A guide to the examination of the urine, intended chiefly for clinical clerks and students / by J. Wickham Legg.

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EXAMINATION OF THE URINE

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INTENDED CHIEFLY FOR CLINICAL CLERKS AND STUDENTS.

BY

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INTRODUCTION.

This little work is intended to supply the clinical clerk and student of medicine with a concise guide to the recognition of the more important characters of the urine: and from its small size to serve as a companion in bed-side analysis to the busy practitioner, who, at the time, may be unable to consult the larger works on the subject. A plan for the examination of the urine, step by step, has been given, with an account of the method for ascertaining the presence of those constituents that most frequently occur in disease. An appendix has been added in which the manner of estimating the urea, chlorides, phosphates, sugar &c., by volumetric or other rapid analysis has been described.

South Street, Park Lane.
September, 1869.

A GUIDE

TO THE

EXAMINATION OF URINE.

In order to assist the student and furnish him with a plan for the systematic examination of the urine, the following scheme for a rough analysis, in which the more important constitutents are looked for, has been given with a reference at the end of each paragraph to the page at which the details of each operation are described.

SCHEME FOR THE EXAMINATION OF THE URINE.

I. Observe the colour of the urine, its appearance, if clear, smoky, turbid, &c. (page 6).

II. Ascertain the specific gravity, (page 8).

III. Examine the reaction, whether acid or alkaline, by means of litmus or turmeric paper, (page 10).

IV. Test the urine for albumen, (page 11). If albuminous, examine microscopically for—Renal Casts, (page 38); Pus Corpuscles, (page 34); Red Blood Corpuscles, (page 35).

V. Test the urine for sugar, (page 14).

VI. If there be no deposit, the urine need not be examined microscopically.

Pink or reddish deposit, dissolved on heating test-tube—urate of soda, (page 29).

White crystalline deposit, soluble in acetic acid—triple phosphates, (page 31).

White amorphous floculent deposit, rendered ropy by alkalies—pus, (page 34).

Brownish red crystaline deposit—uric acid, (page 27).

Red amorphous deposit—blood, (page 35).

PHYSICAL EXAMINATION.

The Physical Examination is the application of the senses, unaided, to the investigation of the urine: not much, however, can be learnt from this mode of observation, the only points which can be made out are the colour, translucency, odour and consistence.

Colour. This may vary in disease from a point where the urine is almost as colourless as water, to where the urine is dark brown black: a smoky tint is absolutely diagnostic of the presence of blood, a brownish green suggests the presence of the colouring matter of the bile: many drugs give a peculiar colour to the urine, as rhubarb and saffron.

Translucency. In health, the urine deposits, after remaining at rest for a short time, a slight cloud of mucus, derived from the bladder: but in all other respects, healthy urine is perfectly clear. On cooling however, it may sometimes become turbid from the presence of urates, which are distinguished from other deposits by their appearing after the cooling of urine which was perfectly clear when

first passed. In disease the urine is often turbid when first voided: and pus is the most frequent cause of this condition.

Odour. It is not yet ascertained to what substance the peculiar odour of the urine is due: nor is it at the present day of much importance to the clinical student: when, however, the urine loses its urinous odour and becomes fetid and ammoniacal, the change is due to the decomposition of urea into carbonate of ammonia: in cases of cystitis and paraplegia the alteration begins very rapidly after emission. Various drugs and articles of diet give a peculiar odour to the urine: as is well known with asparagus: turpentine gives the odour of violets to the secretion: in gout and Bright's disease, it is stated, that after these substances have been taken, they cannot be recognized in the urine by their smell.

Consistence. The urine is a limpid fluid, flowing freely from one vessel to another. But in catarrh of the bladder a large quantity of mucus often causes the secretion to be viscid and ropy, and poured with difficulty from one vessel to another.

The froth on normal urine readily disappears, but if the froth be permanent, albumen, or the constituents of bile may be suspected to be present.

SPECIFIC GRAVITY.

Before passing to the mechanical and chemical examination of the urine, it may be well to state the apparatus

which is necessary for bed-side investigation by the student.

Cylindrical urine glasses, containing 6 to 10 oz.

A urinometer, the stem of which is graduated from 1000 to 1060.

Blue litmus and turmeric paper.

Test Tubes.

A Spirit Lamp, or Bunsen's gas burner.

Dilute Nitric Acid.

Acetic Acid.

Liq. Potassæ or Liq. Sodæ.

Sol. of Sulphate of Copper, 10 grains to the ounce.

Glass Funnel and Filtering Paper.

With this apparatus and list of reagents, the student will be able to perform all the more important reactions described below.

The *specific gravity* of the urine varies in health between 1005 and 1030; the simplest way of estimating it is by means of the urinometer.

In order to use this instrument, a quantity of the urine to be examined is poured into a glass cylinder and care is taken to remove all the froth which may form, either by blotting paper or overfilling the vessel. The urinometer must then be introduced and allowed to float in the fluid, care being taken that it does not touch the sides or bottom of the vessel but that it swims freely in the urine. Since the fluid accumulates around the stem of the urinometer from the physical force of attraction, the specific gravity

appears to be higher than it really is, if read off while the eye is above the surface of the fluid: to obtain a correct reading, therefore, the eye must be lowered to the surface of the fluid and the number on the stem read off by looking at it through the urine: having noted the number, the urinometer should be depressed in the urine and again allowed to come to rest, when the number may be again read off: this second estimation is made to correct any mistake that may have occurred in the first reading. The number should be noted down at once.

The knowledge of the specific gravity of a few ounces of urine is a matter of little value. To render the observation in any way serviceable the whole quantity passed in the 24 hours must be collected and mixed, and the specific gravity of a small amount of this taken. A rough estimation of the solid matters passed may be made from the specific gravity in the following way: the two last numbers of the specific gravity are multiplied by 2 (in diabetes by 2·33) and this gives the quantity of solid matters in a 1000 parts of urine: if, for example, the specific gravity of the urine be 1020, 1000 grains of urine will contain 2×20 *i.e.* 40 grains of solids.

Sugar in the urine is the most common cause of a high specific gravity: if this substance be not present, excess of urea will be the probable cause.

A low specific gravity, below 1010, occurs after fluid has been ingested in quantity. In disease, a low specific gravity is noticed frequently in the contracted form of Bright's Disease.

When a new urinometer is bought, it must be carefully tested, since those sold by the instrument makers give results varying as much as 10 or 12 degrees. The urinometers in common use in Hospitals are very rarely correct.

REACTION.

Reaction. The urine is almost always secreted acid, though it may become alkaline within a very short time of emission. In the majority of cases in which the urine is said to be alkaline, as in paraplegia and cystitis, the alkalinity is really due to decomposition after being passed. If the urine, then, be found to be alkaline, a fresh specimen should be tested immediately after it has been voided. The urine, in cases of retention, often becomes alkaline in the bladder, and can be made alkaline, in health, by the administration of drugs.

The *cause* of the acid reaction of the urine is the presence of the acid phosphate of soda and, according to others, of free lactic and hippuric acids. Very shortly after emission, the acidity increases and lasts, in health, for some days, free uric acid being often deposited.

Sooner or later however, the alkaline fermentation sets in, the urine becomes fetid and ammoniacal from conversion of urea into carbonate of ammonia, while the phosphates are deposited as a white sediment.

Clinical Import. The acidity of the urine is decreased

during digestion and increased by fasting or perspiration. A very acid, high coloured urine is associated with the "uric acid diathesis."

Alkalinity of the urine is always due to decomposition of the urea into carbonate of ammonia, excepting those cases in which the alkaline salts have been taken. It is most frequently present in diseases of the spinal cord and chronic affections of the bladder and urinary organs. When the alkalinity is due to ammonia, the brown colour of the tumeric disappears when the paper is exposed for some time to the air or gently heated: but the change from yellow to brown is permanent if the alkalinity be owing to either potash or soda.

