contrast between the increased cloudiness of the warmed upper portion and the unchanged appearance of the lower portion of the urine the more apparent. If the cloud produced by heat be so indistinct as to leave it still doubtful whether or not it is really due to albumen, a portion of the recently passed urine must be filtered and the clear filtrate examined for albumen.

The daily loss of albumen in inflammatory affections of the kidneys is exceedingly variable, amounting to 5—10 grm. in the less severe cases, and 15—20 grm. in those in which the disease is of greater intensity; the urine is occasionally so loaded with albumen that almost the whole of the fluid in the tube is changed into a firm coagulum on boiling. To observe whether the excretion of albumen is on the increase or the decrease, the test-tubes containing the different specimens of urine examined from day to day should be set aside in an upright position, and the depth of the layer of precipitated albumen in each compared; this method gives, of course, only an approximate quantitative estimate. The glasses must be of the same diameter and an equal volume of urine must be used each day.

Of the various modes of calculating accurately the amount of albumen in the urine the simplest is the optical method, circum-polarization with the Soleil-Ventzke apparatus. After this mechanism has been so arranged that the zero of the nonius corresponds with the zero of the scale, a glass tube is introduced, filled with the albuminous urine, which is previously filtered and decolorized by being passed through animal charcoal. The two halves of the field, which before the introduction of the albuminous fluid appear exactly alike, at once become different in colour. The compensator is now moved, by means of the screw, towards the *left* till both sides of the field are again of precisely the same hue. The nonius shows the extent of the displacement on the scale, and from this the proportion of albumen in the fluid is known; thus, if the compensator requires to be shifted till the nonius points to 3·6 before the desired identity in colour of the two divisions of the field is obtained, the urine is said to contain 3·6 grammes of albumen in every 100 grammes. The exactness of the calculation by this method depends on the examiner's sharpness of vision.

A high degree of albuminuria is always caused by nephritis; the existence of dropsy, above all the discovery of renal elements in the urine by microscopic investigation (epithelial scales, casts of the uriniferous tubules), are also indications which point to the same diagnostic conclusion. The albuminuria usually

attends the nephritic process throughout its whole course, though at times it may diminish very considerably, or in some rare cases may almost totally disappear.

Albuminuria is also observed, altogether apart from any inflammatory condition of the kidneys, in catarrhs and other severer affections of the uropoietic system, from the pelvis of the kidneys to the external orifice of the urethral canal; the presence of the albumen is then due to the admixture of pus and the corpuscles and serum of the blood. In these cases albumen is detected also in the filtered urine; generally, however, the urine is less albuminous than that discharged in pronounced renal disease.—Finally, a moderate degree of albuminuria occasionally appears, but remains only a short time, in a great many severe acute and chronic diseases; in such affections the urine, unlike that passed in nephritis, shows no figurate elements (casts, &c.,) under the microscope.

Besides albumen derived from the serum of the blood there are found, in all albuminous urines, certain other bodies of similar constitution,—paraglobulin (Edlefsen, Senator) and peptone; these are sometimes also found in the urine when it is free of ordinary albumen (Gerhardt). In *chyluria*, a disorder met with in tropical countries, there exists in the urine an albuminoid substance of a totally different nature from the albumen of the serum (Eggel).

Fibrin is invariably present in urine containing *blood;* but it is observed also when there is no hæmaturia, in the form of coagula or of *fibrinous* (granular) *casts,* in many cases of very acute and severe nephritis.

Mucus occurs in mere traces in normal urine; it is derived from the secretion of the lining membrane of the urethral canal, in women often from the vaginal secretion. Pathologically it is discovered in the urine chiefly in cases of catarrh of the bladder, and is easily recognised with the naked eye as a viscid stringy cloud which floats about in the fluid and eventually settles to the bottom of the glass when the urine has been stationary for some time. Examined microscopically it is seen to be formed essentially of a clear, absolutely structureless substance, in which, however, lie embedded large polygonal epithelial cells from the bladder and round oval *mucus-corpuscles.*

Sugar. The saccharine urine passed in diabetes mellitus has the following properties: *its quantity is very notably increased;* its *colour* is very pale or faintly yellowish with a tinge of green; it is perfectly *clear* and *limpid*, and gives no sediment on standing; its *specific gravity is unusually high*, 1030—1040, in certain cases 1050 and even higher.

