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Rees, G. O. 1813-1889.
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Publication/Creation

London : Longman, Orme, Brown, Green & Longman, 1836.

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ON THE

ANALYSIS

OF THE

BLOOD AND URINE,

IN

HEALTH AND DISEASE.

WITH DIRECTIONS FOR THE ANALYSIS OF URINARY CALCULI.

BY

G. O. REES.

LONDON:

PRINTED FOR

LONGMAN, REES, ORME, BROWN, GREEN, & LONGMAN,

PATERNOSTER-ROW.

1836.

London:
Printed by A. Spottiswoode,
New-Street Square.

PREFACE.

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.

Clapham Road,
Jan. 1836.

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INTRODUCTION.

BEFORE I enter on the description of processes, I feel it necessary to offer a few observations on the cautions which ought 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 the 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 ought to be taken in choosing a temperature suited to the nature of the fluid submitted for analysis. Thus, if urine be experimented upon,

it is impossible to use a continued temperature, even 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 may be washed with distilled water. It is often 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 afterwards 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 is liable, after passing the lip, to run backwards to the bot-

tom of the vessel, and thus to be lost. These may seem trifling circumstances; but persons who are accustomed to these operations 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 this, in order to prevent the loss which would otherwise occur by the rapid escape of gases, generated on the application of heat to the fresh animal matter.

The matter for incineration should be placed gradually in the crucible, piece by piece, which is a further security from loss. The crucible is to be managed by a small pair of forceps with

scissor handles, similar to the surgical dressing-forceps.

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 nature that is destructive to the apparatus, 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 at 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 whose weight has been ascertained previously; 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

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

the 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 have desired. This, however, is no great disadvantage, since we can always calculate the proportional quantities in any number of parts we may choose. 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 which occasionally becomes very distressing during manipulation, but which may be easily obviated by this simple expedient.

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

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 continually at the temperature of boiling water; that is, at 212° of Fahrenheit. The salt water-bath is formed in the same manner, excepting that the evaporating dish must be 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 generally is about 212° Fahrenheit. The fresh

water-bath may be preferred to this, except in cases where the evaporating dish is too heavily loaded to float in boiling water, and thus to form a water-bath.

Circular-wicked Spirit Lamp. — This may be either a most useful or most mischievous contrivance, according to its construction. Certainly, nothing is more agreeable than being able to procure a bright red heat at small labour and expense: but it is difficult to conceive a more awkward accident than the destruction of a large metal spirit lamp; a catastrophe which too often occurs with those generally sold in the London shops. This arises from the rapid communication of heat from the wick cylinder to the reservoir, which, by causing the vaporisation of a portion of spirit, at once determines the fate of our lamp. This evil may be sufficiently prevented by making the communication between the reservoir and wick cylinder simply with a very small tube, taking care to avoid all other contact between the cylinder and the body of the lamp.

The sloping sides of the chimney of these lamps should be so formed as to throw the flame as nearly as possible to a point at the top, which tends greatly to increase the heating effect.

I have now only to make a few remarks on the necessity of employing the purest re-agents that can be obtained; for, 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: for 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 (thus indicating the presence of a chloride); this ought not to be the case, and such water should always be discarded as unfit for use.

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

These acids should never be used as re-agents in their officinal condition, but always be 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. Every apothecary must

have observed a whitish coating or sediment in the bottle containing his dilute sulphuric acid. 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.

The officinal liquor potassæ, should never be used as a re-agent, for it frequently contains lime; but this, as well as every other solution intended for the use of the laboratory, should be such as has never had a place in the shop of any of the ordinary chemists and druggists of this city.*

Were I to proceed to show the reasons for avoiding the purchase of all officinally prepared solutions, I should far exceed the intentions of

* In making these remarks, I must beg to exclude from the epithet "ordinary chemists and druggists," the firm of Allen and Co., and perhaps one or two more, well known as scientific men, and such as England will always be proud to acknowledge; but the existence of such a body as the untaught tradesmen who arrogate to themselves the title of chemist, remains as one of the most amusing absurdities of the nineteenth century. I would beg to recommend Messrs. Allen and Co., of Plough Court, as persons well fitted to supply the chemist with his re-agents, &c. &c.

this work; I will, therefore, at once conclude, by earnestly intreating the tyro in chemistry to avoid the shops of those chemists whose names are not known to science.

My especial reason for noticing the impurities of distilled waters, the mineral acids, and the liquor potassæ, is, that these are the most likely to be purchased at druggists' shops.

I subjoin the following list of chemicals, which will be found sufficient for most purposes, in prosecuting animal analysis: —

Pure sulphuric acid
muriatic acid } Strong.
nitric acid

Dilute sulphuric acid
muriatic acid } Formed by mixing 1 part of the strong acid with 9 of water.
nitric acid

Solution of caustic potash.
ammonia.
carbonate of potash.
oxalate of ammonia.
corrosive sublimate.
acetate of lead.
sub-acetate of lead.

Solution of alum.
ferro-cyanate of potash.
pure acetic acid (strong).
tartaric acid.
nitrate of silver.
muriate of barytes.
Tincture of galls.
Sulphuret of iron.*
Litmus paper.
Turmeric paper.
Alcohol — specific gravity ·833.
Rectified ether.

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

A platinum crucible.
A piece of platinum foil.
- - wire.

* 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 made sufficiently long) is to pass to the bottom of the vessel holding the liquid, which is to be subjected to the action of the gas.

Test tubes.
Watch-glasses.
A blowpipe.
Glass rods.
A spirit lamp.
Test glasses.
Forceps.
A pair of scissors.
A bone spatula.
A steel spatula.
Two or three glass funnels.
Wedgewood dishes of various sizes.

ON THE

ANALYSIS

OF THE

BLOOD AND URINE.

ON THE ANALYSIS OF THE BLOOD.

