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Contributors

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Royal College of Surgeons of England

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A GUIDE

TO THE

EXAMINATION OF THE URINE.

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A TREATISE ON HÆMOPHILIA, PURPURA, AND OTHER
Hæmorrhagic Diatheses. Second Edition.   [*In preparation.*

SOME ACCOUNT OF CARDIAC ANEURYSMS, BEING THE
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London, on August 18th, 1883, 8vo.

DISEASES OF THE GALL BLADDER AND GALL DUCTS, GALL
Stones, Portal Thrombosis, Acute Yellow Atrophy of the Liver, Biliary
Accumulation, Cirrhosis of the Liver, Nutmeg Liver, and Hæmophilia,
in Quain's *Dictionary of Medicine.*

A GUIDE

TO THE

EXAMINATION OF THE URINE

DESIGNED CHIEFLY

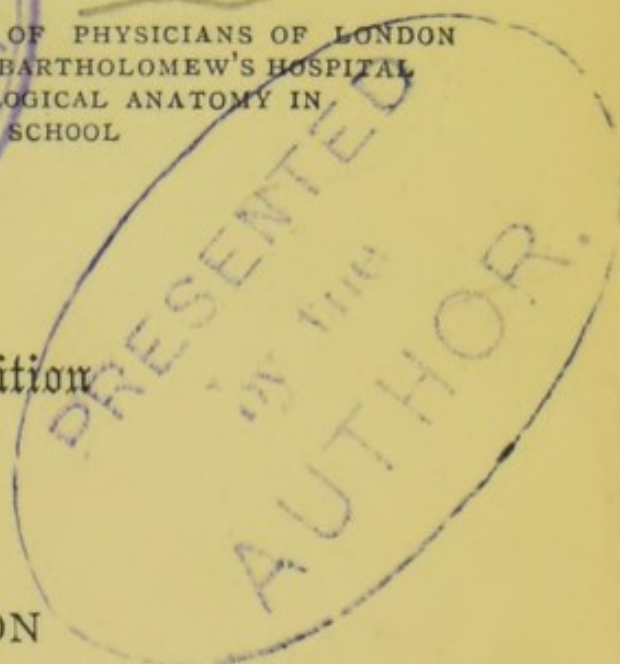## FOR THE USE OF CLINICAL CLERKS AND STUDENTS
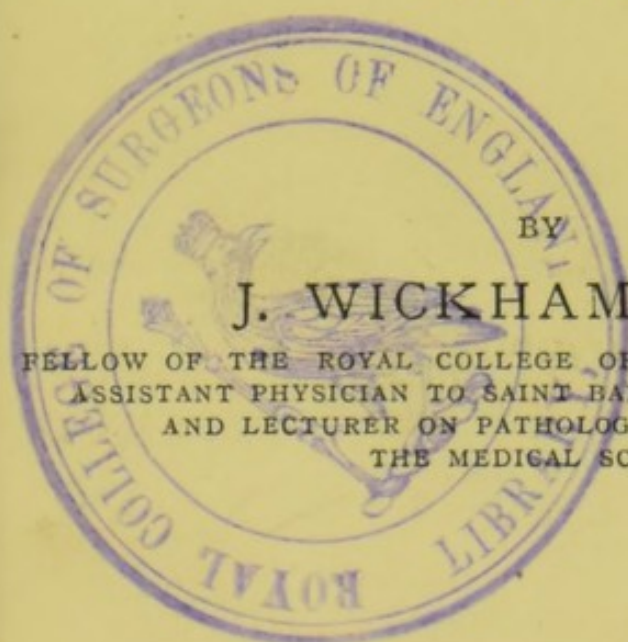
BY

J. WICKHAM LEGG

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS OF LONDON
ASSISTANT PHYSICIAN TO SAINT BARTHOLOMEW'S HOSPITAL
AND LECTURER ON PATHOLOGICAL ANATOMY IN
THE MEDICAL SCHOOL

Sixth Edition

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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 at the bedside to the busy practitioner, who 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 nature of those alterations that are most frequently seen 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.

London, *September*, 1869.

ADVERTISEMENT TO SIXTH EDITION.

THE present edition has again been carefully revised. The author is indebted to Dr. Howard Tooth for much valuable assistance in the reading of the proof sheets.

London, *May* 1, 1885

A GUIDE

EXAMINATION OF THE URINE.

In order that the examination of the urine may be made on a definite plan, the following scheme, in which the most important clinical facts are directed to be ascertained, is recommended to the student. The order of examination that is here given should be followed, the details of each operation being described on the page stated at the end of each paragraph.

SCHEME FOR THE EXAMINATION OF THE URINE.

I. Observe the colour of the urine, its appearance; if clear, smoky, turbid, &c. (page 3.)
II. Ascertain the specific gravity. (page 7.)
III. Examine the reaction, whether acid, neutral, or alkaline, by means of litmus or turmeric paper. (page 10.)
IV. Test the urine for albumen. (page 13.)

If albuminous, look with the microscope for : renal casts ; (page 78.) pus corpuscles ; (page 70.) red blood corpuscles. (page 72.)

V. Test the urine for sugar.   (page 23.)

VI. If there be no albumen or sugar present, and no deposit, the urine need not be further examined, unless some special indication exist.

VII. But if any sediment (page 54.) be observed, it must be examined with the microscope : the following enumeration of the more common deposits may help the student :

Pink or reddish deposit, dissolved on heating test-tube—urate of soda. (page 59.)

White crystalline deposit, soluble in acetic acid with an iridescent scum on surface—phosphates. (page 63.)

Hummocky white sharply defined cloud, insoluble in acetic acid—oxalate of lime. (page 61.)

White amorphous flocculent deposit, rendered ropy by alkalies—pus. (page 70.)

Brownish-red crystalline deposit—uric acid. (page 56.)

Red amorphous deposit—blood. (page 72.)

PHYSICAL EXAMINATION.

The physical examination of the urine is the application of the senses to its investigation without the employment of chemical analysis or the microscope. The colour, translucency, odour, and consistence are the only characters which can be ascertained by this simple method of observation.

Colour. Urine is ordinarily of a reddish-yellow colour; but it may be as colourless as water, or dark brown black like porter; 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, as saffron, and santonin, and the chrysophanic acid in rhubarb and senna give a peculiar red colour to the urine. The carbolic acid treatment of wounds colours the urine black. Tannin given by the mouth renders the urine colourless.

A pale urine is seen in health, as the *urina potus ;* and in disease, in anæmia, diabetes, nervous disorders *(urina spastica)*, and convalescence from acute diseases. A pale

urine contains little colouring matter, and but a small proportion of solid constituents, always excepting, however, the urine of diabetes mellitus. A pale urine is a sign that the patient is not suffering any high degree of pyrexia. A high coloured urine occurs in health, after food, as in the *urina cibi*, and after much exercise; and in disease, in fevers and most acute diseases, in which considerable metamorphosis of the tissues takes place. It contains much colouring matter and urea in proportion to the water. A dark urine should be examined for pigment. (See the section on pigment, page 42). A dirty bluish-coloured urine is sometimes seen in cholera and typhoid fever.

Translucency. In health, the urine deposits, after remaining at rest for a short time, a slight cloud of mucus, derived from the bladder and urinary passages; 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 upon the cooling of urine which was perfectly clear when first passed. It is a mark of disease when the

urine is turbid when first voided; pus is the most common cause of this appearance.

Odour. It is not yet made out to what body the peculiar smell of the urine is due, nor is it of much importance to the clinical student. When the urine loses its natural smell and becomes fœtid and ammoniacal, the change is due to the decomposition of urea into carbonate of ammonia, and the formation of sulphur compounds; in cases of cystitis and paraplegia the alteration begins very quickly after being voided. Various drugs, as cubebs, and articles of diet, as asparagus, give a characteristic smell to the urine; turpentine gives the odour of violets to the secretion.

Consistence. The urine is a limpid fluid, flowing freely from one vessel to another. But in catarrh of the bladder and in retention of urine, the ammoniacal products of the decomposition of the urea render the pus present thick and viscid, thus causing the secretion to be ropy, and poured with trouble from one vessel to another. This is said to be due to the action of the alkali on the albumen, giving rise to the presence of alkali-albuminate.

The froth on normal urine readily disappears: but if the froth be permanent, the presence of albumen, or of bile pigment, may be suspected.

Before passing to the mechanical and chemical examination of the urine, it may be well to speak of the apparatus and reagents which will be found necessary by the student for bedside investigation. They are:

Cylindrical Urine Glasses, each containing about 6 fluid-ounces.

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

Blue and Red Litmus and Turmeric Paper.

Test Tubes.

A Spirit Lamp, or Bunsen's Gas-Burner.

Nitric Acid.

Acetic Acid.

Liquor Potassæ or Liquor Sodæ.

Solution of Sulphate of Copper, 10 grains to the fluid-ounce, or Fehling's Test Solution for Sugar.

Glass Funnel and Filtering Paper.

With this apparatus and these re-agents* the student will be able to perform the more important reactions described below.

* They may be had of Hawksley, 357 Oxford Street, W.

SPECIFIC GRAVITY.

The specific gravity of the urine varies in health between 1015 and 1025 ; the simplest way of estimating it is by means of the urometer.

In order to use this instrument, a quantity of the urine to be examined is poured into a cylindrical glass, and care is taken to remove all the froth which may form, either by blotting paper, or by overfilling the vessel. The urometer must then be slowly introduced, and allowed to float freely in the urine, without touching either the side or bottom of the vessel. Since the fluid accumulates around the stem of the urometer from the physical force of attraction, the specific gravity appears to be higher than it really is, when 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 level of the surface of the fluid, and the number on the stem ascertained by looking at it through the urine : having noted this, the urometer should be depressed in the urine, and again allowed to come to rest,

when the number may be again read off;
the second estimation is made to correct any
mistake that may have taken place in the
first reading.   The specific gravity thus as-
certained should be noted down at once.
The urine must be of the temperature of the
surrounding air, otherwise great errors may
creep in.

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 ser-
viceable, the whole quantity passed in the
24 hours must be collected and mixed, and
the specific gravity of this taken.   A rough
estimation of the solid matters passed may
be made from the specific gravity in the fol-
lowing way;   the two last figures are multi-
plied by 2 or 2·33, and the product gives the
amount 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,
or multiplying by 2·33 = 46·6.

If but a small quantity of urine be given
for examination, it is convenient to dilute it
with two or three times its volume of distilled
water, and then multiply the specific gravity

by the number of volumes employed. If three volumes of water were used to dilute one volume of urine, and the specific gravity of this were found to be 1005, then four volumes multiplied by 5 would be 20, and 1020 would be the specific gravity of the urine.

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

A low specific gravity, below 1010, occurs after fluid has been taken in quantity. A low specific gravity is also noticed frequently in chronic Bright's disease, immediately after the paroxysm of hysteria, in anæmic states, and in diuresis from any cause, such as mental emotion, or exposure to cold.

A high specific gravity with a pale colour, and a low specific gravity with a deep tint, are equally signs of disease.

A new urometer should be carefully tested, since those sold by the instrument makers give results varying as much as 10 or 12 degrees. The urometers in common use in Hospitals are very rarely correct. As a rule, the smaller they are, the less accurate results are attained. Thus a large urometer and a large amount of urine should be used

REACTION.

The urine is almost always secreted acid, although it may become alkaline within a very short time of being passed. In the majority of the 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. In cases of retention, the urine sometimes becomes alkaline in the bladder. In health, the urine can be made alkaline, by the administration of drugs, such as the carbonates, acetates, citrates, or tartrates of the alkalies.

When the alkalinity of the urine is due to ammonia, the brown colour of the turmeric 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.

The urine is rarely neutral to test paper; so that many observers have denied such an

appearance. Occasionally the urine has an equivocal reaction, reddening blue litmus, and restoring the blue colour to reddened litmus paper. This amphigenous or amphoterous reaction, as it has been called, has not yet been satisfactorily explained; it is, however, without any clinical import.

The cause of the acid reaction of the urine is most likely the presence of the acid phosphate of soda; and according to some observers, of free lactic and hippuric acids. Very shortly after being voided, the acidity increases, and lasts, in health, for days, free uric acid being often thrown down.