EXAMINATION FOR ALBUMEN.

This is the first and most important step in the chemical examination of the urine: the presence or absence of albumen must always be determined before proceeding to test for any other substance, and the search must never be omitted in the examination of any urine.

The best way of testing for *albumen*, is to fill a test tube about two thirds full of the urine to be examined and to heat the upper layer of the fluid over the flame of a lamp, the lower end of the tube being held between the thumb and forefinger of the observer. By employing this method two strata of fluid are obtained for comparison.

The heat is applied until the upper portion of the urine begins to boil, for although albumen, when in large quantity coagulates at a point far below boiling yet the presence of a small quantity gives no precipitate below 212° F. The boiled stratum of fluid should now be carefully compared with the cool layer in the lower part, by holding the test tube against the light: if any cloudiness or opacity be seen, it must not at once be concluded that albumen is present: but a drop or two of dilute nitric acid should be allowed to flow gently down the side into the urine: the cloud, if due to albumen, is permanent: but disappears immediately if due to phosphates. This addition of acid after boiling should never be omitted, since the most practised eye cannot distinguish between the cloud produced by phosphates and albumen, by appearance only.

Cautions. (*a.*) The addition of the nitric acid not unfrequently carries down some of the coagulated albumen into the unboiled layer of urine and thus causes the cloud to be less thick than before: phosphates never cause this, but the urine becomes absolutely clear as before boiling; slight brown coloration only, occurring from the addition of the nitric acid.

(*b.*) Should the urine be turbid from the presence of urates, it quickly becomes clear on the application of slight heat: and as it is desirable before testing for albumen to have a clear solution, the whole of the test tube should be passed two or three times through the flame of the lamp until the urates are dissolved: the upper stratum of the urine

should then be boiled and compared with the lower, as above.

(*c.*) If the urine be neutral or alkaline at the time of testing, the albumen, if in small quantity, will not be precipitated by heat; the acid reaction must therefore be restored by a few drops of weak acetic acid and the urine then boiled and nitric acid added. If the alkaline urine be boiled without previous acidulation, a deposit of phosphates is almost sure to occur which is immediately dissolved on addition of an acid.

(*d.*) If the urine be permanently turbid, from any cause, and it is desired to know accurately if albumen be present, the urine must be filtered before boiling: in this way very minute traces of albumen may be discovered.

A rough way of estimating the quantity of albumen present in the urine is to pour some of the urine into a test tube until it is near three quarters full and to boil the whole of the urine in the tube until the albumen is completely coagulated. The test tube is then set aside for 24 hours, and at the end of that time, the proportion of the coagulated albumen, which has collected at the bottom of the tube, to the rest of the fluid, is noticed. Thus if the albumen occupy one-third of the height of the fluid, there is said to be one-third of albumen in the urine; or one-sixth, or one-eighth as may be. If however, at the end of 24 hours scarcely any albumen has collected at the bottom, there is said to be a trace.

If the urates have separated from the urine, it must be filtered before boiling, or an extensive error will creep in by their increasing the apparent amount of albumen.

Clinical Import. The presence of albumen in the urine is an important objective sign of disease.

In a chronic, non-febrile disease, the discovery of albumen, in quantity, in a clear straw-coloured urine would lead to the suspicion of grave kidney affection and to the search for renal casts. In acute febrile diseases, albumen is frequently present in the urine: but in this case, the albumen disappears with the termination of the disease. A frequent cause of the presence of albumen, is pus, in proportion to its quantity: in the urine of women, a small quantity of albumen is frequently due to leucorrhæal discharge which is composed chiefly of pus. Gleet in the male similarly causes albumen to be present in the urine.

The presence of blood in the urine necessitates the presence of albumen as well, from the escape of the serum through the divided vessels.

EXAMINATION FOR SUGAR.

If the specific gravity rise above 1030, *sugar* may be suspected and should be looked for.

Many methods of testing for sugar have been proposed: but only the most prominent and trustworthy will here be mentioned, although it must be confessed that a rapid and yet trustworthy test, suited to practitioners, is a desideratum.

Moore's Test. Equal parts of urine and liq. potassæ or

liq. sodæ are poured into a test tube and the upper stratum of this mixture is heated to boiling, as described under the head of examination for albumen. The heated portion becomes yellow, brown-red, dark-brown or black according to the quantity of sugar present. The least alteration of colour may be perceived by comparing the upper and lower portions of the liquid.

Cautions. High coloured urines and urines containing excess of phosphates, darken perceptibly on boiling with caustic alkalies, and if the urine be albuminous, the colour will be greatly deepened, even if no sugar be present. Before, therefore, applying Moore's test to an albuminous urine, the albumen must be removed by boiling with a drop or two of acetic acid and filtering.

Dr. Roberts has noticed that liq. potass. which has been kept for a few weeks only in white glass bottles, takes up lead from the glass and that a black precipitate of sulphide of lead is formed when boiled with certain urines which contain much sulphur. Care must be therefore taken that the liq. potass. is quite pure.

The value of Moore's test is chiefly negative: if the urine on boiling with liq. potass. does not perceptibly darken, it may be assumed free from a hurtful quantity of sugar; if however darkening occur, a further observation must be made with Trommer's test.

Trommer's Test. This depends on the property which grape sugar possesses, of reducing the higher oxide of copper to a lower. The observation is conducted in the following manner.

About a drachm of the suspected urine is poured into a test tube and liq. potass. or liq. sodæ added in about the same quantity : a weak solution of sulphate of copper (about 10 grs. to the fluid ounce) is then added until the solution acquires a beautiful blue colour, the contents of the test tube must next be boiled, when, if sugar be present, an orange red precipitate is first thrown down which after some time becomes a reddish brown. This precipitate consists of the suboxide of copper.

Since uric acid and mucus will also reduce copper when boiled, a similar solution should be set aside in the cold; and, if after the lapse of 24 hours the reddish precipitate has occurred, sugar is undoubtedly present.

Cautions. Much difficulty is often at first experienced in arranging the proper proportion between the copper solution and the liq. potass. If too much copper be added, which is the most frequent mistake, the potash cannot redissolve the precipitate formed and thus the oxide of copper may be regarded as the suboxide. The best rule is this : always to have an excess of potash present and never to operate except with a clear solution.

Fermentation Test. A few grains of German yeast are put into a test tube, which must then be filled with urine and inverted in a shallow dish already containing a little urine, or better by far, quicksilver, and set aside in a warm place as a mantel-piece or a hob. A similar test tube must be filled with water, a few grains of yeast added, and subjected to the same conditions. If sugar be present, the formation of carbonic acid will, at the end of

24 hours, have driven nearly all the urine out of the test tube : a few bubbles only will have appeared in that containing the water. To prove that this gas is carbonic acid, some caustic potash or soda must be introduced into the test tube, when the gas will be quickly absorbed and the urine rise again in the tube.

The researches of Bruecke have proved that healthy urine contains sugar in about ·01 per cent. Consequently a healthy man excretes daily through the kidneys about 15 grains of sugar.

Clinical Import. If the foregoing tests announce the presence of sugar in considerable quantity, Diabetes mellitus presses itself upon the diagnosis. It is stated that sugar is present in the urine in all cases of impediment to the respiration, and in old persons : this statement must be received with the greatest caution since it has been contradicted by several very excellent observers.

BILE IN THE URINE.

The presence of *bile* in the urine is seldom overlooked, as it causes that secretion to have a dark greenish brown colour. Two substances must be tested for, the bile pigment, and the bile acids. The colouring matters and the acids must be looked for separately.

The *bile pigments.* Gmelin's test. Ordinary nitric acid, which always contains some free nitrous acid, is poured

into a test tube to the depth of half an inch. A portion of the suspected urine is then gently poured down the side of the tube, held almost horizontally, on to the surface of the acid so that the two fluids may touch but not mix. At the line of contact, a zone of red appears in every urine whether bile pigment be present or not: if pigment be present, the zone becomes first green, then violet, blue, and red. The colours most distinctive of bile are the green and the violet.

