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THE EXAMINATION OF THE URINE

By J. K. WATSON, M.D.

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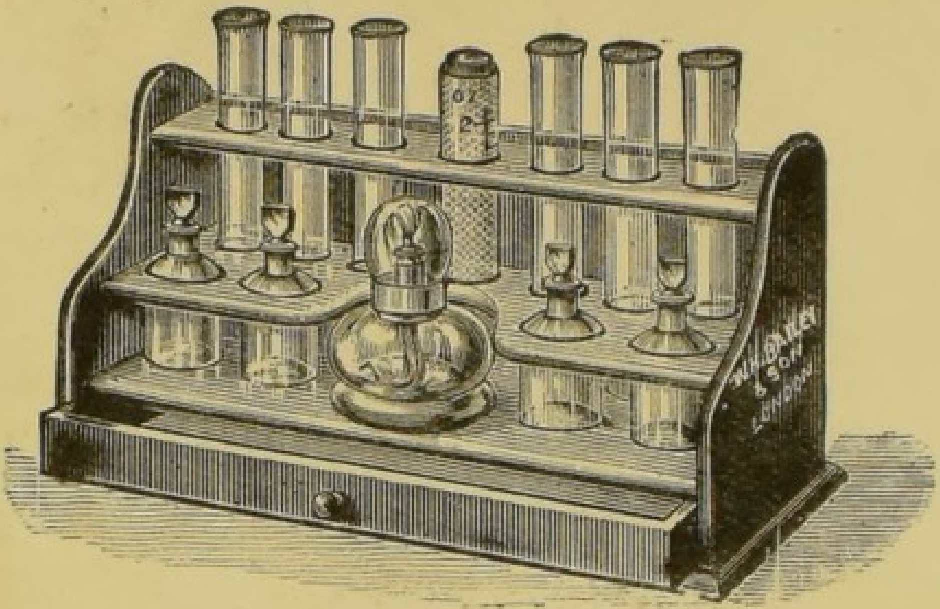

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THE EXAMINATION
OF
THE URINE

BY

J. K. WATSON, M.D. Edin., M.B., C.M.
Author of A "Handbook for Nurses"

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INTRODUCTION.

THIS little work is an elaboration of the parts of my handbook for nurses dealing with the examination of urine and kindred subjects, which I hope will prove a useful addition to the nurses' bookshelf. I consider that before the nurse actually undertakes to examine the urine she should have an elementary working knowledge of the organs which are concerned in its excretion and passage, and also of the urine itself, both in health and disease. I have therefore divided the subject into three parts, and before the nurse studies Part III. she should be well acquainted with Parts I. and II.

J. K. W

Byfleet, Surrey.

CONTENTS.

THE
URINE AND ITS EXAMINATION.

PART I.

THE examination of the urine is not of necessity required of the nurse, but it is advisable that she should have an elementary knowledge of urine testing, since she can often put such knowledge to use and assist thereby the doctors under whom she is working. The subject, if considered in detail, is complex, and all that is now attempted is to discuss it in its more important and practical bearings. In the first place a few physiological and anatomical details will not be out of place. There is a constant wear and tear going on in our bodies, and this requires that waste material shall be removed. The organs concerned in this process are the kidneys, the skin, and the lungs. The chief waste materials of the body may be classified as follows:—(1) A substance called urea, which represents a large proportion of the food stuffs, which have been transformed into it in their passage through the body. (2) Carbonic acid, which leaves the body in the expired air. (3) Various salts, and (4) water. The urea is nearly all discharged by the kidneys. The salts are chiefly eliminated by the kidneys, to a slight degree by the skin, and the water leaves the body by all three channels, but chiefly by the kidneys.

It will be seen, then, that the kidneys are the most important organs for the removal of waste material, or, as we commonly say, excretory organs. (For diagram see p. 17.)

The urinary apparatus consists of the two kidneys, right and left, their respective ducts, the ureters, the bladder, or reservoir where the urine is stored, and the outlet of the bladder, the urethra, which ends in an aperture, the meatus. The kidneys lie on the posterior wall of the abdomen, in the loin, behind the peritoneum, which lines the abdominal cavity and covers, to a large extent, its contents. This is of importance to the surgeon who is able to reach the kidneys from behind without interfering with the peritoneum. Their shape is so well known that we are accustomed to use the term kidney-shaped as a descriptive one. They are surrounded by a varying quantity of fat. Their length is about four inches and they weigh about four and a-half ounces. The inner or concave edge of the organs contains a depression called the hilum. Here the ureter leaves the kidney and the blood-vessels and nerves pass into and out of the organ. The kidneys are covered with a tunic, the capsule, which, in the healthy organ, can be stripped off, but in disease of the kidney it may be difficult or impossible to remove it. The essential structure of the kidney, the secreting part, consists of a complicated system of tubules and tufts. The former communicate with a cavity, called the pelvis (Latin pelvis, a basin) of the kidney, which gives origin to the ureter. This cavity may indeed be regarded as the upper, swollen, or dilated end of the ureter.

