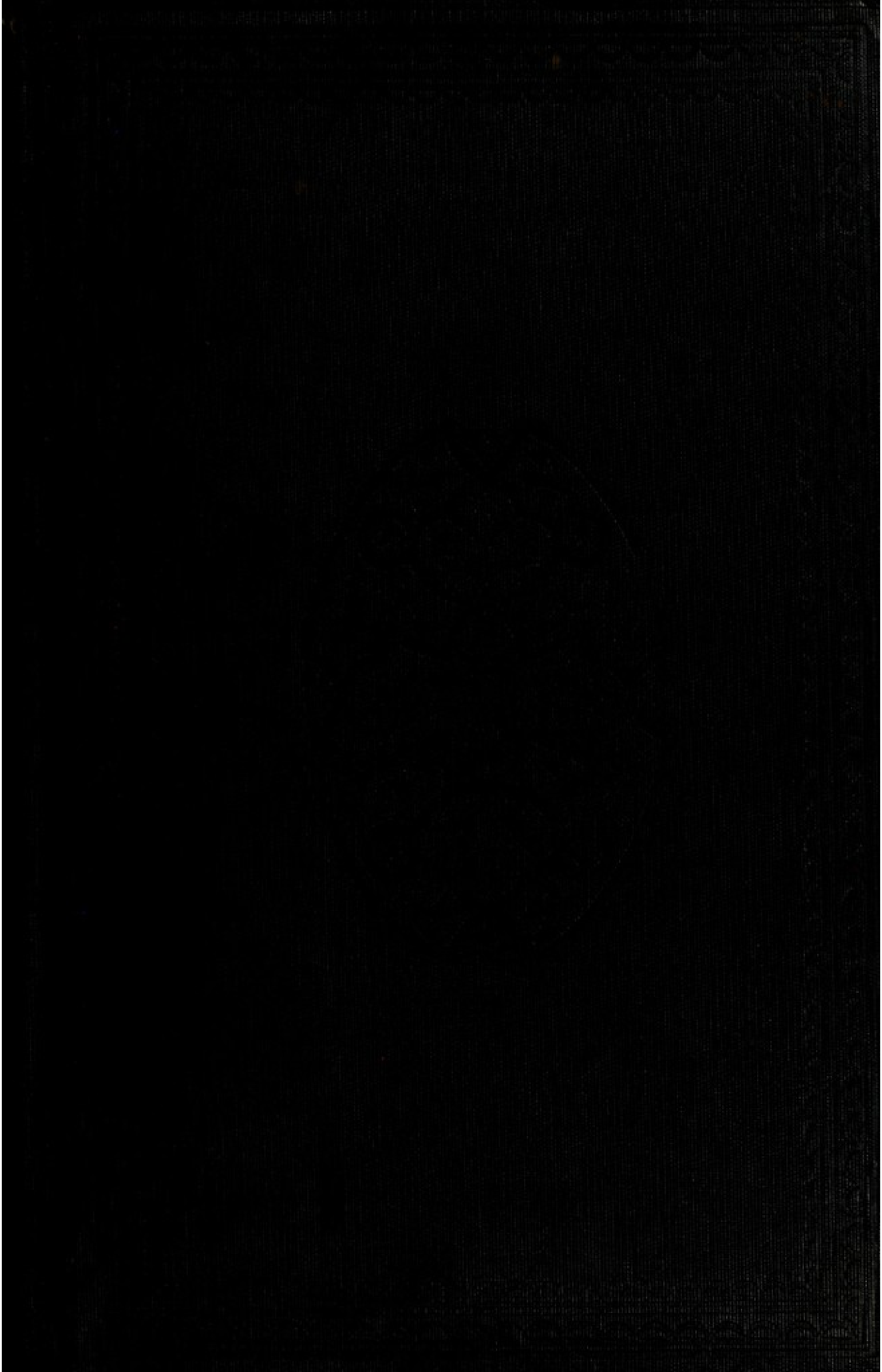
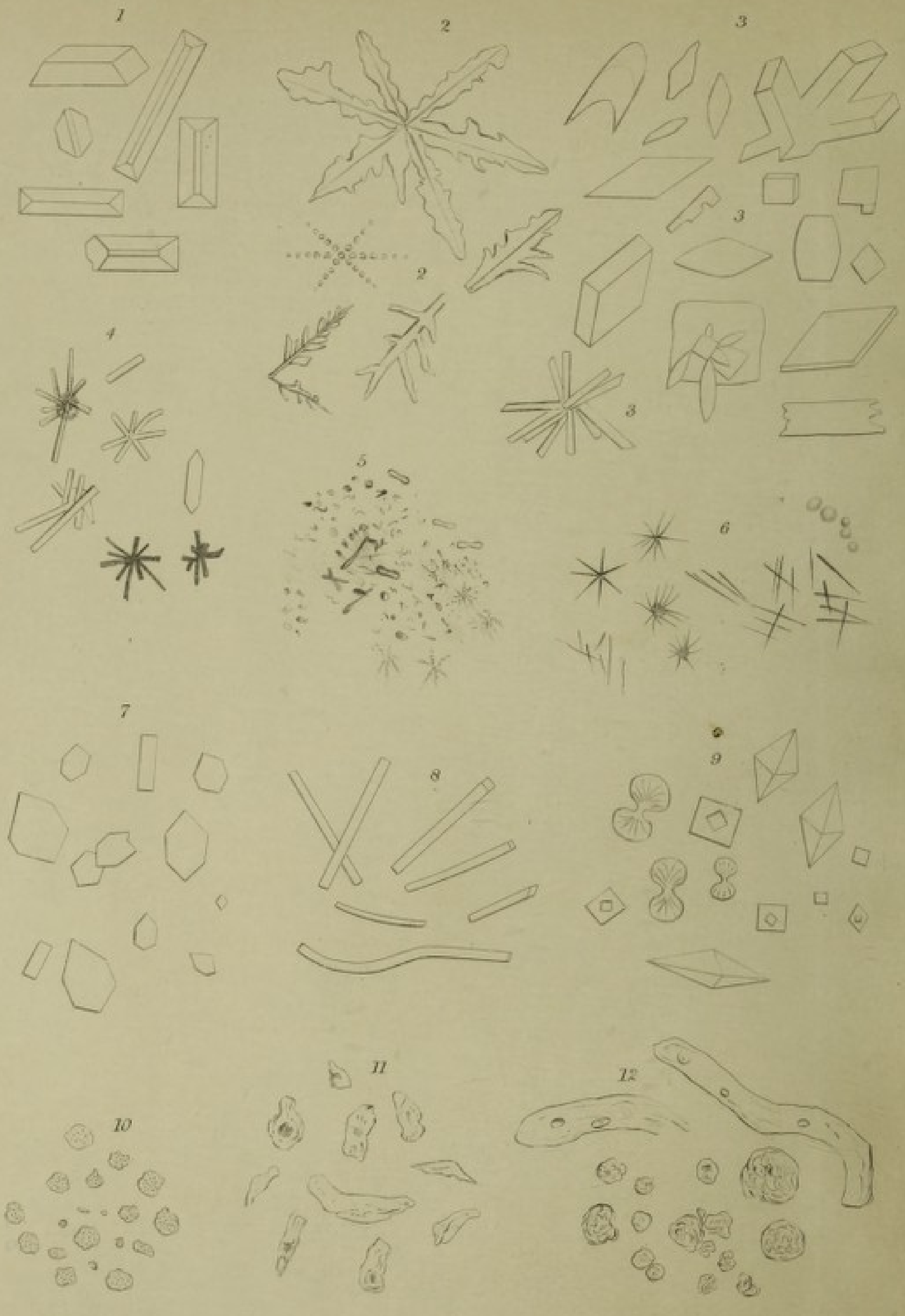
On the analysis of the blood and urine, in health and disease : and on the treatment of urinary diseases / by G. Owen Rees.





H. Adlard, sc.

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ON THE

ANALYSIS

OF THE

BLOOD AND URINE,

IN

HEALTH AND DISEASE;

AND ON

THE TREATMENT OF URINARY DISEASES.

BY

G. OWEN REES, M.D. F.R.S. F.G.S. &c.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS,
PRINCIPAL MEDICAL OFFICER TO THE PENTONVILLE PRISON,
ASSISTANT PHYSICIAN TO GUY'S HOSPITAL,
AND PHYSICIAN TO THE CALEDONIAN ASYLUM.

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TO

RICHARD BRIGHT, M.D., F.R.S.,

&c. &c.

PHYSICIAN EXTRAORDINARY TO THE QUEEN,

CONSULTING PHYSICIAN TO GUY'S HOSPITAL, PRESIDENT OF
THE HUNTERIAN SOCIETY, ETC. ETC.

My dear Sir,

It would have been a pleasure to me to dedicate this work to you, if only to mark my admiration for those discoveries which make your name as a philosopher familiar to the practitioners of medicine throughout the civilised world. I have, however, an additional gratification in availing myself of this opportunity of expressing my gratitude for the kind encouragement received from you when, as a mere boy, I first entered on the study of pathological chemistry. The confidence you have reposed in my results and observations, at more advanced periods of my professional career, I shall ever regard as a flattering assurance that my time has not been ill spent; and though well aware that I have effected very little by my labours, still, had it not been for your friendly aid and council, that little must inevitably have been far less than it is.

That your kind word and noble example have not produced a better result is felt with regret, by

Yours, gratefully and attached,

G. OWEN REES.

59. Guildford Street, Russell Square,
October 1. 1845.

PREFACE TO THE FIRST EDITION.

The increased desire for a more intimate acquaintance with animal chemistry, which has lately been evinced by the medical profession, induces me to present this little work to public notice.

The more philosophical methods of investigation at present adopted to ascertain the diseased conditions of the living system have forced a new branch of inquiry upon the attention of the student; while the further advanced labourers in the medical profession feel the necessity of informing themselves on a subject which becomes important (to them at least) were it only as a shield against the exposure which might occur from the more perfect knowledge of a rising generation.

It has been my object in this work to exhibit a concise view of those plans of analysis which may be performed simply, usefully, and at a small expense; requiring for their execution care and patience rather than skill and perfection in manipulation.

I have avoided as much as was possible those formal methods of description which have frequently disheartened the beginner from even reading a process, much more putting it to practice. If any such feeling be entertained by my readers, let me assure them that it is the reading, and reading only, that perplexes them; and that when once they have commenced the practice of the process, all confusion will pass away, and the facts become clearly and firmly impressed upon their minds.

If the study of this volume should in any way tend to increase the number of those who occupy their leisure hours with the study of animal analysis, as applied to disease, I shall be more than repaid for my slight labours; for I shall feel that I have assisted in directing attention to a subject which, in all probability, is no less rich in discovery than it is neglected and uninvestigated by the great body of the medical profession.

PREFACE TO THE SECOND EDITION.

This second edition is constructed on the plan of the first, with the addition of an essay on the treatment of urinary diseases. Considerable alterations have been rendered necessary by the advances made in animal chemistry since the first edition was published; but I have avoided, as much as possible, entering into scientific details as foreign to the purpose of the work, which must not be regarded as an elaborated treatise on the blood and urine in all their relations, but simply as a work on proximate animal analysis. Substances of rare occurrence in the blood and urine in disease, or which exist as mere traces, and are not well examined or ascertained in the healthy fluids, are here only slightly noticed; and, for information of a more extended kind, the reader is referred to the works of Berzelius, Lecanu, Denis, Becquerel, and Simon. From the latter author I have made extracts in the Appendix relating to the analysis of the blood.

My object has been throughout simply to supply to the medical practitioner the means of analysing blood and urine, and thus to assist him to comprehend and appreciate with more defined ideas the experiments of those animal chemists whose results may have reference to the important subject of humoral pathology.

I have added a microscopical description, and drawings, to that part of the work treating of urinary deposits.

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* As described by Dr. Bird.

INTRODUCTION.

BEFORE I enter on the description of processes, I feel it necessary to offer a few observations on the cautions to be observed in the more important steps of manipulation. It may also be proper to describe the uses of one or two contrivances to which analytical chemistry is pre-eminently indebted, and without which it is difficult to conceive how any degree of perfection could have been attained in the prosecution of analysis. I shall proceed at once, therefore, to a description of the following operations, viz. Evaporation, Filtration, and Incineration; concluding with a few observations on the precautions which are necessary in weighing fluids and solids.

Evaporation. This may be performed at different degrees of heat; and the greatest care should be taken to choose a suitable temperature. Thus, if urine be experimented upon, it is impossible to use a continued heat of 212° Fahrenheit, without risking the loss of a portion, at least, of the urea, which is one of its most important constituents. When the serum of blood is experimented upon, a heat of 212°

is absolutely necessary, for the purpose of rendering the albumen entirely insoluble in boiling water; indeed, it has been stated, that a heat of 225° is necessary for that purpose; but this is not the fact, as will be found on experiment, particularly if the serum be thoroughly dried, and then treated, while warm, with water at 212°.

Filtration.—Considerable care is requisite in performing this operation; fine white bibulous paper should be used, and the filter washed with distilled water before it is applied to the purposes of analysis. After the fluid we are operating upon may have passed through the filter, it often becomes necessary to perform many ablutions of the filter, in order to wash out from the paper all the fluid for analysis: these washings are, of course, to be added to the first-filtered liquor, and evaporated with it in continuing the examination. When pouring from any vessel into a filter, the lip of such vessel should be kept perfectly dry, otherwise the fluid may, after passing the lip, run backwards to the bottom of the vessel, and thus be lost. Another excellent method of avoiding this evil, consists in applying the side of a glass rod, moistened with distilled water, to the lip of the vessel, and pointing it upon the filter. These may seem trifling circumstances to dilate upon, but persons who are accustomed to manipulation are well aware of the value of such remarks to the uninitiated.

Incineration.—Constant attention is necessary in this process, and much tact requisite in placing the crucible in proper positions in order to expedite the dissipation of the carbonaceous matter. The crucible should be somewhat shallow, and of the form of a dish or flat capsule. It should be placed on the top of the flame of the circular-wicked spirit lamp, and with a slight inclination towards one side: this position favours the constant fresh access of air, and assists in dissipating the carbon. The crucible should, of course, be opened immediately that the animal matter is charred; but a loose cover ought to be placed upon it before the salts begin to fuse (as sometimes happens), in order to prevent the loss which may take place by decrepitation.

The crucible is to be managed by a small pair of forceps with scissor handles, similar to the dressing-forceps used by surgeons.

Weighing. — There is, perhaps, no operation in chemistry which demands so much attention as that of weighing: for the substances to be weighed are frequently of a destructive nature, and the balance is more easily injured than any other of the requisites of a laboratory. In weighing animal matters, both solid and fluid, there is continual danger of moistening the balance-dishes, and thus interfering with the accuracy of the result.

To the student in animal chemistry, I would advise the use of a balance, capable of turning to one fiftieth of a grain. This should be mounted in a balance lantern, and kept in a dry room. Accuracy is greatly ensured by the habit of weighing by counterpoise, which is by balancing the substance to be weighed, with dry powdered sand (or any other convenient powder); and then, on removing this substance, whose weight is to be ascertained and counterpoising the sand in the balance with the weights, the most accurate result is obtained; for the number of grains, or parts of a grain required, must be identical in weight with the substance removed, before they can produce the same effect, of precisely balancing the sand. By this method all that is wanted in the balance is a suitable degree of delicacy. The necessity for an equality of length in the scale-arms (which is very difficult to procure) is thus obviated, though it is absolutely necessary to the perfect determination of weight by the common method.

The weight of fluids for analysis may be taken by two methods, viz. by balancing them in a bottle the weight of which has been previously ascertained; or by weighing the vessel and fluid together, and then noting the diminution of weight which occurs, when the fluid for analysis is poured out. The former method possesses the advantage of yielding a fixed quantity; for we can pour into the weighed vessel exactly the weight of fluid we wish: but it is necessary always to wash out the weighing vessel with distilled water* after the weighed fluid is poured out, in order to remove the adherent portions in the bottle, which, of course, were taken into account when the weight was ascertained. By the

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* These washings must, of course, be added to the fluid for analysis, and evaporated with it in pursuing the analysis.

second method we avoid the necessity of washing out the weighing bottle; for the weight we note is just that of the fluid poured out: but then we lose the means of procuring any fixed quantity of fluid which we may desire. This, however, is no great disadvantage, since we can always calculate the proportional quantities in any number of parts we may choose. The former method may sometimes be adopted, the weighing being performed in a dish which may serve also for the evaporation, thus doing away with the necessity of removing the fluid from one vessel to another. The weight of solid animal matters should be taken in an accurately balanced watch-glass, placed upon a curl of paper, which prevents its slipping from the operator; an inconvenience occasionally very distressing during manipulation, but which may be easily obviated by this simple expedient. Before quitting this subject, I must urge upon the reader the propriety of noting with the greatest care the result of every weighing performed during an analysis.

I shall now proceed to describe the contrivances adopted for procuring that degree of heat which may be requisite for the purposes we have in view, and shall notice some chemical implements eminently useful in the prosecution of animal analysis.

Water-bath. — This may be divided into two kinds, viz. the fresh and salt water-bath. The former is formed by floating a dish in water, which is kept at a boiling temperature by means of a lamp or any other steady source of heat. Fluids placed in this floating dish are kept at a temperature approaching that of boiling water; that is, somewhat below 212° Fahrenheit. The salt water-bath is formed in the same manner, excepting that the evaporating dish is floated in a saturated solution of common salt instead of fresh spring water, by which means we can procure a heat of 225° Fahrenheit.

Steam-bath. — This may be divided also into two kinds, viz. the open and closed. The former is eminently useful in the examination of fluids suspected to contain easily destructible animal principles, and is the one which should always be used, if admissible, in preference to any other sort of bath. It is formed by placing a dish over the steam issuing from a vessel in which water is kept at a boiling heat; care being taken that the evaporating dish do not touch the vessel of water in any part, but be supported over it by means of a small wooden rack. In this way we obtain a constant heat, which is far below that of boiling water. The closed steam-bath differs from the open, in being formed by a dish which perfectly closes the vessel from which the steam is issuing. It affords a very variable heat, which frequently approaches 212° Fahrenheit. The fresh water-bath is generally to be preferred.*

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* There is an excellent arrangement for the water or steam bath, made of brown earthenware, sold at the chemical apparatus warehouses.

Circular-wicked Spirit Lamp. — This is a somewhat dangerous piece of apparatus in the hands of the beginner. Many of the lamps sold for the purpose of burning spirit, are so constructed as to allow of the reservoir becoming heated and the spirit consequently boiling within so short a time after the wick has been lighted, that we cannot well obtain a sufficiently continued heat for our purposes. From the experience I have had in the use of this instrument, I am inclined, on all occasions when the application of a long continued heat is necessary, to prefer an open fire to a lamp, even when of the best construction.

When an open fire is used our platinum crucible must be placed within a larger one of clay. In this manner we can very easily effect incineration and dissipate carbon from burned animal matters in the process of obtaining fixed salts, and our platinum vessel is kept perfectly clean, being protected from the fuel by the large clay crucible.

In choosing a spirit lamp the great object should be to select that form which shows the least possible connection between the reservoir and the circular wick, and the connection existing should be formed as much as possible of glass or other badly conducting material.

I have now to make a few remarks on the necessity of employing pure re-agents. Unless this be carefully attended to, we shall frequently find ourselves in most unpleasant difficulties. I would recommend that no one should use any of his solutions until he has tested their purity for himself. We frequently find that the distilled water of the shops becomes cloudy on the addition of a few drops of the solution of nitrate of silver (indicating the presence of a chloride); this ought not to be the case, and such water should be discarded as unfit for use.

The ordinary hydrochloric acid of the shops always contains iron in solution, and is frequently admixed with sulphuric acid, as is also the case with the common nitric acid.

These acids should never be used as re-agents in their officinal condition, but always procured (in their perfectly colourless form) from some well-known operative chemist.

The sulphuric acid of the shops contains sulphate of lead in solution, which is easily detected by diluting the acid, when that substance becomes precipitated. Arsenic has likewise been detected in some specimens of this acid, which may be accounted for, by the fact, that a vast quantity of sulphuric acid is made with sulphur procured from arsenical pyrites. In several specimens of sulphuric acid lately examined, I detected arsenic in amount equal to from 20 to 30 grains in the pint. In some instances I detected the presence of selenium in small quantity.

The officinal liquor potassæ should never be used as a re-agent, for it frequently contains lime.

Were I to proceed to show the reasons for avoiding the purchase of officinally prepared solutions, I should far exceed the intentions of this work; I will, therefore, at once conclude, by earnestly intreating the beginner to exercise extreme caution in the selection of reagents.

My reason for especially noticing the impurities of distilled water, the mineral acids, and the liquor potassæ, is, that these are the most likely to be purchased as officinally prepared.

I subjoin a list of chemicals, which will be found sufficient for most purposes, in prosecuting the proximate analysis of animal bodies.

Pure sulphuric acid,
hydrochloric acid,
nitric acid,
acetic acid,
} Strong.

These acids should also be kept in a dilute form. One part of strong acid to nine of water is a convenient mixture.

Solution of caustic potassa
— ammonia.
— carbonate of potassa.
— oxalate of ammonia.
— bichloride of mercury.
— acetate of lead.
— di-acetate of lead.
— alum.
— ferro-cyanuret of potassa.
— tartaric acid.
— nitrate of silver.
— chloride of barium.
Tincture of galls.

Sulphuret of iron.*
Litmus paper, both blue and reddened.†
Turmeric paper.
Alcohol — specific gravity ·833.
Rectified ether.

The following instruments of analysis, will now render our laboratory pretty complete: —

A platinum crucible, capable of holding about half a fluid ounce.
Platinum foil.
— wire.
Test tubes and stand.
Watch-glasses.
A blow pipe.
Glass rods.
A spirit lamp.
Test glasses.
Forceps.

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* For procuring a stream of sulphuretted hydrogen gas: — This is done by placing the powdered sulphuret in a large phial, and adding sulphuric acid, diluted with three times its bulk of water. The gas which escapes can be conducted to the bottom of the fluid which we wish to act upon, by means of a glass tube, bent twice at right angles; one leg of which must be inserted air-tight into the cork of the phial; and the other (which must be sufficiently long) made to pass to the bottom of the vessel holding the liquid to be subjected to the action of the gas.

† Reddened litmus paper, if well prepared, is an extremely delicate test of alkali, far more so than turmeric paper, which, however, should also be used, as the effect produced upon it by animal solutions (if compared with their effect on reddened litmus) affords a rough, but frequently a useful, test of the degree of alkalinity.

A pair of scissors.

Bone spatulas.

Steel spatulas.

Glass funnels.

Wedgewood dishes of various sizes to contain from a quarter to half an ounce.

German China-ware dishes and capsules.

Lamp rack and dish stands.

ON THE

ANALYSIS

OF THE

BLOOD AND URINE.

ON THE BLOOD.

As it is impossible for the student thoroughly to understand the principles on which the methods for analysing the blood are founded, or to possess a clear and well defined view of the application of chemistry to the advancement of humoral pathology, unless he become acquainted with the minute physical structure of the blood, I shall, in the first place, proceed to a description of that fluid as it circulates in the vessels, and point out, by reference to its minute anatomy as shown under the microscope, what those parts of its history are requiring the assistance of chemistry for their further development. The student will thus be enabled more completely to understand the nature of the changes occurring during coagulation, and more fully to appreciate the extent to which physical actions occurring in the blood, after removal from the body, and over which we have no control, are capable of affecting the positive value of our results.

He will also be able to appreciate the exact point at which chemical methods of analysis should commence, and beyond which physical division can no longer be practised; and, I trust, will thus be impressed with the absolute necessity of possessing an accurate knowledge of the physical structure of the blood before he can hope to enter upon its chemistry with advantage.

The blood as it circulates through the vascular system, may be described as made up of a fluid holding in suspension a number of minute organised bodies of a red colour, which so thickly pervade the suspending fluid as to give it to the unassisted eye the appearance of a homogeneous red solution. There are, existing in the blood, besides these red corpuscles, a smaller number of colourless bodies of a different organisation, and known by the name of fibrinous corpuscles. In addition to these, we also occasionally remark granules of various sizes thinly scattered through the blood, and which seem to appear in greater numbers a short time after a meal, and at a period when the flow of chyle into the blood has taken place freely. When the blood coagulates, the fluid in which the corpuscles float, and which has been called liquor sanguinis, becomes disintegrated, a solid matter depositing from it, known under the name of fibrin, while its fluid portion, containing the albuminous and saline matters in solution, forms serum. The fibrin as it separates becomes mixed up with the red corpuscles, and the two together make up the mass known as crassamentum, which floats in serum, as is seen in coagulated blood. The white bodies which I have described as floating with the red corpuscles in the liquor sanguinis, are entangled with these latter in the fibrin during coagulation: thus the serum is nothing else than a clear solution of animal matters and salts. When blood is about to coagulate, it is always observed, that before the deposition of fibrin from the liquor sanguinis commences, the corpuscles floating in the blood begin to subside, and leave a thin stratum of liquor sanguinis on the surface. If this be removed by carefully skimming the blood, we obtain pure liquor sanguinis of a pale straw colour, which, when set aside, will separate into fibrin and serum. It was by thus skimming inflamed blood, that Hewson first succeeded in obtaining a fluid capable of coagulation; but he did not carry out this observation on healthy blood, and it was left for Dr. Babington to prove, that healthy blood as it circulates is made up of a homogeneous fluid, containing floating corpuscles, and to this fluid, which he proved to be a solution of fibrin in serum, Dr. Babington gave the name of liquor sanguinis.*

When examining the blood, then, under the microscope, we must bear in mind, that, when freshly drawn from a puncture, it is composed of corpuscles floating in a homogeneous fluid, but

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* Med. Chirurg. Trans.

that if coagulation be allowed to take place, we have the corpuscles floating in serum, or, in other words, in liquor sanguinis deprived of its fibrin, a condition which will materially interfere with the natural appearance of the corpuscles, for reasons which will be at once apparent when the physical properties of those bodies have been described.

The anatomy of the red corpuscles has formed a subject for conjecture and experiment among physiologists for a number of years, and a great diversity of opinion has existed as to their true nature. Some have believed them solid bodies, while others, on the contrary, have believed them of more complex vesicular structure. We are now, however, enabled to speak positively as to their nature, their vesicular structure having been put beyond doubt by late experiments, which have shown that endosmodic currents can be induced through their membrane, and that the corpuscles, as seen under the microscope, can either be emptied or filled accordingly as we mix with the blood solutions of a specific gravity higher or lower than that of the liquor sanguinis, in which the corpuscles floated in the natural state.* Now it has not only been proved that the red corpuscle possesses a membrane or envelope, but also that this envelope incloses a red fluid, and this being the case, it follows that the specific gravity of the inclosed red fluid must be identical with that of

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* Vide Guy's Hospital Reports, No. xiii. Rees and Lane on Anatomy, &c.

the liquor sanguinis, in which the corpuscle floats, such being the inevitable result of stasis when a permeable membrane separates fluids. With this knowledge let us now reflect on the change which will take place when the blood coagulates. The liquor sanguinis, in which the red corpuscles float, deposits its fibrin, and becomes thus converted into serum. Having lost part of its solid contents, it now possesses a less specific gravity, and the fluid within the corpuscles, since it retains its normal specific gravity, is heavier than the serum in which the corpuscle floats, and consequently an interchange of fluid through the membrane will take place. In this way we find the corpuscle becomes filled by serum, to an extent which frequently renders its thickness half as great again as it is observed in blood before coagulation, for the reason that in accordance with the endosmodic laws, the lighter fluid without has entered the corpuscle in larger proportion than its heavier contained fluid could pass away. In this manner a portion of the serum, which in the natural state assisted in forming the liquid in which the corpuscles floated, has entered those bodies; and in our analysis of blood after coagulation, we possess no means of separating this serum from the corpuscle; it is, in fact, always retained permanently.

After the description I have now given of the physical structure and qualities of the red corpuscle, I trust the student will be prepared to consider the difficulties we have to encounter in accomplishing an analysis of coagulated blood, such as shall be perfect in all its parts.

I have stated that there are colourless bodies existing in the blood, which are to be seen under the microscope, and are known by the name of fibrinous corpuscles. It may be well to mention that these do not possess the vesicular character so strikingly shown by the red corpuscles, but that they are soft solids, the physical structure of which in no way interferes with the perfection of analysis, whereas we have seen that the endosmodic action set up during coagulation by the red corpuscles becomes a serious obstacle to our obtaining an absolutely correct analysis of the entire blood. I shall now proceed to describe the method employed for ascertaining the proportion of fibrin, red corpuscles, and serum contained in the blood.

My reason for commencing thus is, that I may gradually introduce the student from the simpler to the more intricate processes. I have, therefore, preferred to introduce this simple quantitative examination as a commencement to the more complicated qualitative analysis which follows, and which, in strict propriety, should have preceded. It will be found, however, that this slight sacrifice of order is of the greatest utility to the student. Before noticing the qualitative examination of the various matters entering into the composition of blood, our object will be to describe, in as concise a manner as possible, the most approved processes for making the quantitative analysis of the serum, both in health and disease.

ON THE ANALYSIS OF THE BLOOD IN HEALTH.

Determination of the Proportion of Water, solid Matters of Serum, Fibrin, and Red Corpuscles.[*]

The blood intended for analysis is to be collected in three vessels, one of these being a platinum

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[*] Several methods of effecting the separation of these three constituents of the blood have been proposed by chemists, and there are objections to all, in so far as absolute correctness is concerned. The process I have adopted I believe to be the best in medical inquiries, as it allows of the estimation of the corpuscles with greater precision than most others. The method recently proposed by Simon for the analysis of the entire blood possesses one great disadvantage: for the nuclei and capsules of the corpuscles are by him estimated as albumen, a defect which must render his results unsatisfactory to the pathologist, since a correct appreciation of the proportion of the corpuscles in their integral state is absolutely necessary to a clear understanding of many of the charges occurring in blood during the progress of disease. Simon has shown, however, that no very great discrepancies are to be observed between his results and those of other chemists. The method I now describe, which nearly approaches to that lately employed by Andral and Gavarret in their researches, is by far the most perfect with which I am acquainted. Many objections have been raised against it, of which the following only is deserving of notice. In the estimation of the proportion of serum and corpuscles, all the water of the blood is presumed to exist as a constituent of serum, and the corpuscles are assumed to be solids, whose moisture is entirely owing to the fluid in which they float, whereas in reality they are organised bodies containing, as a constituent, a fluid of a red colour, which is quite distinct from serum in its chemical relations. If we more minutely consider this plan of analysis in relation to the structure of the corpuscles, we shall observe, however, that it is capable of giving results far nearer to the truth than might at first be imagined. It must be remembered that there is a constant endosmodic interchange of position taking

capsule, capable of containing half a fluid ounce; the other two must be glass vessels, each of the capacity of six fluid ounces, and one of which should be a bottle or flask fitted with a glass stopper. The weights of the capsule and glasses in a perfectly dry state must be correctly ascertained, and, if possible, engraved upon them.

From two to three fluid drams of blood are to be received into the platinum capsule, and from four to six into each of the glass vessels. Ten or twelve pieces of lead, each about a quarter the size of a sixpenny piece, and the weight of which has been previously ascertained, are to be *immediately* put into the glass vessel provided with a stopper, and then shaken up with the blood, agitation being continued for ten or twelve minutes. By this action, the fibrin is made to coagulate around the lead. The bottle, with its contents, is now weighed, in order to ascertain the weight of blood operated on, which is at once done by subtracting the weight of the lead and bottle from the whole weight shown by the balance. The bottle is now to be emptied into a saucer, and the fibrin collected, washed with distilled water, dried, and weighed. This gives the weight of fibrin contained in the portion of blood operated on.

place between the contents of the corpuscle and the liquor sanguinis, in which it floats, varying with the entrance and exit of water from the circulation; and that consequently the contents of the corpuscle will always be in part composed of those constituents of the blood which form the liquor sanguinis, and of which serum constitutes the greater part.