Sooner or later, however, the alkaline fermentation sets in, and the urine becomes ammoniacal and fœtid from the conversion of urea into carbonate of ammonia, and the formation of sulphide of ammonium, while the phosphates and the urate of ammonia 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." This condition favours the occurrence of calculus and gravel.

Alkalinity of the urine is nearly always due, if the administration of alkalies can be excluded, to the decomposition of urea into carbonate of ammonia. It is present in some diseases of the spinal cord, and especially in chronic affections of the bladder and urinary organs, as a few drops of urine, which have undergone the alkaline fermentation, will rapidly beget the same change in perfectly fresh urine.

When the alkalinity of the urine is due to fixed alkali, either potash or soda, it is probably caused by the ingestion of alkaline salts, or, failing this, to a catarrh of the urinary passages, or some alteration in the metamorphosis of the tissues. About this last condition, little is known with certainty. It is always best treated by meat diet and iron.

It may often be noticed that effervescence takes place when nitric acid is added to the urine. This is due to the decomposition of the urea by the nitrous acid which is present in nearly all laboratory specimens of nitric acid.

To test for salicylic acid, a neutral solution of the perchloride or sulphate of iron must

be added drop by drop to the suspected urine. With the first drop, there is a precipitate of phosphate of iron; if more be added, a violet or mulberry colour appears.

————

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, in the manner represented in the following woodcut. (p. 14.) By employing this

method, two layers of fluid are obtained for comparison.

The heat is applied until the upper portion of the urine begin to boil, for although albumen, when in large quantity, coagulates at a
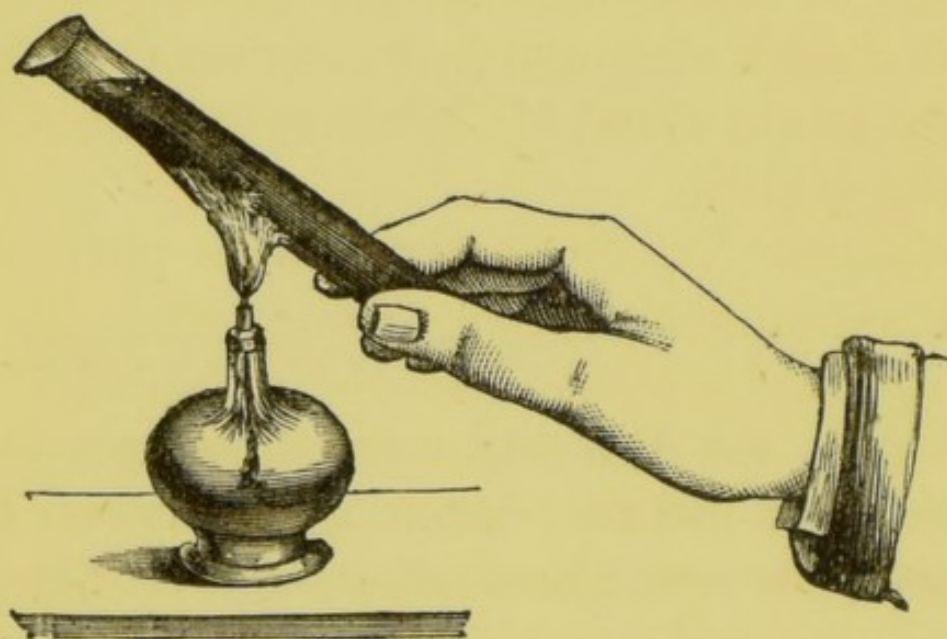

FIG. 1.

point many degrees below boiling, yet the presence of a small quantity gives no precipitate below 212° F.   The boiled layer of fluid should now be carefully compared with the cool layer in the lower part, by holding the test tube against the light, or a black surface ; 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 is permanent, if due to albumen ; but disappears immediately if due to the earthy phosphates. This addition of acid after boiling should never be omitted, since the most practised eye cannot distinguish, by appearance only, between the cloud of albumen, and the phosphate of lime.

Cautions.   i. 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 ; such an appearance is never seen with phosphates ; when they are the cause of the turbidity, the urine becomes absolutely clear, as before boiling ; a slight brown colour only following the addition of the nitric acid.

ii. 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 be dissolved ; the upper stratum of the urine should

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

iii. If the urine be neutral or alkaline at the time of testing, the albumen 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 alkaline urine be boiled without previous acidulation, a deposit of phosphate of lime is almost sure to occur, which is immediately dissolved on the addition of an acid.

If nitric acid be added, before boiling, to an albuminous urine, the albumen will often not be precipitated on the application of heat, because acid-albumen will be formed. Care must therefore be taken that it is acetic acid which is used in the preparatory acidification of the urine.

iv. If the urine be permanently turbid, from any cause, and it is desired to know accurately whether albumen be present, the urine must be filtered before boiling; in this way very minute quantities may be discovered.

The method of testing for albumen, proposed by Heller, which consists in pouring

nitric acid into a test tube, and allowing the urine to flow down upon the acid, so that the two fluids touch, but do not mix, and observing the white layer of coagulated albumen thus produced, is open to so many fallacies, that it cannot be recommended, save to experienced hands. Urea and urates are a common source of error, since they cause the appearance of a band very like that of albumen. A resin, like copaiba, taken internally causes a ring to appear in the urine with nitric acid, which imitates the coagulation of albumen. It does not, however, give the reaction with heat.

Though the old test of heat and nitric acid remains the one in which most confidence may be placed for recognising the presence of the ordinary serum-albumen of the urine, yet during the last few years several tests have been introduced for which equality or even superiority has been claimed. These are: a saturated solution of picric acid, tungstate of soda, ferrocyanide of potassium, and potassio-mercuric iodide. The solutions are all applied in the same manner: the urine is first acidulated strongly with acetic acid (failing that, with citric acid) and the

reagent is then dropped into the urine, and a precipitate or cloudiness looked for : or else the reagent is poured on to the surface of the urine, in a test-tube (just as in Heller's test with cold nitric acid, which has just been spoken of), and a white ring looked for, which is due to the presence of coagulated albumen.   If, however, the reagent be heavier than the urine, as is the case with nitric acid, the reagent must be poured in first, and the urine gently poured in on to the top of the reagent.

It is of great importance that the solutions of these reagents be quite clear, otherwise the turbidity of the solution may be mistaken for a sign of the presence of albumen.   To make these tests more convenient to practitioners, Dr. Oliver, of Harrogate, deposits them on filtering paper. Papers thus charged with these reagents are dropped into the suspected urine: as the reagents dissolve in the urine, a cloudiness will be caused if the urine contain albumen ; but the fluid will remain clear, if no albumen be present.   As it is necessary that the urine should have a strong acid reaction at the time of testing, Dr. Oliver has prepared a citric acid test

paper which is dropped into the urine, before the application of the other test papers. The cloudiness caused by the papers is intensified on the application of heat.

In like manner, Dr. George Johnson recommends the use of the picric acid in powder: a quantity enough to cover the tip of a penknife is shaken gradually into a test-tube half full of urine. As the picric acid dissolves, the urine becomes more or less turbid if it contain albumen.

A saturated solution of sulphate of soda or of common salt, acidulated with hydrochloric acid, is a test for albumen. The two fluids are allowed to come in contact with one another in a test-tube, as in Heller's method of testing for albumen, (p. 16) and the urine is judged to contain albumen if a ring or cloud form. If no cloud form, heat must be applied after shaking the test-tube.

The albumen of the serum of the blood is the albumen which is found most commonly and in greatest quantity in the urine. Other albuminous bodies, as paraglobulin and peptones, may also be found, as Dr. Lauder Brunton and Mr. D'Arcy Power have pointed out.

Peptonuria, or the presence of peptones in

the urine, has lately been much discussed. Peptones are not thrown down by heat and nitric acid; nor by acetic acid and ferro-cyanide of potassium, though they are coagulated by picric acid, tungstate of soda, and potassio-mercuric iodide. The presence of peptones in a fluid may be ascertained by pouring some of the suspected fluid on to the surface of Fehling's or Pavy's solution in a test-tube, after the manner of Heller's test, (see p. 16) and watching the change of colour which follows. A rose or violet colour appears in the fluid if peptones be present. Or a drop of the Fehling's or Pavy's solution may be added to the fluid to be tested in the cold, and the same colour looked for.

This test can, however, but seldom be applied directly to the urine; if other albuminous bodies be present it is absolutely necessary that they be removed; and if the urine be high coloured, it will be necessary to decolorise it with carbonate of lead. These more elaborate processes can seldom be employed by the clinical clerk.

Peptonuria is said to be seen in acute malignant diseases, such as scurvy, purpura, and other acute hæmorrhagic diseases; also

in those cases where a large number of white corpuscles are being destroyed, as in the absorption of large pleuritic effusions, in pneumonia, inflammation of the joints, meningitis, fractures, boils, etc.

A rough way of estimating the amount of albumen present in the urine, is to pour some of the urine into a test-tube, until it be about half full, and to boil the whole of the urine in the tube, till the albumen be completely coagulated. One or two drops of nitric acid are then added, and the test tube is set aside for twenty-four hours; 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 : 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 have collected at the bottom, there is said to be a trace. If the urates have been deposited, the urine must be filtered before boiling, or a considerable error will creep in, by their increasing the apparent amount of albumen.

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

Any state which brings about a mechanical impediment to the return of blood from the kidneys, will be accompanied by albumen in the urine; and the albumen will be persistent so long as the congestion of the kidney continues; the longer the albumen remains in the urine, the greater danger is there of permanent textural injury to the kidney. In many acute febrile diseases, albumen is often present, which, as a rule, disappears with the termination of the illness; but, if persistent, it affords evidence of organic disease of the kidney. In a chronic, non-febrile disorder, there being no hindrance to the return of blood from the kidneys to the heart, the discovery of albumen in a clear urine would point to structural change in the kidney.

The search for renal casts must always follow the detection of albumen in the urine. The discovery of these structures renders it certain that the albumen, or, at least, part of it, is derived from the kidney.

A common cause of the presence of albn-

men is pus, according to its quantity ; in the urine of women, a small quantity of albumen is often due to leucorrhœal discharge, which is composed chiefly of pus. Gleet, and also, it is said, a great quantity of semen, cause albumen to be present in the urine.

If blood be present in the urine, albumen must likewise be present, derived from the corpuscles and plasma.

EXAMINATION FOR SUGAR.

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

The sugar in the urine is grape sugar.

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 still a want.

Before testing urine for sugar, it should be

tested for albumen; and if this body be present, it should be removed by acidulating an ounce or two of the urine with one or two drops of acetic acid, boiling and filtering. In the same way, if the urine be high coloured, it may be well to get rid of the colouring matters by throwing them down with a solution of acetate of lead and filtering. And if the urine be turbid from urates, it is very desirable to free the urine from these by filtration before applying the tests for sugar.

Moore's Test. Equal parts of urine, and liquor potassæ or liquor sodæ, are poured into a test tube, and the upper layer of this mixture is heated to boiling, in the manner described in the section on examination for albumen. (See page 14.) The heated portion becomes brown, red, dark brown, or black, according to the quantity of sugar present. The least change of colour may be perceived by comparing the upper and the lower layers of the liquid.

Cautions. i. High-coloured urines, and urines containing excess of phosphates, darken very perceptibly on boiling with caustic alkalies, and if the urine be albuminous, the colour will be greatly deepened, though no sugar be present.

ii. It has been noticed that liquor potassæ 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 the alkali is boiled with certain urines which contain much sulphur. Care must be therefore taken that the liquor potassæ is free from lead.

The value of Moore's test is chiefly negative; if the urine on boiling with liquor potassæ do not greatly darken, it may be assumed to be free from a hurtful quantity of sugar; if, however, much darkening occur, a further observation must be made with the copper or fermentation tests described below.

The Copper Test depends on the property which grape sugar possesses, of reducing the higher oxyde of copper to a suboxyde. There are two methods of conducting this reaction, identical in principle, named respectively Trommer's Test and Fehling's Test.

Trommer's Test. About a drachm of the suspected urine is poured into a test tube, and liquor potassæ or liquor sodæ added in about the same quantity: a weak solution of sulphate of copper (about 10 grains to the

fluid ounce) is dropped into the mixture. The precipitate which first forms is redissolved on shaking the test tube, and the copper solution should be carefully added, shaking the test tube after each drop has fallen into the mixture, so long as the precipitate is easily redissolved, when the solution will have acquired a beautiful blue or green colour, but should be quite clear, and free from any precipitate; the contents of the test tube must next be heated to boiling, when, if sugar be present, an orange red precipitate is first thrown down, which, after some time, becomes reddish brown. This precipitate consists of the suboxyde of copper.