Cautions. Any urine which contains a large quantity of indican will give a blue or violet and even green colour with nitric acid. This is a frequent occurrence in cases of melanotic cancers when the urine often has a dark brown appearance.

Städeler has proposed a test for bile pigments which consists in recognizing the presence of biliprasin: if this body be in the urine, the colour becomes green on the addition of acetic acid but brown again if neutralised with caustic potash, or soda.

The *bile acids.* Pettenkofer's test. To the fluid containing the bile acids, a drop of saturated solution of cane sugar must be added in a porcelain dish: strong sulphuric acid, is then dropped into the mixture, taking care that this acid is clearly in excess of the amount of bile acid present, *i.e.* about the same volume as the fluid containing the bile acids. On applying heat (which must only be moderate) a beautiful cherry-red colour is produced, passing into a deep purple. The *purple* colour is the only reaction characteristic of the presence of bile acids.

This test should never be applied to urine: setting aside the fact that the bile acids are rarely in sufficient quantity to give the reaction, the urine in jaundice frequently contains a small quantity of albumen, which gives a reddish violet reaction with sugar and sulphuric acid: while the charring of the other organic constituents of the urine makes it well nigh impossible to be sure of a purple colour. If therefore the presence of the bile acids in the urine is particularly wished to be ascertained, they must be separated by the method employed by Hoppe; a long and somewhat complicated process, which can seldom be employed by the clinical clerk.

With this object the urine must be rendered faintly ammoniacal with caustic ammonia and then acetate of lead added, so long as a precipitate occurs. The precipitate must be collected on a filter and well washed with distilled water; then boiled with alcohol over a water bath, and filtered while hot: to the filtrate a few drops of potash or soda are to be added and the solution evaporated to dryness on a water bath. The residue is again to be boiled with alcohol over a water bath until only a small quantity is left: this is then to be well shaken with ether in a stoppered bottle and the alkaline salt of the bile acids will crystallize out. To prove that these crystals are bile acid salts, it is necessary to test them with Pettenkofer's method as given above.

UREA.

The clinical clerk may sometimes wish to know if the urine contain *urea*, or if a given fluid be really urine, or some other secretion. The best way of proceeding is as follows, to ascertain if the fluid contain albumen: then if it do, the albumen must be removed by acidulation with a few drops of acetic acid, raising the heat to boiling point, and filtering: and the filtrate used according to the directions given below for not albuminous urine.

If the urine do not contain albumen, some quantity, 2 or 3 ounces, must be evaporated in a water bath until the fluid has the consistence of syrup. A water bath is essential as an open flame decomposes the urea. To the syrupy fluid, nitric acid, as free as possible from nitrous acid, is added in about half the quantity of the syrupy fluid, and the whole becomes a solid mass of crystals of nitrate of urea. Some of these removed with a glass rod and placed under the microscope, show flat rhombic imbricated crystals, closely united to one another.

Urea is the most important constituent of the urine: a healthy man excretes from 300 to 500 grains in the 24 hours. In some acute diseases, as pneumonia, typhoid fever, and acute rheumatism, it is greatly increased owing to the tissue-metamorphosis, and may be present in such quantity as to give a precipitate, without previous concentration, when the urine is acidulated with nitric acid. In other diseases, as uræmia and Bright's disease, the quantity of urea is below the average.

URIC ACID.

To ascertain if the urine contain *uric acid* it is necessary to acidulate about a couple of ounces of the urine with a drachm or more of hydrochloric acid, or strong acetic acid, in a suitable glass vessel, an ordinary beaker being best, and to set it aside, covered with a glass plate, for 24 or 48 hours. At the end of that time, if uric acid be present, reddish brown crystals will be seen attached to the sides and bottom of the glass, or floating on the surface of the fluid. These crystals have the flat rhombic, oval, or hexagonal shape of uric acid : they are soluble in alkalies and give with nitric acid and ammonia the murexid test. (See page 28).

A healthy man excretes, on an average about 7 or 8 grains of uric acid in the 24 hours.

Clinical Import. The excretion of uric acid is usually increased *pari passu* with the urea : and in pyrexia, acute rheumatism, liver diseases, and *after* an attack of gout. It is often entirely absent from urine passed immediately before the paroxysm of gout, and may disappear for days from the urine when this disease has become chronic.

HIPPURIC ACID.

Hippuric acid exists in small quantity in all healthy urines, but the amount is greatly increased in cases of chorea. The method of preparing it from human urine is

troublesome and will rarely be required to be used by the clinical clerk. Two or more pints of *perfectly fresh* urine must be taken, and milk of lime added till the urine becomes alkaline : the mixture is then boiled and filtered : the filtrate is to be evaporated over a water bath to a syrupy consistence and extracted with alcohol : the solution in spirit must then be filtered and the filtrate evaporated over a water bath to dryness. To this residue, hydrochloric acid must be added so long as crystals are formed.

The crystals of hippuric acid, seen under the microscope, are long and needle-shaped : and distinguished from those of benzoic acid by their insolubility in ether.

When benzoic acid is taken by the mouth, it is converted in the body into hippuric acid, which appears in the urine in quantity equal to that of the benzoic acid ingested.

CHLORIDES.

Chlorides may be known to be present by the following test. To a drachm of urine in a test tube, a drop of nitric acid is added and then a few drops of a solution of nitrate of silver : if a trace of chloride only be present, a cloudiness will be given ; but if in any quantity, a white precipitate is thrown down, soluble in caustic ammonia and reprecipited thence by the addition of nitric acid in excess.

The nitric acid is added at first to prevent the precipitation of the phosphates with the chlorides.

The chlorine in the urine is almost entirely in combination with sodium.

A rough comparative idea of the quantity of chloride present may be made from day to day by always taking the same quantity of urine in a test tube, acidulating with nitric acid, adding solution of nitrate of silver until a precipitate ceases to be given, allowing the test tube to rest for 24 hours, and then comparing the height at which the chloride of silver stands in each.

On an average, a healthy male adult excretes 250 grains of chloride of sodium in the 24 hours.

Clinical Import. The chlorine is diminished or entirely absent during the period of hepatization in acute pneumonia : it is also diminished in acute rheumatism and many pyrexial diseases, especially when large exudation takes place.

PHOSPHATES.

The presence of *phosphates* in the urine may be ascertained by the following test. First make the urine ammoniacal with caustic ammonia and then add the liquid prepared by the following process. To a solution of sulphate of magnesia add a drop or two of caustic ammonia : then hydrochloric acid, to redissolve the precipitate and lastly

caustic ammonia in excess, so that the solution is strongly ammoniacal. To the urine already rendered ammoniacal, add this solution, and a precipitate of the ammoniaco-magnesian phosphate occurs at once, if the urine contain the ordinary amount ; but slowly if in very small quantity.

The normal quantity of phosphoric acid excreted by a male adult is about 50 grains in the 24 hours.

Clinical Import. The amount of phosphoric acid in the urine is increased in diseases of the nervous centres and after great mental application. Acute febrile diseases cause increase of the phosphoric acid from increased tissue metamorphosis : while in Bright's disease and dyspepsia the quantity of the phosphates is diminished.

SULPHATES.

The *Sulphates* are at once recognised by the addition of a drop of hydrochloric acid to some of the urine in a test tube, and afterwards a few drops of a solution of chloride of barium ; a white precipitate, insoluble in *any* acid liquid, is thrown down.

The quantity of sulphuric acid excreted by a healthy male adult in the 24 hours is about 30 grains.

Clinical Import. The sulphates are increased by a full animal diet : very little is known for certain of their amount in disease and that little is at present of not much importance.