The blood received in the other glass vessel is to be set aside to coagulate, in order to afford a clear serum for analysis. The blood received into the platinum capsule is now to be weighed in that vessel, the weight of the capsule being subtracted from the whole weight shown by the balance, giving the true weight of blood. The capsule is next to be removed to a water bath, and the blood dried until it ceases to lose weight by further application of heat.

The capsule containing the dry matter is now to be wiped dry and weighed, and the weight obtained subtracted from that of the capsule and blood taken at the commencement of the analysis. This gives us the weight of water contained in the portion of blood operated on.* By subtracting the weight of the capsule from the weight shown by the balance, we also obtain the proportion of dry matter in the blood.

We have now ascertained the proportion of the following ingredients of the blood; viz.

Water,
Solid matters, and
Fibrin.

Now these results having been obtained on portions of blood differing in weight, our next step consists

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* In thus using a small quantity of blood expressly to ascertain the proportion of water, we insure exactness; for though we operate on a small weight, we do not move it from the capsule, or subject it to loss before weighing, and its small bulk insures perfect drying over the water bath.

in reducing them, in order to ascertain the relative proportions of the ingredients contained in 1000 parts of blood. Having done this by the rule of proportion, we next subtract the weight of the fibrin (as adjusted to 1000 parts) from that of the solid matters of blood, of which of course it formed a part. We thus ascertain the weights of

Water,
Fibrin, and
Blood corpuscles and solid matter of serum mixed;

the two latter ingredients making up the remaining solid matters of blood.

The weight of the blood corpuscles and serum mixed together being known, it is obvious that if we ascertain the weight of either one of them, we shall be able to determine the weight of the other, by subtraction from the mixed weights. It is thus that we obtain the weight of the corpuscles by determining that of the solids of serum, which is done as follows. One hundred grains of serum, taken from the glass vessel which was set aside for coagulation of the contained blood are to be evaporated in a dish over a water bath until weight is no longer lost by further application of heat. The proportion of solid matter and water in the serum is thus ascertained.* Now we have already noted a weight of water in our analysis, as contained in

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* The process in detail is the same as that for determining the proportion of water and solid matter in the blood, and may be performed in the balanced platinum capsule.

1000 parts of blood, and the solid matters of serum contained in the dry matters of blood will bear a proportion to that water. This proportion we have now determined by our experiment on 100 parts of serum. We now, therefore, merely have to make the calculation for the proportion of solid matters of serum indicated by the water in our analysis for 1000 parts of blood; and thus having ascertained the weight, we can also obtain that of the corpuscles by subtracting it from the known weight of the two together.*

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* The method of ascertaining the proportions of red particles, fibrin, and solids of serum here detailed, is only applicable when we can obtain blood before coagulation. When this cannot be managed it is best to use the method of Berzelius, which, though generally found to produce an over estimate of fibrin, still does not do so to any very material extent. The steps of the process are as follows:—

The weight of the whole quantity of blood operated on being noted, the proportion of water and solid matter in the serum is first ascertained by evaporating a known weight of that fluid to dryness in a salt-water bath; the loss of weight indicating the proportion of water, and the residuum the proportion of solid matter existing in the serum. These proportions being observed, the next step consists in dividing the crassamentum into two portions of equal weight; one of which is used to ascertain the proportion of fibrin, and the other the proportion of red particles, as follows:—

Treatment of first Portion.—The mass is to be cut into pieces as minutely as is possible, without losing any appreciable quantity of matter, care being taken that its precise weight be ascertained before comminution. The mass is now to be placed on a filter, with a stream of distilled or rain water so adapted that a constant supply be afforded to wash away the red particles and serum contained in the interstices of the clots. This process occupies some time, and may occasionally be assisted by

I shall next proceed to describe the manner of analysing the serum, by separating its various constituents, which is all that is now necessary to a perfect examination of the blood.

On the Analysis of healthy Serum. — Serum, the fluid part of the blood, which separates from the fibrin and red corpuscles on coagulation, contains the following constituents; viz.

- Water.
- Albumen.
- Extractive matter, soluble in water and alcohol.

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careful pressure, exercised by the thumb and finger. In this manner the fibrin becomes freed from its admixture, and its weight is to be taken, after careful desiccation over a water bath.

Second Portion of Crassamentum. — The second portion is to be weighed, and then thoroughly dried over a salt-water bath. It is now again to be carefully weighed, the loss of weight indicating the proportion of water combined with the coagulum; but since all the water of the crassamentum may be considered to exist in combination as serum, we have to subtract from the weight of this solid residuum a quantity of solid matter proportional to the quantity of water, and which belongs to the serum, and not to the crassamentum. This is at once done; since the proportions of solid matter and water which compose the serum are ascertained at the commencement of the process. After this subtraction, it is obvious we have remaining the proportion of fibrin and red particles in admixture; but as the weight of the fibrin was obtained singly from the first portion of crassamentum operated on, we have only to subtract its weight, to ascertain the proportion of red particles. In this way we obtain the proportion of the fibrin and red particles: the deficit, of course, consists of serum; and the proportion of water and solid matter contained in this fluid being already ascertained, we can declare the weights of the water, solid matter of serum, fibrin, and red particles contained in any given specimen of blood.

Albumen, combined with soda.
Crystalline fatty matter.
Animal oily matter.
Chlorides of potassium and sodium.
Alkaline, carbonate, phosphate, and sulphate.
Earthy phosphate and carbonate.
Subphosphate of iron.
Oxyde of iron.

The process for making the quantitative analysis of the serum is as follows:—

The portion destined for analysis is first to be carefully weighed in a balanced china-ware capsule: 200 grains is frequently used by chemists; but if the operator can afford to wait the requisite time for the evaporations, I should recommend that he use 1000 grains in his experiments.

The weight of the serum being noted, it is now necessary to evaporate it to dryness over a water bath, and then, on ascertaining the weight of the dry extract, and subtracting it from that of the serum, we obtain the proportion of water contained in the specimen.

The dry extract is next to be carefully broken up in the evaporating dish*, and then treated with boiling distilled water; care being taken that the heat be kept to 212 Fahrenheit at the moment of

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* This must be done by the aid of scissors, a spatula, and a sharp knife; and the capsule should be placed on a dark-coloured sheet of glazed paper, in order that any portion of matter projected from it may be at once seen, and replaced.

admixture, as otherwise the albumen is liable to assume a gelatinous form, which greatly interferes with the process. The quantity of water first added should be equal to about four times the bulk of the extract, and should serve to detach it from the sides of the evaporating dish: it then may be allowed to digest for a quarter of an hour, when it is to be thrown on a filter, which has previously been washed with hot distilled water, and allowed to drain. The contents of the filter are now again to be treated with boiling water, which is to be added by small quantities; a small portion of the liquor which passes through being occasionally tested with a solution of nitrate of silver, as it is necessary to continue the washings with boiling distilled water until the re-agent above mentioned ceases to be affected by the percolating fluid. We in this way procure a residue B, and a filtered solution A.

A, the solution, is now to be evaporated to dryness, the result weighed, and its weight noted. The next step consists in adding to the dry mass about four times its bulk of hot alcohol, which should be allowed to digest for ten or twelve minutes. This first portion serves to place the extract on a filter, and when the filtration is finished, two portions of hot alcohol, each equal in bulk to half the first, are successively to be allowed to wash the residue which will be observed on the filter; thus we have formed a clear solution C, and a second residue D.

C. This clear solution on evaporation yields the animal extractive or osmazome, soluble in water and alcohol; this is to be dried over a water bath, and its weight ascertained. From this datum we may likewise obtain the weight of the albumen combined with soda; which is done by subtracting the weight of the osmazome from the weight of the solid matter of the solution A.

D. This second residue is entirely soluble in distilled water, and consists of albumen combined with soda. Its weight may be ascertained directly, or inferred as above mentioned in process C.

B. This residue is to be dried and weighed; successive portions of alcohol are now boiled on the mass until they no longer deposit stearine on cooling; these alcoholic washings are to be added together, and evaporated over a steam bath. The residue B is to be again dried and weighed, which will afford the proportion of albumen. The dried fatty matters may now be washed with cold alcohol, which dissolves the oily and leaves the crystalline fat; these may next be separately dried and weighed, to ascertain their proportion.

The following processes are now necessary, in order to render the analysis complete, by the determination of the proportion of alkaline and earthy salts. With this view, we must first incinerate the albumen, and keep the residue at a red heat in a platinum crucible over a circular-wicked lamp until all carbonaceous matter is dissipated; the weight of the residuum indicates the proportion of earthy salts with an occasional trace of iron: this weight must be subtracted from the original weight of the albumen (obtained by process B), in order to arrive at the exact proportion of that animal principle.

The proportion of alkaline salts may next be ascertained by incinerating the watery and alcoholic extracts obtained by processes C and D. The extracts must be separately incinerated, and the weight of salts in each be subtracted from the weight of the respective extracts, in order to ascertain the real weight of animal matter in each.

It will be observed, that the determination of the proportion of salts is a necessary step in order to ascertain the true amount of the animal matters.

The following results of two analyses, made by M. Lecanu, will serve to show the quantitative constitution of healthy serum:—

Water - - - -	906·00	901·00
Albumen - - - -	8·00	81·20
Organic matter, soluble in water and alcohol	1·69	2·05
Albumen combined with soda	2·10	2·55
Crystalline fatty matter -	1·20	2·10
Oily ditto - - - -	1·00	1·30
Chlorides of potassium and sodium - - - Alkaline phosphate, sulphate, and carbonate -	8·10	7·32
Earthy phosphate and carbonate, with phosphate of iron - - - -	0·91	0·87
Loss - - - - -	1·00	1·61
	1000·00	1000·00

For those who cannot spare time to make an analysis as above, it may be well to mention the formula, as under, in accordance with which an analysis may be very easily effected:—

Water - - - -
Albumen, with earthy salts and phosphate of iron[*] -
Animal extractives[†] - -
Fatty matters[‡] - - -
Alkaline salts - - -

I will now describe the method of proving the presence of the several salts above enumerated, as constituents of serum, beginning with the alkaline salts. These may be proved to be such by dissolving them, as obtained by incinerating the extractives, in a small quantity of distilled water, and then adding a few drops of a solution of carbonate of potassa to a portion of the saline fluid. The carbonate has the power of precipitating both metallic and earthy salts from their solutions, provided no excess of acid be present. It will be now observed, that the liquor remains unaltered by the addition of the re-agent; and we may therefore at once conclude that all the salts present are alkaline. To a second portion of the solution we may add an excess of tartaric acid, and set it aside for a few hours, when a crystalline precipitate will be pro-

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[*] Avoiding the incineration of the albumen.

[†] Avoiding the separation by alcohol.

[‡] Avoiding the separation of the crystalline fat from the oily matter.

cured, consisting of the bitartrate of potassa; thus indicating the presence of that base. A portion of the fused salts is now to be exposed to the inner flame of the blowpipe on a platinum wire, when the outer flame will become coloured yellow, in a very marked degree; proving that soda likewise exists in the salts.

Having now shown the nature of the bases, we will proceed to examine the acids with which they are combined:—1st. Let a portion of the dry salts be treated with a drop of moderately dilute acetic acid, when an effervescence ensues; proving the carbonic acid to be present.* To a third portion of the solution of salts add a few drops of the solution of chloride of barium, which will occasion a dense precipitate, owing to the alkaline carbonate present. This precipitate must now be dissolved by a slight excess of pure hydrochloric acid, and the solution set aside, when a white precipitate of sulphate of baryta will appear, proving the presence of the sulphuric acid.†

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* Enderlin denies the existence of a carbonate in the ashes of blood; and it is true, that if we incinerate the serum and crassamentum together, we obtain an ash which does not effervesce on the addition of acids. If we incinerate serum alone, however, we obtain an ash which effervesces strongly on the addition of acids. The explanation of the above apparent anomaly consists in the fact that the phosphorised fats contained in the clot produce during combustion a sufficient quantity of phosphoric acid to decompose the carbonate formed from the decomposed lactates and albuminate of the serum.

† If the whole of the precipitate be not dissolved by the excess of hydrochloric acid, we may also conclude that the solution contains a sulphate.

A fourth portion of the solution is now to be rendered acid by a very slight excess of pure nitric acid, and then tested with a solution of nitrate of silver, which will occasion immediately a white precipitate, consisting of the chloride of silver; proving the presence of the hydrochloric acid. This precipitate may now be allowed to subside in the acid liquor, which is to be poured off into another tube, and to be carefully neutralised with ammonia. A yellow precipitate will then appear, which before was dissolved by the excess of acid. This precipitate consists of phosphate of silver, and may be further identified by allowing it to remain in the tube exposed to light for a few hours, when it will be found perfectly blackened; thus the phosphoric acid is shown to be present.

We will now proceed to the examination of the earthy and metallic salts: these will be found insoluble in water; an acid must therefore be used to dissolve them, which easily effects the purpose. The dilute nitric acid, perfectly pure, is to be preferred; care being taken to use little more than is absolutely necessary to effect the solution. It will be observed, that when the acid is added, effervescence occurs, occasioned by the escape of carbonic acid. The phosphoric acid may now be shown to be present, by the addition of a few drops of the solution of nitrate of silver to a portion of the acid fluid, and then neutralising the excess of nitric acid with pure ammonia[*]; when the yellow phosphate of silver will be precipitated. The existence of this acid may also be demonstrated before the blowpipe, by subjecting a portion of the dry salts to the action of the inner flame, having previously moistened them with strong sulphuric acid, when the outer flame will assume a fine green colour.

Having now experimented upon the acids, we will proceed to the examination of the bases. To a portion of the acid solution add a sufficiency of ammonia nearly to neutralise it, and then let it be tested with the ferro-prussiate of potassa, when a precipitate of prussian blue or ferro-sesquicyanuret of iron will collect in the solution.[†] Many minutes are sometimes required, however, before this effect is produced. In order to demonstrate the presence of the earthy phosphates, the acid solution must be neutralised with ammonia, when the peculiar gelatinous appearance of the precipitate will sufficiently characterise its nature.

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[*] Great care must be taken that too great a quantity of nitric acid be not added in performing the solution of the salts; for in that case, the great excess of nitrate of ammonia (which is formed on the addition of the ammonia) tends to hold the phosphate of silver in solution. This fact of the solubility of the phosphate in ammoniacal salt will probably account for the frequent disagreements of chemists as to the existence of phosphates in some animal matters.

[†] Iron exists as a mere trace in serum, and when found its presence is probably owing to accidental admixture with a small number of blood corpuscles.

QUALITATIVE ACCOUNT OF THE CONSTITUENTS OF THE HEALTHY BLOOD.

Fibrin — Albumen — Globulin.

The blood is principally composed of proteine compounds, which are in combination with certain salts, fatty matters, and water, necessary either as solvents to the more important principles, or as assistants in the process of nutrition. The more important proteine compounds which we meet with in analysis are fibrin and albumen*, formed by the union of proteine with sulphur and phosphorus in varying proportion. To these most chemists add another, to which they give the name of globulin. This body is a constituent of the corpuscles — the white part of the corpuscles — and is made up of the nuclei and membranes which contained the red colouring fluid. It is estimated as part of the corpuscles in the method of analysis I have detailed. The ashes of globulin have been erroneously stated to contain iron; this only happens when colouring matter has become mixed with it, for I have proved that the whole of the

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* The ultimate constitution of these bodies has been stated as follows:—

	Fibrin.	Albumen.
Proteine	10 atoms	10 atoms.
Sulphur	1	2
Phosphorus	1	1

The proportions of phosphorus and sulphur, however, cannot be relied upon. Proteine itself is constituted as follows:—

$$C_{48} H_{36} N_6 O_{14}.$$

iron contained in the blood exists in the red colouring principle, and that the white matter of the corpuscles, when pure, yields a white ash.*

The general chemical qualities of fibrin and albumen are almost identical, and the re-actions of the white matter of the corpuscles, so far as it has been examined, are of the same character. These principles are soluble in alkaline solutions, and precipitable when so dissolved on neutralisation with acids. They are rendered gelatinous, and dissolved by strong acetic acid.

Ferrocyanuret of potassium precipitates the acetic solution. Strong hydrochloric acid boiled on solid fibrin or albumen assumes a fine purple tinge. The ashes of fibrin, albumen, and globulin, when pure, are perfectly white, and composed principally of phosphate of lime. Albumen when in solution is precipitated on the application of a heat equal to about 160° Fahrenheit. It is coagulated also by the addition of—

Nitric acid,
Solution of bichloride of mercury, and
ferrocyanuret of potassium,

provided a few drops of acetic acid be previously added.

Several metallic and earthy salts also precipitate albumen from some soluble forms of combination.

Hæmatosine.

The red corpuscles of the blood, if collected in

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* *Vide* Guy's Hospital Reports, April, 1843, p. 323.

serum, by washing the clot in that fluid, removing the coarser parts, and then allowing them to subside, may be made to yield hæmatosine free from globulin, by the following process:—The supernatant serum is to be poured off as nearly as possible without disturbing the corpuscles; a solution of common salt is next to be added, being of the same specific gravity as the decanted serum (about 1·029), and the corpuscles having been agitated and washed in this fluid, are again to be allowed to subside, by which means they are freed from adhering albumen. Subsidence being complete, the next step consists in pouring away the saline solution, and throwing the subsided corpuscles into a vessel of distilled water, which bursts the corpuscles by rapid endosmosis, causing the burst vesicles to fall in the fluid together with the nuclei, while the red colouring matter dissolves in the water. The mixture is now to be placed on a filter, when the solution of hæmatosine will pass through, leaving behind the nuclei and membranes of the corpuscles. This solution, if evaporated, yields the red colouring matter in a state nearly approaching to purity. In this condition it will be found greatly to resemble albumen and fibrin in its re-actions with acids and alkalies. It yields, however, an ash rich in iron.*

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* Two colouring matters, called hæmaphæin and hæmacyanin, have been described by Simon and Sanson as constituents of healthy blood. The former is evidently altered, hæmatosine existing in minute quantity in serum. Of the latter I know nothing.

If we digest ether on dried blood, we obtain not only the fatty matters that we extract from serum, but in addition a fatty principle or principles containing phosphorus. The ethereal solution is clear, transparent, and of a yellowish colour. By spontaneous evaporation it leaves a reddish-brown residue, of the consistence of turpentine, which is formed of two very distinct substances; one being oily, and the other of a crystalline, fatty texture. These may be separated by cold alcohol, which dissolves the oily matter, leaving the crystalline matter unchanged.*

This crystalline, fatty matter is now to be dissolved in boiling alcohol, which deposits it on cooling in scales resembling mother of pearl; it is without odour or taste, soluble in cold ether and boiling alcohol, and insoluble in a solution of caustic potassa; when decomposed by heat, it leaves a residue, containing phosphoric acid; it has a great similarity to cholesterine in appearance.

The oily matter is now to be procured by the evaporation of the cold alcoholic solution. It is insoluble in cold and hot water; alcohol and ether dissolve it readily, assuming, at the same time, a yellow colour. It dissolves when gently heated in a solution of potassa; and if it be decomposed from its alkaline solution by hydrochloric acid, the fatty acids are formed.

Besides these fatty matters, we occasionally find cholesterine (a fatty matter supposed to be peculiar

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* Berzelius seems to consider a part of the fatty matters as peculiar to the fibrin.

to the bile) mentioned as a constituent of blood; and I have reason to believe it occasionally is present. Boudet mentions a fatty matter, to which he gives the name of serolin. His definition of this substance indicates properties nearly identical with those of the crystalline fat of the blood; it is, however, less soluble in hot alcohol of ·833, and fuses at a lower temperature than cholesterine, with which it also shows some characters in common.

Animal Extractives.

In the analysis of serum two extractive matters have been noticed, one soluble in alcohol and water, the other soluble in water only. The former of these is called the alcoholic, the latter the aqueous extractive.

The alcoholic extractive is of a yellow colour, and deliquescent. Its properties are as follows:— It is soluble in water and alcohol; precipitable of a brown colour by infusion of galls; precipitable by the di-acetate of lead, the precipitate being soluble in an excess of that re-agent. This substance is what Berzelius once considered as lactate of soda, mixed with peculiar organic matter. It is the osmazome of some chemists. Lecanu says that it does not give out the odour of meat when boiled, which is the case with osmazome, and therefore thinks that the latter, as obtained by former chemists, consisted of this extractive matter, mixed with a portion of the fats, which would produce the odour in question. This is, indeed, more than probable; since in most of the processes for obtaining osmazome no mention is made of any previous ethereal digestion, which would be necessary for the extraction of the fatty matters.

The aqueous extractive, when dry, forms a mass which Berzelius has considered as a result of the action of hot water on albumen. Lecanu, however, considers it to be a combination of albumen and soda, which is more than probable, as its solution in water gives a precipitate with acetic acid, resembling albumen in its gelatinous state; and as the same body may be procured without the use of hot water, it is plain that the action of that fluid is not necessary to its existence.

OF THE BLOOD IN DISEASE.

The analysis of the blood has been so little studied by the medical profession until of late years, that we have but few observations to direct us regarding its diseased condition. The advance of animal chemistry has but just begun to produce those improvements in our pathological knowledge which have been long anticipated, and is gradually silencing those who argue against the utility of chemical investigations as applied to medicine.

The blood may be called diseased, either when any of its constituents become unusually abundant, or when a diminution of these proximate elements is observed. The more interesting deviation from health consists, however, in the existence of principles in the blood which are entirely foreign to its healthy constitution, and belong especially to the secretions or excretions of the body. A knowledge of the processes for the analysis of healthy blood will, of course, suffice to enable the experimenter very easily to analyse those specimens in which disease has either increased or lessened the proportion of any of the constituents. The substances foreign to healthy blood, and which chemistry has served to demonstrate as existing in the diseased condition of that fluid, are few in number, but yet the presence of each will require either a modification of the method of analysis or increased care and attention as to the degree of heat to be employed during the operations. Many observations have now been made in reference to the effects of disease in destroying the normal proportions of the principles of the blood: the most prominent among these changes are those in which the proportions of fatty matter and water become disturbed. The principles introduced into the blood by disease, and which will be especially noticed, are urea, colouring matter of bile, cholesterine, and sugar.

Examination of Blood supposed to contain Urea.

1. Let a portion of serum be accurately weighed, and then evaporated to dryness over an open steam-bath.*

2. A quantity of distilled water (amounting to about one ounce for each 200 grains of serum used for experiment) is to be heated to 200° Fahrenheit, and then poured on the dry extract, which must be previously broken up with a sharp spatula.

A digestion over the steam-bath for about half an hour is now to be performed; the loss of water by evaporation being supplied occasionally by the experimenter.

3. The digested fluid is to be filtered, and the residue on the filter washed with distilled water (the washings being added to the original liquor). The whole of the filtered liquor is now to be eva-

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* By using an *open* steam-bath, we are always certain of keeping the matter of experiment at a heat considerably below 212° Fahrenheit, which is absolutely necessary in these experiments, since urea in dilute solution becomes gradually destroyed if kept at the temperature of boiling water.

porated to dryness over an open steam-bath, and the residue of the evaporation digested, with absolute alcohol*, at a gentle heat, for half an hour; care being taken that the loss by evaporation do not materially diminish the bulk of the fluid.

4. A second filtration is now to be performed, and the filtered fluid must again be evaporated to dryness, and then dissolved in a small portion of lukewarm distilled water. We thus procure an aqueous solution of urea, combined with animal extractive; to this solution (previously evaporated to the consistence of a thin syrup) we now add a few drops of nitric acid, which causes an effervescence. This mixture must be set aside to crystallise.

5. Should crystals appear, of the peculiarly characteristic appearance of nitrate of urea, we may conclude that urea is present: indeed, if crystals exist at all after the foregoing process, they must be nitrate of urea; since no principle of the blood that can possibly exist in the last-tested fluid possesses the property of becoming less soluble by the addition of nitric acid.

6. Crystals being formed in the liquor†, we may now proceed to ascertain the proportion of urea. For this purpose we must first allow some time to

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* About eight times the bulk of the solid extract for digestion.

† It will always be observed in specimens where urea exists, that, long before any material diminution occurs in the bulk of the fluid (which has been mixed with nitric acid), a crop of crystals appears.

elapse, in order that the deposition of crystals may be perfectly accomplished.* When such is the case, the supernatant liquor must be poured off; which, with the assistance of a small glass rod (to retain any very minute crystals) may be perfectly effected. The acid crystals remaining are now to be carefully dried over the open steam-bath and then weighed; from their weight we may infer the proportion of urea present, since we know the composition of nitrate of urea to be—

Urea - -	52·63
Nitric acid -	47·37
	100·00

If it be required to ascertain the relative proportion of the other ingredients of the blood containing urea, it will be right to make a separate analysis for that purpose; since the use of the open steam-bath and distilled water at 200° Fahrenheit will materially interfere with the determination of the quantity of albumen. I feel convinced that the wish to acertain all by a single analysis has frequently been the cause of failure in the detection of urea when it existed in blood.

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* This must be determined by the discretion of the operator, as it is impossible to lay down rules on such a subject: when any difficulty occurs, it is well to have recourse to the use of a freezing mixture, as recommended in the process for separating urea from the urine.

Examination of Blood containing colouring Matter of Bile.[*]

The best account which has yet been given of this diseased condition of serum is by Lecanu, who satisfactorily proves that in jaundice the vital current is strongly impregnated with those matters, which in the healthy state are peculiar to the secretion of the liver. This able chemist has established, that in cases of jaundice the blood contains the following principles foreign to its healthy constitution:—

1. A combination of albumen and soda, scarcely at all soluble in water.
2. An orange-yellow colouring principle.
3. A blue colouring principle.

These colouring principles have been demonstrated to exist in the bile by M. Chevreul.

The examination of the serum of icteric blood is performed as follows:—

The serum is diluted with a considerable excess of alcohol, which renders it turbid, and precipitates a quantity of flocculi. These are collected on a filter, and washed repeatedly with cold alcohol. This filtered alcoholic solution is of a yellow colour, and possesses an alkaline re-action; it yields a dark yellow coloured residue on evaporation, which has a saltish disagreeable taste. It is deliquescent,

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[*] It is probable that bile exists in serum in its perfect state; but the colouring matter is that part which gives evidence of its presence, and therefore it is to the determination of this substance (to which the name of biliphæin has been given) that the attention of chemists has been principally directed.

and almost entirely soluble in ether. The portion insoluble in the last-named menstruum is granular, and of a salt taste, without bitterness. It contains, besides salts, an extractive matter, soluble in alcohol, and another organic matter, such as is met with in healthy blood.

The ethereal solution is now left to spontaneous evaporation, when a considerable orange-yellow residue is obtained, which contains crystals of the crystalline fatty matter of the blood. These crystals may be separated by warm alcohol, which also extracts an oily matter, of a beautiful deep yellow colour.*

The albumen which has been precipitated is now to be treated with boiling alcohol, which assumes a dark green tint, and by cooling deposits crystals of fatty matter. The liquor, when cold, is to be filtered, and then evaporated over a water-bath. During the evaporation, it retains its original tint for some time; but when the alcohol is nearly dissipated, the green colour disappears, and a yellow tint is observable, while at the same time a portion of brownish matter deposits on the sides of the vessel. This brown deposit may be washed with cold alcohol, to free it from the other matters; when it will be found very soluble in boiling alcohol, and capable of producing a fine blue colour when dissolved in that liquid. It is remarkable that exposure to the rays of the sun destroys this colour.

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* This has been lately shown by Braconnot to consist of the yellow matter of bile in combination with an oily matter.

The yellow serum of jaundice may be very easily tested for bile by the addition of nitric acid, which changes the colour to a delicate green after the lapse of a few minutes. This is a very simple method, and no less easy than it is satisfactory, and void of fallacy.

The jaundiced serum is thus described by Lecanu:—It possesses a sickly taste; it is of a saffron colour, which passes to a canary yellow on being diluted with water; it froths by agitation, and turns syrup of violets to a fine green colour.* No method is at present known of separating the biliary matters quantitatively from serum.

Examination of Blood containing Cholesterine.

This principle is very easily discovered when it exists in blood; and many instances are on record, in which it has been detected in icteric serum. The late researches of P. S. Denis have convinced him that cholesterine is not a constituent of healthy blood†; others believe it to exist in the healthy blood, Boudet among the number. However this may be, it is pretty certain that an increased proportion is occasionally present in disease. When

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* See, in reference to this subject, Chevreul, Diction. des Sciences Naturelles, vol. xlvii. p. 198. Lassaigne, Journal de Chimie Médicale, Juin, 1826, pp. 264. 267. Examen Chimique du Sang dans l'Ictère, et Considérations sur cette Liqueur. Deyeux, Considérations Chimiques et Médicales sur le Sang des Ictériques. Collard et Martigny, Analyse Chimique du Sang d'une Femme morte ictérique, &c. &c.

† Recherches Expérimentales sur le Sang Humain considéré à l'Etat sain. Par P. S. Denis.

serum is suspected to contain cholesterine, it should first be evaporated to dryness over a water-bath, and the dry residue digested with ether for several hours. The ethereal solution may now be decanted, and allowed to evaporate spontaneously. The residue consists of the fatty matters of blood combined with cholesterine.

These are to be well washed with cold alcohol, which extracts the oily matter of the blood, leaving the crystalline fatty matter and cholesterine. This latter may now be removed with the point of a penknife, or any fine instrument, as its crystals are very obvious and easily distinguishable.*

Examination of Blood containing Sugar.

Sugar has been detected in the serum of diabetic blood. The best method of determining its presence is that which has been lately proposed by Dr. Bence Jones, who recommends that the serum be first dried, and then that hot water be thrown on the powdered extract, by which means the albumen is separated, while the sugar and other constituents of the serum become dissolved. The filtered liquor may now be tested by Trommer's test as follows:—A few drops of a solution of sulphate of copper are to be added to the suspected

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* There is some difficulty in otherwise separating these two substances; for the crystalline fatty matter, like cholesterine, is insoluble in alkaline lixivia, and is very similar to that principle in all its re-actions. Cholesterine, however, yields an ash having a strong alkaline re-action, which is not the case with that derived from the crystalline fatty matter of the blood.

fluid, so as to give it a pale blue tint. A solution of caustic potassa is next used to precipitate the copper salt; this being done, an excess of the potassa is to be added, in order that the hydrated oxyde of copper precipitated may be redissolved in the alkaline menstruum. The solution will now assume a fine blue colour. Heat to a boiling temperature is next applied, when, if sugar be present, the oxyde of copper is thrown down as a precipitate of a reddish-brown colour, owing to the deoxydising action of the diabetic sugar on the oxyde of copper, which, were that principle not present, would assume a dark-brown tint on precipitation.

We know of no method at present of accurately ascertaining the proportion of sugar in diabetic blood.

The following process will yield sugar tolerably pure; but does not enable us to determine its weight with precision.

The blood is to be evaporated to dryness over a water-bath, the dried mass comminuted and digested several hours in boiling water. The aqueous solution is to be filtered off, evaporated to dryness, and the dried residuum digested in alcohol of sp. grav. 0·825. The alcoholic solution is to be filtered, evaporated to dryness, and treated with rectified ether, which dissolves out fatty matter, and some urea, leaving behind sugar, osmazome, and chloride of sodium. This mass on being dissolved in alcohol, and the solution allowed to evaporate spontaneously, affords a crop of mixed crystals, principally composed of alkaline, chloride, and diabetic sugar. These may be separated by careful manipulation. I have succeeded by the mechanical use of alcohol of low specific gravity, in effecting this by agitation, with a near approach to accuracy; for the chloride sinks before the crystals of sugar, and thus allows of the latter being poured off partly dissolved in the fluid.