On boiling Trommer's test with urine, a change of colour is seen in every urine; but this is no proof of the presence of sugar; the reaction is only known to be present when the reddish precipitate is thrown down.

Since uric acid and mucus will also reduce copper when they are boiled with its salts, a similar solution should be set aside in the cold; and if at the end of the twenty-four hours the reddish precipitate have fallen, sugar is undoubtedly present.

Cautions. Much trouble is often at first

felt in arranging the proper proportion be-
tween the copper solution, and the liquor
potassæ. Much of this, no doubt, arises
from the weak pharmaceutical liquor potassæ
being used instead of the stronger solution of
the chemical laboratory. The liquor potassæ
used in Trommer's test, should be from 20 to
30 *per cent*. in strength. This readily dis-
solves the precipitate formed on adding the
copper; a property which the pharmaceutical
solution possesses in much smaller degree.
Too much copper should not be added. It is
a good rule always to have a slight excess of
potash, and never to operate save with a
clear solution.

Fehling's Solution. (Dr. Pavy's solution is
identical in principle with Fehling's solution.)
In consequence of the difficulty of properly
adjusting the quantity of alkali and copper in
Trommer's test, many practitioners prefer to
use a solution in which the copper and alkali
are present in the exact proportion necessary.
This solution may be prepared in the fol-
lowing way: 665$\frac{1}{2}$ grains of crystallized
potassio-tartrate of soda are dissolved in 5
fluid ounces of a solution of caustic potash, sp.
gr. 1·12. Into this alkaline solution is poured

a fluid prepared by dissolving 133½ grains of sulphate of copper in 10 fluid drachms of water. The solution is exceedingly apt to decompose, and must always be kept in stoppered bottles, and in a cool place.* It is usually, therefore, more convenient not to mix the alkali and copper until the solution be wanted for use. In this case, a fluid drachm of the sulphate of copper solution may be added to half a fluid ounce of the alkaline solution prepared as above.

About a couple of drachms of this test-solution are poured into an ordinary test-tube, and the fluid boiled over a lamp, and set aside for twelve hours. If no deposit form, the solution may be used for analysis; but if a red precipitate be thrown down, the liquid has decomposed, and a fresh supply must be had.

While the solution is boiling in the test-tube, the urine must be added to it, drop by drop, and the effect watched. A few drops of urine which contain a large percentage of sugar will at once give a precipitate of yel-

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* Hawksley, of 357 Oxford St., has succeeded in pre-paring a solution which keeps a long time.

low or red suboxyde; but if no precipitate occur, the urine should be added to the fluid, drop by drop, any deposit being carefully looked for, until a quantity equal to that of the Fehling's solution employed, has been added. If no precipitate be found after setting the test-tube aside for an hour, the urine may be considered free from sugar.

Cautions. i. The test solution should never be used without boiling beforehand for a few seconds; the tartrate being exceedingly apt to decompose, and the solution then reduces copper as effectually as would grape sugar.

ii. The quantity of urine used in the test should never be greater than the quantity of test solution employed.

iii. After adding urine in volume equal to the Fehling's solution, the boiling of the mixture must not be continued, as other bodies present in the urine, besides sugar, will reduce copper at a high temperature.

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 of the urine, or better still, quicksilver, and set aside in a warm place, as a mantel piece, or

a hob.   A glass bird fountain, if at hand, will be much more handy for this purpose than a test-tube.   A similar test-tube or bird fountain must be filled with water, a few grains of yeast added, and both vessels 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, or bird fountain ; 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 again rise in the tube.

Estimation by loss of density after fermentation. Dr. Roberts of Manchester has found that, after fermentation, "the number of degrees of ' density lost ' indicated as many grains of sugar per fluid ounce," and he proposes to estimate by this means the amount of sugar present.

About four fluid ounces of the urine are placed in a 12-ounce bottle with a piece of German yeast of the size of a chestnut.   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 twenty-four hours the fermentation is almost finished; the fermented urine is poured into a urine glass, and the specific gravity taken with the urometer ; 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, the remainder giving 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.

Indigo-Carmine Test. When indigo-blue (indigoline) is heated with an alkali in the presence of glucose, it loses its colour and becomes indigo-white, which when oxydised becomes indigo-blue again. Dr. Oliver has taken advantage of this reaction to contrive a test for sugar, and has prepared a test paper upon which indigo-carmine has been deposited : the paper is introduced with another test paper of carbonate of soda into a test-tube ; enough distilled or common water is poured into the tube to cover the papers and heat

applied; the solution thus prepared should be of a fine blue colour. To the blue solution a drop or two of the suspected urine may now be added, and the contents of the test-tube kept warm, but not boiled or shaken; if sugar be present, the blue colour of the indigo is quickly discharged, and the solution becomes yellow; if the solution be now shaken, blue streaks from the surface of the fluid pass down into the fluid, and if the shaking or boiling be continued, the fluid becomes of its original blue colour.

Picric Acid Test. Dr. George Johnson recommends the following test. Equal parts of urine, liquor potassæ, and a solution of picric acid are boiled together in a test-tube, when if sugar be present, a deep red claret colour is developed. Dr. George Johnson thinks highly of this test, but I do not feel confident that all students will be able to distinguish the colour developed in diabetic urine, from that developed in the urine of health.

It has been thought that the coma so often seen at the end of diabetes, is due to the presence of acetone in the blood, and the state has been named acetonæmia. The

urine will then often give a deep red reaction with perchloride of iron, a reaction which is thought to be due to the presence of acetone, *acetonuria.* Dr. Ralfe tests for the presence of acetone in the urine in the following way: a drachm of liquor potassæ in which about twenty grains of iodide of potassium have been dissolved is boiled in a test-tube: while still hot, a drachm of the urine to be tested is poured on to the surface of the fluid, as in Heller's test, and at the line of contact, a ring of phosphate appears; and if acetone be present, the colour of the ring becomes in a few minutes yellow, and numerous yellow points of iodoform appear, which later on sink to the bottom of the test-tube.

It is still disputed whether the urine in health contain sugar. Brücke holds that a healthy man excretes daily through the kidneys about fifteen grains of sugar. According to Leube, the excretion of sugar in diabetes is far greater during the night, than during the day: urea follows just the opposite rule.

Clinical Import. If the foregoing tests announce the presence of sugar, in considerable

quantity, as often as the urine is examined, diabetes mellitus may be inferred to exist. But should the presence of sugar in the urine be variable, and amount small, the fact is not of any known great diagnostic, or therapeutic, importance.

Sugar is said to be present in the urine of the fœtus, of women when suckling, and of some old persons. It is seen in the urine during convalescence from some acute disorders, especially cholera, in malarious diseases, and in carbuncle. Certain injuries of the nervous system also bring on glycosuria.

BILE IN THE URINE.

The presence of bile in the urine can seldom be overlooked, since it gives a dark greenish brown colour to the secretion. White filtering paper is coloured yellow by the urine ; a permanent froth is also formed by shaking the urine. The colour given to

the urine by drugs such as rhubarb and santonin is distinguished from that given by the bile pigments by the reaction of alkalies. Alkalies deepen the red of vegetable pigments, but turn bilious urine to a dirty brown.

Two bodies must be tested for, the bile pigments and the bile acids, each of which must be looked for by itself.

THE BILE PIGMENTS. *Gmelin's Test.* Ordinary nitric acid, which nearly always contains some nitrous acid, is poured into a test-tube to the depth of half an inch. A portion of the urine to be examined 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; this operation is most conveniently performed by means of a pipette. The test-tube may then be nearly filled with urine. At the line of contact, a zone of red appears in every urine; but if pigment be present, the layer of urine above becomes green. This is the characteristic colour; without it the presence of bile pigments cannot be predicated. This reaction may also be performed by allowing a drop of nitric acid and one of the urine to be

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examined to run together on a porcelain dish, when a play of colours will be observed at the line of contact. But this is not so good as the first method, as the green colour is less perfectly seen. By waiting a few minutes, the green colour will sometimes develop in a fluid which at first gave no reaction.

Caution. Any urine which contains a large amount of indican will give a blue or violet, and even green, colour with nitric acid. The green colour is, however, rarely seen with any other body than bile pigment.

Iodine Test. Some solution of iodine, not more than a drop or two, should be added to the urine in a test-tube, and if bile pigment be present, the whole becomes of a fine green colour. The green colour is due to the formation of the same body, biliverdin, which causes the green reaction in Gmelin's test.

THE BILE ACIDS. *Pettenkofer's Test.* Some of the fluid containing the bile acids, is placed in a porcelain dish, and a drop of saturated solution of cane sugar added; strong sulphuric acid is then dropped into the mixture, taking care that this acid is clearly in excess of the amount of bile acids present, that is, 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.

Another, and perhaps a better, way of applying Pettenkofer's test is to pour the fluid containing the bile acids, into a test-tube; sulphuric acid being then added, at first in small quantity to precipitate the bile acids, but afterwards in amount sufficient to redissolve them, which renders the mixture perceptibly hot to the hand. A drop of syrup may now be let fall into the liquid, which then shows a play of colours passing from pink to cherry-red, and from red to purple.

Strassburg recommends that the test should be applied to urine in this fashion; a little cane sugar is added to the urine and dissolved; a piece of filtering paper is dipped in the urine and then dried. When the paper is quite dry a drop of concentrated sulphuric acid is let fall upon it by means of a glass rod, and after a quarter of a minute a beautiful violet colour appears. I have used this test, but not with success. I feel

unable to recommend it to the clinical student.

Pettenkofer's test should never be applied directly to urine : the bile acids are never present in sufficient quantity to give the reaction, however modified, and the urine in jaundice frequently contains a small quantity of albumen which gives a reddish violet reaction with sugar and sulphuric acid, while the action of the acid upon the other constituents of the urine renders it impossible to be sure of the distinctive colours of Pettenkofer's test.   If, therefore, it be very desirable to ascertain whether the bile acids be present in the urine, the method introduced by Hoppe must be employed for their separation; a long and somewhat complicated process, which can seldom be adopted by the clinical student.

With this object, a pint or more of the urine must be rendered faintly ammoniacal with caustic ammonia, and then subacetate of lead added, so long as a precipitate falls. The precipitate must be collected on a filter, and 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 over a water bath. The residue is again to be boiled with absolute alcohol over a water bath until but a little be left. This must be then thrown into a great excess of æther in a stoppered bottle, and after some time, the alkaline salts of the bile acids will crystallize out. In order to prove that these crystals are salts of the bile acids, they must be dissolved in a little distilled water, and tested with Pettenkofer's method, as directed above.

Clinical Import. The bile pigments and the bile acids are present in the urine in most cases of jaundice. In hot weather, the bile pigments may sometimes be detected, by means of Gmelin's test, in the urine of persons who are not jaundiced. Indeed, some believe that the bile pigments are always present in small amount in health, and the same may be said of the bile acids. The quantity of bile acids present in jaundice is scarcely over ·2 *per cent.* if the estimations on record may be trusted.

HÆMOGLOBIN IN THE URINE.

Hæmoglobin may be known to be present in the urine by finding red corpuscles, (see the section on the Blood, p. 73), or by the characteristic spectrum.

The guaiacum test has of late been much used.   A few drops of the tincture of guaiacum are added to the urine in a test tube, and then an excess of ozonic æther, that is an æthereal solution of peroxyde of hydrogen. The mixture is shaken together, and on standing, the æther separates, of a fine sapphire blue colour, if blood be present.

The reaction depends upon the oxydation of the guaiacum by the ozonic æther; this, however, it is unable to do save in the presence of a body like hæmoglobin; so that it is the addition of the hæmoglobin which determines the reaction.

The results of this test must always be received with caution, and can hardly be accepted unless confirmed by other evidence. Many other bodies besides hæmoglobin seem able to determine the oxydation of the guaiacum.

Heller's test for hæmatin is somewhat out of date. It is practised as follows : liquor potassæ or liquor sodæ is added to the urine in a test-tube, until a pronounced alkaline reaction be obtained ; the mixture is then heated to the boiling point, and set aside. The precipitate of phosphates has a greenish to a reddish colour when the urine contains hæmoglobin, methæglobin, or hæmatin.

