the one hand to assist the efforts which nature has set up for the purpose of ejecting the poison, while, on the other, it is not affirmed that turpentine possesses any affinity for altered phosphorus. It should, however, be given, in case any should be present still unaltered. Should the symptoms have arisen immediately after taking the poison, but assistance not have been sought for some (12) hours, then the altered metalloid will probably have been absorbed, having, first of all, effected what local injury it was capable of. As for any which may even yet remain unaltered, the course to be pursued would in part depend upon the amount first taken. If that were considerable, it would still be proper to excite the action of the bowels, but perhaps rather by large and copious enemata, which may well contain some turpentine, than by a purgative given by the mouth; for it is probable that so irritant a material as the partly altered metalloid will, by this time, have been passed far down the intestine.

But should the symptoms of irritation first occur after a few hours (6), then probably it is owing to the local deposit of the poison then in process of alteration within the stomach; and, if the symptom be of recent occurrence at the time of consultation, a purgative by the mouth, with or without an emetic, may be given. But the irritation may be set up only after a much longer interval (24-98 hours)—

in fact, after the metalloid has been absorbed. The present instance supports this view; for, although solid phosphorus had been in contact with the empty gastro-intestinal tract for six days, it was not until it underwent solution and absorption that symptoms of irritation occurred. When they did arise they were shared by the stomach, in which there could be no phosphorus at the time; while the intestinal irritation was comparatively trifling. That it was then absorbed, and not simply altered, the occurrence of evidence of fatty degeneration within thirty-six hours is proof. Under these circumstances, no treatment but that which is proper to gastritis could be serviceable; and the same remark is applicable to those cases which, apparently recovering in four or five days from the ingestion of the element, then suddenly evince the various symptoms of poisoning, and this one of gastric irritation among them. These few and cursory remarks are intended to illustrate the propositions that since turpentine is not to be regarded as an antidote to phosphorus in the proper sense of that term, it is useful as a remedy in cases of poisoning only under those circumstances in which an evacuant treatment is admissible, and that the latter would probably be found at once a simpler and more effective method. It will be perceived that the case under consideration was treated persistently with turpentine; this course was pursued in ignorance of the *rationale* of its action, just as the case itself arose in the absence of knowledge of the conditions necessary to the absorption of phosphorus. But the writer here feels it due to himself to remark, that that action, and those conditions, are now for the first time considered with regard to the

practical administration of the drug. He may further be permitted to observe that he is not aware of any method of treatment at all calculated to obviate the results of phosphorus poisoning except it be the process of transfusion. This, theoretically, seems to be the proper remedy; but, practically, the operation would most likely require to be carried to the extent of replacing a larger proportion of the patient's blood by substitution than would, with the present appliances, be either safe or practicable. Perhaps that school, which in ascertaining the specific—that is, the antidotal—action of drugs, can discover fourteen hundred and forty different symptoms to arise from the administration of belladonna, may be able to offer some simple drug strictly antidotal to phosphorus.

The re-administration of the drug on the fifty-first day, was directed with regard to the altered condition of every tissue; and specially of the nerve tissue, as shown by the symptoms detailed, which are referrable both to mind and body. It was deemed that no better course could be pursued than to supply that essential of nerve matter, which experience in cases of brain softening has shown may be supplied to it through the stomach. The recurrence of every symptom of poisoning, after the ingestion of eight thirtieths of a grain of phosphorus during four days, is not more remarkable than the striking and sudden improvement which manifested itself as soon as these had been allowed to pass off, and was maintained under the daily use of two fiftieths. After perfect recovery had taken place, the manner in which the patient tolerated, and benefited by, full doses of zinc phosphide (as well as the manner in which she

had on a previous occasion tolerated full doses of the alcoholic tincture) shows that no question of idiosyncracy with regard to the drug can be entertained in this instance.