The following is an analysis I made of diabetic serum obtained from a patient, the specific gravity of whose urine was 1048:—

Water - - - - -	908·50
Albumen (yielding traces of phosphate of lime and oxyde of iron, on incineration) - - -	80·35
Fatty matters - - - -	0·95
Diabetic sugar - - - -	1·80
Animal extractive, soluble in alcohol, urea - - - -	2·20
Albuminate of soda - - -	0·80
Alkaline chloride, with traces of phosphate - - - Alkaline carbonate, and trace of sulphate, the results of incineration	4·40
Loss - - - - -	1·00
	1000·00

I should wish the proportion of diabetic sugar given here to be considered merely in the light of an approximation, as it is impossible to separate it completely from impurity; and the loss sustained during manipulation must be considerable.

ON THE URINE.

I SHALL commence this subject by describing each constituent of the urine, and shall then proceed to give an account of the method used for the performance of the quantitative analysis. In considering the urine in disease, I shall, first, treat of the urinary deposits; and, secondly, of those diseased conditions of the fluid which do not necessarily cause any sediment or turbidity. The examination by reagents will be noticed; and then a particular account given of a method for the quantitative analysis of certain forms of unhealthy urine.

OF THE URINE IN HEALTH.

The urine in health has been stated by Berzelius to contain, besides water, the following substances as ingredients; each of which will be separately noticed:—

Urea.
Free lactic acid.*
Lactate of ammonia.
Osmazome.

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* Liebig denies the existence of lactic acid as a constituent of urine, and adds hippuric acid as present in healthy urine. He seems to think that the substance mistaken by Berzelius for lactic acid was a nitrogenous resinoid body produced during evaporation together with acetic acid.

Animal extractive (soluble in water only).
Lithic acid.
Vesical mucus.
Sulphate of potash.
Sulphate of soda.
Phosphate of soda.
Phosphate of ammonia.
Chloride of sodium.
Hydrochlorate of ammonia.
Phosphates of lime and magnesia.
Silica.

Urea.[*]

The following process is, perhaps, the best for procuring this principle in a separate form:—

Evaporate urine to the consistence of a strong syrup, and then add pure concentrated nitric acid, until the whole mass becomes more or less solid. The crystalline matter which is now produced consists of nitrate of urea. This must be washed from adherent impurities by ice-cold water, and then pressed between folds of bibulous paper to dry. These crystals are now to be dissolved in lukewarm distilled water, and neutralised with carbonate of

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[*] This important constituent of the urine has been supposed by some to form during evaporation. Mons. Cap and Henry believe it to exist in the form of lactate. It is neither formed by evaporation, nor present as lactate, however, for I have succeeded in separating it without evaporation, and that too in a pure state, by agitating urine with the common rectified ether of the shops, and evaporating the ethereal solution which separates above.

barytes. This mixture is to be evaporated to dryness, and alcohol boiled on the dried mass. In this way the urea may be extracted from the barytic salt. It may be obtained in colourless crystals, by digesting the alcoholic solution with animal charcoal, then filtering, and allowing the urea to crystallise by spontaneous evaporation. The chemical properties of urea are as follows:—

When heated on platinum foil it fuses; and if the heat be urged is decomposed, yielding fumes of carbonate of ammonia.

It is very soluble in cold water, but more so in warm. It gives out a great degree of cold when dissolved in any considerable quantity.

The concentrated solution in water will bear a heat of 212°, without decomposition; but in dilute solution it quickly decomposes at that temperature.

Alcohol of specific gravity 0·816 dissolves a fifth of its weight of urea at 60° Fahrenheit; when boiling it dissolves nearly its own weight.

It is slightly soluble in ether. The caustic alkalies decompose urea into carbonate of ammonia.

The nitric and oxalic acids combine with urea, forming salts more or less insoluble. The crystallisation with nitric acid forms one of its best distinctive characters.

Urea possesses neither an acid nor alkaline reaction: its crystalline form is that of a four-sided prism, exceedingly delicate, and silky in texture.

Lactic Acid.

The lactic acid was first stated to exist in the urine by Berzelius, who extracted it by the following process:—

A portion of urine was evaporated to dryness, and alcohol of specific gravity 0·833 boiled on the solid residuum.

The alcoholic solution was now evaporated, and the mass dissolved in water.

The watery solution was then boiled with a considerable quantity of hydrate of lime, till all ammoniacal fumes (from decomposing urea) were dissipated; the hydrate of lime now became coloured yellow, owing to the decomposition of animal matter.

The colourless solution was filtered, dried, and then treated with alcohol of specific gravity ·845. Equal parts of strong sulphuric acid and water were now added, guttatim, to the alcoholic solution, until sulphate of lime no longer precipitated; the clear liquor being decanted was next treated with carbonate of lead (recently precipitated), and was then filtered and evaporated to dryness.

The residue was treated with oxyde of lead and a little water, by which means the lactic acid was converted into a sub-salt of considerable insolubility. This was collected, washed with water, and then decomposed by sulphuretted hydrogen.*

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* This is done by suspending the precipitate in distilled water, and allowing a jet of sulphuretted hydrogen to pass through the liquid to saturation.

Thus, sulphuret of lead subsided, leaving the lactic acid free in the supernatant liquor, which, by evaporation, yielded it in the form of an acid yellow syrup, exceedingly deliquescent, and incapable of being thoroughly dried by heat.

Its chemical properties are the following:—

It gives out an acrid odour* when heated, and leaves a porous charcoal if the heat be continued. Alcohol dissolves it in all proportions. It is nearly insoluble in ether.

Its salts are all of a gummy and uncrystallisable nature, excepting the lactates of zinc and magnesia, which have been obtained in a crystalline form.

When lactic acid is added to a strong solution of the acetates of magnesia or oxide of zinc, the lactates of those bases are precipitated.

Osmazome.

This is a term used to signify an animal extract, soluble both in water and alcohol. Such exists in the urine, and may be procured by digesting alcohol of specific gravity ·833 on an extract of urine; and after crystallising the urea from the alcoholic solution (by means of nitric acid), separating the uncrystallisable matter, and neutralising it with carbonate of baryta: the mass must then be dried, and alcohol will now extract the osmazome from the barytic salts.†

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* Not unlike that of the tartrates.

† This will not be quite pure, but sufficiently so to exhibit its properties.

Its chemical properties are as follows:—

When heated it swells much, and leaves a copious alkaline carbonaceous mass.[*] It reddens litmus paper.

Neither chloride of mercury, nor the acetate of lead, is capable of precipitating its watery solution.[†]

Both acid and alkaline solutions are incapable of effecting any precipitation of this extract from its solution in water.

Protochloride of tin, nitrate of silver, and diacetate of lead, produce precipitates.

It may be well to mention, that if anhydrous alcohol be digested on this osmazome, it is capable of being divided into two portions; the one soluble and the other insoluble in that fluid.

The property of being precipitated by the diacetate of lead, nitrate of silver, and protochloride of tin belongs peculiarly to that part of the extractive matter which is soluble in anhydrous alcohol.

Animal Extractive (*soluble in Water only*).

This matter may be procured by dissolving in water an extract of urine which has been digested with alcohol of specific gravity 0·833. By the resolution we separate any vesical mucus, lithic acid, earthy phosphate, or silica, which may be con-

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[*] It contains an alkaline lactate.

[†] If these salts produce a precipitate, it is because alcohol has been used of higher specific gravity than 0·833.

tained in the mass. The solution is now precipitated with acetate of baryta, in order to rid it of sulphuric acid. The sulphate of baryta is collected on a filter, and the filtered liquor neutralised with ammonia, and then again precipitated with the acetate, which now causes a precipitate of phosphate of baryta.* This is to be collected, and the filtered liquor evaporated, in order to drive off the ammonia; or what is better, it may be neutralised by acetic acid. Neutral acetate of lead is now added to the solution, which causes a copious precipitate. This must be collected and washed, and then decomposed by sulphuretted hydrogen, which precipitates sulphuret of lead, and leaves the animal extractive in solution, which may be obtained by evaporation. This extractive is, however, but part of that meant to be understood as the "animal extractive soluble in water only," so often mentioned in analyses. The remainder of it may be procured by precipitating the liquor (in which the precipitate by neutral acetate of lead subsides), by means of the di-acetate of lead; then collecting the precipitate, decomposing it as before by sulphuretted hydrogen, and procuring the extractive from the clear liquor. It must be remembered that each of these extractives have peculiar properties; perhaps dependent on the processes used to obtain them. There is also a portion of animal extractive left

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* Both these precipitates produced by acetate of baryta contain animal matter, which in the latter case is in very considerable proportion.

unprecipitated by the di-acetate of lead. It is easily obtained from the liquor by ridding the solution of any lead which may exist in it by means of sulphuretted hydrogen, filtering, and then evaporating to dryness.

It is a mixture of these three peculiar extractives which constitutes the "animal extractive soluble in water only" of Berzelius.

The properties of the extractive matter precipitated by the neutral acetate of lead are the following:—

It is of a brownish colour, translucid, and does not deliquesce; has no taste, and scarcely affects litmus paper.

Its solution is rendered cloudy by bi-chloride of mercury, and more so by the proto-chloride of tin.

The extractive precipitable by the di-acetate of lead has the following properties:—

It is of a yellowish-brown colour, has a slightly bitter taste, and does not deliquesce.

The watery solution of this extract is of a deep yellow tint.

It is not precipitable by the solution of bi-chloride of mercury, but the proto-chloride of tin, the di-acetate of lead, and nitrate of silver, precipitate it of a dark-brown colour.

The third extractive, which was precipitated neither by the acetate nor di-acetate of lead, possesses the following characters:—

It is of a yellow colour. Solutions of bi-chloride of mercury, proto-chloride of tin, and nitrate of silver precipitate its aqueous solution. The precipitate produced by the last of these reagents is of a dirty yellowish-red colour.*

Lithic Acid.

This acid may be procured from the urine by the addition of a few drops of strong hydro-chloric acid, which, after the lapse of some hours, produces a reddish crystalline precipitate of lithic acid. The red colour is caused by an admixture of colouring matter of urine; for pure lithic acid is perfectly white. It may be obtained in a pure state from the red crystals by dissolving them in caustic potash, and then precipitating the solution by the addition of hydro-chloric acid. The precipitate may now be collected, and washed on a filter.

For the chemical properties of lithic acid, see the article on the analysis of urinary calculi.

Vesical Mucus.

This substance always exists in healthy urine, but is scarcely to be observed when in normal proportion. It may be procured from urine by throwing it on a filter immediately after evacuation, when we may collect it in transparent colourless flocculi, which, if allowed to dry on the filter, possess a shining appearance. The addition of water, how-

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* For further examination of these extractive matters, see the article by Berzelius in his Traité de Chimie, vol. vii. p. 380.: Sur les Matières indéterminées dans l'Urine.

ever, immediately restores the original form of the flocculi. It possesses the following chemical properties:—

The acetic and nitric acids dissolve it readily, and the solution is precipitated by the ferro-cyanuret of potassium.

Caustic potash dissolves it, and ammoniacal fumes are produced.

It does not dissolve in sulphuric acid.

When mucus exists in considerable quantity in urine, it may be easily recognised by its glairy tenacious appearance. It never, therefore, can be mistaken for pus; but when small quantities of both are present, we are occasionally at a loss to determine the truth by chemical means, and are obliged to have recourse to the microscope. When pus is present in urine with mucus, we sometimes find it lying on the latter, and possessing a yellower tint; it is also opaque, whereas mucus is more or less transparent.

Salts.

These consist of alkaline sulphates, chlorides and phosphates, the earthy phosphates, and silica. They may all be procured for examination by incinerating the urine, if we except the hydro-chlorate of ammonia, which becomes dissipated by calcination, and must be procured by a separate process. I shall first notice the manner of extracting this last-mentioned salt, and then proceed to a general description of the remainder.

To extract the hydro-chlorate of ammonia, a portion of urine must be exposed during several days, by which process we find a crystallisation of various salts to occur at the bottom of the vessel. These consist principally of the chloride of sodium, hydro-chlorate of ammonia, and ammoniaco-phosphate of soda, mixed with earthy phosphates.

These crystals may now be collected on bibulous paper, the cubes extracted from the other crystals, and dissolved in distilled water; from which they may be re-crystallised, in order to rid them of adhering animal matter.* These crystals may be recognised as hydro-chlorate of ammonia by the following characters:—

When heated with potash, vapours of ammonia are evolved, to be recognised as such by their odour, as well as by forming a milk-white vapour if mingled with those of hydro-chloric acid. The crystals are volatile, and easily sublimed. The solution is precipitated by the addition of nitrate of silver.

The other alkaline salts which may be obtained by incinerating dried urine are separated from the earthy phosphates and silica by being dissolved in water; the residuum can be left for after-examination. The solution may now be shown to contain chlorides, phosphates, and sulphates, by the ad-

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* The chloride of sodium crystallises from the urine in octohedrons, owing to the existence of urea in the solution. We avoid that chloride by selecting the cubes.

dition of solutions of nitrate of silver and nitrate of baryta to separate portions of the liquor.

The nitrate of silver will throw down a copious white precipitate, which will be in part only soluble in pure nitric acid; thus showing the insoluble chloride of silver and more soluble phosphate. If the chloride be allowed to subside in the acid solution, and the clear supernatant liquid be then poured off, we shall find that on neutralising the nitric acid present by the cautious addition of caustic ammonia, we can reproduce the precipitate of phosphate of silver, possessing its characteristic yellow colour.

It now remains to show the presence of sulphuric acid, which is done by adding a solution of nitrate of baryta to a second portion of the liquid; when a copious white precipitate occurs, consisting of sulphate of baryta, which will be found insoluble in strong nitric acid.

Having thus proved the salts to contain the above acids, we must next show the nature of their bases. This may be done by adding a solution of carbonate of potash to a portion of their solution, when we shall find no precipitate to occur; a fact that shows we are operating on alkaline salts.

We may now direct our attention to the residuum, which was insoluble in water, consisting of earthy phosphates and silica.*

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* It must be observed, that in order to procure any quantity of this residue, it is necessary to employ a large bulk of urine for evaporation.

The phosphates, consisting of phosphate of magnesia and lime, may be separated from the other insoluble ingredient by digestion with dilute nitric acid, which readily dissolves the phosphates. This solution may be tested for lime with oxalate of ammonia (the liquor having previously been nearly neutralised by caustic ammonia), when a precipitate of oxalate of lime occurs: this takes some time collecting, and it is well to boil it briskly and leave it to cool gradually. When the precipitate has quite subsided, if the clear liquor be poured off, and then rendered alkaline with ammonia, we procure after some time a crystalline precipitate of the ammoniaco-magnesian phosphate: thus we ascertain that magnesia and lime are the earthy bases.

If a considerable quantity of urine has been subjected to experiment, we now have a residue which consists of silica.*

This is easily recognised by being insoluble in strong aqua regia, and forming a perfectly transparent and colourless glass with soda before the blowpipe.

Having now become acquainted with the reactions of the various constituents of the healthy urine, we are prepared to enter on the consideration of its quantitative analysis; a subject which, carried to its fullest extent, may be regarded

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* This has been said to contain traces of fluate of lime; but confirmation is necessary on this point; indeed, there must be great difficulty in proving the presence of a fluate when it exists as a trace, and that, too, in combination with silica.

as one of the most difficult undertakings of the chemist.

ON THE QUANTITATIVE ANALYSIS OF HEALTHY URINE.

It is not my intention to enter deeply into the quantitative analysis of the urine, but rather to give the process to that extent which is requisite for medical inquiry. I do not scruple to assert, that up to the present time, our knowledge of animal chemistry is far from adequate to exhibit in a separate form all the various constituents of a fluid so complex and destructible as the urine. The laborious researches of the much respected Berzelius served but to convince him of the futility of an attempt of the kind, and he concludes the description of a tedious process with the following remark: "Cette marche serait celle à suivre dans l'analyse de l'urine, telle qu'on peut l'exécuter actuellement. Un temps viendra *sans doute* où elle paraîtra forte imparfaite."

The following is the quantitative analysis of the urine, as performed by Berzelius:—

Water - - - -	933·00
Urea - - - - -	30·10
Free lactic acid - - -	17·14
Lactate of ammonia - -	
Osmazome - - -	
Extractive, soluble in water only -	
Lithic acid - - - -	1·00

Vesical mucus	0·32
Sulphate of potash	3·71
Sulphate of soda	3·16
Phosphate of soda	2·94
Biphosphate of ammonia	1·65
Chloride of sodium	4·45
Hydrochlorate of ammonia	1·50
Phosphate of lime and magnesia	1·00
Silica	0·03

This form of analysis involves many troublesome processes for the separation of matters at present unimportant to the consideration of medical inquirers. I shall therefore adopt a modification of the above which will be found both simple and satisfactory. The form is as follows:—

Water
Urea
Free lactic acid
Lactate of ammonia
Osmazome
Animal extractive, soluble in water only
Ammoniacal salts
Alkaline sulphates
Chloride of sodium
Phosphate of soda
Earthy phosphates and silica
Lithic acid
Vesical mucus

By this form of analysis we omit the determination of the proportions of the lithic acid and ammoniacal salts: the former exists in the healthy urine in the proportion of 1-10th per cent., and the latter also in slight proportion. The proportion of lithic acid may be easily ascertained by using a portion of urine for the express purpose; as the addition of acid determines its precipitation after a few hours have elapsed, and it can then be collected on a filter, washed with distilled water, and weighed.*

The process for fulfilling the formula is as follows, two portions of urine of 1000 grains each being requisite for that purpose.

First Portion.—This is evaporated over a steam-bath to dryness, and the weight of the residue noted; which being subtracted from the original weight (1000 grains) will give the proportion of water present. Alcohol, specific gravity ·833, is now to be boiled on the dry extract in separate quantities, until no further action is exerted by it. By this means we obtain an impure solution of urea, which is to be purified as follows:—An extract is first made from the alcoholic solution, and then it is re-dissolved in lukewarm distilled water; to this solution oxalic acid is to be added, until no more becomes dissolved on heating the liquid to

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* Hydrochloric acid should be used for precipitating the lithic acid, in the proportion of about 1 dram to 1 pint of urine, which must be evaporated to half its bulk before the addition of the acid.

200° Fahrenheit. When the liquor cools, a deposit of crystals of oxalate of urea occurs, which are impure and dark-coloured; these are collected on a filter, and washed with a very small quantity of distilled water. This water, together with the mother-liquor, is evaporated to procure any more crystals which may exist in the solution; care being taken, if these liquors be not acid, that more oxalic acid is added to them at a heat of 200° Fahrenheit, when we shall obtain a fresh quantity of crystals on cooling. These crystals, being collected together, are dried between folds of bibulous paper, then redissolved in water, and neutralised with carbonate of lime; the liquor is filtered, and the precipitate well washed. The filtered liquor and washings, being a solution of urea, are then evaporated to dryness over a steam-bath, and the extract weighed. Anhydrous alcohol should dissolve the whole of this; and if there be any portion insoluble in that menstruum, its weight must be deducted from that of the weighed extract, and thus we ascertain the exact weight of the urea.

The residue which resisted the action of alcohol ·833 is now to be treated with water, which leaves an insoluble residue, consisting of vesical mucus, lithic acid, earthy phosphate, and silica; this residue is to be dried and weighed; the weight being noted, the mass is to be incinerated in a platinum capsule. The result of the incineration is silica and earthy phosphates, the weight of which may now be taken.

The loss of weight by incineration will indicate the proportion of lithic acid and vesical mucus.

We have now ascertained from the first portion of urine the proportion of the water, urea, lithic acid and vesical mucus, earthy phosphates, and silica.* It remains for us to determine the weight of the alkaline salts and various animal extractives; this is done with the second portion of urine.

Second Portion.—These 1000 grains are to be evaporated to dryness over a steam-bath, and the weight of the dry extract again ascertained, in order to assure ourselves of the correctness of our former experiment. The extract is now carefully incinerated and decarbonised in a platinum crucible: the weight of the result being taken, and then subtracted from that of the dry extract, gives us the weight of the animal extractives, &c. &c., plus that of the urea, vesical mucus, and lithic acid; but the proportion of these latter being already ascertained, we have but to deduct their weight to ascertain that of the extractives.

The weight of the result of incineration, minus that of the earthy phosphates and silica, is the weight of the alkaline salts. Thus we have fulfilled the formula, which may, if required, be

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* It may be remarked, that if any very notable proportion of these two latter is observed, their separate weights may be taken by extracting the phosphates with dilute muriatic acid, and weighing the remaining silica. This, with the previous knowledge of the mixed weights, enables us to determine the weight of each.

further extended by ascertaining the proportion of each of the alkaline salts.*

ON THE ANALYSIS OF URINE IN DISEASE.

The analysis of urine in disease has been practised with far more advantage and success than that of the blood in its unhealthy condition. This, doubtless, is owing to the more frequent opportunities offered to the physician for inspecting the urine, and also to the more obvious marks of disease presented by that fluid. The most frequently observed variation from health is that of the existence of a deposit, which is generally produced on the fluid becoming cool after evacuation, but is sometimes voided with the urine in a precipitated state. I shall first notice the chemical constitution of these deposits.

Analysis of Urinary Deposits.

Most of these deposits are precisely similar in constitution to urinary calculi, and therefore the same rules are applicable to their analysis.

Some of the urinary deposits have been arranged according to their colour by Dr. Prout; who notices the following varieties:—

Yellowish or nut-brown sediment - -	Lithate of ammonia. Colouring matter of urine. Earthy phosphates and lithate of soda.

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* *Vide* Appendix.

Reddish-brown or lateritious sediments - -	Alkaline lithate. Colouring matter of urine. Alkaline purpurate.[*] Occasionally, earthy phosphates.
Pink sediments - -	Lithate of ammonia. Purpurate of ammonia.

These consist, for the most part, of lithic acid, in combination with a base. There exists, however, the free lithic acid; as,

Red crystalline sediment -	Lithic acid. Colouring matter of urine.

We have next to notice the phosphatic sediments, which are mostly of a dead-white colour.[†]

Amorphous sediment -	Triple phosphate. Phosphate of lime, in variable proportion.
Crystallised sediment -	Triple, or ammoniaco-magnesian phosphate.

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[*] Dr. Prout still adheres to the old name for this colouring matter. It appears, however, from the researches of Liebig, that the purpurate of ammonia is not a salt, but a distinct principle, to which he gives the name of murexid. The purpuric acid of Prout is called murexan by Liebig.

[†] I have occasionally met with the lithates of as pure a white as the phosphates. This is by no means common, however.

We must add to these the oxalate of lime deposit, the deposits of red corpuscles, of pus, mucus, bile, and cystine.

I shall proceed to notice the plan to be adopted in the analysis of these deposits, commencing with —

Yellowish or Nut-brown Sediment *,

Consisting of

Lithate of ammonia.
Lithate of soda. †
Earthy phosphates. ‡
Colouring matter of urine.

The deposit is to be boiled in distilled water, which extracts the lithate of ammonia and lithate of soda, leaving the earthy phosphates. §

For the examination of the earthy phosphates, see the article on the analysis of phosphates in healthy urine, page 61.

The aqueous solution is to be evaporated to dryness, and a portion of the mass treated with nitric acid; which, with the assistance of heat, yields on drying the purple tinge characteristic of lithic acid, which is increased on the addition of ammonia: thus we prove the presence of lithic acid.

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[*] Lithates of lime and magnesia often occur in the nut-brown deposit, in small proportion.

[†] This is almost always in small proportion.

[‡] The phosphate of lime exists in this deposit.

[§] This holds the colouring matter in combination.

A second portion of the dried mass is mixed with caustic lime on platinum foil; when vapours of ammonia will be observed, known by their odour, and by affording a white vapour when mingled with fumes of hydrochloric acid: thus ammonia is detected.

A third portion of the mass is heated to redness on platinum foil; when a residue is obtained, possessing an alkaline re-action, and dissolving in distilled water, thus showing the presence of fixed alkali. This is proved to be soda by directing the tip of the inner flame of the blowpipe upon it; when the outer flame becomes coloured yellow, which is not the case with either potash or lithia. Before finishing the notice of this deposit, I must state that I have occasionally detected lithate of lime in it. This was proved to be present by the solubility of the deposit in warm dilute nitric acid, and the detection of caustic and carbonated lime as a result of incineration.—N. B. No effervescence was produced by the addition of hydrochloric acid to the deposit previous to incineration. No oxalate of lime was present, to whose decomposition the carbonate of lime (of incineration) might be attributed.

Reddish-brown or Lateritious Sediment,

Said to consist of

Alkaline lithate.
Colouring matter of urine.
Alkaline purpurate.
Earthy phosphate (occasional).

The deposit is first to be boiled in a considerable quantity of distilled water, which leaves undissolved any earthy phosphate which may be present. The lithate and colouring matter are held in solution.

The presence of the lithate may be proved as in the first described deposit, the presence of soda being particularly sought for.

Pink Sediment,

Said to consist of

Lithate of ammonia, coloured by
Purpurate of ammonia.

The existence of lithate of ammonia in this deposit is to be proved in the way described above for the examination of the yellowish sediments. For an account of the colouring matter, see Appendix.

Red Crystalline Sediment,

Consisting of

Lithic acid,
Colouring matter of urine.

This deposit may be proved to consist of lithic acid, by yielding all the re-actions mentioned in the article on the examination of lithic acid calculi.

The colouring matter may be separated by boiling the sediment in distilled water.

Amorphous Sediment,

Consisting of

Ammoniaco-magnesian phosphate.

Phosphate of lime.

This sediment may be known by the following chemical characters :—

It is insoluble in water.

It readily dissolves in the dilute acids, from which it is precipitated on the addition of ammonia.

It yields ammoniacal fumes, when treated with caustic potash.

Its solution in acid, if it be first nearly neutralised with ammonia, yields a white precipitate of oxalate of lime when tested with a solution of oxalate of ammonia; and if after the subsidence of this precipitate we pour off the clear liquor, and test it with ammonia, we shall perceive, after some time has elapsed, a crystalline precipitate of triple phosphate to occur in the liquor: thus we prove lime and magnesia to be present.

The phosphoric acid is shown to exist in the solution by the re-actions of nitrate of silver. See p. 60.*

Crystallised Sediment,

Consisting of

Ammoniaco-magnesian phosphate.

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* This amorphous sediment frequently simulates pus in appearance; but may be easily distinguished, the latter being dissipated before the blowpipe.

This dissolves in acids, and is precipitated from its acid solution by the addition of ammonia, like the preceding deposit; but does not yield a precipitate on the addition of oxalate of ammonia to the nearly neutralised solution in acid, in consequence of having no lime in its constitution. This is its best distinguishing characteristic.

As with the preceding sediment, ammonia is evolved when it is treated with caustic potash.

Oxalate of Lime Sediment.

This deposit may be known by the following characters: viz.

It is insoluble in water and warm dilute nitric acid. When heated before the blowpipe on platinum foil, it leaves a residue of carbonate of lime, which may be known as such by its insolubility in water, solubility with effervescence in dilute acids, and precipitation from this solution by oxalate of ammonia.*

Red Corpuscles.

This sediment, when present in small proportion, requires the use of the microscope for detection;

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* These three experiments can be made in a watch-glass or small test tube, without removing the result of the blowpipe experiment, which may be a very minute quantity. First, the water is added, which has no solvent action; secondly, the addition of acid to this water causes effervescence and solution; and thirdly, the addition of oxalate of ammonia throws down a precipitate.

when in large proportion, it can never be mistaken, on account of its peculiar colour. It may sometimes be identified by the property it possesses of becoming of a very bright red colour, when treated with a concentrated solution of chloride of sodium. The deep porter colour occasionally observed in urine may frequently be traced to the existence of red corpuscles in suspension.

The existence of pus and mucus as a deposit in urine is of very common occurrence. I have before stated, that when in small proportion it becomes a matter of difficulty to discriminate, and we are obliged to use the microscope in order satisfactorily to determine their presence.*

Biliary Sediment.

This frequently remains on the filter through which jaundiced urine has passed. It consists of the yellow colouring matter of bile. Its properties are as follow:—

It is insoluble in water.

It dissolves readily in caustic potash.

When dilute muriatic acid is thrown on it, a fine green colour is produced.

The addition of strong nitric acid produces a red colour.

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* When pus is present in quantity, it frequently simulates the phosphates, but may be distinguished by the addition of caustic potassa in solution, when, if pus be present, the whole mass of deposit becomes mucoid and tenacious. This excellent test was proposed by Dr. Babington.

Cystine.

This deposit may be known by the following properties:—

It dissolves in caustic ammonia, and is precipitated from this solution by acetic acid.

It is insoluble in alcohol, water, and solution of carbonate of ammonia.

It is soluble in the nitric and hydrochloric acids.

It is soluble in the caustic fixed alkalies, and in their carbonates.

Braconnot gave the name of Cyanourine to a colouring matter he detected in the urine. It has not been observed in connection with any particular form of disease. It tinged the whole urine of a blue colour.

The following are its characters, according to Braconnot:—

It is tasteless, void of odour, darker than prussian blue, and in a very finely divided powder.

When heated, it yields carbonate of ammonia and empyreumatic oil.

It is slightly soluble in water and boiling alcohol. This alcoholic solution is green, and on cooling, it deposits a dark blue powder, having a crystalline appearance.

This powder is dissolved by the acids, and is thus turned to a red colour.

Its solution in dilute sulphuric acid yields a fine carmine colour on evaporation to dryness; and this residue is rendered brown by solution in water, but resumes its carmine tint on evaporation to dryness.

When the red acid solutions of this colouring matter are neutralised with alkali, the original blue colour is restored, and a precipitate produced.

Caustic potash acted but little on this blue colouring principle, and carbonate of potash had not the slightest effect upon it.*

Other sediments have been described of a black colour by Drs. Marcet and Prout. These, however, are very rare. Prussian blue has also been observed as a precipitate in urine, but always, I believe, in cases in which iron, in some form, had been exhibited internally.†

ON THOSE DISEASED CONDITIONS OF URINE NOT NECESSARILY CAUSING SEDIMENTARY DEPOSITS.

There are such considerable variations occurring in the proportions of the ingredients of urine voided at different periods of the day, that it is exceedingly difficult to draw a determinate line, as to what shall be considered a healthy or morbid proportion of any single constituent of the fluid. There are, however, excessive cases of variation which claim our attention. If it be the wish of

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* This blue urine was most probably caused by the presence of some vegetable colouring matter, more or less modified by passing through the kidney.

† The microscopical figures of the urinary sediments are given at the commencement of the work.

the physician to note such deviations of proportion, he can accomplish his object by making the quantitative analysis as for healthy urine.

When, however, the secretion becomes admixed with matters foreign to its healthy constitution, we must employ a method of quantitative analysis very different from that applicable to healthy urine.

I shall proceed to describe the examination of urine by re-agents, both for the detection of an excess of any ingredient, or for the discovery of any principle not met with in healthy urine.

There are many medicines and vegetable colouring matters that are to be detected in the urine of those who may be using such, either medicinally or as articles of diet; and as these are apt to perplex the inquirer in his observations on the diseased or even healthy fluid, I shall append to the examination by re-agents a short account of such re-actions as are displayed by various matters foreign to urine in a pure state. I shall, lastly, notice the quantitative analysis of diseased urine.

ON THE USE OF RE-AGENTS IN THE EXAMINATION OF URINE.

Nitric Acid.—1. This re-agent is exceedingly useful in the discovery of albumen. If a few drops be added to urine containing that principle, we have a precipitate produced of a dead white colour.

