# EXAMINATION OF THE URINE.

FOWLER.

## ERRATA:

On page 16, 19 and 20, for insipitus, read insipidus.

On page 16 and 54, for miletus and melitus, read mellitus.

On page 34 for 1-120, read 1-3000.

# EXAMINATION OF THE URINE.

BY

GEO. B. FOWLER, M.D.,

EXAMINER IN PHYSIOLOGY, COLLEGE OF PHYSICIANS AND SURGEONS, NEW-YORK, FELLOW OF THE NEW-YORK ACADEMY OF MEDICINE, MEMBER N. Y. COUNTY MEDICAL SOCIETY, ETC.

NEW-YORK:
D. APPLETON & COMPANY,
549 AND 551 BROADWAY.
1874.

# PREFACE.

This book is intended simply as a "Guide." It has been my endeavor to render the subject and the manipulations as plain as possible, hoping thereby to enable the reader to acquire a thorough knowledge of the common and important characters of the urine.

In teaching the subject, I have become convinced that a few words regarding the conditions which produce the various changes in the urine, normal and abnormal, have very greatly assisted the student in mastering the subject, by at once revealing its practical import. I have, therefore, introduced here brief outlines of the physiological and pathological influences which bear upon the subject.

The general arrangement of a manual like this is important; that which I have adopted is as follows:

Part I.

1. Characters of Normal Urine.
2. Effects of Reagents upon Normal Urine.

Part II.—Characters of Abnormal Urine.

Part III.—Urinary Deposits.

1. Those which are Natural Constituents of the Urine, either Separately or in Combination.
2. Those which are Foreign to its Composition under any Form.

Part IV.—Accidental Ingredients which do not Form Deposits.

Part V.—Quantitative Analysis.

Part VI.—Calculi and Gravel.

April, 1874.

# EXAMINATION OF THE URINE.

## PART I.

### 1. CHARACTERS OF NORMAL URINE.

#### Composition.

| | |
|---|---|
| Water, | 938.00 |
| Urea, | 30.00 |
| Creatinine, | 1.50 |
| Creatine, | 1.25 |
| Urate of Soda, " " Potassa, " " Ammonia, | 1.80 |
| Coloring Matter and Mucus, | .30 |
| Biphosphate of Soda, Phosphate of Soda, " " Potassa, " " Magnesia, " " Lime, | 12.45 |
| Chlorides of Sodium and Potassium, | 7.80 |
| Sulphates of Soda and Potassa, | 6.90 |
| | 1000.00 |

**Odor.**—The odor of normal urine has been described as resembling that of violets. It is subject to many changes, however, depending upon articles of food, and some medicines impart to it a peculiar odor. But when this is the case, it is best considered under the head of abnormal, which see.

**Color.**—The tint of healthy urine is liable to variation, though a yellow amber is about the standard color. The coloring matter of urine is a peculiar organic constituent called *urosacine.* It is present in definite proportion, and depends upon the amount of water whether its presence in the urine be marked by a deep or faint color. Excessive indulgence in water, malt liquors and wine, and diminished activity of the perspiratory apparatus, will cause an increase of the watery element in the urine, and consequently more or less dilution, when the urine will assume a light color, and may even resemble pure water. The converse of the above conditions will produce a contrary result.

**Transparency.**—Normal urine is perfectly clear, with the exception of a small collection of mucus and epithelium which nearly always collect at the bottom of the vessel.

**Reaction.**—Healthy urine has an acid reaction, which is due not to the presence of any free acid, but to an acid salt, the biphosphate of soda. This reaction may be decided or faint. But it should not be understood that unless the urine is acid it is abnormal. Indeed, the reaction may vary within healthy limits, between well-marked alkalinity and acidity.

The causes of this irregularity are found to be in the diet. It has been ascertained that a vegetable diet will lessen and sometimes cause the disappearance of the acidity; and it has been found that after a mixed meal, the urine is distinctly alkaline. This reaction continues a little while, when the alkalinity becomes less, and finally the acid state is restored. The acid reaction thus increases during fasting, and reaches its greatest degree of intensity after twelve hours of abstinence from food. (ROBERTS.)

It is well to note that this variation is not due to any diminution in the acid present, but simply to a sudden accumulation of alkaline ingredients, the result of digestion. For during digestion, all the salts of the organic acids, such as tartrates, malates, citrates, and lactates are transformed into carbonates, and as such appear in the urine. Substances containing these organic compounds are in daily use, either as food or medicine. All the fruits and vegetables offer familiar examples, and mineral waters are a common cause of a temporary alkaline urine.

**Specific Gravity.**—The specific gravity of normal urine varies from 1018 to 1025. These limits may be extended in individual cases, and, in fact, depend greatly upon the quantity of urine voided. In other words, the specific gravity bears an inverse ratio to the daily quantity. Should we have an increased flow of urine from unusual indulgence in drink, or from the action of any diuretic, we would not expect the density to equal that where the same amount of solid material was present in a less amount of water. For in diuresis, except in a few instances of disease, we merely have the water increased, and not the solid constituents. And, on the other hand, where the individual has taken little or no fluid, or has perspired freely, or is suffering with diarrhœa, the urine would be what we call concentrated—that is, the normal amount of solid ingredients, salts, urea, etc., would be there dissolved in a small proportion of water. And under these circumstances, the specific gravity would be high—even 1030 would not indicate disease.

**Daily Quantity.**—The total quantity of urine voided by a healthy individual during twenty-four hours is estimated to be from 35 to 50 fluid ounces. This is subject to variation, depending upon the quantity of fluids drunk, the activity of the perspiratory functions, etc.; for it is evident that should there be a small proportion of fluids taken into the system, there will be less secreted by the kidneys, and *vice versa.* And should perspiration prevail to an unnatural degree, we should be getting rid of the water by another channel, and would not expect to find the same volume of urine; and the same may be said of watery discharges from the bowels. The kidneys act as regulators of the water-supply of the blood; they take from it any excess, and when there is an insufficiency, they demand only enough to dissolve the solid substances of the urine, and to facilitate their discharge from the body.

The estimation of the daily secretion of urine is one of the most important points connected with its study. It, however, depends greatly upon another condition for its significance to the physician—namely, specific gravity.

The most important and abundant solid ingredient of the urine, urea, is present in increased quantities as a result of muscular exercise and diet; therefore remember to consider these facts in instances where a greater density than 1024 to 1025 is found.

These variations in specific gravity, ranging from 1006 to 1030, can not be *constant*, and not excite suspicion regarding the integrity of the kidneys, or some pathological condition of the economy. To entitle them to be considered under the head of normal, they must be only temporary and easily referred to some such cause as has been mentioned.