There are four tests which serve for the detection of sugar (grape sugar) in the urine: *Trommer's process*, the *caustic potash*, the *bismuth*, and the *fermentation tests*; the first of these is by far the most delicate and is that most often used.

1. *Trommer's Test.* To a little of the saccharine urine placed in a test-tube are added first a few drops of a *solution of sulphate of copper* and afterwards a certain quantity of *liquor potassæ*, the latter being gently poured in till the whole fluid assumes a clear and beautiful *dark blue colour*. On obtaining this coloration the examiner may feel sure that the urine is saccharine, as no other sort of urine undergoes this change on being treated with these reagents.—On now heating the mixture an *orange yellow* or *brick red* precipitate is formed, which in a short time falls to the bottom of the test-tube. This deposit consists of *suboxide of copper*. The chemical reaction which takes place is the following: the sulphuric acid of the sulphate of copper unites with the stronger base, the caustic potash, forming sulphate of potash; the sugar is oxidised at the expense of the oxide of copper, and the latter, being *reduced* to the condition of a red insoluble suboxide, is at once precipitated.—This process also bears the name of the *reduction test.*

2. *Caustic potash test. Moore's test.* The suspected urine is mixed with a little liquor potassæ and warmed, the heat being applied to only the upper part of the fluid in the tube; the part so treated takes on a clear yellowish-brown colour, deepening, on further heating, to a *brownish-red*, which is the more intense the more potash has been added. The portion of fluid which is not heated preserves its original colour, which renders the change just described the more striking. If the warmth be kept up till the urine boils there is developed, especially on adding a little nitric acid, a sweetish smell of burnt sugar. Urine coloured brown by the caustic potash process turns still darker on keeping for a short time.

3. *Bismuth test.* To the urine should be added first a few drops of *liquor potassæ* and then as much *nitrate of bismuth* as will lie on the point of an ordinary knife, the latter reagent being an insoluble, heavy, white powder which rests on the bottom of the glass. The application of heat now imparts to the urine a clear brownish-red colour, (as in the last test), while it *blackens* the bismuth. The chemical change which takes place is simply the reduction of the bismuth salt, and is exactly analogous to that which occurs in Trommer's test: the nitric acid of the salt of bismuth unites with the caustic potash, a portion of the oxygen of the oxide of bismuth is appropriated by the sugar, and black suboxide of bismuth is left.

4. *Fermentation test.* Saccharine urine, when mixed with yeast, ferments, the sugar being changed into carbonic acid and alcohol.

The indications offered by these tests may be obscured by the presence of various substances in the urine which prevent the reduction of the copper or bismuth salt; the urine may, for instance, contain albumen as well as sugar, when the former must first be precipitated and then removed by filtering before the testing for sugar can be proceeded with.—There are several other tests for sugar in the urine, but as they are not much used no account of them need be given here.

The quantity of sugar present in diabetic urine varies from ½—10 per cent.; in the great majority of cases it fluctuates within narrow limits, from about 3—5 per cent. The per centage is calculated by using *Fehling's standard solution of sulphate of copper* or by means of the Soleil-Ventzke saccharimeter. After introducing the glass tube filled with the saccharine urine into the apparatus just named, the nonius, previously arranged so that it points to zero on the scale, is turned to the *right* till both fields have the same colour; the extent of this displacement to the right indicates the per centage of sugar in the urine.

Figurate elements in the Urine.

Normal urine is perfectly clear, containing neither crystalline nor any other organic figurate element, except possibly now and then traces of mucus. If, however, the urine be turbid immediately after emission, we have distinct evidence of the presence of such constituents. In order to examine these with the microscope the urine must first be filtered, as they occur in very small quantity compared with the volume of the fluid in which they are diffused; or the urine should be allowed to stand some time in a glass which tapers towards the bottom, when a small portion of the sediment may be removed with a pipette.

The organic figurate elements found in the urine in disease are pus cells, blood corpuscles, casts of the uriniferous tubes, epithelial cells, and fungi.