The necessity of strictly enforcing the recumbent posture on these patients is well shown in this case, in which fainting actually occurred on the upright position being assumed. In such a case as this, in which the symptoms persisted without intermission, this necessity would, without doubt, be obvious. But in those examples in which, after a short period of immediate illness, the patient apparently recovers, with the exception of some remaining debility, unless it be understood that the process of poisoning is still going on, this precaution will very probably be omitted. Cases are on record in which patients, who, having under these circumstances, been discharged from hospital, or been allowed to get out of bed, have died from syncope. Had they lived longer further symptoms would have made their condition of danger apparent. The wisdom of administering digitalis to a person suffering from acute fatty degeneration of the heart may be doubted. The medicine was not given without much deliberation, and the event, in the opinion of those who watched the case, justified the decision.

The treatment of the gastric symptoms was that generally applicable to cases of gastritis, with the important exception of the continued exhibition of turpentine. This may, perhaps, have contributed to continue the vomiting.

The fact that this patient, in all probability, conceived at a time when she was suffering from the greatest bodily and mental exhaustion has been alluded to in considering the aphrodisiac properties of phosphorus.

There are many other points about the case which might well be examined at length. But the subject of phosphorus poisoning is both too complicated and too imperfectly explained to render profitable any attempted condensation of the facts at present known.

APPENDIX B.

A Further Note on Phosphorus Pills.

It cannot be denied that all fluid preparations of phosphorus have a nauseous taste, which, as a rule, may be calculated to obstruct a wide use of the drug in those forms. The only exception is the solution in cod-liver oil, and even in that case, in which the only taste present is that of the solvent, a similar difficulty is met with on account of it. For these reasons pills of phosphorus will always command a certain amount of favour, and they have been discussed at some length in former parts of this work.

Their manufacture is not an easy matter. To protect this element from the change which is fatal to its therapeutic powers—oxidation, and to combine it with an easily digestible menstruum at the same time, are the *desiderata*. The pills of the British Pharmacopœia, and those made according to the formula devised by Trousseau, are examples which respectively fulfil these two conditions; but the former are so indigestible that they afford little or none of the effects of phosphorus after ingestion, while the latter, although they are quite soluble, expose the element to changes

which afford compounds dangerous to life. In consideration of these facts, the phosphorus pills offered by two pharmaceutical firms have been discussed in the text at more length, and in a manner somewhat plainer than would, under other circumstances, be fitting in a work of this kind. But since these preparations command a considerable sale, such a discussion has seemed to me to be as important, in this case, as any other part of that section of the work. I do not hesitate, therefore, to add here to what has already been said in the proper place, that Messrs. Kirby and Co. have now manufactured a pill which is easily soluble in cold water; thus the objections to their pills which were raised in previous pages on the score of insolubility, are now obviated. In the absence of exact knowledge of the formula employed, clinical experience alone can show that, being soluble, they are still stable, and safe as well as efficacious.

It will, without doubt, be noticed that the case related in Appendix A was treated with pills of reduced phosphorus. They were made by Messrs. Cox and Co., and it seems due to that firm to repeat once more that the poisoning was not due to the preparation, but to the circumstances of the case. These should have prohibited the exhibition of phosphorus in this form; which is, indeed, excellent, and one which may always be employed with perfect safety if the rules for the administration of solid (reduced) phosphorus be observed.

BIBLIOGRAPHY.

Acton (W.)—"The Functional Disorders of the Reproductive Organs." In 8vo. London. 1871.

Audant—"Bulletin Générale de Thérapeutique," &c. 1869. Tom. XXXVI., p. 273.

Balfour—"The Lancet." 1846. Vol. II., p. 247.

Barchewicz (*Præside* Buechner, A. E.)—"Dissertatio de Phosphori urinæ analysi et usu medico." In 4to. Halæ. 1755.

Bates—"Dispensatory." Ed. William Salmon. Fifth edition. In 8vo. London. 1720.

Batten—"The Lancet." 1846. Vol. II., p. 343; and 1849, Vol. II., p. 315.

Bauer—"Gazette Médicale de Paris." No. 44. 1849.

Beaumetz (Dujardin)—"Bulletin Générale de Thérapeutique Médicale et de Chir." (1868.) In 8vo. Paris. 1831.

Bennett (Hughes)—"Edinburgh Monthly Journal of Medical Science." 1855.

Bibra (F. E. von) and L. Geist—"Die Krankheiten der Phosphor-Zündholzfabriken insbesondere das Leiden der Kreferknochen durch Phosphor-Dampfe." Erlangen. 1847, pp. 347.