## 2. EFFECTS OF REAGENTS UPON NORMAL URINE.

**Cold.**—Cold has no visible effect upon urine of a specific gravity at or below 1020. But in concentrated specimens, after cooling, there will be a precipitate, more or less colored, which consists of the amorphous urates, they being only soluble in warm urine and in an excess of water. This precipitate first appears as a cloud throughout the whole volume of urine, but will gradually collect at the bottom and adhere in specks to the sides of the vessel as a fine powder.

Such a deposit or cloudiness will disappear upon again raising the temperature to that of the body.

**Heat.**—Normal urine of a decided acid reaction is unaffected by the application of heat. But should the reaction be faintly acid, neutral, or alkaline, heat will cause a cloudiness, due to the precipitation of the earthy phosphates, lime and magnesia.

These two phosphates are insoluble in a neutral or alkaline fluid, and are less soluble in warm than in a cold fluid, and therefore will be precipitated by heat if the reaction of urine is even slightly acid.

**Acid.**—The addition of an acid to urine has no visible effect beyond deepening the color. But if nitric acid be added, in the proportion of about one third, after several hours minute but distinct dark brown crystals will be seen clinging to the sides of the test-tube or vessel, and collect at the bottom. These are the crystals of uric acid which have resulted from a decomposition of the urates by the nitric acid.

**Alkalies.**—When urine is rendered alkaline, the earthy phosphates of lime and magnesia will be precipitated.

*The subacetate of lead and nitrate of baryta* precipitate the alkaline sulphates, which are said to vary in certain diseases. But this proportion in the urine is itself variable, and is found to depend greatly upon the kind of food taken.

*The nitrate of silver precipitates the chlorides.* It is sometimes expedient to estimate the comparative quantity of the chlorides, inasmuch as it is pretty well established that they are subject to great fluctuations in certain forms of disease. In all severe inflammations, pneumonia, pleurisy, cholera, etc., the chlorides almost disappear from the urine, and the nitrate of silver produces little or no effect. But when the attack begins to subside, this reagent will detect the return of the chlorides. This precipitate is a very copious white cloud.

*Subacetate of lead and nitrate of silver* also precipitate the mucus and coloring matter of urine.

**Urea.**—Urea represents the wornout nitrogenous elements of the body. It is excreted at the rate of about 500 grains per day. If, through any derangement of the functions of the kidneys, urea is not thrown off by the urine, it accumulates in the circulation and acts as a poison upon the nervous system, inducing what is called uremia.

A convenient way to ascertain whether urea is present in the urine, in about the normal proportion, is as follows:

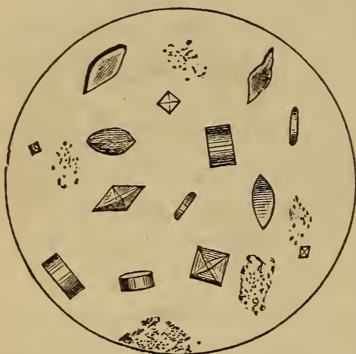
Evaporate 5 ℥ of urine over a water-bath to 1 ℥; filter away the phosphates and urates which are deposited, and allow the clear concentrated specimen to cool. Now add about 1 ʒ of nitric acid, and a copious formation of crystals of *nitrate of urea* will result, if the urea is present in any thing like the normal quantity. Or a few drops of the urine may be placed upon a glass slide and a drop of nitric acid added, and the whole allowed to evaporate, when the crystals will be distinctly seen, and under the microscope will appear as delicate six-sided plates, superimposed one upon another.

## CHANGES WHICH TAKE PLACE IN URINE AFTER BEING DISCHARGED FROM THE BODY.

If a specimen of urine be kept for observation, the following changes show themselves:

At first, after a period varying from two days to a week, the acidity becomes more marked, the color is darker, and crystals of *uric acid* and *oxalate of lime* make their appearance. Even should the urine be faintly alkaline, to commence with, and cloudiness exist from the precipitation of the earthy phospates, it will become acid, and the cloudiness clear up, when the process continues as in the other cases. The acidity increases up to a certain point, and then begins to grow less. It may continue two, four, or seven days; and Lehman states, he has observed the acid reaction to increase for two or three weeks, and then not disappear altogether until eight weeks.* This is the ACID FERMENTATION of urine (Fig. 1).

Fig. 1.



Acid Fermentation: Uric acid and octahedra of oxalate of lime.

The acidity gradually becomes fainter and fainter, and at length the urine is neutral. Now, marked changes will be noticeable. The urine is cloudy; it will contain confervoid vegetations and algæ; myriads of infusorial animalcules are visible under the microscope (vibriones). Neutrality gives place very soon to alkalinity, which is advertised most emphatically by a putrescent, ammoniacal odor. The uric acid crystals will disappear, and others of the *triple phosphate of ammonia* and *magnesia* are produced. These crystals are large prisms, and can be seen glistening on the surface of the urine where a layer of brittle fatty matter has formed. Dark, round

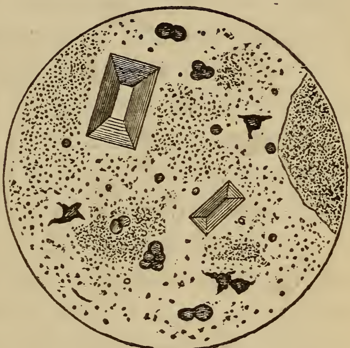
* Physiological Chemistry, vol. 2, p. 121.

crystals of the *urate of ammonia* may also be seen with the microscope.

This state of things continues until the decomposition is complete. Then the ammoniacal odor will no longer be detected, and the urine will have lost most of its color.

This constitutes the ALKALINE FERMENTATION (Fig. 2).

Fig. 2.



Alkaline Fermentation: Crystals of triple phosphate] and urate of ammonia, amorphous phosphate of lime.

The *chemistry* of these two fermentations has been differently explained; but that offered by Scherer is generally accepted as correct.

He says that the organic matters, the coloring matter and mucus, act as catalytic bodies, and induce the fermentation whereby lactic acid is produced. Just how lactic is formed is not well understood, but it is certain that it makes its appearance in urine when allowed to stand, in which it could not be detected when fresh. The presence of lactic acid then decomposes the urates, whereby uric acid is set free and makes its appearance as crystals. At the same time, oxalic acid must be produced, for crystals of the oxalate of lime show themselves. This oxalate of lime is very insoluble, and could not have existed in the urine before without detection. Therefore the supposition is that oxalic acid is formed and immediately unites with the lime already present. So much for the acid fermentation.