2. This re-agent is also used to discover whether the urine contain lithic acid; but some hours are generally necessary for the production of this precipitate, which, if it fall in small quantity, is found adherent to the sides of the vessel used for experiment.*

3. The colouring matter of the bile (which exists in solution as well as in the form of a sediment) is precipitated from the urine by this reagent: the precipitate is of a green colour; but if an excess of nitric acid be added, it is quickly changed to a dingy red, and, finally, to a brown.†

4. When any great excess of urea exists in the urine, it is easily detected by placing a portion of the fluid in a watch-glass, and adding to it an equal bulk of nitric acid, which (if urea be present in a large proportion) will produce a speedy crystallisation of nitrate of urea. This test was first introdued by Prout, but it requires care in its application; because the heat of the atmosphere, being subject to variation, will cause an equal

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* In some fevers, the addition of nitric acid to the urine produces a large precipitate of lithic acid, and that of so white a colour that it closely simulates albumen. It may be distinguished, however, by being produced equally by the addition of hydrochloric acid, which is not the case with albumen.

† This re-action does not take effect unless a considerable proportion of colouring matter be present. If it be required to detect minuter proportions, we must evaporate the urine to dryness, and boil anhydrous alcohol on the extract. This alcoholic solution contains the colouring matter; and by evaporation we can procure it, and then detect its presence by nitric acid, as above described.

variation in the time required for crystallisation, even in identical specimens of urine.

Prout states, that when the specific gravity of urine is above 1·025 or 1·030, this crystallisation is frequently observed: but it is certain that a much higher specific gravity may exist without the urine possessing the property of becoming crystallised with nitric acid before evaporation; for Berzelius examined a specimen of urine of specific gravity 1·030, which, even when evaporated to three fourths its original bulk, failed to yield crystals on the addition of nitric acid. This test requires attention to the atmospheric temperature; and also a practical knowledge of the effects produced upon healthy urine by nitric acid, an equal bulk of the latter being always used in testing.

Solution of Caustic Ammonia.— The proportion of earthy phosphates may be ascertained by the addition of this re-agent. A white precipitate is formed, which may be collected and washed on a filter with distilled water. The precipitate consists of phosphate of lime and magnesia with ammonia.

Solution of Ferrocyanuret of Potassium. — This is a very delicate test of albumen in urine; but always requires the previous addition of a few drops of pure acetic acid.

Solution of Alum causes a white precipitate in urine containing albumen.*

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* If albuminous urine be boiled, we have coagulation produced, which is very significant of the presence of albumen: but nitric acid should be used as a test in conjunction with

Hydrochloric Acid, like nitric acid, precipitates the lithic acid from urine, as also the colouring matter of bile; and is rather to be preferred, since it is less likely to exert a solvent action on the lithic acid, and likewise preserves the characteristic green colour of the biliary matter, which the nitric acid soon changes to brown, if any excess of the acid be present.

Turmeric Paper changes from yellow to brown if moistened with alkaline urine, acid fluid exerting no re-action upon it.

Litmus Paper (*blue*). — This is used to test the urine for acidity, being changed to a red colour if moistened with an acid specimen. Alkaline urine has no re-action on this paper.

Solution of caustic potash, boiled with an equal bulk of urine, is an excellent test for the presence of sugar, rendering the mixture of a dark rich brown colour if that principle be present. This test was proposed by Mr. Moore.

EXTRANEOUS PRINCIPLES IN URINE.

The urine frequently presents the various odours and colours of vegetable matters which have been taken into the stomach; and the examiner must be on his guard against being deceived by such ap-

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ebullition; for the earthy phosphates are sometimes precipitated by boiling, and become a source of fallacy. It has often occurred to me, to prove the phosphates present when the precipitate procured by boiling was considered albuminous.

pearances. Thus, I have known a patient on the point of being treated for hæmaturia, when the urine falling under my observation, I discovered the red coloration to proceed from the presence of a vegetable matter. On inquiry, the patient stated that he had been eating a salad, of which beetroot was an ingredient, during the last eight or ten days of his medical friend's visits.

I have also had occasion to observe the production of a deep brownish colour in the urine when vegetable infusions have been administered as medicines. This is almost always the case when the pyrola umbellata has been exhibited.

These vegetable colouring matters are at once distinguished by adding a solution of caustic potash to the tinctured urine, when a green colour is produced, which is destroyed on super-saturating the alkali with an acid, the original tint being restored.*

Tannin, which exists in many vegetable matters used as remedial agents, is capable of entering the urine. In this case we find the fluid strikes a dark colour with the per-salts of iron.

Mercury has been said to exist in the urine of those who use frictions with mercurial ointments. This observation was made by Cantu, who obtained metallic globules from a sediment. I had occasion to examine the urine of a person who was salivated

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* In a case of poisoning by sumach, which lately came under my notice at Guy's Hospital, I found the urine highly impregnated with vegetable colouring matter.

from large doses of calomel, but could not discover any trace of mercury in it. Arsenic and antimony have also been detected by Orfila in the urine of poisoned persons.

Iodine always exists in the urine of those who take it internally. I detected it in the urine of an individual who had taken only one grain of the remedy, and that in three separate doses of one third of a grain each. The process for the detection of iodine in urine is the following:—

A portion of the suspected fluid is evaporated to dryness over a water-bath, and the residue re-dissolved in a small quantity of distilled water.

This solution must be filtered, and treated with about one eighth part of strong sulphuric acid. If a solution of starch now be added to the liquor, we shall observe a fine blue colour if iodine be present. This colour is sometimes to be heightened by the careful addition of chlorine water, *guttatim*. Iodine is frequently to be detected in urine, simply by mixing that fluid with the above-mentioned proportion of strong sulphuric acid, and then suspending over the containing vessel a piece of bibulous paper, which has had a solution of starch dried upon it. In this way the fumes rise, and, combining with the starch, form the deep blue so characteristic of iodine in a free state.*

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* I once digested alcohol on an extract of urine containing iodine in combination; but the alcoholic solution which I procured yielded no evidence of that body, when tested as above. This seems to show that in the urine the salt containing iodine is not an iodide, but probably an iodate.

Tartaric, *Citric*, and *Malic Acids* have been observed in the urine in combination with lime; they then exist as a deposit. The method of distinguishing these will be given in the Appendix.

Having now noticed the method of detecting the presence of various matters which are foreign to the healthy urine, I shall proceed to describe the means best adapted for performing the quantitative analysis of two very common forms of diseased urine, viz. the albuminous and saccharine.

QUANTITATIVE ANALYSIS OF ALBUMINOUS URINE.

It is requisite in this examination to use a distinct portion of urine, in order to ascertain the quantity of urea which may be present. In this form of diseased urine we frequently find that principle in an exceedingly minute proportion, and it is consequently very liable to escape observation. The urine for analysis is therefore divided into two portions, of equal weight.

First Portion.—This is accurately weighed, and then evaporated to dryness over an open steam-bath, and the residue treated with boiling alcohol, specific gravity 0·833. The alcoholic solution is now to be evaporated, and the extract so obtained redissolved in distilled water.

This aqueous solution is concentrated until it assumes the consistence of a syrup. It is then to be mixed with half its bulk of pure nitric acid, and placed in a freezing mixture capable of lowering the temperature to 32° Fahrenheit.* By this means we produce a crystallisation of the nitrate of urea, and we can then abstract the crystals, which are to be treated as described in the article on the analysis of diseased blood, page 41., in order to ascertain the proportion of urea.

Second Portion.—This is to be weighed, and then evaporated to dryness; the weight of the extract being ascertained, we are enabled to determine the proportion of water by subtracting the weight of extract from the original weight of the fluid. This extract is now to be treated with boiling distilled water, and the mass thrown on a filter; the insoluble portion (consisting of albumen, lithic acid, earthy phosphate, and vesical mucus) is to be washed with warm distilled water, until that fluid exerts no further solvent action. This may be ascertained by occasionally testing the percolating fluid with nitrate of silver, which, if it do not affect the liquid, shows that the washings have been sufficient.† We thus procure a filtered liquor A, and a residue B.

A. The filtered liquor is evaporated to dryness and weighed; its weight being ascertained, it is next incinerated in a platinum capsule, over a cir-

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[*] Such a freezing mixture is easily made, by keeping a mixture in readiness composed of equal weights of nitre and sal ammoniac; two and a half ounces of which, when mixed with one fourth of a pint of water, produce the effect required.

[†] The extract should be quite dry before we add the boiling water, otherwise a portion of albumen will always remain in the filtered solution.

cular-wicked spirit lamp, until all the organic matter is dissipated. The weight of the decarbonised salts may now be taken; and by subtracting this from the weight of the extract from the filtered liquor, we obtain the weight of ammoniacal salts, animal extractive, and urea together: but as the weight of the latter is already known, we can, by subtracting, determine the exact weight of the animal extractive and ammoniacal salts. Thus, we have already ascertained the proportions of

Water - - - -
Urea - - - - -
Animal extractives, lactic acid, and ammoniacal salts - -
Alkaline sulphates, phosphates, and chlorides - - -

In order to finish the formula, we must now determine the proportions of albumen, lithic acid, and earthy phosphates, which is performed with the residue B.

The mass is removed from the filter, and its proportion deduced from our previous knowledge of the weight of the extract of urine, and also the weight of the matters contained in the filtered solution: by subtracting the latter from the former, we obtain the weight of the residue B as a result. Nitric acid, diluted with about six times its bulk of water, is now poured on the albuminous mass, and gentle heat applied for about fifteen seconds. The acid must then be poured off, evaporated to dryness[*], and incinerated; the weight of the result now indicates the proportion of earthy phosphate, which, if subtracted from the weight of the albuminous mass, gives us the weight of the albumen and lithic acid together. By this process then we have executed the following formula:—

Water - - - -
Urea - - - -
Animal extractives, lactic acid, and ammoniacal salts - -
Albumen, with lithic acid, and vesical mucus - - -
Alkaline sulphate, phosphate, and chloride - - -
Earthy phosphate[†] - -

[*] Lithic acid, if present, can be detected during this evaporation by its re-action with nitric acid. It is not always to be satisfactorily discovered in these cases of albuminous urine. I have always in these examinations obtained an especial result for determining the proportion of the lithic acid by using for the purpose a portion of urine deprived of its albumen by boiling, then evaporating to a quarter's bulk, and adding hydrochloric acid as a precipitant, which throws down the lithic acid after a few hours.

[†] There is a variety of urine called by Prout chylo-serous urine. It contains a large quantity of fats in suspension. This urine may be cleared of fatty matter by agitation with ether, and then examined for other ingredients in the same manner as albuminous urine.

QUANTITATIVE ANALYSIS OF URINE CONTAINING SUGAR.

The great difficulty to be overcome in this examination is that of determining the proportion of urea; for the sugar with which it is admixed completely prevents the crystallization on the addition of nitric acid. There seems little doubt that many specimens of diabetic urine have been stated to contain no urea, when that principle has been present in considerable quantity. Mr. Kane made some experiments on this subject, from which he concluded that urea is voided by diabetic patients in the same quantity per diem as by healthy individuals. His method of detection was by plunging the fluid, mixed with nitric acid, into a freezing mixture, formed with ice and common salt; at this temperature a crystallization of nitrate of urea occurred.

In this examination it is best to divide the urine into three portions of equal weight.

First Portion. — This, after being weighed, is evaporated to dryness over a steam-bath; the dry residue is then to be treated with boiling alcohol, specific gravity ·833, until it exerts no further solvent action.

This alcoholic solution, after filtration, is evaporated to dryness, and then re-dissolved in distilled water. The aqueous solution is now evaporated to the consistence of a thin syrup, and plunged into a freezing mixture*, where it is to be mixed with its own bulk of a solution in equal parts of pure nitric acid and water. Crystallization will now occur if urea be present; and in this way it may be presumed that we can remove nearly the whole of the principle. It is, however, but fair to mention in our analysis, that a portion of urea probably exists in combination with the diabetic sugar. The nitrate of urea obtained as above must be treated in the same manner as that from healthy urine, in order to ascertain the proportion of urea present.

Second Portion.—This must be carefully weighed, and then evaporated to dryness; in this way we can ascertain the weight of water and solid extract. The extract is now to be treated with boiling water, which dissolves nearly the whole, leaving only a small residue of vesical mucus and earthy phosphate.

The weight of this residue being taken, we can by incineration determine the proportion of the phosphate (as a result) and vesical mucus (as the loss by incineration). The aqueous solution is now to be evaporated to dryness, and the weight of the extract taken.†

This mass is to be incinerated and decarbonised

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* That of ice and common salt is better for this experiment than the nitre and sal ammoniac before mentioned; but if ice cannot be procured, the salts must be substituted. For further account of this urine vide Appendix.

† This weight might be deduced; but in all these experiments we can scarcely weigh too often.

in a platinum crucible, when the weight of the residue is that of the salts, and the loss of weight by incineration minus that of the urea gives exactly the proportion of animal extractives, lactic acid, lactate of ammonia, and sugar. Thus, we can fulfil the following formula:—

Water - - - -
Urea - - - -
Animal extractive, lactic acid, lactate of ammonia, and diabetic sugar, with probably a small portion of urea in admixture - -
Salts of incineration - Alkaline, sulphate, phosphate, chloride -
Earthy phosphate - - -
Vesical mucus With perhaps a trace of lithic acid - -

Third Portion.—This is to be used for the purpose of determining the weight of sugar present, which is done by pouring it into a retort in admixture with a small proportion of yeast, and placing the nozzle of the retort under an inverted and graduated jar filled with mercury. In this manner we can collect the carbonic acid produced by the fermentation of the sugar, and may estimate its quantity at a grain for every cubic inch of gas produced. This mode of calculating will be found sufficiently accurate for all practical purposes.

The weight of the sugar being ascertained, we may now subtract it from the other matters soluble in alcohol, with which it is mentioned in the formula, and it may be entered as a separate constituent in the analysis.

ANALYSIS OF URINARY CALCULI.

The examination of urinary calculi is very easily performed. We may divide the substances entering into their composition into two classes.

Firstly, those whose texture and composition become destroyed by a red heat; and, secondly, those capable of resisting heat, and whose composition remains unaltered after the action of that agent.

The first class contains the following substances: viz.

Lithic acid.
Lithate of ammonia.
Oxalic acid (existing as oxalate).
Albuminous animal matter.
Dried blood.
Cystine, or cystic oxide.
Xanthic oxide.
Fibrinous calculus.
Ammonia (separated from phosphate of magnesia).

The second class is not quite so numerous; containing as follows:—

Phosphate of lime.
Phosphate of magnesia.
Carbonate of soda (resulting from heating the lithate).

- Carbonate of lime.
- Carbonate of lime, mixed with caustic lime (resulting from the decomposition of oxalate and lithate of lime by heat).
- Silica.

We sometimes find that lithic acid exists in combination with magnesia, but this is generally in an exceedingly small proportion. I have therefore abstained from mentioning it in the list of constituents.

I shall now proceed to describe the properties of each constituent, in the order observed in the list, commencing with the lithic acid. I shall then go through each step in the analysis of a calculus compounded of all the substances ordinarily contained in urinary concretions.

CLASS I. — THOSE CONSTITUENTS OF URINARY CALCULI WHICH ARE DESTRUCTIBLE BY A RED HEAT.

Lithic Acid.

This form of calculus is more commonly met with than any other; it is generally of a yellowish-brown colour, and smooth on the surface: the brown coloration is owing to an admixture of animal matter, since the lithic acid, when pure, is perfectly white.* We usually find that calculi of

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* It has been said that lithic acid never occurs in its pure state in urinary calculi. This is what we should expect; but I once met with a calculus, the nucleus of which was composed of colourless lithic acid.

this description are formed of very distinct concentric layers. Lithate of ammonia, soda, or potash occur, mixed with this form of concretion; and the lithate of lime has also been observed.

The following are the chemical properties of lithic acid:—

It is insoluble in water.

It is easily soluble in a solution of caustic potassa, and is precipitated from this menstruum by the addition of an acid, in a granular and colourless state.

It is dissolved by nitric acid with effervescence; and, by careful evaporation to dryness, yields a red or rather pink colour[*], which becomes of a fine violet tint when ammonia is dropped on it, or even when it is subjected to the action of strong ammoniacal fumes. This reaction of ammonia is very useful, inasmuch as it prevents the yellow stain which many animal matters produce with nitric acid from being mistaken for the re-action of lithic acid. In the former case, the ammonia increases the yellow tinge to an orange colour, which is very distinct from the violet tint of murexid.

Before the blowpipe this substance emits a fetid smell of burnt horn, mixed with an odour approaching to that of hydrocyanic acid.

Lithate of Ammonia.

This substance has several times been observed forming whole calculi; these, however, are generally

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[*] Owing to the formation of murexid.

small; they are of a clay colour, with a smooth external surface. Their fracture is more earthy than that of the lithic acid variety.

Though it is very rarely that we meet with a calculus formed entirely of lithate of ammonia, yet a large majority of calculi contain that lithate in small proportions. Its properties are as follows: —

It is very soluble in boiling water, but much less so in that fluid when cold.

It is soluble in the solutions of alkaline carbonates.

With nitric acid it reacts in the same manner as lithic acid.

When suddenly heated on platina foil, it crepitates strongly.

When treated with potash, it yields vapours of ammonia.

The solubility of this substance in boiling water and solutions of alkaline carbonates sufficiently distinguishes it from the lithic acid.

Oxalic Acid.

This acid always exists as oxalate in urinary concretions; and the oxalate of lime is the only combination that has yet been detected in them. Calculi composed of oxalate of lime, either entirely or in great part, are of very frequent occurrence, and form the variety known by the name of the mulberry calculus, in consequence of its tuberculated exterior, presenting the appearance of that fruit. These calculi are generally of a dark brown colour. When sawn through and polished on the internal surface, we perceive an internal arrangement much resembling that of the fortification-agate, owing to a succession of conformable deposits taking place on the originally tuberculated surface. The chemical properties of oxalate of lime are as follows:—

It is insoluble in cold nitric and hydrochloric acids, but dissolves when boiled with these acids in a concentrated state; by long digestion, however, in cold hydrochloric acid, the powdered calculus becomes dissolved.

When boiled with a solution of carbonate of potash, it becomes decomposed, forming carbonate of lime and oxalate of potash.

Before the blowpipe, on platinum foil, this calculus becomes charred, emits a fetid smell (caused by decomposing animal matter); and if the heat be continued, a white ash remains, possessing an alkaline reaction, and capable of effervescing with the acids, owing to the formation of a portion of carbonate of lime, varying in quantity according to the heat employed for calcination: the alkaline reaction above mentioned is attributable to the presence of caustic lime.

This variety of calculus is easily distinguishable by the fact of its effervescing in dilute acids after calcination, and its insolubility and refractory character, previous to the application of heat.

We occasionally meet with a form of the oxalate of lime calculus, the external surface of which is perfectly smooth and polished. These calculi are very small; seldom more than half the size of an almond, of an oval form, and known as the hemp-seed calculus. I have examined but one specimen of this variety of concretion.

Calculi occasionally occur, having their surfaces studded with octahedral crystals of oxalate of lime. I first published an account of such a calculus with a description of the crystals, in the Guy's Hospital Reports for October, 1837. Dr. Bird has since described octahedral crystals of oxalate of lime as occurring in the urine—these insoluble octahedra had been before noticed by Vigla, but not described as the oxalate.

Albuminous Animal Matter and dried Blood.

The former of these is constantly present, in greater or less proportion, in every kind of calculus. It exists in considerable quantity in calculi composed of lithic acid or the phosphates.

It has been a matter of doubt whether the deeper tints of colour observed in calculi be not owing to some form of animal matter distinct from dried blood, and though it is not very easy to form an opinion by the examination of these matters, as presented to us in calculi, I feel pretty confident that blood is the only colouring matter capable of producing the deep tints observed in many varieties of calculus.

There is also a peculiarity of colour, which a practised eye immediately seems to recognise as the appearance put on by blood coagulated by heat; and I would beg the reader, on the first opportunity, to boil some diluted serum with red particles in admixture, when he will find that, according to the quantity of red particles present, he can produce modifications of colour exactly resembling those observed in the varieties of dark-coloured calculi. To this we may add, that from some calculi possessing such a colour, we can extract hæmatosine from the external layers.

The albuminous animal matter contained in calculi has the following characters: —

It is insoluble both in cold and boiling water.

When treated with a solution of caustic potassa it dissolves, but may be precipitated from this alkaline menstruum by means of hydrochloric acid. It produces a fine yellow colour when boiled with nitric acid, and yields all the well-known re-actions of albumen.

Cystine, or Cystic Oxide.

We are indebted to Wollaston for the discovery of this substance. It is of rare occurrence in the human species, but is frequently met with in the dog. The larger kind (of which there is a beautiful specimen in the museum of Guy's Hospital) is semi-crystalline, and not unlike stearine in appearance; there is a slight greenish tinge, and a radiated texture of a very peculiar character, observable throughout its section. The smaller kind (as those met with in the dog) are not distinctly crystalline, but solid and compact, and frequently want the greenish tinge peculiar to the larger and apparently more completely formed variety. Wollaston's reason for giving the name of cystic oxide to this substance was, that he considered it peculiar to the bladder. This, however, is not the case; for it has been observed in the kidney by Dr. Marcet. Dr. W. chose to call it an oxide, because it resembled some few of that class of substances in being soluble in both acids and alkalies, the term cystine is however more appropriate. Cystine exists in calculi in a perfectly pure form; the only compound calculus, containing cystine as a constituent, is contained in the collection of Guy's Hospital.

It may be procured in crystals, by allowing its solution in caustic ammonia to evaporate spontaneously. We can then observe the crystalline form to be that of flattened hexagonal prisms. Its chemical properties are as follows: —

It dissolves in dilute nitric, hydrochloric, sulphuric, oxalic, and phosphoric acids; but will not combine with the tartaric, acetic, or citric acids.

It is dissolved by caustic ammonia; but not by the carbonate of that alkali.

The fixed caustic alkalies, as also their carbonates, readily dissolve it.

When nitric acid is evaporated on cystine, a dark-brown colour is produced.

It is insoluble in alcohol; and water exerts but a feeble solvent action.

If it is wished to precipitate cystine from its solution in acids, the carbonate of ammonia is best for that purpose; if from its solution in alkalies, the acetic acid is the best we can employ.

The following method of proving the presence of cystine has been proposed by Liebig:—Dissolve the calculous matter in caustic potassa, then add a solution of acetate of lead in such proportion that the oxide of lead shall not precipitate, but be retained in solution by the excess of potassa. This liquor becomes black when boiled if cystine is present,—a re-action dependent on the presence of sulphur in the cystine.

Before the blowpipe it is consumed, yielding a very peculiar fetid smell.

Cystine may easily be distinguished from the other components of calculi, by its being soluble in dilute hydrochloric acid, and also in the solution of carbonate of potash. Its very peculiar odour, when heated on platinum foil before the blowpipe, forms likewise a good distinguishing characteristic.

Xanthic Oxide.

This calculus was first observed by Dr. Marcet, and has since been noticed by other chemists. When reading the re-actions described by Dr. M., we recognise many of the characters of lithic acid. The action of nitric acid on xanthic oxide is what I have more than once had occasion to observe in lithic acid calculi containing much albuminous matter.* Stromeyer found this substance in a calculus. The chemical characters described by Marcet as peculiar to this substance accord pretty completely with those of lithic acid, except in its affording a yellow colour when heated with nitric acid; which colour becomes changed to a reddish tint on being treated with potash.

Before the blowpipe this calculus decrepitates, and is said to give out a peculiar odour, unlike that of cystine or lithic acid; it leaves a slight ash when perfectly incinerated.

Professors Wöhler and Liebig have lately examined a specimen of this calculus. It is stated to differ from lithic acid in not yielding urea by ignition in a close tube, and by dissolving in nitric acid without evolution of gas.†

Fibrinous Calculus.

It has been before mentioned that every species of calculus (except, perhaps, that composed of cystine) contains an animal matter of an albu-

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* In the seventh volume of the Traité de Chimie of Berzelius we find the following passage concerning the re-actions of the xanthic oxide: — " Sans vouloir prétendre que l'oxide xantique était simplement de l'acide urique, ou de l'urate ammonique, avec une matière animale qui modifiat la couleur de la dissolution nitrique évaporée, il paraît cependant qu'on ne pourra avec une entière certitude le considérer comme une matière particulière, que quand il aura été retrouvé et analysé de nouveau."

† A small fragment of the calculus examined by Liebig and Wöhler has been presented to the museum of Guy's Hospital by Dr. Willis.

minoid character. The calculus now under consideration appears, however, to consist entirely of this substance.

It was first noticed by Dr. Marcet, and its chemical characters resemble those of fibrin.

This calculus is said to approach yellow wax, both in colour and consistence; its structure being fibrous, and somewhat elastic. Its re-actions are as follows: —

It is insoluble in water, alcohol, and hydrochloric acid. When treated with a solution of caustic potash it dissolves, and may be precipitated from this solution by the addition of acid.

It dissolves in acetic acid by the assistance of heat; and this solution, like that of fibrin, may be precipitated by the solution of ferrocyanuret of potassium.

It is dissolved with difficulty by nitric acid. Before the blowpipe it gives out the smell of burnt horn, and leaves a bulky charcoal.

Ammonia (*separated from Phosphate of Magnesia*).

It is very easy to determine whether ammonia be present in any specimen of calculous matter submitted to our notice; but the greatest care is requisite before we can determine whether that ammonia proceeds from the presence of the triple phosphate of ammonia and magnesia, or from the lithate of ammonia: this can often be accomplished by determining the absence of one of these bodies by other tests than those dependent on the presence of the volatile alkali. If ammonia can now be proved to exist, it shows the presence of the other constituent; but further than this the testing for ammonia is a useless step in the analysis of calculi. When we separate the lithate of ammonia by means of boiling water, the ammoniacal test is, however, valid as a proof of the nature of the two substances so separated.

Before, therefore, we can be sure that any ammonia which may be detected proceeds from the triple magnesian phosphate, it is necessary to wash the portion used for performing this test with a considerable excess of boiling distilled water, till the liquor ceases to yield the re-actions of lithic acid.

The testing for ammonia is performed as follows:—

A small portion of the calculus is placed on a piece of platinum foil, and treated with carbonate of potash in a concentrated solution. Vapours of carbonate of ammonia are now evolved, which may be detected by their well-known odour; but the best method of proving their presence is by holding over them a rod which has been dipped in fuming hydrochloric acid, when fumes of hydrochlorate of ammonia will be distinctly visible. It is frequently recommended to use caustic potash instead of the carbonate in this experiment; but the former is very liable to form ammoniacal fumes by its peculiar action on a great variety of animal matters, and therefore is not so distinctive as the carbonated alkali.

CLASS II.—THOSE CONSTITUENTS OF URINARY CALCULI CAPABLE OF RESISTING THE ACTION OF HEAT.

Phosphate of Lime.

This substance but rarely exists as the sole ingredient of a calculus; when it does so, the concretion is always very smooth and polished on the surface, and very distinctly laminated. It is generally of a pale-brown colour. Fourcroy and Vauquelin doubt much whether it ever occurs unmixed with the triple phosphate. The phosphate of lime is a very frequent ingredient in compounded calculi; and when united to the triple phosphate in considerable proportion, it forms the fusible calculus, so called from its easy fusibility before the blowpipe.

The chemical properties of the phosphate of lime calculus are the following:—

It is soluble in the dilute mineral acids, and precipitable from this solution on the addition of ammonia.*

Its acid solution, when nearly neutralised by ammonia, and then tested with oxalate of ammonia, gives a precipitate of oxalate of lime.

Before the blowpipe it blackens, and leaves a copious white residue, if the heat be continued.

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* This precipitate is in a gelatinous form, and very characteristic of the earthy phosphates.

It requires a very intense degree of heat for fusion.

This form of calculus is best distinguished by its negative properties. Thus, it is known from the triple phosphate by not yielding ammoniacal fumes when treated with potash; and from the fusible calculus by the great difficulty experienced in even rounding the edges of its fracture with the blowpipe flame.

Phosphate of Magnesia (*resulting from the triple Phosphate*).

This salt, which remains as the result of heating the triple phosphate, was for a long time confounded with the phosphate of lime. It possesses the following chemical characters:—

It readily dissolves in the acids: even cold dilute acetic acid acts powerfully on it.

It cannot easily be fused by a blowpipe heat.

When oxalate of ammonia is added to its solution in acid, no precipitate is observable, which serves to distinguish it from the phosphate of lime. When these earthy salts occur together, they may be separated by a method which will be described in the process for the analysis of mixed calculi.

Carbonate of Soda (*resulting from heating the Lithate*).

It may be known by its solubility in water, and alkaline re action, as also by effervescing with acids: it occurs but in very minute proportion in urinary calculi; but the lithate forms the great bulk of gouty concretions occurring about the smaller joints, and it is also found very generally in the urinary deposits of rheumatic subjects. The carbonate of soda may be known from that of potash by its colouring the flame of the blowpipe of a fine yellow hue.

Carbonate of Lime.

This substance sometimes occurs as an ingredient of mixed calculi; but I do not know of any well-authenticated case in which it has been shown to exist alone as the constituent of a calculus from the human subject. When carbonate of lime is tested in a calculus, we must always make our examination before any incinerating process has been had recourse to; for by such a step we run the risk of forming a carbonate of lime (which did not originally exist in the calculus) by the decomposition of any oxalate or lithate of lime which may be present in the concretion. Since, however, neither oxalate or lithate of lime produce effervescence with acids, there is no danger of confusion when tests are applied prior to calcination.

If, then, calculous matter produces an effervescence on the addition of cold dilute hydrochloric acid, we may conclude that a carbonate is present.

The chemical properties of the carbonate are the following:—

It effervesces when moistened with cold dilute hydrochloric acid.

The solution in acids is precipitated on the addition of oxalate of ammonia; care being taken previously nearly to neutralise the acid liquor.

It is insoluble in water.

Carbonate of Lime mixed with Caustic Lime (resulting from the Decomposition of Oxalate of Lime by Heat).

It may always be known that this substance is the result of incinerating the oxalate of lime, if we find the matter subjected to examination capable of effervescing, only after incineration.*

If a specimen of calculous matter effervesces both before and after incineration, then of course we may conclude that carbonate and oxalate of lime are both present; provided we have taken care to extract all the carbonate by means of dilute hydrochloric acid (which must be well washed from the calculous matter previous to performing the incineration); for the acid having removed all the carbonate, any which may be detected after calcination must be regarded as a result of that process.

Silica.

This substance was twice detected by Vauquelin and Fourcroy during their laborious researches

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* When lithate of lime exists in a calculus, we may have effervescence produced after incineration. When we have any suspicions, we should take care to employ a digestion with muriatic acid, previous to performing the calcination. When this precaution is used, we can be sure that any effervescence which may occur is caused by the decomposition of oxalate of lime.

into the nature and composition of urinary concretions. Venables also reports the case of a woman who passed a calculus containing silica. It seems highly probable that this substance may exist in small proportion in most calculi; nor can we be surprised at its having been overlooked by those who examine the concretions; for, to do justice to such an investigation, it would be necessary to sacrifice the greater portion of most calculi, which is seldom permitted to the chemist, since such minute investigation has rarely been a desideratum with those who subject their specimens to his operations.

Silica may be known by its perfect insolubility in water, and the concentrated mineral acids; and likewise by its forming a transparent colourless glass, when fused with carbonate of soda on charcoal before the blowpipe.

Having now separately noticed each constituent of urinary calculi, I shall proceed to describe the method for determining the composition of a compound calculus, containing all the ingredients which are ordinarily met with in such a concretion*; viz.

Lithic acid.
Lithate of ammonia.
Lithate of soda.

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* Calculi for examination should always be sawn through the centre, in order to expose the layers to view. A portion of each of these layers must be used to form the powder for analysis.

Lithate of lime.	
Oxalate of lime.	
Ammoniaco-magnesian phosphate or triple phosphate.	Forming the fusible calculus, if the phosphate of lime be in sufficient proportion.
Phosphate of lime.	
Carbonate of lime.[*]	

The portion of calculus intended for examination must be reduced to a fine powder, in a small agate mortar, and the powder divided into two parts.

