Notes on urinary analysis / by John Cowan and Archibald W. Harrington.

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JOHN COWAN, M.D.

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SECOND EDITION

GLASGOW:
ALEXANDER STENHOUSE,
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CONTENTS.

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The paragraphs marked (*) are important.

THE QUANTITY OF URINE.

The **quantity** of urine passed in twenty-four hours by a healthy adult averages 2 to 3 pints, but it varies greatly in different individuals, and in the same person is affected *directly* by the quantity of fluid absorbed, and *inversely* by that given off by the skin, lungs, and bowels. It is in consequence diminished in warm weather, after exercise, in diarrhœa, &c., and increased in cold weather, constipation, and during rest. In febrile conditions it is usually diminished.

Polyuria.—The quantity secreted depends ultimately on the functional integrity of the kidneys and on their blood-supply; and the latter may be influenced by general factors (high or low blood-pressure), as well as by local ones (dilatation or constriction of the renal arteries), both being under the control of the nervous system.

The quantity of urine is increased in diabetes mellitus (O v-xx), diabetes insipidus (O v-lvi), the early stages of renal cirrhosis (O iv-vi), and, as a rule, in amyloid disease (O-iv-vi). Cardiac failure, however, not infrequently obtains in the later stages of these diseases, and the quantity may then be of normal, or even smaller, amount. Polyuria may occur in hysteria, neurasthenia, migraine, epilepsy, and in cases where organic lesions involve the central nervous system. Polyuria may also appear as an epicritical phenomenon in acute pneumonia, &c.

Oliguria.—The quantity of urine is diminished in acute nephritis, the later stages of chronic nephritis and renal cirrhosis, and in most cases of obstruction of the renal passages. In hepatic cirrhosis and in cases of cardiac failure (valvular disease, myocardial disease, chronic wasting diseases, acute infections) the amount is usually small. In acute disease, where the kidneys are intact, the quantity of urine may be taken as an index to the cardiac strength.

THE COLOUR OF URINE.

The **colour** of the urine varies from a pale yellow to a brownish yellow according to the degree of concentration; it is due to the presence of UROCHROME, which is derived from bilirubin. The amount of urochrome present is increased when resorption of large extravasations of blood is taking place, and is diminished in cases where the hæmoglobin-content of the blood is small (chlorosis, &c.).

URO-ERYTHRIN, the pigment of pink urates, is not present normally, but tends to appear with the slightest deviation from health, and is present in notable amount in cases of hepatic insufficiency (cirrhosis, congestion, cancer, acute infections).

The *tests* for urochrome and uro-erythrin are complicated and difficult.

Several **chromogens** are present in normal urines. The indol formed during intestinal putrefaction is oxidized to indoxyl in the blood, and is excreted by the kidneys as potassium or sodium indoxyl sulphate (INDICAN). The amount is augmented by an increase in animal foods, and is diminished during a milk diet. In pathological states it is found in abnormal quantity whenever albuminous putrefaction in the bowel is excessive, a condition which is likely to arise in cases where the HCl of the gastric secretion is absent or deficient (gastric carcinoma, gastritis); and in cases of obstruction of the *small* intestine. Simple constipation is probably not associated with increase in the amount excreted. It may also be increased in cases of empyema, bronchiectasis, gangrene of the lung.

Test.—The urine is mixed with equal parts of a 0·2 *per cent.* solution of ferric chloride in concentrated HCl. The mixture is then shaken with $CHCl_3$, which, on separating, is coloured a more or less deep blue. (The ingestion of iodides produces with this test a carmine colour from the liberation of free iodine.)

UROHÆMATIN, the chromogen of the red pigment, is probably closely allied to indican, and its presence in increased amount

suggests the same conclusions. The existence of the chromogen can best be shown by shaking up the urine with $CHCl_3$, and decanting after several days. The addition of a drop of HCl to the $CHCl_3$ extract produces a rose colour.

Uroroseinogen occurs in normal urine in small quantities. A rose-red ring at the junction of the fluids, when the ordinary HNO_3 test is employed, may be found in urines containing an abnormal amount.

In **pathological conditions** many abnormal pigments and chromogens may occur.

Blood is not uncommonly present, and may be derived from any part of the urogenital tract. The urine may be definitely "bloody" in cases where the hæmorrhage has occurred recently, but is usually opalescent and "smoky" (acid-hæmatin and methæmoglobin) when it has been mixed with the urine for some time. The deposit on standing may be "bloody" or chocolate colour.

Renal hæmorrhage usually gives rise to "smoky" coloured urine, and blood-casts may be found in the deposit. Hæmorrhage from the *bladder* is usually associated with a "bloody" colour, and clots of fair size may be passed; not infrequently it is most profuse towards the end of the act of micturition. Hæmorrhage from the *urethra* may occur independently of micturition; it is usually most marked in the first portions of urine passed. Hæmorrhage from the *prostate* is usually most profuse towards the end of the act.

Urethral bleeding is most frequently traumatic in origin. Vesical bleeding may be due to cystitis, tumour, calculus, ulceration, rupture of varicose veins, bilharzia disease. Bleeding from the ureter or the renal pelvis may be due to calculus, ulceration, tumour; the exact site can only be diagnosed from the symptoms associated with the hæmaturia. Bleeding from the kidney may occur in acute nephritis, chronic nephritis, calculus, tumours, abscess, tuberculosis, embolism of arteries, thrombosis of veins; in malignant forms of the infections, especially small-pox, yellow fever, and malaria; in scurvy, hæmophilia, purpura, leukæmia, filariasis, distomiasis; in cases of poisoning by turpentine, carbolic acid, cantharides, urotropin, &c.

Tests—

Spectroscope.

Microscopic examination of the fresh centrifuged deposit.

Guaiacum test.—A few drops of simple tincture of guaiacum are added to the fresh deposit (preferably centrifuged), and intimately mixed with it. Ozonic ether is added slowly so as to prevent admixture. If blood is present, a blue line forms at the junction of the fluids. If the reaction is indefinite the test tube should be shaken, and the blue tint may then be more apparent. If the patient is taking iodides internally, a greenish blue colour may result; the addition of a few drops of nitric acid will, however, in these cases liberate free iodine which tinges the ether yellow or brown. The blue colour produced by blood is simply discharged by the acid.

Benzidin Test.—2 c.c. of a freshly prepared saturated solution of benzidin puriss. (dissolved by heat) in glacial acetic acid are mixed with a few c.c. of urine, and 2 c.c. of a 3 *per cent.* solution of H_2O_2 are then added. In the presence of blood a greenish blue or almost black colour appears—if not at once, after standing for a little while.