Sometimes it becomes enormously distended, at the expense of the kidney substance. Such a condition is liable to occur when the ureter becomes blocked, as may occasionally happen from the impaction of a stone (calculus) in its interior, and the urine is dammed back in the kidney. The urine which is poured out by the tubules is collected in the pelvis of the kidney, to be discharged by the ureter into the bladder. The ureters pass down obliquely to enter the back wall of the bladder, one on each side, by a valvular opening. These openings are only about two inches apart, and are so arranged as to prevent a reflux of the urine. The ureters are about sixteen inches long and their diameter is that of a goose-quill. Their position is of great importance to the surgeon in connection with certain operations, especially on the uterus (womb), as they may be easily damaged. The bladder varies in shape according to its degree of distension; when moderately full it is rounded, but it becomes more ovoid in shape when it is fully distended. In the adult the bladder lies in the pelvis in front of the rectum and behind the pubic bones. In the female the uterus is placed between the bladder in front and the rectum behind. When the bladder becomes very full it rises up out of the pelvis, and may even reach up to the umbilicus in cases of retention of urine, where the urine, for one reason or another, cannot be passed. Such a condition as this (retention of urine) must be distinguished from suppression of urine, where there is no urine secreted at all. The bladder may be said to hold, in the adult, about a pint of urine, but its capacity varies very greatly. The urine passes down into the bladder partly by the action of gravity, and partly by muscular contractions taking place in the walls of the ureter, similar to those which take place in the walls of the intestine (peristalsis). It is evacuated by a complex mechanism, which is usually under our control, but under certain conditions may act involuntarily.

The urethra is situated at the lower and front part of the bladder, and differs in its anatomical relations in the two sexes.

PART II.

Having now briefly described the urinary apparatus we next pass to a description of the urine, but before doing so it will be well to refer to the function of the kidneys. How do they produce the urine? The urine is secreted in virtue of two conditions, namely, a mechanical one and a vital or selective one. The tufts, to which we have referred, are collections of capillaries surrounded by a capsule, and these act largely as filters, through which the watery part of the urine, together with a small part of the solids passes under a varying degree of pressure. The more important part of the secretion of urine, however, is that which occurs in the tubules; for these have the power to select and to refuse the solid constituents of the urine. Thus their action becomes a vital one, and this selective action is performed by their lining membrane, which consists of a special (glandular) form of epithelium. This epithelium will be referred to later on when we come to speak of abnormal constituents of the urine. Suffice it to say that on its power of performing this selective task efficiently depends, in large measure, the healthy condition of the urine and of the body generally.

Description of the Urine.

We shall describe the urine under certain heads, pointing out in each case some of the variations which are commonly met with both in health and disease :—

I. *Quantity.*—This varies with the quantity of liquid drunk, also with the temperature; for, when the skin acts freely, as it does in warm weather, less water leaves the body by the kidneys and vice versâ. The average quantity passed in the 24 hours is 50 ounces, but the limits in health may be said to range from 35 to 60 ounces. Less urine is usually secreted during sleep. Children, of course, pass less urine than adults, but after the age of 15 the amount passed is much the same as in adults. Nurses should, in estimating the quantity of urine passed in the 24 hours, keep a separate record of the "day urine" and "night urine" and add these together to get the sum for the 24 hours.

When the "night urine" approaches to or equals in quantity the "day urine" an abnormal state of affairs exists, and such a symptom calls for investigation. For instance, this may be an early sign of chronic kidney disease. It is often difficult or impossible to collect all the urine voided, especially in children, and in cases where great accuracy is of importance a catheter must be used.

In the various fevers the urine is diminished in quantity, also in acute inflammation of the kidneys (acute nephritis) and in cases characterised by profuse diarrhœa or perspiration where most of the water leaves the body by the bowels and the skin respectively. Heart disease, too, may cause a diminution in the quantity by lowering the pressure under which the urine is secreted. In cases of great prostration and collapse, such as occur in cholera and severe head injuries, the kidneys may fail to secrete any urine (suppression of urine). The same may occur, too, in long standing kidney disease where both kidneys are extensively diseased.

The quantity is increased in the two forms of diabetes—

the one form (diabetes insipidus) being characterised merely by the regular passage of a very large quantity of urine in the 24 hours, and the other (diabetes mellitus) by, in addition, a varying amount of sugar in the urine. The earlier stages of chronic kidney disease cause an increased quantity, and some diseases of the nervous system, notably hysteria. Drugs which act more especially in promoting a flow of urine (diuretics) have also the same effect.

II. *Colour.*—This is due chiefly to two pigments, urochrome and urobilin, especially the former. It varies from pale yellow to darkish brown, even in health, and we may thus classify urines as to their colour, as (*a*) pale; (*b*) normal coloured, and (*c*) high coloured. As a rule, the greater the amount of urine passed the paler is the colour and the smaller is the amount of solids in solution, and vice versâ; thus we are accustomed to look for pale urine in cases of diabetes and hysteria and for high coloured urine in fever. The urine may be altered in colour from the presence of bile, as in the case of jaundice, blood and various pigments other than those we have mentioned. Several drugs, too, colour the urine; for instance, carbolic acid, which produces an olive-green tint, santonin and rhubarb which increase the reddish tint.

III. *Transparency.*—Healthy urine is nearly always clear when passed, but soon a cloud of mucus forms which causes a slight turbidity. The transparency may be impaired or lost in various conditions as when the urine contains mucus (excess of), phosphates, urates, blood, pus or albumin. The presence of oxalate of lime (oxaluria), too, causes a cloud in the upper part of the urine glass. The urine may thus be turbid under a variety of conditions.