Now, urea is decomposable into the carbonate of ammonia by contact with a decomposing organic substance, and the addition of two equivalents of water. Here then we have the conditions of this decomposition. The mucus gradually loses its power of producing lactic and oxalic acids, and begins itself to decompose; and surrounded by water, the arrangement for the transformation is complete. It accordingly takes place, and the first effect of the presence of carbonate of ammonia is to neutralize the acid reaction, and then to induce the alkaline. Now, of course, the earthy phosphates are no longer soluble, and render the urine opalescent by this precipitation; the uric acid crystals are dissolved; a scum of animal matter intermixed with the amorphus phosphates now forms on the surface, and very soon glistens with crystals of a new formation, the *triple phosphate* or *ammonio-magnesian phosphate.* (It is called *triple* because it consists of two equivalents of magnesia and one of ammonia.)

At the same time, the carbonate of ammonia acts upon the phosphate of soda of the urine, and another double salt, the phosphate of soda and ammonia, is formed.

The crystals of this last compound salt are very similar to those of the preceding, and having the same history, and being affected alike by different substances, need not be studied apart.

The urea continues to be decomposed, and the carbonate of ammonia to unite and form these several new substances, until there is nothing more for it to unite with. Now it escapes as gas, and the odor reminds us of that common to public urinals, where, indeed, the same process as just described is going on. At length, all the urea is decomposed, and the evolution of the ammonia ceases. The other substances either remain unchanged or some pass off in the form of other gases.

These are the important facts concerning normal urine, and a knowledge of them is indispensable, in that if we are not acquainted with them, we certainly shall not be prepared to detect and appreciate the variations which constantly present themselves, and constitute an abnormal condition.

# PART II.

## CHARACTERS OF ABNORMAL URINE.

**Odor.**—The odor of urine is frequently affected, and is likely to attract the attention of both patient and physician, and lead to its examination. Many articles taken as food and medicine impart to it an odor peculiar to themselves. Such are asparagus, onions, turpentine, cubebs, and copaiba. An ammoniacal odor tells the story of decomposition.

**Color.**—The color of urine is subject to many changes, depending on the degree of concentration, where it will be more or less dark ; on dilution, where the lighter shades will prevail. In febrile diseases, where we have a partial suppression of urine, the secretion is high-colored. In diabetes miletus, a disease characterized by an inordinate flow of urine of a high specific gravity and the presence of sugar, the tint is light ; also in diabetes insipitus, when there is a great increase in the amount of urine of low specific gravity. Some articles of food and medicine also affect the color of the urine. Strong coffee heightens the color, rhubarb imparts a deep yellow, and logwood gives it a reddish hue. Santonine renders it an orange red when alkaline ; when acid, a golden yellow. Creosote and compounds of tar have been known to cause the urine to become almost black; and, lastly, blood and bile may be present in such quantities as to be readily recognized.

The presence of bile may be distinguished from the effects of rhubarb by the addition of a little liquor ammonia, when the deep yellow of the latter will be converted into a crimson.

**Transparency.**—If a specimen of urine under examination is not clear and transparent, it should be first ascertained whether there was any turbidity when first voided; for we have seen that perfectly healthy urine, when kept for any length of time, will undergo changes and a marked opalescence exist. And abnormal urine may be at first perfectly clear, but on cooling or standing exhibit a cloudiness or deposit. It is possible for urine to be abnormal, and yet remain free from turbidity or deposit. For example, albumen and sugar are perfectly soluble, and can not be detected by simple ocular inspection.

Substances which interfere with the transparency of recently discharged urine are, *pus*, *blood*, *phosphates*, *urates* (if the specimen is cool), *chyle*, *spermatozoa*, and *epithelium*.

The reader is referred to each of these under the head of "Urinary Deposits."

**Reaction.**—After what has been said concerning the variability in the reaction of normal urine, it is sufficient to add now that when we meet with a patient whose urine is habitually or most of the time neutral or alkaline, we should regard him as a subject for treatment.

Remember that the alkalinity may be due to the presence of the fixed salts (soda and potassa), or to a volatile one (ammonia); that the former are derived from the blood, and the latter is the result of the decomposition of urea. These two conditions can easily be distinguished apart by the ammoniacal odor which betrays the presence of carbonate of ammonia, and the fact that the blue color which it imparts to reddened litmus-paper fades away. And also, if the reaction be due to carbonate of ammonia, we shall find crystals of the triple phosphate under the microscope. (Fig. 6.) Where either the fixed salts or the volatile one is present, of course the urine will be turbid from a precipitation of the earthy phosphates. And this precipitation occurring in the bladder is likely to give rise to a calculus; yet it is pretty well established that the urine can remain alkaline a long time from the carbonates of soda and potassa (fixed salts), and a stone not form. It is crystalline deposits which we have to fear in this regard, and therefore, as the presence of carbonate of ammonia results in crystalline formations, calculi or concretions are apt to be induced by it. Therefore it is very important to recognize these two alkaline conditions, and to know that when the reaction is due to one, the cause pre-existed in the blood; when to the other, the cause is the decomposition of urea somewhere in the urinary passages.

Then, too, we may have the urine abnormally acid, producing a scalding sensation during micturition. Now, we know what the result is when an acid is added to the urine outside the body: uric acid crystals will be precipitated. So it is in the bladder under the same conditions. These crystals then accumulate and form gravel, some of which is voided by painful efforts by the urethra, but others soon grow by union and very soon become a calculus, and by their presence irritate and inflame the bladder, which then throws off a quantity of mucus and epithelium. These products of inflammation supplied with the necessary conditions for decomposition, warmth and moisture, quickly begin to affect the urine as it comes down from the kidneys. The result is, the decomposition of urea, production of carbonate of ammonia; and growth of the original uric-acid stone by successive layers of the earthy phosphates.

**Daily Quantity and Specific Gravity.**—We have seen, in the case of healthy urine, how closely the specific gravity and daily quantity are related, and that as one increased, the other decreased; or, in other words, that they bore an inverse ratio to each other. In certain diseased conditions, however, both are increased and decreased together. The specific gravity may be 1030, and the daily quantity 60 ℥. Here we would recognize the fact that there is a double waste of both water and solids. And, again, the specific gravity may be 1006 to 1012, and the quantity not exceed 12 ℥. In this case, there is a suppression of both elements, and from retention of the chief solid constituent, urea, the most fatal results may follow. There is also a disease—diabetes insipitus—where the daily quantity of urine is fifty and sixty ounces, and the specific gravity much *below* the normal standard. This state of thing robs the system of its proportion of water, occasioning great thirst, whereby nature endeavors to counteract the drain.

Here, then, in abnormal urine, the specific gravity and the daily quantity are in direct ratio, except in diabetes insipitus. *When the amount of water is increased, the solids will be also, and vice versa.*

The specific gravity of urine may be increased by accidental ingredients, such as pus, blood, mucus, albumen, and sugar.

