Pus from the bladder is generally alkaline, although in tuberculosis it may be acid; pus from the kidney is generally acid. When both organs are involved, as is frequently the case, we have a mixture of the characteristics of both types of pyuria, and cystoscopic examination with or without catheterization of the ureters is usually necessary.

In *renal pyuria* we often have local signs in the renal region (tumor and tenderness), a history of renal colic, and decided constitutional symptoms.

In *vesical pyuria* we have vesical pain, often tenesmus, no renal pain or tumor, and usually slighter constitutional symptoms. The amount of squamous epithelium (see below) is sometimes larger in cystitis than in renal suppurations, but no reliable inferences can be drawn from the size or shape of the cells.

To determine whether pus from the bladder or the kidney is tuberculous or non-tuberculous in origin, we usually inject the sediment into a guinea-pig, which develops tuberculosis or not according to the nature of the pus injected. This method is much more reliable than the bacteriological examination of the sediment, for besides the tubercle bacillus other bacilli which retain fuchsin and resist decolorization by strong mineral acid and by alcohol occasionally occur in the urine.

Hæmaturia.—In searching for the source of the blood we must be sure to exclude the female genital organs. Menstrual blood and uterine bleeding from various other causes often contaminate the urine, and must be excluded by using a catheter.

The causes of true hæmaturia, arranged approximately in the order of frequency, are:

1. Early cystitis.
2. Stone in the kidney (less often vesical stone).
3. Acute nephritis and acute exacerbation of chronic nephritis.
4. Tumors of the kidney or bladder.
5. Tuberculosis of the kidney or bladder.

Less common causes are: floating kidney, acute infectious fevers (malaria, smallpox), animal parasites in the urinary passages, poisons (turpentine, carbolic acid, cantharides), hemorrhagic diseases

(purpura, scurvy, leukæmia), trauma and renal infarction, angioneurotic and other mystical conditions.

In *cystitis* there are bladder symptoms—pain, tenesmus, frequent and painful micturition. The blood is mixed with pus and epithelium, and is especially abundant in the urine passed near the end of the act of micturition. If the bladder is irrigated it is hard to get the wash-water clear.

In *renal stone* there are no bladder symptoms to speak of, the blood is pure and thoroughly mixed with the urine, and if the bladder is washed out the final wash water is clear. There is often renal colic (see below) and sometimes the passage of stones or gravel by urethra.

In *acute nephritis* the blood is rarely fresh, generally dark chocolate in color. The twenty-four-hour amount of urine is small, and albumin and casts (see below) are abundant. General œdema is common. Local symptoms in the kidney or bladder are absent.

In *renal tumor* or *tuberculosis* we have often pyuria and the local and constitutional evidences above described (page 416), with an absence of bladder symptoms (provided the bladder is not also diseased).

Tumors of the *bladder* need cystoscopy for diagnosis.

In the diagnosis of the rarer forms of hæmaturia we rely chiefly on the history (trauma, poisons ingested) and on the evidences afforded by general physical examination.

Chemical Examination of the Urine.

1. Reaction of Normal Urine.

The reaction of normal urine is acid to litmus, except temporarily after large meals. Its acidity becomes excessive in fevers or occasionally without any known cause.

Alkaline urine has generally an ammoniacal odor and suggests cystitis. As a result of decomposition and bacterial fermentation all urine becomes alkaline (ammoniacal) on standing exposed to air.[1]

[1] Simultaneously a dark-brown color rarely appears: *alkaptonuria*, a fact

Occasionally we find urine alkaline from fixed alkali and without known cause.

The *value* of the litmus test is chiefly as *prima-facie* evidence of stasis in the bladder and cystitis. Occasionally tuberculous cystitis and the first stages of any variety of cystitis are associated with acid urine, but in almost all cases lasting over a week ammoniacal fermentation and alkalinity appear.

II. Albuminuria and the Tests for It.

Serum albumin is the only variety of clinical importance, and for this but two tests are necessary: (1) Nitric-acid test; (2) test by boiling.

The *nitric-acid test* is best performed in a small wineglass. After filling this half full of urine, insert a small glass funnel to the bottom of the urine and gently pour in concentrated nitric acid. If albumin is present, a white ring forms at the junction of the acid with the urine, either immediately or in the course of ten minutes. If carefully performed this test is delicate enough for all clinical purposes, but since some of the albumoses give a similar precipitate, the boiling test should be used as a control whenever a positive reaction is obtained with nitric acid. None of the other rings, observable above or below but not at the junction of the acid with the urine, is of any clinical importance.