Clinical Import. The late Dr. Mahomed pointed out that the urine of patients who are about to suffer an attack of Bright's disease, will sometimes give the guaiacum test for blood before albumen appear in the urine. He acknowledged, however, that confirmatory tests with the spectrum and the microscope sometimes failed.

In certain other diseases it is said that hæmoglobin may be detected by chemical tests, but yet no blood corpuscles seen with the microscope ; such as poisoning by arseniuretted hydrogen, phosphorus, and sulphuric acid, jaundice, malignant cases of the acute specific diseases, and scurvy. Also in the disease called paroxysmal hæmaturia, it is said that no corpuscles can be found.

But little is known about the colouring

matters of the urine which have been named urohæmatin, uroxanthin, hæmaphæin, &c. Indican is a constant constituent of the urine, and by boiling with mineral acids, is decomposed into sugar, indigo-red and indigo-blue. With nitric acid, it imitates the reactions of the bile pigment. (See p. 36.) Heller pours a few drachms of fuming hydrochloric acid into a beaker glass, and then adds about thirty or forty drops of the urine. The fluid becomes red, violet, or blue, if much indican have been present. Heller attributes the reaction to the presence of uroxanthin.

According to Jaffé, indican should be tested for as follows: equal volumes of urine and hydrochloric acid are mixed together, and drop after drop of saturated solution of calcic chloride added, and according to the amount of indican present does the fluid change in colour; if little indican be present, the fluid is only red; if much, it becomes blue.

Urobilin is one of the colouring matters of the urine, and is said to arise from bile pigment. When bilirubin is given to an animal by the mouth, urobilin appears in the urine in quantity equal to the amount of bilirubin taken.

Clinical Import. Our knowledge of the urinary pigments in health is in so imperfect a state that nothing is known of the changes which they undergo in disease.

In obstruction, catarrh, and other diseases of the small intestines, it is said that there is an increase of indican in the urine ; and that thus a distinction can be made between diseases of the large and the small intestine.

Much indican is also said to·be present in the urine in melanotic cancers : and thus the presence of indican may be of help to the diagnosis when the cancer is situated in an internal organ, for example, the liver.

UREA.

Urea is the body characteristic of the urine; unless a fluid contain urea, it cannot be said to be urine.

The source of the urea is still unknown ; and it is much disputed if all or any part of it be made in the kidneys, the liver, the muscles, or the system at large.

The clinical student may sometimes wish to know if the urine contain urea, or if a given fluid be really urine, or some other secretion. The fluid is first to be tested for albumen, which, if present, must be removed by acidulation with two or three drops of acetic acid, raising the temperature of the fluid to the boiling point, and filtering. This filtrate is used for the subsequent operations of evaporation, &c., as stated below.

If the urine be free from albumen, some quantity, two or three fluid ounces, must be evaporated in a Berlin dish over a water bath, until the fluid have the consistence of syrup. A water bath is essential, because an open flame would decompose the urea. After the syrupy fluid has completely cooled, nitric acid, as free as possible from nitrous acid, is added drop by drop, so long as a precipitate is formed. An excess of nitric acid is desirable. Some of these crystals of nitrate of urea, removed with a glass rod and placed under the microscope, show flat rhombic or hexagonal plates closely united to one another. Or a drop of the concentrated fluid may be let fall on a slide, and a drop of strong nitric acid may be added with

a glass rod while under the microscope. Sometimes only a few drops of the fluid can be had, and the student should then let a little fall on the glass slide, set it aside in a warm place, such as a mantle piece, for the fluid to concentrate, then add some strong nitric acid, and place the crystals under the microscope. If the fluid contain urea, rhombic or hexagonal plates will be seen.

Clinical Import. Healthy urine may be looked upon as being for the most part a solution of urea and chloride of sodium ; one half of the solids being made up of urea, and one quarter of chloride of sodium. Urea is the most important constituent of the urine ; a healthy man excretes from 300 to 500 grains in the twenty-four hours. Its amount is increased in health by a high meat diet, and decreased by purely vegetable food. In some acute diseases, as pneumonia, typhoid fever, and acute rheumatism, it is said to be greatly increased owing to the excessive tissue-metamorphosis ; it may be present in such quantity as to give a precipitate, without previous concentration, when the urine is acidulated with nitric acid. In chronic diseases especially those attended by a cachexia.

or in uræmia and chronic Bright's disease, the amount of urea is below the average. In diabetes, the amount of urea secreted in twenty-four hours is increased; although the amount *per cent.* of urea is much decreased by the excessive flow of water which passes out through the kidneys.

URIC ACID.

If an urate be injected into the veins of a mammal an equivalent amount of urea appears in the urine. Uric acid is found in the urine of all carnivorous animals. In that of reptiles it entirely replaces the urea in the urine.

To ascertain if the urine contain uric acid, it is necessary to acidulate about a fluid ounce of the urine with a fluid drachm 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 p. 58.)

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

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

HIPPURIC ACID.

The method of preparing hippuric acid from human urine is troublesome, and will rarely be required to be used by the clinical

student. Half a pint of perfectly fresh urine is made highly alkaline with carbonate of soda, evaporated almost to dryness in a water bath, and then extracted with absolute alcohol; the alcohol evaporated, the residue mixed with hydrochloric acid and repeatedly extracted with acetic æther. The solution in acetic æther is then poured off, and washed with a little water or saline solution, the acetic æther is evaporated and the residue exhausted with fresh petroleum æther, which takes up the benzoic acid but leaves the hippuric acid undissolved.

Hippuric acid, when evaporated to dryness with nitric acid, in a porcelain crucible, over a lamp, and then further heated to redness, gives off a gas smelling like oil of bitter almonds. This reaction is common to benzoic and hippuric acids.

The crystals of hippuric acid, seen under a microscope, are long and needle-shaped prisms; they are distinguished from those of benzoic acid by their difficult solubility in æther.

Clinical Import. Hippuric acid exists in small quantity in the urine in health; its amount is greatly increased by the eating of

much fruit, and also by the ingestion of benzoic acid. The hippuric acid appears in the urine in quantity equivalent to the benzoic acid taken. Excluding these circumstances, hippuric acid is also found in quantity in the urine of fever patients, and may even be the cause of the acid reaction; the amount is also increased in diabetes and chorea.

Nothing is known of the importance of this acid in therapeutics or diagnosis. In health the amount varies from 7 to 15 grains in the twenty-four hours.

CHLORIDES.

Chlorides may be known to be present by the following test. To a fluid 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 be present, a cloudiness only will be given; but if any quantity, a white precipitate is thrown down, soluble in caustic ammonia, and re-precipitated 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.

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, acidulating it in a test tube with nitric acid, and adding a solution of nitrate of silver until no further precipitate be formed. The test tube must then be set aside for twenty-four hours, and a note then taken of the proportion of the chloride of silver deposit, for comparison with other observations.

On an average, a healthy man secretes 250 grains of chloride of sodium in the twenty-four hours.

Clinical Import. During acute pneumonia, acute rheumatism, and most other pyrexial diseases, the chlorides diminish in quantity, or even disappear from the urine. Their reappearance in daily increasing quantity is a sign of the diminution of the intensity of the disease. The amount of chlorides apparently depends upon the digestive powers of the patient even in chronic diseases.

PHOSPHATES.

The presence of phosphates in the urine may be ascertained by the following test. A fluid is prepared by adding a drop or two of caustic ammonia to a fluid drachm of a solution of sulphate of magnesia in a test tube; hydrochloric acid is added until the precipitate caused by the ammonia be redissolved. Caustic ammonia is again added in excess until the fluid be strongly ammoniacal. A fluid drachm of urine is now poured into another test tube, and rendered ammoniacal with caustic ammonia; to this urine some of the prepared solution is added, and a precipitate of the ammoniaco-magnesian phosphate occurs at once, if the urine contain the ordinary amount of phosphates; but the precipitate forms slowly, if the phosphates are present in very small amount.

The quantity of phosphoric acid excreted by a healthy man in the twenty-four hours is about 50 grains.

Clinical Import. The amount of phosphoric acid in the urine is increased in diseases of the nervous centres, and of the bones, and

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after great mental application, Acute febrile diseases cause increase of the phosphoric acid from increased tissue-metamorphosis, while in Bright's disease and some other forms of dyspepsia, the quantity of the phosphates is diminished. Dr. Gee and Dr. Zuelzer have pointed out that the phosphates diminish or disappear after the acme of the paroxysm in ague, and after some other febrile disorders.

SULPHATES.

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

The quantity of sulphuric acid excreted by a healthy man in the twenty-four hours is about 30 grains.

Clinical Import. The quantity of the sulphates is 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. In carbolic acid poisoning, the sulphates are absent from the urine.

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The following table of the amount of urinary constituents excreted by a grown-up man in the twenty-four hours is compiled from Dr. Parkes' book on 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.

In a healthy man, the hourly excretion of urine may vary from 20 to 2000 C.C. In general, it is from 50 to 70 C.C. when much drink is taken, and 40 to 60 C.C. when little is taken. One kilogramme of body-weight, therefore, excretes about 1 C.C. of urine every hour.

The urine is always diminished in quantity during the height of a pyrexial disease; a sign of improvement is the increase in the quantity of urine. When a disease is about to prove fatal, the quantity often sinks. In

diabetes and interstitial nephritis, the quantity is increased; and this is often the case when collections of fluid in serous cavities are being absorbed.

URINARY SEDIMENTS.

When a urinary deposit is to be examined, about 4 or 5 fluid ounces of the urine should be collected in a tall narrow cylindrical glass, and set aside for a few hours. Cylindrical glasses have, in my own 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 they be present in but small quantity. Lately I have seen vessels in use with the bottom broader than the top, which seem likely to be useful for the purpose of collecting sediments.

When the sediment has collected at the bottom, the supernatant urine may be poured

off, and a drop of the fluid containing 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 really 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 edge of the thin glass upon the slide, and resting the other upon the needle, then inclining the needle gradually, until it be horizontal. All superfluous moisture around the glass cover must be carefully removed with a cloth, or with 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 the student will have to deal

with.   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 with the coarse adjuster in the focus which suits his own eyesight.

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

UNORGANISED SEDIMENTS.

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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 appearance, like cayenne

pepper, 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 at once known to be uric acid by their reddish-brown colour, all other crystalline deposits being transparent and colourless. If, indeed, the student be in doubt as to the nature of a crystal, he will never be very wrong, if he judge it to be uric acid when there is a slight tinge of
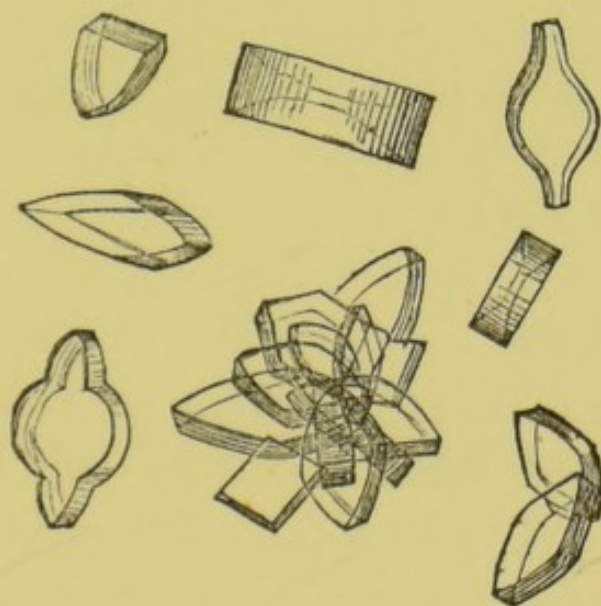
FIG. 2.—Uric Acid.

brown visible. The crystals, themselves, have numerous forms; they occur very commonly in rhomboidal, or long oval plates with acute angles; these crystals are often

united so as to form rosettes, or they may be rectangular, barrel shaped, or in hexagonal plates, with two parallel sides longer than the other four.

If the student be not quite sure of their nature, he should add to the specimen under the microscope, a little liquor potassæ or liquor sodæ, which will dissolve uric acid if present; when dissolved by the alkali, it can be reprecipitated in hexagonal plates by the addition of hydrochloric or acetic acid.