IV. *Specific Gravity.*—By this, which is usually written as "sp. gr.," is meant the ratio between the weight of a given volume of urine and an equal volume of water, the latter being regarded as 1,000. It depends on the amount of solid matter in the urine, and varies from 1,015, or even less, to 1,025 in health. The average is 1,020. The specific gravity is taken by means of a urinometer, a glass apparatus weighted by mercury and having a graduated stem. Its use we shall describe when we speak of urine testing. Before drawing any conclusions from the specific gravity, we should ascertain the quantity of urine passed. In pale watery urine the specific gravity is generally low; when it is high in such a urine it is generally due to the presence of sugar. In concentrated high-coloured urine, the specific gravity is high from the large quantity of solids present. Albuminous urine has usually a low sp. gr.

V. *Reaction.*—Healthy urine has usually an acid reaction, but after a meal it may be alkaline. After it is passed, urine generally undergoes a change in its reaction, at first becoming more acid, but finally becoming alkaline. These changes are due to fermentation set up by micro-organisms. But urine may be alkaline in its reaction constantly, and the most common cause of this is inflammation of the bladder (cystitis), and is very apt to arise in such cases from the use of a dirty catheter, and it also occurs in some forms of paralysis.

VI. *Odour.*—Healthy urine has a slight characteristic odour. Alkaline urine has very often a smell of ammonia, which is, as we have said, due to alkaline fermentation, whereby the urea is transformed into carbonate of ammonia.

The urine under such conditions is termed ammoniacal, and it is usually very offensive. In diabetes mellitus the sugar gives to the urine a sweetish smell, said to resemble the odour of apples or of new-mown hay.

The presence of acetone in the urine also produces a fruity smell. Certain drugs, such as turpentine and cubebs, produce a characteristic odour, the former causing an odour of violets. Asparagus, too, produces a peculiar odour in the urine after it has been eaten.

VII. *Deposit.*—There is seldom any deposit in healthy urine, although a brick-red sediment, signifying the presence of urates, sometimes occurs in cold weather, especially after prolonged exercise, which cannot then be considered abnormal. The cloud of mucus which we have mentioned, may come to form a deposit. Phosphates are sometimes deposited in the urine. This usually signifies insufficient exercise with sedentary occupation, a febrile condition, nervous exhaustion or actual disease of the nervous system. Urates or, as they are sometimes termed, lithates,[1] are only deposited on cooling of the urine. When passed, the urine is clear. Gastric derangements, great exertion and fever are responsible for their deposit. They are of little consequence unless they persist. Uric acid may be deposited as a "cayenne-pepper" sediment. Pus may be deposited either as pure pus or mixed with mucus (muco-pus). It resembles phosphates at first sight, but on tilting the glass the phosphatic deposit is not so compact and, being more easily separated, tends to float up from the bottom of the glass.

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[1] Greek lithos, a stone.

VIII. *The Solid Constituents of the Urine.*—We now pass to consider the composition of the urine, first referring to the normal and afterwards to the abnormal constituents. The daily average amount of solids passed in the urine is usually stated to be 950 grains, or, if we use the metric system about 60 grammes (1 gramme = about $15\frac{1}{2}$ grains). A useful and fairly accurate way to determine the solids is to take the specific gravity and multiply the last two figures by the number of ounces passed in the 24 hours, and then to multiply the result by $1\frac{1}{10}$ or, using decimals, by 1·1. The following will serve as an example:—A man passes 46 ounces of urine in the 24 hours having a specific gravity of 1018. How much solids does he pass in the urine in 24 hours? Applying our formula we get $46 \times 18 \times 1{\cdot}1 = 910{\cdot}8$ grains, which amounts to just over two ounces. Such a method is not applicable to urine containing albumin or sugar or other abnormal ingredients. There are a considerable number of solids in the urine, which we may divide into organic and inorganic, the former being derived from the animal and vegetable worlds the latter from the mineral world. The most important constituent of all and that which represents the chief waste matter of the body is a substance called urea. It represents about one-half of the total solids of the urine and about 500 grains are excreted daily. Urea is very soluble. It is found in the blood and in nearly every tissue of the body, from which it is extracted by the kidneys. The more nitrogenous, that is to say animal, food we eat the more urea do the kidneys remove from the body up to a certain point. But even when no nitrogenous food is taken, some urea is excreted in the urine; this shows us that the urea is derived from the waste that goes on in the tissues as well as from the food. The quantity of urea is affected by disease; in fevers and in diabetes mellitus it is increased in amount, in the various forms of Bright's disease it is diminished. We have already mentioned the pigments of the urine which must be included in the organic constituents. The only other organic solid requiring mention is uric acid, which does not usually occur in normal urine as the free acid, but is combined with potash, soda and ammonia to form salts known as urates. About ten grains (or one-fiftieth of the amount of urea) leave the body daily on an average. The chief inorganic constituents of the urine, in addition, of course, to water, are chlorides, sulphates, phosphates (which, as we have seen, may form a deposit), and, to a slight extent, oxalates.