Pus corpuscles. These are in no respect different from the colourless globules of the blood. A highly purulent urine is perfectly turbid and of a whitish-yellow, milky colour, even at the moment it is passed; if set aside for a short time the pus corpuscles are deposited at the bottom of the glass as a yellowish sediment. The pus globules retain their ordinary shape in the urine so long as this fluid remains acid or neutral in reaction; but the occurrence of alkaline fermentation converts them into a gelatinous mass which is quite devoid of structure under the microscope.

Pus corpuscles are found in the urine in greatest number in *catarrh of the bladder;* they are more or less abundant, however, in catarrh of any part of the urinary tract, from the pelvis of the kidneys down to the orifice of the urethra, being mechanically mixed with the urine in its passage outward. It is generally easy to infer from what part of the urinary apparatus the pus comes by noting the further results of objective examination and the other symptoms of the affection. If it be derived from the urethra, in men, a purulent fluid may also usually be expressed from the canal before as well as after micturition; in women pus cells often gain admission into the urine from the admixture of vaginal secretions (as in cases of leucorrhœa); to prevent error it is advisable in such circumstances to draw off the urine with a catheter. If the pus be secreted by the bladder, which in chronic cases of purulent urine is the usual source, it is accompanied by a number of the large vesical epithelial cells. If it proceed from a point considerably higher, from the pelvis of the kidney, for example, there are usually also observed the other signs of positive renal disease; the principal element in the diagnosis in such cases is the exclusion of every other part of the urinary passages as a possible source of the discharge.

Red blood corpuscles. They are found in the urine in sufficiently large quantity to impart to that fluid a distinctly blood-like coloration, only as the result of hæmorrhage (rupture of some vessel) within the uropoietic apparatus. They occasionally appear in smaller numbers, but still abundantly enough to suggest to the eye at once that the urine contains blood, without rupture of the walls of the vessels; this form of bleeding, *hæmorrhage per diapedesin,* may occur in all inflammatory conditions within the uropoietic system, particularly in very severe acute nephritis, but also in the course of chronic nephritis, when the inflammatory action is from any cause increased in violence.—The shape and colour of the red blood corpuscles as they are seen in the urine, have already been described on p. 378.

Epithelial cells. The epithelial cells found in the urine may be detached from any part of the urinary apparatus, and are met with in all affections of these parts. The renal epithelial cells, as they appear in the urine in kidney diseases, are sometimes separate from each other, at other times adherent. The urinary passages throughout their whole length are protected by several layers of pavement epithelium, disposed one over the other, forming a lining membrane which is of greatest thickness in the bladder. The vesical epithelial cells are generally large, provided with only a single nucleus (like the buccal epithelial scales), polygonal, and more or less rounded at the angles,—characters which render their recognition easy. Below the superficial pavement epithelium of the bladder are numerous smaller, nucleated, *spindle-shaped* cells, which make their appearance in the urine when the catarrh is severe enough to involve the deeper layers of the epithelial lining of the bladder.

Tube-casts in the Urine.

Before beginning to look for these bodies, which play such an important part in the diagnosis of renal diseases, the urine should be filtered, or should be allowed to stand and deposit a sediment in a glass of suitable construction, as the casts are seldom so abundant as necessarily to be present in every single drop of the urine when agitated, as immediately after emission. One drop of the sediment from the glass, or of that which is caught on the filter, should be placed under the microscope and examined with a power of 300 diameters.

These cylinders are simply casts of the uriniferous tubules, which are washed out of the kidneys by the flow of urine. They are divided into three principal varieties: epithelial, granular, and hyaline casts. *Epithelial* casts consist of the epithelial lining of the tubuli uriniferi, expelled in a more or less complete form (desquamative nephritis). As regards the manner in which the *granular* and *hyaline* casts are formed authorities are not by any means unanimous. Whilst according to the older (and recently revived) view they should be regarded as transudation-products derived from the blood, they are described by some as due simply to degenerative change in the epithelial cells. It is generally assumed that the granular casts represent the primary form of the degeneration of the renal epithelium, and that the hyaline casts are a secondary modification resulting from the same degenerative process.