Treatment of first Part. — This is placed in a small glass flask, and distilled water boiled upon it for several minutes.

The liquor is now to be poured off, and a few drops of it evaporated to dryness on a watch-glass; when, if there be any residue, we must again treat the powder in the flask with a fresh portion of distilled water, which is to be boiled as before, and tested for a residue.

This treatment is to be pursued until we no longer extract any thing with boiling water.[†] Thus we procure an aqueous solution A, and a residue B.

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[*] Cystine, xanthic, and fibrinous oxide are here excluded, because they never exist in any considerable quantity as components of calculi. Several other matters, which appear rarely and in small proportion, are also omitted: such are silica and hydrochlorate of ammonia; the latter first noticed by Dr. Yellowley, in the Philosophical Transactions.

[†] This soon happens, if we use each time a large bulk of water in proportion to the quantity of calculous matter.

A. The aqueous solutions are to be added together, evaporated to dryness, and the residue of the evaporation examined as follows:—

Lithic acid.

A portion is placed on a watch-glass, and treated first with nitric acid and then with ammonia, as before described, when we shall procure the characteristic re-action of lithic acid (this residue of the aqueous solution consisting of the lithates). Having now tested the acid, our attention must be directed to the bases.

Ammonia.

A small portion of the residue is placed on a watch-glass, and moistened with a solution of caustic potash, when ammoniacal vapours will be produced, known by their characteristic odour, and also by testing them with fumes of hydrochloric acid, as before described.

Soda.

The remainder of the residue may now be carefully heated on platinum foil at a low heat, when it will char, and partly volatilise. The remainder (if any exist), when perfectly decarbonised, will possess an alkaline re-action. When cold distilled water is digested on it, we shall find a portion becomes dissolved, and the liquor so formed not being precipitable by the solution of an alkaline carbonate, we at once recognise the dissolved matter as a fixed alkali.

Lime.

The matter which was not dissolved by the distilled water will be found to dissolve with effervescence in a drop of dilute hydrochloric acid, and to be precipitable from this acid on the addition of a solution of oxalate of ammonia: this precipitates lime.* The aqueous solution contained then,—

Lithate of ammonia.
——— soda.
——— lime.

B. The calculous matter, insoluble in water, is now treated as follows:—

Lithic acid. A small portion is tested for lithic acid, with nitric acid and ammonia.

Carbonate of lime. A second portion is mixed with dilute hydrochloric acid; and if any effervescence occurs, we may conclude that carbonate of lime is present.

Oxalate of lime. The remaining matter insoluble in water is now to be digested in dilute hydrochloric acid, then incinerated and decarbonised in a platinum capsule, over the spirit lamp: the residue when cold is tested with dilute acid; and if effervescence ensue, we may be sure that oxalate of lime is a component of the calculus.†

Treatment of second Part.—This is to be placed in a platinum capsule over the spirit lamp, and perfectly incinerated and decarbonised.

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* It must be observed, that this result of incineration on platinum foil is always minute, and great care is requisite in adding the water, to dissolve out the carbonate of soda, as well as in the addition of acid to the lime: a drop of dilute acid being quite enough for the latter purpose, and the same quantity of the test being quite sufficient as a precipitant for the lime.

† The reason for using a digestion with hydrochloric acid is to extract all the carbonate of lime before incineration is performed: by which means we may be sure that any which appears after incineration is the result of decomposed oxalate.

Should carbonate of lime be present in this result of incineration (which of course is the case when the carbonate or oxalate of that earth exist in the calculus), we must dissolve the whole in dilute hydrochloric acid, and precipitate the solution with caustic ammonia, by which means we throw down the phosphates only which may exist in the liquor. This precipitate is to be placed on a filter, and washed with cold distilled water; it must be dried, and then is ready for examination.*

Phosphates.

A small portion is placed on the end of a platinum wire, which must previously be curled into a small noose, in order to hold more of the matter for experiment. The flame of the blowpipe must now be carefully directed on the mass; when, if fusion occur quickly on urging the heat to incipient whiteness, we may conclude that we are operating on the phosphates of lime and magnesia in the proportions constituting the fusible calculus. If no fusion occur, we must have recourse to other proof, in order to show that these two phosphates are present, which is often the case though they be not in the proportions necessary to form the fusible compound. This extra proof of their presence may always be recurred to if we wish for any corroboration on the subject. The examination is as follows:—

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* If no carbonate or oxalate of lime exists in the calculus, then we may at once proceed with the examination of the result of incineration, without using the solution in hydrochloric acid and precipitation with ammonia, which is otherwise necessary in order to separate the phosphates.

Phosphoric acid.

The incinerated or dried mass is to be dissolved in dilute and pure nitric acid, and the solution divided into two portions. One is tested with nitrate of silver, which produces a yellow precipitate on neutralising the excess of acid in the solution by the addition of an alkali. This precipitate is phosphate of silver, and thus we prove the presence of phosphoric acid.

Lime.

The second part of the solution is to be nearly neutralised with ammonia*, and then a solution of oxalate of ammonia added, which will precipitate lime after a short interval has elapsed.

Magnesia.

The precipitate (which is oxalate of lime) is allowed to subside, and the clear liquor poured off. This, when tested with caustic ammonia, will produce a crystalline precipitate of triple phosphate, if magnesia be present. It is very seldom that we have calculi presented for examination containing so many ingredients as the one here noticed. Very frequently we cannot extract any thing from the mass by means of boiling water, and then it may at once be concluded that the lithates are absent. Indeed, when we procure a residue by evaporation from the boiling aqueous solution, we shall continually find that it consists of lithate of ammonia only, and is entirely volatilised when heated on platinum foil. Again, we but seldom encounter

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* The solution should, however, always be slightly acid, in order to preserve the magnesia in solution till the lime is precipitated, and the liquor should be well boiled, in order completely to get down the precipitate of oxalate of lime thrown down by the oxalate of ammonia.

the carbonate of lime in these researches, and this renders the determination of the oxalate of lime more simple and satisfactory. It is not at all uncommon to meet with calculi that are entirely dissipated on the application of heat. When this is the case, our examination is much simplified; for we can exclude from the possible list of constituents the triple phosphate, phosphate of lime, oxalate and carbonate of lime: thus but few matters are left for our consideration. These destructible calculi consist for the most part of lithic acid, combined with more or less of the lithate of ammonia. When a calculus consists of the earthy phosphates, in a tolerably pure state, we find that it blackens before the blowpipe, owing to the presence of vesical mucus. When incinerating such a specimen, we cannot be sure but that this carbonisation is owing to the presence of lithic acid. The effect of the blowpipe, therefore, though of considerable assistance as a test, in cases where all the calculous ingredients are volatile, cannot expedite our analysis if a residue be obtained after its incinerating action.

I would advise those who analyse calculi to commence their examinations by incinerating a small portion on platinum foil; when, if no residue be observed, they much simplify their labours—as they can be sure that no earthy or fixed alkaline salt exists in the concretion.

It frequently happens that calculi are given to the chemist for examination, consisting of different layers of considerable thickness, and it is required to know the constitution of each separate formation. When this is the case, it generally becomes necessary to examine a portion of each layer, according to the process described above; for though we may have examined a powder formed from triturating a portion of the layers, yet we cannot always determine which of these has yielded any one or more of the constituents of the whole calculus.

In conclusion, I may observe, that when we are extracting portions for examination from the different layers of a calculus, it is very necessary to avoid turning over and shaking the sawn surface, in order to dislodge the fragment which we have detached; for by so doing we are very likely to admix portions of the other layers if they happen to be friable, as is often the case. The best way of avoiding this source of error is to pick up the detached portion for examination, by means of a thin glass rod, moistened with distilled water, to which the calculous matter readily attaches itself, and can thus be removed for experiment.

ON THE
TREATMENT
OF
URINARY DISEASES.

ON THE

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OF

URINARY DISEASES.

In presenting the reader with the following essay on urinary diseases, my object has been to describe as concisely as possible the ordinary features of each class of affection, to enter upon a consideration of the most approved methods of treatment, and to add the results of my own experience on several parts of the subject. On some points of practice I have been led to form opinions materially affecting treatment, and not entirely devoid of novelty. I therefore venture to hope, that this contribution to the literature of the subject may contain matter of interest, if not of advantage, to the reader.

ON THE LITHIC DEPOSITS.

Urine depositing the crystalline red gravel is generally of fine deep yellow colour, and contains an excess of acid. Its specific gravity will in most cases be found to exceed that of health, varying from 1022 to 1025, or even higher. When viewed under the microscope, this deposit presents a crystalline texture, and is seen under various forms. (Vide plate, figure 3.) It yields all the re-actions of lithic acid when chemically examined. (Vide p. 93.)

The symptoms observed in those who suffer from the crystalline lithic acid deposit are occasionally of a very severe character, and are constantly brought before the attention of practitioners as occurring among those members of every class of society who either from idleness or necessity fail to take the regular exercise indispensable to the preservation of health, and who at the same time may have the opportunity of indulging freely in animal food, either with or without the use of spirituous drinks. The tendency to the formation of lithic acid deposit is frequently marked by a liability to sharp lancinating pains affecting the extremities, and by lumbar pains combined with a certain degree of irritation experienced during micturition. These symptoms are seldom observed when the lateritious sediments composed of the lithates are being excreted by the patient, except of course when they occur in fever, rheumatism, or gouty disease, and not as constituting an unmixed variety of urinary affection. When transient but sharp pains are experienced by the patient, and any complaint is made of scalding or irritation after micturition, while no other prominent symptom of constitutional disturbance is to be observed, we may very generally conclude that any deposit found in the urine will be composed of crystalline lithic acid, and not the lateritious sediment. The two causes of distress above alluded to constantly exist together as symptoms indicative of a tendency to lithic acid deposit, and that too when the general functions of the body are for the most part regularly discharged, and the general tone of the system preserved in a manner not to be observed in any other form of urinary disease attended with pain.

It is true that such patients complain frequently of dyspeptic symptoms; but these for the most part are of trivial character, and by no means approaching the importance of those characterising the phosphatic and oxalic forms of deposit, in which we constantly observe an irritability and lassitude in connection with dyspepsia which render the patient either unwilling or unable to enter upon the ordinary avocations of life, and, when obliged to use exertion from necessity, injured and not benefited by the effort.

The lithic acid deposit either in the crystalline or agglutinated form is generally a disease of the middle or advanced stages of life, and when occurring in youth or infancy seldom fails to indicate a tendency to grave disease. The liability to calculus is frequently shown by the occurrence of lithic acid deposit in childhood, and a gouty tendency is often indicated in the same manner. In youth, the lithic acid deposit is sometimes observed in connection with Morbus Brightii.

I have known the lithic acid to exist in the urine of a child hereditarily predisposed to gout, and eventually lead to the formation of calculus in the bladder, which being passed by the urethra at an early period of its formation, thus for a short time relieved the sufferer. This patient, however, subsequently became the subject of gout in a severe form, but never afterwards experienced a return of calculous symptoms. As regards the formation of lithic acid calculi, it is chiefly at a more advanced age that the deposit is found in the urine in a form threatening their production. Thus the deposit, instead of appearing at the bottom of the chamber vessel as a crisp crystalline sand, is observed to assume a more rounded form, each little mass being more or less circular, and adhering occasionally to the bottom of the vessel even when the urine is shaken over it with some degree of rapidity.

Dr. Prout has stated, as a general rule, that it is in middle life that the deposit of lithic acid assumes this concrete form, threatening calculus of the kidney or bladder. The *crystalline* lithic deposit, however, is not at all uncommon in middle life: I have met with several such cases showing its presence. Where the concrete form exists, of course there will be an increased tendency to the formation of calculus. I never saw, however, the *concrete* lithic acid deposit in a child, and believe it rarely if ever to exist.

In old age, a tendency to the excretion of very small rounded lithic acid calculi is sometimes observed. Dr. Prout has particularly noticed this condition of urinary disease, which appears connected, in general, with mischief in the urinary passages, and a tendency to the secretion of alkaline urine.

Deposit of Lithates (*Lateritious Deposits*).

This form of deposit, formed of lithic acid in combination with ammonia, lime, magnesia, or soda, presents under the microscope the appearances described by figures 4, 5, and 6. (Vide plate.) Examined chemically, it yields the re-actions described at pages 109. and 110. If urine containing the lithates be heated the whole deposit is immediately dissolved. The colours assumed by the various lithates, when existing as deposits, are indicative of certain conditions of system, and they become thus valuable guides to treatment. When a dusky nut-brown colour occurs, we may very generally infer that little else than an ordinary dyspeptic attack has supervened, and if the urine be in other respects of normal character, no great anxiety need be entertained on the subject. There is not, however, the same security in those forms of lateritious deposit characterised by a white or dark purple colour. When urine depositing the nut-brown sediment is not much above the normal specific gravity, (that is to say, not above from 1018 to

1022,) and when no evidence can be obtained of the presence of sugar, we shall seldom be wrong in attributing the attack to some accidental exposure or intemperance in diet; but it will sometimes happen, and that in cases in which other symptoms to countenance such a belief are entirely wanting, that traces of sugar can be detected in the urine, and then it becomes our duty carefully to investigate the case, and steadily to enforce treatment. It is not uncommon for persons, who have passed lithates for years without the supervention of any disagreeable symptom, suddenly to become the subjects of dyspepsia, attended with thirst, and then, on applying to their medical attendant, to doubt the possibility of any mischief having arisen from neglect of a symptom to which they have become, as it were, habituated; nor is it uncommon to learn from them that they never feel so well as when excreting the deposit in large quantity. It is only when this form of deposit is associated with a saccharine condition of urine, that it becomes of importance as a disease, and it is always well to be sure of the absence of sugar in the secretion before we promise the patient that certain and immediate relief, which we need seldom fail to afford in the uncomplicated form of dyspepsia, leading to the deposition of brown lithates as a sediment. Dr. Prout remarks, when treating of this subject, that the tendency to the deposit of lithic sediments is almost invariably connected with hæmotrophy of the kidney. Now it is true that we observe the lithic acid in the crystalline form, and the lithates also, occasionally appearing in the urine of those who are the subjects of albuminuria; but this is far from always the case, and again, the lithic acid and lithates are most decidedly found unconnected with a coagutable state of urine; so that I cannot well understand how the close connection spoken of by Dr. Prout can have presented itself to his mind, nor upon what grounds he has determined the presence of hæmotrophy in the cases to which he alludes. When the lithates deposit in the urine entirely devoid of colouring matter, and approach the white tint of the phosphates, it is not uncommon to observe dysuria as a symptom. I am far from considering with Dr. Prout, that this deposit is indicative of a tendency to deposit the phosphates, that is to say, if it be secreted pure, and entirely soluble in the urine when heated. The nut-brown deposit noticed above, I have, however, not uncommonly found alternating with the triple phosphate, which would tend to show that when these two deposits follow each other, the white lithates are not necessarily to be expected. The cause of this alternation of phosphatic with lithic deposit will be hereafter entered upon. The lithates, when excreted of a red or pink colour, are generally concomitants of a febrile condition, and disappear immediately the cause for constitutional disturbance (if it admit of remedy) is removed. In rheumatism and rheumatic gout, I have observed the red sediments to occur very frequently; and in a case of the kind recently under my care, I had an opportunity of witnessing their gradual change to a bright pink, while the urine assumed a dark purple colour, resembling that of murexid. In this case there had been long neglect of the bowels, and dyspepsia, while constipation formed an obstinate symptom throughout the course of the disease.

In cases such as that above described, it is not uncommon to find old visceral derangement; and provided rheumatism and gout do not appear as part of the disease, the appearance of the pink deposit must be regarded with anxiety. When, however, such symptoms are present we know they alone are occasionally capable of producing this urine with the pink deposits, and there is less cause to fear the existence of deep-seated disease affecting the liver or other chylopoietic organs.

The red and pink sediments have been regarded as peculiar to fever, to the exclusion of the yellow amorphous sediment. I have observed the latter several times in typhus and remittent. As a general rule, however, the red sediments are produced by the febrile state.

The treatment to which it is necessary to have recourse in these affections must vary according to the character assumed by each kind of deposit.

When the red crystalline form of lithic acid is excreted, it has been very commonly supposed that the chief benefit we can derive is to be expected from the administration of alkaline remedies, which are known to correct the acid state of urine found in connection with this form of disease, and, moreover, to act as solvents on the deposit itself. It is a matter of fact that alkaline remedies will constantly cause the urine of patients suffering from the lithic acid deposit to become clear and transparent, and that the symptoms of dysuria are generally relieved by the remedy; but I have seldom known this palliative treatment attended by any lasting benefit; and we must remember, that it should be our object to correct those general conditions of system on which the production of the unhealthy urine depends, rather than to afford a temporary benefit, by the use of means in themselves but ill calculated to effect the great object of all treatment.

It is true that in those forms of deposit having a tendency to agglutinate, and therefore threatening the formation of calculi, the use of alkaline remedies may be necessary for a short period, and should be used in virtue of their mechanical as well as chemical powers to rid the bladder and urinary passages of the irritation produced by adherence of the deposit; but it is not to the continuance of such treatment, that we are to look for relief even in this form of disease.

It has probably been matter of experience with most of those who met with cases of red deposit, before the chemistry of urine had received attention, that any remedy possessing the power of invigorating the system, improving the appetite, and relieving the sense of fulness and tendency to sleep after meals, was capable of exerting a powerful controlling action over the excretion of lithic acid by the urine. The labours of animal chemists, however, produced so great a revolution in the minds of practitioners, that notwithstanding the force of prejudice (in our profession not generally so easily conquered), the practitioners of our art almost universally adopted the opinions of those whose labours and results in the laboratory unfortunately assumed a complexion giving them an apparent right to dogmatise in physic; and the indiscriminate and mischievous use of alkaline remedies in cases of lithic disease is a prominent instance among the evils they were allowed to inflict. Apart from their use as mechanical agents acting through their solvent chemical power, I have good reason to discredit the production of benefit by their use, and they retard rather than expedite the good effects we can derive from the exhibition of other remedies. There are several forms of disease in which the elements of the urine appear to arrange themselves in an unusual manner; and the formation of urinary deposit, not only in those cases of disease in which it is formed by a natural constituent of urine, but even when a material foreign to health appears, would seem sometimes to depend rather upon this tendency, than to the secretion of a positive excess of the constituent in the one case, or the production by the blood of some unusual body in the other. In such instances it is that we are generally at a loss to comprehend the causes in action competent to the production of the effect upon the urine; and though we may sometimes contrive, by the ingenious doubling and mingling of atoms, to extract a probable explanation by the transposition of elements, we are in no way assisted by this process to a better understanding either of the true nature of the disease or the plan of treatment best adapted to its cure. Although we derive but little assistance from chemistry, so far as the treatment of this form of disease is concerned, we yet have present a certain set of symptoms indicative of general constitutional disturbance, by treating which the urinary mischief admits of being alleviated.

The exhibition of mild aperients combined with alteratives at night, and the use of vegetable tonics administered at intervals during the day, will generally be found of immediate efficacy in the cure of the disease in its early stages. When, however, the patient suffers from symptoms indicating a tendency to the formation of calculus, such as lumbar pains or sharp cutting sensations in the course of the ureters, it is well to combine our tonics with the liquor potassæ, or bicarbonate of potash, in moderate doses. From fifteen to twenty minims of the former, or ten to fifteen grains of the latter, will generally be found sufficient in most cases. It is well, however, and more especially in hypochondriacal persons of low power, gradually to omit the use of alkali on the disappearance of the pains. This is best done by substituting small doses of magnesia for a few days, after which all alkaline remedies may be set aside.

As regards the diet advisable in this form of disease, in early cases, there appears no objection to the use of any article known by experience to agree with the stomach of the patient. A careful regard to quantity is of course as valuable here as in every description of disease in which dyspepsia takes a prominent part. When long-continued inconvenience has been experienced from discharge of the lithic acid however, fish diet may be enjoined, with rest and perfect freedom from causes of irritation and anxiety during the hours of digestion.

The use of wine is objectionable; and in all cases, however mild, it is right to diminish the quantity to which the patient may have been accustomed, as an indispensable part of the treatment. Ripe fruits, which, from containing vegetable acids combined in excess with alkaline bases, yield alkaline carbonates to the blood and urine, are sometimes of use in cases characterised by the cutting pains of gravel; but, like alkaline remedies in general, are more valuable in the removal of immediate symptoms than as adjuvants in effecting a permanent cure. In simple cases of lithic deposit they are not needed; and as they are frequently productive of much evil by causing increased dyspepsia and much distress from flatus, it is generally better that they should be avoided. This same objection, and for the same reason, applies to acid wines and beer. When the patient passing lithic acid possesses a pulse indicative of power, I know of no better means of relief, and no better prophylactic when the attack has passed off, than that afforded by the use of the cold sponging-bath and friction of the skin. It is not every constitution, however, that is capable of bearing this somewhat severe method of rendering the skin an active organ, and care is therefore requisite in prescribing such discipline. Whatever the condition of the patient, however, as regards diathesis or constitution, we shall seldom do wrong in enjoining the daily use of the horse-hair gloves or flesh-brush, applied over the surface every morning. Steady exercise, always short of fatigue, is an important adjuvant in every form of lithic disease in its early stages. The increased exhalation thus obtained from the skin, of those nitrogenous ingredients of the blood which are constantly excreting from the nephritic and cutaneous surfaces, will be found greatly to relieve the kidney, and produce urine less abounding in lithic acid.

The general treatment of the sediments composed of lithates nearly corresponds with that required for the relief of the lithic acid form of deposit; viz. tonics and alteratives, with the use of cutaneous friction.

In persons who become the subjects of this deposit after excessive exertion or occasional irregularities of diet, the free use of cold bathing and frictions in the morning, as a habit, will constantly be found a most rapid means of effecting a cure.* It would appear that weakly persons, in whom the cutaneous surface is inactive, convert the tissue wasted during exertion into a constituent of the urine, rather than into an excretion of the skin, and thus it is that, after exercise, some persons become liable to the deposit of lithates. The improvement of the general health by acid tonics and shower-baths is in such cases attended with immediate relief from urinary symptoms.

It is not uncommon to find patients in whom, for days together, an alternation takes place by the excretion of phosphatic deposits on the same day with the lithate of ammonia—the one forming the deposit of the night urine, the other that of the morning. This form of urinary affection is often observed in persons of advanced age, and is then generally attended with considerable irritation, and frequently complicated with disease of the bladder, prostate, and urinary passages. The phosphatic deposit is generally composed of the monobasic ammoniaco-magnesian salt, and the lithates are of the nut-brown colour. In some cases the explanation of this condition would appear to consist in the fact, that during the day the skin is less actively engaged in excreting water than during the

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* So complete is the influence of cutaneous friction on the urine of these cases, that I have known its omission followed by an immediate return of the deposit, which again disappeared on having recourse to the sponging-bath.

hours passed in bed, and that therefore more water appears with the evening urine, and thus the deposit of lithates is prevented, while the irritable mucous membrane of the urinary passages pours out an alkaline secretion in a sufficiently large quantity partially to neutralise the acid of the urine, and thus lead to a condition favourable to the crystallisation of the phosphatic salt. During the day there will, of course, be causes of irritation in action on the mucous membrane which do not exist during the night, and we therefore have the alkaline flux from that surface occurring in increased quantity in the day-time. When this alternation of phosphates with lithates occurs in the urine of young persons, it is indicative of the phosphatic tendency, and generally co-exists with irritation of the gastric as well as urinary mucous membrane.

In severe dyspeptic cases, characterised by the deposition of the lithates either of a lighter colour than usual or of a red tint, we sometimes observe, as mentioned before, that sugar can be detected in small quantity. The patient himself will sometimes mention that he has observed a peculiar odour in his urine. These cases should be treated with the greatest care, and the patient fully informed of the danger to which he will subject himself by neglecting the rules of life and method of treatment enjoined by the medical adviser. In the general, we shall seldom do wrong to prescribe small doses of opium in these cases, in combination with ipecacuanha, at night, while the greatest benefit will be derived from the use of the hydrochloric acid in large dose. I have lately been induced, from the benefit derived from the use of this remedy, to make trial of its efficacy in confirmed diabetes, but have not yet had sufficient experience to speak confidently of its powers. Strict attention to the bowels and state of the liver, as shown by the stools, is very necessary in the treatment of this class of disease, which is frequently connected with visceral obstruction.

The pink deposit of lithates is so generally connected with rheumatic or gouty disease, or with organic visceral mischief, that the treatment necessary must vary with the peculiar character of each case, and the indications of the urine in no way allowed especially to influence us, either in the adaptation of means, or the selection of remedies.

ON THE PHOSPHATIC DEPOSITS.

These deposits generally occur in urine possessing a specific gravity lower than that of health; sometimes it is found slightly acid, but generally neutral or alkaline. When viewed under the microscope, these deposits assume peculiar definite forms, indicating their character. (Vide description of plate, figs. 1. and 2.) Examined chemically, they yield the re-actions described at p. 61.

The forms of disease characterised by the deposit of the bibasic stellated salt of ammonia and magnesia do not always necessarily differ from those yielding the monobasic salt, the deposit showing itself either as one or the other, according as more or less alkali is developed in the urine. The stellated bibasic salt is, however, as a general rule, observed in the more advanced cases yielding alkaline urine, and is constantly present in the latter stages. The decomposition of urine containing the monobasic salt, owing to the generation of ammonia, frequently causes a deposit of the stellated crystals to occur in combination with phosphate of lime. This is far from uncommon when, from long-continued exercise or a full meal, the patient passes urine of high specific gravity, that is to say, from 1028 to 1031, or even higher than this.

We may divide the cases of alkaline urine into two classes; 1st, those depositing the crystalline sediment, and, 2dly, those depositing the amorphous white sediment. The first of these is the most frequently met with in young persons, while the last is generally indicative of confirmed mischief, and observed most frequently in old age in connection with disease of the bladder and prostate; it is also a sequela of calculous disease in every form, at the advanced period of life.

Dr. Prout, in treating of these affections, has described a variety of disease as separable from the two above mentioned, and as characterised by the secretion of the carbonates of soda, potash, and ammonia. From the description of this variety of urine, and the symptoms accompanying its excretion, it would seem to be produced as the result of that state of the urinary apparatus occurring in advanced stages of prostatic disease, when the ureters and kidneys have become involved, owing to the continuance of obstruction by stricture. Thus in cases going on to suppurative disease of the kidney, the urine is voided of this character, which I believe to be entirely dependent on the state of the canals from the kidney to the urethra acting on the urine after secretion, rendering it ammoniacal and mixed with blood, and in no way to be connected with any peculiar constitutional condition influencing the secretion of the kidney.

As regards the question of phosphatic deposits generally, and the tendency to the alkaline character of the urine, I feel persuaded that in nearly all cases the real disease exists, not in the presence of any peculiarity on the part of the kidney as a secreting organ, but on a tendency to the production of alkaline fluid on the lining membrane of the whole, or a part, of the urinary apparatus. The treatment of these diseases, as founded on this view of their pathology, has led to such favourable results, that I am daily becoming more and more persuaded of the truth of the position. It has been far too much the fashion to regard the abnormal qualities of the urine as indicative of some general state of the system showing itself through the medium of the kidney, whereas it almost admits of demonstration that the kidney frequently secretes urine possessing the qualities of health, with its acid re-action and other normal qualities, while it passes from the urethra fœtid and ammoniacal. I do not here allude to cases of old bladder disease, or on that condition of the viscus observed in cases of spinal lesion, but to cases admitting of cure, and not necessarily characterised by any symptoms of cystitis. A young or middle-aged person becomes the subject of irritation during the passage of urine, in connection with gastric symptoms, and aching irregular pains in the course of the ureters. His appearance is that which we are apt to describe as indicative of a general want of tone, and on examining his urine we find it either ammoniacal, neutral, or faintly acid, with a deposit of mucus and phosphates. If it be supposed that this depends on mal-secretion on the part of the kidney, knowing as we do that mineral acids will increase the acidity of healthy urine, nothing can be more reasonable than to supply these remedies for the cure of the patient; but if, on the contrary, no such mal-secretion is going on, and the urine only becomes alkaline after leaving the kidneys, and during its course through the passages, nothing can be required from the mineral acids. That, however, which remains to be done, in accordance with the pathological view I have advanced, is to act upon the urine in such a manner as to render it less irritating to the lining mucous membranes, and thus prevent the secretion of that alkaline flux which has been pouring out in quantity. It appeared to me that the use of alkaline remedies might be of advantage in these cases of alkaline urine, and, moreover, that if the alkali were administered in small doses so as only partially to neutralise the acid state of urine as secreted by the kidney, we might relieve the irritation of the mucous membranes, stop the excretion of alkaline matter, and have an acid urine excreted, the natural acidity having been only partially destroyed by our remedy. It may appear somewhat unaccountable to those who merely look to the chemical view of the matter that any one should expect to render alkaline urine acid by the administration of alkalies, but such was the treatment I adopted, and the result fully corroborated the correctness of the theory which suggested it as a crucial test.

The first case I met with, and which afforded the symptoms indicative of phosphatic disease, occurred in a gentleman of leuco-phlegmatic temperament, who had suffered much from despondency, and whose urine was generally alkaline and occasionally neutral. His appetite had given way; his bowels were constipated; and he had become the subject of shooting pains in the loins and down the ureters. There was no very great distress experienced in passing urine, nor was there frequent desire to do so at any period of night or day. The excretion was loaded with mucus mixed with the earthy phosphates.

In this case I exhibited the liquor potassæ in doses of twenty minims three times during the day, combined with hyoscyamus, in a mucilaginous vehicle. The result was, that my patient's urine became acid on the second day, and continued so till all his disagreeable urinary symptoms were removed. It was not of course necessary to continue the alkali beyond this point, as by its prolonged use it undoubtedly would have eventually caused an alkaline urine to be secreted from the kidney. At this period of treatment, therefore, I had recourse to tonics containing an acid, a form of medicine which had been tried before the alkali was exhibited, and had produced so much irritation and so great an increase of the fœtid odour of the urine without decreasing the deposit, that we were forced to abandon its use. It was found, however, that the acid could now be borne with advantage, and much good was obtained by its careful exhibition.

The second case in which I had an opportunity of making the same kind of observation occurred among the patients at Guy's Hospital, in the person of a woman under the care of my friend and colleague, Dr. Babington, who kindly allowed me to prescribe for his case.

This patient had been subject to fits from childhood, and was admitted into the Hospital for the cure of epilepsy. She, however, became suddenly seized with urinary symptoms, experiencing difficulty in passing her urine, which was turbid, alkaline, and fœtid if long retained. When I saw her she was stated to have suffered increased distress from the exhibition of acids, though there were no indications of bladder disease. The quantity of mucus voided was very considerable; the sequel of this case, however, as well as its history, sufficiently showed that the bladder was not materially involved. The acid remedies being laid aside, I ordered this person the liquor potassæ with tincture of hyoscyamus three times a day, and in a few days had the satisfaction of perceiving the urine passed to be of acid re-action, clear, and in every respect natural.

I am not prepared to say that all cases characterised by the deposit of the earthy phosphates are pathologically identical with those alluded to above;

but I am certain that in the greater number of cases in which alkaline and neutral urine exists, with mucus and phosphates as a deposit, we shall find alkaline remedies of avail; and that if given in regulated dose we shall by their action obtain the excretion of an acid urine, showing that the cause of mischief is seated below the kidneys, but not necessarily in the bladder.

In the mild form of disease in which we observe the triple phosphate as an occasional deposit, we shall often detect a general state of irritability, with gastric disturbance, which I believe is connected with a condition of the urinary mucous membrane resembling that so evidently produced upon the gastric surface, as shown by the tongue and state of the bowels.