In treating of the analysis of the blood, I shall first describe the method of ascertaining the proportion of fibrin, red particles, and serum contained in any specimen of that fluid. My reason for commencing thus is, that I may gradually introduce the student from the simpler to the more intricate processes. I have on this account preferred 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. After the qualitative analysis of the

various matters entering into the composition of blood, our object will be to exhibit, 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 BLOOD IN HEALTH.

Of the proportion of Serum, Fibrin, and Red Particles.

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 ooserved, 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 careful pressure, exercised by the thumb and finger. In this manner the fibrine 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 now 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 exists 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 which was 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.

Method of separating each Constituent of the Blood for Examination.

The separation of each constituent of the blood may be executed in two ways; either by the prosecution of several processes on the serum, after having separated the fibrin and red particles of the clot, or by the method proposed by Lecanu, which yields the albumen, fibrin, and red particles in admixture. As this process, however, is adapted to the examination of blood before coagulation, and as the three prin-

ciples in admixture are easily examined by the first-mentioned process*, I shall proceed to its details. Lecanu recommends that the blood freshly drawn be mixed with a considerable excess of alcohol at 106° Fahrenheit. Red flocculi are then precipitated, and a liquor remains, unprecipitable by the addition of more alcohol. The flocculi are now to be collected on a linen rag, and, after being strongly pressed, must be frequently treated with boiling alcohol, which is then to be added to the expressed liquor: from this process results a solid mass, insoluble in alcohol †, and a rose-coloured liquor, containing those principles of the blood soluble in weak and strong boiling alcohol. This liquor is now to be evaporated to dryness over a water-bath, and will be found to afford a yellowish brown very deliquescent matter. This is to be placed

* The hæmatosine may be procured by retaining the washings from the fibrin, and precipitating them with a solution of the subacetate of lead, which precipitates the albumen, leaving the hæmatosine in solution. This is to be decanted off, and freed from the excess of lead by the addition of sulphate of soda, which precipitates sulphate of lead. The solution must now be poured off from the precipitate, and on boiling it, the hæmatosine falls in brown flocculi.

† Consisting of fibrin, albumen, and red particles.

in a flask, and treated several times with ether: part only is dissolved, forming an ethereal solution A, and a residue B.

A, 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

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

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.

B, the residue (of the ethereal digestion which extracted the fats), is now to be treated with alcohol at 122° Fahrenheit, until the mass no longer imparts colour to that menstruum. By this means we procure a yellowish brown liquor, and a fresh residue, c. This alcoholic solution, when evaporated, yields an orange-yellow deliquescent matter. Its properties are as follows: — It is soluble in water and alcohol; precipitable of a brown colour by infusion of galls; precipitable by the subacetate of lead, the precipitate being soluble in an excess of that reagent. 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

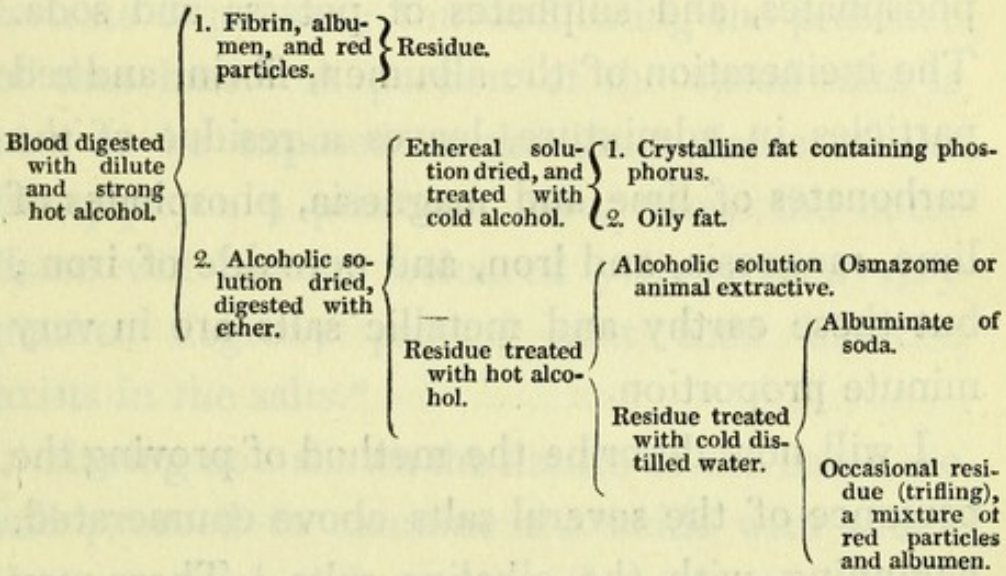
fats, which would produce the odour in question. This is, indeed, more than probable; since in most of the processes for obtaining osmazome no mention is made of any ethereal digestion, which would be necessary for the extraction of the fatty matters.

c, the residue of the alcoholic digestion, is now treated with cold distilled water, which dissolves it almost entirely, leaving only a residue, very minute in quantity, which is insoluble both in hot alcohol and water, and is believed by Lecanu to consist of a mixture of albumen and colouring matter.* The aqueous extract, 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

* This matter is probably in part, if not entirely, composed of what Dr. O'Shaunessey has called subrubrine, as that principle resists strong alcohol and water. It is, however, soluble in boiling dilute alcohol, but deposits on cooling. A portion of the subrubrine is probably left with the hæmatosine or colouring matter by the process here detailed.

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.

Diagram of the Process.



The blood, therefore, contains the following animal ingredients, capable of separation: —

Water.
Fibrin.
Colouring matter.
Albumen.
Crystalline fat.
Oily matter.
Extractive matter, soluble in water and alcohol.
Albumen combined with soda.

By incineration of any of these solid principles of the blood, we obtain a saline residue, which, in the case of the alcoholic and watery extract, is composed of the alkaline salts; viz. chlorides of sodium and potassium, carbonates, phosphates, and sulphates of potassa and soda. The incineration of the albumen, fibrin, and red particles in admixture, leaves a residue of the carbonates of lime and magnesia, phosphates of lime, magnesia, and iron, and peroxide of iron; but these earthy and metallic salts are in very minute proportion.