In support of the theory that tube-casts are formed by exudation from the blood, Weissgerber and Perls have recently brought forward the following arguments: the epithelial lining of tubules filled with homogeneous casts is found perfectly intact; casts are often entirely wanting in tubuli whose epithelium is already the seat of very extensive degenerative change; on raising the pressure within the renal veins in animals, by constricting the principal vein, not by closing it absolutely, as this would arrest circulation in the part, fibrinous casts are invariably found in the kidneys; on microscopic examination of such sections of the kidney no appearance is discovered at any point which suggests the idea that the epithelium is metamorphosed into casts, but there are very often seen the various stages of a process in which a simple albuminous fluid, which completely fills the lumen of the uriniferous canals, seems to be gradually transformed into casts of these tubes.

The *granular* (or fibrinous) casts are of different lengths, according as they are expelled from the uriniferous tubules uninjured or in fragments; they vary in length from ½ to 1, seldom 2 mm. or a little more, and in breadth from 0·04—0·06 mm.; they are very *darkly* granular, a feature by which they are very readily known when seen, are frequently covered by blood and pus corpuscles, and contain also a yellowish fatty detritus. In very violent acute nephritis they occur in great numbers in the urine; they are also very abundant in chronic nephritis.

Hyaline casts are strikingly pale and transparent, their outline being also made more distinctly visible by staining with carmine or aniline; they are occasionally absolutely free of any figurate element, but in other cases show here and there a little granular fatty detritus or a few epithelial cells. Between the typically granular and hyaline casts come many intermediate forms; many present the characters of both varieties, being darkly granular at one part and perfectly pale and clear at another. In length and breadth there is no difference between hyaline and granular casts.

Epithelial casts consist almost entirely of the detached epithelial lining of the uriniferous canals; the individual cells of which they are composed present generally the signs of being in a more or less advanced state of degeneration, they are dull and clouded in appearance, swollen, dotted with numerous brilliant globules of fat, and are occasionally surrounded and almost hidden by blood and pus corpuscles and fatty débris. They are, as a rule, easily distinguished from the other figurate constituents of the urine.

Tube casts in the urine are commonly accompanied by free red blood corpuscles, colourless blood globules (pus corpuscles), and epithelial cells. These elements often afford a clue to the

particular stage which the morbid process within the kidneys has reached, though any inference based on the results of microscopic examination alone is apt to be fallacious. A very abundant fatty detritus mingled with epithelial cells in a state of fatty degeneration, and the presence also of large numbers of thin narrow casts, generally indicate that the nephritis has arrived at a somewhat advanced stage,—atrophy; very large, broad granular casts and red blood corpuscles are indicative of the early stages of nephritis or of a fresh exacerbation of an old-standing affection; very frequently, however, all the different kinds of casts are found together in the same urine. The special *form* of nephritis present in each case cannot be determined by microscopic examination *alone*.

Whilst in all cases the occurrence of tube-casts in the urine may of itself be accepted as conclusive evidence of the existence of an inflammation of the kidneys,—an inflammation which may be simple and uncomplicated, or which may appear in connection with other affections, such as scarlatina, diphtheria, cholera, small-pox, &c.,—the other figurate elements, the red and white blood corpuscles, epithelial cells, detritus, are to be regarded as diagnostic of nephritis only when accompanied by casts; wherever such casts are wanting the microscope alone is not sufficient to fix with precision the site of the disease.

Coagula of fibrin are often observed in the urine in acute and hæmorrhagic nephritis; these bodies are somewhat elongated in shape and are not unlike granular casts, but may be distinguished from these by the irregularity of their outline and the total absence of structure and of figurate elements.

Every urine which contains casts is albuminous. There exists no absolute relation between the quantity of the albumen and the number of the casts; the latter may be few in a highly albuminous urine, or plentiful when the albuminuria is slight. Thus, in amyloid degeneration of the kidneys the urine may be loaded with albumen but may show very few casts under the microscope, while in acute renal disorders tube-casts are often abundant in a urine which is but feebly albuminous.—Nothnagel states also that *hyaline casts* always appear in the urine in intense *icterus*.

Inorganic Urinary Sediments.

The sediments which are met with in acid urines, both normally (but only in traces) after cooling and in pathological conditions, are the urate of soda and free uric acid, more rarely the oxalate of lime; the sediments of ammoniacal urine consist of urate of ammonia and phosphates (phosphate of lime and ammoniaco-magnesian phosphate).

