age of chlorin by weight is about one-twelfth the bulk-percentage.

TABLE FOR THE ESTIMATION OF CHLORIDS AFTER CENTRIFUGATION

Showing the bulk-percentage of silver chlorid (AgCl) and the corresponding gravimetric percentages and grains per fluidounce of sodium chlorid (NaCl) and chlorin (Cl).—(Purdy.)

Bulk-percentage of AgCl.	Percentage NaCl.	Gr. Per Oz. NaCl.	Percentage Cl.	Gr. Per Oz. Cl.	Bulk-percentage of AgCl.	Percentage NaCl.	Gr. Per Oz. NaCl.	Percentage Cl.	Gr. Per Oz. Cl.
¼	0.03	0.15	0.02	0.1	8	1.04	4.98	0.63	3.02
⅜	0.07	0.31	0.04	0.19	8½	1.1	5.29	0.67	3.22
½	0.1	0.47	0.06	0.28	9	1.17	5.6	0.71	3.4
1	0.13	0.62	0.08	0.38	9½	1.23	5.91	0.75	3.6
1¼	0.16	0.78	0.1	0.48	10	1.3	6.22	0.79	3.79
1½	0.19	0.93	0.12	0.57	10½	1.36	6.53	0.83	3.97
1¾	0.23	1.09	0.14	0.67	11	1.43	6.84	0.87	4.16
2	0.26	1.24	0.16	0.76	11½	1.49	7.2	0.91	4.35
2¼	0.29	1.41	0.18	0.85	12	1.56	7.46	0.95	4.54
2½	0.32	1.56	0.2	0.96	12½	1.62	7.78	0.99	4.73
2¾	0.36	1.71	0.22	1.04	13	1.69	8.09	1.02	4.92
3	0.39	1.87	0.24	1.13	13½	1.75	8.4	1.06	5.11
3¼	0.42	2.02	0.26	1.23	14	1.82	8.71	1.1	5.29
3½	0.45	2.18	0.28	1.32	14½	1.88	9.02	1.14	5.49
3¾	0.49	2.35	0.3	1.42	15	1.94	9.33	1.18	5.67
4	0.52	2.49	0.32	1.51	15½	2.01	9.65	1.22	5.86
4¼	0.55	2.64	0.34	1.61	16	2.07	9.94	1.26	6.06
4½	0.58	2.8	0.35	1.7	16½	2.14	10.27	1.3	6.24
4¾	0.62	2.96	0.37	1.8	17	2.2	10.51	1.34	6.43
5	0.65	3.11	0.39	1.89	17½	2.27	10.87	1.38	6.62
5½	0.71	3.42	0.43	2.09	18	2.33	11.2	1.42	6.81
6	0.78	3.73	0.47	2.27	18½	2.4	11.51	1.46	7.0
6½	0.84	4.05	0.51	2.46	19	2.46	11.82	1.5	7.19
7	0.91	4.35	0.55	2.62	19½	2.53	12.13	1.54	7.38
7½	0.97	4.67	0.59	2.84	20	2.59	12.44	1.58	7.56

Bulk-percentage to be read on the side of the tube.

2. Phosphates.—Phosphates are derived largely from the food, only a small proportion resulting from metab-

olism. The normal daily output of phosphoric acid is about 2.5 to 3.5 gm.

The urinary phosphates are of two kinds: *alkaline*, which make up two-thirds of the whole, and include the phosphates of sodium and potassium; and *earthy*, which constitute one-third, and include the phosphates of calcium and magnesium. Earthy phosphates are frequently thrown out of solution in neutral and alkaline urines, and as " amorphous phosphates " form a very common sediment. This sediment seldom indicates an excessive excretion of phosphoric acid. It is usually merely an evidence of diminished acidity of the urine, or of an increase in the proportion of phosphoric acid eliminated as earthy phosphates. This form of " phosphaturia " is most frequent in neurasthenia and hysteria. When the urine undergoes ammoniacal decomposition, some of the ammonia set free combines with magnesium phosphate to form ammoniomagnesium phosphate (" triple phosphate "), which is deposited in typical crystalline form (p. 148).

Excretion of phosphates is *increased* by a rich diet; in active metabolism; in certain nervous and mental disorders; in leukemia; and in phosphatic diabetes, an obscure disturbance of metabolism (not related to diabetes mellitus) which is associated with an increase in the output of phosphates up to 10 gm. or more in twenty-four hours. Phosphates are *decreased* in chronic diseases with lowered metabolism; in hepatic cirrhosis and acute yellow atrophy; in pregnancy, owing to developing fetal bones; and in nephritis, owing to kidney impermeability.

Quantitative estimation does not furnish much of

definite clinical value. The centrifugal method is the most convenient.

TABLE FOR THE ESTIMATION OF PHOSPHATES AFTER CENTRIFUGATION

Showing bulk-percentages of uranyl phosphate ($H[UO_2]PO_4$) and the corresponding gravimetric percentages and grains per ounce of phosphoric acid (P_2O_5).—(Purdy.)

Bulk-percentage of $H(UO_2)PO_4$.	Percentage P_2O_5.	Gr. Per Oz. P_2O_5.	Bulk-percentage of $H(UO_2)PO_4$.	Percentage P_2O_5.	Gr. Per Oz. P_2O_5.
½	0.02	0.1	11	0.14	0.67
1	0.04	0.19	12	0.15	0.72
1½	0.045	0.22	13	0.16	0.77
2	0.05	0.24	14	0.17	0.82
2½	0.055	0.26	15	0.18	0.86
3	0.06	0.29	16	0.19	0.91
3½	0.065	0.31	17	0.2	0.96
4	0.07	0.34	18	0.21	1.
4½	0.075	0.36	19	0.22	1.06
5	0.08	0.38	20	0.23	1.1
6	0.09	0.43	21	0.24	1.15
7	0.1	0.48	22	0.25	1.2
8	0.11	0.53	23	0.26	1.25
9	0.12	0.58	24	0.27	1.3
10	0.13	0.62	25	0.28	1.35

Bulk-percentage to be read from graduation on the side of the tube.

Purdy's Centrifugal Method.—Take 10 c.c. urine in the graduated tube, add 2 c.c. of 50 per cent. acetic acid, and 3 c.c. of 5 per cent. uranium nitrate solution. Mix; let stand a few minutes, and revolve for three minutes at 1200 revolutions. The bulk of precipitate is normally about 8 per cent. The percentage of phosphoric acid by weight is, roughly, one-eighty-fifth of the bulk-percentage.

3. Sulphates.—The urinary sulphates are derived partly from the food, especially meats, and partly from body metabolism. The normal output of sulphuric acid is about 1.5 to 3 gm. daily. It is increased in condi-

tions associated with active metabolism, and in general may be taken as a rough index of protein metabolism.

Quantitative estimation of the total sulphates yields little of clinical value.

Purdy's Centrifugal Method.—Take 10 c.c. urine in the graduated tube and add barium chlorid solution to the 15 c.c. mark. This consists of barium chlorid, 4 parts; strong hydrochloric acid, 1 part; and distilled water, 16 parts. Mix; let stand a few minutes, and revolve for three minutes at 1200 revolutions a minute. The normal bulk of precipitate is about 0.8 per cent. The percentage by weight of sulphuric acid is about one-fourth of the bulk-percentage.

TABLE FOR THE ESTIMATION OF SULPHATES AFTER CENTRIFUGATION

Showing the bulk-percentages of barium sulphate ($BaSO_4$) and the corresponding gravimetric percentages and grains per fluidounce of sulphuric acid (SO_3).—(Purdy.)

Bulk-percentage of $BaSO_4$.	Percentage SO_3.	Gr. Per Oz. SO_3.	Bulk-percentage of $BaSO_4$.	Percentage SO_3.	Gr. Per Oz. SO_3.
$\frac{1}{8}$	0.04	0.19	$2\frac{1}{4}$	0.55	2.64
$\frac{1}{4}$	0.07	0.34	$2\frac{1}{2}$	0.61	2.93
$\frac{3}{8}$	0.1	0.48	$2\frac{3}{4}$	0.67	3.22
$\frac{1}{2}$	0.13	0.62	3	0.73	3.5
$\frac{5}{8}$	0.16	0.77	$3\frac{1}{4}$	0.79	3.79
$\frac{3}{4}$	0.19	0.91	$3\frac{1}{2}$	0.85	4.08
$\frac{7}{8}$	0.22	1.06	$3\frac{3}{4}$	0.91	4.37
1	0.25	1.1	4	0.97	4.66
$1\frac{1}{4}$	0.31	1.49	$4\frac{1}{4}$	1.03	4.94
$1\frac{1}{2}$	0.37	1.78	$4\frac{1}{2}$	1.09	5.23
$1\frac{3}{4}$	0.43	2.06	$4\frac{3}{4}$	1.15	5.52
2	0.49	2.35	5	1.21	5.81

Bulk-percentage to be read from graduation on the side of the tube.

About nine-tenths of the sulphuric acid is in combination with various mineral substances, chiefly sodium,

potassium, calcium, and magnesium (*mineral* or *preformed sulphates*). One-tenth is in combination with certain aromatic substances, which are mostly products of albuminous putrefaction in the intestine, but are derived in part from destructive metabolism (*conjugate* or *ethereal sulphates*). Among these aromatic substances are indol, phenol, and skatol. By far the most important of the conjugate sulphates and representative of the group is potassium indoxyl sulphate.

Potassium indoxyl sulphate, or **indican,** is derived from indol. Indol is absorbed and oxidized into indoxyl, which combines with potassium and sulphuric acid and is thus excreted. Under normal conditions the amount in the urine is small. It is increased by a meat diet.

Unlike the other ethereal sulphates, which are derived in part from metabolism, indican originates practically wholly from putrefactive processes. It alone, therefore, and not the total ethereal sulphates, can be taken as an index of such putrefaction. A pathologic increase is called indicanuria. It is noted in:

(*a*) *Diseases of the Small Intestine.*—This is by far the most common source. Intestinal obstruction gives the largest amounts of indican. It is also much increased in intestinal indigestion—so-called "biliousness"; in inflammations, especially in cholera and typhoid fever; and in paralysis of peristalsis, such as occurs in peritonitis. Simple constipation and diseases of the *large* intestine alone do not so frequently cause indicanuria.

(*b*) *Diseases of the stomach* associated with deficient hydrochloric acid, as chronic gastritis and gastric cancer.

Diminished hydrochloric acid favors intestinal putrefaction.

(*c*) *Diminished Flow of Bile.*—Since the bile serves both as a stimulant to peristalsis and an intestinal antiseptic, a diminished flow from any cause favors occurrence of indicanuria.

(*d*) *Decomposition of exudates* anywhere in the body, as in empyema, bronchiectasis, and large tuberculous cavities.

Detection of indican depends upon its decomposition and oxidation of the indoxyl set free into indigo-blue. This change sometimes takes place spontaneously in decomposing urine, causing a dirty blue color. Crystals of indigo (Fig. 36) may be found both in the sediment and the scum.

Obermayer's Method.—In a test-tube take equal parts of the urine and Obermayer's reagent and add a small quantity of chloroform. Mix by inverting a few times; avoid shaking violently. If indican be present in excess, the chloroform, which sinks to the bottom, will assume an indigo-blue color. It will take up the indigo more quickly if the urine be warm. The depth of color indicates the comparative amount of indican if the same proportions of urine and reagents are always used, but one should bear in mind the total amount of urine voided. The indican in normal urine may give a faint blue by this method. Urine of patients taking iodids gives a reddish-violet color, which disappears upon addition of a few drops of strong sodium hyposulphite solution and shaking. Bile-pigments, which interfere with the test, must be removed (p. 69).

Obermayer's reagent consists of strong hydrochloric acid (sp. gr., 1.19), 1000 parts, and ferric chlorid, 2 parts. This makes a yellow, fuming liquid which keeps well.

4. Urea.—From the standpoint of physiology urea is the most important constituent of the urine. It is the principal waste-product of metabolism, and constitutes about one-half of all the solids excreted—about 20 to 35 gm. in twenty-four hours. It represents 85 to 90 per cent. of the total nitrogen of the urine, and its quantitative estimation is a simple, though not very accurate, method of ascertaining the state of nitrogenous excretion.

This is true, however, only in normal individuals upon average mixed diet. Under pathologic conditions, the proportion of nitrogen distributed among the various nitrogen-containing substances undergoes great variation. The only accurate index of protein metabolism is, therefore, the total output of nitrogen, which can be estimated by the Kjeldahl method. The whole subject of "nitrogen partition" and "nitrogen equilibrium" (relation of excretion to intake) is an important one, but is out of the province of this book, since as yet it concerns the physiologic chemist more than the clinician.

It may be helpful to state here, however, that upon a mixed diet the nitrogen of the urine is distributed about as follows: urea nitrogen, 86.9 per cent.; ammonia nitrogen, 4.4 per cent.; creatinin nitrogen, 3.6 per cent.; uric acid nitrogen, 0.75 per cent.; "undetermined nitrogen," chiefly in amino acids, 4.3 per cent.

Normally, the amount is greatly influenced by exercise and diet. It is increased by copious drinking of water and administration of ammonium salts of organic acids.

Pathologically, urea is increased in fevers, in diabetes, and especially during resolution of pneumonia and ab-

sorption of large exudates. As above indicated, when other factors are equal, the amount of urea indicates the activity of metabolism. In deciding whether in a given case an increase of urea is due to increased metabolism the relation between the amounts of urea and of the chlorids is a helpful consideration. The amount of urea is normally about twice that of the chlorids. If the proportion is much increased above this, increased tissue destruction may be inferred, since other conditions which increase urea also increase chlorids.

Urea is decreased in diseases of the liver with destruction of liver substance, such as cirrhosis, carcinoma, and acute yellow atrophy. It may or may not be decreased in nephritis. In the early stages of chronic nephritis, when diagnosis is difficult, it is usually normal. In the late stages, when diagnosis is comparatively easy, it is decreased. Hence estimation of urea is of little help in the diagnosis of this disease, especially when, as is so frequently the case, a small quantity of urine taken at random is used. When, however, the diagnosis is established, estimations made at frequent intervals under the same conditions of diet and exercise are of much value, *provided a sample of the mixed twenty-four-hour urine be used.* A steady decline is a very bad prognostic sign, and a sudden marked diminution is usually a forerunner of uremia.

The presence of urea can be shown by allowing a few drops of the fluid partially to evaporate upon a slide, and adding a small drop of pure, colorless nitric acid or saturated solution of oxalic acid. Crystals of urea nitrate or oxalate (Fig. 23) will soon appear and can be recognized with the microscope.

Quantitative Estimation.—The hypobromite method, which is generally used, depends upon the fact that urea is decomposed by sodium hypobromite with liberation of nitrogen. The amount of urea is calculated from

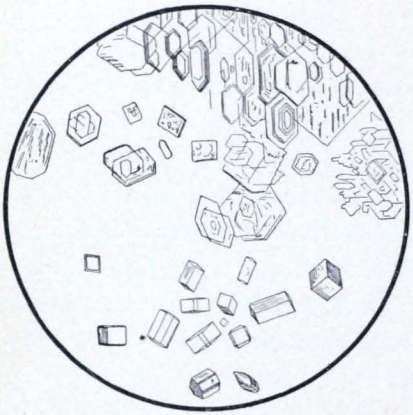


Fig. 23.—Crystals of nitrate of urea (upper half) and oxalate of urea (lower half) (after Funke).