I will now describe the method of proving the presence of the several salts above enumerated, beginning with the alkaline salts. These may be proved to be such by dissolving part of them 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 reagent; and, as no excess of acid exists (the liquor possessing an alkaline reaction), we may

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 procured, 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 muriate of baryta (chloride of barium), which will occasion a dense precipitate, owing to the alkaline carbonate pre-

* It is scarcely worth while here to introduce the subject of lithia; it is proved to be absent, however, by the addition of phosphate of soda and ammonia to a portion of the solution, when no characteristic precipitate is observed.

sent. This precipitate must now be dissolved by a slight excess of pure hydrochloric (muriatic) acid, and the solution set aside; when a white precipitate of sulphate of baryta will appear, proving the presence of the sulphuric acid.*

A fourth portion of the solution is now to be rendered acid by a 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.

* 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.

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, a lively effervescence occurs, occasioned by the carbonic acid showing its presence. The phosphoric acid may now be proved present, by the addition of a few drops of the solution of nitrate of silver to a portion of the saline 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

* 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.

inner flame, having previously moistened them with strong sulphuric acid, when the outer flame will be coloured of a beautiful green.

Having now experimented upon the acids, we will proceed to the examination of the bases. To a portion of the saline solution add a sufficiency of ammonia nearly to neutralise the acid, and then let it be tested with the ferro-prussiate of potassa, when a precipitate of the prussian blue or ferro-prussiate 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. For a further examination of the earthy phosphates, and also of the phosphate of iron, *vide* Appendix.

ON THE ANALYSIS OF HEALTHY SERUM.

The analysis of the serum approaches very nearly to that of the blood, differing from the latter only in the absence of fibrin and red particles. The table of the constituents of serum is therefore at once procured by erasing these

two bodies from the list of principles contained in the entire fluid. Thus the constituents of serum are as follows: —

Water.
Albumen.
Extractive matter, soluble in water and alcohol.
Albumen, combined with soda.
Crystalline fatty matter.
Animal oily matter.
Chlorides of potassium and sodium.
Alkaline subcarbonate, phosphate, and sulphate.
Earthy phosphate and subcarbonate.
Subphosphate of iron.
Oxide of iron.

I shall proceed to the description of the process for making the quantitative analysis of the serum; a knowledge of which will now enable the student to ascertain the proportions of each ingredient of the entire blood, the method of determining the quantities of fibrin and red particles contained in any given specimen having already been noticed.

A portion of serum destined for analysis is first to be carefully weighed: 200 grains is fre-

quently 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 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 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 reagent 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, and the result must be weighed, its weight being 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 phosphate of iron: this weight must be subtracted from the original weight of the albumen (obtained by process B), in order to arrive at the correct 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 extract, in order to ascertain the real weight of animal matter in each of these extracts.

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 extracts.

Before proceeding to the consideration of the unhealthy serum, it will be necessary to observe the quantitative constitution of that fluid in its healthy state. I therefore annex the following results of two analyses, as made by M. Lecanu: —

Water - - -	906·00	901·00
Albumen - - -	78·00	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, which may be very easily effected.

Water - - - -

Albumen, with earthy salts and phosphate of iron * - -

* Avoiding the incineration of the albumen

Animal extractive, with albumen and soda *	}
Fatty matters† -	-
Alkaline salts -	-

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 rapid advances of animal chemistry have failed to produce the improvements which might have been anticipated in our pathological knowledge; and physicians have been content to quote this as an argument against the utility of chemical investigations; without considering that their own supineness has produced the mischief; and that, since chemists are not physicians, we shall scarcely benefit by their art, except by making the physician a chemist.

The blood may be called diseased, either when any of its constituents become unusually abun-

* Avoiding the separation by alcohol.

† Avoiding the separation of the crystalline fat from the oily matter.

dant, 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. Few observations exist in reference to the effects of disease in destroying the normal proportions of the principles of the blood: the most prominent are those in which the proportions of fatty matter and water become disturbed: the former occurring occasionally in icterus and diabetes, the latter in cholera. Marcet mentions

his having found so much fat in the serum of a diabetic patient that the fluid was like an emulsion in appearance, and deposited a matter like cream; it putrefied very quickly. The foreign principles occasionally introduced into the blood by disease, and detected by analysis, are urea*, colouring matter of bile, and cholesterine.

I may add also, sugar and free carbon; but these substances, having escaped the analysis of most chemists, are regarded in a somewhat equivocal light by the profession, and will not be further noticed in this treatise. Before quitting this subject, I would call the attention of the reader to a specimen of blood which was examined by Caventou, and which exhibited reactions and appearances altogether novel. Unfortunately, no mention is made of the state of the patient from whom this specimen was drawn; it is described as follows: — Colour milky white, with red striæ; no smell or taste; no reaction on reddened litmus; coagulated by heat into a coherent mass, which was incapable of being coloured blue by ebullition with strong hydrochloric acid; (thus distinguishing its coagulable

* In cholera, and anasarca with coagulable urine.

principle from fibrin and albumen.) Alcohol and the acids produced scarcely any coagulation. It was precipitated by infusion of galls, but not by the bichloride of mercury.

Examination of Blood supposed to contain Urea.

1. Let a portion of serum destined for analysis 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

* 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 by the temperature of boiling water.

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 evaporated to dryness over an open steam-bath, and the residue of the evaporation digested, with a considerable proportion* of 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,

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

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 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

* 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.

† This must be determined by the discretion of the

If it be required to ascertain the relative proportion of each other ingredient of 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 ascertain all by a single analysis has frequently been the cause of failing in the detection of urea when it existed in the blood.

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, that 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: —

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operator, as it is impossible to lay down rules on such a subject.

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 reaction; it yields a dark yellow coloured residue on evaporation, which has a saltish disagreeable taste. It is deliquescent, 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 crys-

tals 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.