The following account of the quantity of substances excreted by a male adult in the 24 hours is compiled from Parkes "On the Composition of the Urine."

Quantity	40 to 50 fluid ounces.
Total Solids	800 to 1000 grains.
Urea	350 to 600 grains.
Uric Acid	5 to 15 grains.
Chlorine	50 to 150 grains.
Phosphoric Acid.	30 to 60 grains.
Sulphuric Acid.	20 to 60 grains.

URINARY SEDIMENTS.

If it be wished to examine the sediment thrown down by the urine, it is best to collect some quantity, half a pint or more, in a tall narrow cylindrical glass, and to set it aside for a few hours. Cylindrical glasses have, in the writer's experience, succeeded better than conical vessels, since the sloping sides of the latter tend to cause the sediment to collect on them, without falling to the bottom. This is particularly the case with uric acid and renal casts, especially if present in small quantity only.

When the sediment has collected at the bottom, the supernatant urine may be poured off, and a drop of the sediment placed on a glass slide, for examination under the microscope.

In looking for renal casts, it is better to use only the very last drops which fall from the vessel, after the rest of the urine is poured away.

Directions for the Microscope. A drop of the fluid containing the deposit is placed in the centre of the glass slide (which must be absolutely clean), and the drop very gradually covered with a piece of thin glass, (seven-eighths of an inch square is the best size), so as to drive all the air before it, and to prevent any air bubbles being present under the glass. This is best accomplished by the aid of a needle, placing one side of the thin glass upon the slide and resting the other upon the needle and then inclining the needle gradually until it is horizontal. All superfluous moisture around the glass cover must be carefully removed with a cloth or blotting paper. The slide is then ready to be placed under the microscope.

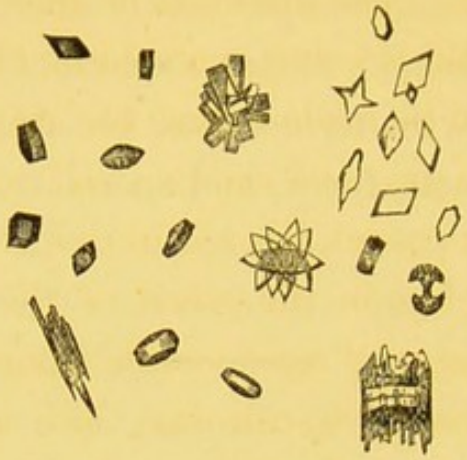
A quarter-inch object glass will be sufficient for the recognition of nearly all the sediments that occur. The tube of the microscope must be moved down until the object glass is about a quarter of an inch distant from the slide: the light from the mirror is now thrown upon the slide at a point immediately under the object glass: the observer should then look through the microscope, placing the instrument in proper focus with the coarse adjuster, so as to suit his individual eye.

Sediments are either organised or unorganised. To the latter belong uric acid, urates, oxalate of lime, phosphates, cystine, &c. To the former, pus, blood, mucus, and epitheleum, renal-casts, fungi, and spermatozoa.

URIC ACID.

Uric Acid is only met with as a deposit in very acid urine and is usually accompanied by a considerable sediment of urates. Owing to its peculiar colour, varying from a yellow to a brownish red, it can at once be recognised by the naked eye, never being deposited from the urine in colourless crystals.

When the sediment is examined under the microscope the crystals are known at once to be uric acid by their reddish brown colour, as all other crystalline deposits are transparent and colourless. When indeed, the student is in doubt as to the nature of a crystal, he will never be very wrong if he regard it as uric acid when there is a slight tinge of brown visible. The crystals, themselves, have numerous forms : they occur very commonly in rhomboidal plates, or a long oval with acute angles : these crystals are often united so as to form rosettes, or they may be rectangular, barrel shaped; or in dumb bells, or hexagonal plates, with two parallel sides longer than the other four.



If the student be not quite sure of their nature, he should add a little liq. potass. or liq. sodæ to the specimen under the microscope, and the deposit, if uric acid, is dissolved; and can be reprecipitated in the same forms by the addition of hydrochloric acid.

Very small traces may also be detected in the following way: a small portion of the suspected sediment should be placed in a porcelain dish, and a drop of nitric acid let fall upon it; the dish is then heated over a lamp until all the nitric acid is driven off, when, if uric acid be present, a beautiful red staining is seen: after cooling, a drop of caustic ammonia should be allowed to roll over the reddened spot, which then becomes purple; if liq. potass. be used instead of ammonia, the colour becomes violet. This is the murexid test. It does not however distinguish uric acid from its salts.

Very often the uric acid is not free in the urine when voided, but is precipitated by the increase of acidity which always occurs shortly after emission. This is especially the case in the urine of diabetes, where the whole of the uric acid may be set free from this cause.

Clinical Import. The presence of free uric acid is no proof that uric acid is being excreted in excess; the only inference that can be made is that the urine is extremely acid. But if free uric acid shows itself immediately after the urine has been passed, it is not improbable that a deposit may be taking place in the pelvis of the kidney, or the bladder; a condition of considerable danger, since it may lay the foundation of a calculus; uric acid, and urate, calculi being the most frequent of all urinary formations.

URATES.

This deposit is the most frequent and least important of all the urinary sediments. Any febrile condition will lead to this deposit: even a greater amount of perspiration than usual, will be followed by urine that becomes turbid on cooling, as a result of concentration, merely. Urine containing an excess of urates is never turbid when fresh passed: it is only when the urine has cooled, that the peculiar muddiness is observed. If the urine be gently warmed, the turbidity disappears immediately. The urates differ in colour considerably, varying from white, through pink to red.

In the urine uric acid is found combined with three bases: with soda, with ammonia, and with lime. The urate of soda is the most frequent of the three and is seen under the microscope as an amorphous precipitate. Sometimes it forms round dark bodies with short spikes projecting from them. The urate of ammonia is rarer and

occurs in beautiful globular forms with spikes closely resembling the urate of soda, but of greater length. The urate of lime is very rare and forms only amorphous deposits. If any doubt be entertained as to the nature of these salts it is only necessary to add a drop of strong acetic acid to the specimen, when crystals of uric acid will immediately be formed. These crystals are again dissolved by caustic soda, or potash. If further evidence be required, the murexid test with nitric acid and ammonia may be applied. (Page 28).

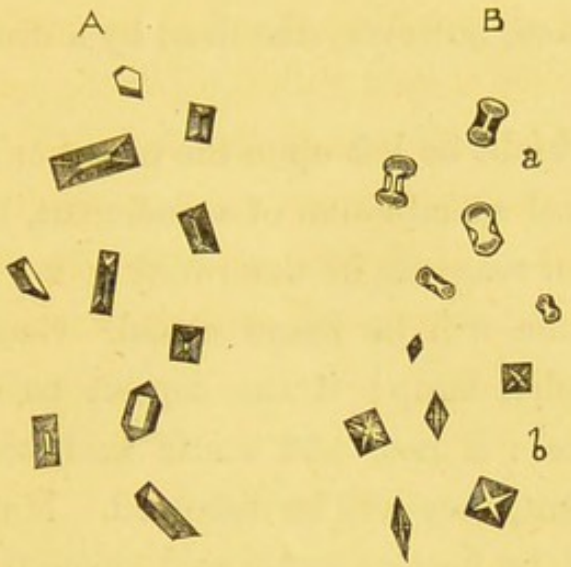
OXALATE OF LIME.

Oxalate of lime occurs as a urinary sediment in colourless square octahedral crystals, having the so-called 'envelope' appearance which, when once seen, is difficult to be mistaken for anything else. This deposit also occurs in colourless dumb bells.

Oxalate of lime is insoluble in acetic acid; by this it is distinguished from the phosphates: it is colourless and insoluble in alkalies, and thus differs from uric acid. It is however soluble in the mineral acids, as, for example, in hydrochloric acid.