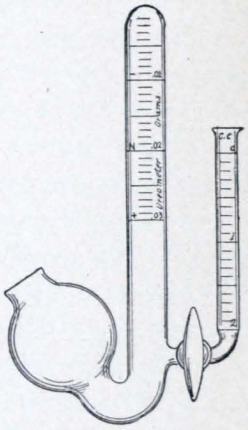


Fig. 24.—Doremus-Hinds' ureometer.

the volume of nitrogen set free. The improved Doremus apparatus (Fig. 24) is the most convenient.

Pour some of the urine into the smaller tube of the apparatus, then open the stopcock and quickly close it so as to fill its lumen with urine. Rinse out the larger tube with water and fill it and the bulb with 25 per cent. caustic soda solution. Add to this 1 c.c. of bromin by means of a medicine-dropper and mix well. This prepares a fresh solution of sodium hypobromite with excess of caustic soda, which serves to absorb the carbon dioxid set free in the decomposition of urea. When handling bromin, keep an open vessel of ammonia near to neutralize the irritant fumes.

Pour the urine into the smaller tube, and then turn the stopcock so as to let as much urine as desired (usually 1 c.c.)

run slowly into the hypobromite solution. When bubbles have ceased to rise, read off the height of the fluid in the large tube by the graduations upon its side. This gives the amount by weight of urea in the urine added, from which the amount excreted in twenty-four hours can easily be calculated. If the urine contains much more than the normal amount, it should be diluted.

To avoid handling pure bromin, which is disagreeable, Rice's solutions may be employed:

(*a*)	Bromin,	31 gm.
	Potassium bromid,	31 "
	Distilled water,	250 c.c.
(*b*)	Caustic soda,	100 gm.
	Distilled water,	250 c.c.

One part of each of these solutions and two parts of water are mixed and used for the test. The bromin solution must be kept in a tightly stoppered bottle or it will rapidly lose strength.

5. Uric Acid.—Uric acid is the most important of a group of substances, called *purin bodies,* which are derived chiefly from the nucleins of the food and from metabolic destruction of the nuclei of the body. The daily output of uric acid is about 0.4 to 1 gm. The amount of the other purin bodies together is about one-tenth that of uric acid. Excretion of these substances is greatly increased by a diet rich in nucleins, as sweetbreads and liver.

Uric acid exists in the urine in the form of urates, which in concentrated urines are readily thrown out of solution and constitute the familiar sediment of " amorphous urates." This, together with the fact that uric

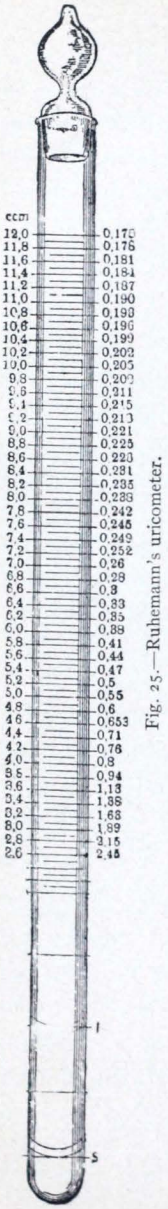


Fig. 25.—Ruhemann's uricometer.

acid is frequently deposited as crystals, constitutes its chief interest to the practitioner. It is a very common error to consider these deposits as evidence of excessive excretion.

Pathologically, the greatest increase of uric acid occurs in leukemia, where there is extensive destruction of leukocytes, and in diseases with active destruction of the liver and other organs rich in nuclei. Uric acid is decreased before an attack of gout and increased during it, but its etiologic relation is still uncertain. An increase is also noted in acute articular rheumatism during the febrile stage.

Quantitative Estimation.—The following are the best methods for ordinary clinical purposes, although no great accuracy can be claimed for them.

Cook's Method for Purin Bodies.—In a centrifuge tube take 10 c.c. urine and add about 1 gm. (about 1 c.c.) sodium carbonate and 1 or 2 c.c. strong ammonia. Shake until the soda is dissolved. The earthy phosphates will be precipitated. Centrifugalize thoroughly and pour off all the clear fluid into a graduated centrifuge tube. Add 2 c.c. ammonia and 2 c.c. ammoniated silver nitrate solution. Let stand a few minutes, and revolve in the centrifuge until the bulk of precipitate *remains constant.* Each one-tenth cubic centimeter

of sediment represents 0.001176 gm. purin bodies. This amount may be regarded as uric acid, since this substance usually constitutes nine-tenths of the purin bodies and the clinical significance is the same.

Ammoniated silver nitrate solution is prepared by dissolving 5 gm. of silver nitrate in 100 c.c. distilled water, and adding ammonia until the solution clouds and again becomes clear.

Ruhemann's Method for Uric Acid.—The urine must be slightly acid. Fill Ruhemann's tube (Fig. 25) to the mark *S* with the indicator, carbon disulphid, and to the mark *J* with the reagent. The carbon disulphid will assume a violet color. Add the urine, a small quantity at a time, closing the tube with the glass stopper and shaking vigorously after each addition, until the disulphid loses every trace of its violet color and becomes pure white. This completes the test. The figure in the right-hand column of figures corresponding to the top of the fluid gives the amount of uric acid in parts per thousand. The presence of diacetic acid interferes with the test, as do also, to some extent, bile and albumin.

Ruhemann's reagent consists of iodin and potassium iodid each, 1.5 parts; absolute alcohol, 15 parts; and distilled water, 185 parts.

6. Ammonia.—A small amount of ammonia, combined with hydrochloric, phosphoric, and sulphuric acids is always present. Estimated as NH_3, the normal average is about 0.7 gm. in twenty-four hours. This represents 4 to 5 per cent. of the total nitrogen of the urine, ammonia standing next to urea in this respect.

Under ordinary conditions, most of the ammonia which results from the metabolic processes is transformed into urea. When, however, acids are present in excess, either from ingestion of mineral acids or

from abnormal production of acids within the body (as in fevers, diabetes, pernicious vomiting of pregnancy, etc.), ammonia combines with them and is so excreted, urea being correspondingly decreased. It is thus that the body protects itself against acid intoxication. A marked increase of ammonia is, therefore, important chiefly as an index of the tendency to acidosis, particularly that associated with the presence of diacetic and oxybutyric acids.

In diabetes mellitus ammonia elimination may reach 4 or 5 gm. daily. It is likewise markedly increased in pernicious vomiting of pregnancy, but *not in nervous vomiting;* and in conditions in which the power to synthesize urea is interfered with, notably cirrhosis and other destructive diseases of the liver and conditions associated with deficient oxygenation.

Quantitative Estimation.—The urine must be fresh, since decomposition increases the amount of ammonia. The following method is satisfactory for clinical purposes, though subject to some inaccuracies.

Ronchese-Malfatti Formalin Test.—This depends upon the fact that when formalin is added to the urine, the ammonia combines with it, forming hexamethylene-tetramin. The acids with which the ammonia was combined are set free, and their quantity, ascertained by titration with sodium hydroxid, indicates the amount of ammonia.

Take 10 c.c. of the urine in a beaker or evaporating dish, add 50 c.c. water and 10 drops of 0.5 per cent. alcoholic solution of phenolphthalein. Neutralize by adding a weak caustic soda or sodium carbonate solution until a permanent pink color appears. To 5 c.c. formalin add 15 c.c. water and neutralize in the same way. Pour the formalin into the

urine. The pink color at once disappears, owing to liberation of acids. Now add decinormal sodium hydroxid solution from a buret until the pink color just returns. Each cubic centimeter of the decinormal solution used in this titration corresponds to 0.0017 gm. of NH_3. This must be multiplied by ten to obtain the percentage from which the twenty-four-hour elimination of ammonia is calculated.

The method is more complicated, but distinctly more accurate when carried out as suggested by E. W. Brown. Treat 60 c.c. of urine with 3 gm. of basic lead acetate, stir well, let stand a few minutes, and filter. Treat the filtrate with 2 gm. neutral potassium oxalate, stir well, and filter. Take 10 c.c. of the filtrate, add 50 c.c. water and 15 gm. neutral potassium oxalate, and proceed with the ammonia estimation as above outlined.

B. Abnormal Constituents

Those substances which appear in the urine only in pathologic conditions are of much more interest to the clinician than are those which have just been discussed. Among them are: proteins, sugars, the acetone bodies, bile, hemoglobin, and the diazo substances. The "pancreatic reaction" and detection of drugs in the urine will also be discussed under this head.

1. Proteins.—Of the proteins which may appear in the urine, serum-albumin and serum-globulin are the most important. Mucin, proteose, and a few others are found occasionally, but are of less interest.

(1) **Serum-albumin and Serum-globulin.**—These two proteins constitute the so-called "urinary albumin." They usually occur together, have practically the same significance, and both respond to all the ordinary tests for "albumin."

Their presence, or *albuminuria*, is probably the most important pathologic condition of the urine. It is either *accidental* or *renal*. The physician can make no greater mistake than to regard all cases of albuminuria as indicating kidney disease.

Accidental or *false albuminuria* is due to admixture with the urine of albuminous fluids, such as pus, blood, and vaginal discharge. The microscope will usually reveal its nature. It occurs most frequently in pyelitis, cystitis, and chronic vaginitis.

Renal albuminuria refers to albumin which has passed from the blood into the urine through the walls of the kidney tubules or the glomeruli.

Albuminuria sufficient to be recognized by clinical methods probably never occurs as a physiologic condition, the so-called *physiologic albuminuria* appearing only under conditions which must be regarded as abnormal. Among these may be mentioned excessive muscular exertion in those unaccustomed to it; excessive ingestion of proteins; prolonged cold baths; and childbirth. In these conditions the albuminuria is slight and transient.

There are certain other forms of albuminuria which have still less claim to be called physiologic, but which are not always regarded as pathologic. Among these are *cyclic albuminuria*, which regularly recurs at a certain period of the day, and *orthostatic* or *postural albuminuria*, which appears only when the patient is standing. They are rare and of obscure origin, and occur for the most part in neurasthenic subjects during adolescence. It is noteworthy in this connection that nephritis sometimes begins with a cyclic albuminuria.

In pathologic conditions and in most, at least, of the "functional" conditions just enumerated, renal albuminuria may be referred to one or more of the following causes. In nearly all cases it is accompanied by tube-casts.

(*a*) *Changes in the blood* which render its albumin more diffusible, as in severe anemias, purpura, and scurvy. Here the albumin is small in amount.

(*b*) *Changes in circulation in the kidney*, either anemia or congestion, as in excessive exercise, chronic heart disease, and pressure upon the renal veins. The quantity of albumin is usually, but not always, small. Its presence is constant or temporary, according to the cause. Most of the causes, if continued, will produce organic changes in the kidney.

(*c*) *Organic Changes in the Kidney.*—These include the inflammatory and degenerative changes commonly grouped together under the name of nephritis, and also renal tuberculosis, neoplasms, and cloudy swelling due to irritation of toxins and drugs. The amount of albumin eliminated in these conditions varies from minute traces to 20 gm., or even more, in the twenty-four hours, and, except in acute processes, bears little relation to the severity of the disease. In acute and chronic parenchymatous nephritis the quantity is usually very large. In chronic interstitial nephritis it is small—frequently no more than a trace. It is small in cloudy swelling from toxins and drugs, and variable in renal tuberculosis and neoplasms. In amyloid disease of the kidney the quantity is usually small, and serum-globulin may be present in especially large proportion, or even alone. Roughly distinctive of serum-globulin is the

appearance of an opalescent cloud when a few drops of the urine are dropped into a glass of distilled water.

Detection of albumin depends upon its precipitation by chemicals or coagulation by heat. There are many tests, but none is entirely satisfactory, because other substances as well as albumin are precipitated. The most common source of error is mucin. The tests given here are widely used and can be recommended. They make no distinction between serum-albumin and serum-globulin. They are given as nearly as possible in order of their delicacy. Usually the best time to detect albumin is in the evening or a few hours after a meal.

It is very important that urine to be tested for albumin be rendered clear by filtration or centrifugation. This is too often neglected in routine work. When ordinary methods do not suffice, it can usually be cleared by shaking up with a little purified talc or animal charcoal and filtering.

(1) **Trichloracetic Acid Test.**—The reagent consists of a saturated aqueous solution of trichloracetic acid to which magnesium sulphate is added to saturation. A simple saturated solution of the acid may be used, but addition of magnesium sulphate favors precipitation of globulin, and, by raising the specific gravity, makes the test easier to apply.

Take a few cubic centimeters of the reagent in a test-tube or conical test glass, hold the tube or glass in an inclined position, and run the urine gently in by means of a pipet, so that it will form a layer on top of the reagent without mixing with it. If albumin be present, a white, cloudy ring will appear where the two fluids come in contact. The ring can be seen most clearly if viewed against a black background,

and one side of the tube or conical glass may be painted black for this purpose.

This is an extremely sensitive test, but, unfortunately, both mucin and proteoses respond to it; urates, when abundant, may give a confusing white ring, and the reagent is comparatively expensive. It is not much used in routine work except as a control to the less sensitive tests.

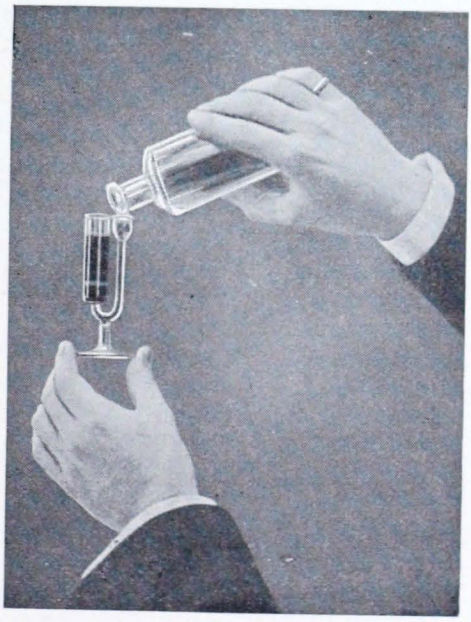


Fig. 26.—Horismascope: adding the reagent.

A most convenient instrument for applying this or any of the contact tests is sold under the name of " horismascope " (Fig. 26).

(2) **Robert's Test.**—The reagent consists of pure nitric acid, 1 part, and saturated aqueous solution of magnesium sulphate, 5 parts. It is applied in the same way as the preceding test.

Albumin gives a white ring, which varies in density with

the amount present. A similar white ring may be produced by primary proteose and resinous drugs. White rings or cloudiness in the urine above the zone of contact may result from excess of urates or mucus. Colored rings near the junction of the fluids may be produced by urinary pigments, bile, or indican.

Robert's test is one of the best for routine work, although the various rings are apt to be confusing to the inexperienced. It is more sensitive than Heller's test, of which it is a modification, and has the additional advantage that the reagent is not so corrosive.

(3) **Purdy's Heat Test.**—Take a test-tube two-thirds full of urine, add about one-sixth its volume of saturated solution of sodium chlorid, and 5 to 10 drops of 50 per cent. acetic acid. Mix, and boil the upper inch. A white cloud in the heated portion shows the presence of albumin.

This is a valuable test for routine work. It is simple, sufficiently accurate for clinical purposes, and has practically no fallacies. *Addition of the salt solution, by raising the specific gravity, prevents precipitation of mucin.* Proteose may produce a white cloud, which disappears upon boiling and reappears upon cooling.