1. The first of the abnormal constituents is albumin. The term albuminuria is used to express the presence of albumin in the urine. Albumin may occasionally be present in health (functional albuminuria); but, in nearly every instance, at any rate where it persists, it indicates a diseased condition. It is not easy to explain why, under certain conditions, albumin passes into the urine, but, probably, in the vast number of cases it is due to the lining (epithelium) of the urinary tubules failing in their "selective" action, whereby water and various salts are allowed to pass the barrier, but other substances such as albumin are held back. Albumin most commonly occurs in the urine in acute and chronic kidney disease (Bright's disease), in certain forms of heart disease, especially when accompanied by dropsy, in certain fevers such as scarlet fever (in the later stages where the kidneys are apt to become affected), diphtheria, and in certain nervous and in some chronic general affections such as anæmia. It must be understood that albuminuria is not necessarily present in all these diseases; very often it is

absent, sometimes throughout the course of the illness, if we except cases of Bright's disease, in which the urine always contains albumin at some period of the illness. It will be well here to refer to what are known as tube casts which are often found in kidney disease. These may be regarded as moulds, more or less complete, which have been washed away from the walls of the inflamed tubes by the urine. These tube-casts are sometimes the only positive evidence of kidney disease. They can only be detected microscopically unless very numerous, when they may form a sediment at the bottom of the urine glass, which can be seen by the naked eye. The more important kinds of casts are epithelial, granular, hyaline (transparent and colourless), and blood, the last-named being due to blood, which has been poured out into the tubules, becoming coagulated.

2. The next abnormal ingredient is blood, its presence in the urine being signified by the term hæmaturia when all its ingredients are passed; when the pigment without the corpuscles is passed the term hæmoglobinuria is used. The former is by far the commoner condition. When blood or pus are present in the urine albumin in greater or less amount is necessarily present as blood and pus both contain albumin. When blood is in small amount it gives to the urine a peculiar opaque appearance which is generally described as "smoky"; in larger amount it produces a red colour depending for its intensity on the amount of blood present. Blood may be present in the urine as a result of a variety of conditions, and it may be derived from the kidney, the ureter, the bladder, or the urethra. In the last-named situation the blood is nearly always passed with the first part of the urine, the latter portion of the urine being free from blood. Blood derived from the kidney is usually well mixed

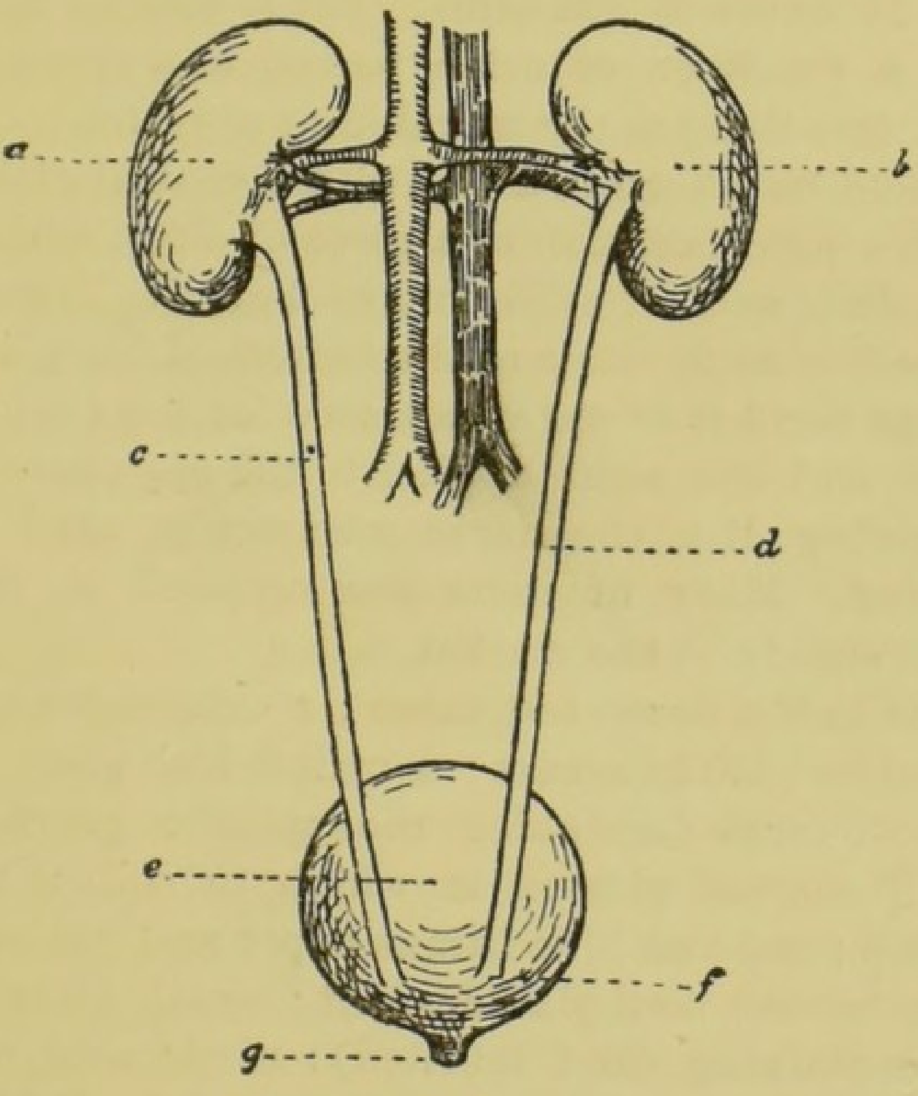
with the urine. If the blood is seen to be in long, thin cylindrical clots, it has probably come from the pelvis of the kidney, and has been moulded in its passage by the ureter.