Clinical Import. The occasional presence of a few crystals of oxalate of lime is not of much importance. When however the deposit is constant and in large quantity, the formation of the mulberry calculus may be feared.

This deposit is generally associated with a dyspeptic and hypochondriacal condition, sometimes termed the "oxalic acid diathesis."



A. Triple Phosphates.
B. Oxalates.

a. Dumb Bells.
b. Octahedra.

PHOSPHATES.

The *phosphates* are always deposited when the urine has undergone the alkaline fermentation, and are not separated from acid urine. They consist of the phosphate of lime and the ammoniaco-magnesian phosphate. Under the microscope, the ammoniaco-magnesian phosphate appears in beautiful right rhombic prisms, which disappear immediately on the addition of acetic acid, and are thus distinguished from the oxalate of lime, with which an unexperienced observer might confound them.

The phosphates of lime chiefly occur as an amorphous deposit, it is insoluble in water but soluble in acetic acid, and is precipitated by heat in flakes resembling albumen, which are at once, however, dissolved by a drop of acid.

If the least doubt be left upon the observer's mind after the microscopical examination of a sediment, he must use the assistance of reagents in determining its nature: the following scheme will be found useful. Gently heat the slide over a spirit lamp: if the deposit be dissolved, it consists of urates: if not, add acetic acid, when if phosphates be present, they will be dissolved. If no effect has been produced by heat or acetic acid upon the sediment, it probably consists of uric acid or oxalate of lime: liq. potassæ should be added, and if the sediment be uric acid, it is dissolved: if not, it is oxalate, then add hydrochloric acid and the crystals will disappear.

CYSTIN.

Cystin is a rare deposit in the urine: it occurs in colourless hexagonal plates, united by their flat surfaces, and overlapping one another. When dissolved in the urine, cystin may be thrown down by the addition of acetic acid and the precipitate examined under the microscope. It may be distinguished from uric acid, which sometimes

crystallises in hexagonal plates, by the absence of colour in the crystals.

Cystin contains a large quantity of sulphur, and Liebig has proposed a test which is founded on this fact. The urine is boiled with a solution made by adding, to a small quantity of solution of acetate of lead, liq. potass. or liq. sodæ until the precipitate first formed is redissolved; about equal parts of solution and urine are taken: as the fluid is boiled, the black sulphide of lead is formed in quantity from the separation of sulphur and its combination with the lead. The test is, however, a very bad one, since many bodies frequently present in the urine, *e.g.* albumen, contain enough sulphur to give this reaction.

LEUCIN AND TYROSIN.

Leucin and *Tyrosin* are very rare deposits in the urine. Examined by the microscope, leucin appears in dark globular bodies, which have been compared to a mass of fat cells; tyrosin however, crystallises in beautiful bundles of delicate needles, sometimes arranged in a stellate form.

These two bodies have been detected in the urine in cases of acute yellow atrophy of the liver, of small pox and of typhoid fever. In one case of acute atrophy, the deposit was in great quantity and furnished sufficient materials for an analysis.

ORGANISED SEDIMENTS.

PUS.

Pus is a frequent deposit in the urine and causes a thick sediment, according to its quantity, at the bottom of the urine glass. The urine frequently becomes alkaline soon after being passed, and rapidly decomposes. It is permanently turbid; that is, the turbidity is unaffected by heat.

Under the microscope, the deposit shows numerous pus corpuscles, round colourless bodies, not varying much in size, and having granular contents and nuclei varying from 1 to 4 in number. If acted on by acetic acid, the nuclei become much more distinct: if the urine has been passed long, the pus corpuscles undergo changes which render them incapable of being recognised.

The urine of course contains albumen: and this in proportion to the amount of pus present. If the quantity of albumen exceed that which should be given by the pus present in the urine, evidence of kidney disease, as casts of tubes, should at once be looked for.

The deposit from urine containing pus is rendered viscid and gelatinous by the addition of about half its quantity of the caustic alkalies; it becomes ropy and cannot be dropped from one vessel to the other: urine containing mucus, on the other hand, becomes more fluid and limpid by the addition of caustic alkalies.

Pus occurs in the urine in the following diseases:

Leucorrhœa in the female.

Gonorrhœa or Gleet in the male.

Pyelitis, due to whatever cause.

Cystitis.

Any abscess bursting into any part of the urinary tract.

Leucorrhœa is an exceedingly frequent cause of the presence of a slight amount of albumen in the urine of women; if it is necessary to exclude this origin, the urine must be obtained by means of the catheter.

BLOOD.

Blood is not at all unfrequently found in the urine, and may be derived from any part of the urinary-renal tract. If derived from the kidneys, the blood will be completely diffused through the urine and give it a peculiar smoky appearance, absolutely diagnostic. If the hæmorrhage from the kidney be great, however, the urine will have a bright red colour, like blood.

The deposit at the bottom of the urine glass shows under the microscope the circular discs, familiar to every one as the red corpuscles of the blood. Their peculiar colour will prevent the student mistaking them for any other deposit: they may, however, in a urine of low specific gravity become swollen and at last burst from endosmosis: in those of high specific gravity, they will often

become contracted, shrivelled and distorted from exosmosis.

The urine will of course contain albumen in proportion to the quantity of blood present, which may be so great that the urine will solidify on the application of heat. The urine very readily becomes alkaline and care must be taken to restore the acid reaction with acetic acid, before testing for albumen.

Blood may be present in the urine from

A. *Disease of the Kidney.*
   Acute Bright's Disease.
   Congestion of Kidney.
   Cancer of Kidney.
   External Injury.
   Tubercle (*very rare*).

B. *Disease of Pelvis and Ureter.*
   Calculus in Pelvis and Ureter.
   Parasite as Bilharzia hæmotobia.
   Cancer.
   Tubercle (*very rare*).

C. *Disease of the Bladder.*
   Calculus.
   Cancerous or Villous Growths.
   Congestion of Mucous Membrane.

D. *Disease of Urethra.*
   Congestion, as in gonorrhœa.
   Tearing of the mucous membrane from mechanical injury.

E. *Constitutional.*

Purpura and Scurvy.

Hæmorrhaphilia.

The acute specific diseases, (*rarely, in malignant cases*).

F. In female, uterine discharges, as menstruation, &c.

As a general rule, if the blood be completely mixed with the urine, the hæmorrhage is from the kidneys; if the urine first passed be clear, and that at the end of micturition become bloody, or even pure blood be passed, the hæmorrhage is from the bladder or prostate: while if the first portion of the urine be bloody, and the last drops clear, the hæmorrhage is from the urethra.

MUCUS AND EPITHELIUM.

Mucus is a constant constituent of every urine, and if healthy urine be allowed to remain at rest for an hour, a light cloud will be found to have settled at the bottom of the urine glass; on microscopical examination, it will be found to consist of mucous corpuscles, and epithelium scales, detached from the surfaces over which the urine has passed. In some diseases of the bladder the amount of mucus is greatly increased, causing the urine to be exceedingly viscid and gelatinous and to be poured from one vessel to another in heavy lumps, instead of a uniform flow.

The urethra and bladder give up a roundish or oval epi-

thelium cell to the urine: in the urine of the female, the epithelium cells of the vagina are very numerous, especially in cases of leucorrhœa, and they exactly resemble the squamous epithelium of the mouth. Under irritation, the mucous membrane of the pelvis and ureter will produce cells, caudate, spindle-shaped, and irregular; exactly similar to those formerly considered diagnostic of cancer. From this circumstance it is impossible to speak positively of the existence of cancer cells in the urine.

In some forms of Bright's Disease, acute and chronic, the epithelium of the tubules of the kidney is separated, and discharged in large quantities by the urine. This epithelium varies much in its characters being normal, or granular, or containing large shining globules of fat.

CASTS.