The yellow serum of jaundice may be very

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

easily tested for bile by the addition of dilute sulphuric acid, which is capable of changing 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.*

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

* 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.

convinced him that cholesterine is not a constituent of healthy blood; and it is on the faith of his observations * that I class it as a substance foreign to the normal constitution of serum. I am at present engaged in a series of observations on the fatty matter of the blood, which will bear strongly on this subject, and I hope to be able to communicate the results in the Appendix. When serum is suspected to contain cholesterine, it should first be evaporated to dryness over a water-bath, and the dry residue must be 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.†

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

† There is some difficulty in otherwise separating these

In taking leave of this subject, I cannot refrain from expressing my regret, that so little has been done in the analysis of diseased blood. It is a subject no less interesting than it promises to be useful; and the philosophic revival of a humoral pathology bids fair to rank the analysis of diseased blood as one of the most useful adjuncts to our medical knowledge. I cannot lose this opportunity of expressing my admiration of the late discoveries of Dr. Stevens; and though I do not say that I agree with all the conclusions that gentleman has drawn from his most original and valuable experiments, yet I must believe that we are frequently capable of rendering assistance, by supplying any well-ascertained defect in the vital fluid. There are, indeed, many facts on record in favour of this system of treatment; and such facts too, as the most bigoted can scarcely fail to respect.

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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.

ON THE ANALYSIS OF THE URINE.

The examination of the urine may be regarded as a study of great importance to the physician. Indeed, a considerable knowledge of its healthy constitution and diseased conditions are quite necessary to the education of a medical man.

I shall commence this subject with a description of each constituent of the urine, giving its chemical reactions, &c. &c. I shall then proceed to describe the method used for the performance of the quantitative analysis of that fluid. The consideration of the urine in disease will be divided into two parts: the first treating of the urinary deposits; and the second, 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 be given of a method for a quantitative analysis of certain forms of unhealthy urine.

The reactions of certain medicines, &c., with directions for their detection in the urine, will be also described.

ON THE URINE IN HEALTH.

The urine in health contains, besides water, the following substances as ingredients; each of which will be separately noticed: —

Urea.
Free lactic acid.
Lactate of ammonia.
Osmazome.
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.
Muriate of ammonia.
Phosphates of lime and magnesia.
Silica.*

* The above list of constituents is that mentioned by Berzelius, who, it will be observed, entirely discountenances the opinion of Prout regarding the existence of lithates in the urine. It is, however, highly probable that these salts are present. Indeed, the experiments of Dr. Prout seem almost conclusive on the subject.

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 observable 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 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 salts. It may be obtained in colourless crystals, by digesting the alcoholic solution with animal charcoal, then filtering, and allowing the urea to crystallize by spontaneous evaporation of the alcohol. The chemical properties of urea are as follows : —

When heated on platinum foil it fuses; and if the heat be urged it 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 strong solution in water will bear a heat of 212°, without decomposition; but in dilute solution it quickly decomposes at that degree of heat.

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

It is almost insoluble in ether. The caustic alkalies decompose urea, it being resolved into carbonate of ammonia.

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

Urea has neither 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 discovered 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 oxide 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.* 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 uncrystallizable 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

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

† Not unlike that of the tartrates.

exists in the urine, and may be procured by digesting alcohol of specific gravity ·833 on an extract of urine; and after crystallizing the urea from the alcoholic solution (by means of nitric acid), separating the uncrystallizable matter, and neutralizing it with carbonate of baryta: the mass must then be dried, and alcohol will now extract the osmazome from the barytic salts.*

Its chemical properties are as follows: —

When heated it swells much, and leaves 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.

Protomuriate of tin, nitrate of silver, and subacetate of lead, produce precipitates.

It may be well to mention, that if an hydrous

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

† 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.

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 subacetate of lead, nitrate of silver, and protomuriate 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 re-dissolving in water an extract of urine which has been digested with alcohol of specific gravity 0·833. By the re-solution we separate any vesical mucus, lithic acid, earthy phosphate, or silica, which may be contained 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 neutralized with ammonia, and then again precipitated with the acetate, which now causes a precipitate of phosphate of baryta.* This is

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

to be collected, and the filtered liquor evaporated in order to drive off the ammonia; or what is better, it may be neutralized 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 sub-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 unprecipitated by the sub-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 corrosive sublimate, and more so by the protomuriate of tin.

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

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

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

It is not precipitable by the solution of corrosive sublimate; but the protomuriate of tin, the sub-acetate of lead, and nitrate of silver precitate it of a dark brown colour.

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

It is of a yellow colour. Solutions of corrosive sublimate, protomuriate 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 muriatic acid, which, after the lapse of some hours, produces a reddish crystalline precipitate of lithic acid. This 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 being dissolved in caustic potash, and then precipitated from its solution by the addition of muriatic 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.

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

Vesical Mucus.

This substance always exists in healthy urine, but is scarcely observable when in proper proportion. It may be procured from urine by throwing it on a filter immediately after being evacuated, when we can collect it in transparent colourless flocculi, which, if allowed to dry on the filter, possess a shining appearance. The addition of water, however, 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 capable of being precipitated by the ferro-cyanate of potash.

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 might occasionally be at a loss to determine the truth.

* This is probably owing to the presence of a small quantity of urate of ammonia, which is precipitated with the mucus.

The physician fortunately seldom requires such an examination in small proportions; for we have no very well-determined means of distinguishing minute quantities of pus from mucus by chemical examination. If pus be present in urine with mucus, we always find it lying on the latter, and possessing a much yellower tint; it is also quite opaque, whereas mucus is always 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 muriate of ammonia, which becomes dissipated by the calcination, and which must be procured by a separate process. I shall first notice the manner of extracting the last-mentioned salt, and then proceed to the general description of the remainder.