Traces may also be detected by means of the murexid test; a small portion of the suspected sediment is placed in a porcelain dish, and a drop of nitric acid let fall upon it; the dish is then gently heated over a lamp until all the nitric acid be 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 liquor potassæ be used instead of ammonia, the colour will be violet. The test does not, however, distinguish uric acid from its salts.

Usually the uric acid is not free when the urine is voided, but it is thrown down 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 present 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 shew 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 state of considerable danger, since it may lay the foundation of a calculus; uric acid, and urate, calculi being the most common of all urinary concretions.

URATES.

This deposit is the most common and least important of all the urinary sediments. Any febrile state will lead to this deposit; even a greater amount of perspiration than usual, will be followed by urine that becomes turbid on cooling, merely as a result of a diminished secretion of water. Urine containing an

excess of urates is never turbid when passed; it is only when the urine has cooled, that the peculiar muddiness is observed. If the urine be gently warmed, the turbidity immediately disappears. The urates differ in colour considerably, according to the amount of colouring matter in the urine, varying from white to pink or red. In young children the

FIG. 3.—Amorphous Urates.
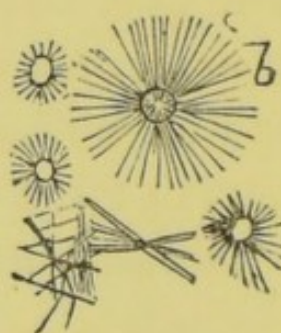
FIG. 4.—Crystals of Urate of Soda.
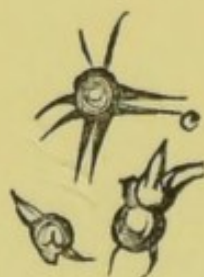
FIG. 5.—Hedge-hog crystals of Urates of Soda.

FIG. 6.—Urate of Ammonia.

"milky" urine which alarms mothers, is due to a deposit of peculiarly white urates.

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 common of the three, and is usually seen under the microscope as an amorphous deposit; 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 an amorphous sediment. If any doubt be entertained as to the nature of these salts, it is necessary to add a drop of hydrochloric or 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 (page 58) may be applied.

OXALATE OF LIME.

Oxalate of lime is sometimes deposited from the urine during the acid fermentation, or even later.

Oxalate of lime occurs as a urinary sedi-

ment in colourless octahedral crystals, having the so-called "envelope" appearance which, when once seen, can hardly be mistaken for anything else. This deposit also occurs in colourless dumb bells.
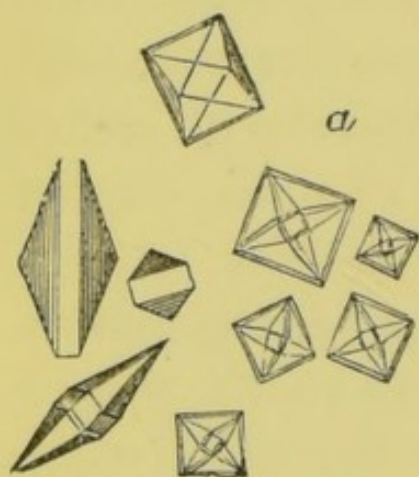
FIG. 7.—Oxalate of Lime.
a. Octahedra and pyramids.
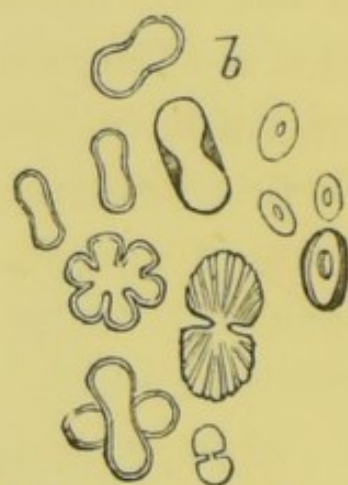
FIG. 8.—Do. *b.* Dumb-bells and ovals.

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. After urates, oxalate of lime is the most common unorganized urinary sediment; it is often seen in the urine of patients convalescent from acute diseases; and many writers state that it may always be found when there is lessened oxydation,

as in bronchitis. The occasional presence of a few crystals of oxalate of lime is not of much importance. They are frequently seen in the urine after the eating of fresh fruit and vegetables. When the deposit is constant, and in large quantity, the formation of the mulberry calculus may be feared. This sediment is said to be associated with a dyspeptic and hypochondriacal condition, sometimes termed the " oxalic acid diathesis."

PHOSPHATES.

The phosphates are only separated from alkaline, or very feebly acid, urine; and they are always deposited when the urine undergoes the alkaline fermentation. They consist of the ammoniaco-magnesian phosphate, and the phosphate of lime. Both are usually found together.

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 inexperienced observer might perhaps, confound them.

The phosphate of lime chiefly occurs as an amorphous deposit; it is insoluble in water,
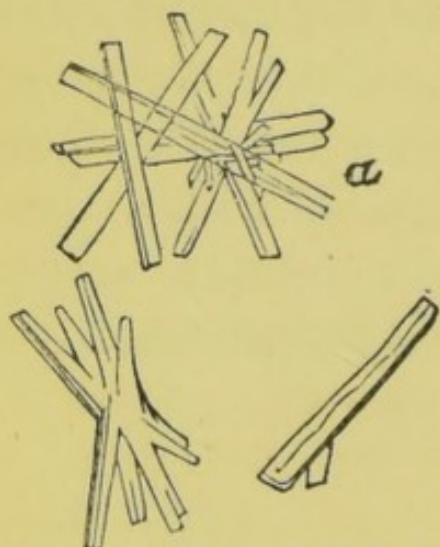
FIG. 9.—Stellar phosphates.　　FIG. 10.—Triple phosphates.
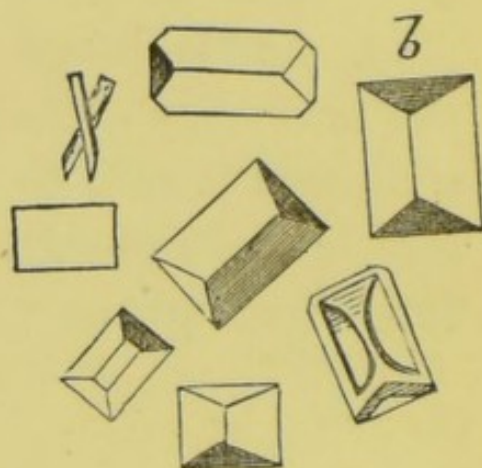
but soluble in acetic acid; in feebly acid urines, it appears to be held in solution by the carbonic acid, so that it is precipitated by heat in flakes resembling albumen, which are at once, however, dissolved by a drop of acid.

Clinical Import. The deposit of phosphates indicates an alkaline reaction of the urine, a condition favourable to the formation of phosphatic calculi.

If the least doubt be left upon the observer's mind after the examination of a sediment with the microscope, he must use the aid of

reagents in determining its nature. The following scheme will be found useful; a drop of strong acetic acid should be placed on the glass slide, near the thin covering glass, so that the acid may run in between the two pieces of glass, but it should be carefully prevented from wetting the upper surface of the cover, as this will produce an obscurity over the object. Or after having placed a drop of the fluid containing the sediment upon the glass slide, the end of a thread should be placed in the drop, and then the covering glass laid upon it, so that the other end remains free; the acid or other reagent may then be placed upon the free end of the thread, and is thus conducted along the thread to the sediment under the cover. Should the deposit be phosphatic, the acid quickly dissolves the crystals, or amorphous sediment; but if the sediment consist of urates, crystals possessing the well-known shape of uric acid are formed. If no effect upon the sediment is produced by acetic acid, it consists of either uric acid or oxalate of lime. Liquor potassæ, added with the same precautions as acetic acid, bring about a solution of the crystals of uric acid,

but the alkali has no effect upon the oxalate of lime, which will be dissolved by the action of hydrochloric acid.

CYSTIN.

Cystin is a rare deposit in the urine; it occurs in regular 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
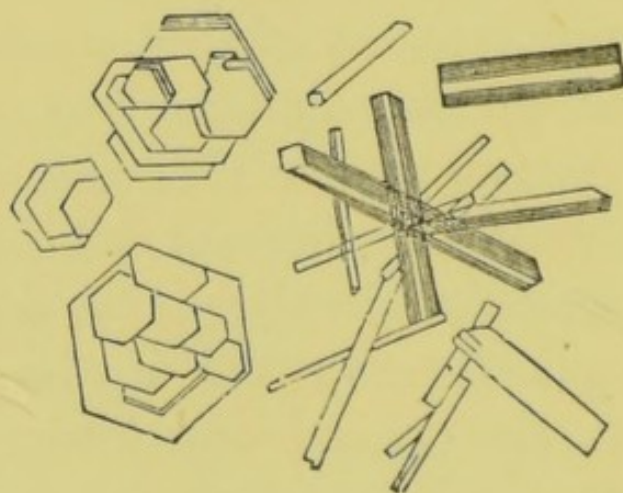
Fig. 11.—Cystin.

under the microscope. It may be distinguished from uric acid, which sometimes crystallizes in hexagonal plates, by the absence of colour in the crystals.

Urine which contains cystin is usually feebly acid, of a yellowish green colour, and of a peculiar odour, compared to sweet briar, but which sometimes resembles that of putrid cabbage. The urea and uric acid are diminished in most cases. The ammoniaco-magnesian phosphate often accompanies the crystals of cystin.

Cystin contains a large quantity of sulphur, and Liebig proposed a test which is founded on this fact. A solution is made by adding liquor potassæ or liquor sodæ to a small quantity of solution of acetate of lead until the precipitate first formed be redissolved; about equal parts of this solution and of urine are boiled, when black sulphide of lead is formed from the combination of the sulphur with the lead. This test is, however, by no means a good one, since many bodies frequently present in the urine, for example albumen, contain enough sulphur to give reaction.

Of the *Clinical Import* nothing is known.

The appearance of cystin in the urine is believed by some to be hereditary and to be connected with calculous disorders. Other observers have found it in the urine of chlorosis.

LEUCIN AND TYROSIN.

Leucin and Tyrosin are very rare deposits in the urine. Under the microscope, leucin appears in dark globular forms, which have been compared to masses of fat cells; tyrosin, however, crystallizes in beautiful bundles of delicate needles, sometimes arranged in a stellate form.

It is said that these bodies have been detected in the urine in cases of acute yellow atrophy of the liver, of small pox, of typhoid fever, and acute tuberculosis.

If these bodies do not occur as a sediment, they may be looked for by the following method: a large quantity of the urine must have a solution of acetate of lead added to it so long as a precipitate forms. Through the filtrate, sulphuretted hydrogen is passed to remove the excess of lead; and the fluid is filtered again, evaporated over a water bath to a syrup, and then extracted with spirit. The leucin is dissolved in the spirit while the tyrosin for the greater part remains undissolved. The part insoluble in spirit may

now be dissolved in water and boiled with a few drops of nitrate of mercury; if tyrosin be present, the fluid becomes rose red and soon after a red precipitate is thrown down. This test for tyrosin is called Hoffmann's test, and is said to be very delicate.

The solution in spirit contains the impure leucin and requires further preparation. It must again be filtered, evaporated to dryness, and dissolved in ammonia, and then acetate of lead added so long as a precipitate forms, then filtered and washed with a little water. The precipitate on the filter, which is a combination of leucin with lead, is suspended in water, and sulphuretted hydrogen passed through, the liquid again filtered, evaporated, and set aside to crystallize. The crystals that form must be tested in the following manner: They are carefully heated with nitric acid in a platinum crucible: if leucin be present, a colourless, almost invisible, residue is left, which, warmed with a few drops of soda solution, becomes of a yellow colour passing into brown. Another test is this; if leucin be heated in a dry test tube, oily drops are formed which give off the smell of amylamin.

This preparation is undoubtedly very long and troublesome; but without it, it is impossible to speak with confidence of the presence of leucin and tyrosin: of course, if a sediment suspected to be leucin or tyrosin be found in the urine, it may be tested at once by the reactions given above. But the recognition of crystals under the microscope, having the same form as leucin and tyrosin, is of no value, as in many cases, whether in health or disease, the urine will give crystals identical in form with leucin and tyrosin, but in which chemical tests altogether fail, or give the well-known reactions of other bodies.

ORGANISED SEDIMENTS.

PUS.