(4) **Heat and Nitric Acid Test.**—This is one of the oldest of the albumin tests, and if properly carried out, one of the best. Boil a small quantity of filtered urine in a test-tube and add about one-twentieth its volume of concentrated nitric acid. A white cloud or flocculent precipitate (which usually appears during the boiling, but if the quantity be very small only after addition of the acid) denotes the presence of albumin. A similar white precipitate, which disappears upon addition of the acid, is due to earthy phosphates. The acid should not be added before boiling, and the proper amount should always be used; otherwise, part of the albumin may fail to be precipitated or may be redissolved.

Quantitative Estimation.—The gravimetric, which is the most reliable method, is too elaborate for clinical work. Both Esbach's, which is very widely used, and the centrifugal method give fair results, but Tsuchiya's recent modification of the Esbach method is preferable to either.

(1) **Esbach's Method.**—The urine must be clear, of acid reaction, and not concentrated. Always filter before testing, and, if necessary, add acetic acid and dilute with water. Esbach's tube (Fig. 27) is essentially a test-tube with a mark U near the middle, a mark R near the top, and graduations $\frac{1}{2}$, 1, 2, 3, etc., near the bottom. Fill the tube to the mark U with urine and to the mark R with the reagent. Close with a rubber stopper, invert slowly several times, and set aside in a cool place. At the end of twenty-four hours read off the height of the precipitate. This gives the amount of albumin in *grams per liter, and must be divided by* 10 *to obtain the percentage.*

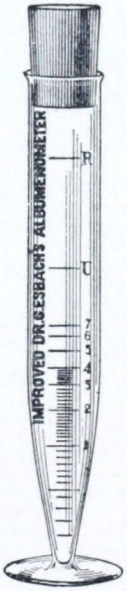


Fig. 27.—Esbach's albuminometer, improved form.

Esbach's reagent consists of picric acid, 1 gm., citric acid, 2 gm., and distilled water, to make 100 c.c.

(2) **Tsuchiya's Method.**—This is carried out in the same manner as the Esbach method, using the following reagent:

Phosphotungstic acid	1.5 gm.
96 per cent. alcohol	95.0 c.c.
Concentrated hydrochloric acid	5.0 "

The urine should be diluted to a specific gravity not exceeding 1.008. The method is said to be much more accurate than

the original Esbach method, particularly with small quantities of albumin.

(3) **Purdy's Centrifugal Method.**—This is detailed in the table on opposite page. The percentage by weight is approximately one-fiftieth of the bulk percentage.

(2) **Mucin.**—Traces of the substances (mucin, mucoid, etc.) which are loosely classed under this name are present in normal urine; increased amounts are observed in irritations and inflammations of the mucous membrane of the urinary tract. They are of interest chiefly because they may be mistaken for albumin in most of the tests. If the urine be diluted with water and acidified with acetic acid, the appearance of a white cloud indicates the presence of mucin.

True mucin is a glyco-protein, and upon boiling with an acid or alkali, as in Fehling's test, yields a carbohydrate substance which reduces copper.

(3) **Proteoses.**—These are intermediate products in the digestion of proteins and are frequently, although incorrectly, called albumoses. Two groups are generally recognized: *primary proteoses*, which are precipitated upon half-saturation of their solutions with ammonium sulphate; and *secondary proteoses*, which are precipitated only upon complete saturation.

The secondary proteoses have been observed in the urine in febrile and malignant diseases and chronic suppurations, during resolution of pneumonia, and in many other conditions, but their clinical significance is indefinite. In pregnancy, albumosuria may be due to absorption of amniotic fluid.

Primary proteoses are rarely encountered in the urine.

PURDY'S QUANTITATIVE METHOD FOR ALBUMIN IN URINE (CENTRIFUGAL).

Table showing the relation between the volumetric and gravimetric percentage of albumin obtained by means of the centrifuge with radius of six and three-quarter inches; rate of speed, 1500 revolutions per minute; time, three minutes.

Volumetric Percentage by Centrifuge.	Percentage by Weight of Dry Albumin.	Grains per Fluidounce Dry Albumin.	Volumetric Percentage by Centrifuge.	Percentage by Weight of Dry Albumin.	Grains per Fluidounce Dry Albumin.	Volumetric Percentage by Centrifuge.	Percentage by Weight of Dry Albumin.	Grains per Fluidounce Dry Albumin.
¼	0.005	0.025	13½	0.281	1.35	31½	0.656	3.15
½	0.01	0.05	14	0.292	1.4	32	0.667	3.2
¾	0.016	0.075	14½	0.302	1 45	32½	0.677	3.25
1	0.021	0.1	15	0.313	1.5	33	0.687	3.3
1¼	0.026	0.125	15½	0.323	1.55	33½	0.698	3.35
1½	0.031	0.15	16	0.333	1.6	34	0.708	3.4
1¾	0.036	0.175	16½	0.344	1.65	34½	0.719	3.45
2	0.042	0.2	17	0.354	1.7	35	0.729	3.5
2¼	0.047	0.225	17½	0.365	1.75	35½	0.74	3.55
2½	0.052	0.25	18	0.375	1.8	36	0.75	3.6
2¾	0.057	0.275	18½	0.385	1.85	36½	0.76	3.65
3	0.063	0.3	19	0.396	1.9	37	0.771	3.7
3¼	0.068	0.325	19½	0.406	1.95	37½	0.781	3.75
3½	0.073	0.35	20	0.417	2.	38	0.792	3.8
3¾	0.078	0.375	20½	0.427	2.05	38½	0.801	3.85
4	0.083	0.4	21	0.438	2.1	39	0.813	3.9
4¼	0.089	0.425	21½	0.448	2.15	39½	0.823	3.95
4½	0.094	0.45	22	0.458	2.2	40	0.833	4.
4¾	0.099	0.475	22½	0.469	2.25	40½	0.844	4.05
5	0.104	0.5	23	0.479	2.3	41	0.854	4.1
5½	0.111	0.55	23½	0.49	2.35	41½	0.865	4.15
6	0.125	0.6	24	0.5	2.4	42	0.875	4.2
6½	0.135	0.65	24½	0.51	2.45	42½	0.885	4.25
7	0.146	0.7	25	0.521	2.5	43	0.896	4.3
7½	0.156	0.75	25½	0.531	2.55	43½	0.906	4.35
8	0.167	0.8	26	0.542	2.6	44	0.917	4.4
8½	0.177	0.85	26½	0.552	2.65	44½	0.927	4.45
9	0.187	0.9	27	0.563	2.7	45	0.938	4.5
9½	0.198	0.95	27½	0.573	2.75	45½	0.948	4.55
10	0.208	1.	28	0.583	2.8	46	0.958	4.6
10½	0.219	1.05	28½	0.594	2.85	46½	0.969	4.65
11	0.229	1.1	29	0.604	2.9	47	0.979	4.7
11½	0.24	1.15	29½	0.615	2.95	47½	0.99	4.75
12	0.25	1.2	30	0.625	3.	48	1.	4.8
12½	0.26	1.25	30½	0.635	3.05	. . .	. . .	. . .
13	0.271	1.3	31	0.646	3.1	. . .	. . .	. . .

Test.—Three cubic centimeters of 10 per cent. solution of ferrocyanid of potassium and 2 cubic centimeters of 50 per cent. acetic acid are added to 10 cubic centimeters of the urine in the percentage tube and *stood aside for ten minutes*, then placed in the centrifuge and revolved at rate of speed and time as stated at head of the table. If albumin is excessive, dilute the urine with water until volume of albumin falls below 10 per cent. Multiply result by the number of dilutions employed before using the table.

The protein known as the "Bence-Jones body" was originally classed under this head, but its true nature is uncertain. It is regarded as practically pathognomonic of multiple myeloma.

The proteoses are not coagulable by heat, but are precipitated by such substances as trichloracetic acid and phosphotungstic acid. The primary proteoses, alone, are precipitated by nitric acid.

Proteoses may be detected by acidifying the urine with acetic acid, boiling and filtering while hot to remove mucin, albumin, and globulin, and testing the filtrate by the trichloracetic acid test. As above indicated, the nitric acid test, and half and complete saturation with ammonium sulphate will separate the two groups.

To detect Bence-Jones' body the urine is acidified with acetic acid and gently heated. If this substance be present, a precipitate will form at about 60° C. As the boiling-point is reached, it wholly or partially dissolves. It reappears upon cooling.

2. Sugars.—Various sugars may at times be found in the urine. Dextrose is by far the most common, and is the only one of clinical importance. Levulose, lactose, and some others are occasionally met with.

(1) **Dextrose (Glucose).**—It is probable that traces of glucose, too small to respond to the ordinary tests, are present in the urine in health. Its presence in appreciable amount constitutes "glycosuria."

Transitory glycosuria is unimportant, and may occur in many conditions, as after general anesthesia and administration of certain drugs, in pregnancy, and following shock and head injuries. It may also occur

after eating excessive amounts of carbohydrates (alimentary glycosuria).

Persistent glycosuria has been noted in brain injuries involving the floor of the fourth ventricle. As a rule, however, persistent glycosuria is diagnostic of diabetes mellitus, of which disease it is the essential symptom. The amount of glucose eliminated in diabetes is usually considerable, and is sometimes very large, reaching 500 gm., or even more, in twenty-four hours, but it does not bear any uniform relation to the severity of the disease. Glucose may, on the other hand, be almost or entirely absent temporarily.

Detection of Dextrose.—If albumin be present in more than traces, it must be removed by boiling and filtering.

(1) **Haines' Test.**—Take about 1 dram of Haines' solution in a test-tube, boil, and add 6 or 8 drops of urine. A heavy yellow or red precipitate, which settles readily to the bottom, shows the presence of sugar. Neither precipitation of phosphates as a light, flocculent sediment nor simple decolorization of the reagent should be mistaken for a positive reaction.

This is one of the best of the copper tests, all of which depend upon the fact that in strongly alkaline solutions glucose reduces cupric hydrate to cuprous hydrate (yellow) or cuprous oxid (red). They are somewhat inaccurate, because they make no distinction between glucose and less common forms of sugar; because certain normal substances, when present in excess, especially mucin, uric acid, and creatinin, may reduce copper, and because many drugs—*e. g.*, chloral, chloroform, copaiba, acetanilid, benzoic acid, morphin, sulphonal, salicylates—are eliminated as copper-reducing substances. To minimize these fallacies *dilute the urine, if it be concentrated; do not add more than the specified amount of urine, and do not boil after the urine is added.*

Haines' solution is prepared as follows: completely dissolve 30 gr. pure copper sulphate in ½ oz. distilled water, and add ½ oz. pure glycerin; mix thoroughly, and add 5 oz. liquor potassæ. The solution keeps well.

(2) **Fehling's Test.**—Two solutions are required—one containing 34.64 gm. pure crystalline copper sulphate in 500 c.c. distilled water; the other, 173 gm. Rochelle salt and 100 gm. potassium hydroxid in 500 c.c. distilled water. Mix equal parts of the two solutions in a test-tube, dilute with

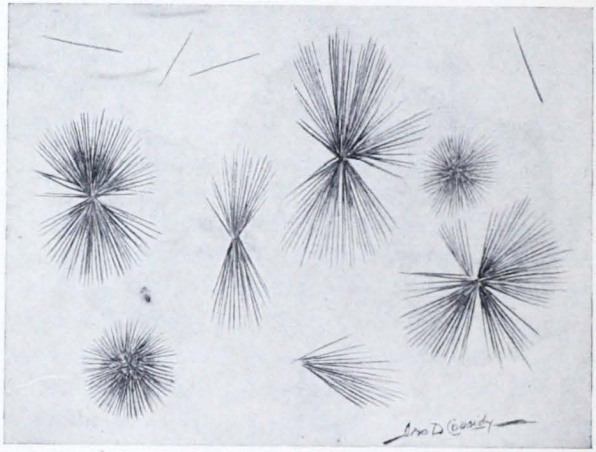


Fig. 28.—Crystals of phenylglucosazone from diabetic urine—Kowarsky's test (×500).

3 or 4 volumes of water, and boil. Add the urine a little at a time, heating, but not boiling, between additions. In the presence of glucose a heavy red or yellow precipitate will appear. The quantity of urine should not exceed that of the reagent.

(3) **Benedict's Test.**—This new test promises to displace all other reduction tests for glucose. The reagent is said to be ten times as sensitive as Haines' or Fehling's, and not to be reduced by uric acid, creatinin, chloroform, or the aldehyds. It consists of:

Copper sulphate (pure crystallized),	17.3 gm.
Sodium or potassium citrate,	173.0 "
Sodium carbonate (crystallized), (or 100 gm. of the anhydrous salt).	200.0 "
Distilled water, to make	1000.0 c.c.

Dissolve the citrate and carbonate in 700 c.c. of water, with the aid of heat, and filter. Dissolve the copper in 100 c.c. of water and pour slowly into the first solution, stirring constantly. Cool, and make up to one liter. The reagent keeps indefinitely.

Take about 5 c.c. of this reagent in a test-tube, and add *8 or 10 drops* (*not more*) of the urine. Heat to vigorous boiling, keep at this temperature for one or two minutes, and allow to cool slowly. In the presence of glucose the entire body of the solution will be filled with a precipitate, which may be red, yellow, or green in color. When traces only of glucose are present, the precipitate may appear only upon cooling. In the absence of glucose, the solution remains clear or shows only a faint, *bluish* precipitate, due to urates.

(4) **Phenylhydrazin Test.**— *Kowarsky's Method.*—In a wide test-tube take 5 drops pure phenylhydrazin, 10 drops glacial acetic acid, and 1 c.c. saturated solution of sodium chlorid. A curdy mass results. Add 2 or 3 c.c. urine, boil for at least two minutes, and set aside to cool. Examine the sediment with the microscope, using a two-thirds objective. If glucose be present, characteristic crystals of phenylglucosazone will be seen. These are yellow, needle-like crystals arranged mostly in clusters or in sheaves (Fig. 28). When traces only of glucose are present, the crystals may not appear for one-half hour or more. Best crystals are obtained when the fluid is cooled very slowly. It must not be agitated during cooling.

This is an excellent test for clinical work. It requires slightly more time than Haines' test, but more than compensates for this by increased accuracy. It is fully as sensitive as Haines', and has practically no fallacies excepting levulose, which is a fallacy for all tests but the polariscope. Other carbohydrates which are capable of forming crystals with phenylhydrazin are extremely unlikely to do so when the test is applied directly to the urine by the method just detailed. Even if not used routinely, this test should always be resorted to when Haines' test gives a positive reaction in doubtful cases.

Quantitative Estimation.—In quantitative work Fehling's solution, for so many years the standard, has been largely displaced by Purdy's, which avoids the heavy precipitate that so greatly obscures the end-reaction in Fehling's method. The older method is still preferred by many, and both are, therefore, given. The new method of Benedict is likewise included, since it appears to be more exact than any other titration method available for sugar work. Should the urine contain much glucose, it must be diluted before making any quantitative test, allowance being made for the dilution in the subsequent calculation. Albumin, if present, must be removed by acidifying a considerable quantity of urine with acetic acid, boiling, and filtering. The precipitate should then be washed with water and the washings added to the urine to bring it to its original volume.