Blondlot—"Journal de Chimie Medicale." 1802.

Boennekenius—"Commentarii de Rebus in Scientiâ Naturali et Medicinâ Gestis." 1763.

Bollinger—"Centralblatt für die medicinischen Wissenschaft." 1869, p. 246.

Borsarelli — Omodei's "Annali Universali." Vol. CLXXVI., p. 407.

Bouchardat — "Annuaire de Thérapeutique." Paris. 1841, &c.

Bouchardat—"Formulaire." Paris. 1866.

Boudet (J. P.)—"Essai sur quelques Préparations du Phosphore et de ses combinaisons." Thèse. In 4to. Paris. 1815.

Bouttatz (F.)—"Ueber den Phosphor als Arzneimittel." In 8vo. Gottingen. 1800.

Boyle (R.)—"The Aërial Noctiluca." In 4to. London. 1680.

Boyle (R.)—"Philosophical Transactions."

Bradley (S. M.)—"British Medical Journal." Vol. II. 1873.

Brera (V. L.)—"Riflessioni Medico-pratiche sull' usu interno del fosforo particolarmente nell' emiplegia." In 8vo. Pavie. 1798.

Broadbent—"The Lancet." 1871. Vol. I., p. 538.

Buechner (A. E.)—(*Respondit* Barchewitz.) — "Dissertatio sistens Spicelegium ad phosphori urinarii usum internum pertinentia." In 4to. Halæ. 1760.

Bullé—"De l'Empoisonnement par le Phosphore." Thèse. In 4to. Paris. 1864.

Burgess—"The Medical Times and Gazette." Vol. I. 1849.

Burness and Mavor—"On the Specific Action of Drugs," &c. London. 1874.

Bussy—"Journal de Pharmacie." 1856, p. 56.

Bussy et de Vrij—"Annuaire de Thérapeutique." 1855, p. 103.

Chevallier—"Annales d'Hygiène." 1856, Vol. I., p. 374; 1857, Vol. I., p. 422; 1859, Vol. II., p. 370.

Christison—"A Treatise on Poisons." In 8vo. Edinburgh. 1845.

Claubry (Gaultier de)—"Journal Générale de Médicine." XVI., p. 1.

Conradi—"Versuche mit dem Phosphor als dem kürzesten Mittel die Gesunkenen Lebenskräfte zu stärken." *Vide* Hufeland's Journal, VI. Bd. 2., p. 317.

Cotton—"Medical Times and Gazette." 1867. Vol. II., p. 7.

Crantz—"Materia Medica." Tom II., p. 172.

Crawcour—"Medical Times and Gazette." 1859, p. 222.

Delarue—"American Medical Monthly Journal." Sep., 1858.

Devergie (A.)—"Médicine Légale." Ed. 3me. Tom. III., p. 162.

Devergie (A.)—"Dictionnaire de Médicine et de Chirurgie Pratiques." In 8vo. Paris. 1829.

Distenon (C. de)—"Nonnulla de Phosphori vi et usu medico interno." In 8vo. 1830.

Druitt.—"The Surgeon's Vade Mecum." London. 1865.

Dybkowski—"Medicinisch chemische Untersuchungen aus dem Laboratorium von Hoppe-Seyler." Berlin. 1866. pp. 49, *et seq.*

Eames—"The British Medical Journal." 1871. Vol. II., p. 685.

Ebel—"Casper's Wochenschrift." 1851. Nos. 10 and 11.

Eulenberg and Landois—"Centralblatt." 1867. No. 19.

Fabre (E.)—"Sur L'Empoisonnement aïgu par le Phosphore." Thèse. Paris. 1864.

Fabre (Editeur)—"Dictionnaire des Dictionnaires de Médicine." Paris. 1841. Vol V.

Fontenelle—"Revue Médicale." Tom. III. 1829.

FORD (W. E.) — "American Journal of Insanity." 1874.

FRITZ, RANVIER, et VERLAC—"Archives Générales de Médicine." 1860.

GALTIER—"Toxicologie." Vol. I., p. 87 and p. 184.