Great care is necessary in collecting urine for examination. The patient must be made to pass the entire secretion of twenty-four hours in one clean vessel, and from this total quantity a portion must be selected for examination, especially as regards the specific gravity.

# PART III.

## 1. URINARY DEPOSITS.

THE urine is subject to deposits, or collections of solid and semi-solid substances, which, on account of their weight, subside when undisturbed. These deposits consist of various materials, some of which are normal constituents of the urine, either separately or in combination, while others are foreign to its composition altogether.

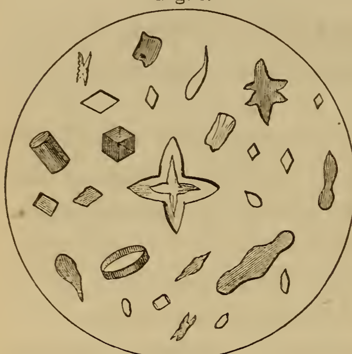
Therefore, it will be convenient to study urinary deposits by dividing them into these two classes.

TO THE FIRST CLASS BELONG URIC ACID, THE URATES, THE PHOSPHATES, OXALATE OF LIME, EPITHELIUM, MUCUS, AND PIGMENTS.

**Uric Acid.**—Uric acid does not exist in a free state in the urine, but is there in combination with the alkaline bases, soda, potassa, and ammonia. It, however, presents itself independent of these, and forms a deposit of dark brown crystals. We have seen that this occurs during the acid fermentation of urine, and that it is due to the development and action of lactic acid, which decomposes the urates. We can accomplish the same result by adding any strong acid to a test-tube containing urine, and allowing it to remain quiet for several hours. Then the characteristic uric-acid crystals will be seen attached to the sides and collected at the bottom.

The dark brown color which almost invariably distinguishes these crystals is derived from the coloring matter of the urine, for which they have a great affinity. Yet we sometimes see almost colorless and pure crystals of uric acid, and these are apt to be small square plates or diamonds.

Fig. 3.



Uric acid.

The formation of crystals of uric acid may take place in the urinary passages, not only as a result of fermentation, but spontaneously, due to an excessive acid condition of the urine. In either case, gravel and calculi are likely to result. It is therefore very important to know whether a deposit took place previous to the discharge or afterward.

Fig. 4.

Uric acid.

A deposit of uric acid is of a dark brown color, or if pure, it is a white, glistening powder, and under the microscope presents the greatest variety of crystalline forms. In fact, so numerous are the shapes and arrangements of these crystals, that it is very difficult to give any description. Yet when familiar with urinary crystals, they are not likely to confuse one. For it is only necessary to be able to recognize the other crystalline deposits, which vary little or none; and then when a brown crystal of an unusual form is seen, it is pretty safe to pronounce it uric acid. The most common appearances are represented in Figs. 3 and 4.

Tests.—Uric acid is insoluble in water, alcohol, and ether. It is soluble in an alkali, especially at a high temperature.

There is a beautiful test for uric acid called the murexid test. Place the uric acid in a clean white porcelain capsule, and add a drop or two of nitric acid; then evaporate over the flame of a spirit-lamp. When the nitric acid has been driven off, there will a pink stain show itself, which, on the addition of a little liquor ammonia, assumes a beautiful purple color.

**Urates.**—The urates, of soda, potassa, and ammonia, are present in the urine, in solution, but frequently are precipitated, and appear as a dense cloud or powder, which collects at the bottom of the urine-glass, and at the same time dusts the sides over with a powdery film. The color of the precipitate may vary from a white to a red, according to the concentration of the urine, these substances having a great affinity for the coloring matter. As a class, the urates have very much the same qualities.

They are soluble in an excess of water at a low temperature, but at an elevated temperature, and that of the body, they will dissolve in a less amount of water. It is this reason that, however concentrated the urine may be when voided, it is never turbid with the urates. But in a short time, the temperature falls, and a cloudiness is visible, followed shortly by a copious deposit.

Knowing, then, that the urates are precipitated when the urine is deficient in water, we can understand how abstinence from drink, profuse perspiration, a watery discharge from the bowels, or any influence which lessens the normal quantity of water in the system, or turns it away from the kidneys, will have the effect of concentrating the urinary secretion, and causing the urates to appear when the urine cools.

In fevers, the urates are deposited, and are high colored. Irregularity in the digestive apparatus is likely to be followed by an appearance of these substances. In children teething, we often encounter a copious white deposit, which is mostly the urate of ammonia.

As to the relative quantity of the three urates in the urine, that of soda stands first, and ammonia last.

This deposit of the urates is almost always amorphous, though sometimes crystals of urate of soda and urate of ammonia are seen under the microscope. The amorphous granules sometimes arrange themselves in regular forms, resembling very much granular casts, but the application of heat will quickly clear up any confusion. Crystals of the urate of soda are met with in the urine of gouty patients mostly, and have the appearances represented in Fig. 5 *b*—round masses of dark color, with radiating lines from the centre, and irregular projections along the circumference.

The crystals of urate of ammonia appear as very dark, spherical masses, and as delicate dumb-bells (Fig. 5 *a*). These crystals form during the ammoniacal decomposition of urine, and can be seen under that condition (Fig. 1).

Fig. 5.


*a*, Urate of ammonia.
*b*, Urate of soda.

TESTS. — The amorphous urates are dissolved by an alkali and also by an excess of an acid, but their presence usually indicates an acid urine. The application of heat is the most simple test. They dissolve at a temperature of 50° Fahr. The murexid test for uric acid is applicable to the urates also.

**Phosphates.**—It is the earthy phosphates of lime and magnesia with which we have to deal as precipitates.

The earthy phosphates are precipitated in three forms: *the amorphous phosphate of lime*, *the stella phosphate of lime*, *and the ammonio-magnesian phosphate*, *or triple phosphate.*

The *amorphous phosphate of lime* is the common deposit of urine, which is alkaline from the effects of a meal from the carbonates, citrates, etc., taken by the mouth, and frequently becomes abundant after nervous exhaustion, as want of sleep, hard study, etc.

The *stellar phosphate of lime* is a crystalline form which sometimes appears in urine. Roberts considers its presence indicative of some grave disorder, he having encountered it in diabetes, cancer, and phthisis.* It may, however, appear in urine where much lime has been taken as food; then if the urine is reduced to a neutral or alkaline state, the stellar crystals may form. These crystals are arranged in radiating stars and bundles, and are perfectly colorless.