3. *Sugar.*—We have already seen that sugar is present in the urine in cases of diabetes mellitus. The form of sugar which is passed is not, however, the cane sugar to which we are accustomed, but another kind of sugar named "glucose," "grape sugar," or "dextrose." The presence of sugar in the urine is generally referred to as glycosuria. It should be understood that although the presence of sugar in the urine in the large proportion of cases is due to diabetes mellitus, yet it is not always so due. In fact, very slight traces of glucose do occur in healthy urine, but so slight is the amount, that it cannot be detected by the tests which we shall describe (see Part III.). We must regard, therefore, the presence of sugar in the urine as due to a fault in the transformation of the food substances whereby sugar comes to circulate in the blood. The only part the kidneys play in this connection is that of removing this sugar from the blood through the medium of the urine.

4. Bile may be found in the urine. This substance is poured out by the liver and passes into the first part of the small intestine (duodenum). When, from any cause, bile circulates in the blood a condition known as jaundice arises, and bile is separated from the blood by the kidneys, and passes out in the urine. The colouring matter of the bile is known as bilirubin and it is this which gives to the urine in such cases its yellowish-brown colour. After standing, the bilirubin becomes changed to another substance called biliverdin, which produces a greenish tint. Bilious urine becomes frothy on shaking.

5. Pus in the urine has been mentioned when speaking of

deposits. It may occur in many conditions. The commonest are abscess of kidney or an abscess bursting into the urinary tract, inflammation of the bladder (cystitis), where it is generally combined with mucus (muco-pus), gonorrhœa, and leucorrhœa (in women), commonly called "white discharge" or "the whites."



URINARY ORGANS FROM BEHIND (*see page* 6).

(*a*) Left kidney. (*b*) Right kidney. (*c*) Left ureter. (*d*) Right ureter. (*e*) Urinary bladder. (*f*) Opening of ureter into bladder. (*g*) Opening of urethra.

PART III.

The Collection and Examination of the Urine.

There are certain points to be observed in the obtaining of a specimen. As a rule, a specimen taken from the mixed urine of 24 hours is examined; but it may be necessary to examine a specimen of urine passed at a special time, for instance, first thing in the morning or after food. The fresh urine should be placed in a tall, clean, conical glass, covered over with a porcelain slab or a piece of clean white paper to keep out dust, and set aside in a cool place. Time is allowed for any sediment to settle to the bottom of the glass. There are a large number of chemicals used for the examination of the urine, and the same applies to the apparatus used. In the following list the more commonly used ones are enumerated. Many of these are supplied in the various urine test stands on the market.

At least half a dozen test tubes; a urinometer with a stem graduated to 1060 in a case; a cylindrical glass to hold at least two ounces for taking the specific gravity; one or more tall conical glasses in which to collect the urine spirit lamp; red and blue litmus paper and yellow turmeric paper in books; methylated spirit; small glass stoppered bottles containing (and labelled): nitric acid, acetic acid, picric acid, liquor potassæ[1] (caustic soda); Fehling's solution "No. 1"; Fehling's solution "No. 2"; Pavy's solution (may be used *vice* Fehling's); sulphate of copper (1 per

[1] The bottle containing liquor potassæ should be green tinted.

cent. solution); ferrocyanide of potassium (5 per cent. solution); czonic ether; tincture of guaiacum; a pipette; a small glass funnel; a glass stirring rod; filter papers blotting paper; test tube holder; Esbach's albuminometer, and solution for same; Doremus's ureometer, and solution for same. All appliances can be obtained of a good surgical instrument maker.

I. The quantity passed in the 24 hours should, as a rule, be recorded, where this is possible.

II. Describe the colour.

III. Describe the appearance, for example, whether clear, thick, ropy, or frothy.

IV. Take the specific gravity (sp. gr.). Clean and dry the urinometer and the urine glass, and nearly fill the glass with the urine, removing any froth from the surface with blotting paper. Then gently lower the urinometer into the glass, taking care that it floats and does not touch the sides of the glass. Look through the fluid and read off the number on the stem of the urinometer at the level of the fluid. Confirm this result by pushing down the urinometer and allowing it to rise again, and, when it is steady, reading the number again. In cases where two ounces of urine are not available, add an equal quantity of water to the urine, or, if necessary, even three parts of water to one of urine. Take the specific gravity of the mixture and multiply the last two numbers by two or by four according as one or three parts of water have been added. Thus, if half an ounce of urine and an ounce and a half of water have been mixed the dilution is 1 in 4. Suppose the sp. gr. to be 1007, then the true sp. gr. would be 1028 ($07 \times 4 = 28$).