(1) **Purdy's Method.**—Take exactly 35 c.c. of Purdy's solution in a flask or beaker, add twice its volume of distilled water, heat to boiling, and, still keeping the solution hot, add

the urine very slowly from a buret until the blue color entirely disappears. Read off the amount of urine added; considering the strength of Purdy's solution, it is readily seen that this amount of urine contains 0.02 gm. of glucose, from which the amount in the twenty-four-hour urine, or the percentage, can easily be calculated. Example: Suppose that 2.5 c.c. of urine discharged the blue color of 35 c.c. of Purdy's solution. This amount of urine, therefore, contains exactly 0.02 gm. glucose, and the percentage is obtained from the equation: 2.5 : 100 : : 0.02 : x, and x equals 0.8 per cent. If, then, the twenty-four-hour quantity of urine were 3000 c.c., the twenty-four-hour elimination of glucose would be found as follows: 100 : 3000 : : 0.8 : x, and x equals 24 gm.

It will be found that after the test is completed the blue color slowly returns. This is due to reoxidation, and should not be mistaken for incomplete reduction.

A somewhat simpler application of this method, which is accurate enough for clinical purposes, is as follows: Take $8\frac{3}{4}$ c.c. (roughly, 9 c.c.) of Purdy's solution in a large test-tube, dilute with an equal volume of water, heat to boiling, and, while keeping the solution hot but not boiling, add the urine drop by drop from a medicine-dropper until the blue color is entirely gone. Toward the end add the drops very slowly, not more than 4 or 5 a minute. Divide 10 by the number of drops required to discharge the blue color; the quotient will be the percentage of glucose. If 20 drops were required, the percentage would be $10 \div 20 = 0.5$ per cent. It is imperative that the drops be of such size that 20 of them will make 1 c.c. Test the dropper with urine, not water. If the drops are too large, draw out the tip of the dropper; if too small, file off the tip.

Purdy's solution consists of pure crystalline copper sulphate, 4.752 gm.; potassium hydroxid, 23.5 gm.; ammonia (U. S. P.; sp. gr., 0.9), 350 c.c.; glycerin, 38 c.c.; distilled water, to make

1000 c.c. Dissolve the copper sulphate and glycerin in 200 c.c. of the water by aid of gentle heat. In another 200 c.c. of water dissolve the potassium hydroxid. Mix the two solutions, and when cool, add the ammonia. Lastly, bring the whole up to 1000 c.c. with distilled water. This solution is of such strength that the copper in 35 c.c. will be reduced by exactly 0.02 gm. of glucose.

(2) **Fehling's Method.**—Take 10 c.c. Fehling's solution (made by mixing 5 c.c. each of the copper and alkaline solutions described on page 110) in a flask or beaker, add three or

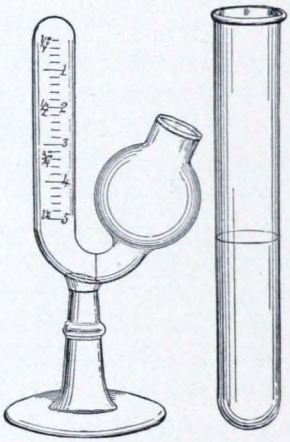


Fig. 29.—Einhorn's saccharimeter.

four volumes of water, boil, and add the urine very slowly from a buret until the solution is completely decolorized, heating but not boiling after each addition.

The chief objection to Fehling's method is the difficulty of determining the end-point. The use of an "outside indicator," however, obviates this. When reduction is thought to be complete, a few drops of the solution are filtered through a fine-grained filter-paper on to a porcelain plate, quickly acidified with acetic acid, and mixed with a drop of 10 per

cent. potassium ferrocyanid. Immediate appearance of a red-brown color shows the presence of unreduced copper.

Fehling's solution is of such strength that the copper in 10 c.c. will be reduced by exactly 0.05 gm. of glucose. Therefore, the amount of urine required to decolorize the test solution contains just 0.05 gm. glucose, and the percentage is easily calculated.

(3) **Benedict's Method.**—The following modification of his copper solution has recently been offered by Benedict for quantitative estimations.

The reagent consists of:

Copper sulphate (pure crystallized),	18.0 gm.
Sodium carbonate (crystallized),	200.0 "
(or 100 gm. of the anhydrous salt).	
Sodium or potassium citrate,	200.0 "
Potassium sulphocyanate,	125.0 "
5 per cent. potassium ferrocyanid solution,	5.0 c.c.
Distilled water, to make	1000.0 "

With the aid of heat dissolve the carbonate, citrate, and sulphocyanate in about 800 c.c. of the water and filter. Dissolve the copper in 100 c.c. of water and pour slowly into the other fluid, stirring constantly. Add the ferrocyanid solution, cool, and dilute to 1000 c.c. Only the copper need be accurately weighed. This solution is of such strength that 25 c.c. are reduced by 0.05 gram glucose. It keeps well.

To make a sugar estimation, take 25 c.c. of the reagent in a porcelain evaporating dish, add 10 to 20 grams sodium carbonate crystals (or one-half this weight of the anhydrous salt) and a small quantity of powdered pumice-stone or talcum. Heat to boiling, and add the urine rather rapidly from a buret until a chalk-white precipitate forms and the blue color of the reagent begins to fade. After this

point is reached, add the urine a few drops at a time until the last trace of blue just disappears. This end-point is easily recognized. During the whole of the titration the mixture must be kept vigorously boiling. Loss by evaporation must be made up by adding water. The quantity of urine required to discharge the blue color contains exactly 0.05 gram glucose, and the percentage contained in the original sample is easily calculated.

(4) **Fermentation Method.**—This is convenient and satisfactory, its chief disadvantage begin the time required. It depends upon the fact that glucose is fermented by yeast with evolution of CO_2. The amount of gas evolved is an index of the amount of glucose. Einhorn's saccharimeter (Fig. 29) is the simplest apparatus.

The urine must be so diluted as to contain not more than 1 per cent. of glucose. A fragment of fresh yeast cake about the size of a split-pea is mixed with a definite quantity of the urine measured in the tube which accompanies the apparatus. It should form an emulsion free from lumps or air-bubbles. The long arm of the apparatus is then filled with the mixture. At the end of fifteen to twenty-four hours fermentation will be complete, and the percentage of glucose can be read off upon the side of the tube. The result must then be multiplied by the degree of dilution. Since yeast itself sometimes gives off gas, a control test must be carried out with normal urine and the amount of gas evolved must be subtracted from that of the test. A control should also be made with a known glucose solution to make sure that the yeast is active.

(5) **Robert's Differential Density Method.**—While this method gives only approximate results, it is convenient, and requires no special apparatus but an accurate urinometer. Mix a quarter of a yeast-cake with about 4 oz. of urine. Take the specific gravity and record it. Set the urine in a warm place for twenty-four hours or until fermentation is com-

plete. Then cool to the temperature at which the specific gravity was originally taken, and take it again. The difference between the two readings gives the number of grains of sugar per ounce, and this, multiplied by 0.234, gives the *percentage* of sugar. If the original reading is 1.035, and that after fermentation is 1.020, the urine contains $1.035 - 1.020 = 15$ grains of sugar per fluidounce; and the percentage equals $15 \times 0.234 = 3.5$.

(2) **Levulose,** or **fruit-sugar,** is very rarely present in the urine except in association with glucose, and has about the same significance. Its name is derived from the fact that it rotates polarized light to the left. It behaves the same as glucose with all the ordinary tests, and is not readily distinguished except by polarization.

(3) **Lactose,** or **milk-sugar,** is sometimes present in the urine of nursing women and in that of women who have recently miscarried. It is of interest chiefly because it may be mistaken for glucose. *It reduces copper, but does not ferment with yeast.* In strong solution it can form crystals with phenylhydrazin, but is extremely unlikely to do so when the test is applied directly to the urine.

(4) **Pentoses.**—These sugars are so named because they contain five atoms of oxygen. Vegetable gums form their chief source. They reduce copper strongly but slowly, and give crystals with phenylhydrazin, but do not ferment with yeast.

Pentosuria is uncommon. It has been noted after ingestion of large quantities of pentose-rich substances, such as cherries, plums, and fruit-juices, and is said to be fairly constant in habitual use of morphin. It sometimes accompanies glycosuria in diabetes. An obscure

chronic form of pentosuria without clinical symptoms has been observed.

Bial's Orcin Test.—Dextrose is first removed by fermentation. About 5 c.c. of Bial's reagent are heated in a test-tube, and after removing from the flame the urine is added drop by drop, not exceeding twenty drops in all. The appearance of a green color denotes pentose.

The reagent consists of:

30 per cent. hydrochloric acid	500 c.c.
10 per cent. ferric chlorid solution	25 drops
Orcin	1 gram.

3. Acetone Bodies.—This is a group of closely related substances—acetone, diacetic acid, and beta-oxybutyric acid. Acetone is derived from decomposition of diacetic acid, and this in turn from beta-oxybutyric acid by oxidation. The origin of beta-oxybutyric acid is not definitely known, but it is probable that its chief, if not its only, source is in some obscure metabolic disturbance with abnormal destruction of fats. The three substances generally appear in the urine in the order mentioned. When the disturbance is mild, acetone only appears; as it becomes more marked, diacetic acid is added, and finally beta-oxybutyric acid appears. The presence of beta-oxybutyric acid in the blood is probably the chief cause of the form of auto-intoxication known as "acid intoxication."

(1) **Acetone.**—Minute traces, too small for the ordinary tests, may be present in the urine under normal conditions. Larger amounts are not uncommon in fevers, gastro-intestinal disturbances, and certain nervous disorders. A notable degree of acetonuria has

likewise been observed in pernicious vomiting of pregnancy and in eclampsia.

Acetonuria is practically always observed in acid intoxication, and, together with diaceturia, constitutes its most significant diagnostic sign. A similar or identical toxic condition, always accompanied by acetonuria and often fatal, is now recognized as a not infrequent late effect of anesthesia, particularly of chloroform anesthesia. This postanesthetic toxemia is more likely to appear, and is more severe when the urine contains any notable amount of acetone before operation, which suggests the importance of routine examination for acetone in surgical cases.

Acetone is present in considerable amounts in many cases of diabetes mellitus, and is always present in severe cases. Its amount is a better indication of the severity of the disease than is the amount of sugar. A progressive increase is a grave prognostic sign. It can be diminished temporarily by more liberal allowance of carbohydrates in the diet.

According to Folin, acetone is present in only small amounts in these conditions, the substance shown by the usual tests, particularly after distillation of the urine, being really diacetic acid. In this connection, Frommer's test is to be recommended, since it does not require distillation, and does not react to diacetic acid unless too great heat is applied.

Detection of Acetone.—The urine may be tested directly, but it is best to distil it after adding a little phosphoric or hydrochloric acid to prevent foaming, and to test the first few cubic centimeters of distillate. A simple distilling apparatus is shown in Fig. 30. The

test-tube may be attached to the delivery tube by means of a two-hole rubber cork as shown, the second hole serving as air vent, or, what is much less satisfactory, it may be tied in place with a string. Should the vapor not condense well, the test-tube may be immersed in a glass of cold water.

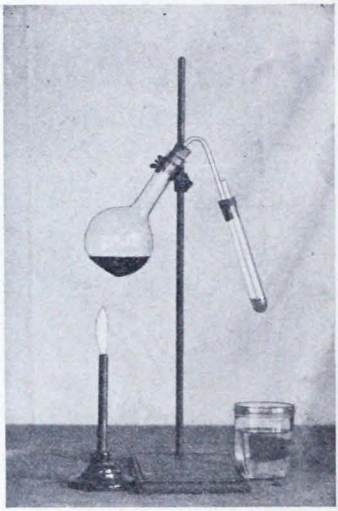


Fig. 30.—A simple distilling apparatus.

When diacetic acid is present, a considerable proportion will be converted into acetone during distillation.

(1) **Gunning's Test.**—To a few cubic centimeters of urine or distillate in a test-tube add a few drops of tincture of iodin and of ammonia alternately until a heavy black cloud appears. This cloud will gradually clear up, and if acetone be present, iodoform, usually crystalline, will separate out. The iodoform can be recognized by its odor, especially upon heating (there

is danger of explosion if the mixture be heated before the black cloud disappears), or by detection of the crystals microscopically. The latter only is safe, unless one has an unusually acute sense of smell. Iodoform crystals are yellowish, six-pointed stars or six-sided plates (Fig. 31).

This modification of Lieben's test is less sensitive than the original, but is sufficient for all clinical work; it has the advantage that alcohol does not cause confusion, and especially that the sediment of iodoform is practically always crystalline. When applied directly to the urine, phosphates are precipi-

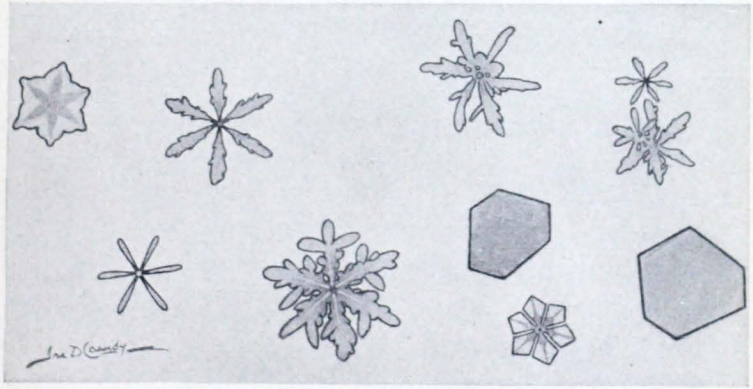


Fig. 31.—Iodoform crystals obtained in several tests for acetone by Gunning's method (× about 600).

tated and may form star-shaped crystals which are very confusing to the inexperienced. Albumin prevents formation of the crystals, and when it is present, the urine must be distilled for the test.

(2) **Lange's Test.**—This is a modification of the well-known Legal test. It is more sensitive and gives a sharper end-reaction. To a small quantity of urine add about one-twentieth its volume (1 drop for each 1 c.c.) of glacial acetic acid and a few drops of fresh concentrated aqueous solution of sodium nitroprussid, and gently run a little ammonia upon its

surface. If acetone be present, a purple ring will form within a few minutes at the junction of the two fluids.

(3) **Frommer's Test.**—This test has proved very satisfactory in the hands of the writer. The urine need not be distilled. Alkalinize about 10 c.c. of the urine with 2 or 3 c.c. of 40 per cent. caustic soda solution, add 10 or 12 drops of 10 per cent. alcoholic solution of salicylous acid (salicyl aldehyd), heat the upper portion to about 70° C. (it should not reach the boiling-point), and keep at this temperature five minutes or longer. In the presence of acetone an orange color, changing to deep red, appears in the heated portion.

The test can be made more definite by adding the caustic soda in substance (about 1 gram), and before it goes into solution adding the salicyl aldehyd and warming the lower portion.

(2) **Diacetic acid** occurs in the same conditions as acetone, but is less frequent and has more serious significance. In diabetes its presence is a grave symptom and often forewarns of approaching coma. It rarely or never occurs without acetone.

Detection.—The urine must be fresh.

(1) **Gerhardt's Test.**—To a few cubic centimeters of the urine add solution of ferric chlorid (about 10 per cent.) drop by drop until the phosphates are precipitated; filter and add more of the ferric chlorid. If diacetic acid be present, the urine will assume a Bordeaux-red color which disappears upon boiling. A red or violet color which does not disappear upon boiling may be produced by other substances, as phenol, salicylates, and antipyrin.

(2) **Lindemann's Test.**—To about 10 c.c. of urine add 5 drops 30 per cent. acetic acid, 5 drops Lugol's solution, and 2 or 3 c.c. chloroform, and shake. The chloroform does not change color if diacetic acid be present, but becomes reddish

violet in its absence. This test is claimed by its advocates to be more sensitive and more reliable than Gerhardt's.