To extract the muriate of ammonia, a portion of urine must be exposed during several days, by which process we find a crystallization of various salts to occur at the bottom of the vessel. These consist principally of the chloride of soda, mu-

riate of ammonia, and ammoniaco-phosphate of soda, mixed more or less 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-crystallized, in order to rid them of adhering animal matter.* These crystals may be recognised as muriate of ammonia by the following characters: —

When heated with potash, vapours of ammonia are evolved, which may be recognised as such by their odour, as well as by forming a milk-white vapour if mingled with that of muriatic 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 sul-

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

phates, by the addition of solutions of nitrate of silver and nitrate of barytes, 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 neutralizing 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. By this means, the muriatic and phosphoric acids are detected.

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

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.*

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 neutralized by caustic ammonia), when a precipate of oxalate of lime occurs: this takes some time collecting; but when 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

* 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.

lime are the earthy bases. The phosphoric acid combined with the earths is detected as before with nitrate of silver, care always being taken to neutralize the tested liquid with ammonia, if it be at all acid.

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 its insolubility in strong aqua regia, and its 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 as one of the most difficult undertakings of the chemist.

* 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.

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 have but served 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."

From a quantitative analysis of the urine, made by Berzelius, that eminent chemist has produced the following result: —

Water - - -	933·00
Urea - - -	30·10

Free lactic acid - - -		
Lactate of ammonia - -		17·14
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
Muriate of ammonia -	-	1·50
Phosphate of lime and magnesia	-	1·00
Silica - - -	-	0·03

This form of analysis involves many troublesome processes, in separating matters which are at present quite unimportant to the medical inquirer. 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 easily collected and weighed.

The process for fulfilling the last-mentioned formula is as follows, two portions of urine

of 1000 grains each being requisite for its performance: —

First Portion. — This is evaporated over a steam-bath to dryness, and the weight of the residue is 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 redissolved in lukewarm distilled water; to this solution oxalic acid is to be added, until no more becomes dissolved on heating the liquid to 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 have a fresh

quantity of crystals on cooling. These crystals, being collected together, are dried between folds of bibulous paper; then redissolved in water, and neutralized 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. An hydrous 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 solid extract again ascertained, in order to re-assure ourselves of the former weight being correct. The extract is now carefully incinerated and decarbonized in a platinum crucible: the weight of the result being taken, and then subtracted from that of the 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 obtain the proportion of the matters required.

The weight of the result of incineration, minus that of the earthy phosphates and silica, is the

* 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 ten the weight of each.

weight of the alkaline salts. Thus we shall observe the *fulfilment* of the formula, which may, if required, be 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 in the urine, which is produced on the fluid becoming cool after evacuation, or which is voided with the urine in a precipitated state. I shall first notice the chemical constitution of these deposits; many of which are found to exist as constituents of urinary calculi.

Analysis of Urinary Deposits.

Most of these deposits are precisely similar in their constitution to urinary calculi, and there-

* *Vide* Appendix.

fore the same rules are applicable to their analysis. Those deposits, which contain matters differing in kind from the constituents of urinary calculi, may be easily distinguished by their peculiar colour, which is always more or less pink. It must be observed, however, that even these deposits consist almost entirely of ingredients which are met with in calculi, and that they differ only (in chemical constitution) from those bodies in possessing a colouring matter of a peculiar nature.

Some of the various 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.
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 but to add two more varieties of sediment, in order to complete the list of deposits mentioned by Dr. Prout. These are the phosphatic sediments: viz.

Amorphous sediment { Triple phosphate. Phosphate of lime, in variable proportion.

Crystallized sediment { Triple, or ammoniaco-magnesian phosphate.

We must add to these the oxalate of lime deposit, which is excessively rare; but a case is recorded by Dr. Prout, in his work on gravel and calculous disorders.

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 62.

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 when dry the purple tinge characteristic of lithic acid, which is increased on the addition of ammonia: thus we prove lithic acid to be present.

A second portion of the dried mass is mixed

* This is almost always in small proportion.

† The phosphate of lime exists alone in this deposit, and I believe rather as a secretion from the bladder than as a deposit from the urine.

‡ This holds the colouring matter in combination.

with caustic lime on platinum foil; when vapours of ammonia will be observed, cognizable by their odour, and by affording a white vapour when mingled with muriatic acid fumes: 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 muriatic acid to the deposit previous to incineration. The easy solubility of the deposit in warm dilute nitric acid served to show that no oxalate of lime was present, to whose decomposition the

carbonate of lime (of incineration) might be attributable.

Reddish-brown or Lateritious Sediments,

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.

I am far from thinking that the purpurate forms any part of the colouring matter in this deposit. In several specimens which I have examined it has consisted entirely of the peculiar red colouring matter of urine; probably the

* I have strong reasons for believing that this substance does not exist in the red deposit, and therefore shall exclude it from my consideration in the analysis.

same as that which we observe to fall in combination with lithic acid.

Pink Sediments,

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 Sediments,

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 muriatic acid, if it be first nearly neutralized 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. 61.*

* This amorphous sediment frequently simulates pus in appearance; but may be distinguished by the dissipation of the latter before the blowpipe.

Crystallized Sediment,

Consisting of

Ammoniaco-magnesian phosphate.

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 neutralized 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 very rare 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.*

* These three experiments can be made in a watch-glass or small test tube, without removing the result of the blow-

Some deposits have been observed by foreign chemists which have attracted but little attention in England. A notice of the chemical properties of these is, however, indispensable for the completion of this subject. The first to be described is the sediment of jaundice, or

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 follows:—

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.

Blue Sediment.

This consists of a peculiar matter; to which

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pipe experiment, which may be a very minute quantity. First, the water is added, which has no solvent action; second, the addition of acid, to this water causes effervescence and solution; and third, the addition of oxalate of ammonia throws down oxalate of lime.

Braconnot has given the name of Cyanourine. It has not been observed in connection with any particular form of disease. When present it tinges the whole urine of a blue colour.

It possesses the following 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 neutralized 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.*

Red Particles.

This sediment can never be mistaken, on account of its peculiar colour. It may be identified by the property it possesses of becoming of a very bright red colour, when treated with a concentrated solution of muriate of soda.

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.