Hæmoglobin.—In certain conditions free hæmoglobin (usually methæmoglobin) appears in the urine, and can be recognised by the spectroscope and guaiacum tests, while the microscope reveals few or no red blood cells. Its presence seems to be due to excessive destruction of red cells and insufficiency of hepatic action. Hæmoglobinuria may occur in poisoning by potassium chlorate, arsenious hydride, hydrogen sulphide, pyrogallic acid, naphthol, hydrochloric acid, tincture of iodine, carbon monoxide; in burns, sunstroke, and after transfusion of the blood of a different species; in the acute infections, scarlatina, small-pox, enteric and yellow fevers, icterus gravis; in blackwater fever, and in epidemic form in children; in Raynaud's disease, paroxysmal hæmoglobinuria, &c.

Urohæmato-porphyrin.—This pigment may be present in traces in normal urine, as it is probably formed in the liver normally and excreted in the bile. It has been found in increased amount in many diseases, especially those involving the liver, and it may succeed the ingestion of lead, sulphonal, trional, tetronal. Such urines are usually dark red in colour.

Test.—Spectroscope.

Hæmatin, Urorubrohæmatin, Urofuscohæmatin have occasionally been observed in the urine. The colour of the urine is dark red or reddish-brown. The significance of their presence is obscure, and the *tests* are complicated.

Bile Pigments.—Bilirubin alone of the biliary pigments is met with in fresh urine, though biliverdin, biliprasin, bilifuscin may form upon standing. Choluria results whenever the biliary passages are blocked, and the pressure within them becomes greater than that in the capillaries. It may thus be due to catarrh of the ducts, gall stones, parasites in, and tumours of, the ducts, as well as to tumours of adjacent organs which exercise pressure upon the ducts.

The urine in such cases varies in colour from a bright yellow to a greenish-brown, and stains filter paper, foam, or cellular elements a golden yellow.

Tests—

Test.—A few c.c. of urine are poured into a test tube, and a small quantity of tincture of iodine (10 *per cent.*) in alcohol is added slowly, so that the two liquids do not mix. If bilirubin is present, an emerald green (biliverdin) ring forms at the point of contact.

Gmelin's test.—The urine is filtered through thick white filter paper, and a drop of fuming nitric acid, which has been allowed to stand exposed to the air for a short time, is thrown upon it. If bilirubin is present, a prismatic play of colours will be seen to occur at the margins of the drop. (This reaction may also be applied as a contact test.)

Biliary Acids are generally present in the urine when bile pigments are found. The *tests* for them are complicated and difficult. Flowers of sulphur, if sprinkled upon the surface of urine containing bile salts, sink at once to the bottom of the glass owing to the lowering of the surface tension produced by their presence. This test is, however, not very sensitive.

Urobilin, if present in large quantity, may cause a darkening in colour of the urine. Urobilin is probably formed from the bile pigments in the intestine by bacterial action. It is commonly present in small amount in febrile urines, and has also been found in cases of hepatic disease, chronic malaria, pernicious

anæmia, &c. The skin in these patients may be yellowish in hue, and suggest the presence of jaundice.

Tests—

Spectroscope.

Gerhardt's test.—A small quantity of urine is shaken with a few c.c. of $CHCl_3$, and the latter is allowed to separate. The chloroform extract is then mixed with a few drops of a dilute solution of iodo-potassic iodide, and a few drops of a weak solution of sodium hydrate are added. The colour becomes yellow or yellow-brown, and exhibits a green fluorescence.

Test.—The urine is made alkaline with NH_4OH and filtered if necessary. On the addition of a few drops of a 10 *per cent.* alcoholic solution of zinc chloride a green fluorescence appears.

Black Urines.—In some cases urine, of normal colour when passed, becomes dark brown or black on prolonged exposure to the air. This may be due to several different chromogens.

Melanogen.—In cases of melanotic sarcoma with visceral involvement (especially hepatic), the chromogen may be present, and if the amount is large the urine may ultimately become ink-black.

Tests.—The urine, mixed with excess of Tinct. ferri perchlor., becomes black at once. Mixed with nitric acid it also blackens at once, while indican only blackens when the mixture is heated. On the addition of bromine water a yellow or brown deposit occurs, which blackens on standing.

Alkaptonuria.—Urine containing alkapton becomes dark on standing, and the change is hastened by the addition of a little alkali. The probable cause of this is the presence of homogentisic acid, and the condition is, as a rule, congenital in origin and of little clinical importance. It does not depend on intestinal causes. The linen of these patients may be deeply stained by drops of urine. *Fehling's solution is reduced by these urines*, but the fermentation and polarimeter tests are negative. If a dilute solution of ferric chloride is added, drop by drop, to the urine a deep blue colour appears, and disappears in a moment.

Phenol Urines.—The urine on standing may become notably dark in colour after the ingestion of large quantities of carbolic acid,

salol, impure creosote, hydroquinon, salicylic acid, pyrocatechin, tar, &c. The melanin tests will prevent confusion with melanin, and the history will generally suggest the diagnosis. Urines containing salicylic acid become violet coloured on the addition of an excess of Tinct. ferri perchlor. The exact nature of the pigmentation is not definite. The colour may be due to homogentisic acid or to oxidation products of hydroquinon.

Salkowski's test.—10 c.c. of urine are boiled in a test-tube with a small quantity of nitric acid, and, on cooling, mixed with bromine water. The development of a pronounced turbidity, or the occurrence of a precipitate, indicates the presence of an abnormal amount of phenol.

Pyrocatechin.—Urines containing pyrocatechin may also darken in colour on standing, although normal when passed.

Urine may be **milky** in colour, when passed, from admixture with fat (chyluria); the tint is sometimes rosy from the presence of blood. Chyluria occurs in cases of obstruction of the lymph channels, if the blocked lymphatics happen to rupture into the urinary tracts. It is most common in cases of infection by the filaria sanguinis hominum (which may be found in the urine and blood), but may also obtain in cases of abdominal tumour, tuberculosis, &c., which block the thoracic duct.

The urine may be coloured by **drugs** which have been administered for medicinal or other reasons.

Methylene blue and indigo colour it blue. Santonin, rhubarb, and senna colour it yellow in acid solutions, and red in alkaline ones. Logwood and fuchsin colour it red. Iodides may occasion colour changes in urine which is being tested with nitric acid. "Laxoin" (phenophthalein) imparts a reddish tint to alkaline urine.

THE ODOUR OF URINE.

The **odour** of urine is characteristic. It may be ammoniacal from conversion of the urea into ammonium carbonate, but this is of no importance unless the change has occurred *within* the urinary passages as the result of their infection. Diabetic or other urine may smell of acetone. Copaiba, cubebs, turpentine, garlic, asparagus, champagne, &c., impart specific odours.

THE SPECIFIC GRAVITY OF URINE.