Pus is often present in the urine, and forms a thick sediment at the bottom of the urine glass. The urine readily becomes alkaline, and rapidly decomposes after being passed. 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, having granular contents, and nuclei varying from one to four in number; if acted on by acetic acid, the nuclei become much more distinct. If the urine have been long passed, the pus corpuscles undergo changes which render them incapable of being recognised.
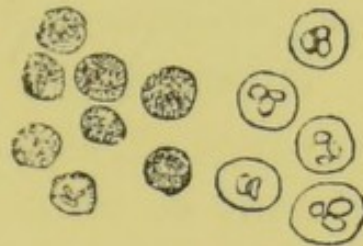
FIG. 12.—Pus-corpuscles in urine, unaltered, and affected by acetic acid.

The urine of course contains albumen, and 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 liquor potassæ; 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 alkali.

Pus occurs in the urine in the following diseases :

Leucorrhœa in women.

Gonorrhœa or Gleet in men.

Pyelitis, from any 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 be 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 it 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, quite diagnostic. If the hæmorrhage from the kidney

be great, however, the urine will have a bright red colour, like blood. But when the urine contains a great deal of blood, the blood is usually derived, not from the kidneys, but from some other part of the urinary tract.
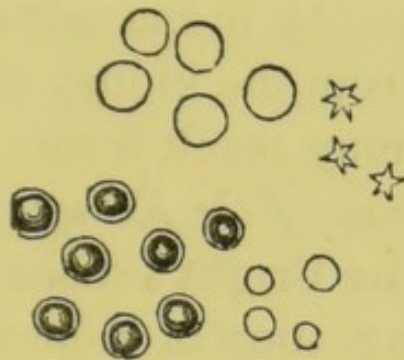
FIG. 13.—Blood corpuscles in urine.

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, pale, 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.

Clinical Import.—The presence of blood, or of blood corpuscles, in the urine is a sign of hæmorrhage from the kidney or the urinary passages. It may result from:

  i. *Disease of the Kidney.*
      Acute Bright's disease.
      Congestion of kidney.
      Cancer of kidney.
      External injury.

  ii. *Disease of Pelvis and Ureter.*
      Calculus in pelvis or ureter.
      Parasite, as Bilharzia hæmatobia.
      Cancer.

  iii. *Disease of the Bladder.*
      Calculus.
      Cancerous or villous growths.
      Congestion or ulceration of mucous
          membrane.

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

v. In women, uterine discharges, as menstruation, &c.

If the amount of blood in the urine be small, the chances favour the belief that the blood is derived from the kidneys; search must therefore be made for renal casts. If the amount of blood be large, it probably comes from the pelvis of the kidney, ureter, or bladder; if from the pelvis or ureter, there will be pus, and probably also gravel, in the urine, with pains in the loins, passing down into the thighs and testicles. If there be none of these indications, the blood probably comes from the bladder. It is commonly said, that 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 if 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. These rules will, however, often be found to fail.

The chief danger of hæmaturia is the formation of clots in the passages, and con-sequent ischuria. Small clots may some-times form the nucleus of a calculus.

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 examination with the microscope, it will be found to consist of mucus corpuscles, and epithelium scales detached from the surfaces over which the urine has passed.

The urethra and bladder give up a roundish or oval epithelium cell to the urine. In the urine of women, especially in cases of
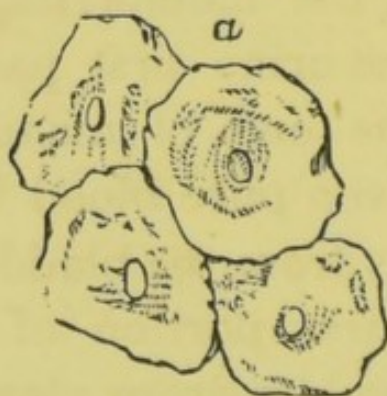
FIG. 14.—Vaginal epithelium.

leucorrhœa, the epithelium cells of the vagina are very numerous; they exactly resemble the squamous epithelium of the mouth. Under irritation, the mucous mem-

brane of the pelvis and ureter will produce
cells, caudate, spindle-shaped, and irregular,
very like those formerly looked upon as
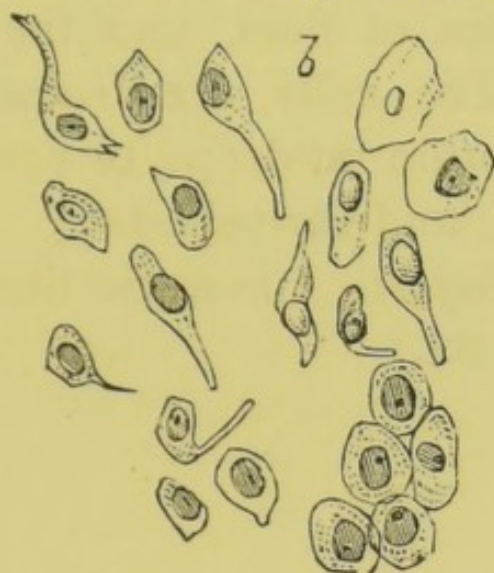
FIG. 15.—Epithelium from the bladder, ureter and pelvis
of the kidney.

diagnostic of cancer. From this circum-
stance it is impossible to speak positively of
the existence of cancer cells in the urine.
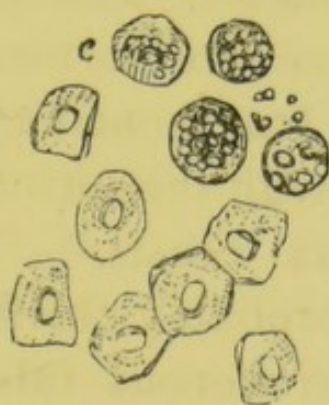
FIG. 16.—Renal epithelium, healthy and fatty.

Desquamation of the tubular epithelium of
the kidney occurs only in disease; the cells

as seen in the urine, are slightly swollen, and acquire a more spheroidal, and less distinctly polygonal shape, apparently from the imbibition of fluid, and the removal of pressure. The cells are frequently granular and contain fat drops, or are contracted, withered up, and shrivelled.

Clinical Import. See Section on Renal Casts, page 84.

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RENAL 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." Those found in the urine are probably chiefly formed in the the straight uriniferous tubes; and there are two views of the origin of renal casts: one that casts are formed by the escape of blood or plasma 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. It is possible that many of the hyaline casts are formed in this way. The other view is that the epithelial and granular casts are produced by a desquamation and degeneration of the renal epithelium.

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. If there be but few casts present, the whole of the urine of the twenty-four hours should be collected in a tall glass and allowed to settle for about twelve hours. The urine must then be all poured away, save the four or five ounces which have collected at the bottom. This residue must then be allowed to settle again for a few hours, when if casts be present, they will be found at the bottom of the glass, the last drops poured away being put under the microscope. Casts may oftentimes be missed if the urine given for examination

be only the upper layer of a specimen which has settled for some hours and of which all the casts have fallen to the bottom. It thus sometimes becomes of importance to collect all the urine passed.

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 six, or less than two, red blood corpuscles in diameter; but they vary considerably in length, never, however, exceeding the $\frac{1}{50}$ 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 likely to be mistaken for renal casts, are cotton fibres, hair, and pieces of deal.

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

Hair can often be distinguished from renal casts by its colour alone; and if this be not

very apparent, by its possessing a cortical and medullary structure; and by its length being greater than that of any cast.

Fibres of Deal, which have their source in furniture, flooring, &c. may perhaps be mistaken for renal casts. They are at once recognised by the presence of the large round wood cells which characterise the tribe of Coniferæ.

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.

The epithelial cast. The cylinder consists of a mass of epithelium 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 limited to a few dark points in the substance of the casts, or be so intense as to give the casts an almost black appearance. In this kind of cast may often be found epithelial cells, blood corpuscles, red or

white, pus corpuscles, crystals of uric acid, urates, and especially oxalate of lime.   The fatty cast is a variety of the granular, pro- duced by the running together, into globules, of the granules of fat.

The hyaline cast.   This cast is usually very transparent, and the outline is often so indis- tinct 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 show indistinct markings on their surface, or a few granules and nuclei. There are two kinds, the wide and the narrow; the latter are sometimes of great length.

In observing casts, notice must be taken of the action of acids upon them, or their contents.   It is thought that when the cylin- ders resist the solvent action of hydrochloric acid to any great degree, that the inflamma- tion of the kidney is correspondingly in- tense.   The granules on the cast, if albu- minous, will disappear, when acted on by acetic acid; but if oily, they are rendered more distinct.   The width of the cylinder is of some importance, as 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.
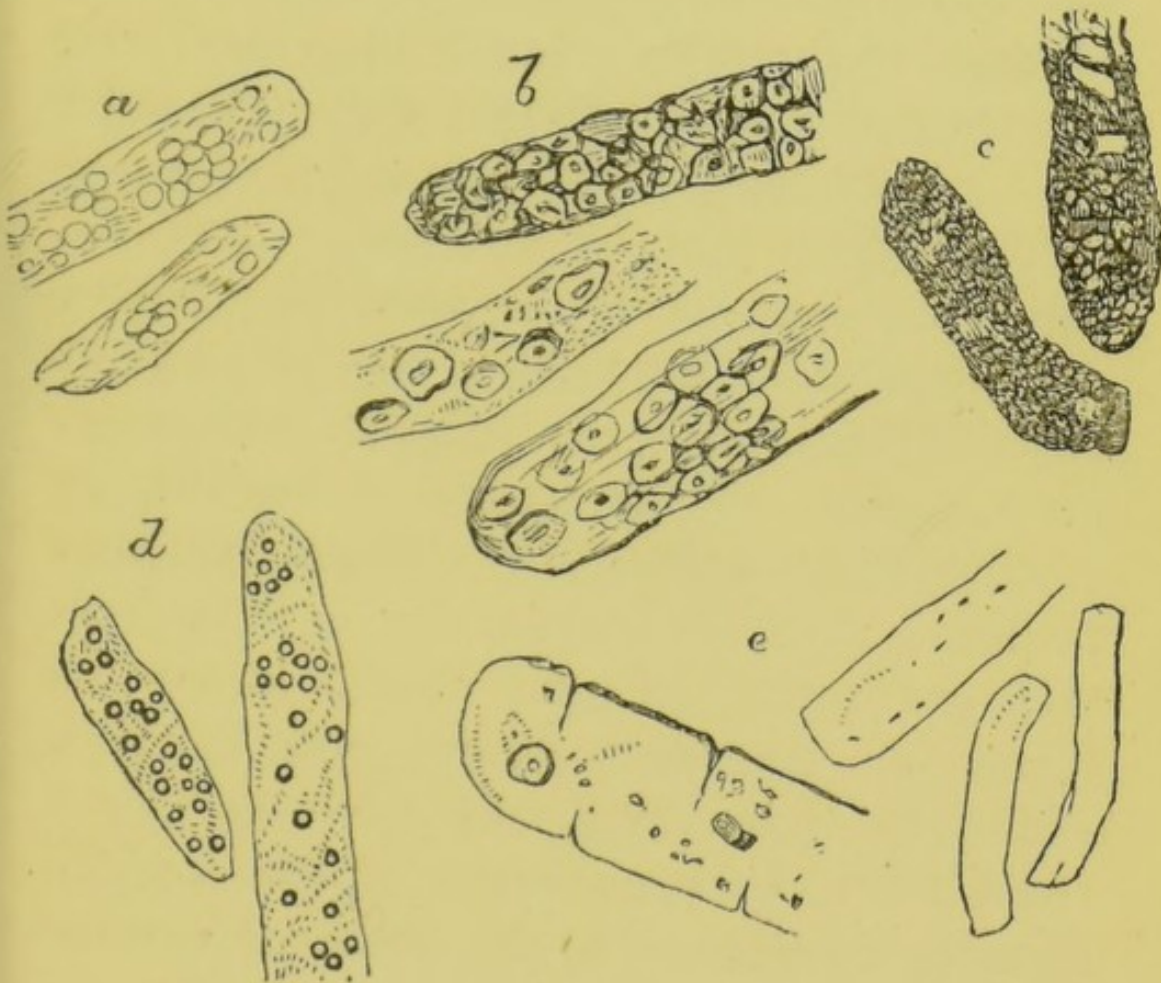
FIG. 17.—*a*. Blood casts. *b*. Epithelial casts. *c*. Granular casts. *d*. Fatty casts. *e*. Hyaline casts.