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

There are such variations occurring in the proportions of ingredients in urine voided at different periods of the day, that it is exceedingly

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

difficult or almost impossible 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, cases in which we can at once form an opinion, and such are usually to be detected without any quantitative analysis; since the action of re-agents becomes so excessive as at once to claim our attention and decide our judgment. If it be the wish of the physician to note more minute deviations of proportion, he can now accomplish this 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 the diseased fluid, 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 frequently 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 re-agent: the precipitate is of a green colour; but if an excess of nitric acid be added, this 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 crystallization of nitrate of urea. This test was first introduced by Prout, but it requires care in its application; because the heat of the atmosphere being subject to variation, will cause an equal variation in the time required for crystallization, even in identical specimens of urine.

Prout states, that when the specific gravity of urine is above 1·025 or 1·030, this crystallization is frequently observed: but it is certain that a much higher specific gravity may exist without such a property of becoming crystallized with nitric acid before evaporation; for Berzelius examined a specimen of urine of specific gravity

* 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.

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 the 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 subphosphate of lime and magnesia with ammonia.

Solution of Ferrocyanate of Potash. — This is a very delicate test of albumen in urine; but always requires the previous addition of a few drops of pure acetic acid, if the urine be either alkaline or neutral.

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

Muriatic Acid, like nitric acid, precipitates

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

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 Bichloride of Mercury is a very good and delicate test for albumen: but we must be careful that the urine is acid, before we apply this re-agent; for urine that contains no albumen is liable to be precipitated by the bi-

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conjunction with ebullition; for the 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 as albumenous. The amorphous sediment has frequently been mistaken for pus by a similar mistake.

chloride, if it be a specimen either neutral or alkaline in its re-actions.

EXTRANEOUS PRINCIPLES IN URINE.

The urine frequently presents the various odours and colours of vegetable matters which are taken into the stomach; and the examiner must be on his guard against being deceived by such appearances. Thus, I have known a patient on the point of being treated for hæmaturia, when the urine (by a mere chance) 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 beet-root 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 is used by patients.

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 from large doses of calomel, but could not discover any trace of mercury in it.

Iodine always exists in the urine of those who take it internally. I have 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.*

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 quan-

* 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 hydriodate, but probably an iodate.

titative analysis of two very common forms of diseased urine, viz. the albumenous and saccharine degenerations.*

QUANTITATIVE ANALYSIS OF ALBUMENOUS URINE.

It is always 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 parts, equal in 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 re-dissolved in distilled water.

This aqueous solution is concentrated until it assumes the consistence of a syrup. It is

* The former of these conditions exists when anasarca co-exists with disease of the kidneys, as shown by Dr. Bright. The latter is indicative of diabetes.

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 crystallization 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 40., 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

* 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.

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 circular-wickt spirit lamp, until all the organic matter is dissipated. The weight of the decarbonized 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 - -	}

* The extract should be quite dry before we add the boiling water; otherwise a portion of albumen will always remain in the filtering solution.

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 albumenous 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 albumenous mass, gives us the weight of the albumen and lithic acid together. By this process then we have executed the following formula:—

* 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 albumenous urine, although for the most part the lithic diathesis prevails.

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

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 has made some experiments on this subject, from which he concludes that urea is voided by diabetic patients in the same quantity per diem as by healthy individuals. His method of detection was by plunging a mixture of

the fluid 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 as in the preceding, it is best to divide the urine into two portions of equal weight; one of which is to be used for determining the proportion of urea.

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 next 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,

* 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.

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 decarbonized 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 extrac-

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

tives, 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, and chloride - }
- Earthy phosphate - -
- Vesical mucus { With perhaps a trace of lithic acid - - }

ANALYSIS OF URINARY CALCULI.

The examination of urinary calculi is very easily performed; and it is surprising that so few of the medical profession are capable of conducting the analysis of substances so frequently presented to their notice, and whose varieties are so easily discriminated. We may divide into two classes the substances entering into the composition of calculi.

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).
Albumenous 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 (resulting from triple phosphate).

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 of lime by heat).

Silica.

We frequently find that lithic acid exists in combination with lime as well as with ammonia and soda; but this is always 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 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

* 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.

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 this reaction of lithic acid. In the former case, the ammonia increases the yellow tinge to an orange colour, which is very distinct from the beautiful violet tint of the purpurate of ammonia.

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, which, however, are generally very small; they are of a clay colour, with a smooth external surface. Their

* Owing to the formation of the purpuric acid.

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 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 having the appearance of that fruit. These calculi are generally of a dark brown colour. When sawed through and polished on the internal surface, we have an appearance much resembling that of the fortification-agate; which is owing to a succession of conformable deposits on the originally tuberculated surface. The chemical properties of oxalate of lime are as follows:—

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

When boiled with a solution of carbonate of potash, it becomes decomposed, forming carbonate f 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 form-

ation 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.

Before dismissing this subject, I have to notice a particular 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, and of an oval form. I have examined but one specimen of this variety of concretion.

Albumenous Animal Matter and dried Blood.

The former of these is constantly present, in greater or less proportion, in every kind of calculus. It is almost always present 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; but 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 coagulated blood; 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 albumenous animal matter contained in calculi has the following characters: —

It is insoluble in both 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 muriatic acid. It produces a fine yellow colour when

boiled with nitric acid, and yields all the well-known reactions of albumen.

Cystine, or Cystic Oxide.

We are indebted to Wollaston for the discovery of this substance. It is of very rare occurrence in the human species, but is more 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; but it seems somewhat extraordinary to use the word oxide, as applied to a

body so purely organic as is this; and the term cystine, used by foreign chemists, seems more appropriate, and certainly more correct. Cystine exists in calculi in a perfectly pure form; no compound calculus, containing cystine as a constituent, has yet been discovered.

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, muriatic, 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.

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 character.

Xanthic Oxide.