Urate of Soda. This salt, which is found in small quantities in normal urine, is deposited in great abundance in all febrile diseases, especially during the critical period, after violent physical exertion, and in the urine of those who habitually indulge to excess in eating. It is precipitated only when the urine cools, and forms a dirty yellowish clay-coloured or reddish (brick-dust) sediment. Under the microscope it is seen to be *amorphous*, and is made up of very minute, irregular granules, often aggregated into small masses, but easily broken up and reduced to its original divided condition by gentle pressure with the object-glass. The opacity occasioned in the urine by the urate of soda disappears rapidly on the application of heat, the fluid becoming perfectly clear.

Uric Acid. In warm urine this substance is but very sparingly soluble; it falls at once as a crystalline sediment when the urine cools, and in being precipitated takes up a portion of the urinary colouring matter, from which it acquires a yellowish red or sometimes faintly brown coloration. Under the microscope it shows the most diverse crystalline forms, appearing usually in rhombic plates or columns, four-sided prisms, often in dumb-bell or barrel-shaped crystals. Sometimes these crystals are separate from each other, at other times arranged in groups; many of them are large enough to be visible to the naked eye, and for microscopic examination they demand at most only a low power, 100—150 diameters. In the urine it is commonly combined with the acid urates of soda and potash. On adding hydrochloric acid to the urine the uric acid is set free and in a short time crystallizes out; the process of crystallization may be observed in the field of the microscope on adding one drop of hydrochloric acid to a sediment of urate of soda.

Uric acid may be recognised by its chemical reaction as well as by its microscopic characters. Thus, on dissolving a few crystals in a little nitric acid, warming and evaporating, and treating the reddish residue with a weak solution of caustic ammonia, a deep purple coloration is obtained (purpurate of ammonia, murexid), which changes to violet blue on the further addition of a few drops of caustic potash or soda.

The excretion of uric acid is doubled, sometimes trebled, in febrile and other diseases (of the respiratory and circulatory organs, disturbances of nutrition, &c.); in arthritis it is deposited in the joints. Renal calculi are often composed exclusively or in great part of uric acid and its salts.

The oxalate of lime, a normal though by no means a constant constituent of the urine, presents itself under the microscope in the form of exceedingly minute octohedra, bearing a certain resemblance to the envelope of a letter. This deposit is generally very scanty, and is most often thrown down in urine which also contains uric acid. The abundant discharge of such crystals is not an unfailing sign of a pathologically increased oxaluria; the urine may be moderately rich in oxalic acid without giving rise to the separation of oxalate of lime crystals, as the latter salt may be held in solution, especially by the acid phosphate of soda. Its quantity per day seldom rises above 2 centigrammes (Fürbringer). It sometimes forms calculi in the kidneys and bladder.

Phosphate of lime and *phosphate of magnesia* are soluble in acids and are therefore not deposited in acid urines; they are excreted to about the extent of 1 gramme per day (Neubauer). When present in the urine in large quantity they are precipitated as an abundant white sediment, the urine being neutral or alkaline to test-paper. Phosphate of lime occurs as an amorphous powder, sometimes also in crystals, often forming beautiful star-shaped masses. The phosphate of *magnesia* is also sometimes deposited in the crystalline form as elongated plates (Stein). Increase of the earthy phosphates is noticed often in phthisis, in rachitis in children, and in other diseases, frequently keeping pace with a similar increase in the separation of indican (Senator).—*Cystine* is rather a rare constituent of the urine, only 52 cases in which it was detected being recorded in medical literature; it sometimes forms concretions in the kidneys, at other times crystallizes in colourless hexagonal plates or prisms. Among other points by which cystine may be distinguished from uric acid, which frequently assumes exactly the same crystalline forms, there is this, that the former, when dissolved in nitric acid and treated with ammonia, gives no murexid reaction. The daily excretion of cystine amounted, in the case recently put on record by Niemann, to about 0·5 gramme, and in that reported by Loebisch to 0·4 gramme.—*Leucine* and *Tyrosine* are met with in the urine in certain cases of acute atrophy of the liver and variola; the former substance appears in granular, yellowish, globular masses, or, when perfectly pure, in white and exceedingly thin plates; the latter crystallizes in very fine white needles.

Urate of ammonia is formed when the urine undergoes alkaline fermentation, crystallizing in small spherical masses studded over with spines (the thorn-apple crystals).