From later observations on the varying diameters of the uriniferous tubes, the importance of the breadth of the cast becomes less.

Clinical Import. The presence of casts in the urine is a sure sign of disease of the kidney, but not, however, necessarily of permanent disease of the kidney. They are present in many acute diseases, accompanied by albumen in the urine; but if they are found for several weeks together after all fever have left the patient, then permanent disease of the kidney may be inferred. Casts are constantly present in the urine in all cases of congestion of the kidney, and of acute or chronic Bright's disease. But no certain information as to the nature of the disease existing in the kidney, for example, whether lardaceous or otherwise, can be had from the characters of the casts, since all forms of Bright's disease end in fatty changes. Some help may, however, be derived from the appearance of the casts in forming a judgment of the acute or chronic character, or a prognosis, of the disease. If, for example, there be found in the urine epithelial casts which have undergone little, or no, granular change, and casts studded with red blood corpuscles, together with a large quantity of epithelium from the tubules of the kidney, having a natural or only

slightly clouded appearance, there can be little doubt that the patient is suffering from an acute attack of Bright's disease ; while if the casts be chiefly fatty, or intensely granular, and the epithelium be small in amount, and the cells withered and contracted, or containing globules of oil, it will be more than probable that the case is one of chronic Bright's disease.

Since little trust can be put in the characters of the casts as an aid to special diagnosis, some of the leading characters of the renal derivatives in the chief forms of kidney affection will now be spoken of more at length.

Congestion of the Kidney. The casts are chiefly hyaline, seldom showing any marks of fatty change. Very rarely may blood or epithelial casts be discovered.

Acute Bright's Disease. At the beginning, the urine deposits a sediment which consists of blood-corpuscles, narrow hyaline casts, and casts covered with blood corpuscles, the "blood cast" of some authors. In the next stage, the amount of blood present is not so great, but a great desquamation of the renal tubules taking place, renal epithelium and

epithelial casts are found in great numbers; the epithelium has undergone little, if any, granular change; hyaline casts are observed together with epithelial. In the next stage, the changes in the epithelium may be almost daily observed; at first they become granular, cloudy in appearance, which change often goes on to fatty degeneration, and the epithelial cells then contain large fat drops, while the epithelial casts undergo a like change, and become distinctly granular and even fatty.

If the patient recover, the casts and epithelium slowly disappear from the urine, but if the case become chronic, the renal derivatives show the characters described in the next paragraph.

Chronic Bright's Disease. Numerous forms of casts are met with; the hyaline, both narrow and wide forms; the larger are often beset with granules dissolved on the addition of acetic acid; the granular, whose surface is often covered with fatty or shrivelled-up epithelium cells; fat drops may stud the cylinder. Epithelial casts are rare, except in febrile exacerbations, when the renal derivatives found in acute Bright's disease are

present, together with granular and fatty casts, evidence of the previous alteration of the kidney.

Lardaceous or Amyloid Kidney. The urinary deposit contains hyaline casts, which sometimes give the amyloid reaction, and which are often accompanied by pus corpuscles. Atrophied epithelial cells, becoming fatty in the latter stages of the disease, are almost invariably present.

MICRO-ORGANISMS.

Many kinds of organisms form in the urine after it has been voided for some time, and when the ammoniacal decomposition has begun, or is about to begin. The most important are (*a*) *micrococci, bacteria.* Their origin has been warmly contested, but it cannot yet be said that any source save that of *omne ovum ex ovo* is proved. When found in freshly passed urine, they are often due to the introduction into the bladder of catheters

imperfectly cleansed.   In other cases, where introduction into the bladder from without can be excluded, their presence has been explained by supposing that they had passed from the blood into the urine, and this may happen to those who are in perfect health.   They will be often known by their incessant motion;   but care must be taken not to confound with bacteria inorganic particles showing the molecular movement. They show the various forms of bacteria, chiefly the linear, and need a high power of the microscope to recognise them ; (*b*) the *penicillium glaucum*, the fungus which forms ' mildew,' and which often appears when the acid fermentation has begun ; (*c*) the yeast fungus, *torula cerevisiæ*, or *saccharomyces urinæ*, oval cells about the size of a blood-corpuscle, joined together in a row, considered by Dr. Hassall to be diagnostic of diabetes ; (*d*) *sarcinæ* are apparently formed in the urine before it be voided ; they are square bodies, divided into secondary squares, which number 4, 16, 64, &c., and are like 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 a few days. It appears to consist chiefly of the mould fungus, globules of fat, and crystals of phosphates. Formerly it was thought to be a sign of pregnancy; but is is seen in the urine of men, and it is not always present in pregnancy.

SPERMATOZOA.

These little bodies are present in urine of men first passed after an emission of semen. A few pass away in the urine, probably, without venereal excitement, especially when the person is continent. In the urine of women, they are almost positive proof of sexual intercourse.

The seminal secretion forms a glairy white deposit at the bottom of the urine glass. When examined with the microscope, (for which a high power, magnifying 400 or 500 diameters, is best, although a power of 250 will identify them,) spermatozoa show the characteristic oval head or body often somewhat pear-shaped, and 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 short account of the method of estimating the chief substances found in the urine, since the clinical clerk may often be desired to make an analysis of the urea, chlorides, phosphates, &c. No account of the method of making standard solutions will be given, as this preparation requires a greater knowledge of chemistry than is usually possessed by the clinical student. For the same reason, no details have been introduced which require the use of a balance.

The metric weights and measures only will be employed: they are :—

The litre, the unit for measures of capacity $= 1 \cdot 76$ pints.

The cubic centimeter, (C.C.) the $\frac{1}{1000}$ 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, $= 15 \cdot 43$ English grains.

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

The apparatus required will be :—

A measure of litre capacity, divided into parts containing 10 C.C. at least.

Burettes, divided into quarters of a C.C.

Pipettes, which deliver 5, 10, 15, 20, 30 and 50 C.C.

Beakers, Berlin dishes, stirring rods, &c.

GENERAL DIRECTIONS.

The whole of the urine passed in the 24 hours must be obtained : 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 kept, 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 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 used in 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., is heated in a Berlin dish, the bottom of which is protected by a piece of iron wire gauze, over a small, naked flame, to nearly the boiling point. If the albumen do not separate in flakes, dilute acetic acid is *very* carefully added until the acid reaction be marked. If too much acetic acid be added, part of the albumen may be redissolved. The heat must be moderate and only just rise to boiling point, or the urea will be decomposed. The urine, after cooling, is then to be filtered into the same measure that was used in the beginning to ascertain the volume (100 or 200 C.C.) the dish and filter washed with small quantities of distilled water, which are added to the filtrate, until the urine stand at exactly 100 or 200 C.C. according to the initial quantity. This fluid is then used in the esti-

mation of the urea, chlorides, phosphates, sugar, &c.

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ESTIMATION OF UREA.

There are two methods now commonly in use for the estimation of urea: one, lately introduced by Dr. Russell and Dr. Samuel West; the other a method first employed by Liebig and known by his name.

In both of these it is necessary to ascertain beforehand the presence or absence of albumen. If albumen be present, it must be separated by the method given on the page above. If the urine be free from albumen, both the methods may be used without further preparation of the urine.

The first process, a modification of Hüfner's, is based upon the fact that when urea is acted on by an alkaline hypobromite, nitrogen is given off, and this nitrogen, when collected and measured, gives an estimation of the urea decomposed.

The hypobromite solution used in this process is made by dissolving 100 grammes of common solid caustic soda in 250 C.C. of

water and then gradually adding 25 C.C. of bromine. The solution may be had of any manufacturing chemist, but it must be quite freshly prepared.

The apparatus* necessary is figured in the
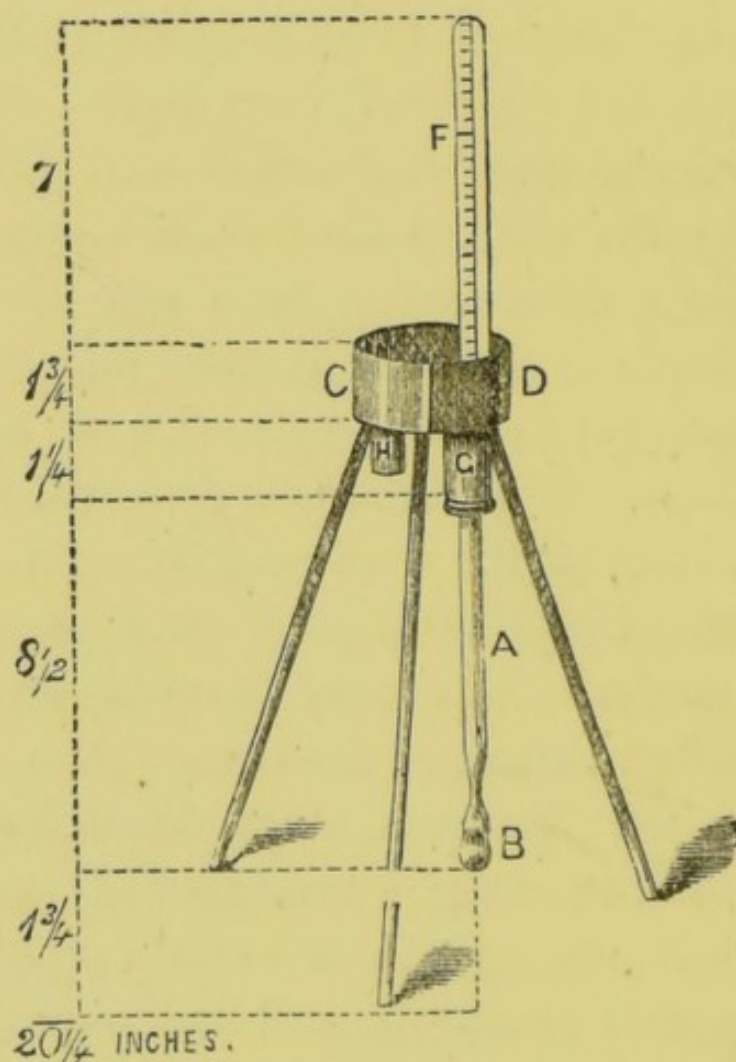
FIG. 18.

adjoining woodcut. It consists of the tube A, which is about nine inches long, nar-

* It may be had of Cetti, Brooke Street, Holborn.

rowed somewhat before the closed end
be reached, which end is blown out into
a bulb, B. The free end is fitted by means
of an india-rubber cork into the hole G
at the bottom of the trough C D which
stands on three legs. When an estimation
is to be made, 5 C.C. of urine are measured
off with a pipette and allowed to run down
the side of the tube A, into the bulb B. Dis-
tilled water is then added by means of a
wash-bottle, to wash away the urine adher-
ing to the sides of the tube, but in quantity
enough only to fill up the bulb as high as the
constriction, or a very little above it. A
glass rod tipped with india rubber is then
introduced into the tube, A, so that the india
rubber fills up the constriction and acts as a
cork. Care must be taken that no air bub-
bles are present below the constriction. The
hypobromite solution is then poured into the
tube until it be quite full: and the trough
filled with common water. The graduated
tube F, is then filled with water, the thumb
slipped over it, so that it contains no air
bubbles, and then inverted in the trough.
The glass rod tipped with india rubber is
withdrawn, and the graduated tube, F, im-

mediately slipped over the mouth of the tube
A. The mouth of this should project well
up into the tube F, so as to prevent the
escape of any of the gas. The reaction
begins immediately, but in order to bring
it to an end as quickly as possible, the bulb
should be heated by a spirit lamp or Bun-
sen's burner, till the bulb be hot to the hand.
In five minutes the amount of gas may be
read off. After some hours the gas is les-
sened in quantity; it is thus important to
read it off as soon as the reaction is over.
The amount of gas measured by the divisions
on the tube gives the percentage of the urea
in the specimen of urine examined.

The estimation of the total amount of urea
excreted in the twenty-four hours is now easy.
All that is to be done is to multiply the total
number of cubic centimeters of urine passed
in the twenty-four hours by the figures read
off on the measured tube. Thus if the
amount of urine passed in twenty-four hours
be 1770 C.C. and the number on the tube
read off 1·8 it is only necessary to multiply
1770 by 18 to get the amount of urea in
milligrammes. In this case it will be 31860
milligrammes, and since 1000 milligrammes

equal one gramme, the total amount of urea passed will be 31·86 grammes.