I am satisfied the urine is not secreted in an alkaline state in many of these cases, but that the deposits of phosphates occur occasionally in consequence of an alkaline discharge taking place from the mucous lining of the kidneys and ureters, just in the same manner as we know the mucous intestinal surface to be irregular in this respect, subjecting the patient one week to constipation and the next to diarrhœa, of a mixed mucous and bilious character.

Now, an alkaline state of the urine will account for the deposit of the phosphates contained in it; but it can in no way be regarded as a cause for their absolute increase in proportion, and when this takes place, very important changes must be going on in the economy. In mollities ossium this increase occurs, and probably in other forms of disease; but the great multitude of cases met with in practice are not of this kind, but are rather to be considered as instances in which no increase takes place in the positive proportion of the phosphates, but which, owing to the urine becoming alkaline or neutral, are characterised by the deposit of those earthy salts which were before held in solution.

Any one in health may assure himself that the normal proportion of earthy phosphates is sufficient to produce a copious deposit, by adding ammonia to his urine, and allowing the precipitate to subside. If it be remembered, when making this experiment, that an excretion of mucus frequently accompanies the deposit of phosphates, greatly increasing its apparent bulk, it will probably be a matter of surprise to the experimenter, that the phosphatic deposits occurring in disease are not even more voluminous than they are observed to be. The mucous membrane of the bladder has been supposed to secrete phosphate of lime in considerable quantity, and many circumstances connected with the history of calculous disorders would tend to support such an opinion. With the knowledge, however, of the capability of the mucous surfaces to secrete an alkaline mucus, and the facility afforded for the deposit of phosphatic salts from the urine in virtue of this property, great care is required before such an opinion can be generally adopted in the case of the urinary organs.

There is an apparent analogy afforded here by the intestinal mucous surface, which is known not unfrequently to produce calculous matter, but these masses are of slow growth, and it is not easy to determine how much may depend upon the decomposition of the chylous and other fluids containing phosphates, by detention in the neighbourhood of diseased portions of membrane. A reason which has been quoted for conceiving the concretions in both cases to depend on the secretion of earthy matter by the membrane itself, is, that a deficiency of the magnesian salt is observed in the urinous concretion, which could scarcely be expected were it derived from the urine, simply owing to the production of alkali by the membrane. These concretions, however, really contain magnesia in considerable quantity.

Carbonate of lime is sometimes found associated with phosphate adhering to the surface of mucus voided from the diseased membrane of the bladder in advanced cases, which may possibly be the result of decomposition of the urine, but the mucous membrane can scarcely be supposed to secrete a carbonate. On the whole, the probability is greatly in favour of such deposits being dependent on the decomposition of the fluids passing over the membranes, rather than on any power on the part of the surfaces themselves to secrete earthy salts.

There is a condition of urine to which I have directed attention in a former part of this work, in which we find that it deposits a precipitate of the earthy phosphates on the application of heat. This state of urine has been described as dependent on the presence of an excess of the earthy salts, whereas it is rather the result of a tendency on the part of the constituents of the urine to arrange themselves in a peculiar manner; the phosphates thus depositing not necessarily indicating their presence in excess. The urine may be acid or alkaline, and yet this deposit occur ; in the former case, however, the deposit generally consists of the triple phosphate. On considering generally the pathology of the phosphatic deposits and the tendency to the secretion of alkaline urine, which is an almost constant concomitant, it would appear that the general system, so far as is shown by the secretion of the kidney, is rarely so seriously involved as has been supposed; that, in fact, the mucous surfaces are involved rather than the nervous structures, which has been assumed as a condition necessary to the existence of this class of affection. The facts, we observe, in the great majority of cases are easily explained on the former supposition, while, if we except some cases of paraplegia, little else than gratuitous assumption has been brought forward in support of the latter opinion.

In the management of these cases, it is of the utmost importance to watch the urine as an index of the effect of the remedies employed, and when about to commence treatment, much is to be done by examining the excretion several times before any plan is determined upon. If the general symptoms observed are those of gastric irritation, and the urine deposits mucus with either an amorphous or crystalline phosphatic sediment, we may conclude that alkaline remedies are indicated as the first part of the treatment, and that the kidney is not greatly in fault. The bicarbonates may be exhibited with advantage in such cases. If, on the contrary, we observe a large amorphous deposit in conjunction with blood and mucus, while the urine is extremely fœtid, and incontinence exists as a symptom, we may conclude that fatal disease is established, and the kidney in all probability is greatly involved in the mischief. Little remains to be done in such cases than to palliate the sufferings of the patient by attention to diet and regimen, while care is taken that any stricture existing is prevented exercising a pernicious influence by the constant use of the catheter. In the former class of cases, the use of alkalies should be discontinued immediately we perceive the urine to have become acid under their employment, and then alteratives, containing mild mercurials and ipecacuanha, with vegetable tonics, will generally complete the cure. It will be found in some few cases of recent origin, and of mild character, that the use of alkalies may be dispensed with, and this is especially the case when the morobasic triple phosphate alone is secreted; but if any considerable irritation be observed, and mucus detected in abnormal proportion in the urine, it is always well to combine an alkali with our tonic remedy. As regards diet in this form of disease, we can say little more than enjoin general temperance and the use of nutritious and easily digestible food, while all articles of diet either solid or fluid, known by experience to produce flatulency, should be carefully avoided.

I shall now say a few words on the treatment of that form of phosphatic disease so often set up during the formation of a calculus, and which, as the result of irritation of the mucous membrane of the bladder, is complicated with certain peculiar conditions of the urine. A knowledge of these conditions is absolutely necesssary before we can form a correct prognosis, and the determination of the value of the signs observed must often influence the conduct of the surgeon in attempting the permanent cure of his patient by operation. Whatever may be the nature of the original deposit forming a calculus in the bladder, it constantly happens in irritable subjects that the urine becomes alkaline, while mucus and phosphates occur as a deposit. The bladder next becomes further affected, and pus is poured out in addition to the mucus and phosphates; while, owing to the excretion of this pus from the lining membrane of the bladder, albumen may be detected dissolved in the urine. Now, an albuminous state of urine occurring independently of the presence of pus or blood, and showing itself day after day, is an indication of disease of the kidney, and if such disease could be discovered to exist, our prognosis would be very unfavourable; but if, on the contrary, we are able to trace the presence of the albumen dissolved in the urine to the existence of pus, our prognosis assumes a more favourable character, and hopes may be reasonably entertained that on the extraction of the calculus the bladder will be relieved from irritation, and the urine assume its healthy qualities. Under these circumstances it becomes of extreme importance to determine the absence of kidney disease; and we shall rarely fail to do so by attention to the following rule:—If the bladder alone be in fault, we shall always find that the quantity of albumen to be detected in the urine by the nitric acid test will bear a proportion to the quantity of purulent deposit, and the urine must be examined from day to day in order to determine this point. If, on the contrary, the albumen to be detected does not undergo diminution or increase in quantity proportionally with the purulent deposit, we may reasonably suspect the kidney to be involved. A case of calculus in the bladder lately occurred at Guy's Hospital, under the care of my colleague, Mr. Morgan, in which I was consulted, in consequence of the existence of albumen in the urine rendering the propriety of operating a matter of doubt. In this case pus, mucus, and phosphates were passed from the bladder; and by repeated observation I assured myself that on favourable days, when but little pus appeared, a corresponding decrease took place in the proportion of albumen in the urine.

I therefore had no hesitation in expressing an opinion that the operation would benefit the patient, by relieving the bladder of that cause of irritation on which the presence of albumen in the urine depended, and that in all probability the kidneys were unaffected. This patient underwent the operation, and recovered rapidly, his urine, after the healing of the wound, being no longer albuminous, which would not have been the case had he been affected with kidney disease.

When relief from calculous symptoms cannot be obtained by operation, and phosphatic deposits become mechanically inconvenient, we shall generally find that the benefit which might at first view be hoped for from the solvent action of acid remedies cannot be obtained, inasmuch as the urinary mucous membrane only becomes the more irritated by their use, and the urine more loaded with mucus and phosphates. In such cases, alkalies in small dose are frequently of service, and much advantage has occasionally been gained by the dexterous use, on the part of the surgeon, of sedative injections made weakly acidulous by nitric acid.

ON THE OXALATE OF LIME DEPOSITS.

Urine depositing the oxalate of lime often possesses a peculiar greenish-yellow colour. It is seldom of a specific gravity, varying greatly from that of health. Viewed under the microscope the deposit represents forms shown on the plate (fig. 9.). When examined chemically it yields the re-actions described at page 73. These crystalline forms would appear, according to the statements of Dr. Bird, to be of more common occurrence than was formerly supposed the case.

The state of system on which the secretion of urine characterised by the deposit of oxalate of lime depends is not well investigated. There appears some degree of probability that it is connected with the formation of lithic acid in excess, and with that state of system in which a considerable proportion of urea is secreted. This view has been advocated by Dr. Willis, and since adopted by others. Dr. Prout, however, states that he has known several instances in which the abuse of sugar led to the oxalic acid form of dyspepsia, and afterwards to the formation of calculus.

The pathological chemistry of the subject is at present somewhat a matter of doubt, and it would almost appear that more than one source existed for the production of a tendency to this form of disease. Further and more correct observations are needed into the physical condition of patients suffering from oxalate of lime deposit than any we yet possess. We find that chemistry is at no loss, however, to devise theories for the transformation of several organic principles into oxalic acid, and whether it be derived from sugar, urea, or lithic acid, we can make our formulæ by abstracting or adding oxygen as the case may require. All this, however, must be looked upon as a display of ingenuity on the part of the chemist, and we should wait till accurate and long-continued observation, conducted on the urine of patients, helps us to better evidence on which to found a conclusion. Unfortunately, the addition or subtraction of oxygen necessary to some of these theories has not been proved or even rendered probable, and no good reason has been given in most cases for transforming one proximate element rather than another for the formation of a diseased product. It is often the case that more than one proximate element would answer the purpose required, owing to their similarity of composition; and the profusion with which chemists are in the habit of taking away or adding oxygen by as many atoms as it may please them, still further lessens any difficulty that might at first appear to stand in the way of effecting an explanation.

In connection, however, with the subject of oxalic acid, as produced in the urine, I have great pleasure in noticing a contribution to the pathology of oxalic disease by Dr. Aldridge of Dublin*, who so far differs from most other chemical theorists of the day that he has really rendered it more probable that oxalic acid is formed from lithic acid than from any other of the constituents of the urine. This gentleman has shown that lithic acid, by the addition of the elements of water, in varying proportion, may theoretically be converted into oxalate and carbonate of ammonia, hydrocyanic and formic acids, according to the circumstances of decomposition, and further, by heating urine, and in some cases evaporating it, has succeeded in producing re-actions in the fluid indicative of the presence of the acids above named; oxalate of lime depositing, while evidence of the hydrocyanic and formic acids could be obtained from the fluid. This is really a step in pathology, and has more practical bearings than may at first sight appear evident. Now when urine is secreted by the healthy organism, we know that the constituents are so arranged, that the fluid possesses certain definite qualities recognised as those indicative of health, and that when disease sets in, there is sometimes observed a tendency on the part of the constituent elements of the fluid to arrange themselves in a different manner to this, and that, too, without any very notable increase or decrease in the proportion of such elements being observed. Considering the question in this point of view, and remembering that in Dr. Aldridge's experiments no

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* See Bird on Urinary Deposits, p. 160.

re-agents were had recourse to, and that ebullition alone produced oxalate of lime in healthy urine, which did not yield such crystals before being boiled, we are justified in the belief that such a deposit may very easily form in the urine in certain states of system after secretion by the kidneys, and during its detention in the urinary tubes and bladder. It seems highly probable that in some cases which have been described, the oxalate of lime has been rather formed after the urine has been secreted, than as a result of the secreting process; and Dr. Aldridge's experiments point to the absolute necessity of examining urine soon after excretion, and without applying heat, which tends to the formation of oxalate of lime even in healthy urine.

The symptoms observed in those who suffer from the oxalate of lime deposit are characteristic of general debility and irritation, not unlike those observed in the phosphatic form of disease; with the exception, that the patient is liable to the more severe forms of hypochondriasis, and frequently to such an extent as to cause considerable anxiety on this account alone. This tendency to extreme depression indeed would seem to form a distinctive character of the complaint. The uneasiness experienced after taking food, so commonly felt in dyspepsia, is, in this disease, very frequently accompanied with disturbance of the circulatory system, attended with palpitation and dyspnœa. The bowels are often constipated while the tongue is coated and white. In advanced cases, however, we sometimes observe the tongue to be dry, clean, and glazed. When oxalate of lime calculi are forming we frequently observe a tendency to hæmorrhage from the kidney, which accounts for the peculiar colour observed in this variety of concretion.

In advanced cases of this disease Dr. Prout describes a peculiar tint of complexion, of which, however, I have never been able to satisfy myself, though I lately observed very much what he has described in a patient suffering from calculous symptoms, whose urine, unfortunately, I had not an opportunity of examining, but whose history was by no means discordant with the existence of oxalate of lime in the urine.

The treatment of this form of disease in the early stage is such as is applicable to all forms of dyspepsia. It is often combined with symptoms of irritation and mental anxiety, which demand the use of sedatives in combination with alteratives; but it is advisable, as much as possible, to avoid the use of the former. I have no doubt that much mischief has arisen from the indiscriminate use of sedatives for the cure of this disease, and that attention to diet, with the enforcement of regular exercise, especially in the evening shortly before retiring to rest, would have answered every purpose, without enfeebling the system as by the use of hyoscyamus, conium, and such class of remedies. A fish diet is of the greatest service in this affection, nor is there any objection to the use of vegetables in moderation. Wine is very generally preferable to beer, which can seldom be taken by the patient without giving rise to distressing flatulency. In severe cases the use of frictions to the skin is advisable every morning, with the warm bath at intervals of three days; but in slighter cases cold bathing and friction is of far more service, and will be found to assist and expedite the cure in every case, as recovery advances. As regards the use of medicine, there is no doubt that in effecting the removal of the oxalate of lime deposit great benefit is frequently derived by following Dr. Prout's suggestion of prescribing acids; but perhaps the most important secret, in mild cases, consists in emptying the intestinal canal, which will sometimes be found sufficient to remove the whole mischief. Attention to this point, combined with the administration of alteratives, and acid tonics, comprises nearly all that need be done in the general treatment of the oxalate of lime deposit. The severer form of this affection is to be classed among the most obstinate of urinary diseases, and being liable to return upon the least exposure or intemperance, the patient often becomes a prey to the most complete despondency. In such cases calculi frequently form, and the phosphatic salts appear in the urine, which loses its acid re-action, while the state of the patient deters the surgeon from removing, by an operation, that which has now become an additional source of misery. In this form of urine, the exhibition of alkaline remedies is of the greatest service. The liquor potassæ or bicarbonate of potash, in moderate dose, combined with hyoscyamus and mucilage, are to be preferred, while, if there be much irritation during the night, with frequent micturition, an opium suppository should be introduced, followed in the morning by a saline purgative.

There is an anæmiated condition in these patients, which is greatly benefited by the administration of iron and salines; and when the more urgent symptoms can be subdued, it is always right to have recourse to such a plan of treatment.

CYSTINE, ETC.

The cases in which cystine has been detected as a constituent of the urine have been so few that sufficient opportunity has not yet been afforded of investigating the pathology of the subject, and ascertaining the principles which should guide us in treatment. I shall not, therefore, enter here upon a description of the disease; and for the same reason, while considering treatment, refrain from noticing the subjects of xanthine and the fibrinous calculus.

ON ALBUMINURIA, OR THE MORBUS BRIGHTII.

This disease has now been a matter of observation and experiment to the profession for many years, but unfortunately so far as treatment is concerned, little advance has been made since the discovery of Dr. Bright was first announced to the public; and it is curious to reflect upon the fact, that, while in its milder or more recent forms it occasionally yields to the simplest remedies, yet in a somewhat more advanced stage every variety of means adopted for its cure has either failed or met with but partial success. We can, however, I believe in the present day, do more to lengthen life, and render it supportable by the application of remedies in the advanced stages than was formerly the case; and our inability to perform cures must rather be attributed to the nature of the affection than the want of perspicacity on the part of the profession.

The researches of Dr. Bright, which pointed out the connection between this albuminous state of the urine and granular disease of the kidney, first attracted attention in connection with the subject of anasarca; but the further observations and publications of that discoverer subsequently made us acquainted with other and more general states of system of the highest importance to pathology, as connected with the excretion of albumen with the urine. We may now, indeed, regard the state of kidney as associated with albuminous urine as indicative of a state of the fluids generally, tending to modify and complicate nearly every disease to which the patient may become liable, either from exposure or accident. Not only do we occasionally observe kidney disease and albuminuria, when no indications of anasarca can be detected in the patient, but I have known some of the most fatal cases of apoplectic seizure to occur in those who exhibited scarcely any signs of œdema, showing that anasarca must be regarded only as an occasional and not necessary symptom of some general morbid derangement. Why the kidney should be more prone to congestion or granular deposit than any other organ cannot be explained in the present state of our knowledge; but if we assume the blood as first implicated in the disease, this would seem a necessary step to prove, as all the other organs are supplied with the same blood. This is a difficulty; and yet that the kidney is originally involved scarcely seems consistent either with physiology or the history of the complaint. Thus, in the mild forms admitting of cure, we very often observe extreme degeneration of the blood, and the urine loaded with albumen, and yet in such instances the kidney can be but slightly diseased, for permanent recovery often takes place. The albuminous urine appears, therefore, in such cases to be connected rather with a degeneration of the fluids than a disease of the kidney, since that organ is almost certainly in merely a congested condition. The researches in morbid anatomy which have been pursued in connection with this subject seem clearly to point to the kidney as the first link in the chain of causation so far as the solids are concerned; and the lesions of heart and liver so often remarked in cases of albuminuria hold comparatively an unimportant place in the pathology of the affection. The changes effected in the kidney during the early stage have been noticed principally in acute cases, rapidly fatal from the supervention of some disease complicating an important organ. In such patients the kidney has shown extreme congestion, the cortical portion especially being distended, and appearing as though the cellular structure of the organ had become filled with extravasated blood, giving it a dark, chocolate-brown colour. The next change observed in the kidney in the course of this disease may be regarded as that indicative of the commencement of grave mischief, and threatening permanent alteration of the structure of the organ. The cortical portion now becomes impregnated with an albuminous deposit, encroaching gradually at parts upon the tubular structure. At this stage the organ frequently varies from its natural size, becoming larger and softer, or smaller and harder; its colour also changes to a more yellow tinge, and white markings and dots appear on its surface, giving an appearance of mottling, which at once strikes the eye on tearing off the investing membrane. In the latter stages of degeneration the kidneys become one mass of disease; the tubular as well as cortical portion has become compressed by the morbid deposit; absorption of their natural structure seems to have taken place, and they are generally found compressed and hardened. When cut through, the natural structure seems to have become obliterated; and the whole organs appear made up of a white albuminous matter, representing imperfectly, in some places, an approach to tubular arrangement. The kidney is now generally observed to present an irregular surface, the protuberances varying in size from mere papillary elevations to large rounded prominences, which give a lobulated form to the organ. When the investing membrane is torn off, we see the kidney of a light colour, with occasional dark spots or ecchymoses in streaks variegating its surface.

The above are the principal appearances put on by the kidney, as the granular disease advances, and in every stage we observe the urine to contain albumen. The first question which might be expected from the pathologist who was for the first time made acquainted with the fact that this degeneration of the kidney was accompanied with the excretion of albumen by the kidney, would be an inquiry as to whether the proportion of this principle found in the urine bore any relation whatever to the stage of degeneration to which the kidney had advanced. This relation, however, is wanting; and we yet need a guide for determining, in many cases at least, at what stage the disease may have arrived when examining our patient.

The proportion of albumen excreted is generally observed most abundant in early stages of this affection, and is sometimes scanty in very advanced cases; the reverse of this, however, is sometimes the case in these latter instances. In early cases the specific gravity of the urine is often but little changed from that of health; but I have occasionally seen it as light as 1010 and 1012—a specific gravity which rather belongs to the later periods of the disease. In the early stages the quantity of urine excreted is very variable, being sometimes much less than the healthy proportion, and at others equalling that amount. This, together with the fact that the specific gravity of health is sometimes maintained, might lead to the supposition that the evacuation of solids by the kidneys was going on to a natural extent; but Dr. Christison has shown that the preservation of the normal specific gravity is owing to the presence of albumen; and that if we separate this principle we shall find evidence, from the decrease in the weight of the urine, that the daily discharge of the normal solid matters by the kidney is much less than that occurring in health. In the advanced stages of the disease the quantity of urine passed during the day is very variable; it occasionally possesses a very low specific gravity, generally from 1010 to 1015, and the proportion of urea is greatly diminished. In one specimen I examined no trace of lithic acid could be detected.* When a large proportion is passed, this low specific gravity always pertains; but sometimes, when the skin has been active (a common occurrence in advanced cases), the specific gravity of the urine will rise nearly to the normal standard, a proportional decrease occurring in the quantity excreted. In the later as well as early stages of this affection, the solid matter evacuated with the urine during the day is far below the proportion of health.

When testing urine for albumen, we should never be contented with a single examination, as it has been observed free from albumen on some days, even in confirmed cases.

The state of the blood in advanced stages of this disease is such as to render it unfit for the discharge of those functions necessary to the preservation of life, and it early becomes materially degenerated. The three conditions most prominently shown by analysis are the deficient proportions of albumen and hæmatosine, according to the stage of the disease, and the existence of urea in the blood, probably in conjunction with other principles found only in the urine in the healthy state of the system. This contamination of the blood by urea occurs in various other affections, and appears common to every condition of body characterised by ischuria to any extent.

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* It has been considered as probable that in the course of this disease the lithic acid or lithates may alternate with albumen in the urine. Vide Med. Gaz. April 9. 1836.

Immediately that albumen commences passing from the kidney the blood begins to degenerate. The proportion of albumen becomes less, and the specific gravity of the liquor sanguinis diminishes. As the disease advances, the proportion of blood corpuscles is observed to decrease, while not uncommonly the albumen approaches to its healthy proportion. The quantity of fibrin varies greatly, being generally, however, somewhat above the natural proportion, and becoming increased if any inflammatory action takes place in the course of the disease. Dr. Christison states that he has observed the albumen in the serum of some advanced cases to be above the healthy proportion. I have never yet observed this; but more than once have known it approach the proportion of health. The highest specific gravity of serum observed by Dr. C. was 1031 in the advanced stage, and 1019 is mentioned by him as the lowest in the early stage. In the latter case, however, I once saw serum as low as 1015.*

Having now given a general sketch of the changes observed in the kidney and the degenerations of the blood and urine characteristic of this disease, I proceed to consider the causes and symptoms; premising, that there is a difference observed in its duration and severity which appears to authorise a division into the acute and chronic forms.

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* For physico-chemical experiments on the causes of deterioration of the blood in the Morbus Brightii, vide Guy's Hospital Reports, April, 1843.

When albuminuria sets in it is often to be traced to exposure to cold, or a damp and cold atmosphere, under circumstances of depression and fatigue, sometimes, also, to intemperance, and, more especially, the use of ardent spirits. The type this disease may assume, as regards the acute and chronic forms, would appear to depend on the age, constitution, and habits of life of the patient. Thus in some we find such exposure followed by immediate and violent re-action, indicated by a hot skin and dry tongue, with a hard pulse, pain in the head, and severe thirst, while pain in the loins, and sometimes, but not always, ischuria, point to the kidney as the seat of mischief. The urine is high coloured, loaded with albumen, and occasionally tinged with blood. The stomach is irritable, and vomiting not unfrequently occurs, while partial œdema of the face, or complete anasarca, are the most common concomitants. There is great liability to complication by serous inflammation in this form of the disease; and it is thus, in fatal cases, that life is most frequently destroyed. All symptoms which may be referred to the brain are to be carefully watched; as coma and epileptico-apoplectic seizures will sometimes suddenly prove fatal.* When by the early application of remedies this acute form of albuminuria is relieved, it appears probable that complete and permanent cure is sometimes effected; but, again, in

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* See Guy's Hospital Reports, No. 8. Dr. Addison on Disorders of the Brain connected with Disease of the Kidneys.

a large number of cases there is little doubt that such acute attack is followed, at no very distant interval, by the same set of symptoms assuming a more chronic type; and that by repetitions of these attacks the patient sooner or later sinks.

Mild cases of short duration, and generally admitting of permanent relief, are often observed after scarlatina in children, occasioning the anasarca so common as a sequel to that disease.

As regards the chronic form of albuminuria, though we often find on interrogating our patients that they have before suffered from anasarca and other symptoms indicative of the previous occurrence of the acute disease, we as often meet with chronic symptoms as the first indicated by the patient; and these not unfrequently supervene in so masked a manner, and encroach so gradually on the comfort of the individual, that a practised eye is necessary to detect the disease by the slight indications now afforded, and which, when the condition of the urine has been overlooked, have often passed for those of dyspepsia or inactivity of the liver. As regards the symptoms in this chronic form of the affection (though nearly identical in kind), we have them present in a less marked degree than when characteristic of the acute disease. The pain in the loins is much less severe, and sometimes absent. Ischuria, as in the acute form, is not necessarily a symptom, and more commonly, as stated before, large quantities of urine are voided; from 70 to 100 ounces per diem being no uncommon discharge. Anasarca is frequently wanting as a symptom, or only indicated by slight œdema of the face; thus the under eyelids are occasionally swelled, and that only in the morning, and sometimes so slightly, that the patient does not observe it. Dyspeptic ailments, with irritability of stomach, are often present; and when complained of as producing vomiting, may serve to guide us to the examination of the urine, and consequent detection of the true nature of the patient's disease. In this chronic form of the complaint it is often observed that the urine becomes a source of irritation to the bladder, and the patient is distressed with frequent desire to make water, leaving his bed several times in the night for that purpose. This condition is not necessarily connected with a discharge of lithates or lithic acid, which are the common deposits in albuminuria, nor with any peculiarity of the excretion as yet ascertained.

There are many complications attendant on this disease of the kidneys, dependent, in all probability, on the state of the blood, though we are at present unable to trace the manner in which it influences the solids, and much remains for experiment and observation. It may be well to remark, however, in connection with this subject, that the deficient proportion of albumen and hæmatosine, the one observed in the early and the other in the later stages of the disease, are as prominently marked in certain cases of leucorrhœa going on to chlorotic anæmia, as in the disease of which we are now treating; and that I have had occasion to prove the presence of urea in the blood, and that too in considerable quantity, in a case of the mild form of albuminuria occurring after scarlatina, and which was rapidly cured. These facts would seem to show that the state of the blood in albuminuria requires further experiment. The organs most commonly implicated in albuminuria, in addition to the kidneys, are the heart, the liver, and the brain; and in examining cases it is of great importance to ascertain their conditions, so far as we are able, by physical signs, as well as by the evidence to be obtained from symptoms described by the patient. The state of the brain especially should be watched, as death is commonly occasioned by implication of that organ. In many cases, however, œdema of the glottis with more or less bronchitis, or sudden effusion into the pericardium, closes the disease.

The treatment of acute albuminuria differs materially from that adapted to the relief of the chronic form of the disease; and we frequently find that the simplest means are capable of working a permanent and rapid cure. This is remarkably the case in those instances of albuminuria and anasarca observed after scarlatina, in which mild purgatives and salines are generally found sufficient remedies. In other cases, however, the acute form of this disease is attended with violent symptoms requiring the active interference of treatment for the preservation of life; and this remark applies to some few cases of anasarca occurring after scarlatina, though these, for the most part, are mild in character.

When acute albuminuria exists, I have always found the greatest benefit from treating the disease by the application of remedies affecting the skin. Of the various plans of treatment recommended, nearly all of which I have either seen practised or myself prescribed, I must confess that none ever impressed me so fully with a conviction of its beneficial effect as that which enforced the use of diaphoretic remedies as a principle means of obtaining relief. The favourable results which have been observed from the use of antimony I feel no hesitation in ascribing purely to its diaphoretic action, and further than this, am inclined to prefer, in most cases, the use of ipecacuanha, or of Dover's powder: the latter a formula in which the opium present assists us greatly in obtaining a ready action on the skin. The use of the warm bath every other day, with acetate of ammonia and Dover's powder, taken in draught twice during the twenty-four hours, if combined with the occasional administration of saline purgatives, will generally be found an excellent plan of affording relief in acute cases, unattended with any inflammatory complications.

When, however, bronchitis or pneumonia are discovered to exist, we should have recourse to depletion with mercurials, but may still continue our diaphoretics as a part of the treatment. As regards depletion in the acute stage of albuminuria, all that we know of the state of the blood in the disease would lead to its disuse, as a remedy having a tendency to lead the case into the chronic form of the affection, by decreasing the proportion of red corpuscles in the blood; and though I have occasionally observed benefit from the use of the lancet or cupping, I do not believe such treatment to possess any advantage over the diaphoretic plan; and unless rendered an imperative measure by the presence of high inflammatory complications, experience has made me averse to its use in every form of this disease. The strong objection to the use of mercury expressed by many writers on this subject, though it would appear justified by the results of some few cases which have been subjected to the mercurial influence, is not so strongly impressed upon my mind as to induce me altogether to reject it as a remedy in acute cases, even when no complications exist. It appears to relieve the kidney greatly, but care must be used in its exhibition; and very small doses of mild mercurials are sufficient for the required purpose, as this mineral produces its effects very rapidly in albuminuria, occasionally causing profuse ptyalism when not more than two or three grains of calomel have been taken by the patient. In the more chronic form of albuminuria the employment of diaphoretics is of almost as much importance as in the acute disease; but it now becomes necessary to avoid their use to such an extent as to produce a depressing effect on the system. Patients on whom we are inducing diaphoresis, either by means of antimony, ipecacuanha, or any other medicine, should be constantly watched, and the remedy discontinued on the first signs of remission in the power of the pulse.

The free use of purgatives is of the greatest importance when commencing the treatment of the chronic form of this disease, and is a most powerful means of lessening the painful tension of the skin produced by anasarcous effusion, and often relieves the patient in a surprising manner from the dull sleepiness and tendency to coma, a cause for so much anxiety to the practitioner. The anæmia existing in this chronic form of albuminuria is best treated by those remedies known to influence the blood, and to assist in restoring it to its healthy constitution. When the first distress experienced by tense anasarca or pain in the loins is relieved by the use of diaphoretics and purgatives, the greatest benefit will accrue from the use of ferruginous medicines. The lactate of iron given three or four times a day in doses of five grains, with columba or any mild tonic, I believe is better adapted to restore the patient than any medicine with which I am acquainted.

As regards local treatment directed to the kidney, the use of counter irritation is greatly to be advised in cases of chronic albuminuria which are not very advanced. Setons or issues in the lumbar region I have known to assist in obtaining an early recovery. Much has been said concerning the propriety of administering diuretic forms of remedy in albuminuria, and it would appear desirable in most cases to avoid them; indeed they will often be found to produce considerable distress when the pulse is hard, and the tendency to the excretion of large quantities of albumen is observed on examining the urine. In some advanced cases, however, I have seen digitalis in small dose combined with squills of service in relieving symptoms of ischuria and bronchitis; as a general rule, my conviction is that they are better avoided.

CHYLO-SEROUS URINE.

The chemical history of chylo-serous urine is given in the Appendix.

I have seen but one case of this disease, which is of rare occurrence in our climate, and more frequently observed in warmer latitudes. The pathology of the affection is exceedingly obscure, and is probably connected with the history of a subject as yet but imperfectly investigated; viz. the changes occurring in the circulation during the admission of chyle. It is well ascertained that the disease may exist for many years without creating much distress. According to an observation made by Dr. Prout, on the body of a patient who died of inflammation of the bowels while passing this kind of urine, it would appear that its presence is not necessarily connected with any appreciable organic lesion of the kidneys. No particular remedy or plan of treatment has exercised any especial influence upon the disease, though benefit has been derived, as in most other cases, from carefully watching and treating symptoms.