This calculus was first observed by Dr. Marcet, but has not been noticed by other chemists. Indeed, from the description alone, I should be much inclined to doubt its existence as a substance *sui generis;* and when reading the reactions described by Dr. M., we at once seem to recognize 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 albumenous matter.* It has been stated that

* In the seventh volume of the Traité de Chimie of Berzelius we find the following passage concerning the reactions 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 cou-

Stromeyer had found this substance in a large calculus; but no satisfactory report has been published. 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.

Fibrinous Calculus.

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

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leur 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."

both in colour and consistence; its structure being fibrous, and somewhat elastic. Its reactions are as follows:—

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

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 wheter 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

* This would tend to show that it differs in its nature from fibrin.

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 reactions 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 muriatic acid, when it will be observed that the fumes become

more dense, white, and determinate in form, owing to the production of muriate of ammonia. 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 a 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 neutralized 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. It requires a very intense degree of heat before it can be fused.

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: —

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

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 reaction, 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 for 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 of lime which may be present in the concretion. Since, however, oxalate of lime produces no 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 muriatic 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 muriatic acid.

The solution in acids is precipitated on the addition of oxalate of ammonia; care being taken previously nearly to neutralize 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 muriatic acid, which must be well washed from the calculous matter previous to performing the incineration; for muriatic acid having removed all the carbonate, any which may be detected after calcination must be regarded as a result from that process.

* When lithate of lime exists in a calculus, we should have effervescence produced after incineration, were it not that we took care to employ a digestion with muriatic acid, previous to performing the calcination. When this precaution is used, we can be sure that such effervescence is caused by the decomposition of oxalate of lime.

Silica.

This substance was twice detected by Vauquelin and Fourcroy during their laborious researches 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 are we to be surprised at its being 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 the desideratum of 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 com-

position of a compound calculus, containing all the ingredients which can be ordinarily met with in such a concretion*; viz.

Lithic acid.
Lithate of ammonia.
Lithate of soda.
Lithate of lime.
Oxalate of lime.

Ammoniaco-magnesian phosphate or triple phosphate.
Phosphate of lime.
} Forming the fusible calculus, if the phosphate of lime be in sufficient proportion.

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.

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

† Cystine, xanthic, and fibrinous oxide are here excluded, because they have never been discovered as components of compound calculi. Several other matters, which appear rarely and in small proportion, are also omitted: such are silica and muriate of ammonia; the latter first noticed by Dr. Yellowley, in the Philosophical Transactions.

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.

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

A portion is placed on a watch-glass, and treated with nitric acid and ammonia, as before described, when we shall procure the characteristic reaction 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. Lithic a

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

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, which may be known by their characteristic odour, and also by testing them with fumes of muriatic acid, as before described.

The remainder of the residue may now be carefully heated on platinum foil before the blow-pipe, when it will char, and partly volatilize. The remainder (if any exist), when perfectly decarbonized, will possess an alkaline reaction; and 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.

The matter which was not dissolved by the distilled water, will be found to dissolve with effervescence in a drop of dilute muriatic 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,—

* 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

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

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

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

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

The remaining matter insoluble in water is now to be digested in dilute muriatic acid, then incinerated and decarbonized in a platinum capsule, over the circular-wickt 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.* Oxalat lime.

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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 muriatic acid is to extract all the carbonate of lime before incineration is performed: by which means we may be sure that that which appears after incineration is the result of decomposed oxalate.

Treatment of second Part.— This is placed in a platinum capsule over the circular-wickt spirit lamp, and perfectly incinerated and decarbonized.

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 existed in the calculus), we must dissolve the whole in dilute muriatic acid, and precipitate this 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.*

es. 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

* 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 muriatic acid and precipitation with ammonia, which is otherwise necessary to separate the phosphates.

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, 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: —

Phosph 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 neutralizing 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 neutralized with ammonia *, and then a solution of oxalate of ammonia is to be added, which

* The solution should, however, always be acid, in order to preserve the magnesia in solution till the lime is precipitated.

will precipitate lime after a short interval has elapsed.

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 volatilized when heated on platinum foil. Again, we but seldom encounter 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, phos-

phate 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 entirely of the earthy phosphates, we find that it blackens before the blowpipe; and when engaged in the examination of such a specimen, we cannot be sure but that this carbonization is owing to the presence of lithic acid. The effect of the blowpipe heat, 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 ge-

nerally 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, it is very necessary to avoid everting the face of the sawn calculus, 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 confusion 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.

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 there is as yet no well ascertained method of performing their quantitative separation. The nearest approach, however, is by the following process: —

The mixed phosphates are dissolved in dilute muriatic acid, and the solution is then nearly neutralised by ammonia. Alcohol is next added to the muriatic solution, and sulphuric acid is to be 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 muriatic 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 further 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 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 can 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 ferroprussiate of potash, which yields a fine blue precipitate of Prussian blue. This test will also serve to separate the iron from the earthy salts.

Subrubrine.

An article communicated by Dr. O'Shaughnessy to the "Lancet," enters into a full description of a principle which appears somewhat novel in its re-actions. Further examination, however, is necessary, before we are justified in acknowledging subrubrine as a proximate animal element. It was discovered by O'Shaughnessy in the blood of various animals, as the cow, sheep, fox, and dog, as well as in the human subject. The account of its chemical properties, as mentioned in the "Lancet" for February 7. 1835, is as follows: —

In the dry state it is opaque, pulverulent, of a reddish brown colour, totally infusible by heat, leaving a

* This precipitate is oxalate of lime.

† 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. This magnesian precipitate frequently requires some time for its formation.

very minute earthy residuum * when calcined on platinum foil or mica.

Insoluble in water or absolute alcohol when cold, but soluble in dilute alcohol at the boiling point. Insoluble in ether, and the oils both fixed and essential. It is deposited on cooling from the boiling solution in dilute alcohol, and appears of a pale flesh colour. It is dissolved by very dilute nitric acid, and the solution rendered turbid by tincture of galls and ferroprussiate of potash.

When this discovery was made the author was absent from England; it is much to be hoped that he will make further experiments on the subject.