The Boiling Test.—To half a test tube full of urine add three or four drops of dilute acetic acid, and boil the upper three-quarter inch of the urine. If albumin is present a white cloud appears. If albumose is present a white cloud appears on heating, disappears on boiling, and reappears on cooling. In performing this test the addition of acetic acid as above described is absolutely necessary to prevent error.

For the detection of albumin no other tests are needed. For its approximate quantitative estimation, Esbach's method is the best.

Esbach's Method.—A special tube (see Fig. 190) is employed.

at present of no clinical significance except that such urines reduce Fehling's solution and may be mistakenly supposed to contain sugar.

Urine is poured in up to the mark "U," and then Esbach's reagent[1] up to the mark "R." The tube is then corked, inverted about half a dozen times, and set aside for twenty-four hours. A precipitate falls and the amount per mille is then read off on the scale etched upon the tube. If the urine is not acid it must be made so with dilute acetic acid, and unless its specific gravity is already very low it should be diluted once or twice with water so as to bring the gravity below 1.008. After such a dilution we must, of course, multiply the result obtained by a figure corresponding to the dilution. The method is not accurate, but is probably accurate enough for practical purposes.

FIG. 190.—Esbach's Albumenometer.

III. Significance of Albuminuria.

It is important to realize that albuminuria very often occurs without nephritis and that nephritis occasionally occurs without albuminuria. Among the more important types not due to kidney disease are the following: (1) Febrile albuminuria; (2) albuminuria from renal stasis; (3) albuminuria due to pus, blood, bile, or sugar in the urine; (4) toxic albuminuria.

Besides these, there are a good many cases of albuminuria occurring in diseases of the blood, after violent exertion, after epileptic attacks, and without any known cause. Many of the latter group occur only in the daytime when the patient is in an upright position, and are absent as long as the patient lies down (*orthostatic albuminuria*); others occur intermittently and sometimes at regular intervals (*cyclic albuminuria*).

Exclude fever, circulatory disturbance, irritants, poisons—such as cantharides, turpentine, carbolic acid, and arsenic—and deposits

[1] Esbach's reagent: Picric acid, 10 gm.; citric acid, 20 gm.; distilled water, 1,000 c.c.

of blood or pus in the urine, before deciding that a case of albuminuria is due to nephritis. To exclude the cyclic and orthostatic varieties is more difficult, and some authorities believe that these represent true nephritis in a more or less latent stage. In general, however, it is a good rule not to attribute albuminuria to nephritis unless there is other and more convincing evidence in the physical characteristics of the urine and in the other organs of the patient. If the twenty-four-hour amount and the specific gravity are approximately normal, and if the patient shows no œdema, no cardiac hypertrophy, no uræmic manifestations, and nothing alarming in the sediment of the urine, we should not diagnose nephritis. I shall discuss this point further in the section on the examination of the sediment (see page 429). It will be noted that *practically all the types of albuminuria not due to nephritis are transient*, while, with the exception of certain stages of chronic interstitial nephritis, the albuminuria of nephritis is as permanent as the nephritis itself.

IV. Glucosuria and Its Significance.

For glucose in the urine we need but one qualitative and one quantitative test, viz., Fehling's test and the fermentation test.

1. *Fehling's Test.*—Mix in a test tube equal parts of a standard solution of copper sulphate [1] and a standard solution of alkaline tartartes,[2] and add to this mixture an equal amount of urine. Mix and heat nearly to boiling. The amount of error entailed by boiling is slight and unimportant, but the only advantage of boiling is a slight saving of time. If sugar is present a yellow or reddish-yellow precipitate occurs, either at once or (if the amount of sugar is very small) after the urine has cooled. Fehling's solution may also be used for quantitative estimation of sugar, but it is more convenient to use:

[1] Made by dissolving 34.64 gm. pure $CuSO_4$ in water and then adding enough water to make 500 c.c.

[2] Made by dissolving 173 gm. Rochelle salts and 60 gm. sodic hydrate each in 200 c.c. of water, mixing the two solutions, and adding water to make 500 c.c.

2. *The Fermentation Test.*—Take the specific gravity of the urine as carefully as possible. Pour six or eight ounces of urine into a wide-mouthed vessel and crumb into it half a cake of fresh Fleischmann's yeast. Set the flask aside in a warm place, and after twenty-four hours test the supernatant fluid with Fehling's solution as above; if sugar is still present fermentation must be allowed to go on twenty-four hours longer. As soon as a negative reaction to Fehling's has been secured (whether in twenty-four or forty-eight hours), the specific gravity of the filtered urine is again taken. It will be found lower than before the fermentation, and for every degree of specific gravity lost we may reckon that 0.23 per cent of sugar has been fermented out of the urine. Thus if the reading was 1.040 before fermentation and 1.020 afterward, we multiply the difference between these readings, 20, by 0.23, giving 4.6 per cent—the percentage of sugar.