The **specific gravity** of the urine depends upon the amount of solid constituents dissolved in it, and may thus vary from alterations in the quantity of either the fluid or the solid elements. Generally speaking, it is highest when the quantity passed in the twenty-four hours is small, and lowest when large quantities are secreted; but in diabetes mellitus the specific gravity may be high (1·030-1·074), if the sugar content is considerable, even when many pints are being passed daily; and in obstructive suppression of urine (calculus, &c.) the specific gravity is often low, though the daily output may be very scanty.

The average specific gravity of the twenty-four hours' urine in normal persons is generally between 1·015 and 1·025, but it varies considerably at different times of the day from variations in the quantity of fluid ingested, and the output from the skin and bowels. Low specific gravities (below 1·010) occur in renal cirrhosis and in diabetes insipidus. High specific gravities (above 1·040) are most commonly found in diabetes mellitus.

The urinometer must be slowly introduced into the urine, and the reading taken at the lower meniscus as soon as the instrumen has come to rest. It must have ample room at the sides, and be dry and clean before its introduction. The urine must be at ordinary atmospheric temperature; urines at a higher temperature give lower readings.

THE REACTION OF URINE.

Normal urine is *acid* when passed, from the presence of acid sodium phosphate (NaH_2PO_4), urates, and carbonic acid, though the influence of the two latter is infinitesimal; but if allowed to stand exposed to the air for some time, it becomes alkaline as the result of the decomposition of urea, and the formation of ammonium carbonate. ($CO(NH_2)_2 + 2H_2O = (NH_4)_2CO_3 = 2NH_3 + H_2O + CO_2$) Occasionally the acidity is increased on standing from the formation of new acids from carbohydrate or alcohol fermentation (diabetes, &c.). The acidity of the urine is increased in concentrated urines, especially in fevers; in gastric disorders associated with deficient HCl secretion; in gout, lithiasis, chronic nephritis, leukæmia, scurvy, diabetes.

The urine may be *alkaline* when passed if the dietary contains an excess of vegetables, as the organic salts of the alkalies, when absorbed into the blood as carbonates, may completely neutralise the acids present and allow of the elimination of neutral sodium phosphate (Na_2HPO_4). A dietary rich in animal food, on the other hand, will not allow complete neutralisation of the acids in the blood, and an excess of acid phosphate will be eliminated.

An alkaline urine may be passed in cases of debility, anæmia, frequent vomiting, &c., or after the ingestion of salts of the organic acids, or the alkaline carbonates. In all these cases the alkalinity is due to fixed alkali.

If the alkalinity is due to volatile alkali (ammoniacal smell; return of red colour to litmus paper when dried), decomposition of the urine must have occurred in the urinary tract. It is essential in these cases to make certain that the urine is ammoniacal *when passed.*

It is said that normal urine is never neutral in reaction, but that it may be amphoteric—*i.e.*, turn red litmus blue, and *vice versa.* This occurs when the acid and neutral phosphates are present in certain definite proportions.

Urine can be made alkaline very readily by the administration of alkaline carbonates. It is difficult to render an alkaline urine acid, but the administration of boracic acid (excreted as boracic acid) or benzoates (excreted as hippuric acid) sometimes effects this.

ALBUMINURIA.

The albumens which are most commonly found in the urine are serum-albumen and serum-globulin. Albuminuria may thus be due to the presence of blood or pus in the urine, and either may be derived from lesions in the lower urogenital tract (vaginal or uterine discharges; balanitis; lesions in urethra, prostate, testes, vesiculæ seminales, bladder, ureter, renal pelvis); or from rupture of abscesses into it. The presence of tube-casts indicates a *renal* origin.

INTERMITTENT ALBUMINURIA of renal origin occurs in a large number of apparently healthy individuals as the result of excessive muscular exertion, the ingestion of large quantities of albumen, and exposure to cold; and it sometimes occurs in young adults during the daytime, being absent as long as the patient remains in bed (postural A.). Intermittent albuminuria of these types is not necessarily associated with actual renal disease, but the subjects during its continuance cannot be considered to be absolutely normal. The urine in these cases is not infrequently found to contain abnormal quantities of uric acid or oxalate of lime.

TEMPORARY ALBUMINURIA of renal origin may occur as the result of venereal excess, and from renal irritation following the ingestion of drugs, cantharides, turpentine, antimony, alcohol, mineral acids, mustard, potassium nitrate, tar, salicylic acid, carbolic acid, iodine, phosphorus, arsenic, lead, which are excreted in the urine. Febrile albuminuria is a common occurrence, the kidney being irritated during the excretion of the products of the causal bacteria (diphtheria), or of the bacteria themselves (enteric fever). When the infection is overcome, the urine becomes again free from albumen. Albuminuria is common in the venous congestion of cardiac failure, and may also result from embolism of the renal artery.

Albuminuria may be the result of ACTUAL RENAL DISEASE; sometimes the glomeruli are mainly affected, and the albumens of the blood are allowed to enter the renal passages; or the tubules

may be chiefly involved, in which case the albumen is at least partially due to the disintegration of the degenerated cells. In acute nephritis, the large white kidney, the small white kidney, and in amyloid kidney, the quantity of albumen present is usually considerable. In renal cirrhosis but little albumen is found, and it may be absent for days at a time. Febrile albuminuria is usually trifling in amount, but it may be profuse (diphtheria); the amount in chronic venous congestion is usually small.

Tests for serum-albumen and serum-globulin—

Heat test.—The upper part of a column of urine in a test-tube is boiled, and a few drops of acetic acid are added after boiling. The occurrence of a precipitate indicates the presence of albumen. If the urine is notably acid or alkaline, a precipitate may not form, as neither acid nor alkali albumen are precipitated by boiling. Sometimes a faint precipitate forms on the addition of the acetic acid from precipitation of (?) mucin; a negative result with nitric acid makes the assumption certain. Phosphates are precipitated on boiling, but dissolve on the addition of the acid. Resinous acids, from the ingestion of balsams, may, if present, give a precipitate; it, however, is dissolved on the addition of alcohol.

The test is seen best in clear urines, but can be successfully applied in those which are turbid from urates. Urines turbid from the presence of phosphates or bacteria should be carefully filtered. The reaction of the urine should be slightly acid.

Nitric acid test.—A few c.c. of pure nitric acid are introduced into a test-tube, and an equal quantity of urine is carefully lowered by a pipette on to its upper surface, so that admixture of the two liquids does not occur. In the presence of albumen a white ring, varying in depth and intensity according to the amount of albumen present, forms at the line of junction. The urine in this test must be clear. The test-tube must be examined against a dark background after standing for a short time.

Urates or nitrate of urea may be precipitated if they are present in excess, but they dissolve on gentle heating. Resinous acids will also give a precipitate; it dissolves on the addition of alcohol.