GERRARD—"The Pharmaceutical Journal." 1873. (3) IV., p. 359.

GIULIO—"Sur les effets dangereux du phosphore pris interieurement :" Mémoires de la Société des Sciences Phys. et Mathemat. de Turin. An. XII. et XIII.

GLOVER—"The Lancet." 1853. Vol. I.

GUBLER—"Bulletin Générale de Thérapeutique Medicale," &c. 1873.

HABERSHON—"Transactions of the Royal Medico-Chirurgical Society of London." Vol. L., p. 87.

HAMMOND (W. A.)—"A Treatise on Diseases of the Nervous System."

HANDEL—"Hufeland's Journal." VII. Bd. 3, p. 110.

HANKEL (F.)—"De Phosphoro Dissert. Inaug. Medico-chemica." Berolini. 1817.

HARTMANN (P. E.)—"Dissertatio sistens spicelegium ad phosphori urinarii usum internum pertinens." 1752.

HARTMANN (J. J.)—*Respondit* Elfoenberg (E. M.); "Dissertatio de noxio phosphori urinæ in medicinâ usu." In 4to. Aboæ. 1773.

HELLOT—"Académie de Paris (Memoires de l')." 1737.

HERAPATH—"The Medical Times and Gazette." 1864. Vol. I., p. 339 and p. 554.

HILLIARD—"Transactions of the Royal Medico-Chirurgical Society." Vol. L., p. 87.

HUFELAND'S "Journal der Praktischen Heilkunde."

HUNEFELD—"Horn's Archiv. für Medicinische Erfahrungen." II., 861. 1830.

JACQUEMIN (E. C.)—"Dissertation sur l'usage Medicamenteux du phosphore." In 4to. Paris. 1804.

JENKINS—"The Medical and Surgical Reporter." 1869.

JONES (H. BENCE)—"Lectures on some of the Applications of Chemistry to Pathology and Therapeutics." London. 1867.

JURIN—"Journal Générale de Medicine." (Edit. Sedillot.) Tom. XLVII. 1813.

KAY—"The Lancet." 1869. Vol. I., p. 836.

KÖHLER—"Berliner klinische Wochenschrift." No. 1. 1870.

KNŒVENHAGEL—"Berliner klinische Wochenschrift." No. 16. 1869.

KÖHLER und SCHIMPF—"Berliner medicinische Wochenschrift." 1870. No. 50.

KÖHLER—"The British and Foreign Medico-Chirurgical Review." 1872, p. 262.

KRAMER—"Comment. Litter. Novic. Hebdom." XVIII., p. 138. 1733.

KUNKEL—"Chemische Anmerkungen," p. 302. Erfurt. 1721.

LASSAIGNE et REYNAL—"Annuaire de Thérapeutique."

LAUTH (TH.)—"Mémoire sur l'usage interne du phosphore." (*Vide* "Mémoires de la Société des Sciences Agricult. et des Arts de Strasbourg.") In 8vo. Strasbourg. 1811.

LEBERT (H.) and WYSS (O.)—"Études cliniques et experimentales sur l'Empoisonnement aïgu par le Phosphore." Archives Générales de Médicine. 1868, pp. 257, 407, 531, 685.

LECORCHÉ.—"Archives de Physiologie." 1868, p. 571, &c.

LENS (de)—"Dictionnaire des Sciences Médicales." Vol. XLI. Paris. 1829.

LEROY (ALPHONSE)—"Gazette de Santé." Paris. Aôut, 1779.

LEROY (ALPHONSE)—"Bulletin de la Société Philomatique de Paris." 1798.

LEROY (ALPHONSE)—"Mémoires de la Société Médicale d'Émulation de Paris." In 8vo. Paris. An. VI. (1798.)

LEROY (ALPHONSE)—"Expériences et Observations sur l'emploi de phosphore à l'intérieure." Magasin Encyclopédique. 1798. No. 22.

LEROY (ALPHONSE)—"Sur les Propriétés Medicinales du Phosphore." Société Médicale d'Émulation. Paris. 1802.

LÖBEL (LÖBENSTEIN von)—"On the Employment of Phosphorus in Medicine." Horn's Archiv. 1811. Tom. II.