The obscure pathology of this affection, and its rare occurrence in this country, induce me to pass it with this slight notice, notwithstanding that its connection with the subject of sanguification affords an inviting field for hypothetical reasoning.

ON DIABETES.

The urine passed in this form of disease contains sugar, and is of high specific gravity, being generally above 1030, and often as high as 1057. Dr. Prout states that he has seen it as low as 1015. It is but rarely, however, that it is observed even so low as 1025. Diabetic urine is of a pale straw colour, and clear, seldom depositing a sediment, and froths considerably when agitated. The quantity passed during the twenty-four hours is very great, varying however from four to thirty pints; the latter is an excessively rare quantity, and we shall seldom observe excretion to half the amount. The odour of diabetic urine is peculiar, resembling that of hay, but of a more pungent character.*

When a deposit occurs in diabetes, it will generally be found to consist of lithic acid, and its presence is considered by Dr. Prout as a favourable symptom. We also occasionally meet with caseous matter as an urinary deposit, and when present it induces rapid fermentation. The proportion of urea in diabetic urine is generally diminished; and in the course of the disease that principle is not always excreted in normal quantity, notwithstand-

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* In some aggravated cases of diabetes, the weight of egesta absolutely exceeds that of the ingesta, a fact first clearly pointed out by Mr. M'Gregor.

ing the large bulk of urine discharged daily, and we are occasionally able to detect it in the blood of the patient. The microscopic appearance of the fungoid growth found diffused in diabetic urine is given on the Plate (fig. 15.).

At the commencement of diabetes the train of symptoms are as follows:—General dyspeptic lassitude after food, and occasional gastrodymia are observed, notwithstanding that the appetite is good, and sometimes excessive. The bowels are constipated, the pulse irritable, and the tongue coated with a white mucus, which, when removed, leaves a glossy red appearance of the organ. Pain in the loins is often present, and the skin is dry, yielding a white scurf on the least friction; the flow of urine is increased, and thirst is an early and prominent symptom.

This disease is very insidious at the commencement, and its symptoms are not unfrequently overlooked as those of common dyspepsia, generally owing, I believe, to the time required by the patient to become aware of the increased flow of urine, which is that feature of the disease most likely to attract the attention of the practitioner to the true nature of the case. Of the two symptoms most prominently marked, viz. the thirst, and the increased flow of urine, I believe the former will, however, more frequently serve to assist our diagnosis than the latter, for the reason that it more prominently affects the comfort of the patient, and is therefore more likely to be related as a symptom. It certainly has happened to myself to have had this urged upon my attention by patients, who made no allusion to diuresis until especial inquiries were directed to the point. The value of this indication cannot be too strongly impressed on the mind of the practitioner; and whenever dyspepsia is attended with thirst, it is right to examine the urine particularly.

When diabetes is in an advanced stage, emaciation becomes a very prominent symptom. The tongue presents a peculiar dry and red appearance, and is sometimes cleft in rugæ, while aphthous inflammation affects the gums and mouth. The appetite is ravenous, and the breath possesses a peculiar odour, while the urine passed is in large quantity and of high specific gravity. There is also a general feeling of lassitude, and occasional giddiness, with a tendency to sleep during the day. The venereal appetite is frequently deficient. These symptoms increase, and death is most commonly occasioned either by an attack of effusion on the brain, gradually ushered in by coma, or by the supervention of phthisis, a frequent complication of this disorder.

Post-mortem examinations have shown little else in this disease than enlargement of the kidneys, and a peculiar appearance of the blood, with some few of the ordinary effects of debility.

The general belief that diabetes is necessarily a fatal disease has in all probability arisen from the circumstance that it was formerly seldom detected until far advanced, and beyond the reach of remedies.

Attention having been of late, however, more actively directed to the general subject of urinary disease, cases are earlier detected and subjected to treatment; and it now occasionally happens that we meet with patients with a well authenticated and old diabetic history, who, on examination, show no signs of diabetes, appearing to have been permanently cured, and who only apply to the medical man for complaints not necessarily connected with the original malady. I am now attending a case of this description. The causes producing diabetes have been stated very variously by writers. Mercurial erythism and inherited taint, either scrofulous or directly diabetic, are quoted as predisposing to the disease; but, with the exception of the latter, the causes noticed appear merely such as tend to the developement of general debility.

Among the exciting causes, Dr. Prout enumerates mental anxiety; and every one who has seen much of this disease will agree that mental distress is often a part of the past history of diabetic patients. In the present state of our knowledge, however, we are unable to trace this disease to any very especial cause.

The observations which have been made on this disease in all its relations and in every stage have not yet been rewarded with success, so far as regards obtaining a knowledge of its true nature.

A near approach to this, however, has been made by Mr. M'Gregor; who, in several valuable communications laid before the profession, has shown that sugar is developed in diabetes during digestion, having succeeded in obtaining it from fluid vomited after a meal. This is a very valuable point to have decided; and it seems to prove that either the stomach or salivary glands must be seriously involved, since the food has only been subjected to the action of the secretions of these organs, when sugar admits of detection in considerable quantity.

In connection with this subject, I now have to notice the observations of M. Mialhe, which are replete with interest so far as regards the formation of sugar in the stomach. M. Mialhe has proved that in the digestion of amylaceous and saccharine ingesta the saliva takes a prominent part; and he has separated from that secretion a substance analogous to diastase, to which he gives the name of animal diastase. This principle decomposes starch into dextrine, and requires a very short time for the purpose, as he proves by the blue colour of iodide of farina, not being produced when starch is submitted to the action of the diastase, and iodine is subsequently added. The importance of this discovery, with reference to the pathology of diabetes, will at once occur to every mind; and if this constituent of the saliva is alone concerned in the digestion of amylaceous and saccharine ingesta, or in any way necessary to the result, it would seem that the disease should be investigated with relation to the condition of the salivary glands; a point of view in which it has never yet received the attention of pathologists. M. Mialhe, in a paper on diabetes, has stated it as his belief, that saccharine and amylaceous principles are partly assimilated by an action consequent on admixture with the alkaline matters of the blood. It appears, however, according to the experiments of MM. Bernard and Barreswil*, that if sugar is injected into the blood, it is passed as such by the kidneys; while, if it first be subjected to the action of the gastric juice, it cannot be detected in the urine; which shows that the alkali of the blood alone is insufficient to effect the transformation.

It is pretty certain that the stomach of every animal during digestion contains saliva as well as gastric secretion; and it appears, therefore, very likely, that the diastase of the saliva effected the transformation in the experiments of MM. Bernard and Barreswil, and not the gastric juice.

In taking this as a guide to the pathology of diabetes, we have as yet little but chemical evidence to assist us. It is clear, however, that sugar in diabetic cases is first formed in the stomach when amylaceous ingesta are taken; and, therefore, that either pepsin or salivary diastase fail in their action, or are not present to assist in digestion; and the experiments of M. Mialhe seem clearly to point to the action of saliva as the active means of effecting the transformations of health.

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* Comptes Rendus, Dec. 7. 1843, and April 15. 1844.

It has often appeared to me that the importance of the saliva has been underrated. The large quantity secreted and poured into the stomach during a meal, and the existence of a substance closely resembling, if not absolutely identical with, salivary matter in the chyle of animals, would seem to indicate that it plays some more important part in the economy than any with which we have yet become acquainted. The obscurity still involving the pathology of diabetes entitles every suggestion connected with it to the most attentive consideration of the practitioner; and the state of the salivary glands and their secretion will, I trust, before long, be fully investigated in this disease. There is a fact connected with the history of diabetes, which I have several times had occasion to observe; it is that on some days, and that too in advanced cases, the sugar is not to be detected in the urine, while the high specific gravity of the secretion is kept up by the presence of an enormous excess of urea taking as it were the place of the sugar. I believe this has been observed before by others. During some experiments I made on the use of oxalic acid in diabetes, I observed this alternation of urea and sugar to occur very frequently, and was inclined at the time to regard it as an effect of the remedy; but I have since known it to occur without any acid form of medicine having been prescribed.

The treatment of diabetes proposed from time to time has varied greatly in character. It is true that for the most part it has agreed in the one particular, in consisting of means directed to the stomach; but still some of those remedies considered as the most efficacious have been such as in health greatly tend to the derangement of that organ. Among the most powerful of these may be placed opium, which, in combination with other medicines, is frequently of service in checking symptoms, and has occasionally been known so far to restore the patient as to justify a hope that permanent benefit had been obtained. As regards the stomachic remedies, we find the alkalies and acids have both been fully tried; and the alkaline earth magnesia is still highly prized, as of service in this disease, by many experienced practitioners. Nitric acid has enjoyed an equally high reputation in the hands of others; and I have recently seen apparent advantage derived from the continued use of hydrochloric acid. It has always appeared to me, however, that the cases most benefited by treatment have been those in which no especial regard has been paid to a specific remedy, but where general principles have been carried out steadily, and so as to meet every emergency as it arose. The use of opium, though it is always found to diminish the quantity of water excreted, can in no way be regarded as an advisable measure, if the drug be exhibited in its uncombined state. Large doses become eventually necessary to keep up the effect first produced; and whatever apparent benefit may be observed in the secretion of the kidney, we find the general symptoms of the disease become aggravated, and, moreover, that considerable difficulty is experienced in desisting from the use of the remedy. The Dover's powder is a favourite medicine in this disease; and I have constantly seen the greatest benefit follow its use, and considerable relief afforded to the patient by its bringing about the partial restoration of the function of the skin. In acute cases, when pain is felt in the loins or head, the use of this remedy, combined with the hydrargyrum cum cretâ, in small and divided doses taken during the day, will be found a most valuable means of decreasing action, and with the use of moderate bleedings greatly to assist in affording relief to the drowsiness which forms a distressing symptom in some cases.

In addition to the above remedies, I know of none more applicable in the chronic form of the affection than magnesia taken frequently during the day. Warm bathing at intervals of a day or two is of great assistance; and if we can sufficiently restore the powers of our patient, this may afterwards be replaced by cold sponging, or the shower-bath. It is absolutely necessary, however, that the pulse should improve, and the power of undergoing fatigue have increased, before the skin is called upon for this re-action, and the cold bath should always be taken immediately on rising from bed, when the powers of life are recruited and in full vigour. Among the tonics which have acquired credit in the treatment of diabetes, are several metallic salts; the sulphates of zinc and iron, and the phosphate and lactate of the latter, have been used with benefit. Various vegetable tonics have also at times flattered the practitioner into a belief of their efficacy. Whatever may be the plan adopted, however, one important indication should never be lost sight of, and that is, the constipated state of the bowels almost always observed in this disease.

The importance of attending to this point will at once be obvious, when we remember the emaciation so characteristic of this affection, and the propriety of affording as large a surface of intestine as possible for lacteal absorption, which cannot take place if the intestinal canal be obstructed. As regards the diet best suited to this form of disease, it appears any thing but reasonable to subject the stomach to the severe discipline which has been applied by the fashion of the day in prohibiting the use of vegetable food, and restricting the patient to a purely animal diet.

All the benefit derived from this plan of treatment consists in the fact that the profession are now well aware that the diabetic stomach will not convert fibrinous and albuminous ingesta into sugar, but that any advantage has accrued to the patient is greatly a matter of doubt. Several cases which I have seen do best have not been so restricted as regards vegetable aliment, but have been fed upon a wholesome, mixed, but restricted diet. The patient should be allowed his ordinary food, unless it be of a nature obviously calculated to produce or maintain dyspepsia; the restriction being made in quantity rather than in quality or proportion. As regards drink, not only much good, but agreeable relief from thirst, is to be obtained from the use of Seltzer water, the salts contained in it probably exercising an immediate influence on the condition of the blood. Wines, spirits, and beer should be avoided in the more acute forms of this disease, but they become necessary to maintain power in the advanced stages.

ON EXCESSIVE EXCRETION OF UREA.

There is a condition of system characterised by the excretion of large quantities of urea, which is sometimes accompanied by an excessive quantity of water, thus occasionally leading to a suspicion that the individual is the subject of diabetes. The specific gravity of the urine in this disease varies greatly, but it is generally above that of health; and when such is the case, we obtain a copious and almost immediate crop of crystals of nitrate of urea, on the addition of an equal bulk of nitric acid to the urine. This crystallisation nearly always occurs if the urine be above 1030 in specific gravity. When a large quantity of water, and, consequently, urine of a low specific gravity, is passed, the *relative* proportion of urea in the excretion is of course not increased, and may even be diminished; but in all cases the *absolute* quantity excreted during the day is greater than in health. Nothing is satisfactorily ascertained concerning the causes of this tendency to increased excretion. The symptoms of this disease do not differ particularly from those observed in ordinary cases of dyspepsia; there is, however, sometimes a frequent desire to pass urine. It is not uncommon to find the skin greatly in fault, and attention to the restoration of its function is always necessary as a first part of our treatment. This is especially desirable when the quantity of urine passed is large, and the specific gravity not above the healthy standard of 1022.

It is not often that we meet with this disease unless combined with an excessive discharge of water, for the reason that this is often the only urinary symptom to which the patient's attention can be directed, and the dread of diabetes induces him to apply for relief.

The waste of tissue shown by the large discharge of urea indicates the absolute necessity in these cases of abstaining from all causes calculated to induce an increase of that action; and violent exercise and hard study should be avoided as much as possible, while wines and beer, with a light diet of fish and vegetables, should form the dinner of such patients. Opiates have been found serviceable by Dr. Prout in this form of disease, and they are certainly often of great value, notwithstanding the prevalence of severe dyspeptic symptoms. The power they possess of restricting the rapid waste of tissue greatly assists in restoring the proportion of urea excreted to its normal standard. Mercurial alteratives with ipecacuanha or Dover's powder, according to the severity and duration of the disease, are among the most powerful remedies; but it is well to avoid opiates in early cases, which will generally be found to yield to purgatives, diaphoretics, and a restricted diet.

ON DEFICIENT EXCRETION OF UREA.

This disease, which has been called diabetes insipidus, to distinguish it from that form of excessive discharge from the kidneys known to contain sugar, is often confounded with those cases which have been treated of in the foregoing section, more especially when a large quantity of water accompanies the excess of urea. There is always a large excretion of urine in this disease, which, on being examined, sometimes shows a specific gravity as low as 1002. I have seen it 1001, but for the most part it is observed at from 1002 to 1008. The proportion of urea is not only relatively small in this urine, but the quantity excreted is absolutely less than in health, notwithstanding the enormous quantity of urine poured from the kidney. From six to ten pints are commonly excreted in the twenty-four hours, and cases are recorded in which as much as twenty pints have been noticed. The dyspeptic symptoms are generally severe in this affection, and great thirst is always present, with a dry skin and red tongue, while the appetite is irregular. The bowels are constipated, and there is pain in the head and drowsiness, with mental depression, and sense of fatigue on the slightest exertion. The predisposing and exciting causes of this disease are not well ascertained, nor has its pathology been satisfactorily investigated. When large quantities of urine of very low specific gravity are passed, and there is great roughness of skin, the case may be looked upon as of very serious character, and the greatest difficulty will be encountered in affording relief. When, however, the symptoms are less severe, the following plan of treatment frequently relieves the patient: the skin should be kept clean by warm baths, while antimonials with small quantities of hydrargyrum cum cretâ are given at night. The bowels must be kept freely open, which is best effected by an aperient senna draught in the morning, which should not contain any saline purgatives in admixture, as they tend to aggravate thirst. Twice during the day a full dose of infusion of cascarilla or gentian will assist the treatment. I have lately attended a case of this disease in which hippuric acid was passed in the urine to the entire exclusion of lithic acid, and am inclined to believe, that in many of these cases characterised by a cloudy urine of very low specific gravity the hippuric acid will hereafter be found to exist. Should this prove to be the case, it may perhaps assist us in acquiring a clue to the pathology of the disease.*

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* A case has lately been read before the London Medical Society by Dr. Garrod, in which a very large quantity of hippuric acid was found to exist in the urine. Lithic acid was, however, also present in considerable proportion in this case.

APPENDIX.

ON LIME AND MAGNESIA, WHEN THEY EXIST TOGETHER IN COMBINATION WITH PHOSPHORIC ACID.

THERE are some difficulties attending the chemical examination of these mixed phosphates, owing to the great similarity of re-action which exists between them; and we have not yet arrived at any well-ascertained method of performing their quantitative separation. The nearest approach, however, is by the following process:—

The mixed phosphates are dissolved in dilute hydrochloric acid, and the solution is then nearly neutralised by ammonia. Alcohol is next added to the solution, and sulphuric acid carefully dropped into the mixture. In this way we precipitate a sulphate of lime of considerable purity, which must be collected on a filter, and washed with dilute acid and water which has been digested on sulphate of lime. By this means we remove any magnesian salt which may adhere. The sulphate of lime may now be dried and weighed; and from its weight we may deduce that of the lime, and also of the magnesia; for the proportional constitution as phosphate being known, we are able to do so from our previous knowledge of the original weight of the mixture on which we operated.

Magnesia.—Lime.

The presence of lime and magnesia, when they exist as phosphates, dissolved in an acid, is easily proved by first precipitating the liquid (previously nearly neutralised by ammonia), with the solution of oxalate of ammonia, and allowing the precipitate to subside. The mixture should now be briskly boiled to perfect the precipitation of the oxalate of lime; the clear liquor is then to be poured off; and if the oxalate ceases to produce a further effect*, we must add ammonia. Should we now observe a precipitate to occur, we may be sure that magnesia is present in the solution. When phosphate of iron exists in admixture with these earths, as is the case in the ashes of blood, we can easily prove its presence by testing the solution with the ferrocyanuret of potassium, which yields a fine blue precipitate of prussian blue.

The following substances have been noticed in minute quantity in the blood: viz. silica, manganese, copper, and titanic acid. An account of my experiments regarding the presence of the last-mentioned substance may be seen in the Philosophical Magazine for March, 1835.

Marchand denies the existence of titanium in the blood; the blowpipe re-actions, however, which I have obtained from the ashes of blood, are not such as I have ever been able to produce with any other substance than titanium.

Fatty Matters of the Blood.

Besides the fatty matters which are contained in the serum of blood, and which were first pointed out by Dr. Babington, we can procure others by the action of ether on the mixture of fibrin, albumen, and red particles. The best process for preparing these fats is as follows:—

Let a quantity of fibrin, albumen, and red particles, be well dried, and then pulverised. Alcohol is now to be boiled on the powder, by separate portions, until the last added possesses no solvent action on the mass, which may easily be known by evaporating a portion of the fluid to

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* Should the oxalate of ammonia continue to precipitate the solution, we must add an excess, and again allow the precipitate to subside before testing for magnesia with the ammonia. The magnesian precipitate frequently requires some time for its formation.

dryness; when, if no residue be observed, we may be sure that the action is complete.

The alcoholic solutions are now to be added together, and evaporated to half, when we frequently can observe that red particles become precipitated: in order to render this precipitation more complete, we must add a portion of cold alcohol to the warm fluid, when we shall perceive that a precipitate immediately collects, and the supernatant liquor becomes yellow.* This clear liquor may be removed by a pipette, and left to spontaneous evaporation: as the alcohol dissipates, we shall observe a precipitate of a firm white fatty matter; this may be removed, and set aside; the clear liquor must now be evaporated to dryness, when we shall procure a fat of a reddish tint, which, from its containing phosphorus, has been called the red phosporised fat. It has no very peculiar properties: when heated it becomes of a dark-reddish colour, and its cinder has an acid re-action. It contains both sulphur and phosphorus. It does not saponify with the alkalies.

The solid white fat which separated from the alcoholic solution also contains phosphorus and sulphur; it has been named the white phosphorised fat: its re-actions are very similar to those of the red fatty matter. The alkalies possess no solvent action on this substance.

Cholesterine has been rejected from the list of constituents of healthy blood, in the admirable work of P. S. Denis; but there are many re-actions procurable from the crystalline fatty matter, which much resemble those of cholesterine; and if it be not that substance, I cannot but think that at least it is an incipient form of the biliary fat which exists in the blood.

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* This precipitate contains the fatty matter called serolin.

ON THE VARIABLE PROPORTIONS OF THE CONSTITUENTS OF THE HUMAN BLOOD.

The extensive researches of M. Lecanu have led him to the following results, which I here append in a table, together with a translation of his observations on the subject:—

“ The proportion of water varies in the blood of individuals of different sex and age.

From 853·135, maximum quantity of water contained in 1000 parts of blood, to 778·625, the minimum,

Difference 74·510
Mean - 815·880

In the blood of individuals of the same sex, but of different ages.

From 853·135, maximum quantity of water contained in 1000 parts of female blood, to 790·394, the minimum,

Difference 62·741
Mean - 821·7645

And from 805·263, maximum quantity of water contained in male blood, to 778·625, minimum,

Difference 26·638
Mean - 791·944

The proportion of water is less in man than in woman.

Mean proportion of water in woman's blood - - -	821.7645
Mean proportion in man -	791·9440
Difference of excess in woman's blood - - -	29·8205.

The quantity of water is not proportional to the age, at least from 20 to 60 years old, among individuals of the same sex.

1000 parts of blood, from females, have yielded of water:—		1000 parts of blood, from males, have yielded of water:—	
at 22 years	853·135	at 26 years	790·900
25	796·175	26	778·625
34	801·918	from 30 to 32 years	788·323
36	799·230	at 32 years	785·881
38	827·130	34	795·870
53	790·840	36	782·271
54	799·432	from 38 to 40 years	783·890
58	790·394	from 45 to 48 years	780·211
58	792·897	from 48 to 50 years	805·263
60	792·561	from 62 to 64 years	801·871

In individuals of the same sex, there is less water in the blood of those possessing a sanguine temperament than in that of those of a lymphatic temperament.

In 1000 parts of blood from females: —

Sanguine temperament.	Lymphatic temperament.
Water 796·175	Water 790·840
792·561	827·130
792·897	801·918
790·394	799·432
	799·230

Mean of sanguine temperament - - - 793·007
Mean of lymphatic temperament - - - 803·710
Difference of excess for lymphatic temperament - - 10·703

1000 parts of blood from males yielded: —

Sanguine temperament.	Lymphatic temperament.
Water 780·210	Water 805·263
783·890	795·870
801·871	
778·625	
788·323	

Mean of sanguine temperament - - - 786·584
Mean of lymphatic temperament - - - 800·5665
Difference of excess for lymphatic temperament - - 13·9825

The proportion of albumen varies in the blood of individuals of different sex and age.

From 78·270, maximum quantity of albumen in 1000 parts of blood, to 57·890, the minimum,

Difference 20·380
Mean - 68·080

In the blood of individuals of the same sex, but of different ages.

From 74·740, maximum quantity of albumen contained in 1000 parts of blood from women, to 59·159, the minimum,

Difference 15·581
Mean - 66·9495

The quantity of albumen bears no proportion to the age, at least within the limits of from 20 to 60 years, in individuals of the same sex.

From 78·270, maximum quantity of albumen contained in 1000 parts of blood from men, to 57·890, the minimum,

Difference 20·380
Mean - 68·080

1000 parts of blood, from females, have yielded, of albumen,		1000 parts of blood, from males, have yielded, of albumen,	
at 22 years,	68·756	at 26 years,	71·560
25	73·065	26	62·949
34	59·159	from 30 to 32 years	71·061
36	69·125	at 32 years	64·790
38	69·100	34	78·270
53	71·180	36	66·090
54	74·740	from 38 to 40 years	57·890
58	70·210	from 45 to 48 years	71·97
58	72·796	from 48 to 50 years	65·133
60	69·082	from 62 to 64 years	65·389

It is almost the same in proportion for individuals of sanguine and lymphatic temperaments, of the same sex.

In 1000 parts of blood from females: —

Sanguine temperament.	Lymphatic temperament.
Albumen 73·065	Albumen 71·180
69·082	69·100
70·210	59·159
72·796	74·740
	69·125

Mean of sanguine temperament 71·264
Mean of lymphatic temperament 68·660

In 1000 parts of blood from males: —

Sanguine temperament.	Lymphatic temperament.
Albumen 71·970	Albumen 65·133
57·890	78·270
65·389	
62·949	
71·061	

Mean of sanguine temperament 65·85
Mean of lymphatic temperament 71·7015
Difference - - - 5·8515

The proportion of globules varies in the blood of individuals of different ages and sex.

From 148·450, maximum quantity of globules contained in 1000 parts of blood, to 68·349, the minimum.

Difference 80·101
Mean - 108·3995

Also in the blood of individuals of the same sex, but of different ages.

From 148,450, maximum quantity of globules contained in 1000 parts of blood from males, to 115·850, the minimum,

Difference 32·60
Mean - 132·150

The proportion of globules is greater in men's blood than in that of women.

From 129·999, maximum quantity of globules contained in 1000 parts of blood from females, to 68·349, the minimum,

Difference	61·641
Mean -	99·1695

Mean of female blood - -	99·1695
Mean of male blood - -	132·1500
Difference of excess in male blood	32·9805

The quantity of globules does not appear to be proportional to the age in individuals of the same sex within the limits of from 20 to 60 years.

1000 parts of blood from females have yielded, of globules,		1000 parts of blood from males have yielded, of globules,	
at 22 years	68·349	at 26 years	128·670
25	121·720	26	146·885
34	129·610	from 30 to 32 years	131·688
36	119·000	at 32 years	139·129
38	92·670	34	115·850
53	129·990	36	141·290
54	115·319	from 38 to 40 years	148·450
58	127·730	from 45 to 48 years	133·820
58	125·590	from 48 to 50 years	117·484
60	129·654	from 62 to 64 years	121·640

In individuals of the same sex, the proportion of globules is greater in those of a sanguine than in those of a lymphatic temperament.

1000 parts of blood, from females, yielded —

Sanguine temperament.		Lymphatic temperament.	
Globules	121·720	Globules	129·990
	129·654		92·670
	127·730		129·610
	125·590		115·319
			119·000

Mean of sanguine temperament	126·174
Mean of lymphatic temperament	117·300
Difference of excess in sanguine temperament - -	8·874

1000 parts of blood, from males, yielded —

Sanguine temperament.		Lymphatic temperament.	
Globules	133·820	Globules	117·484
	148·450		115·850
	121·640		
	146·885		
	131·688		

Mean of sanguine temperament	136·497
Mean of lymphatic temperament	116·667
Difference of excess in sanguine temperament - -	19·830

On these results, the following remarks are made by Monsieur Lecanu:—

1. "The proportion of serum varies in the blood of individuals of different sex and age; also in the blood of individuals of the same sex, but differing in age." It is greater in the blood of women than in that of men. It is also greater in the blood of lymphatic individuals than in that of those possessing a sanguine temperament, the sex being the same. No relation is to be observed between the quantity of serum and the age of individuals of the same sex, at least within the limits of from twenty to sixty years old.

2. The proportion of albumen, fibrin, and colouring matter—in other words, the nutritive substances—varies in the blood of individuals of different sex and age. In the blood of individuals of the same sex, but of different age, it is less in the blood of women than in that of men; and also less in the blood of lymphatic persons than it is in the blood of those possessing a sanguine temperament, the sex being the same. No relation is to be observed between the quantities of nutritive matters and the ages of individuals of the same sex, at least within the limits of from twenty to sixty years.

As regards the serum (essentially formed of water and albumen), the proportion of water, and, consequently, that of the albumen, varies in individuals of different sex and age. In individuals of the same sex and of different ages, it appears to be nearly the same in men as in women, and in individuals of sanguine and lymphatic temperament. In relation to the analysis of the blood of females, it must be observed that the menstrual losses to which they are subject contribute especially to vary the proportion of globules; thus the analysis of the blood of a female affected with the uterine discharges afforded, in a first experiment—

Water - - -	851·590
Albumen - - -	66·870
Soluble salts and extractives -	11·290
Globules - - -	70·250
Total - - -	1000·000

And in a second experiment —

Water - - -	832·754
Albumen - - -	60·891
Soluble salts and extractives -	13·210
Globules - - -	93·145
Total - - -	1000·000

That is to say, in these two cases, and especially in the first, the quantity of globules was only about half that observed in the other analyses of woman's blood.

It is easily foreseen that a similar effect to the above may be produced by repeated bleedings. Thus, the woman who was the subject of the sixteenth experiment, having been blooded for the third time, I found that the blood, instead of containing as before —

Water - - -	792·897
Albumen - - -	70·210
Soluble salts and extractives -	9·163
Globules - - -	127·730
Total - - -	1000·000

Contained only —

Water - - -	834·050
Albumen - - -	71·111
Soluble salts and extractives -	7·329
Globules - - -	87·510
Total - - -	1000·000

The proportion of albumen in the serum shows much less sensible variation in cases of successive bleedings or uterine discharges; which is easily conceived, since the liquid, absorbed at the expense of the whole system, and proportionably to the blood drawn or discharged, is water charged with albumen."

I shall now append a statement of the inferences which have been drawn by various other experimenters, as the result of their researches into the constitution of the blood under different conditions both in health and disease.

Arterial and Venous Blood.

Simon states that arterial blood contains more water than venous blood, and that the blood corpuscles of arterial blood contain less colouring matter than those of venous blood.

Denis did not detect more water in arterial than in venous blood, but found them alike in this respect.

Hering examined the arterial and venous bloods of several animals, viz. the bullock, the sheep, and the horse, and agrees with Simon in making arterial blood to contain more water than venous.

Hering states the corpuscles in venous blood to exceed in number those of the arterial.

Lecanu differs from all the foregoing chemists in finding a smaller proportion of water to exist in arterial than in venous blood — he also found a larger proportion of fibrin in the arterial blood.

Simon, Denis, and Hering could discover no law as to the proportion of fibrin; sometimes it was in larger proportion in the arterial, sometimes in the venous blood.

The evidence of other chemists is very conflicting as to the relative proportions of water and fibrin. There appears to have been some modifying cause in action to produce these discrepancies, and which has been entirely overlooked; probably the time allowed to elapse after taking food before the blood was drawn may have caused these differences in result.

Blood of the Vena Portæ.

Schultz has experimented on this blood as obtained from the horse. He states it to be of a much darker colour than ordinary venous blood; but that it becomes brighter after a full meal. The neutral salts and atmospheric air do not brighten the colour of portal blood. Simon analysed the arterial and portal blood of a horse, and concludes from his experiments that portal blood contains less fibrin, more fat, more extractives and salts, and more colouring matter in proportion to globulin than arterial blood.

Blood from the hepatic Vein.

This blood has been examined by Simon, who concludes from his analyses that it is richer in solid constituents than either ordinary venous or arterial blood, even more so than that taken from the vena portæ. It contains less fibrin, fat, globulin, and colouring matter than the blood of the vena portæ.

Blood from the renal Veins.

This blood has been shown by Simon to contain more solid constituents and albumen than that of the aorta, but it contains less fibrin and fewer corpuscles.

Blood from the Capillaries.

Pallas analysed blood taken by leeches and cupping, and by comparing his results with the analyses of venous blood, came to the conclusion that capillary blood is richer in solid and coagulable constituents than either venous or arterial blood. Denis contradicts this, having found that blood taken from the arm and compared chemically with that taken from the side of the chest of the same person by cupping, yielded results almost identical in the proportions of water, corpuscles, and solids of serum.

Blood of the Fœtus compared with that of the Mother.

Denis found the blood of the fœtus to contain more solid matter and corpuscles than that of the mother. The fœtal blood contains more iron than that of the mother, the ratio being 2·5 to 1. His analysis was made on blood taken from the umbilical artery, and is compared with the analysis of the venous blood of the mother.

Influence of Blood-letting.

Becquerel and Rodier have made a great number of analyses of the blood of persons who have undergone repeated venesection. From the tables they have constructed it appears that loss of blood is followed by a decrease in the specific gravity of the circulating fluid. The albumen diminishes very slowly. The fibrin is not much influenced, the extractives and salts are unaltered, the fat is diminished, the corpuscles are greatly decreased in number.