Picric acid test.—The urine is acidified if necessary, and mixed with an excess of a saturated watery solution of picric acid. Albumen, if present, is precipitated as a flocculent cloud. Uric acid, urates, albumoses, kreatinin, however, are also precipitated;

and this may likewise occur if the patient is taking any alkaloidal salts (morphine, quinine, &c.). A negative test is therefore valuable, but a positive one requires confirmation. Urates, albumoses, and alkaloids are all dissolved on gentle heating.

Esbach's quantitative test.—The tube is filled with urine to the mark U, and Esbach's solution is then added up to the mark R. The tube is corked and the fluids are mixed carefully, so as to avoid the formation of bubbles on the surface. If albumen is abundant, the urine must be diluted. The height of the deposit after the mixture has stood for 24 hours is read off the scale directly, and is supposed to represent grammes of dried albumen per 1,000 parts. As urates, kreatinin, &c., are also precipitated, the test is inaccurate, but it is useful from the clinical point of view.

Esbach's reagent contains 10 grammes of picric acid and 20 grammes of citric acid in 1000 c.c. of water. The urine should not have a S.G. of over 1·008, and should not contain more than 0·4 per cent. of albumen, and may have, in consequence, to be diluted. The temperature of the room should be 58·5° F.

Test for serum globulin.—The urine is added drop by drop to a vessel containing distilled water. In the presence of globulins a white cloud forms from their precipitation. Globulin is precipitated on the addition of a small quantity of acetic acid; but is redissolved by excess of acid.

Albumoses have been found in the urine in many varieties of disease, but their clinical importance is little understood. They are said to be present during autolysis and absorption of exudates. A substance, which was formerly regarded as an albumose, has however been found in the urine, associated with the presence of multiple tumours of the bones (Bence Jones Proteinuria). It may be a true albumen (Simon. Magnus Levy). This protein is coagulated by heat at 60° C., but redissolves on boiling, though it is again precipitated on cooling. A precipitate also forms with the nitric acid test, which is dissolved on heating and reappears as the mixture cools.

Mucin (nucleo-albumen).—In all urines which are allowed to stand for some time a translucent deposit (nubecula) forms at the bottom of the vessel. Under the microscope this is seen to contain a few round granular cells (mucous corpuscles) and some

large epithelial cells. In catarrhal conditions of the urinary passages the amount of deposit may be large. The deposit is probably mucin.

In some urines which remain clear on boiling a faint deposit forms on the addition of acetic acid. If the nitric acid test is negative, the deposit is probably mucin or nucleo-albumen and not serum albumen.

GLYCOSURIA.

Normal urine contains minute quantities of glucose, but the amount is too small to be recognised by the usual tests, unless the urine is artificially concentrated. The amount of sugar which can be utilised without its appearance in the urine in recognisable quantity is, however, always limited, though the quantity required varies in different individuals. The appearance of sugar in the urine after the ingestion of 100 grammes of pure glucose dissolved in water, is generally considered to be pathological—(Glycosuria e saccharo). The stomach must be empty at the time of the experiment. *Alimentary* Glycosuria following the ingestion of starches in excessive amount (150-200 grammes)—(Glycosuria ex amylo)—is probably always pathological.

The assimilation of sugar may be interfered with in various diseases. *Glycosuria e saccharo* may thus be present in cases of alcoholism, Graves' disease, or after the administration of thyroid extract or thyroiodin; in pregnancy, the neuroses, the infections (pneumonia, enteric fever, rheumatic fever, scarlatina); in some chronic skin complaints, chronic cardiac disease, &c.; but hepatic disease does not seem to be specially provocative.

A *transitory glycosuria* may occur in a great variety of diseases. It is not uncommon in acute lesions of the central nervous system, in mental cases, epilepsy, Graves' disease, and the acute infections. It may also follow toxic doses of curare, chloral, sulphuric acid, alcohol, CO, morphia, phloridzin, &c., or occur after saline transfusion.

Persistent glycosuria is occasionally due to lesions affecting the base of the brain, and may follow removal of the thyroid gland, but it is usually a part of diabetes mellitus. The quantity of sugar eliminated in diabetes may be large, and the urinary fluids excessive, or the opposite conditions may obtain, and this without affecting the gravity of the case.

Tests for glucose—

Fehling's test.—Fehling's solution is a solution of hydrated cupric oxide in excess of caustic soda, of such a strength that 200 grains is completely reduced by 1 grain of glucose (10 c.c. is completely reduced by ·05 gramme glucose).

Some Fehling's solution is poured into a test tube and rapidly brought to the boil. An equal quantity of urine is then gradually added to it, and the mixture is again brought to boiling point, and then laid aside to cool. If no precipitate occurs within two minutes, the specimen may be regarded as free from pathological quantities of glucose. (Solutions containing 0·2 *per cent.* glucose give a precipitate within this time). In the presence of sugar a brick red (anhydrous) or yellow (hydrated) precipitate of cuprous oxide is thrown down. Uric acid, urates, and glycuronic acid if present in large amount in the urine, may reduce Fehling's solution in the absence of glucose; and kreatin, kreatinin, or mucin, if present in large amount, may cause the test to fail in the presence of glucose. Urine with a S.G. below 1·020 will not contain sufficient of these substances to interfere with the test, and the urine, if of S.G. above 1·020, should be diluted until that figure is attained. Alkapton and pentose may also reduce Fehling's solution.

Albumen, if present, must be removed from the urine, by boiling and filtration, before the test is applied. As Fehling's solution "keeps" badly, it should be boiled before the addition of the urine, to make certain of its reliability. The urine must be added gradually to the solution, as the presence of large quantities of glucose may inhibit the precipitation of the copper.

Occasionally a precipitate is not thrown down, but the blue of the mixture turns green and the fluid becomes turbid; such a reaction is probably due to the presence of reducing agents other than glucose; confirmatory tests should be applied.

Quantitative estimation of glucose.—10 c.c. of Fehling's solution, diluted with 40 c.c. of water, are placed in a porcelain dish and boiled. While boiling, diluted urine is added from a burette, 0·5 c.c. at a time, until the blue colour of the fluid is wholly gone. The reaction is then complete, and the quantity of diluted urine is read off. As 10 c.c. of Fehling's solution are completely reduced by .05 gramme of glucose, this quantity must be contained in the amount of urine required. For example, if 20 c.c. of diluted urine are required, and if the urine is diluted with water to ten times its bulk, then 2 c.c. of undiluted urine will contain 0·05 gramme of sugar; and the quantity excreted in twenty-four hours can be readily estimated by multiplying 0·05 by the number of c.c. passed in twenty-four hours divided by 2.