*The ammonio-magnesian or triple phosphate* is a crystalline deposit, the result almost always of the alkaline fermentation and the decomposition of urea. (See "Fermentation of Urine.") This deposit very seldom takes place inside the body, and when it does, it is the result of paralysis of the bladder, stone, or retention of urine from some other cause. Under these circumstances, decomposition takes place, and the ammonia, which is one of the results, unites with the magnesia already present, and the deposit is formed. The ammonia normally present in the urine is seldom sufficient to constitute this deposit *without the decomposition of urea.*

The earthy phosphates are only soluble in an acid fluid. It is the acid salt, biphosphate of soda, which holds them in solution in the urine. But we have seen that the urine is frequently neutral and alkaline (see "Reaction of Normal Urine"), and should expect to meet with the phosphates in those instances as a precipitate. It is true that we do. Even in urine which is weakly acid, they will be thrown down when the temperature is elevated, for it is a fact to remember

---

* Urinary and Renal Diseases. Am. Ed., 1871, p. 108.

that the phosphates are less soluble in hot than in cold solutions.

A deposit of amorphous phosphates has the appearance of a white powder, but if the triple phosphate be present, the crystals will be easily seen and quickly recognized by their large size and characteristic glistening, prismatic forms. (Fig. 6.)

Fig. 6.

Triple phosphates.

Tests. — The earthy phosphates are distinguished by their solubility in any acid solution. Therefore if an opalescence or precipitate be composed of these matters, a drop of any acid will immediately cause it to disappear.

**Oxalate of Lime.**—Oxalate of lime is found in urine as a result of the acid fermentation, and also in perfectly fresh and undecomposed specimens of this fluid. Indeed, the formation may take place before the urine is discharged. The source of this formation is oxalic acid and lime. It is claimed by many that oxalic acid is a normal constituent of the urine, and that it, like the other ingredients, is subject to variation, and when furnished in a little more than the usual amount, it unites with the lime, and the oxalate of lime is the result.

It appears as a whitish powder, and never is very abundant.

A great deal has been said concerning the clinical significance of oxalate of lime in the urine, under the heads of "Oxaluria" and "Oxalic Diathesis." Some writers have maintained that oxalic acid normally exists in the blood and urine, and others have declared the contrary.

A long train of symptoms were attributable to its presence in the urine, such as nervous prostration, despondency, loss of sexual power in the male, etc. But I believe these theories have all exploded, and from the simple fact that oxalate of lime is very often found in the urine of persons in blooming health. Indeed, about the only clinical value which attaches to this deposit is the possibility of the formation of a calculus and gravel. And as these concretions are very hard and rough, they are dreaded more than any other.

Tests.—This deposit is always crystalline, and the microscopic appearance is sufficient in every respect to distinguish them from any thing else. There are two kinds of crystals: the octahedra, which are the most common, and the dumb-bell. The first consist of two pyramids placed base to base. (Fig. 7.) Sometimes only a single pyramid exists. Crystals of oxalate of lime are usually very small and colorless. Oxalate of lime is soluble in strong mineral acids.

Fig. 7.

Oxalate of lime: Octahedra and dumb-bells.

**Epithelium.**—Every specimen of urine contains some epithelium, which is augmented in certain diseases of the kidneys and urinary passages. In the healthy state, we find that from the bladder in the greatest amount; and in the female, vaginal epithelium will be mingled with the urine, if great care is not exercised.

As the genito-urinary apparatus is lined with epithelium of different forms throughout its extent, it is well to know what are the peculiarities which distinguish that of one region from that of another.

*Vaginal epithelium* is very common in the urine of women, especially when there is any discharge from the vagina or uterus. It is easily recognized by its large size, thinness, wavy outline, and disposition to fold upon itself. (Fig. 8, *b*.) The female urethra contains very similar forms, but they are somewhat smaller.

Fig. 8.


Epithelium: *a*, Bladder; *b*, Vaginal; *c*, Renal.

*The urethra* is lined by epithelium, which differs in the spongy and prostatic portions. From the meatus to the prostatic region, the cells are round and oval. About the prostate, they are spindle-shaped, caudate, and irregular.

In the *bladder*, the size is increased, and they are often seen still united by their edges. (Fig. 8, *a*.) Those from the ureters possess the same characters, only are of smaller size.

The pelvis of the kidney contains small round and oval cells, of the flat variety, which are a little larger than tubular epithelium.

*The epithelium of the kidney tubules* is a very complicated one, but it is sufficient for our purposes to know that it is spherical, about twice as large as a blood-globule, from which it may be distinguished, should any doubt arise, by its nucleus. It usually comes away from the kidney adhering to fibrinous moulds of the tubes, but may often be seen floating free in the urine. (Fig. 8, *c.*)

When epithelium is present in abundance, it will be accompanied by an increase in the natural amount of mucus, and the two substances settle to the bottom of the urine-glass, intimately mingled. Under the microscope, patches of epithelium-cells will be seen held together by the adhesive mucus.

Epithelium appears in the urine as a result of any inflammation or mechanical irritation of the mucous membrane of the urinary tract.

**Mucus.**—There is always a small amount of mucus in healthy urine, especially in the first passed in the morning. It is to the presence of mucus, however limited in quantity, that the decomposition of urine is due. For if the urine be filtered, it may be kept for an indefinite time without any change manifesting itself.*

Mucus appears as a deposit at the bottom of the glass, or may entangle air-bubbles and float as a fea-

---

* Scherer.

thery ball below the surface. It appears of the color of the urine containing it, but when separated on a filter, is perfectly transparent and glairy. All amorphous and crystalline deposits, blood, pus, casts, etc., become mingled with it and interfere with its transparency, or may mask its presence.

Excessive secretion of mucus may be the result of mechanical irritation, ammoniacal decomposition of the urine in the bladder, or chronic inflammation. Sometimes there is such an amount of mucus secreted, that the whole volume of urine will be rendered semi-solid, and will rope like the white of egg.

TESTS.—Mucus is liable to be confounded with pus, especially when colored by amorphous deposits. It may be distinguished from pus by its ropy and viscid nature, and, best of all, by its appearance under the microscope, mucus having no corpuscular elements.

**Pigments.**—We frequently encounter peculiar little bodies under the microscope, possessing indefinite shapes and appearances, and attracting the attention of the observer by their high color, being either red, dark brown, or yellow.

They sometimes resemble epithelium, but show no nucleus; again, they may be an irregular mass, unlike any thing we are familiar with. What is their origin and significance? This is an unsettled question, and has not been much investigated. They are likely to occur in any specimen of urine, but Roberts states that in several cases of chronic Bright's disease, he has noticed a great increase of them.

It has been thought that they might be epitheliumscales, stained by the coloring matter of the urine, and this coloring matter itself is known to undergo changes whereby other colors are produced capable of tinting any foreign substance from the atmosphere, which is exceedingly liable to get into a specimen.