Fehling's test should be applied to every urine examined; it takes but a minute or two. *When it shows a yellow or red precipitate, the fermentation test should also be tried;* and *if both tests are positive we shall run but a negligible risk in saying that glucose is present.* From the result of the fermentation test and the twenty-four-hour amount of urine, we can estimate the daily output of sugar through the urine.

Permanent glucosuria means diabetes mellitus. Transitory glucosuria may be due to a great many causes, among which are: (1) Diseases of the liver; (2) diseases of the brain, organic or functional, especially the latter; (3) infectious fevers; (4) poisons, especially narcotics (alcohol, chloral, morphine); (5) pregnancy; (6) exophthalmic goitre.

Experimental ("alimentary") glucosuria can be produced in many of these same diseases by giving the patient 100 gm. of glucose in solution.

The differential diagnosis of the cause of glucosuria depends on the recognition of one of the above conditions.

V. The Acetone Bodies.

Acetone, Diacetic and Beta-Oxybutyric Acids.

1. *Test for Acetone.*—To about one-sixth of a test tube of urine add a crystal of sodium nitroprusside, and then NaOH to strong alkalinity. Shake and add to the foam a few drops of glacial acetic acid. *A purple color shows acetone.*

2. *Test for Diacetic Acid.—A Burgundy red color* when a strong aqueous solution of ferric chloride is added to fresh urine (*not* previously boiled) in a test tube. If this reaction is well marked beta-oxybutyric acid is probably also present, but we possess no clinical test for the latter substance.

Significance of the Acetone Bodies.—Diminished utilization of carbohydrate food by the body appears to be the cause of the appearance of these bodies in the urine. This may occur: (*a*) Because sufficient carbohydrates are not *eaten* (starvation, rectal alimentation, fevers, etc.). (*b*) Because they are not *absorbed* (vomiting, diarrhœa, etc.). (*c*) Because they are not *assimilated* (diabetes).

VI. Other Chemical Tests.

The information to be derived from testing for indican, for the amounts of urea, uric acid, chlorides, phosphates, and sulphates, does not seem to me sufficient to justify the time spent. The same is true of the diazo reaction.

Simon's lucid arguments for the value of the *indican* test have not been borne out by my experience with it in diagnostic puzzles. The tests for *urea* and *uric acid* are of value only when we possess a knowledge of all the factors governing their excretion, knowledge which in clinical work we almost never have. Diminution or absence of the urinary chlorides in pneumonia is not constant, and occurs in many other infections (typhoid, scarlet fever, etc.). The diazo reaction is nearly constant in typhoid, but is occasionally found in so many other febrile and cachectic states that most clinicians have ceased to rely on it. Its value in the prognosis of phthisis is slight. I believe that the general abandonment of the tests for the sulphates and phosphates will soon be followed by the abandonment of the tests for urea, uric acid, indican, and the chlorides. The use of these tests gives the *appearance* of accuracy and scientific method in diagnosis—the appearance, *but not the reality*.

VII. Microscopic Examination of Urinary Sediments.

Methods.—A centrifuge is convenient, but not necessary. The sediment should be allowed to settle in a conical glass (see Fig. 191), whence a drop of it can be transferred to a slide by means of a pointed glass pipette. Close the upper end of this with the forefinger and introduce the pointed end into the densest portion of the sediment; next very slightly relax the pressure of the forefinger until urine and sediment flow into the lower one-half or three-fourths inch of the pipette. Then resume firm pressure with the forefinger, withdraw the pipette, wipe the outside of it dry, put its point upon a microscopic slide, and again *slightly* relax the pressure of the forefinger so as to let a small drop of urine and sediment run out upon the slide. Cover this drop with a seven-eighths inch cover glass, and examine it with a Leitz objective No. 5 or Zeiss DD.

FIG. 191.—Conical Glass for Urinary Sediments.

The arrangement of the light is most important. The iris diaphragm should be closed until one can just distinguish the outlines of the cells and other objects in the field. If more light is admitted the pure hyaline casts will be invisible.

Results.—The objects of chief importance in the sediment are: (*a*) Casts; (*b*) cells; (*c*) crystals; (*d*) animal parasites or their eggs.