Blood in Inflammation.

Andral and Gavarret have established, by analysis, the fact, that the proportion of fibrin is greatly increased in inflamed blood. Becquerel and Rodier have also shown this to be the case, and, moreover, have established, that the proportion of albumen in such blood is less than in the healthy state.

Blood in Phthisis.

Andral and Gavarret state that as this disease advances the proportion of fibrin increases, and that of the corpuscles decreases. In extreme cases, however, the whole blood becomes impoverished.

Blood in Puerperal Fever.

According to an analysis of this kind of blood made by Heller, the fibrin was increased beyond the normal standard, and the corpuscles greatly decreased in number.

Blood in Typhus Fever.

The general results of Andral and Gavarret show that in this disease the proportion of fibrin in the blood decreases, while that of the corpuscles increases.

Becquerel and Rodier analysed the blood of eleven men affected with typhoid fever, and obtained the following as the mean composition of their blood:—

Water - - - -	797
Fibrin - - - -	2·8
Albumen - - - -	64·8
Fat - - - - -	1·7
Corpuscles - - - -	127·4
Extractives and Salts - -	6.3
	1000·0

Here we observe the fibrin and corpuscles in about normal proportion, while the albumen is only very slightly decreased.

Scherer found the salts of blood in typhoid fever to amount to 11·92 per 1000, which is an increase on the proportion of salts in health. The alkaline salts alone amounted to 10 per 1000, while in health they never amount to 9 per 1000.

Blood in simple continued Fever.

Andral and Gavarret have shown that in this disease we generally have a slight increase in the proportion of the fibrin of the blood, and a decrease in that of the corpuscles. When inflammatory complications occur in the course of this disease, however, we find the fibrin increasing very greatly indeed, while the corpuscles decrease to the proportion observed in inflammatory affections generally.

In three analyses made by Becquerel and Rodier, the albumen and fibrin of the blood from a case of continued fever were in healthy proportion, while the corpuscles were slightly above the average weight in health.

Blood in intermittent Fever.

Andral and Gavarret have examined the blood in ague, and found an excess of fibrin and decrease of the proportion of the corpuscles. No difference was observed in the blood whether drawn during the hot or cold stages, or during the remissions.

Blood in Scarlatina.

Andral and Gavarret give the three following analyses of the blood in this disease:—

Water.	Fibrin.	Corpuscles.	Solids of Serum.
761·5	3·1	146·0	89·4
776·3	3·5	136·1	84·1
798·3	6·8	112·2	82·7

Blood in Apoplexy.

Andral and Gavarret state that in the greater number of cases of cerebral apoplexy, the proportion of fibrin in the patient's blood is deficient, and the corpuscles in excess.

The following is the mean of twenty-one analyses made by Andral and Gavarret of blood taken from patients suffering from cerebral congestion, threatening apoplexy. It is compared with healthy blood.

	Water.	Fibrin.	Corpuscles.	Solids of Serum.
Mean -	787·1	2·6	120	89·7
Healthy blood	790	3·0	127	80

Blood in Chlorosis.

An analysis of this kind of blood by Dr. Vetter showed the proportion of corpuscles to be greatly diminished, the water in excess, and fibrin in about normal quantity.

Andral and Gavarret have analysed the blood of chlorotic patients, both at the commencement of the disease, and when it has advanced.

The mean of eight analyses of the first kind of blood, and nine of the second, is compared below with the blood in health.

	Water.	Fibrin.	Corpuscles.	Solids of Serum.
Health - -	790	3	127	80
Insipient chlorosis	801	3·5	106·8	88
Advanced chlorosis	853·2	2·9	56·7	88

Organic Acids of Urine.

Besides the acids which have been treated of as existing in this excretion, we have to notice the following; viz.

Acetic.
Butyric.
Benzoic—hippuric or uro-benzoic.

These acids have not been much examined, and there is some contrariety of opinion regarding them. Thus, though Proust and Thenard admit the existence of acetic acid in urine, we find that Berzelius expresses a directly opposite opinion, and believes that the odour of the butyric acid mingled with that of hydrochloric acid has led to the error; for, on the addition of sulphuric acid to a dry mass containing a chloride and a butyrate, we have an odour evolved which simulates that of acetic acid. It is the opinion of Berzelius, that neither acetic acid nor acetates are to be detected in the urine; and Liebig has lately shown that acetic acid exists in urine only as a result of decomposition.

The butyric acid has been observed but in one specimen of urine, and it is a matter of doubt whether it be not rather an accidental than a necessary constituent of the fluid.

The benzoic acid was supposed to have been discovered in the urine of the cow by Rouelle. Liebig made some minute investigations into the nature of this acid as found in the urine, and has proved it to be a distinct acid from the benzoic — as its salts are less soluble in water, and it contains nitrogen, which the benzoic does not, being an oxide of a hydro-carbonous body, to which the name of benzule has been applied.

Liebig named this acid the hippuric, as he considered it peculiar to the urine of the horse; but this is not the case, as he has lately detected it in the urine of man. Berzelius calls it the uro-benzoic acid, which is certainly a more appropriate term. The salts formed by this acid have been examined and described by Berzelius.

When urine becomes stale it no longer contains hippuric acid, but benzoic acid becomes developed.

Quantitative Estimation of Fixed Alkaline Chlorides, Phosphates, and Sulphates in the Urine.

The residue of the incinerated urine contains these salts, which may be separated as follows: —

They are to be dissolved in distilled water, and the solution filtered. Half the filtered liquor is then rendered acidulous by the addition of a few drops of nitric acid. An excess of a solution of nitrate of barytes is now added. The precipitate is collected on a filter and dried perfectly; from the weight of this sulphate of barytes, we can deduce that of the sulphuric acid. The filtered liquor, which is acidulous, must now be saturated with ammonia, which lets fall a precipitate of phosphate of barytes; this is to be collected and dried on a filter; from its weight we can deduce that of the phosphoric acid.*

It is to be remembered that we have here operated on half the liquor, and that, consequently, we must double our resulting quantity of sulphuric and phosphoric acids.

The remaining portion of the filtered liquor is used to determine the quantity of hydrochloric acid present in the salts, as follows: —

A solution of nitrate of silver is added to the liquid, previously acidulated with nitric acid. A chloride of silver now precipitates, which is to be collected on a filter, and then dried in a platinum crucible over the spirit lamp; from its weight we deduce that of the hydrochloric acid.

Having ascertained the weight of the acids, we have but to add the correct proportions of alkali for neutral combination, in order to discover the quantity of each alkaline salt.

The sulphuric acid may here be divided between potash and soda.

The phosphoric and hydrochloric acids are in combination with soda only.

If we wish to ascertain the exact proportion of soda which exists in combination with the sulphuric acid, we must have recourse to precipitation by the chloride of platinum, on a known quantity of the saline solution,

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* Care should be taken not to add too much nitric acid at the commencement of this process; for by this means we produce so much nitrate of ammonia, when we saturate, that the precipitated phosphate is liable to be dissolved.

estimating the proportion of the alkali from the known constitution of the potash chloride of platinum.

Albuminous Urine.

This form of diseased urine is generally coagulable by heat, and is for the most part acid. We, however, occasionally meet with specimens which are alkaline, and incapable of becoming coagulated by a boiling temperature. It was supposed that this depended upon the presence of some fixed alkali, which held the albumen in solution; and in order more thoroughly to examine the matter, I made analyses of two specimens of urine taken at different times from the same individual: the one was neutral and coagulable by heat; the other not coagulable by heat, and possessing an alkaline re-action. Both these specimens became coagulated on the addition of nitric acid.

1st specimen. — Neutral, coagulable by heat, as also on the addition of nitric acid —

Water - - - -	195·0
Albumen - - - -	1·1
Alkaline salts - - - -	1·4
Urea, ammoniacal salts, and extractives	2·2
Earthy phosphates, loss - -	0·3
	200·0

2d specimen. — Alkaline, not coagulable by heat, but becoming coagulated on the addition of nitric acid —

Water - - - -	195·8
Albumen - - - -	1·7
Alkaline salts - - -	0·5
Urea, ammoniacal salts, and extractives	1·8
Earthy phosphates and loss - -	0·2
	200·0

It will be observed that the alkaline specimen contained the greatest proportion of albumen, and a much smaller proportion of alkaline salts, than the neutral urine. This would go strongly against the probability of any fixed alkali being the solvent of the albumen; for in this case we should expect a redundant quantity of fixed saline matter in proportion to the albumen present, whereas exactly the opposite was the case, in this specimen at least.

There has been said to exist in the urine an animal substance, to which the name of incipient albumen has been given. I do not believe in the existence of such a substance, and am of opinion that the fact of the precipitation of the earthy phosphates by heat led to the erroneous belief in the presence of such a body.

Tests of the Presence of Albumen in the Urine.

It is customary with practitioners to test for albumen in the urine by the application of heat,[1] and the addition of nitric acid. I will now notice the sources of fallacy connected with the use of each test. The test of heat fails to show the presence of albumen when the urine is alkaline, and this is also the case in some neutral specimens, no opalescence being produced even at a boiling temperature. It is necessary, therefore, before using this test, to examine the state of the urine, as to acidity or alkalinity.

Specimens of urine, when possessing either an acid or alkaline re-action, will occasionally, when no albumen is present, become opaque when boiled, the flocculi produced simulating the appearance of albumen. This opacity is caused by the precipitation of the earthy phosphates which may be distinguished from albumen by becoming immediately dissolved on the addition of a drop of dilute nitric acid. These phosphatic specimens are not precipitated by nitric acid, and therefore this source of fallacy is removed by testing with that re-agent. Nitric acid, however, is not in itself a satisfactory test for albumen, being productive of a source of fallacy in throwing down lithic acid in large quantity from some kinds of urine. These instances are rare, however, and may be distinguished by the addition of hydrochloric acid, which throws down the lithic acid quite as completely as the nitric acid does, while such is not the case with albumen. From what I have related above, it will be perceived that it is quite possible to meet with a specimen of urine coagulable both by nitric acid and by heat, and which shall notwithstanding be free from albumen, for heat may throw down the phosphates, while nitric acid may cause a deposit of lithic acid. I once met with such a case. There is another source of error connected with testing urine for albumen by nitric acid, of which it is necessary that the practitioner should be aware, and I therefore here append a notice extracted from the Guy's Hospital Reports, in which I entered at full upon several questions connected with the chemical pathology of albuminous urine.

In a recent number of the Medical Gazette, I noticed a peculiarity in the urine passed by patients taking copaiba; such urine becoming coagulated on the addition of nitric acid, notwithstanding that no albumen was present. Since the publication of my observations on those specimens, I have had several opportunities of examining the urine voided by patients to whom cubebs had been administered; and have found a curious similarity between the re-actions afforded by such specimens, and by those which were impregnated with copaiba.

The latter urine, which I have examined several times, always yielded a precipitate, on the addition of nitric acid: in some cases, this was very slight; but in the majority, very dense and white, and greatly resembling albumen. The action of the acid on urine impregnated with cubebs is precisely similar in character, excepting that the colour of the precipitate occasionally verges on a pale pink. Previous to my publishing the re-actions of copaiba, there was but one substance (albumen excepted) supposed to be precipitable from the urine by nitric acid: this was lithic acid, which, however, could not be regarded as a frequent source of fallacy; as, when thus precipitated, it seldom comes down till the tested liquid has been allowed to stand some time, and then appears in a semi-crystalline form, and of a brownish-red colour. The precipitate afforded by cubebs and copaiba is, however, of that cloudy opaque character which simulates albumen, and moreover occurs immediately on adding the test.

It became an object now, to discover some simple method of discriminating between this precipitate and that obtained by nitric acid from albuminous urine. Fortunately, a very easy means of doing so is afforded us, by allowing the urine to which the acid has been added to remain at rest for an hour or two; when, should the precipitate consist of albumen, it will be found to have collected at the bottom of the tube, or to be arranged in flocculi through the liquor, the greater part of which will appear clear. If, however, the precipitate be caused by the presence of a vegetable matter derived from copaiba or cubebs, the precipitate does not subside for several days; not, indeed, till decomposition has occurred. Another and more speedy method of discriminating between these two impregnations and albumen is by the use of the ferro-cyanuret of potassium as a precipitant, the urine being previously acidulated by acetic acid. If albumen now be present, it is immediately thrown down; but in the other cases, even if the acetic acid cause a slight turbidity, it is not increased by the addition of the ferro-cyanuret. It is interesting to observe how supposed exceptions to the law declared by Dr. Bright become explained away by advances in the chemical pathology of the urine; copaiba, for instance, has been stated to cause albuminous urine; and probably cubebs may also have been looked upon as capable of affording the symptom which Dr. Bright has regarded as characteristic of a peculiar morbid tendency in the kidney.

It is greatly to be regretted, that the tests both of heat and nitric acid are not applied to the examination of urine: both are certainly not generally used. Perhaps, where one test only is employed, that of heat is the most common, and the sources of fallacy above alluded to are therefore less likely to occur; but still there are many who use nitric acid exclusively, and such are not very unlikely to meet occasionally with the deceptive re-actions I have mentioned. On the whole, it would be far better, if one test only were applied, that it should be the nitric acid; for the phosphatic precipitates which so often occur on the application of heat to urine, and the suspension of albumen, even after long boiling in some alkaline specimens, tend to render this an exceedingly imperfect test. Now, nitric acid throws down but one precipitate, resembling albumen; and that not being a constituent of the urine, but a matter derived from ingesta, we are the less likely to encounter such source of error: and even when it occurs, a little patience, in watching the after-behaviour of the precipitate, might occasionally betray the real cause of the re-action obtained.

Until very recently, it has been supposed, that if nitric acid and heat both caused a precipitate in urine, albumen must be present: this, though true in the general, is not strictly correct: and it is right to recollect, that we may have earthy phosphates precipitated by heat, while vegetable matters derived from ingesta may be thrown down by nitric acid. Such kind of urine lately occurred to me, while collecting specimens impregnated by cubebs. There is no doubt that until very lately such a case would have been confidently quoted as one in which albumen existed in the urine.

I must mention, that the conditions I have noticed are not always to be expected, either in the case of copaiba or cubebs; appearing most strongly when the urine smells powerfully of the drug, and being scarcely perceptible when the characteristic balsamic odour is wanting. I have reason to believe, that when either cubebs or copaiba are administered with an alkali, that the urine becomes more rapidly and completely impregnated; but it is difficult to conceive what cause can be in operation to produce an occasional difference in this respect, the urine suddenly becoming (even when large doses of the medicine are being exhibited) comparatively free from impregnation. The frequent occurrence of the earthy phosphatic precipitate afforded by the action of heat on urine, and, consequently, the fallacious nature of the test by heat, may be better appreciated, if I now lay before the reader a statement drawn up from some valuable Tables which were formed by Dr. Barlow and Mr. Tweedie, at the suggestion of Dr. Bright. I find, by examining these Tables—in forming which, the tests both of heat and nitric acid were used to ascertain the presence of albumen—that in 482 cases, taken promiscuously from the hospital wards, 34, or about 7 per cent., were found which coagulated or became opalescent by heat, while they were not affected by nitric acid: these, therefore, were cases in which the phosphates were precipitated; and had heat alone been used as a test for albu men, we now observe how many errors must have been committed, and how many cases might have been cited as exceptions to Dr. Bright's law. Though well aware of the frequent occurrence of this source of fallacy, still I must say, I was scarcely prepared to find it in so large a proportion of cases as 7 per cent. In Tables constructed by Dr. Barlow, in which he examined the urine of 300 individuals, we find that 1 in 11 had albuminous urine: other Tables make 1 in 6 as the proportion; the former being about 9, and the latter nearly 17 per cent. This shows how impossible it is to arrive at a satisfactory approximation to the truth by the use of the test by boiling alone: for among 100 persons, 16 might be declared to have albuminous urine; and of these, only 9 might present the degeneration of kidney on post-mortem examination, the 7 cases opposing the general truth which the observer was seeking to confirm.

As it may be interesting to know the particulars of the cases showing the deposit of phosphates on the application of heat, I will give the names of the wards, and the number of cases found in each, with such particulars as the Tables afforded.

These observations were not all made at the same time; a considerable period having elapsed between the first and second examinations of the patients in those wards, the names of which occur twice in the following Table.

Name of Ward.	Cases yielding a Precipitate of earthy Phosphate on Application of Heat.	Number of Patients in the Ward.	OBSERVATIONS on Cases yielding the Precipitate.
Job - - -	3	22	1. Patient hemiplegic and cachectic from intemperance. 2. Fever. 3. Anasarca: hydrothorax worn by intemperance.
Martha - -	0	30	
Name of Ward omitted in the Table	0	28	
Lazarus - -	1	23	Long an invalid, with chronic rheumatism and catarrh.
Charity - -	6	30	1. Boy with calculus, $3\frac{1}{2}$ years old. 2. Worn and feeble: malignant disease. 3. Strumous, with hip-joint diseased. 4. Abscess in the mouth: somewhat emaciated. 5. Much depressed: paralysis. 6. Constipation: plethoric person.
Luke - - -	0	29	
Cornelius - -	0	18	
Dorcas - -	1	30	Axillary abscess.
Petersham - -	2	17	1. Renal tumour: has suffered much pain. 2. Knee-joint disease: strumous.
Esther - -	2	13	1. Fractured tibia and fibula. 2. Burn: child 5 years old.
Lazarus - -	0	22	
Job - - -	0	16	
Miriam - -	0	8	
Mary - - -	0	20	
Mary and Dorcas -	1	10	Secondary symptoms: takes bichloride of mercury and sarsaparilla.
Martha - -	3	25	1. Tumour of thigh: operation. 2. No account. 3. Phthisis: hip-disease.
Naaman - -	2	26	1. Amputation: takes ammonia. 2. Effusion: not mentioned into what cavity.
Charity - -	4	28	1. Boy $2\frac{1}{4}$ years old: paralysis. 2. Long illness: takes calomel and opium; disease not mentioned. 3. Morbus cordis: has had rheumatism. 4. Pleuritis.
Cornelius - -	3	15	1. Taking tonics and alteratives. 2. Old disease: asthma. 3. No history.
Dorcas - -	2	26	1. Abscess of leg. 2. Bad leg: is taking stimulants.
Two Tables without the names of Wards affixed.	4	In the two Wards, 46	1. Scrofula. 2. Morbus cordis. 3. Paralysis and diseased vertebræ. 4. Amenorrhœa.

The examination of this Table becomes particularly instructive, as a warning to observers not to be too apt to draw conclusions from a few instances;—an error which is committed day after day in our profession, and which cannot be too often noticed and condemned. In this Table we have instances from Charity Ward of 6 patients out of 30; while, if we look to Luke's Ward, there is not a single case among 29. Again, in Martha Ward we do not find a case in 30; while in Esther Ward there occur 2 in 13. I need hardly say how completely 30 cases would have satisfied the minds of most inquirers as to the great rarity of these phosphatic cases; how, indeed, the question would be looked upon as well nigh settled; and a strong defence for the conclusion have been afforded, by the undeniable fact, that more than half the doctrines of medicine were based on a less substantial foundation. Here are 30 consecutive cases affording no instance. Now, let us suppose the inquiry to cease. What would be the impression on the mind of the observer not cognisant of the fact, that the next thirty might yield him 6 instances? To one entirely unacquainted with the variable nature of the functions of the body, 30 consecutive cases would be strong evidence. They might be strong evidence to the mathematical philosopher, who, if not a physiologist, would not duly appreciate the variations which so puzzle those who inquire into the more intimate parts of medicine. It may well be asked, If these varying causes are so numerous, how can we ever hope to arrive at a due appreciation of the value of our collected instances? The table above quoted is an answer to this question. It is only by such collected groups of facts, such as those of 30 here mentioned, that we can arrive at an estimation of the power of such varying causes, and, consequently, of the multiplicity of instances which may or may not be required, for satisfying the mind on any particular point; by making us feel a conviction, that the cases are sufficiently numerous to overpower the sources of fallacy. In the present inquiry, it was a difficult thing to conceive, that, after 30 cases were consecutively examined, and no result obtained, that the next 30 should yield us 6 instances: but having now ascertained this second result, we can bear in mind, that such groups may again occur (or something approaching to them) in future examinations connected with the pathology of the urine: and, by observing the limits of variation in a large collection of similar groups, we may hope eventually to arrive at something approaching to a correct estimation of the value of any number of instances which may be offered us as evidence, by future observers. From the observations on the cases contained in the Table, I think it may be concluded that the phosphates are apt to be precipitated from urine, on the application of heat, in patients of a cachectic habit, and in those worn by disease and suffering. The specific gravity of such urine is often as low as 1010 and 1012: though this is not always the case, as we sometimes find it natural, viz. from 1017 to 1022. It has frequently been stated, that mercury, when administered in quantity, renders the urine albuminous. I was very anxious to put this to the test; and accordingly formed the plan of a Table which my friend Dr. D. Francis (who has attended much to the examination of diseased urine, and for whose accuracy and judgment I can vouch) kindly undertook to fill up with observations on those patients admitted into the hospital, who would probably be subjected to salivation. The urine of these patients was tested when salivation was complete, and, in some cases, before the administration of the remedy; the latter being necessary, to exclude cases of true Morbus Brightii, which would interfere with the inquiry.

I have great pleasure in being able here to quote the following results of Dr. Francis's labours:—

No.	Name, Date, and Disease.	Action on Litmus and Turmeric.	Effects of Heat.	Effects of Nitric Acid.	S. G.	State of Gums.	Observations.
1.	Benjamin Neale. Dec. 18. 14 Samaritan. Syphilis.	Acid	No change	No change	1016	Gums fairly affected: fœtor: saliva increased	Urine was not examined previous to administering of mercury.
2.	John Hart. Dec. 18. 30 Samaritan. Syphilis.	Acid	No change	No change		Mouth not affected.	
	Jan. 2. - - -	Acid	Lithates dissolved	No change	1022	Gums sore and turgid: fœtor.	
3.	Edward May. Dec. 18. 32 Samaritan. Syphilis.	Acid	No change	No change		Mouth not affected.	
	Jan. 6. - - -	Acid	Slight precipitate	No change	1021	Teeth loose: gums very sore: fœtor: increased saliva	Precipitate by heat dispelled by nitric acid. Urine clear, copious, and natural in colour.
4.	Edward Ford. Dec. 18. 18 Samaritan. Syphilis.	Acid	No change	No change		Mouth not affected.	
	Jan. 6. - - -	Acid	No change	No change	1004	Teeth loose: gums sore	Urine very copious, clear, and limpid.
5.	Edward Bryant. Dec. 18. 9 Samaritan. Syphilis.	Acid	No change	No change		Mouth not affected.	
	Jan. 4. - - -	Acid	No change	No change	1024	Gums ulcerated: teeth loose	Urine natural in quantity and colour, and clear.
6.	Mary Hart. Jan. 9. 2 Ruth. Wound of the eye.	Acid	No change	No change	1009	Gums turgid and aphthous: teeth loose: fœtor	Urine copious and limpid: not examined previous to administering mercury: saliva slightly reddened litmus.
7.	Celia Everett. Jan. 15. Ruth. Syphilitic iritis.	Acid	No change	No change	1006	Face and glands beneath the jaw swollen: teeth loose: gums very turgid and aphthous	Urine rather copious, not examined before the mercurial influence: saliva slightly acid.

8.	Jan. 15. Naaman. Cerebral disease.	Acid	No change	No change	1016	Gums turgid and ulcerated: fœtor: face swollen	Urine natural in appearance: not examined previously to exhibition of mercury: saliva neutral.
9.	Thomas Wells. Jan. 9. 35 Samaritan. Syphilis.	Acid	No change	No change	1018	Gums not sore.	
	Jan. 22. - - -	Acid	No change	No change	1010	Gums turgid: teeth loose: fœtor	Urine clear, pale, and copious: saliva slightly acid.
10.	Alex. Kennedy. Jan. 9. 27 Samaritan. Syphilis.	Acid	No change	No change	1022	Gums not sore.	
	Jan. 23. - -	Acid	Slight precipitate	No change	1020	Gums ulcerated: face swollen: upwards of a pint of saliva flowing from the mouth daily	Urine pale, natural quantity: precipitate by heat dispelled by addition of nitric acid: saliva neutral.
11.	Elizabeth Gain. Feb. 24. 3 Petersham. Sequelæ of puerperal convulsions.	Acid	No change	No change	1020	Gums turgid and sore: glands of neck swelled: teeth loose	Saliva slightly acid.
12.	Harriet Willett. Feb. 24. 26 Dorcas.	Acid	Deposit dissolved: no subsequent change	No change	1016	Gums turgid: teeth loose: fœtor: sputa about ½ pint a day	Saliva neutral.
13.	James Hawkes. Feb. 24. Samaritan. Syphilis.	Acid	No change	No change	1017	Gums turgid and ulcerated: teeth loose.	
14.	Mary Grist. March 2. 13 Lydia. Acute bronchitis.	Acid	No change	No change	1013	Gums turgid: mercurial sores on lips	Urine pale and copious, free from deposit: saliva slightly acid.
15.	Elizabeth Allan. March 3. 14 Lydia. Jaundice.	Acid	Deposit dissolved	No change	1030	Teeth loose: gums sore and turgid: fœtor	Urine scanty and loaded with deposit: saliva neutral.

From these observations we may safely conclude that mercury does not always produce albuminous urine: and though we cannot say, from these few instances, that it never is a cause of the existence of that principle in the excretion, yet these cases may serve to warn the reader from depending too much upon loose assertions. I have myself observed, that urine containing albumen sometimes becomes freed from that substance by exhibiting mercury to the patient. Dr. Francis, during his late inquiries, met with such a case: and I quote the following from a note I received from him:—

"The other case was one of albuminous urine. The patient was salivated: and whilst under the mercurial influence, the albumen entirely disappeared."

Guy's Hospital Reports, No. xii. 1841.

Colouring Principle of the Pink Deposits.

Dr. Prout has lately examined this point, and comes to the conclusion that the colouring matter is not necessarily composed of murexid, but may be produced by the action of nitric acid or any oxygenating agent on the colouring matters of urine as well as on lithic acid. He believes, however, that nitric acid is the principal cause of such change of colour.

Distinction of the more Ordinary Deposits.

It is frequently desirable to form a correct judgment concerning the nature of deposits, when visiting patients, and when we have not our laboratory at hand. We cannot always determine their nature from their appearance; for though the lithates are generally darker in colour than the phosphates, still they sometimes approach so nearly in external appearance, that we are scarcely able to distinguish them but by chemical means. I lately was consulted concerning the nature of a deposit which had been regarded as phosphatic, owing to its being of a pure white. It proved to be made up of lithates. When we observe a deposit concerning which we are in doubt, the sedimentary matter can be extemporaneously examined by shaking it up in the urine, and then applying heat to a portion of the turbid fluid; if the sediment dissolves, we may at once conclude that it consists of the alkaline lithates, and, for the most part, of the lithate of ammonia*; if, on the contrary, the action of heat fails to render the urine clear, we may be pretty sure that we operate on phosphates, or organic matter in the form of pus or mucus. These may easily be distinguished, since the phosphates are at once dissolved on the addition of hydrochloric acid, whereas the latter substances resist that solvent.

Deposits of Matters accidental to the Urine.

The deposits which have been observed to occur owing to the presence of ingesta in the urine are composed of lime united to the citric, tartaric, and malic acids.

These salts are all reduced to carbonates at a red heat.

Citrate of lime is to be distinguished by the following examination: —

When boiled with a solution of carbonate of potash, a carbonate of lime is deposited, and the citric acid forms citrate of potash with the alkali present.

This alkaline citrate is precipitated by neutral nitrate of lead, and the precipitate collected on a filter. This is known to be citrate of lead from the fact of its being soluble in a solution of caustic ammonia.

Tartrate of lime is known from the characteristic odour of tartaric acid which it evolves when subjected to a charring heat; this test distinguishes the tartrates very completely.

Malate of lime, like the citrate, forms an alkaline salt when boiled with a solution of carbonate of potash; but the precipitate in neutral nitrate of lead produced by this

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* These salts are often found as deposits, in urine which holds albumen in solution. When this is the case, the turbid urine first becomes clear on the application of heat, but afterwards an opaqueness is produced by the coagulation of the albuminous matter.

solution is distinguished from that formed by the citrate of potash, in not being soluble in ammonia, but being very freely dissolved by boiling water, and crystallising as the water cools in fine needle-shaped crystals.

Diabetes.

Dr. Henry has constructed the following table, by which we are enabled to determine the proportion of solid extract contained in any quantity of diabetic urine, simply by ascertaining its specific gravity. In the experiments which afforded these results a steam bath was used, and the heat continued until the extract ceased to lose weight.

Specific Gravity, compared with 1000 Parts of Water at 60°.	Quantity of solid Extract in a Wine Pint.	Quantity of solid Extract in a Wine Pint, in Ounces, &c.			
		oz.	dr.	scr.	grs.
1020	382·4	0	6	1	2
1021	401·6	0	6	2	1
1022	420·8	0	7	0	0
1023	440·0	0	7	1	0
1024	459·2	0	7	1	19
1025	478·4	0	7	2	18
1026	497·6	1	0	0	17
1027	516·8	1	0	1	16
1028	536·0	1	0	2	16
1029	555·2	1	1	0	15
1030	574·4	1	1	1	14
1031	593·6	1	1	2	13
1032	612·8	1	2	0	12
1033	632·0	1	2	1	12
1034	651·2	1	2	2	11
1035	670·4	1	3	0	10
1036	689·6	1	3	1	9
1037	708·8	1	3	2	8
1038	728·0	1	4	0	8
1039	747·2	1	4	1	7
1040	766·4	1	4	2	6
1041	785·6	1	5	0	5
1042	804·8	1	5	1	4
1043	824·0	1	5	2	3
1044	843·2	1	6	0	3
1045	862·4	1	6	1	2
1046	881·6	1	6	2	1
1047	900·8	1	7	0	0
1048	920·0	1	7	1	0
1049	939·2	1	7	1	19
1050	958·4	1	7	2	18

The quantity of solid matter voided by diabetic patients is thus to be ascertained without the delay of evaporation. I have had occasion to test the correctness of this table, and can recommend it as calculated to afford most satisfactory results.

Torulæ in Diabetic Urine.

This fungoid vegetable growth, which is delineated on the plate fig. 15., is characteristic of the existence of fermentation, and its presence may be regarded as a very correct microscopic test of the presence of sugar.

Urine containing the Principles of Milk. — Kiestein.

There is a substance of a caseous character which has been called kiestein, and gravidine, occasionally found in the urine of women during gestation. I have had several opportunities of examining this, and believe it to be the caseous matter of milk altered by passing through the kidney. In several cases of advanced pregnancy I was enabled to detect the presence of milk globules in such urine, and that too in considerable numbers, and so as to leave no doubt as to the real origin of the so-called kiestein.

Fatty or Chylous Urine.

I lately had an opportunity of examining a specimen of chylous or chylo-serous urine, and being at the time engaged in the microscopical and chemical examination of chyle, was enabled to determine the existence of chyle in the excretion satisfactorily to my own mind. The microscopical appearances were such, indeed, as to leave but little doubt that in this form of disease the chyle passes through the kidney. The ordinary chyle granule and globule could be easily detected with the fatty globules intermixed. This kind of urine occasionally deposits a coagulum. The specimen I examined, however, remained unaltered by rest, and had quite the appearance of milk. The specific gravity was 1·021, and it was slightly acid, and remained so for several days. Agitated with ether, it became transparent, the ether dissolving out the fatty matter. These fats were soluble with difficulty in alcohol, and did not saponify with caustic potassa. When incinerated they yielded an alkaline ash. The urine, when cleared by ether, proved to contain albumen, being coagulable by heat and nitric acid.

THE END.

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