One other source, and a common one, of these colored specks under the microscope, it is important to guard against: it is that they may exist in the glass slides or covers; for these articles are polished with a red powder, particles of which become imbedded in its minute irregularities. Dr. Edward Curtis was the first to warn microscopists against this source of error.

## II.

*Second class of deposits:* those which are foreign to the composition of the urine, under any form.

This class differs from the preceding in that most of the deposits have a pathological significance.

The following are included under this head: *blood, casts, pus, oil, chyle, spermatozoa, cystine, keistine, confervoid vegetations, and vibriones.*

**Blood.**—Blood may be mingled with the urine from either of the organs through which it has to pass. Urine containing blood may or may not give evidence of it when first passed. It depends upon the quantity of blood present whether there will be any distinction as regards color.

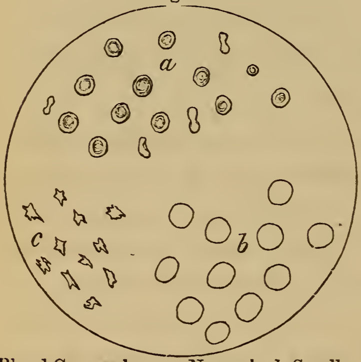
If the quantity is small, we probably will not suspect its presence until the urine has stood some hours in a urine-glass, when a red line or layer will be discernible at the bottom. (It must not be confounded with uric acid, which is of a dark brown color, instead of a blood-red.) The deposit consists of the red corpuscles.

We may have urine stained with blood, and yet containing no, or very few, corpuscles. Thus the blood may be represented in the urine under these two conditions: *hæmaturia*, where the elements of the blood are present under their natural forms; *hæmatinuria*, where the red corpuscles appear to have disintegrated or dissolved, and only a few perfect ones can be found. It is necessary to consider these apart.

**Hæmaturia.**—Hæmaturia is that condition where red blood corpuscles are present in the urine, and impart to that fluid a more or less marked bloody color. It is the result of ruptured blood-vessels. The rupture may have taken place from direct violence, congestion, ulcers, abscess, or the presence of a stone. When the kidney is the seat of the lesion, the discoloration of the urine will be equally diffused, on account of the admixture beginning at the fountain-head, so to speak. The urine will have a smoky hue; and the source of the hemorrhage in the kidney is rendered still more conclusive by the finding of casts under the microscope. When the blood has originated lower down, in the bladder or urethra, it has an opportunity to coagulate before the current of the urine diffuses it, and consequently when voided, small clots will be seen, and the volume of urine will be irregularly colored.

Tests.—A rupture permitting the escape of the blood corpuscles will, of course, allow of the passage of albumen, and consequently we always find this substance in hæmaturia. The corpuscles themselves are albuminoid, and were there no free albumen present, would respond to the heat and nitric acid tests. (See "Albumen.") But the most positive proof of the presence of blood is furnished by the appearances of the sediment under the microscope. This instrument, with a $\frac{1}{4}$-inch lens, will reveal the corpuscles. They are bi-concave discs, about $\frac{1}{120}$ of an inch in diameter. By careful focusing, their form can be distinguished, the outline and centre never being equally distinct at the same time; then if a current be excited in the drop under the eye, by touching the side of the thin glass cover with a bit of blotting-paper, the corpuscles will roll over and over and show their thin edges and concave surfaces. All these points are illustrated in Fig. 9, *a*.

Fig. 9.




Blood Corpuscles: *a*, Normal; *b*, Swollen by absorption; *c*, Shriveled from lack of water.

There are changes, however, which blood corpuscles undergo when subjected to unnatural influences. In the blood serum, they maintain their shape and size, but immersed in a watery solution like urine, they immediately begin to absorb water, and very soon have swollen to twice their natural size, lost their color and bi-concave character, and are now spherical. When allowed to dry, they shrivel and become so irregular that should one not be familiar with the change, he will not suspect their presence.

**Hæmatinuria.**—This curious affection is characterized by a chocolate-colored urine due to the presence of hæmatine, which has transuded through the blood-vessels, and appears independent of the blood corpuscles which are thought to have dissolved. A few corpuscles, however, are usually seen. Dark granular and hyaline casts are frequently found, as well as amorphous matter and octahedra of oxalate of lime.

Tests.—Heat will reveal the presence of albumen, which must necessarily be present. When the albumen is coagulated, it is stained by the dark coloring matter, and the specimen, when allowed to settle, will present the appearance of the chocolate-colored coagulum at the bottom, and the transparent urine above.

## CASTS.

Casts are moulds of the uriniferous tubules. The kidney is largely supplied with capillaries, which form a complex network about the tubules, and any congestion of the organ is very apt to result in an exudation from the blood-vessels into these little canals, of a peculiar substance, the composition of which is not well understood. This substance has the property of spontaneous coagulation, and thus adapts itself to the shape and size of the tube, and the urine collecting behind, washes it out, and it appears as a cast of the tubule. The pressure which induces this exudation is also sufficient to cause a transudation of the liquid portion of the blood; and it results that *albuminuria* always exists where casts are formed.

We depend upon the microscope altogether for the detection of casts, and considerable skill is sometimes necessary to distinguish between them and certain extraneous matters. The most frequent sources of confusion in this respect are cotton fibres and feathers. Cotton fibres are striated, and are apt to be folded or twisted. A particle of feather or hair has definite anatomical characters, which should be too well known to allow of a mistake. The appearances of these accidental substances are shown in Figure 10.

Fig. 10.


*a*, Hairs; *b*, Cotton fibres; *c*, Starch grains; *d*, Air-bubbles; *e*, Feathers.

As a guide, it may be said of casts, that they are generally rounded at one extremity, and their sides are parallel. They are not flexible enough to allow of folding or twisting, which is so common to cotton fibres.

*Casts are not all of the same diameter.* One reason for this is, that the tubules themselves vary in size in different parts of their course. Another cause depends upon the fact that in certain affections of the kidney, the epithelium lining the tubules is detached and voided with the urine. Now, a tubule thus denuded is larger than it was previous to the shedding of its lining, and consequently will afterward form a larger cast.

*Casts differ as regards appearance.* The coagulable matter which transudes into the tubules is perfectly transparent and structureless, so far as we have been able to ascertain. The theory is, then, that this material when collected in the tubules fills and distends them. This distention causes pressure upon the epithelium lining which adheres to and sinks into them to a certain extent. Now, when the cast is washed out by the pressure of urine from behind, it pulls slightly upon its epithelial attachments, and if the cells be detached or detachable, through degeneration, they must come along with it.