V. Test the reaction. Blue litmus paper is turned red (acid reaction) by acid urine, and red litmus paper is turned blue (alkaline reaction) by alkaline urine. If neither litmus paper is altered in colour the urine is neutral. Occasionally the same urine will present both the alkaline and the acid reaction (amphoteric reaction). This, which should be recorded, is, however, of no special importance. If red litmus paper which has been turned blue by alkaline urine be heated or even allowed to dry in the air and the red colour returns this shows that the alkalinity is due to ammonia; in such a case, however, we should probably be able to tell the presence of ammonia by smelling the urine. It should be noted whether the change produced in the litmus paper is slight or well-marked; for example, the urine may be slightly or markedly acid. Yellow turmeric paper is turned brown by alkaline urine.

VI. Odour. Make a note of this; whether the urine has a natural, a sweet, or an offensive odour, or any other characteristic in this respect.

VII. Deposit. Describe the character, the colour, and the amount of any deposit; for example, the brick-red deposit of urates, or the dirty greyish-white deposit of phosphates.

VIII. Next test for albumin. This should never be omitted, and in so doing we may be able to throw light on the nature of any deposit which may be present. There are certain fallacies connected with nearly every test which is employed in examining urine, and it is partly on this account that we employ more than one test so as to make assurance doubly sure. When albumin is present in considerable amount it is perfectly easy to detect it, but it is also important to be able to detect faint traces of it, and sometimes this is a difficult matter. When there is more albumin than a trace it is necessary to estimate its amount.

To ascertain its presence the urine must be filtered, unless it is quite clear. It may be necessary to repeat this, and if then the urine be still opaque, a little caustic potash or caustic soda should be added (liquor potassæ or liquor sodæ), which produces a precipitate (cloud) of phosphates, and this precipitate renders the urine above it clear, which can be pipetted off into a test tube as required. If the urine be alkaline, it should be rendered acid by adding a few drops of acetic acid, since albumin is not precipitated by heat if the urine is alkaline. Now boil an inch of urine in a test tube. If it remains quite clear there is no albumin. If it becomes turbid this is probably due to albumin. It may possibly be due to phosphates; add one drop of nitric acid, and if the precipitate still remains, then we know it must be due to albumin, and vice versâ.

To confirm this result we shall mention three other tests, the most important of which is that known as the cold nitric acid test, called after Heller, who described it.

Take about half an inch of nitric acid in a test tube, and slant the tube; while holding it in this position pour down the side of the tube very carefully a few drops of the urine. Where the urine joins the acid a whitish ring is produced if albumin is present. The urine should not be allowed to mix with the acid. A pipette may be used to drop the urine on to the acid. It nearly always happens that this ring forms at once, or within a minute, and this test is so delicate that even traces of albumin may be discovered. Acid urates, urea, or certain balsams (such as cubebs or copaiva, which have been taken in medicine) may produce with this test a white cloud, but there should seldom be any difficulty in detecting albumin, since heat will nearly always dispel such a cloud, whereas it has no effect on the ring produced by albumin.

The next test is known as the picric acid test. Place about two inches of the acid in a test tube and drop the urine drop by drop on to the acid with a pipette. If there is no cloud formed there is no albumin. If there is a cloud formed then apply heat, and if the cloud remains albumin is present, if it disperses the cloud is caused by other substances.

Lastly, we may make use of the ferro-cyanide of potassium test. Take the same quantity of urine as in the previous test, and add about 10 drops of the ferrocyanide and then some acetic acid. Turbidity shows the presence of albumin. The urine must be strongly acid for this test to succeed. Dr. Pavy uses pellets of citric acid, and of the ferrocyanide, which are convenient. The citric acid pellet is first dropped in and allowed to dissolve. If a cloud now forms, this is not albumin but mucin or urates. In such a case start afresh, and if we are dealing with mucin, add the two pellets together to a fresh lot of urine, and compare the precipitate caused by the mucin and that produced by the albumin. If urates are thrown down by the citric acid pellet, add to a fresh supply of urine an equal amount of water, and then on adding the citric acid there will be no cloud. After the citric acid pellet has dissolved, add the ferrocyanide pellet, and then the cloud of albumin, if any be present, will appear.

To estimate the amount of albumin, we use Esbach's albuminometer, which is a thick test-tube half an inch in diameter and about eight inches long, having a mark U at a level of about 2¼ inches, and a mark R about 1½ inches higher. The tube is filled with urine up to U, and the special solution (one part of picric acid and two parts of dried citric acid in 100 parts of water), called after Esbach, is added up to R (reagent). A rubber cork is now fitted into the mouth of the tube (or the tube may be closed with the finger), and the tube is gently moved up and down, but not shaken, to mix the two fluids.

It is then put aside for 24 hours to allow the albumin to settle. By this time we can read off the level of the albumin, as the tube is graduated from 1 up to 12, each space representing one part per thousand of urine. Supposing the albumin reached to the figure 5, we should say that there were 5 parts of albumin per thousand or 0·5 per cent. As there are 437·5 grains in an ounce we can estimate the grains of albumin passed in the 24 hours. If 50 ounces containing this amount of albumin per cent. were passed, then the grains would be $0{\cdot}5 \times 4{\cdot}375 \times 50 = 109{\cdot}375$.

Esbach's albuminometer will not estimate traces of albumin (the least amount recorded is 0·1 per cent.). Remember to filter the urine here, as before, if it is not clear, and also to render it acid with acetic acid if it be alkaline. If the sp. gr. is over 1010 dilute the urine with an equal amount of water and allow for this by multiplying by two when making the calculation. Albumin may be roughly estimated by boiling the urine in a test-tube and allowing the albumin to settle. The amount of albumin may then be read off as a fraction of the length of tube occupied by the urine; for example, the albumin may be one-third or one-sixth or one-tenth.