(3) **Oxybutyric acid** has much the same significance as diacetic acid, but is of more serious import. There is no satisfactory clinical test for it.

4. **Bile.**—Bile appears in the urine in all diseases which produce jaundice, often some days before the skin becomes yellow; and in many disorders of the liver not severe enough to cause jaundice. It also occurs in diseases with extensive and rapid destruction of red blood-corpuscles. Both bile-pigment and bile acids may be found. They generally occur together, but the pigment is not infrequently present alone. Bilirubin, only, occurs in freshly voided urine, the other pigments (biliverdin, bilifuscin, etc.) being produced from this by oxidation as the urine stands. The acids are almost never present without the pigments, and are, therefore, seldom tested for clinically.

Detection of Bile-pigment.—Bile-pigment gives the urine a greenish-yellow, yellow, or brown color, which upon shaking is imparted to the foam. Cells, casts, and other structures in the sediment may be stained brown or yellow. This, however, should not be accepted as proving the presence of bile without further tests.

(1) **Smith's Test.**—Overlay the urine with tincture of iodin diluted with nine times its volume of alcohol. An emerald-green ring at the zone of contact shows the presence of bile-pigments. It is convenient to use a conical test-glass, one side of which is painted white.

(2) **Gmelin's Test.**—This consists in bringing slightly yellow nitric acid into contact with the urine. A play of

colors, of which green and violet are most distinctive, denotes the presence of bile-pigment. Colorless nitric acid will become yellow upon standing in the sunlight. The test may be applied in various ways: by overlaying the acid with the urine; by bringing a drop of each together upon a porcelain plate; by filtering the urine through thick filter-paper, and touching the paper with a drop of the acid; and, probably best of all, by precipitating with lime-water, filtering, and touching the precipitate with a drop of the acid. In the last method bilirubin is carried down as an insoluble calcium compound.

Detection of Bile Acids.—Hay's test is simple, sensitive, and fairly reliable, and will, therefore, appeal to the practitioner. It depends upon the fact that bile acids lower surface tension. Other tests require isolation of the acids for any degree of accuracy.

Hay's Test.—Upon the surface of the urine, which must not be warm, sprinkle a little finely powdered sulphur. If it sinks at once, bile acids are present to the amount of 0.01 per cent. or more; if only after gentle shaking, 0.0025 per cent. or more. If it remains floating, even after gentle shaking, bile acids are absent.

5. Hemoglobin.—The presence in the urine of hemoglobin or pigments directly derived from it, accompanied by few, if any, red corpuscles, constitutes *hemoglobinuria*. It is a rare condition, and must be distinguished from *hematuria*, or *blood* in the urine, which is common. In both conditions chemic tests will show hemoglobin, but in the latter the microscope will reveal the presence of red corpuscles. Urines which contain notable amounts of hemoglobin have a reddish or brown color, and may deposit a sediment of brown, granular pigment.

Hemoglobinuria occurs when there is such extensive destruction of red blood-cells within the body that the liver cannot transform all the hemoglobin set free into bile-pigment. The most important examples are seen in poisoning, as by mushrooms and potassium chlorate, in scurvy and purpura, in malignant malaria (blackwater fever), and in the obscure condition known as " paroxysmal hemoglobinuria." This last is characterized by the appearance of large quantities of hemoglobin at intervals, usually following exposure to cold, the urine remaining free from hemoglobin between the attacks.

Detection.—Teichmann's test (p. 274) may be applied to the precipitate after boiling and filtering, but the guaiac test is more convenient in routine work.

Guaiac Test.—Mix equal parts of " ozonized " turpentine and fresh tincture of guaiac which has been diluted with alcohol to a light sherry-wine color. In a test-tube or conical glass overlay the urine with this mixture. A bright blue ring will appear at the zone of contact within a few minutes if hemoglobin be present. The guaiac should be kept in an amber-colored bottle. Fresh turpentine can be " ozonized " by allowing it to stand a few days in an open vessel in the sunlight.

This test is very sensitive, and a negative result proves the absence of hemoglobin. Positive results are not conclusive, because numerous other substances—few of them likely to be found in the urine—may produce the blue color. That most likely to cause confusion is pus, but the blue color produced by it disappears upon heating. The thin film of copper often left in a test-tube after testing for sugar may give the reaction, as may also the fumes from an open bottle of bromin.

6. Alkapton Bodies.—The name, alkaptonuria, has been given to a condition in which the urine turns reddish-brown upon standing and strongly reduces copper (but not bismuth), owing to the presence of certain substances which result from imperfect protein metabolism. The change of color takes place quickly when fresh urine is alkalinized, hence the name, *alkapton bodies*.

Alkaptonuria is unaccompanied by other symptoms, and has little clinical importance. Only about forty-five cases, mostly congenital, have been reported. The change in color of the urine and the reduction of copper with no reduction of bismuth nor fermentation with yeast would suggest the condition.

7. Melanin.—Urine which contains melanin likewise darkens upon exposure to the air, assuming a dark brown or black color. This is due to the fact that the substance is eliminated as a chromogen—melanogen—which is later converted into the pigment.

Melanuria occurs in most, but not all, cases of melanotic sarcoma. Its diagnostic value is lessened by the fact that it has been observed in other wasting diseases.

Tests for Melanin.—(1) Addition of ferric chlorid gives a gray precipitate which blackens on standing.

(2) Bromin water causes a yellow precipitate which gradually turns black.

8. Diazo Substances.—Certain unknown substances sometimes present in the urine give a characteristic color reaction—the "diazo reaction" of Ehrlich—when treated with diazo-benzol-sulphonic acid and ammonia.

This reaction has much clinical value, provided its limitations be recognized. It is at best an empirical test and must be interpreted in the light of clinical symptoms. Although it has been met with in a considerable number of diseases, its usefulness is practically limited to typhoid fever, tuberculosis, and measles.

(1) **Typhoid Fever.**—Practically all cases give a positive reaction, which varies in intensity with the severity of the disease. It is so constantly present that it is sometimes said to be " negatively pathognomonic ": if negative upon several successive days at a stage of the disease when it should be positive, typhoid is almost certainly absent. Upon the other hand, a reaction when the urine is highly diluted (1: 50 or more) has much positive diagnostic value, since this dilution prevents the reaction in most conditions which might be mistaken for typhoid; but it should be noted that mild cases of typhoid may not give it at this dilution. Ordinarily the diazo appears a little earlier than the Widal reaction,—about the fourth or fifth day,—but it may be delayed. In contrast to the Widal, it begins to fade about the end of the second week, and soon thereafter entirely disappears. An early disappearance is a favorable sign. It reappears during a relapse, and thus helps to distinguish between a relapse and a complication, in which it does not reappear.

(2) **Tuberculosis.**—The diazo reaction has been obtained in many forms of the disease. It has little or no diagnostic value. Its continued presence in pulmonary tuberculosis is, however, a grave prognostic sign, even when the physical signs are slight. After it once appears it generally persists more or less intermit-

tently until death, the average length of life after its appearance being about six months. The reaction is often temporarily present in mild cases during febrile complications, and has then no significance.

(3) **Measles.**—A positive reaction is usually obtained in measles, and may help to distinguish this disease from German measles, in which it does not occur. It generally appears before the eruption and remains about five days.

Technic.—Although the test is really a very simple one, careful attention to technic is imperative. Many of the early workers were very lax in this regard. Faulty technic and failure to record the stage of the disease in which the tests were made have probably been responsible for the bulk of the conflicting results reported.

Certain drugs often given in tuberculosis and typhoid interfere with or prevent the reaction. The chief are creosote, tannic acid and its compounds, opium and its alkaloids, salol, phenol, and the iodids. The reagents are:

(1) Saturated solution sulphanilic acid in 5 per cent. hydrochloric acid.

(2) 0.5 per cent. aqueous solution sodium nitrite.

(3) Strong ammonia.

Mix 100 parts of (1) and one part of (2). In a test-tube take equal parts of this mixture and the urine, and pour 1 or 2 c.c. of the ammonia upon its surface. If the reaction be positive, a garnet ring will form at the junction of the two fluids; and upon shaking, a distinct pink color will be imparted to the foam. The color of the foam is the essential feature. If desired, the mixture may be well shaken before the ammonia is added: the pink color will then instantly appear in that portion of the foam which the ammonia has reached, and can be readily seen. The color varies from eosin-pink to deep

crimson, depending upon the intensity of the reaction. *It is a pure pink or red; any trace of yellow or orange denotes a negative reaction.* A doubtful reaction should be considered negative.

9. Pancreatic Reaction.—Cammidge has shown that in cases of pancreatitis a substance capable of forming crystals with phenylhydrazin can be developed by boiling the urine with a mineral acid, and has offered the following test as an aid in diagnosis of this obscure condition. The nature both of this substance and the antecedent substance from which it is derived is not known. As originally proposed, the test was complicated and probably not trustworthy, but with his improved and simplified technic, Cammidge has had very promising results. In 200 consecutive examinations in which the diagnosis was confirmed, *postmortem* or at operation, 67 cases of pancreatitis (65 chronic, 2 acute) gave positive reactions; 4 cases of cancer of the pancreas were positive, 12 negative; 4 cases in which no pancreatitis was found were positive, 113 were negative. Normal urines do not give the reaction. The difficulty and importance of diagnosis in pancreatitis warrant inclusion of the method here, even though more recent work indicates that its value is not so great as originally claimed.

While the test is somewhat tedious, all the manipulations are simple and require no apparatus but flasks, test-tubes, and funnels.

Technic.—Careful attention to detail is imperative. An ordinary routine examination is first made. Albumin and sugar, if present, must be removed: the former, by acidifying with acetic acid, boiling, and filtering; the latter, by fermenta-

tion with yeast after the first step of the method proper. An alkaline urine should be made slightly acid with hydrochloric acid.

(1) Forty cubic centimeters of the urine, which has been rendered perfectly clear by repeated filtration through the same filter-paper are placed in a small flask, treated with 1 c.c. concentrated hydrochloric acid and gently boiled on a

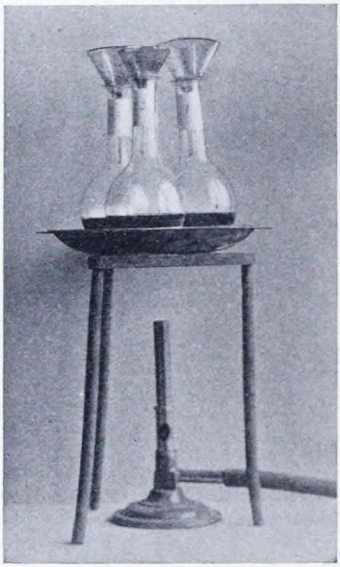


Fig. 32.—"Pancreatic reaction" flasks fitted with funnel condensers on a sand-bath (Robson and Cammidge).

sand-bath for ten minutes, a funnel with long stem being placed in the neck of the flask to act as a condenser (Fig. 32). After boiling, the urine is cooled in a stream of cold water and brought to its original bulk with distilled water; 8 gm. of lead carbonate are then added to neutralize the acid. The fluid is allowed to stand a few minutes and then filtered through well-moistened fine-grain filter-paper until perfectly clear.

(2) The filtrate is shaken up with 8 gm. powdered tribasic lead acetate and filtered. The excess of lead is then removed by passing hydrogen sulphid gas through the fluid (see page 135) or by shaking well with 4 gm. finely powdered sodium sulphate, heating to boiling, cooling to as low a temperature as possible in a stream of water, and filtering as before until perfectly clear.

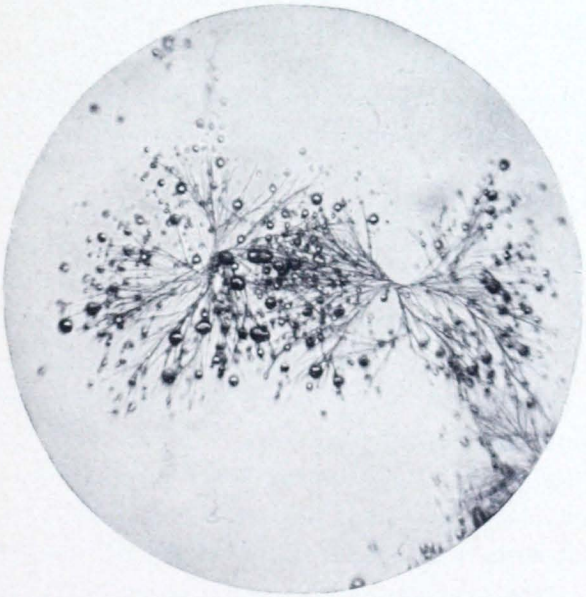


Fig. 33.—Improved "pancreatic reaction." Crystals obtained from a case of chronic pancreatitis with gall-stones in the common duct (×200) (from a photo by P. J. Cammidge).

(3) Ten cubic centimeters of the filtrate are then made up to 17 c.c. with distilled water, and added to a mixture of 0.8 gm. phenylhydrazin hydrochlorate, 2 gm. powdered sodium acetate, and 1 c.c. 50 per cent. acetic acid in a small flask with funnel condenser. This is boiled on a sand-bath for ten minutes, and filtered while hot through filter-paper moistened with hot water into a test-tube with a 15 c.c. mark. Should

the filtrate not reach this mark, make up to 15 c.c. with hot distilled water. Allow to cool slowly.

(4) In well-marked cases of pancreatitis a yellow precipitate appears within a few hours; in milder cases, it may not appear for twelve hours. The microscope shows this sediment to consist of " long, light yellow, flexible, hair-like crystals arranged in sheaves, which, when irrigated with 33 per cent. sulphuric acid, melt away and disappear in ten to fifteen seconds after the acid first touches them " (Fig. 33).

(5) To exclude traces of glucose which might be overlooked in the preliminary examination a control test should be carried out in the same manner with omission of step 1.

10. Drugs.—The effect of various drugs upon the color of the urine has been mentioned (p. 71). Most poisons are eliminated in the urine, but their detection is more properly discussed in works upon toxicology. A few drugs which are of interest to the practitioner, and which can be detected by comparatively simple methods, are mentioned here.

Acetanilid and Phenacetin.—The urine is evaporated by gentle heat to about half its volume, boiled for a few minutes with about one-fifth its volume of strong hydrochloric acid, and shaken out with ether. The ether is evaporated, the residue dissolved in water, and the following test applied: To about 10 c.c. are added a few cubic centimeters of 3 per cent. phenol, followed by a weak solution of chromium trioxid (chromic acid) drop by drop. The fluid assumes a red color, which changes to blue when ammonia is added. If the urine is very pale, extraction with ether may be omitted.

Antipyrin.—This drug gives a dark-red color when a few drops of 10 per cent. ferric chlorid are added to the

urine. The color does not disappear upon boiling, which excludes diacetic acid.

Arsenic.—*Reinsch's Test.*—Add to the urine in a test-tube or small flask about one-seventh its volume of hydrochloric acid, introduce a piece of bright copper-foil about one-eighth inch square, and boil for several minutes. If arsenic be present, a dark-gray film is deposited upon the copper. The test is more delicate if the urine be concentrated by slow evaporation. This test is well known and is widely used, but is not so reliable as the following.