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.

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: —

* This would render it impossible that red particles formed any part of the mixture, even if subrubrine were a compounded substance; for hæmatosine would yield a ferruginous ash.

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 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 phosphorized 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 phosphorized fat: its re-actions are very similar to those of the red fatty matter. The alkalies possess no solvent action on this substance.

* It is necessary to powder the solid matter very completely; otherwise the alcoholic digestions become very tedious.

In preparing these fats, it is best, if possible, to avoid using any colouring matter of blood, and to procure them from the fibrin and albumen alone; for the hæmatosine is difficult of separation from the alcoholic solution, as it always becomes in part dissolved, when boiled even with strong alcohol. It is highly probable that these fats are nothing more than elain and stearine, altered, more or less, in their chemical properties, by combination with sulphur and phosphorus.

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.

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 statistical 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

From these results, the following facts may be elicited: —

1. The proportion of serum varies in the blood of individuals of different sex and ages; also in the blood of individuals of the same sex, but differing in age. It is greater in the blood of women than in the blood f 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 remarked 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 ages. In the blood of individuals of the same sex, but of different ages 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 remarked 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 ages. 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, I shall observe, that the menstrual losses to which they are subjected 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 may easily be foreseen that a similar effect to the above can 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.

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 muriatic acid has led to the error; for, on the addition of sulphuric acid to a dry mass containing a muriate 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. We have, however, no very decided experiments on either side of the question, and the matter may still be considered as open for investigation.

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 discovered in the urine of the cow by Rouelle; it has since been detected in the urine of children. Liebig made some minute investigations into the nature of this acid as found in the urine, and seems to consider it as 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 has therefore named this acid the hippuric, as he considers it peculiar to the urine of the horse; but this is not the case. 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.

Quantitative Estimation of Fixed Alkaline Muriates, 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 of 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 muriatic acid present in the salts, as follows: —

A solution of nitrate of silver is added to the liquid, which is previously acidulated with nitric acid. A chloride of silver now precipitates, which is to be collected on a filter, and then fused in a platinum crucible over the circular-wickt spirit lamp; from its weight we deduce that of the muriatic 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 is here to be divided between potash and soda.

* 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. This is especially the case if the ammoniacal salt be a muriate; for muriate of ammonia is an active solvent of phosphate of barytes.

The phosphoric and muriatic 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, estimating the proportion of the alkali from the known constitution of the potash chloride of platinum.

Albumenous Urine.

This form of diseased urine is generally coagulable by heat, and is for the most part acid. I have, however, occasionally met with specimens which were 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 different specimens of urine taken from the same individual: the one was neutral and coagulable by heat; the other not coagulable by heat, and possessing an alkaline reaction. 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 sometimes exists in the urine an animal substance, to which Dr. Prout has given the name of incipient albumen. This principle is coagulable by heat, but is soluble in dilute nitric acid, which distinguishes it from the albumen ordinarily met with in diseased urine. Specimens of urine containing incipient albumen are not very common; but it must be recollected that such exist, or we shall be occasionally at a loss in our researches.

Colouring Principle of the Pink Deposits in Urine.

The opinion of Dr. Prout, that the purpurates form the colouring principle of these deposits, has been objected to by several continental chemists, who state that the colouring matter of the urinary sediment may be extracted by alcohol, which distinguishes it from purpurate of ammonia. This fact has frequently been quoted as conclusive against the opinion of Dr. Prout; but there is no doubt that alcohol is as ready, if not more active, a solvent of purpurate of ammonia as it is of the matter colouring the pink deposit, and therefore we must not regard these observations as affecting the question.

It is indeed extraordinary that such declarations have been so generally received and quoted as true, affording a strong instance of the proneness of our chemists to receive facts without even the most cursory examination. There is a decided difference between these colouring matters, as regards their re-action with certain powerful re-agents; but it is well known that organic substances, identical in chemical constitution, are very liable to undergo modifications in form, from the action of other organic matters with which they may be admixed, or with which they have previously existed in solution. It is then impossible to draw a decided conclusion, as regards chemical difference, from the mere optical fact of change of colour, which we know often occurs without any chemical change being effected. It is, I think, very probable that a purpurate of ammonia may exist as the colouring principle of these deposits; and I am far from being surprised at the colour being affected differently from that of purpurate of ammonia,

which is artificially procured, and has never been dissolved in urine, and then precipitated from that fluid; for it is most likely that its form becomes modified, which is quite sufficient to account for any peculiarity of re-action relating to its colour. We must not here omit the fact, as stated by Dr. Prout, that nitric acid can be sometimes detected in urine depositing the purpurates. This, which is the most active agent in forming purpuric acid, by its action on the lithic acid contained in urine, has likewise been discovered by Vogel, but he failed to detect it in several specimens which he examined; this is not to be wondered at, for though nitric acid may have been the agent, and have formed a purpurate, it does not follow that an excess should always exist in the urine after the action is completed. Besides, there must be a very considerable excess, in order that its presence may be satisfactorily proved, for our means of detecting nitric acid are far from delicate, and quite inadequate to the determination of small quantities.

There is a fact which tends strongly to show that the peculiar re-actions on these colours are nothing more than optical phenomena, dependent on peculiarity of form alone. Thus, if strong muriatic acid be added to purpurate of ammonia artificially procured, the colour is no longer observable; this is not the case with the colouring matter procured from the pink deposits; but should not this be regarded as an optical and not a chemical distinction, when we find that if the muriatic solution be evaporated to dryness, we can again procure the colour of the purpurate? We have not as yet any experiments which authorise us to give a decided opinion as to whether the purpurates exist or not in the pink deposits.

Distinction of the 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. 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 muriatic acid, whereas the latter substances resist that solvent.

Deposits of Matters accidental to the Urine.

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

* 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 opakeness is produced by the coagulation of the albumenous matter.

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 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 crystallizing 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.

THE END.

LONDON :
Printed by A. SPOTTISWOODE,
New-Street-Square.