Ammoniaco-magnesian phosphate is invariably separated, as soon as the urine becomes alkaline, in colourless prismatic crystals of various sizes, most of them slightly modified and tending to the ordinary coffin-lid shape. These crystals are freely soluble in acetic acid, a property by which they may readily be distinguished from the oxalate of lime, which is not soluble in acetic acid; this is a reaction of some importance, as the phosphatic crystals, when very small, resemble closely those of the oxalate of lime.

Of the lower organisms found in the urine should be noticed the *rod bacteria* which always accompany fermentation of the urine, and *sarcinæ*.

VOMITING.

When the ramifications of the pneumogastric nerve in the mucous membrane of the stomach and pharynx are subjected directly or indirectly to any abnormal irritation, reflex and very energetic contraction of the diaphragm and abdominal muscles is set up, whereby the stomach is firmly compressed on all sides and its contents discharged upwards. The stomach itself is not *actively* concerned in the act of vomiting, except in so far as it contributes by the opening of its cardiac orifice; its muscular coat contracts very little, if at all.*

The irritation of the sensory nerve-terminations in the stomach may be direct or indirect. *Direct* irritation is produced by emetics, poisons, nauseous substances, violent shocks, or by merely overloading the stomach; in all gastric diseases, from simple catarrh to the malignant new formations, and often also in simple hyperæsthesia of the gastric nerves, unaccompanied by any anatomical change, the stomach is more or less directly irritated. There is no disease of the stomach in which vomiting, transient or persistent and recurrent, may not appear as a symptom in some part of its course, though in many cases it is entirely wanting from beginning to end; it is only in cancer, especially when it causes stricture of the pylorus, that vomiting comes to be an absolutely constant symptom.

* It is necessary that the cardiac orifice of the stomach should be opened before vomiting can take place. The abdominal pressure alone is not sufficient to effect this, as there are certain conditions, difficult and painful defæcation, for example, in which, notwithstanding the amount of pressure brought to bear on the stomach by the abdominal muscles, the contents of the stomach are not ejected, simply because the cardiac orifice of the organ remains closed; on the other hand, vomiting is not unfrequently observed in animals on exposing the stomach and injecting tartarated antimony into the veins, though in this case the force exerted by the walls of the abdomen is completely eliminated as a factor in the process.

In diseases of the stomach vomiting takes place more readily when the organ is full than when it is empty; it is occasionally brought on also in such circumstances by every variety of solid food, sometimes even by the blandest fluids, at other times only by taking things which are difficult to digest or by special articles of diet; it may occur immediately after eating or only after the lapse of some time. In certain cases it is possible to form some idea as to the seat of the disease from the interval which elapses between the taking of food and the starting of the vomiting; thus, in cancer of the stomach the patient rejects his food almost directly after a meal when the cardiac orifice is contracted, but if the disease be located about the pyloric end, producing stenosis of the pylorus, the vomiting does not begin till several hours have passed.

The irritation of the gastric nerves may be *indirect*, the organ itself being perfectly healthy in structure. This is sometimes due to abnormal excitation of the vagus at its origin in the brain,—hence the frequency of vomiting in cerebral diseases and in certain affections of the nervous system,—or to reflex irritation of the vagus through some of the abdominal plexuses of the sympathetic, with which it is connected by anastomoses. In some cases the vomiting which so often attends affections of the abdominal organs may be explained by the relation which subsists between these two portions of the nervous system; in many other cases, however, this explanation is not so satisfactory.

Examination of the Vomited Matters.

This is generally made with the naked eye, which in most instances is quite sufficient for diagnostic purposes; in certain circumstances, however, a microscopic examination becomes necessary.

According to the stage of digestion at which vomiting has occurred, the matters brought up, consisting partly of fluids and partly of solids, are more or less acted upon by the gastric juice, and have a more or less powerful acid odour. When the stomach is empty, or after repeated evacuation of its contents, vomiting expels only a ropy, viscid, mucous secretion, with which are sometimes mingled biliary matters from the duodenum, which give to the discharges a greenish coloration. The bile is pressed out of the duodenum into the stomach by the energetic contraction of the abdominal muscles, particularly when the vomiting is severe and accompanied by much straining,—as it always is when the stomach is empty.