Now, it follows, from the above theory, that if the kidney is not diseased to such an extent as to allow of desquamation of its epithelium, or, on the other hand, if the epithelium has been previously shed, leaving the tubule bare, the cast will come away and appear in the urine unaltered as regards its structure, and will appear as a transparent mould of a renal tubule. These we call *hyaline casts.*

It is not necessary, after the above explanation, to say more than that when the epithelium does show itself adhering to the cast, we recognize another variety—namely, *epithelium casts.*

And suppose these epithelium cells to have undergone a fatty degeneration, we should then have *fatty casts.* Go a little further, and imagine the epithelium to have suffered what is known as a granular degeneration, then we should find *granular casts.*

Besides these varieties, we meet with several others, having nothing to do, however, with the epithelium element. These are *blood*, *pus*, and *waxy casts.*

As it is my purpose to give a few hints respecting the practical bearing of the subjects treated of in this manual, it will be necessary to glance at each one of these casts separately.

**Hyaline Casts**, as their name implies, are structureless and transparent. They vary in diameter from the width of one blood corpuscle to that of three. Their length is not definite. Being transparent, they are difficult to find, and on this account are often overlooked.

The mode of formation of these casts has been stated above; and therefore when they are small, it is fair to suppose the kidney yet to be comparatively sound, and the cause of the symptoms which led to the examination of the urine not of long standing. At any rate, we meet with small hyaline casts in acute Bright's disease. But what does a large hyaline cast signify? It tells the story of a more advanced disease, and its transparency is not due to a refusal of the epithelium to come off with it, and thereby asserting its healthiness; but, on the contrary, its very size bears evidence of the previous shedding of the epithelium, and of the present nudity of the tubule whence it came.

Fig. 11.


*a*, Hyaline casts; *b*, Epithelium casts.

A cast of this last variety may be perfectly transparent, or it may be dotted over with a few specks of granular matter, and perhaps here and there a broken-down epithelium cell.

It is evident, that in chronic disease of the kidney, both small and large hyaline casts will be found in the urine, because the organ is not equally diseased in all its parts. (Fig. 11, *a*.)

**Epithelium Casts.**—We have seen that the effusion of fibrinous material into the uriniferous tubules undergoes spontaneous coagulation, and is afterward washed out by the urine which collects behind it; and that if the epithelium lining the tubules be detached or detachable, it will adhere to the mould, and be afterward found in that situation in the urine.

The cells may be scattered upon the surface of the cast or may present a regular arrangement, the same which existed while they yet occupied their normal place in the kidney. At the same time, there will be found free epithelium in the urine.

Epithelium casts are found in the urine of persons convalescing from scarlet fever, and in acute Bright's disease. In pneumonia and severe inflammatory diseases, they are the prevailing variety of cast. (Fig. 11, *b*.)

**Fatty Casts** are epithelium casts in which the epithelium has undergone a fatty degeneration. The cells appear to have been filled with fat and to have burst, discharging their oily contents into the tubules, where they have adhered to the fibrinous effusion. The cast will be more or less covered with these minute oil-drops and epithelial cells, which are also full of oil or fat. At the same time, fatty cells and free fat will be seen floating in the urine. (Fig. 12, *a*.)

Casts of this description are found in chronic affections of the kidney, and their presence in the urine is a very grave sign.

**Granular Casts** represent the epithelial element in a state of granular degeneration. What this granular material is, is not very well understood, though supposed to be fat in a state of fine subdivision. The cell may have entirely disappeared or may remain, filled with these granules. These casts, appearing in abundance, are indicative of serious changes in the kidneys, and their presence determines an unfavorable prognosis. Fig. 12, *b*, illustrates the granular cast. It will be noticed that they are dark, and have ragged extremities.

Fig. 12.


*a*, Fatty casts; *b*, Granular casts.

**Blood Casts.** — If there is a hemorrhage in the kidney when the conditions are present which induce the formation of casts, the blood-globules will attach themselves to the mould, sometimes very regularly, and form what is called a blood cast. At the same time, they will be present in a free state in the urine.

Blood casts are common in scarlet fever and any form of acute Bright's disease. They do not generally present themselves for any length of time, being the result of a hemorrhage which is not apt to continue.

**Pus Casts.**—These are rare. They are met with where the kidney is the seat of abscess. Yet cases where abscess was found at post-mortem examinations, and furnished no pus casts during life, are recorded. When present, they have the appearance of pus corpuscles adhering to the fibrinous cast. The urine will at the same time contain more or less pure pus. To prevent confounding pus corpuscles and epithelium, it is well to note that they are smaller, and the addition of acetic acid will render the cell-wall of the pus corpuscle transparent, and reveal a distinct granular nucleus.

**Amyloid or Waxy Casts** are the large, transparent, and waxy-looking objects which are occasionally seen, and are thought by some to denote a corresponding condition of the kidney. But nothing definite is yet known concerning them. They sometimes present a few transverse markings and fissures, as though they were very brittle and had been broken.

This completes the list of casts, and it may be useful to sum up their clinical significance.

The appearance of a few small hyaline casts may be, and probably is, the result of a congestion in the kidney of recent origin.

Epithelial and hyaline casts are very frequently found in the urine of patients recovering from scarlet fever, pneumonia, bronchitis, and congestive diseases generally.

Fatty, granular, and waxy casts have a grave significance; yet the appearance of one or two of them should not induce us to pronounce too certainly the fatal termination of the case.

*It is the continuance of a prevailing kind of cast which is most to be relied upon in the way of diagnosis and prognosis.*

Casts are liable to disintegrate, and may become so changed as to escape detection if allowed to remain in decomposing urine. Therefore it is important to look for them before decomposition begins. The lightest cast will have fallen to the bottom of the urine-glass in ten or twelve hours. Then gently pour away all the urine except about two drachms, and from this, with the aid of a glass tube, take up, from the bottom, a drop or two for microscopic examination. (See last page for detailed directions for microscopic manipulations.)

**Pus.**—There are various causes giving rise to pus in the urine. Cystitis, pyelitis, gonorrhœa—in fact, an abscess or ulceration communicating with the urinary tract at any point. In women, purulent discharges from the vagina are likely to confuse us as to the origin of the pus.

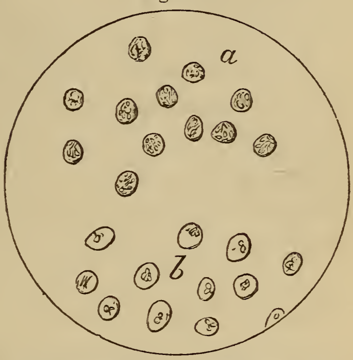
Urine containing pus is turbid when voided, and, on standing, deposits a whitish cloud of a ropy consistency, which distinguishes it from an inorganic deposit.