A specimen of the mixed twenty-four hours' urine should always be used, as the excretion of sugar varies from time to time during the day. The urine used should be diluted to ten times its bulk to minimise possible inaccuracies. To determine the point when all the blue is discharged, the boiling should be stopped, and the red oxide allowed to deposit. By tilting the capsule a white background can be obtained as contrast. If doubt still exists, a few drops of the supernatant fluid should be filtered, acidified with acetic acid, and mixed with a drop or two of a solution of potassium ferrocyanide. If unreduced copper is still present, a brown colouration results.

In cases where the red oxide does not precipitate, *Cause's modification* of the test may be used. 10 c.c. of Fehling's solution are mixed with 20 c.c. of water and 4 c.c. of a 0·05 *per cent.* solution of potassium ferrocyanide. The mixture is boiled, and the diluted urine is added as before. The red oxide is not precipitated, and the reaction is completed when the blue colour is fully discharged.

A modification of Gerrard and Allan's method is rapid and accurate. To four parts by volume of a 50 *per cent.* solution of chemically pure potassum sulphocyanide, is added one part by volume of Fehling's Solution. 25 c.c. of this mixture are placed in a porcelain, and diluted urine added as before. Throughout the titration, the solution should be slowly boiled, and constantly stirred with a glass rod. The end reaction is very sharp, the fluid becoming colourless, or assuming a faint yellow tint. The mixture represents Fehling's Solution diluted five times, and the calculation is made accordingly.

To prevent gross errors, a rough estimation should first be made. Two careful tests, adding small quantities at a time as the critical point approaches, should then be made, and the average of the two tests accepted.

Phenyl-hydrazin test.—6 c.c. of urine are mixed with 0·5 gramme of phenyl-hydrazin hydrochloride and 1·0 gramme of sodium acetate. The mixture is gently heated until solution is complete; the test-tube is then placed in a water bath for one hour and afterwards allowed to cool. If glucose is present, a bright yellow precipitate of acicular crystals of phenyl-glucosazone is thrown down. They are often arranged in bundles and sheaves. A microscopic examination is always requisite, as sometimes a

yellow precipitate forms from other substances, but these are not definitely acicular in shape. Other osazones (maltosazone, lactosazone, galactosazone) may form similar crystals. They can be distinguished by the difference in shape of the crystals, and by their varying melting point.

Fermentation test.—Glucose, when mixed with yeast, ferments with evolution of CO_2 gas. Three saccharometers are taken. One, A, is filled with urine. Another, B, is filled with recently boiled water, and a pellet of ordinary baker's yeast, which has been well washed, is mixed with it before inversion. The third, C, is filled with the urine, and a similar yeast pellet is mixed with it. The tubes are then placed in a warm room for twelve hours. If sugar is present, the tube C will be gradually emptied of its liquid contents by the CO_2 evolved. If the CO_2 is introduced into lime-water it will make it milky. Urine normally contains a small amount of gases, and baker's yeast is often mixed with some sugar; the controls are useful in cases where the percentage of glucose in the urine is small, as the amount of gas present in C must be greater than that in A and B together for the test to be positive.

Fermentation is also useful as a rough quantitative test. With the development of fermentation the specific gravity of the urine is reduced, and after twenty-four hours' fermentation each point of loss of specific gravity may be taken as representing one grain of sugar per ounce of urine. The quantity of sugar can also be estimated by the polarimeter.

Other sugar besides glucose are occasionally present in the urine—*viz.*, lactose, galactose, lævulose, maltose, pentose, all of which reduce Fehling's Solution, but the significance of the last three is undetermined. Alimentary laevulosuria and galactosuria are common in hepatic disease.

Lactose is, however, not infrequently present in the urine of women who are pregnant or nursing. It is more common in the latter case, and is of no serious import. Lactosuria may be inferred when the Fehling test is positive, and the phenylhydrazin and fermentation tests are negative. Lactosazone is obtained only from isolated lactose.

In some cases of glycosuria the whole fault may consist of imperfect utilisation of carbohydrate food. As a result, sugar

makes its appearance in abnormal amount in the blood, and is in consequence drained off by the kidneys. The error is simply one of assimilation, and the glycosuria ceases with cessation of the supply of carbohydrate.

In another (clinical) form of diabetes, sugar persists in the urine even when no carbohydrate food is being ingested. Protein, and probably fat, are broken down in an abnormal way, and hyperglycæmia and glycosuria result. The error is not merely assimilative; a katabolic defect is present (composite form). In these latter cases the *acetone series* (acetone, diacetic acid, β-oxybutyric acid) may make their appearance in the urine, and if all these are present in quantity the immediate prognosis is rendered very grave, as the possibility of the near occurrence of coma is considerable. The significance of the presence of acetone, alone, or with diacetic acid, in small quantity is, however, not so serious.

Acetone is, indeed, normally present in the urine in small quantity, the amount being largely dependent on the nature of the food stuffs, and greatest when little proteid and no carbohydrate food at all are being taken. Acetonuria may thus be noticed in cases of starvation, prolonged fever, &c.; and it has also obtained in cases of nervous disease, such as tabes dorsalis, and general paralysis; of gastric disease, especially carcinoma; after chloroform narcosis, phosphorus poisoning &c. The odour of acetone is characteristic, and can frequently be recognised in the breath of such patients. The administration of carbohydrate food to these cases frequently lessens the acetonuria.

Test for Acetone.—Add 1 c.c. of glacial acetic acid to 15 c.c. of urine and treat with a few drops of freshly-prepared nitroprusside of sodium solution (5 *per cent.*); a few c.c of ammonia are allowed to flow slowly on to the top of the mixture. In the presence of acetone a bright violet ring appears at the line of contact.

Less than 0·025 *per cent.* of acetone gives a positive reaction. Alcohol and aldehyde do not give the reaction, nor does kreatinin.

The presence of diacetic acid in the urine must be considered abnormal, and as significant of similar conditions to those which induce acetonuria.

Test for Diacetic Acid.—Equal quantities of urine and Tinct. ferri perchlor. are mixed together in a test-tube. If phosphates are present they are precipitated, and more of the iron solution

must be added until they are dissolved. In the presence of diacetic acid the clear fluid becomes deep red in colour. (If antipyrin is being taken, a purple precipitate forms with this test, and salicylates produce a violet one.) A second portion of the urine is boiled before the addition of the perchloride solution; the red colouration does not appear. A third portion is taken, treated with sulphuric acid, and extracted with ether; a positive reaction of the etheral extract mixed with ferric chloride, with disappearance of the colour on standing for forty-eight hours, indicates the presence of diacetic acid.

The presence of β-oxybutyric acid in any quantity, in the urine of diabetic patients, is probably always significant of impending coma. Its recognition is somewhat difficult. It is, however, lævo-rotatory to polarised light, and its presence may be inferred if quantitative estimations by Fehling's method and the polarimeter are notably different; or the sugar may be fermented off, and the lævo-rotatory power of the residue measured directly.