LÖBEL (LÖBENSTEIN von)—"Mémoire sur l'usage Médicale de la solution du phosphore dans l'huile animale." "Hufeland's Journal Der Praktischen Heilkunde." 1817. (*Vide* "Bibliothéque Médicale.") Tom. LIX.

LÖBEL (LÖBENSTEIN von)—"Annales d'Occulistiques." 1855.

LOBSTEIN (J. F. D.)—"Recherches et Observations sur le Phosphore: ouvrage dans lequel on fait connaître les effets extraordinaires de ce réméde dans le traitement des differentes maladies internes." In 8vo. Paris. 1815.

LUDWIG—"Journal de Chimie Médicale." 1863, p. 581.

LUTZENBERGER—"Hufeland's Journal." XXVI., Bd. 1, p. 152.

MARGRAAF—"Chem. Schriften." Tom. I., p. 75. §§ 34 and 35.

MARTIN (STANISLAS.)—"Bulletin Générale de Thérapeutique," &c. 1858, p. 360.

MAUND—"The Australian Medical Journal." 1856.

MÉHU—"Gazette Médicale de Paris" (Société de Thérapeutique). 1869. No. 11.

MERAT et de LENS—" Dictionnaire de Materia Medica et de Thérapeutique." Tom. V., p. 280.

MERTENS—"Journal de Chimie Médicale." Mai, 1860.

MIALHE—" L'Union Médicale." 1868. No. 66.

MORGENSTERN (F. S.)—*Vide* " Schubrii Prælect. in Dispensat. Brandenb." Ed. 2da. Berol. 1753.

MUSSET (de)—" Gazette Médicale de Lyons." 1868.

ORFILA et RIGAUT—" Comptes Rendus de l'Académie des Sciences." Fevrier, 1856.

PARROT and DUSART (Acadamie des Sciences)—" Arch. Gen. de Méd." 1870. Vol. I., p. 503.

PASSERINI—" The Medical Times and Gazette." 1863, p. 287.

PENTZKI (C. W.)—"Dissert. Inaug. Chemico-Medica sistens phosphori urinæ analys. et usum medicum." Halæ-Magdeburg. 1755.

PEPPER—" American Journal of Medical Science." April, 1869.

PERSONNE—" Gazette Médicale de Paris." 1869.

PERSONNE—" Archives Générales de Médicine." 1869. Vol. I., p. 489.

PERSONNE—" L'Union Médicale." 1853, p. 72.

PESTEL (J.)—" L'Union Médicale." Aug., 1867.

POILROUX—" Journal Gen. de Méd." Tom. XXVIII., p. 12.

POLLOCK—" The Lancet." 1866.

PREVOUST—" Gazette Médicale de Paris" (Société de Thérapeutique). 1869. No. 12, p. 163.

PROCTOR (B. S.)—" Pharmaceutical Journal." (3) 1873. IV., p. 359.

REEDALE—" The Lancet." 1844. Vol. I., p. 754.

RANVIER (L.)—" Archives Générales de Medicine." 1868.

RANVIER—" Gazette Médicale de Paris." 1867.

RANVIER—"Robin's Journal de l'Anatomie," &c. 1867, p. 221.

RANVIER — "Mémoires de la Société de Biologie." 1866.

SACHS—"Dissertatio de Phosphoro." In 4to. Argentorati. 1731.

SCHAUFFENBUEL—"Dissertation sur le Phosphore." Thèse. In 4to. Strasbourg. 1813.

SOLON (MARTIN)—"Dictionnaire de Médicine et de Chirurgie Pratiques." Article "Phosphore."

SORBET—"Gazette des Hôpitaux." 1869. No. 65.

SORGE—"Der Phosphor ein grosses Heilmittel." In 8vo. Leipzig. 1862.

SOUBEIRAN (and others)—"Pharmaceutical Journal" (3). 1868.

SOUBEIRAN—"Bulletin Générale de Thérapeutique." Tome VI., p. 312.

SOUBEIRAN—"Nouveau Traité de Pharmacie." Tome II., p. 403.

STUVE (D.)—"Dissertatio Inaug. physico-chemico-medica de Phosphoro." Erfordiæ. 1816.