Gutzeit's Test.—In a large test-tube place a little arsenic-free zinc, and add 5 to 10 c.c. pure dilute hydrochloric acid and a few drops of iodin solution (Gram's solution will answer), then add 5 to 10 c.c. of the urine. At once cover the mouth of the tube with a filter-paper cap moistened with saturated aqueous solution of silver nitrate (1:1). If arsenic be present, the paper quickly becomes lemon-yellow, owing to formation of a compound of silver arsenid and silver nitrate, and turns black when touched with a drop of water. To make sure that the reagents are arsenic-free, the paper cap may be applied for a few minutes before the urine is added.

Atropin will cause dilatation of the pupil when a few drops of the urine are placed in the eye of a cat or rabbit.

Bromids can be detected by acidifying about 10 c.c. of the urine with dilute sulphuric acid, adding a few drops of fuming nitric acid and a few cubic centimeters of chloroform, and shaking. In the presence of bromin the chloroform, which settles to the bottom, assumes a yellow color.

Iodin from ingestion of iodids or absorption from

iodoform dressings is tested for in the same way as the bromids, the chloroform assuming a pink to reddish-violet color. To detect traces, a large quantity of urine should be rendered alkaline with sodium carbonate and greatly concentrated by evaporation before testing.

Lead.—No simple method is sufficiently sensitive to detect the traces of lead which occur in the urine in chronic poisoning. Of the more sensitive methods, that of Arthur Lederer is probably best suited to the practitioner:

It is essential that all apparatus used be lead-free. Five hundred cubic centimeters of the urine are acidified with 70 c.c. pure sulphuric acid, and heated in a beaker or porcelain dish. About 20 to 25 gm. of potassium persulphate are added a little at a time. This should decolorize the urine, leaving it only slightly yellow. If it darkens upon heating, a few more crystals of potassium persulphate are added, the burner being first removed to prevent boiling over; if it becomes cloudy, a small amount of sulphuric acid is added. It is then boiled until it has evaporated to 250 c.c. or less. After cooling, an equal volume of alcohol is added, and the mixture allowed to stand in a cool place for four or five hours, during which time all the lead will be precipitated as insoluble sulphate.

The mixture is then filtered through a small, close-grained filter-paper (preferably an ashless, quantitative filter-paper), and any sediment remaining in the beaker or dish is carefully washed out with alcohol and filtered. A test-tube is placed underneath the funnel; a hole is punched through the tip of the filter with a small glass rod, and all the precipitate (which may be so slight as to be scarcely visible) washed down into the test-tube with a

jet of distilled water from a wash-bottle, using as little water as possible. Ten cubic centimeters will usually suffice. This fluid is then heated, adding crystals of sodium acetate until it becomes perfectly clear. It now contains all the lead of the 500 c.c. urine in the form of lead acetate. It is allowed to cool, and hydrogen sulphid gas is passed through it for about five minutes. The slightest yellowish-brown discoloration indicates the presence of lead. A very slight discoloration can be best seen

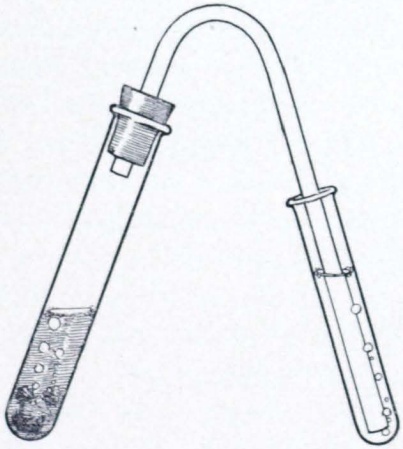


Fig. 34.—A simple hydrogen sulphid generator.

when looked at from above. For comparison, the gas may be passed through a test-tube containing an equal amount of distilled water. The quantity of lead can be determined by comparing the discoloration with that produced by passing the gas through lead acetate (sugar of lead) solutions of known strength. One gram of lead acetate crystals contains 0.54 gram of lead. Hydrogen sulphid is easily prepared in the simple apparatus shown in Fig. 34. A small quantity of iron sulphid is placed

in the test-tube; a little dilute hydrochloric acid is added; the cork is replaced; and the delivery tube is inserted to the bottom of the fluid to be tested.

Mercury.—Traces can be detected in the urine for a considerable time after the use of mercury compounds by ingestion or inunction.

About a liter of urine is acidified with 10 c.c. hydrochloric acid, and a small piece of copper-foil or gauze is introduced. This is gently heated for an hour, and allowed to stand for twenty-four hours. The metal is then removed, and washed successively with very dilute sodium hydroxid solution, alcohol, and ether. When dry, it is placed in a long, slender test-tube, and the lower portion of the tube is heated to redness. If mercury be present, it will volatilize and condense in the upper portion of the tube as small, shining globules which can be seen with a hand-magnifier or low power of the microscope. If, now, a crystal of iodin be dropped into the tube and gently heated, the mercury upon the side of the tube is changed first to the yellow iodid, and later to the red iodid, which are recognized by their color.

Morphin.—Add sufficient ammonia to the urine to render it distinctly ammoniacal, and shake thoroughly with a considerable quantity of pure acetic ether. Separate the ether and evaporate to dryness. To a little of the residue in a watch-glass or porcelain dish add a few drops of formaldehyd-sulphuric acid, which has been freshly prepared by adding one drop of formalin to 1 c.c. pure concentrated sulphuric acid. If morphin be present, this will produce a purple-red color, which changes to violet, blue-violet, and finally nearly pure blue.

Phenol.—As has been stated, the urine following

phenol poisoning turns olive-green and then brownish-black upon standing. Tests are of value in recognizing poisoning from ingestion and in detecting absorption from carbolized dressings.

The urine is acidulated with hydrochloric acid and distilled. To the first few cubic centimeters of distillate is added 10 per cent. solution of ferric chlorid drop by drop. The presence of phenol causes a deep amethyst-blue color, as in Uffelmann's test for lactic acid.

Phenolphthalein, which is now widely used as a cathartic, gives a bright pink color when the urine is rendered alkaline with caustic soda.

Quinin.—A considerable quantity of the urine is rendered alkaline with ammonia and extracted with ether; the ether is evaporated, and a portion of the residue dissolved in about twenty drops of dilute alcohol. The alcoholic solution is acidulated with dilute sulphuric acid, a drop of an alcoholic solution of iodin (tincture of iodin diluted about ten times) is added, and the mixture is warmed. Upon cooling, an iodin compound of quinin (herapathite) will separate out in the form of a microcrystalline sediment of green plates.

The remainder of the residue may be dissolved in a little dilute sulphuric acid. This solution will show a characteristic blue fluorescence when quinin is present.

Resinous drugs cause a white precipitate like that of albumin when strong nitric acid is added to the urine. This is dissolved by alcohol.

Salicylates, salol, and similar drugs give a bluish-violet color, which disappears upon heating, upon addition of a few drops of 10 per cent. ferric chlorid solution. When the quantity of salicylates is small, the urine may

be acidified with hydrochloric acid and extracted with ether, the ether evaporated, and the test applied to an aqueous solution of the residue.

Tannin and its compounds appear in the urine as gallic acid, and the urine becomes greenish-black (inky, if much gallic acid be present) when treated with a solution of ferric chlorid.

III. MICROSCOPIC EXAMINATION

A careful microscopic examination will often reveal structures of great diagnostic importance in urine which seems perfectly clear, and from which only very slight sediment can be obtained with the centrifuge. Upon the other hand, cloudy urines with abundant sediment are often shown by the microscope to contain nothing of clinical significance.

Since the nature of the sediment soon changes, the urine must be examined while fresh, preferably within six hours after it is voided. The sediment is best obtained by means of the centrifuge. If a centrifuge is not available, the urine may be allowed to stand in a conical test-glass for six to twenty-four hours after adding some preservative (p. 69). The " torfuge " (Fig. 35) is said to be a very satisfactory substitute for the centrifuge, and is readily portable.

A small amount of the sediment should be transferred to a slide by means of a pipet. It is very important to do this properly. The best pipet is a small glass tube which has been drawn out at one end to a tip with rather small opening. The tube or glass containing the sediment is held on a level with the eye, the larger end of the pipet is closed with the index-finger, which must be dry, and the

tip is carried down into the sediment. By carefully loosening the finger, but not entirely removing it, a small amount of the sediment is then allowed to run slowly into the pipet. Slightly rotating the pipet will aid in accomplishing this, and at the same time will serve to loosen any structures which cling to the bottom of the tube. After wiping off the urine which adheres to the outside, a drop from the pipet is placed upon a clean slide. A hair is then placed in the drop, and a large cover-glass

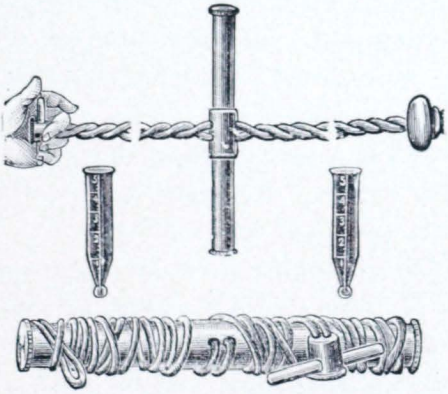


Fig. 35.—Wetherill's torfuge.

applied. Many workers use no cover. This offers a thicker layer and larger area of urine, the chance of finding scanty structures being proportionately increased. It has the disadvantage that any jarring of the room (as by persons walking about) sets the microscopic field into vibratory motion and makes it impossible to see anything clearly; and since it does not allow of the use of high-power objectives, one cannot examine details as one often wishes to do. A large cover-glass with a hair beneath it avoids these disadvantages, and gives enough urine to find any structures which are present in sufficient

number to have clinical significance, provided other points in the technic have been right. It is best, however, to examine several drops; and, when the sediment is abundant, drops from the upper and lower portions should be examined separately.

In examining urinary sediments microscopically no fault is so common, nor so fatal to good results, as improper illumination (see Fig. 4), and none is so easily corrected. The light should be central and very subdued for ordinary work, but oblique illumination, obtained by swinging the mirror a little out of the optical axis, will be found helpful in identifying certain delicate structures like hyaline casts. The 16 mm. objective should be used as a finder, while the 4 mm. is reserved for examining details. An experienced worker will rely almost wholly upon the lower power.

It is well to emphasize that *the most common errors which result in failure to find important structures, when present, are lack of care in transferring the sediment to the slide, too strong illumination, and too great magnification.*

In order to distinguish between similar structures it is often necessary to watch the effect upon them of certain reagents. This is especially true of the various unorganized sediments. They very frequently cannot be identified from their form alone. With the structures still in focus, a drop of the reagent may be placed at one edge of the cover-glass and drawn underneath it by the suction of a piece of blotting-paper touched to the opposite edge; or a small drop of the reagent and of the urine may be placed close together upon a slide and a cover gently lowered over them. As the two fluids mingle, the effect upon various structures may be seen.

Urinary sediments may be studied under three heads: A. Unorganized sediments. B. Organized sediments. C. Extraneous structures.

A. Unorganized Sediments

In general these have little diagnostic or prognostic significance. Most of them are substances normally present in solution, which have been precipitated either because present in excessive amounts, or, more frequently, because of some alteration in the urine (as in reaction, concentration, etc.) which may be purely physiologic, depending upon changes in diet or habits. Various substances are always precipitated during decomposition, which may take place either within or without

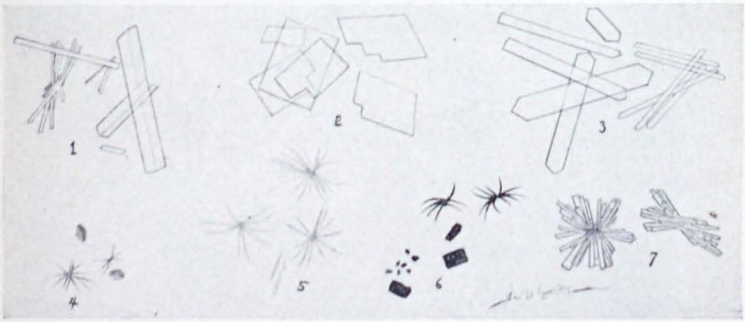


Fig. 36.—Unusual urinary crystals (drawn from various authors): 1, Calcium sulphate (colorless); 2, cholesterin (colorless); 3, hippuric acid (colorless); 4, hematoidin (brown); 5, fatty acids (colorless); 6, indigo (blue); 7, sodium urate (yellowish).

the body. Unorganized sediments may be classified according to the reaction of the urine in which they are *most likely* to be found:

In acid urine: Uric acid, amorphous urates, sodium urate, calcium oxalate, leucin and tyrosin, cystin, and fat-globules. Uric acid, the urates, and calcium oxalate

are the common deposits of acid urines; the others are less frequent, and depend less upon the reaction of the urine.

In alkaline urine: Phosphates, calcium carbonate, and ammonium urate.

Other crystalline sediments (Fig. 36) which are rare and require no further mention are: Calcium sulphate, cholesterin, hippuric acid, hematoidin, fatty acids, and indigo.

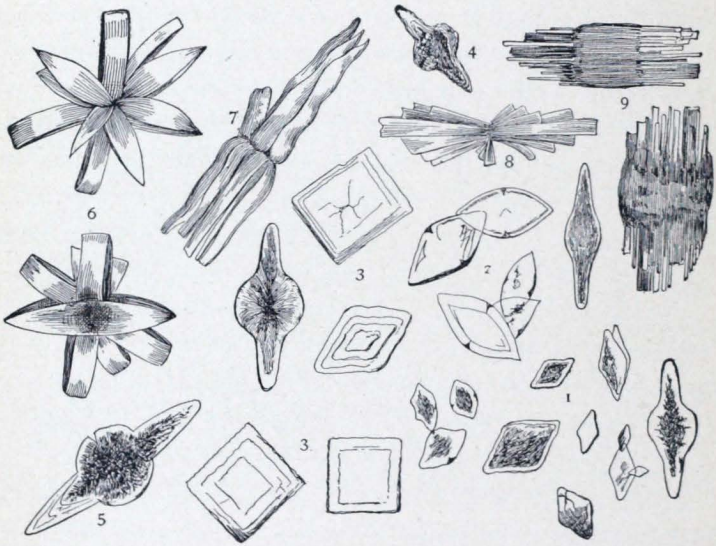
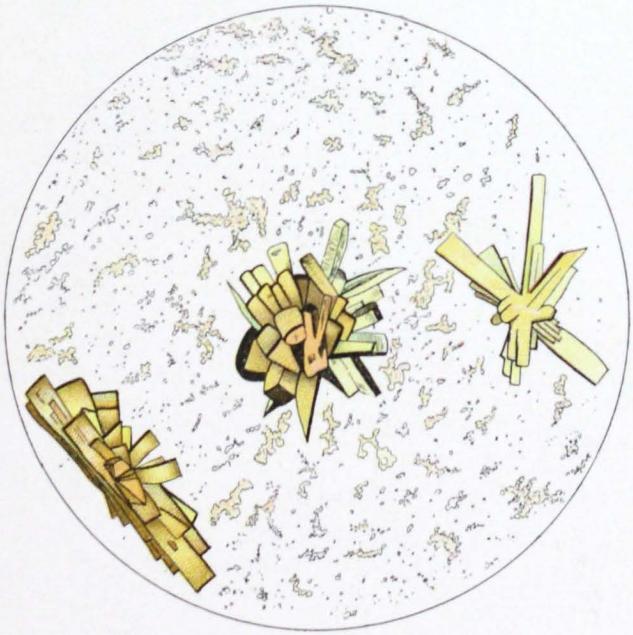


Fig. 37.—Forms of uric acid: 1, Rhombic plates; 2, whetstone forms; 3, 3, quadrate forms; 4, 5, prolonged into points; 6, 8, rosets; 7, pointed bundles; 9, barrel forms precipitated by adding hydrochloric acid to urine (Ogden).