If the urine contain more than two *per cent.* of urea, the urine must be diluted with an equal bulk of distilled water, and the results doubled.

This method seems likely to be of great value in clinical research, for it may readily be used in the wards of a hospital.

The following method is that described by Liebig.

The solutions required are :—

> A standard solution of nitrate of mercury, of which 1 C.C. corresponds exactly to 10 milligrammes of urea.

> A solution of baryta, made by mixing two volumes of cold saturated solution of caustic baryta, with one volume of cold saturated solution of nitrate of baryta.

> A saturated solution of carbonate of soda.

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

solution which is then added to the urine previously measured off. There are thus two volumes of urea to one of baryta solution. The mixture of the urine and baryta is then passed through filtering paper; a drop or two of the filtrate is to be tested with the baryta solution to see if any precipitate occur, and if any precipitate do occur, it is best to take a fresh quantity of urine and to add an *equal* volume of baryta solution; after filtration, this must again be tested. The object of the addition of the baryta is to remove the phosphates from the urine.

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 solution 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 solution 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 standard 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 be exactly on a level with the first division of the burette. Care must be taken that the solution fills the whole of the apparatus below the pinch-cock, and that no air bubbles are there contained : for if the latter rise to the surface during the analysis, the estimation is, of course, worthless.

The measured quantity of the filtrate of the urine and baryta is then to be placed in a small glass vessel, a beaker holding about 100 C.C. being best ; a few drops of dilute nitric acid are to be added and the vessel placed under the burette.* The work of

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* A great saving of time may be effected by making two separate estimations ; in the first estimation, at once adding 15 C.C. of the mercury solution to the fluid in the beaker, testing this with the soda, and then adding the mercury solution in 5 C.C. at a time, and testing with soda after each addition, until a yellow colour is produced. The exact point for the estimation of the urea is found to be between 15 and 20 C.C. or 20 and 25 C.C., as the case may be. A second estimation

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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 be produced : the absence, at first, of a permanent precipitate is caused by the chlorides present; 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 give a yellow colour when brought into contact with solution of carbonate of soda.

The most convenient method of ascertain·ing the first appearance of the yellow colour is to place a small glass disc on a piece of black paper, with a few drops of saturated solution of carbonate of soda spread over it; and to let fall as small drop as possible of the fluid from the beaker into the margin of the soda solution. If no yellow colour be

is then made, and mercury solution to the amount of the smallest number of C.C. *before* the yellow colour was produced, is at once allowed to flow into the beaker, and then added more carefully by quarters or halves of a C.C. as described in the text.

seen, another half C.C. of the mercury solution must be added, and the fluid from the beaker again tested with the soda, and the mercury solution must be added, until the least appearance of yellow occur, when one drop more of the mercury solution must be added to the beaker, the fluid well stirred about, and another small drop taken from the mixture and tested with the soda, when if the process have been rightly performed, an increase in the yellow colour will be perceived. Great care must be taken during the whole of these operations, not to lose one single drop of the fluid from either the beaker or burette. 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 now appear, 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 appear 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 pre-

cipitate was produced, and the remainder multiplied by 10 gives the number of milligrammes of urea contained in 10 C.C. of urine, because 1 C.C. of the mercury solution corresponds to 10 milligrammes of urea.

Thus far the amount of urea contained in 10 C.C. of urine as been ascertained; by simple proportion it is easy to find the quantity passed in the twenty-four hours. For example, suppose that 1 C.C. of the mercury solution were 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. subtracted from 19 C.C. leaves 18, which multiplied by 10 gives 180 milligrammes of urea in 10 C.C. of urine. Suppose that the patient had passed 1770 C.C. of urine in the twenty-four hours, then the calculation would be as follows :

$$10 : 1770 : : 180 : 31860$$
$$180$$

$$10) \overline{318600}$$

$$\overline{31860 \text{ milligrammes.}}$$

As 1000 milligrammes equal 1 gramme, 31860 milligrammes equal 31·860 grammes.

ESTIMATION OF CHLORIDES.

The solutions required are :

A standard solution of nitrate of silver, of which 1 C.C. corresponds exactly to 10 milligrammes of chloride of sodium.

A 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 92. 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 standard solution of nitrate of silver, and the precautions as to filling burettes, described in speaking of the estimation of urea (p. 98) must be observed. The silver solution must then be allowed to fall into the beaker, and each drop well mixed with the urine by means of a glass rod. As each drop falls into the urine, it must be carefully

watched for the least tinge of red surrounding the precipitate of chloride of silver. This reddish colour announces the approaching termination of the process, and is at first not permanent, but disappears when the fluid in the beaker is well stirred. The first drop, however, which produces a reddish tinge not disappearing by agitation, indicates that the whole of the chloride present has been precipitated, and that chromate of silver is beginning to be formed. The quantity of silver solution used is now read off, and another drop let fall into the beaker from the burette, when the reddish colour ought to be heightened. From the number of C.C. used, the quantity of chloride is calculated; for, since 1 C.C. of the silver solution corresponds to 10 milligrammes of chloride of sodium, the number of C.C. of the silver solution used, multiplied by 10, will give the amount in milligrammes of the chloride of sodium present in 10 C.C. of urine. Thus if 6 C.C. of silver solution were used before a permanent reddish precipitate was produced, 10 C.C. of urine will contain 60 milligrammes of chloride of sodium : and if the patient passed 1200 C.C. of urine in the twenty-four

hours, the amount of chloride passed can be easily calculated in the following way:

10 : 1200 : : 60 : 7200.

7200 milligrammes equal 7·2 grammes which will be the total quantity passed in the twenty-four hours.

This process, as applied to urine, nearly always gives a result a little above the real amount present.

For greater accuracy, therefore 10 C.C. of the urine are measured off into a porcelain crucible, 1 or 2 grammes of nitrate of potash free from chlorides, are dissolved in it, and the whole slowly evaporated to dryness, and exposed to a low red heat, until the carbon be completely oxydised, and the contents of the crucible white. After cooling, these are dissolved in distilled water, a few drops of nitric acid added until a faintly acid reaction be produced, a small quantity of carbonate of lime being then added in order to make the solution again neutral, the solution filtered, and the chlorides then estimated in the manner described above.

ESTIMATION OF PHOSPHATES.

The solutions required are:

A standard solution of acetate of uranium, of which 1 C.C. corresponds exactly to 5 milligrammes of phosphoric acid.

A 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 equal 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 C.C. of the solution of acetic acid and acetate of soda. The beaker is placed over a water bath, and when the mixture is well warmed, the standard uranium solution is dropped into the beaker until precipitation cease; this can easily be ascertained 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 be produced at their line of meeting, more of the uranium solution must be added to the urine, until a drop tested with the solution of ferrocyanide of potassium, produce a light brown colour where the two fluids meet. The number of C.C. of the uranium solution that have 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, no increase in the intensity of the colour be produced, the process may be regarded as completed; but if a dark brown colour be produced by this second trial, too much uranium solution has been added and the estimation must be begun again with another 50 C.C. of urine.

The calculation for the amount of phosphoric acid passed in twenty-four hours is now easy.

1 C.C. of uranium solution equals 5 milligrammes of phosphoric acid. So that, if 15 C.C. of the uranium solution have been used, 50 C.C. of the urine will contain 75 milli-

grammes of phosphoric acid, and if the patient have passed 1500 C.C. in the twenty-four hours, the calculation will be :

$$50 : 1500 : : 75 : 2250$$

$$\frac{75}{50)112500}$$

2250 milligrammes.

2250 milligrammes equal 2·25 grammes, which will be the quantity of phosphoric acid passed in the twenty-four hours.

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ESTIMATION OF ALBUMEN.

No easy, rapid, and trustworthy method of estimating 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 observations.

A fairly good method for clinical observa-

tion is the estimation by means of the polari-scope. It is necessary to have the urine moderately transparent, and free from blood-corpuscles, sugar, and bile acids, to obtain results which are tolerably accurate. If the turbidity be persistent after filtration, a few drops of acetic acid, or a little carbonate of soda or milk of lime added to the urine before filtration may remove the turbidity. For the method of using the polariscope,

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. A patient may pass 2 to 20 grms. of albumen in the twenty-four hours. This latter amount is extreme.

ESTIMATION OF SUGAR.

There are two methods of estimating the amount of sugar present in diabetic urine, one by volumetric analysis, the other by means of the polariscope.

Volumetric Method. A standard copper solution is required, containing sulphate of copper, neutral tartrate of soda or potash, and caustic solution of soda 20 C.C. of which 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 if the copper solution remain undecomposed : it may be used in the analysis, if, after boiling some portion in a test-tube, and setting it aside for an hour, no precipitate of copper oxyde have fallen. 20 C.C. of the copper solution are then measured off with a pipette, allowed to flow into a glass flask, and 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 measure 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 boiling begin; 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 have lost its colour, or be 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 colour must be noticed and if it be still blue, the operation should be repeated until the colour of the fluid have become yellow. The analysis is not yet, however, completed. The fluid 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 an orange-red precipitate of suboxide of copper be produced: to the second test-tube a small quantity of hydrochloric acid is then 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 occur, too much urine has been

added; if, in either of the two last-mentioned test-tubes, a precipitate occur, not enough o 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 copper solution will be accomplished by exactly 100 milligrammes of sugar. If therefore, for the 20 C.C. of copper, 15·5 C.C. of the dilute 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 grms. of sugar; as by proportion:

$$1\cdot55 : 100 : : 100 : 6450.$$

If the urine contain albumen as well as sugar, the former must be removed as directed at page 92.

Estimation by means of the Polariscope. By means of this instrument an estimation of the sugar present can be made, provided that the urine be moderately transparent. 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 92. The bile acids when present, can scarcely effect the result, since they are found in such very small amount in the urine.

The polariscope consists of a tube, supported upon a foot, and divided into three parts, one of which, the middle, is moveable, but the other two, which are at the ends of the instrument, are fixed. One of the fixed tubes is furnished with a small screw, attached to its lower surface; this may be called the eye-piece. The other fixed tube has no screw attached to it; it may be called the object-glass.

A good argand burner, sodium flame, or a gas lamp, protected by a neutral tinted glass cylinder, is necessary. When the polariscope is to be used the lamp is placed an inch or so in front of the object-glass. The hollow glass tube in the middle of the instrument must now be removed, and filled with distilled water; the small glass disc being slid over the end of the tube completely filled with water, in such a manner that no air-bubble is included in the tube; the metal

cover to keep the glass disc in its place is then attached to the tube, and the tube, freed carefully from all moisture. The tube is now set in its place in the middle of the instrument; and the observer, looking through the eye-piece, draws out, or pushes in, the moveable tube close to the eye, until he see at the end of the eye-piece, nearer to the lamp, a circular field divided into two equal parts by a black line, which ought to be sufficiently well defined. He next turns the screw attached to the under surface of the eye-piece to the right or left as may be required, until the colour of the two halves of the field be exactly the same. The observer then notices whether the zeroes on the scale above the eye-piece be exactly opposite to each other. If they be not, the little button at the end of the scale should be gently turned, until they quite coincide.

Before adjusting the instrument, the urine may be set aside to filter, or to pass through animal charcoal, if that be at hand. If the fluid be as free from colour as ordinary diabetic urine, it may be observed in the longer tube, 20 centimeters in length, since the accuracy of the estimation is increased with the

length of the tube. But if the fluid be dark, the shorter tube, 10 centimeters long, must be used.

The tube is now filled with the urine, in the same manner as it was previously filled with distilled water, and again placed in the middle of the instrument. The observer then notices if any alteration in colour of the two halves of the field have taken place. If the uniformity of colour no longer exist, he should turn the screw below the eye-piece until the two halves of the field appear of precisely the same tint. The eyes are best rested occasionally during this part of the operation by looking on some white surface, as the ceiling of the room, or a sheet of paper. When the two semi-circles become exactly the same in colour, the number of degrees which the moveable zero is distant from the fixed zero is read off; and if the fluid observed contain sugar, the moveable scale will be found to the right; but if albumen only, to the left. The number of degrees that the zero has moved gives when divided by 2, the percentage amount of either sugar or albumen, if the longer tube were used; but the percentage is at once

known, if the shorter tube were employed, as it is the same in amount with the number of degrees by which two zeroes are separated from each other.

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