TARDIEU et ROUSSIN—"Étude Médico Légale sur l'Empoisonnement." Paris. 1867.

TAVIGNOT—"Chimie Médicale." Avril, 1864.

TAYLOR (A. S.)—"On Poisons."

THOROWGOOD—"The Medical Times and Gazette." 1868. Vol. I., p. 619.

THOROWGOOD—"The Practitioner." 1869, p. 14.

THOMPSON (THEOPHILUS)—"Clinical Lectures on Phthisis," p. 97.

TIETZ (C.)—"Dissertatio de Phosphori usu urinarii interno a nuperis opprobrio vindicans." In 4to. Trajecti ad-Rhenum. 1786.

Tozzetti (Targioni)—"Bibliothéque Médicale," &c. (Edit. Sedillot.) Tom. XXXIX., p. 268.

Tüfferd—"Journal de Chimie Médicale." Aôut, 1859.

Tüngel—"Clinical Report of the Hospital of Hamburgh." 1861.

Vater—(A.) and J. G. Mentz—"De Phosphori loco medicinæ assumpti virtute medicâ, aliquot casibus singularibus confirmata." Vitteberg. 1751. (*Vide* "Disputat. ad Morborum," &c. Albrecht Haller. Vol. VII. In 4to. Lausanne. 1760.)

Vigier—"Annales de Physique et de Chimie." Aôut, 1867.

Vigier et Curie—"Bulletin Générale de Thérapeutiques." 1868.

Voit und Bauer—"Neues Repert. für Pharm." XX. 340.

Voit und Bauer—"Zeitschrift für Biologie." VII. 63.

Walser—"Wurtemburg Correspondenz Blatt." XXXVIII. 1868.

Watt's—"Chemical Dictionary."

Weickard (M.A.)—"Vermischte medicinische Schrifften." 1780.

Weickard—"Recueil Médicale de Littérature," &c. Vol. III., p. 24.

Weguelin (Hieronym)—"Animadversiones Chymicomedicæ de Phosphoro." In 8vo. Gottingæ. 1813.

Weigel (C. E.)—"Dissertatio de phosphori urinæ usu medico." In 4to. Jena. 1798.

Wilson (Erasmus)—"Journal of Cutaneous Medicine." 1868.

Winslow (Forbes)—"Journal of Psychological Medicine." 1849.

Wolff (A. F., junior)—"Analecta quædam Medicin. de phosphori virtute medicâ observat." In 12mo. Gottingæ. 1790.

WORBE—"Memoire sur l'Empoisonnement par le phosphore." (*Vide* "Memoires de la Société Médicale d'Émulation de Paris.") 1826.

"Annuaires de Thérapeutique." 1841, p. 48; 1846, p. 75; 1847, p. 84; 1854, p. 42.

"British and Foreign Medico-Chirurgical Review." 1844, p. 536; 1850, p. 554; 1857, p. 506.

"British Medical Journal." 1867, Vol. II., p. 500; 1869, Vol. II., p. 454; 1870, Vol. I., pp. 18 and 246.

"London and Edinburgh Monthly Journal of Medical Science." In 8vo., 1841, &c. (1860.)

"Journal de Chimie Médicale." 1857, p. 84.

"The Lancet." 1869, p. 836; 1857, p. 600; 1871, p. 189; 1845, p. 374; 1844, p. 754.

"Archives Générales de Médicine." 1857, p. 308.

"Retrospect of Practical Medicine and Surgery." In 12mo. London. 1840, &c.

"Bulletin et Journal de Pharmacie et de Chimie." In 8vo. Paris. 1815-40.

"The British Homœopathic Review." Oct., 1873, and Jan., 1874.

"The Medical Times and Gazette." 1863. Vol. II., p. 375.

"Frank's Magazin."

"Zeitschrift der K. K. Gesellschaft der Aerzte in Wien." Dec., 1853.

"Rankin's Abstract." 1848.

"Journal Générale de Médicine" (Ed. Sedillot). Tom. XLVII., p. 48.

PRINTED BY JUDD AND CO., PHŒNIX WORKS, ST. ANDREW'S HILL, DOCTORS' COMMONS.