IX. If we are dealing with a urine containing a deposit of urates we may apply heat, before filtering; fill a test-tube two-thirds full and heat the upper part of the urine. The turbidity, if due to urates, quickly disappears at the spot where the urine is heated, and this we may contrast with the turbid urine below. If we are dealing with a urine which contains albumin and is turbid from the presence of urates, as we apply heat the urine clears but on continuing to heat the urine again becomes cloudy, due to the precipitation of albumin. Thus in one test-tube we may have from above downwards (1) a cloud of albumin, (2) a portion of clear urine where heat has dissolved the urates, and (3) turbid urine which has not been heated and in which therefore the urates are precipitated.

X. The nurse should always test for the presence of sugar as a routine practice, although the medical man may not always consider it necessary. We have seen the more important characters of diabetic urine. There are, as in the case of albumin, many tests for sugar and of these that known as Fehling's test is the most commonly used. This and similar tests depend on the fact that the glucose in the urine has the power, when heated, of taking away some of the oxygen from the copper solution which is used and, as we say, reducing it and thereby producing another compound of copper of a different colour. To ensure the Fehling's solution being fresh and active it is best to keep its ingredients in two bottles labelled "Fehling No. 1" and "Fehling No. 2," and to mix equal parts of these in the test-tube at the time we perform the test. This mixture, then, constitutes Fehling's solution, and its deep blue colour should persist after a little is boiled in a test-tube. After, then, boiling an inch of Fehling's solution (made by taking one half inch from bottles 1 and 2) for two minutes, we add a few drops of the suspected urine (which should be free from albumin) and again boil, a yellowish red precipitate forms if sugar is present in considerable amount. If there be no precipitate then add as much urine as there was Fehling and boil again and then set aside. If in a few moments the solution remains clear there is no sugar present. There are certain fallacies connected with this test since certain other substances than glucose have a reducing action on the copper, but it is not in the scope of these remarks to consider them. The nurse should make use of one or more of the following tests for sugar if she has got a reaction with Fehling's test, in order to confirm her result. Pavy's solution, which acts in the same way as does Fehling's solution may be used instead.

Trommer's test is performed as follows:—Take about 2 inches of urine in a test tube and add about half the amount of liquor potassæ and then drop in carefully a solution of sulphate of copper, drop by drop. A precipitate forms, if sugar is present, which re-dissolves. Now boil the mixture when a thick precipitate occurs, first yellow, then orange, then reddish brown in colour.

Picric acid is used to detect sugar as well as albumin. Boil an inch of picric acid and liquor potassæ in a test tube. Then add the urine (about 1 inch) and continue the boiling. If sugar is present the solution becomes of a dark red colour depending for its depth on the amount of glucose present. Normal urine, especially if high coloured, may cause a darkening of the fluid but the colour is not nearly so dark as that due to sugar. Test the picric acid, to see if it is pure, before using it, as it may darken of itself when heated with liquor potassæ if it is impure.

Böttger's or Nylander's test is sometimes used and is considered a delicate one. Heat the urine with a little carbonate of soda and a little subnitrate of bismuth. If sugar is present the solution becomes black owing to the power of glucose to reduce the bismuth compound when in an alkaline solution to a black powder (oxide of bismuth).

Moore's test for sugar is not recommended, as it i not reliable for detecting small amounts of sugar. Equal parts of urine and caustic potash are heated in a test-tube, and, if sugar be present, a deep red brown colour is produced. High-coloured and albuminous urines and those containing phosphates usually darken on boiling with liquor potassæ. If the liquor potassæ contains lead (which it may absorb from the glass it is contained in) urine, when boiled with it, will darken, as black lead sulphide is produced, even if no sugar be present.

The last test for sugar which we shall describe is known as the fermentation test. It may also be used to estimate the amount of sugar, and it is in this connection that we shall describe it. It depends on the fact that glucose is changed by fermentation into alcohol and carbonic acid gas. A half-pint bottle is filled half full with urine, and into it is introduced a small piece of dry German yeast. The bottle is then corked, a groove having been first made in the cork to allow of the escape of the carbonic acid gas which is formed. Another bottle of similar capacity is filled with the urine and corked tightly. The two bottles are then placed, side by side, in a warm place and left for 24 hours. At the end of that time the fermentation process is complete. The specific gravity of both samples is now taken, that of the unfermented urine being regarded as the standard. The fermented urine will have been found to have lost some degrees of specific gravity according to the amount of sugar present.

The sugar, which has been acted upon by the yeast, has been converted into alcohol and carbonic acid gas, the latter of which has escaped through the groove in the cork. It has been found that every degree of specific gravity lost represents one grain of sugar in every ounce of urine. To ascertain, then, the amount of sugar passed in 24 hours, we have only to find out the quantity of urine passed in that time. A loss of 15 degrees of specific gravity would give us a total of 1,200 grains of sugar where 80 ounces of urine were passed in the 24 hours (80 × 15).

The nurse need not trouble herself with any other means employed to estimate the quantity of sugar passed.