In Bright's disease and in congestion of the kidney there are formed, in the uriniferous tubules, lengthened cylinders which are discharged with the urine and form the deposit known as "casts." They are probably chiefly formed in the straight uriniferous tubes and the view which has found most favour in this country, is that the casts are formed by the escape of blood into the tubes of the kidney and coagulation of the fibrin, which thus becomes moulded to the shape of the tube into which it has been extravasated.

When the urine contains casts in great quantity, they

can scarcely be overlooked, if the urine be allowed to settle for a few hours in a tall cylindrical glass, the whole of the supernatant fluid poured off, and the last drops which flow from the lip of the glass put under the microscope and examined. But if there are only a few of them, other plans may be adopted; the urine may be acidulated with a drachm or more of acetic acid and thus the uric acid precipitated, with which the casts will be carried down as well; or the urine may be filtered and the casts searched for on the filter paper; or, if the specific gravity be high, the urine may be diluted with distilled water, allowed to settle, and the deposit examined. In looking for the cylinders under the microscope, a diaphragm with a very narrow opening must be used and in some cases it is necessary to add solution of iodine or magenta to the specimens to render the outline of the casts visible. With a little experience, the student will soon become familiar with the appearance of casts, and will at once be able to distinguish them from foreign bodies in the urine. They are never broader than 6, or less than 2, red blood corpuscles in diameter: but they vary considerably in length, never exceeding the one-fiftieth part of an inch. The same cast does not vary greatly in its diameter and never becomes twisted on itself, as a cotton fibre does.

The foreign bodies most liable to be mistaken for renal casts, are cotton fibres, hairs, and pieces of deal and wood.

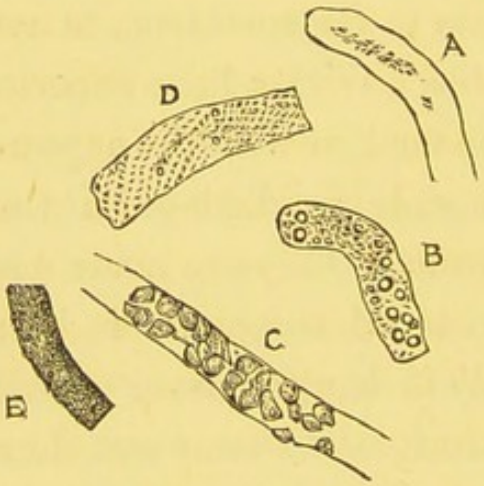
Hair can often be distinguished from renal casts by its colour alone: and if this is not very apparent, by its pos-

sessing a cortical and medullary structure, which renal casts have not; and by far greater length than a cast ever has.

Cotton fibres have a very irregular outline and are much broader at one part than at another: they are often irregularly twisted and of great length, which will distinguish them from casts. Their structure is often striped in a longitudinal direction.

Fibres of Deal, which have their origin in the furniture &c. of the apartment, may perhaps be mistaken for renal casts. They are at once detected by the presence of the large round cells which characterise the group of fir trees.

Casts may be conveniently divided, according to their appearance under the microscope, into three kinds, the epithelial cast, the granular cast, and the hyaline cast.



Casts.—A. Hyaline or waxy. B. Fatty. C. Epithelial. D. Pale granular E. Dark granular. All medium size.

The epithelial cast. This cylinder consists of a mass of epithelial cells derived from the tubules of the kidney; the cells may become granular and acquire a dark appearance by transmitted light. The cast is usually wide, never very narrow.

The granular cast. This is a solid cylinder having a granular appearance; which may be only a few dark points in the substance of the cast, or be so intense that the cast have an almost black appearance: oil globules are often seen. In this kind of cast may often be found epithelial cells, blood corpuscles, red or white, pus corpuscles, uric acid, urates, and especially oxalates.

The hyaline cast. The outline of this cast is often so indistinct that a little iodine or magenta must be added to the urine before it can be detected, or a diaphragm with a narrow opening must be used. They are of two sorts, the wide and the narrow. The narrow are often of great length and show a few granules or nuclei on their surface.

In observing casts, notice must be taken of the action of acids upon them or their contents. It is thought that when the cylinders resist the solvent action of hydrochloric acid to any great degree, that the inflammation of the kidney is correspondingly intense. The granules on the cast, if due to olein, will be unaffected by acetic acid. The width of the cylinder is of some importance. It is supposed that very broad casts are formed in tubules completely stripped of their epithelium, and that the prognosis is more grave when these wide casts show on their sides no nuclei or attempt at re-formation of epithelium. From the recent observations on the varying diameters of the uriniferous tubes, the importance of the breadth of the cast becomes less.

Clinical significance of casts. The presence of casts in the urine is a sure sign of disease of the kidney, but not,

however, of *permanent* disease of the kidney. They are present in many acute diseases, accompanied by albumen in the urine. They are present in pyelitis; since pyelitis does not exist for any time without leading to congestion of the kidney and thus to the formation of casts. If however, pyelitis can be excluded, and casts are present in the urine continuously, and long after all other symptoms of acute disease have disappeared, grave disease of the kidney may be inferred.

With regard to the microscopical appearances of the casts; too hasty conclusions should not be made from one or two observations; but the casts should be carefully watched every day for a week or more, when their more constant appearances will be familiar to the observer. If granular casts be constantly observed, the granules of which are unaffected by acetic acid, and the casts possess a large diameter, the patient will probably be suffering from the fatty form of Bright's disease. The narrow hyaline casts, recent epithelial and blood casts, are formed in the early stages of acute Bright's Disease: the epithelial casts indicating a desquamation of the renal tubules.

FUNGI.

Many kinds of *fungi* grow in the urine after it has been voided some time and when the ammoniacal decomposition has begun or is about to set in. The most important are

(*a*) *vibriones*, which may be seen in almost every albuminous urine which has been passed a little time; they are known by their linear form and incessant motion. (*b*) The *penicilium glaucum*, the fungus which forms 'mildew' and (*c*) the yeast fungus, *torula cerivisiæ*, which is considered by Dr. Hassall to be diagnostic of diabetes.

Sarcinæ are apparently formed in the urine before it is voided; they are square bodies divided into secondary squares which number 4, 16, 64, &c. and are similar to the sarcinæ found in the vomited matters of persons suffering from stenosis of the pylorus.

Kiestein is a whitish pellicle formed on the surface of the urine of pregnant women, when allowed to remain at rest for a few days. It appears to consist chiefly of the mould fungus and crystals of phosphates. It was formerly regarded as a sign of pregnancy: but it occurs in the urine of persons who are not pregnant, and is not always present in pregnancy.

SPERMATOZOA.

These little bodies are present in the urine of males first passed after an emission of semen from whatever cause, coitus, masturbation, or nocturnal emission. A few pass away, in the urine, probably, without venereal excitement; especially when the person is continent. In the urine of

females, they are almost positive proof of sexual intercourse.

Spermatozoa form a glairy white deposit at the bottom of the urine glass. When examined with the microscope, (for which a high power, 400 or 500 diameters is best, although they may be identified with a power of 250), they show the characteristic oval head or body, often somewhat pear-shaped, and with a long delicate tail, two or three times the length of the head. In the urine no movement is ever shewn by these bodies.

APPENDIX.

It has been thought desirable, to add a succinct account of the method of estimating the principal substances found in the urine, since the clinical clerk is often desired to make an analysis of the urea, chlorides, phosphates, &c. No account of the method of standardising the solutions nor of the apparatus required, will be given, since both solutions and apparatus are provided in nearly all clinical hospitals, &c. No details have been introduced which require the use of a balance.

The French weights and measures only will be employed: they are

The litre, the unit for measures of capacity =1·76 pints.

The cubic cemtimeter, (C.C.) the $\frac{1}{1000}$ th part of a litre.

The gramme (grm.), the unit of weight, the weight of a cubic centimeter of distilled water, at 4°C, at normal barometer pressure,=15·43 English grains.