β-oxybutyric acid is probably never present without acetone and diacetic acid; and the amount of the latter is generally considerable.

THE SOLID CONSTITUENTS OF THE URINE.

The solid constituents of normal urine average about 60 grammes per diem, but the amount varies considerably in individual cases from variations in the quantity and the nature of the food ingested, and the amount of the fluid excreted. Generally speaking, the excretion is greater the greater the amount of urine passed, but occasionally (renal cirrhosis) the solid output may be deficient, while the fluid output is excessive.

ANALYSIS OF URINE (Simon).

	Grammes.
WATER, ...	1,200-1,700
SOLIDS, ...	60
Inorganic solids, ...	25·0-26·0
Sulphuric acid (H_2SO_4), ...	2·0-2·5
Phosphoric acid (P_2O_5), ...	2·5-3·5
Chlorine (NaCl), ...	10·0-15·0
Potassium (K_2O), ...	3·3
Calcium (CaO), ...	0·2-0·4
Magnesium (MgO), ...	0·5
Ammonia (NH_3), ...	0·7
Fluorides, nitrates, &c., ...	0·2
Organic solids,	20-35
Urea, ...	20-30
Uric acid, ...	0·2-1·0
Xanthin bases, ...	1·0
Kreatinin, ...	0·05-0·08
Oxalic acid, ...	0·05
Conjugate sulphates, ...	0·12-0·25
Hippuric acid, ...	0.65-0.7
Volatile fatty acids, ...	0·05
Other organic solids, ...	2.5

THE CHLORIDES.

The chlorides are mainly present as sodium chloride, with traces of the potassium, ammonium, calcium, and magnesium salts. They are chiefly derived from the food stuffs, and are thus reduced in quantity in starvation, when they may be almost wholly absent from the urine. Any increase in the amount of circulating albumens is followed by an increase in their excretion, but the reasons for this are at present undetermined.

Their excretion is deficient in most cases of acute febrile disease (notably in pneumonia), in renal diseases associated with albuminuria, in cases of gastric disease, anæmia, &c.

Their excretion is increased after the acute febrile diseases, when resorption of effusions is taking place, in diabetes insipidus, &c., and, generally, whenever diuretics are being administered.

Test.—A few drops of pure nitric acid are mixed with 10 c.c. of urine, and an equal quantity of a 5 *per cent.* solution of silver nitrate is added to it. A white curdy precipitate is thrown down; it is soluble in ammonia, and insoluble in nitric acid.

THE PHOSPHATES.

The phosphates are present as the sodium, potassium, calcium, and magnesium salts, the most important being the diacid sodium phosphate (NaH_2PO_4), and the alkaline salts are present in larger amount than the earthy ones. The greater portion present is derived from the food stuffs, and only a small portion from the tissues. About a third of the phosphates ingested are excreted with the fæces.

Their excretion is thus increased on an animal, and decreased on a vegetable diet. It is usually increased during starvation (probably from increased breaking down of bony tissues), with increase in the amount of urine secreted, in phosphatic diabetes, &c.; but in diabetes mellitus the excretion, as a rule, varies inversely with the amount of sugar eliminated. The output in nephritis and acute febrile disease is generally diminished, but may be increased.

Tests.—

(1) 10 c.c. of urine are rendered alkaline by the addition of ammonia. The *earthy* phosphates are precipitated in flocculent form ($Ca_3(PO_4)_2$).

(2) The earthy phosphates are now filtered off, and to the ammoniacal filtrate a few drops of magnesia mixture * are added. The *alkaline* phosphates are thrown out of solution as ammonio-magnesium phosphate ($MgNH_4PO_4$), which is almost insoluble in ammonia.

Several varieties of phosphates may occur as sediments.

1. Amorphous Calcium Phosphate ($Ca_3(PO_4)_2$) occurs as a white flocculent deposit, and the urine when passed may be turbid.

The reaction of the urine is invariably alkaline, from the presence of fixed alkali. In ammoniacal urine it may be present with "triple" phosphate.

Tests.—

(1) *Microscopic.*—Colourless granules.

* Crystallised magnesium sulphate, 1; ammonium chloride, 2; ammonium hydrate, 4; distilled water, 8.

(2) These are very soluble in dilute acids, and insoluble in alkaline solutions. They are not affected by heat.

2. Neutral Calcium Phosphate ($CaHPO_4 + 2H_2O$), "Stellar Phosphate," may be found in alkaline, neutral, or slightly acid urine. To the naked eye the deposit closely resembles amorphous phosphates. *Microscopically* it appears as pointed wedge-shaped prisms, either single, or more often grouped into rosettes, stars, fans, or sheaves.

3. Ammonio-magnesium Phosphate ($MgNH_4PO_4 + 6H_2O$), "Triple Phosphate," occurs as a white deposit in alkaline, neutral, or very rarely in feebly acid, urines. Glittering colourless crystals may be seen on the sides of the glass, and an iridescent film usually covers the surface. It is frequently found in small quantity along with amorphous phosphate in urine alkaline from fixed alkali. When abundant, its presence is usually due to ammoniacal decomposition.

Tests.—

(1) *Microscopic.*—Triangular prisms with bevelled ends, of variable size; "coffin-lid," "knife-rest," forms. Minute crystals somewhat resemble those of calcium oxalate; the latter are, however, insoluble in acetic acid. Occasionally at the beginning of alkaline fermentation "feathery" phosphates may be seen—fronds, feathers, and star-like figures.

(2) The crystals are very soluble in dilute acids, and are unaffected by alkalies or heat.

4. Basic Magnesium Phosphate ($Mg_3(PO_4)_2 + 22H_2O$) occurs as granules mixed with amorphous calcic phosphate, or as large highly refractive rhombic plates or tables. The crystalline form is very rare, and is seen in highly concentrated alkaline, neutral, or feebly acid urines.

THE SULPHUR.

The **Sulphates** of the urine are mainly derived from the albuminous metabolism of the body, only a very small portion being referable to the mineral constituents of the food. The greater portion is excreted in the form of mineral sulphates, but about 10 *per cent.* (conjugate sulphates) are in combination with the aromatic substances, indol, skatol, and phenol; and as these are formed during intestinal putrefaction, their amount will vary according to its intensity.

An increased excretion of the sulphates as a whole, occurs on a dietary rich in animal proteid, in the acute febrile diseases, diabetes, leukæmia, &c.; and a diminution of the amount is noted on a vegetable diet, in renal disease, &c.

An increase in the excretion of the conjugate sulphates indicates excessive intestinal putrefaction, and is thus of similar import to an increased excretion of indican.

Morphia, potassium bromide, sodium salicylate, antifebrin produce an increase in the sulphate excretion. The ingestion of terpenes, camphor, Carlsbad and Marienbad waters produce diminution in the excretion of the conjugate sulphates.