Before we leave the subject of sugar in the urine it will be well to refer to two substances which may occasionally circulate in the blood in diabetes mellitus and which are believed to be closely connected with the diabetic coma which so often is the cause of death in diabetes. These substances may both be present in the urine and it is important that they should be discovered when they are so present. They are aceto-acetic acid and acetone, the former being decomposed into the latter and carbonic acid gas.

To test for aceto-acetic acid the urine must be fresh and unboiled. To some of the urine in a test-tube add a solution of the perchloride of iron, and if this or its allied acids be present the "ferric chloride reaction" is got, namely, a deep claret-red colour. On boiling the urine this disappears; but where the coloration is due to certain drugs, such as salicylates and carbolic acid, it is not affected by heat. To test for acetone, note first of all the fruity odour usually present in such a case. Hutchison recommends the following test: "To one inch of urine add five drops of a 10 per cent. solution of liquor potassæ. Heat gently. Then drop in a saturated solution of iodine in potassium iodide until the liquid has a yellowish-brown colour. Then add a little more liquor potassæ. Iodoform appears as a yellowish turbidity, which settles down into a crystalline precipitate. It may be recognised by its odour."

To test for blood take an inch of urine in a test-tube and add a drop of tincture of guaiacum and then about half an inch of ozonic ether (which should give off bubbles of gas when poured into the test-tube). If blood is present a blue colour appears at the junction of the fluids. This is caused by the guaiac resin being acted upon (oxidised) by oxygen brought to it by the blood pigment which it has taken away from the ozonic ether.

Certain other substances may produce a blue colour when this test is used, but such blue colour appears much more slowly than it does when blood is present, and it appears also simultaneously all through the fluid and not firstly at the junction of the fluids. Pus may give, when present, a greenish blue tint with this test, but it disappears on heating.

To test for the bile pigment pour a little urine on to a plate and, dipping a glass rod into some nitric acid,[1] apply it to the urine, when, at the point of contact, a play of colours is obtained, yellow, violet, blue and green rings being produced. This is known as Gmelin's test.

To test for pus firstly heat the urine. The turbidity does not disappear as it would do if it were due to urates. Take two inches of the pus-containing urine and add one inch of liquor potassæ. A ropy gelatinous mixture is produced. Mucus is distinguished from pus by becoming more fluid when liquor potassæ is added to it.

It will not be necessary for the nurse to test every specimen of urine for blood, bile, or pus, but she should know how to

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[1] The nitric acid acts best if it is impure, containing some nitrous acid.

test for these substances when occasion arises. Neither will it come within her province to examine the urine for uric acid and certain rare deposits which require the aid of the microscope for their detection. Indeed, the microscope is a necessity to the proper and complete analysis of the urine; but it stands to reason that it would be quite out of place to refer here to its use in this connection. It may be necessary to estimate the quantity of urea passed in the 24 hours (but it is not likely that the nurse will be asked to do this), and the most convenient apparatus for this purpose is the ureometer of Doremus (also called Southall's) or one of its modifications. The nurse will probably have it pointed out to her in the hospital ward if she wishes to see it. It consists of a bent tube with a long arm which is closed and a short arm which is open and expanded at its free end into a bulb, the whole instrument being conveniently fixed on a wooden stand. The estimation of urea depends on the fact that when urea comes into contact with a solution of hypobromite of soda, a chemical change takes place whereby the urea is split up into water, nitrogen, and carbonic acid. The nitrogen gas is collected in the long arm of the instrument and in about a quarter of an hour it is read off by means of a graduated scale on the long arm, and the appropriate calculation is made.

The following table gives the more important characters of the urine in some of the commoner diseases.

	Name of Disease.	Condition of the Urine.
I.	Gastric catarrh	Quantity normal; high coloured; sp. gr. often raised; acid; urates, oxalates, or phosphates may be deposited.

	Name of Disease.	Condition of the Urine.
II.	Jaundice	Urine greenish brown in colour ; frothy ; acid reaction ; contains bile ; quantity and sp. gr. usually normal.
III.	Heart and lung disease	Urine often diminished ; dark in colour ; acid ; high sp gr. ; urates often deposited ; albumin often present.
IV.	Fevers general and special	Quantity nearly always diminished ; high coloured ; usually acid ; high sp. gr. ; turbid ; urates ; may be albumin, blood and tube casts ; urea increased in amount.
V.	Diabetes mellitus	Quantity increased, pale, usually acid, sweet odour ; high sp. gr. ; sugar in greater or less amount ; amount of urea usually increased.
VI.	Acute Bright's disease	Quantity diminished or urine may be suppressed ; sp gr. at first raised, then lowered ; albumin; sometimes blood, tube casts, sometimes urates; urea diminished.
VII.	Chronic Bright's disease	Urine usually increased in quantity, pale, frothy, sp. gr. low ; albumin in small amount or may be absent ; no blood ; a few tube casts ; urea diminished.
VIII	Chronic cystitis	Quantity not usually altered, turbid ; often alkaline and offensive ; large quantities of ropy mucus and pus (muco-pus) ; often a deposit of phosphates.
IX.	Acute gout	Quantity usually diminished ; high coloured ; strongly acid ; urates deposited ; may also be uric acid deposited ; sp. gr. raised.

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