The milligramme, the $\frac{1}{1000}$th part of a gramme.

GENERAL DIRECTIONS.

The whole of the urine passed in the 24 hours must be collected; it will be found most convenient to collect it from 9. A.M. on one day, to 9. A.M. on the following day, making the patient micturate precisely at this hour.

The urine must be preserved as it is passed in a covered glass vessel. When the analysis is to be made, the urine must be measured in a vessel graduated to a 1000 C.C. and divided into parts containing at least, 10 C.C, each. After measuring, the whole of the urine must be mixed together and a portion of this taken for the estimation of the urea, chlorides, &c.

A complication arises, if the urine contain albumen: and in this case, the albumen must be removed before proceeding to the analysis of the urea, &c.; a measured quantity of urine, 100 or 200 C.C must be heated in a Berlin dish, protected by gauze, over a small, naked flame, to nearly the boiling point. If the albumen does not separate in flakes, dilute acetic acid must be *very* carefully added until the acid reaction is marked. If too much acetic acid be added, the albumen is redissolved. The heat must be moderate, and only just rise to boiling point or the urea will be decomposed. The urine is then to be filtered into the same measure that was used at the beginning to ascertain the volume (100 or 200 C.C), the dish and filter well washed with distilled water, which is added to the filtrate until the urine stands at exactly 100 or 200 C.C, according to the initial quantity. This fluid is then used in the estimation of the urea, chlorides, phosphates, sugar, &c.

ESTIMATION OF UREA.

For the estimation of urea, a standardised solution of nitrate of mercury is required, a baryta mixture made by adding 2 volumes of cold saturated solution of caustic baryta to one volume of saturated solution of nitrate of baryta, burettes graduated to a quarter of a cubic centimeter, and a pipette measuring 15 or 20 C.C.

The first step is to ascertain the presence or absence of albumen. If albumen be present it must be separated by the method described immediately above, (page 46); but if the urine be free from albumen, a measured pipette, containing 10 or 15 C.C. is filled with urine, *twice*, and the urine allowed to run into a urine glass or beaker. The same pipette is next filled with the baryta mixture which is then added to the urine previously measured off. The mixture of urine and baryta is then passed through filtering paper: a drop or two of the filtrate is to be tested with the baryta mixture to see if any precipitate occurs, and if any precipitate do occur, it is best to take a fresh quantity of urine and to add an *equal* volume of baryta mixture: after filtration, this must be again tested. The object of the addition of the baryta is to remove from the urine all the phosphates.

The next step is to measure off a definite quantity of the filtrate, so that in any case it may contain 10 C.C. of urine. Thus, if one volume of baryta mixture were used with two volumes of urine, 15 C.C. of the filtrate would be measured off with a pipette. If equal volumes

of urine and baryta mixture were employed, 20 C.C. must be measured off. A burette divided into quarters of a cubic centimeter is then to be filled with the standardised solution of nitrate of mercury. The burette must be filled to the brim and allowed to remain at rest for some time, so that all bubbles may rise to the surface and burst. The solution must then be let off by the pinch cock at the bottom of the burette until the lower of the two black lines, seen by means of transmitted light on the surface of the fluid, is exactly on a level with the first division of the burette.

The measured quantity of the filtrate of the urine and baryta mixture is then to be placed in a small glass vessel, a beaker holding about 100 C.C. is best: a few drops of dilute nitric acid are to be added and the vessel placed under the burette. The work of estimating the urea now begins. The solution of nitrate of mercury is allowed to run drop by drop into the fluid below, stirring the latter well with a glass rod, until a permanent precipitate is produced: the amount of nitrate of mercury used is then read off and noted down: the nitrate of mercury is then added by quarters or halves of a C.C. the mixture being well stirred after every addition, until a drop of the mixture brought into contact with solution of carbonate of soda gives a yellow colour.

The way to ascertain this is the following: a small glass disc is placed on a piece of black paper and a few drops of saturated solution of carbonate of soda spread over the glass: as small a drop as possible of the fluid

from the beaker is then brought into contact with the soda at the edge of the solution. If the least appearance of yellow occur, one drop more of the mercury solution must be added, the fluid well stirred about, and another small drop taken from the mixture and tested with the soda, when an increase in the yellow colour will be perceived. Then the whole of the carbonate of soda solution contained on the glass plate is to be poured into the beaker and a drop from this mixture tested with fresh soda; if the yellow colour appears, the number of C.C. used must be read off: but if not, more of the mercury solution must be dropped into the beaker until the yellow colour appears in the soda: and the number of C.C. used, then read off. From the total number of C.C. used, there must be subtracted the number of C.C. used in the first part of the process before a permanent precipitate is produced, and this number multiplied by 10 gives the number of milligrammes of urea contained in 10 C.C. of urine.

We have thus far ascertained the amount of urea contained in 10 C.C. of urine: by a simple rule of three it is easy to find the quantity passed in the 24 hours. For example, suppose that 1 C.C. of the mercury solution was used before a permanent precipitate was produced and that 19 C.C. were used before the yellow colour was distinctly seen, then 1 C.C. is subtracted from 19 C.C. which gives 18, and this multiplied by 10 gives 180 milligrammes of urea in 10 C.C. of urine. Suppose the patient had passed 2000 C.C. of urine in the 24 hours: then the calculation is this:

10 : 2000 : : 180
2000

10) 36000,0

36,000 milligrammes

As a 1000 milligrammes equal 1 gramme, 36,000 milligrammes equal 36 grammes.

ESTIMATION OF THE CHLORIDES.

The solutions required are :

Standardised solution of nitrate of silver.

Saturated solution of neutral chromate of potash.

The urine should be as fresh as possible and if albuminous, submitted to the preparation described at page 46, 10 C.C. of urine are then measured off into a glass vessel or beaker, and two or three drops of the solution of chromate of potash added. A burette divided into quarters of a C.C. is then filled with the standardised solution of nitrate of silver and the precautions observed as to filling burettes described in speaking of the estimation of urea. (page 46). The silver solution must then be allowed to fall into the glass vessel, and each drop well mixed with the urine by means of a glass rod. The termination of the process is arrived at, when the precipitate caused by the addition of the silver acquires a slight tinge of red : another drop of silver solution must be added and the reddening of the precipitate will be heightened. The quantity of

silver solution used is read off: and since 1 C.C. of the silver solution corresponds to 10 milligrammes of chloride of sodium, the number of C.C. multiplied by 10 will give the quantity of chloride of sodium in 10 C.C. of urine in milligrammes, and the quantity of chloride passed in 24 hours will be obtained by comparing this result with the quantity of urine passed in 24 hours.

ESTIMATION OF PHOSPHATES.

The solutions required are:

Standardised solution of acetate of uranium.

Solution containing acetic acid and acetate of soda: 100 grammes of acetate of soda are dissolved in water, 100 C.C. of acetic acid added and the mixture diluted until it equals 1000 C.C.

A weak yellowish solution of ferrocyanide of potassium.

50 C.C. of the filtered urine are mixed in a beaker with 5 CC. of the solution of acetic acid and acetate of soda. The beaker is placed over a water bath and the water in the bath heated to boiling. While the water is still boiling the standardised uranium solution is dropped into the beaker until precipitation ceases; this can easily be seen by allowing the solution to trickle down the side of the beaker. A small drop from the beaker is then to be placed on a porcelain dish by means of a glass rod, and a drop of the solution of ferrocyanide of potassium placed

close to it by means of another glass rod and the two drops allowed to run together. If no alteration of the colour is produced at their point of meeting, more of the uranium solution must be added to the urine and another drop tested with the solution of ferrocyanide of potassium. The number of C.C. of the uranium solution that has been used is read off: and if, after a second warming of the urine contained in the beaker, and a second trial of the fluid with the solution of the ferrocyanide, only a slight increase in the intensity of the colour is produced, the process may be regarded as complete.