Calcium Sulphate ($CaSO_4 + 2H_2O$) has occasionally been found in crystalline form as long colourless needles, and elongated tables with abrupt extremities. They are insoluble in acids and ammonia.

Small quantities of **non-oxidised sulphur bodies** (neutral sulphur) are also found in every urine, but little is accurately known concerning them. Some sulphocyanides, and a substance called Cystein ($C_3H_7NSO_2$), are, however, generally present. In some cases Cystin ($C_6H_{12}N_2S_2O_4$)—the disulphide of cystein—makes its appearance in the urine, and may give rise to calculus formation. Cystinuria is usually permanent and of congenital origin; its cause is not understood.

Cystinuria is rarely recognised unless calculi form; in some cases, however, H_2S develops in the urine on standing, and the

characteristic cystin crystals are recognised on examination. The addition of acetic acid to these urines usually hastens crystallisation.

The deposit when copious is light in colour, like fawn coloured urates. When H_2S develops the sediment becomes dark in colour.

Tests.—

(1) *Microscopic.*—Symmetrical colourless hexagonal plates.

(2) They are soluble in ammonia and hydrochloric acid, and are insoluble in water, alcohol, ether, and acetic acid.

THE NITROGEN.

The urinary nitrogen is mainly excreted as Urea, but other nitrogenous compounds are also present in normal urine (uric acid, xanthin bases, hippuric acid, kreatinin, &c.). Urea represents about 85 *per cent.* of the nitrogenous excretion. The exact nature of its origin is somewhat obscure, but the current opinion is that the nitrogen leaves the tissues as the ammonium salt of paralactic acid, and that this is transformed in the liver into ammonium carbonate, and then into urea. In some forms of hepatic disease (acute yellow atrophy, &c.) leucin and tyrosin may appear in the urine; but it has not yet been decided whether this is due to autolytic digestion of necrotic liver cells, or to disturbance of the normal protein metabolism. Urea is not only derived from the food stuffs, but also from the tissues themselves, and this continues during starvation. Whenever tissue destruction is excessive, the elimination of urea is increased, and it is thus notable in acute febrile diseases, diabetes mellitus, leukæmia, &c. Coffee, morphia, ammonium, sodium and potassium chlorides, &c., also increase the elimination.

The amount of urea excreted is markedly deficient in acute yellow atrophy of the liver and in Weil's disease, and it may even be wholly absent. It is also deficient in hepatic cancer and cirrhosis. As urea is mainly excreted by the tubules of the kidney, while the salts and water are eliminated by the glomeruli, in cases of renal disease involving the former in particular, the watery and saline constituents (phosphates) may be fairly abundant and the urea deficient; and conversely, in glomerular disease the phosphatic secretion may be poor, while the urea output is fair.

Quantitative estimation of urea: sodium hypobromite method.—Gerrard's apparatus consists of a tall glass graduated to percentages, or to grains of urea per ounce of urine, connected by one indiarubber tube with a movable reservoir for water, and by a second with a wide-mouthed bottle. A short test tube to contain 5 c.c. of urine completes the apparatus. A fresh solution

of sodium hypobromite is prepared by dissolving 100 parts of NaOH in 250 parts water, and adding 25 parts bromine. (A convenient method is to use glass capsules containing 2·2 grammes bromine, with 23 c.c. of the soda solution, for each estimation).

(1) Albumen, if present, is removed by boiling and filtration.

(2) The apparatus is arranged so that the surface of the water in the graduated tube marks zero.

(3) 25 c.c. of test solution are poured into the bottle, and the test tube containing 5 c.c. of urine is carefully introduced into it, so that the urine does not mix with the solution. The bottle is then tightly corked, and the urine and hypobromite solution mixed. Effervescence occurs from the evolution of nitrogen and carbonic acid. The carbonic acid is absorbed by the excess of caustic soda, while the nitrogen displaces the water in the graduated tube ($CH_4N_2O + 3NaBrO = CO_2 + N_2 + 2H_2O + 3NaBr$).

(4) The position of the reservoir is rearranged, so that the water in it and the graduated vessel stand at the same level, and the volume of nitrogen evolved is read off from the scale as soon as the apparatus is cool.

Southall's apparatus consists of a graduated bulb tube closed at one end, and a bent pipette to measure the urine.

Hypobromite of soda solution is poured into the bulb tube up to a certain mark and diluted with water, so as to fill up the long arm and bend. The urine to be tested is drawn into the pipette to the graduation mark. The pipette is then passed into the ureometer as far as the bend, and the urine expelled into the long arm. The gas evolved collects in the upper part of the tube. The quantity of urea is then read off.

LEUCIN and TYROSIN are usually found together. They occur in quantity in acute yellow atrophy of the liver, and, in traces, in hepatic cirrhosis and cancer, gall-stones, jaundice, the infections, &c., but only rarely in phosphorus poisoning. Leucin is rarely deposited in crystalline form in the urine, and tyrosin only when present in large quantity. The urine should be concentrated on a water bath, and the deposit examined on cooling.

Tyrosin ($C_9H_{11}NO_3$) occurs as yellow acicular crystals, which are usually grouped as sheaves or bundles. They are insoluble

in acetic acid, and soluble in ammonia and hydrochloric acid.

Leucin ($C_6H_{13}NO_2$) occurs as dark-coloured spherules, with concentric and radiating lines. They resemble fat globules, but are insoluble in ether.

A small quantity of AMMONIA is always present in the urine, the nitrogen being probably retained in this form in the blood, so as to be able to neutralise any excessive formation of acid during the albuminous metabolism of the body. Whenever excessive formation of acids obtain (diabetes mellitus, pernicious vomiting of pregnancy) an increased elimination of nitrogen in the form of ammonium salts occurs, and they may, too, replace some of the urea if the hepatic parenchyma is gravely injured (acute yellow atrophy, phosphorus poisoning, pneumonia, enteric fever).

Quantitative estimation of ammonia : Folin's method—25 c.c. of urine are rendered alkaline by the addition of 1 gramme of sodium carbonate. A current of air is sent through the urine into a measured quantity of $\frac{n}{10}$ H_2SO_4. The ammonia is thus driven off and combines with the sulphuric acid. Its amount can be calculated by determining the loss of acidity of the H_2SO_4 solution.

URIC ACID ($C_5H_4N_4O_3$), according to the current opinions, is not derived from metabolism of all albumens, but from the nucleins alone ; and it may thus be derived from any of the purin (xanthin, alloxin) bases, or from nuclear nuclein. The quantity excreted will then depend upon the quantity and composition of the food stuffs, as liver, kidney, thymus, &c., contain large quantities, while the vegetable foods, milk, &c., contain but little ; and will also vary according to the metabolism of the tissues of the body as a whole (organs, leucocytes, muscles). In pathological conditions the greatest increase is found in leukæmia, pneumonia, &c., where leucocytosis and leucolysis are at a maximum ; while in anæmia, renal cirrhosis, &c., the quantity is often small. Some of the uric acid derived rom the food stuffs may be excreted with the fæces.