1. *Casts.*—Casts, or moulds of the renal tubules, may be homogeneous and transparent (hyaline, Fig. 192, *1*) or may have attached to this matrix a variety of *granules*, *cells*, *crystals*, or *fat drops*. According to the variety of passengers carried down from the kid-

ney on the casts, we call them *granular*, *brown-granular*, *cellular*, *blood*, *fatty*, or *crystal-bearing* casts (see Fig. 192, *2* and *3*, and Fig. 193, *1*, *2*, *3*, and *4*).

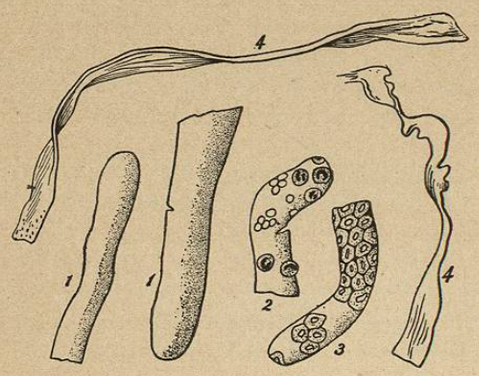

FIG. 192.—Casts. *1*, Hyaline casts; *2* and *3*, hyaline casts with cells and blood adherent; *4*, "cylindroids."

Dense or *highly refractile casts*, colorless or straw colored, are occasionally seen, and are often given a variety of names quite unjustified by any knowledge of their composition (*e.g.*, "waxy,"[1] "fibrinous," etc.).

From strands of mucus, foreign bodies, and other sources of error, true casts may be distinguished by the following traits:

(*a*) Their sides are parallel.

(*b*) One end is rounded; sometimes both ends.

Red corpuscles and other cells upon casts are to be recognized—the former by the size, shape, and, if fresh, by their color (pale straw); the latter by the presence of a nucleus.

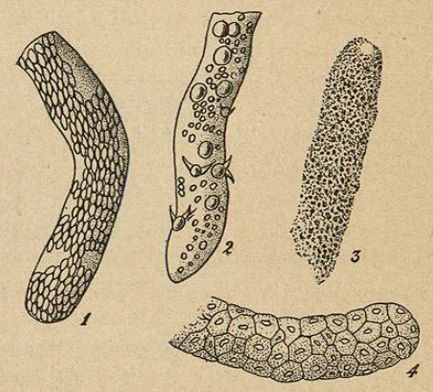

FIG. 193.—Casts. *1*, Blood-casts; *2*, fatty casts; *3*, granular casts; *4*, cellular casts.

Fat drops are spherical and very highly refractile, so that they seem to have a black line at their periphery.

Crystals can be recognized by their angles. They are of no importance.

Other bodies on casts are called *granules*.

SIGNIFICANCE OF CASTS.—Casts may occur in health (unless we choose to class muscular fatigue as disease) as well as under any of the conditions giving rise to albuminuria (see page 425). They are usually more numerous in nephritis than in most other conditions. Any type of cast may occur in any type of nephritis, but

Cellular,[1] *blood*, and *brown-granular* casts are most often found in *acute nephritis*.

Fatty, *highly refracting*, or *dense* casts most often predominate in *chronic glomerular nephritis* ("diffuse" or "parenchymatous" nephritis).

Hyaline and *granular* casts may occur in any type of nephritis and in many other conditions (fatigue, renal stasis, etc.). In the urine of persons over fifty years of age the presence of a few hyaline and granular casts has no known clinical significance, and may probably be considered physiological.

Periods occur in the course of many cases of chronic interstitial nephritis when no casts can be found. If any occur they are usually of the hyaline and fine granular types.

2. *Free Cells in Urinary Sediment.* *A. Recognition.*—The presence of macroscopic pus or blood already alluded to may be verified by the microscope.

(*a*) Fresh red cells, lately freed from the blood-vessels, preserve their straw-yellow color. Their presence points to the recent effusion of blood, probably from the bladder, urethra, or renal pelvis.

(*b*) Abnormal blood, decolorized and shadowy red discs, can be recognized with practice by their size and shape. We may infer that they have remained some time in the urine and have probably come from the kidney.

[1] Some dense, refractile casts give the amyloid reaction, but this does not indicate amyloid kidneys and has no known clinical significance.

[1] "Cellular" is a better term than "epithelial," since we have no marks for recognizing renal epithelium or for distinguishing a renal cell from a lymphocyte.