I. In Acid Urine.—(1) **Uric-acid Crystals.**—These crystals are the red grains—" gravel " or " red sand "—which are often seen adhering to the sides and bottom of a vessel containing urine. Microscopically, they are yellow or reddish-brown crystals, which differ greatly in

PLATE III



Uric-acid crystals with amorphous urates (after Peyer).

size and shape. The most characteristic forms (Plate III and Fig. 37) are "whetstones"; roset-like clusters of prisms and whetstones; and rhombic plates, which have usually a paler color than the other forms and are sometimes colorless. A very rare form is a colorless hexagonal plate resembling cystin. Recognition of the crystals depends less upon their shape than upon their color, the reaction of the urine, and the facts that they are soluble in caustic soda solution and insoluble in hydrochloric or acetic acid. When ammonia is added, they dissolve and crystals of ammonium urate appear.

A deposit of uric-acid crystals has no significance unless it occurs before or very soon after the urine is voided. Every urine, if kept acid, will in time deposit its uric acid. Factors which favor an early deposit are high acidity, diminished urinary pigments, and excessive excretion of uric acid. The chief clinical interest of the crystals lies in their tendency to form calculi, owing to the readiness with which they collect about any solid object. Their presence in the freshly voided urine in clusters of crystals suggests stone in the kidney or bladder, especially if blood is also present. (See Fig. 65.)

(2) **Amorphous Urates.**—These are chiefly urates of sodium and potassium which are thrown out of solution as a yellow or red "brick-dust" deposit. In pale urines this sediment is almost white. It disappears upon heating. A deposit of amorphous urates is very common in concentrated and strongly acid urines, especially in cold weather, and has no clinical significance. Under the microscope it appears as fine yellowish granules, often so abundant as to obscure all other structures (Plate III). In such cases the urine should be warmed

before examining. Amorphous urates are readily soluble in caustic soda solutions. When treated with hydrochloric or acetic acid, they slowly dissolve and rhombic crystals of uric acid appear.

Rarely, sodium urate occurs in crystalline form—slender prisms, arranged in fan- or sheaf-like structures (Fig. 36).

(3) **Calcium Oxalate.**—Characteristic of calcium oxalate are colorless, glistening, octahedral crystals, giving the appearance of small squares crossed by two intersect-

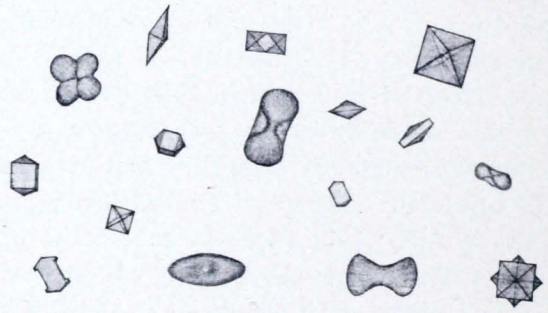


Fig. 38.—Various forms of calcium oxalate crystals (Ogden).

ing diagonal lines—the so-called "envelop crystals" (Fig. 51). They vary greatly in size, being sometimes so small as to seem mere points of light with medium-power objectives. Unusual forms, which, however, seldom occur except in conjunction with the octahedra, are colorless dumb-bells, spheres, and variations of the octahedra (Fig. 38). The spheres might be mistaken for globules of fat or red blood-corpuscles. Crystals of calcium oxalate are insoluble in acetic acid or caustic soda. They are dissolved by strong hydrochloric acid,

and recrystallize as octahedra upon addition of ammonia. They are sometimes encountered in alkaline urine.

The crystals are commonly found in the urine after ingestion of vegetables rich in oxalic acid, as tomatoes, spinach, asparagus, and rhubarb. They have no definite significance pathologically. They often appear in digestive disturbances, in neurasthenia, and when the oxidizing power of the system is diminished. When abundant, they are generally associated with a little mucus; and, in men, frequently with a few spermatozoa. Like uric acid, their chief clinical interest lies in their tendency to form calculi, and their presence in fresh urine, together with evidences of renal or cystic irritation, should be viewed with suspicion, particularly if they are clumped in small masses.

(4) **Leucin and Tyrosin.**—Crystals are deposited only when the substances are present in considerable amount. When present in smaller amount, they will usually be deposited if a little of the urine be slowly evaporated upon a slide. Addition of alcohol favors the deposit. They generally appear together, and are of comparatively rare occurrence, usually indicating severe fatty destruction of the liver, such as occurs in acute yellow atrophy and phosphorus-poisoning.

The crystals cannot be identified from their morphology alone, since other substances, notably calcium phosphate (Fig. 42) and ammonium urate, may take similar or identical forms.

Leucin crystals (Fig. 39) as they appear in the urine do not represent the pure substance. They are slightly yellow, oily-looking spheres, many of them with radial and concentric striations. Some may be merged to-

gether in clusters. They are not soluble in hydrochloric acid nor in ether.

Tyrosin crystallizes in very fine colorless needles, usually arranged in sheaves, with a marked constriction at the middle (Fig. 39). It is soluble in ammonia and hydrochloric acid, but not in acetic acid.

(5) **Cystin crystals** are colorless, highly refractive, rather thick, hexagonal plates with well-defined edges. They lie either singly or superimposed to form more or less irregular clusters (Fig. 40). Uric acid sometimes

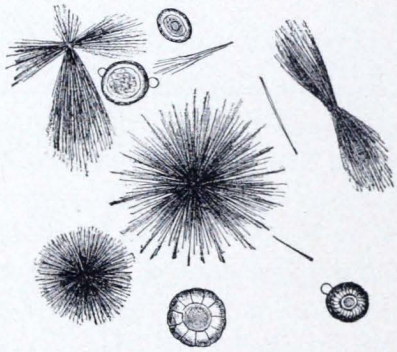


Fig. 39.—Leucin spheres and tyrosin needles (Stengel).

takes this form and must be excluded. Cystin is soluble in hydrochloric acid, insoluble in acetic; it is readily soluble in ammonia and recrystallizes upon addition of acetic acid.

Cystin is one of the amino-acids formed in decomposition of the protein molecule, and is present in traces in normal urine. Crystals are deposited only when the substance is present in excessive amount. Their presence is known as *cystinuria*. It is a rare condition due to an obscure abnormality of protein metabolism and usually

continues throughout life. There are rarely any symptoms save those referable to renal or cystic calculus, to which the condition strongly predisposes.

(6) **Fat-globules.**—Fat appears in the urine as highly refractive globules of various sizes, frequently very small. These globules are easily recognized from the fact that they are stained black by osmic acid and orange or red by Sudan III. The stain may be applied upon the slide,

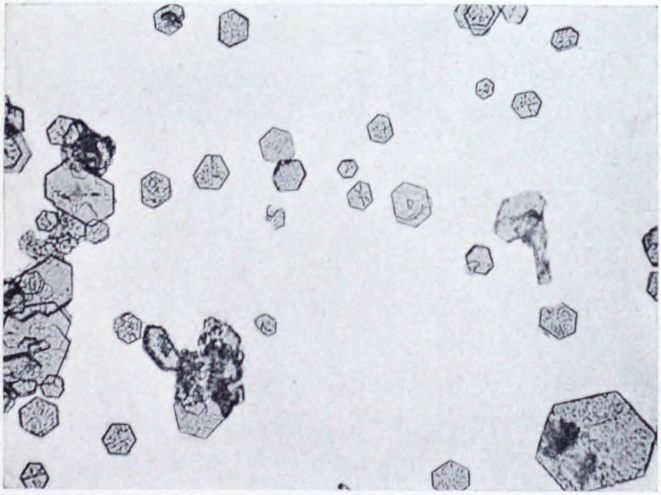


Fig. 40.—Cystin crystals from urine of patient with cystin calculus (× 200) (photograph by the author).

as already described (p. 140). Osmic acid should be used in 1 per cent. aqueous solution; Sudan III in saturated solution in 70 per cent. alcohol, to which one-half volume of 10 per cent. formalin may advantageously be added.

Fat in the urine is usually a contamination from unclean vessels, oiled catheters, etc. A very small amount may be present after ingestion of large quantities of cod-

liver oil or other fats. In fatty degeneration of the kidney, as in phosphorus-poisoning and chronic parenchymatous nephritis, fat-globules are commonly seen, both free in the urine and embedded in cells and tube-casts.

In *chyluria*, or admixture of chyle with the urine as a result of rupture of a lymph-vessel, minute droplets of fat are so numerous as to give the urine a milky appearance. The droplets are generally smaller than those of milk. The fluid is often blood-tinged. Chyluria occurs most frequently as a symptom of infection by filaria (p. 357), the embryos of which can usually be found in the milky urine.

2. In Alkaline Urine.—(1) **Phosphates.**—While most common in alkaline urine, phosphates are sometimes deposited in amphoteric or feebly acid urines. The usual forms are: (*a*) Ammoniomagnesium phosphate crystals; (*b*) acid calcium phosphate crystals; and (*c*) amorphous phosphates. All are readily soluble in acetic acid.

(*a*) *Ammoniomagnesium Phosphate Crystals.*—They are the common " triple phosphate " crystals, which are generally easily recognized (Figs. 41 and 66, and Plate IV). They are colorless, except when bile-stained. Their usual form is some modification of the prism, with oblique ends. Most typical are the well-known " coffin-lid " and " hip-roof " forms. The long axis of the hip-roof crystal is often so shortened that it resembles the envelop crystal of calcium oxalate. It does not, however, have the same luster; this, and its solubility in acetic acid, will always prevent confusion.

When rapidly deposited, as by artificial precipitation, triple phosphate often takes feathery, star-, or leaf-like

forms. These gradually develop into the more common prisms. X-forms may be produced by partial solution of prisms.

(*b*) *Acid Calcium Phosphate Crystals.*—In feebly acid, amphoteric, or feebly alkaline urines acid calcium phosphate, wrongly called "neutral calcium phosphate," is not infrequently deposited in the form of colorless prisms arranged in stars and rosets (Fig. 42, 1). The individual prisms are usually slender, with one beveled,

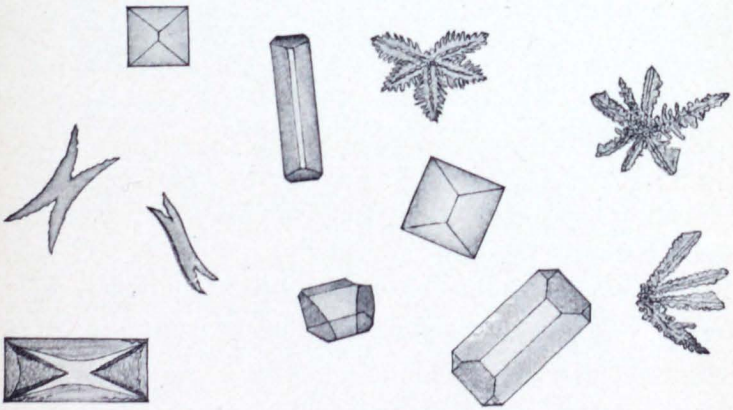


Fig. 41.—Various forms of triple phosphate crystals (Ogden).

wedge-like end, but are sometimes needle-like. They may sometimes take forms resembling tyrosin (Fig. 42, 2), calcium sulphate, or hippuric acid, but are readily distinguished by their solubility in acetic acid.

Calcium phosphate often forms large, thin, irregular, usually granular, colorless plates, which are easily recognized (Fig. 42, 3).

(*c*) *Amorphous Phosphates.*—The earthy phosphates are thrown out of solution in most alkaline and many amphoteric urines as a white, amorphous sediment,

which may be mistaken for pus macroscopically. Under the microscope the sediment is seen to consist of numerous colorless granules, distinguished from amorphous

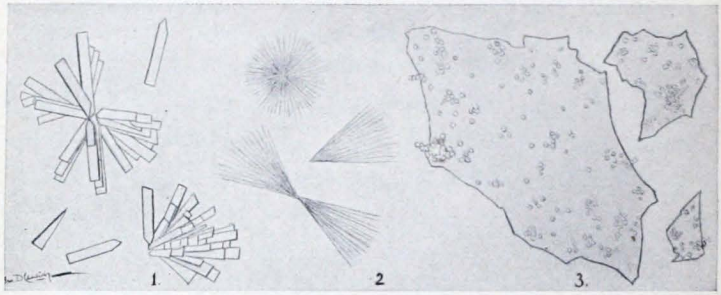


Fig. 42.—Crystals of calcium phosphate: 1, Common form (copied from Rieder's Atlas); 2, needles resembling tyrosin (drawn from nature); 3, large, irregular plates (from nature).

urates by their color, their solubility in acetic acid, and the reaction of the urine.

The various phosphatic deposits frequently occur together. They are sometimes due to excessive excre-

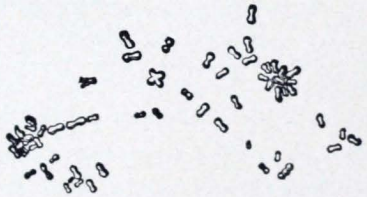
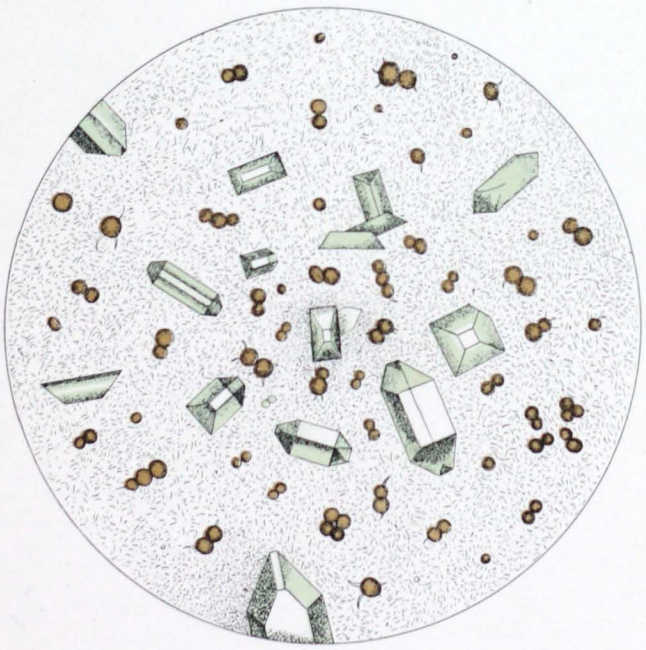


Fig. 43.—Indistinct crystalline sediment (dumb-bell crystals) of calcium carbonate. Similar crystals are formed by calcium oxalate and calcium sulphate (after Funke).

tion of phosphoric acid, but usually merely indicate that the urine has become, or is becoming, alkaline. (See Phosphates, p. 86.)

(2) **Calcium carbonate** may sometimes be mingled with the phosphatic deposits, usually as amorphous

PLATE IV



Sediment of alkaline fermentation (after Hofmann and Ultzmann).

granules, or, more rarely, as colorless spheres and dumb-bells (Fig. 43), which are soluble in acetic acid with gas-formation.