The excretion of uric acid in abnormal quantity has been

promoted by certain writers to the dignity of a specific disease; but it must be remembered that this excessive excretion is not incompatible with (apparently) perfect health, and that uric acid is in no way a poison, and can only produce symptoms when crystals are deposited in the urinary passages, and so cause local irritation. The excretion of large quantities is, however, often associated with alterations in metabolism, which, if continued, are prejudicial to health.

The exact nature of its relationship to gout is still undetermined, and little more is known now than when Garrod first showed that in gout it was present in the blood stream in large amount.

The presence of crystals of uric acid in the urine, on standing, *is no indication of its presence in abnormal amount*, and quantitative estimations are required to establish the fact. The soluble urates in the urine are precipated as biurates if acid sodium phosphate is the predominant salt, while the free acid is thrown down when the dibasic phosphate alone is present.

Uric acid forms a crystalline deposit varying in tint from the lightest amber to the darkest brown. Pure uric acid is colourless, and the colour depends on the amount of pigment in the urine (chiefly urochrome and uroerythrin). The crystals deposited in carboluria are almost black, and in choluria they are of a greenish-yellow colour. The deposit is rarely abundant, and usually appears as amber-coloured or brownish-yellow crystals deposited singly on the sides of the urine glass, or among the mucus ("cayenne pepper deposit"). Uric acid deposits only occur in acid urines.

Tests.—

(1) *Microscopic.*—The crystals appear as quadrangular and oval tablets, lozenges, cubes, barrel-shaped figures, sometimes as longitudinally striated spicules, rarely as dumb-bells. They may be grouped together to form stars, fans, rosettes, &c.

(2) The crystals are not dissolved by weak acids or alkalies, unless after long contact.

(3) *Murexide test.*—The sediment is filtered, washed in water, and dried over a water bath. A few drops of fuming HNO_3 are added, and the mixture is again dried. The residue, exposed to strong ammonia fumes or moistened with ammonia solution, becomes a brilliant purple colour.

The URATES are present as the ammonium, sodium, potassium, and calcium salts, and are not infrequently thrown out of solution in concentrated acid urines on cooling. The deposit may be copious, and though when pure, colourless, is generally reddish in tint from combination with uroerythrin. The common deposit of pink "lithates" is mainly composed of the potassium and sodium salts. *Urate of sodium* may, in children, be the cause of turbidity of the urine, and in such cases is not uncommonly colourless. *Urate of ammonium* practically never occurs unless in decomposing urine.

Tests.—

(1) *Microscopic.*—Amorphous urates occur as pink granules or strings or masses; urate of sodium as "hedgehog" crystals; urate of ammonium as coloured spheres, or minute crosses, dumb-bells or rosettes; (von Jaksch describes "hedgehog" crystals of this salt).

(2) Amorphous urates and urate of sodium crystals occur in acid urines, urate of ammonium in ammoniacal urines.

(3) Urates are readily dissolved by heat and weak alkalies. They are unaffected by weak acids, but are soluble in the strong mineral acids.

The XANTHIN BASES which have been found in the urine are xanthin, hypoxanthin, heteroxanthin, paraxanthin, guanin, and adenin; but little information is available as to the significance of their presence. Xanthin ($C_5H_4N_4O_2$) may, however, occur as a constituent of calculi, and excessively rarely as a deposit. Xanthin forms whetstone-shaped crystals, which are insoluble in acetic acid, and soluble in ammonia.

HIPPURIC ACID ($C_9H_9NO_3$) may be derived in part from the albuminous metabolism of the body, but also follows the ingestion of benzoic acid, which is present in many fruits, &.).

The crystals are found as isolated rhomboidal prisms.

KREATININ ($C_4H_7N_3O$) is a constant constituent of the urine, and is probably derived from the kreatin of the muscle tissue of the body and of the food. The output is increased in fever. It crystallises as transparent prisms, but is readily soluble in water.

Test.—A saturated solution of picric acid is mixed with an equal quantity of urine and 10 *per cent.* NaOH is added until the mixture is alkaline. The presence of kreatinin is shewn by the

appearance of a red colouration. Acetone also gives a similar reaction but the colouration is evanescent.

The urinary Oxalic Acid ($HCO_2)_2$) is probably in the main derived from the food stuffs, but it may result from tissue metabolism, as it is still excreted during starvation. Its exact origin is, however, indefinite.

In pathological states calcium oxalate crystals are not infrequently found in the urine; they may, apparently, be formed in the digestive tract from fermentation of carbohydrate food, perhaps, in particular, in cases where the HCl of the gastric juices is deficient; but it also occurs in cases of hyperchlorhydria. It occurs in the urine as the calcium salt, and may irritate the urinary passages if crystals are formed within them. Oxalate calculi are not uncommon.

A few crystals are often found in acid urines, mixed with uric acid or urates. They are rarely present in neutral or faintly alkaline urines. When abundant they form a white glittering layer upon the surface of the mucous deposit, as if dusted over it —"powdered-wig deposit." They are also seen as fine glittering streaks on the sides of the urine glass.

Tests.—

(1) *Microscopic.*—The crystals are usually colourless, but in bilious urines may have a faint yellow or greenish tint. They generally form highly refractive octohedra with a greatly shortened principal axis, so that they appear as squares with two diagonal lines ("envelope" form). Sometimes they assume the form of short rectangular prisms with pyramidal ends. They may also occur as bi-concave oval discs, somewhat resembling the oval corpuscles of avian blood, and as dumb-bells.

(2) The crystals are unaffected by heat or organic acids, and only slightly affected by dilute mineral acids or alkalies. They are readily dissolved by strong mineral acids.

Calcium Carbonate may be deposited from alkaline urine, and forms dumb-bell shaped masses and coarsely granular concretions, which dissolve in acetic acid with the evolution of gas.

Indigo occurs as amorphous particles and broken fragments, and also as blue crystals and fine blue needles, often aggregated into clusters. They are not very uncommon in urine undergoing alkaline fermentation.

THE GASES

All urines contains small quantities of gases, mainly CO_2, O, N.

In rare instances H_2S is given off by the urine when passed, as the result of bacterial infection ; but the organism required has not yet been isolated. The sulphur utilised is probably the "neutral" sulphur, and in cystinuria this H_2S formation has been not infrequently observed. In exceptional cases of diabetes a yeast infection of the bladder has occured with formation of excessive CO_2.

Rupture of the bowel, or of septic abscesses, into the bladder may allow the admixture of various kinds of gases with the urine.