The quantity of phosphoric acid is now easily calculated. 1 C.C. of uranium solution equals 5 milligrammes of phosphoric acid. So if 15 C.C. of the uranium solution have been used, 50 C.C. of the urine will contain 75 milligrammes of phosphoric acid and the quantity for the whole 24 hours can be easily calculated.

ESTIMATION OF ALBUMEN.

No easy, rapid, and trustworthy method of estimating the albumen has yet been suggested. The ordinary way of coagulating the albumen by heat and acetic acid, throwing the precipitate on a weighed filter, washing, drying, and reweighing, is so long and troublesome that it is never employed in clinical observation.

By far the best method for clinical observation is the estimation of means of the polariscope. It is only neces-

sary to have the urine moderately clear, and free from blood-corpuscles, sugar, and bile acids, to obtain results which are more than sufficiently accurate for all clinical purposes. For the method of using this instrument, see page 56.

The quantity of albumen in the urine is usually not more than 1 per cent: it very rarely rises to 4 per cent or more.

ESTIMATION OF THE SUGAR.

There are several ways of estimating the amount of sugar present in diabetic urine, all more or less accurate.

Dr. Roberts has proposed to estimate the amount of sugar in the urine by the decrease in density that takes place after fermentation.

He has found that the "number of degrees of 'density lost' indicated as many grains of sugar per fluid ounce." He proceeds in this way. He places about 4 ounces of the urine in a 12 ounce bottle with a piece of German yeast the size of a chesnut. The bottle is then set aside, very lightly covered, in a warm place, such as the mantel piece, or hob, and by its side, a bottle filled with the same urine, but without any yeast, and *tightly corked.* In 24 hours the fermentation is finished: the fermented urine is poured into a urine glass and the specific gravity taken with the urinometer: the specific gravity of the unfermented

urine is also taken, and the specific gravity of the fermented, is subtracted from the specific gravity of the unfermented, which gives the number of grains of sugar contained in a fluid-ounce: for example, if the specific gravity of the unfermented be 1040 and that of the fermented 1010, the number of grains of sugar in a fluid ounce will be 30.

Volumetric Method. A standardised copper solution is required; containing sulphate of copper, neutral tartrate of soda or potash, and caustic solution of soda, so that 20 C.C. correspond to 100 milligrammes of grape sugar. This solution is exceedingly apt to decompose and must therefore be preserved in well stoppered, completely filled, glass vessels and in a cool, dark place.

In estimating the sugar, the first step is to ascertain the goodness of the copper solution: this is done by boiling a small quantity of it in a test tube, and allowing it to stand for an hour; when, if it give no precipitate of copper oxide, it may be used in the analysis. 20 C.C. of the copper solution are then measured off with a pipette, allowed to flow into a glass flask and then diluted with about 4 times their volume of distilled water. 10 C.C. of the urine are then measured off and distilled water added until the mixture exactly measures 100 C.C. If however the urine contain sugar in but small quantity it may be diluted with its volume of water only, or indeed with none at all. A burette is filled with the diluted urine, and the flask containing the copper solution is heated over a small flame, wire gauze intervening, until ebullition begins: 2 C.C. of

the urine are then allowed to flow into the boiling copper solution. After a few seconds, it must be carefully noticed if the copper solution has lost its colour or is still blue. If it still appear blue when the flask is held between the light and the eye of the observer, another C.C. of the urine must be added to the boiling copper solution; then the blue colour must be noticed and if it is still there, the operation should be repeated until the blue colour has completely disappeared. The analysis is not yet however complete. The fluid boiling in the flask must be filtered into three test tubes, and to the first test tube a few drops of the copper solution must be added, and the whole boiled to see if a red precipitate of suboxide of copper be produced; to the second test tube a small quantity of hydrochloric acid is added, and sulphuretted hydrogen passed through; to the third acetic acid and ferrocyanide of potassium are added. None of these reagents ought to produce a precipitate.

If on boiling with the copper solution, a precipitate occurs, too much urine has been added: if in either of the two last test tubes a precipitate occurs, not enough of the urine has been added to decompose all the copper: in either case the estimation must be repeated.

Since 20 C.C. of the copper solution correspond exactly to 100 milligrammes of sugar, the complete decoloration of the solution employed above will be accomplished by exactly 100 milligrammes of sugar. If therefore for the 20 C.C. of copper, 15·5 C.C. of the diluted urine were required for complete removal of colour, and if the dilute urine contained only 10 per cent of urine, 1·55 C.C. of urine will

contain 100 milligrammes of sugar, and 100 C.C. of urine will contain 6·45 gramme of sugar as by proportion.

1·55 : 100 : : 100 : 645.

If the urine contain albumen as well as sugar, the former must be removed as directed, page 46.

THE POLARISCOPE.

The Polariscope. By means of this instrument an estimation of the sugar present in diabetic urine can be made, provided only that the urine be filtered and perfectly clear. If it be passed through animal charcoal, the accuracy is greater, of course, but not so great as to be of much consequence in purely clinical research. If the urine contain albumen, it must be removed by the method given above, page 46. Biliary acids can scarcely affect the result, since, when present, they are in such small amount. If, however, it be necessary to correct any inaccuracy arising from their possible presence, the amount of rotation must first be ascertained with the polariscope, the sugar completely removed by fermentation, and the fluid again observed. Any dextro-rotation that then occurs may be attributed to the biliary acids.

In order to use this instrument, it is necessary to have a good light from an argand burner or gas lamp, protect-

ed by a neutral tinted glass cylinder. The end of the polariscope which is the farther from the screw is placed within an inch or so of the light. The observer then looks through that part of the instrument most distant from the light and draws out or pushes in the tube until a line dividing the field vertically is distinctly seen, and then moves the instrument until a bright rose-red colour is visible in the field. By moving the screw below the scale, the colour of the two halves of the field becomes altered and the screw must be moved until both sides are perfectly equal in colour. This ought to be the point where the two zeroes are equal. If however this be not the case, the screw must be moved until the two fields are exactly equal and t e point at wh ch the zero stands noted.

The urine must now be filtered, or better, passed through animal charcoal. If the fluid be as free from colour as ordinary healthy urine, it may be observed in the longer tube, 200 millimeters in length, since the accuracy of the observation is increased by a corresponding length of tube.

If, however, the fluid is dark, the shorter tube must be used, which is only 100 millimeters in length. The tube is then filled to overflowing with the fluid and the small glass disc is slid along the end of the tube, so that no air bubbles remain enclosed, the metal screw is then attached to the tube, to keep the glass disc in its place. One or two small air bubbles are, however, of no consequence The tube is carefully wiped dry with a cloth and then placed in the vacant space between the two ends of the instru-

ment; the observer then sees if any alteration of the colour of the two halves of the field has taken place and moves the screw until they appear completely equal in colour: the eyes are best rested occasionally during this task by looking on some white surface, as the ceiling or sheet of paper. When the two sides are exactly equal in colour, the scale is read off: and if the zero point of the moveable scale be to the right of the zero point of the fixed scale, the fluid is dextro-rotatory and contains sugar; if to the left, it is levo-rotatory and contains albumen.

The scale shows the percentage amount of either sugar or albumen, if the short tube, 100 millimeters long, be used: but if the longer tube, 200 millimeters, have been used, the amount on the scale must be divided by two, to give the percentage amount.

ERRATA.

Page 6, 5th line from top, read *crystalline* for *crystaline*.
—— 7, 9 and 10th lines from top, read *cystitis*, for *cytitis*.
—— 17, 12 and 13th lines from top, read *mellitus*, for *melitus*.
—— 27, 4th line from top, read *epithelium* for *epitheleum*.
—— 45, 12th line from top, read *centimeter*, for *cemtimeter*.
—— 50, 7th line from bottom, read 48, for 46.
—— 56, 3rd line from top, read 6450, for 645.

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