(3) **Ammonium Urate Crystals.**—This is the only urate deposited in alkaline urine. It forms opaque yellow crystals, usually in the form of spheres (Plate IV. and Fig. 66), which are often covered with fine or coarse

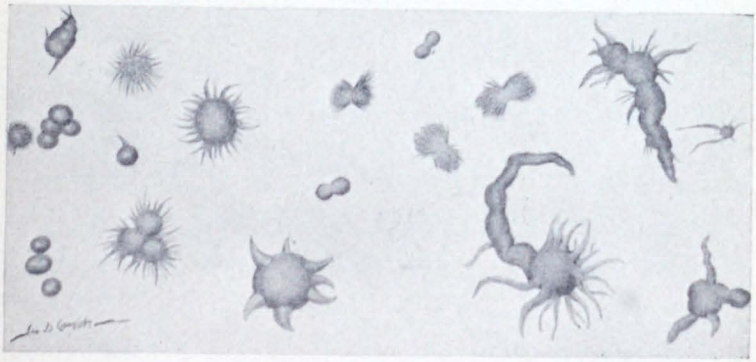


Fig. 44.—Crystals of ammonium urate (one-half of the forms copied from Rieder's Atlas, the others from nature).

spicules—"thorn-apple crystals." Sometimes dumb-bells, compact sheaves of fine needles, and irregular rhizome forms are seen (Fig. 44). Upon addition of acetic acid they dissolve, and rhombic plates of uric acid appear.

These crystals occur only when free ammonia is present. They are generally found along with the phosphates in decomposing urine and have no clinical significance.

B. Organized Sediments

The principal organized structures in urinary sediments are: Tube-casts; epithelial cells; pus-corpuscles;

red blood-corpuscles; spermatozoa; bacteria, and animal parasites. They are much more important than the unorganized sediments just considered.

1. Tube-casts.—These interesting structures are albuminous casts of the uriniferous tubules. Their presence in the urine probably always indicates some pathologic change in the kidney, although this change may be very slight or transitory. Large numbers may be present in temporary irritations and congestions. *They do not in themselves, therefore, imply organic disease of the kidney.* They rarely occur in urine which does not contain, or has not recently contained, albumin.

While it is not possible to draw a sharp dividing-line between the different varieties, casts may be classified as follows:

(1) Hyaline casts.
    (*a*) Narrow.
    (*b*) Broad.
(2) Waxy casts.
(3) Fibrinous casts.
(4) Granular casts.
    (*a*) Finely granular.
    (*b*) Coarsely granular.
(5) Fatty casts.
(6) Casts containing organized structures.
    (*a*) Epithelial casts.
    (*b*) Blood-casts.
    (*c*) Pus-casts.
    (*d*) Bacterial casts.

As will be seen later, practically all varieties are modifications of the hyaline.

The significance of the different varieties is more readily understood if one considers their mode of formation. Albuminous material, the source and nature of which are not definitely known, but which are doubtless not the same in all cases, probably enters the lumen of a uriniferous tubule in a fluid or plastic state. The material has been variously thought to be an exudate from the blood, a pathologic secretion of the renal cells, and a product of epithelial degeneration. In the tubule it hardens into a cast which, when washed out by the urine, retains the shape of the tubule, and contains within its substance whatever structures and débris were lying free within the tubule or were loosley attached to its wall. If the tubule be small and have its usual lining of epithelium, the cast will be narrow; if it be large or entirely denuded of epithelium, the cast will be broad. *A cast, therefore, indicates the condition of the tubule in which it is formed, but does not necessarily indicate the condition of the kidney as a whole.*

The search for casts must be carefully made. The urine must be fresh, since hyaline casts soon dissolve when it becomes alkaline. It should be thoroughly centrifugalized. When the sediment is abundant, casts, being light structures, will be found near the top. In cystitis, where casts may be entirely hidden by the pus, the bladder should be irrigated to remove as much of the pus as possible and the next urine examined. In order to prevent solution of the casts the urine, if alkaline, must be rendered acid by previous administration of boric acid or other drugs. Heavy sediments of urates, blood, or vaginal cells may likewise obscure casts and other important structures. The last can be

avoided by catheterization. Urates can be dissolved by gently warming before centrifugalizing, care being taken not to heat enough to coagulate the albumin. The albumin shield of the centrifuge tube may also be heated. Blood can be destroyed by centrifugalizing, pouring off the supernatant urine, filling the tube with water, adding a few drops of dilute acetic acid, mixing well, and again centrifugalizing; this process being repeated until the blood is completely decolorized. Too much acetic acid will dissolve hyaline casts.

Their cylindric shape can be best seen by slightly moving the cover-glass while observing them, thus causing them to roll. This little manipulation should be practised until it can be done satisfactorily. It will prove useful in many examinations.

Various methods of staining casts so as to render them more conspicuous have been proposed. They offer no special advantage to one who understands how to use the substage mechanism of his microscope. The " negative-staining " method is as good as any. It consists simply in adding a little India-ink to the drop of urine on the slide. Casts, cells, etc., will stand out as colorless structures on a dark background.

(1) **Hyaline Casts.**—Typically, these are colorless, homogeneous, semitransparent, cylindric structures, with parallel sides and usually rounded ends. Not infrequently they are more opaque or show a few granules or an occasional oil-globule or cell, either adhering to them or contained within their substance. Generally they are straight or curved; less commonly, convoluted. Their length and breadth vary greatly: they are sometimes so long as to extend across several fields of a

medium-power objective, but are usually much shorter; in breadth, they vary from one to seven or eight times

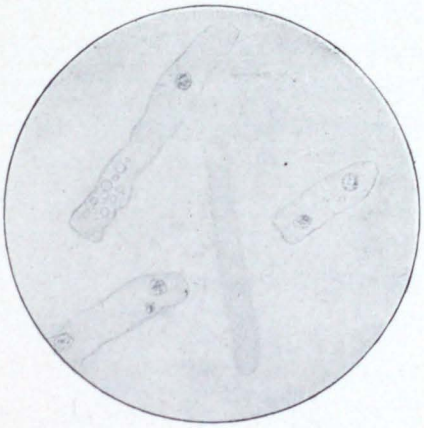


Fig. 45.—Hyaline casts showing fat-droplets and leukocytes (obj. one-sixth) (Boston).

the diameter of a red blood-corpuscle. (See Figs. 4, 45, 46, and 50.)

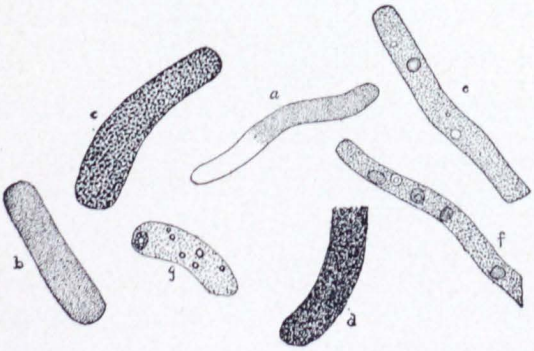


Fig. 46.—Various kinds of casts: *a*, Hyaline and finely granular cast; *b*, finely granular cast; *c*, coarsely granular cast; *d*, brown granular cast; *e*, granular cast with normal and abnormal blood adherent; *f*, granular cast with renal cells adherent; *g*, granular cast with fat and a fatty renal cell adherent (Ogden).

Hyaline casts are the least significant of all the casts, and occur in many slight and transitory conditions.

Small numbers are common following ether anesthesia, in fevers, after excessive exercise, and in congestions and irritations of the kidney. They are always present, and are usually stained yellow when the urine contains much bile. While they are found in all organic diseases of the kidney, they are most important in chronic interstitial nephritis. Here they are seldom abundant, but their constant presence is the most reliable urinary sign of the disease. Small areas of chronic interstitial change are probably responsible for the few hyaline casts so frequently found in the urine of elderly persons.

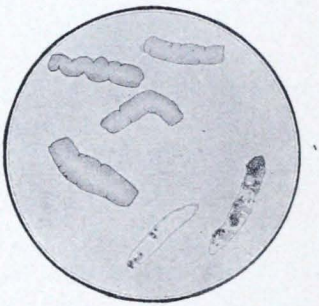


Fig. 47.—Waxy casts (upper part of figure). Fatty and fat-bearing casts (lower part of figure) (from Greene's "Medical Diagnosis").

Very broad hyaline casts commonly indicate complete desquamation of the tubular epithelium, such as occurs in the late stages of nephritis.

(2) **Waxy Casts.**—Like hyaline casts, these are homogeneous when typical, but frequently contain a few granules or an occasional cell. They are much more opaque than the hyaline variety, and are usually shorter and broader, with irregular, broken ends, and sometimes appear to be segmented. They are grayish or colorless, and have a dull, waxy look, as if cut from par-

affin (Figs. 47 and 64). They are sometimes composed of material which gives the amyloid reactions. Waxy casts are found in most advanced cases of nephritis, where they are an unfavorable sign. They are perhaps most frequently found in amyloid disease of the kidney, but are not distinctive of the disease, as is sometimes stated.

(3) **Fibrinous Casts.**—Casts which resemble waxy casts, but have a distinctly yellow color, as if cut from beeswax, are often seen in acute nephritis. They are

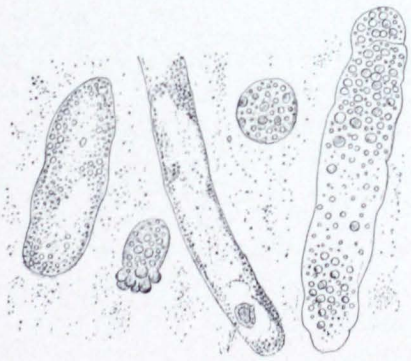


Fig. 48.—Granular and fatty casts and two compound granular cells (Stengel).

called fibrinous casts, but the name is inappropriate, as they are not composed of fibrin. They are often classed with waxy casts, but should be distinguished, as their significance is much less serious.

(4) **Granular Casts.**—These are merely hyaline casts in which numerous granules are embedded (Figs. 46, 48, and 50).

Finely granular casts contain many fine granules, are usually shorter, broader, and more opaque than the hyaline variety, and are more conspicuous. Their color is grayish or pale yellow.

Coarsely granular casts contain larger granules and are darker in color than the finely granular, being often dark brown owing to presence of altered blood-pigment. They are usually shorter and more irregular in outline, and more frequently have irregularly broken ends.

(5) **Fatty Casts.**—Small droplets of fat may at times be seen in any variety of cast. Those in which the droplets are numerous are called fatty casts (Figs. 47 and 48). The fat-globules are not difficult to recognize. Staining with osmic acid or Sudan (p. 147) will remove any doubt as to their nature.

The granules and fat-droplets seen in casts are products of epithelial degeneration. Granular and fatty casts, therefore, always indicate partial or complete disintegration of the renal epithelium. The finely granular variety is the least significant, and is found when the epithelium is only moderately affected. Coarsely granular, and especially fatty casts, if present in considerable numbers, indicate a serious parenchymatous nephritis.

(6) **Casts Containing Organized Structures.**—Cells and other structures are frequently seen adherent to a cast or embedded within it. (See Figs. 45 and 46). When numerous, they give name to the cast.

(*a*) *Epithelial casts* contain epithelial cells from the renal tubules. They always imply desquamation of epithelium, which rarely occurs except in parenchymatous inflammations (Figs. 63 and 64). When the cells are well preserved they point to acute nephritis.

(*b*) *Blood-casts* contain red blood-corpuscles, usually much degenerated (Figs. 49 and 63). They always indicate hemorrhage into the tubules, which is most

common in acute nephritis or an acute exacerbation of a chronic nephritis.

(*c*) *Pus-casts* (see Fig. 65), composed almost wholly of pus-corpuscles, are uncommon, and point to a chronic suppurative process in the kidney.

(*d*) True *bacterial casts* are rare. They indicate a septic condition in the kidney. Bacteria may permeate a cast after the urine is voided.

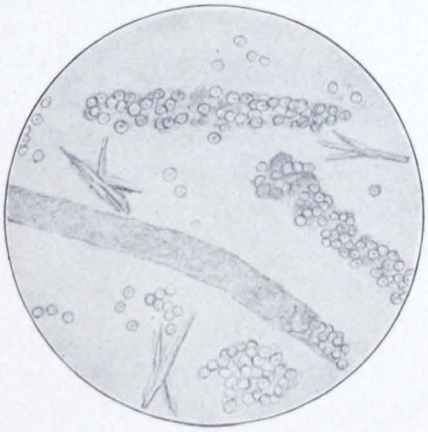


Fig. 49.—Red blood-corpuscles and blood-casts (courtesy of Dr. A. Scott) (obj. one-sixth) (Boston)

Structures Likely to be Mistaken for Casts.—(1) **Mucous Threads.**—Mucus frequently appears in the form of long strands which slightly resemble hyaline casts (Fig. 50). They are, however, more ribbon-like, have less well-defined edges, and usually show faint longitudinal striations. Their ends taper to a point or are split or curled upon themselves, and are never evenly rounded, as is commonly the case with hyaline casts.

Such threads form a part of the nubecula of normal urine, and are especially abundant when calcium oxalate

crystals are present. When there is an excess of mucus, as in irritations of the urinary tract, every field may be filled with an interlacing meshwork.

Mucous threads are microscopic and should not be confused with urethral shreds, which are macroscopic, and consist of a matrix of mucus in which many epithelial and pus-cells are embedded.

(2) **Cylindroids.**—This name is sometimes given to the mucous threads just described, but is more properly

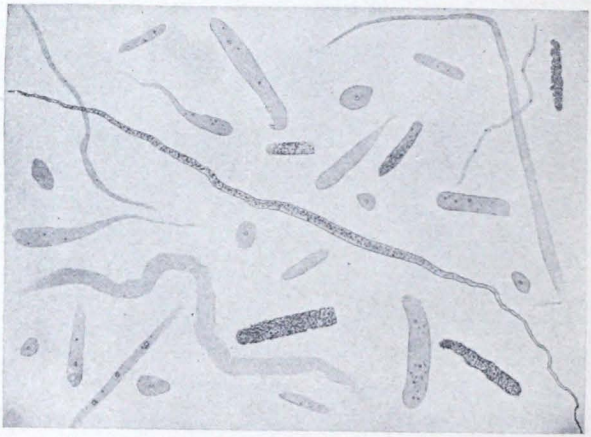


Fig. 50.—Hyaline and granular casts, mucous threads, and cylindroids. There are also a few epithelial cells from the bladder (Wood).

applied to certain peculiar structures more nearly allied to casts. They resemble hyaline casts in structure, but differ in being broader at one end and tapering to a slender tail, which is often twisted or curled upon itself (Fig. 50). They frequently occur in the urine along with hyaline casts, especially in irritations of the kidney, and have no definite pathologic significance.

(3) **Masses of amorphous urates, or phosphates, or**

very small crystals (Fig. 51), which accidentally take a cylindric form, or shreds of mucus covered with granules, closely resemble granular casts. Application of gentle heat or appropriate chemicals will serve to differentiate them. When urine contains both mucus and granules, large numbers of these "pseudocasts," all lying in the same direction, can be produced by slightly moving the cover-glass from side to side. It is possible—as in urate infarcts of infants—for urates to be molded into cylindric bodies within the renal tubules.

Fig. 51.—Calcium oxalate crystals, showing a pseudocast of small crystals (Jakob).

(4) **Hairs** and **fibers** of wool, cotton, etc. These could be mistaken for casts only by beginners. One can easily become familiar with their appearance by suspending them in water and examining with the microscope (Fig. 61).

(5) **Hyphæ** of **molds** are not infrequently mistaken for hyaline casts. Their higher degree of refraction, their jointed or branching structure, and the accompanying spores will differentiate them (Fig. 62).