Tests.—Pus consists of a fluid and a corpuscular element. The fluid is albuminous, and will be acted on accordingly by heat and nitric acid, although purulent urine never gives a marked coagulum; and this fact serves as a good test, the turbidity not disappearing with heat and nitric acid, and at the same time scarcely becoming more marked.

Liquor potassa causes a semi-solid, gelatinous precipitate.

The microscope will reveal the pus corpuscles, and this is conclusive evidence. Pus corpuscles are a little larger than the blood corpuscles, colorless and spheroidal. They are made up of cell-wall, granular contents, and nuclei. By the addition of a drop of acetic acid, the cell-wall is rendered transparent, and the nucleus is brought sharply into view. (Fig. 13.)

Fig. 13.




*a*, Pus corpuscles; *b*, Effect of acetic acid.

**Oil.**—It has been asserted that oil is a constituent of normal urine in very small proportion, and only detected after a careful analysis. It, however, sometimes makes its appearance in quantities sufficient not only to be recognized under the microscope, but visible to the unassisted eye.

It may present itself either as distinct oil-drops, as granules, or as a very fine emulsion, each particle of which appears as a mere point under the microscope (this latter condition we have in *chylous urine*). If either of these forms of fat are in the urine, we shall have a layer of it on the surface when allowed to rest. In the case of granular fat, the layer will appear creamy; where the globules are of any size, a yellow, oily layer will be seen.

Oil globules were detected in the urine of a man who was taking cod-liver oil by Roberts. Fatty degeneration of the kidneys is accompanied by oil in the urine. Much speculation has been indulged in concerning the source of oil where there is no recognizable affection of any organ. It is known that during digestion, the blood is loaded with chyle, and may, under circumstances not understood, permit it to escape into the urine. (See "Chylous Urine.")

A frequent source of oil-drops in the urine is the vessel in which it is collected, or the bottle in which it is brought to the physician, and, in many instances, the passage of catheters and sounds, which are always oiled before introducing.

TESTS.—Oil is soluble in ether. But if it be in small quantity, it often becomes necessary to first extract it with ether, and afterward evaporate almost to dryness before any traces of it can be seen.

*Under the microscope*, oil-drops are distinguished by their perfectly circular outline, difference in size, and solubility in ether. As seen in urine, the globules are never very large, and might be mistaken for blood corpuscles. But their sharp-cut, bright outline, absence of color, and peculiar properties mentioned above, can scarcely fail to identify them.

**Chylous Urine.**—Chylous urine has ever been one of the most interesting and at the same time puzzling conditions with which we have to deal. In appearance, it is milky, and on standing collects in a creamy layer on the surface. There is always more or less blood, fibrine, and albumen present. Sometimes it coagulates spontaneously when passed, and very closely resembles blanc mange. Cases are related where it coagulated in the bladder and completely blocked up the urethra, from which it was extracted in long flakes. It is a rare affection, and but few cases are reported. Writers disagree widely concerning its pathology and symptoms; but without going over the history at length, the following are the main points regarding this peculiar disease:

It is most common in warm climates; makes its appearance suddenly, and as suddenly ceases, to reappear again after months or even years. Sometimes it coagulates spontaneously, like lymph, and again does not undergo this change. The milkiness is more marked after meals. The older authors considered the kidneys and the assimilative functions of the system to be at fault and diseased. But casts have been searched for in vain, and several post-mortem examinations of individuals who were affected with this disease have failed to afford evidence of alterations in any organ. So that now it begins to be stated that the chyle and lymph are discharged directly into the urinary passages from the lymphatic vessels themselves; and Roberts especially advances this opinion, having noticed, in patients voiding chylous urine, appearances which indicated disease of the lymphatics.

I had an opportunity recently of examining a specimen of chylous urine, the history of which it may be well to relate. It occurred in the practice of

Professor Alonzo Clark. The patient had resided in the South most of his life. About ten weeks before he consulted Professor Clark, he had attempted to pass his urine five times within an hour. This necessitated great straining, and he was suddenly alarmed by a severe pain and a discharge of blood and milky urine. (The pain was located in the prostatic urethra, and as he had undergone an operation for stone a few years before, it and the hemorrhage were referred to that cause.) This condition came and disappeared several times until I saw the urine. The patient stated that the milky fluid sometimes was perfectly free from any urine. He was able to know this from the fact that the uriniferous odor was entirely absent, and, moreover, the bladder had just been emptied only a few minutes before.

This urine did not coagulate spontaneously. It contained blood, and had an alkaline reaction.

Tests.—Besides the characters above stated, other tests are scarcely necessary. Chyle is oil in a state of emulsion.

Under the microscope, the granules appear very minute.

**Spermatozoa.**—The spermatic elements sometimes become mingled with the urine in sufficient numbers to form a deposit. As a deposit, they resemble mucus and pus, though never so abundant. Their presence may be accounted for as a result of coition or an involuntary discharge of semen. This latter may be continuous and constitute spermatorrhœa. With the exception of this last-named condition, the presence of spermatozoa in the urine is without significance.

Tests.—The semen is albuminous, and will be rendered cloudy, to a more or less degree, by heat and nitric acid. But the microscope will reveal whether the albuminous reaction is due to the presence of semen, in that the characteristic filaments or spermatozoa will be seen. If the specimen be recent, they will be in active motion. Spermatozoa are possessed of a head and tail-like extremity, the former being slightly flattened from before backward. Their length is about $\frac{1}{600}$ of an inch. (Fig. 14, *a*.)

Fig. 14.


*a*, Spermatozoa; *b*, Vibriones.

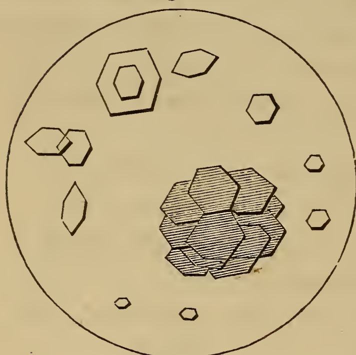
**Cystine.**—This is a substance but rarely met with, compared with other deposits. Its source is not positively known, though supposed to be the liver. A remarkable fact concerning it is its liability to run in families. The most important clinical significance attached to it is its liability to form a calculus; otherwise cystine may appear in the urine of an individual for years and not depreciate the health.

Urine containing cystine has usually an oily appearance, and deposits a light, rose-colored powder. Decomposition takes place very soon, and, according to Dr. Bird, the color changes to a green. Cystine contains sulphur, which is decomposed and evolved as sulphuretted hydrogen.

TESTS.—Acetic acid will cause a further precipitate to take place. It is insoluble in the vegetable acids, and is not dissolved by heat. It is soluble in ammonia and mineral acids.

The crystals are six-sided plates, and colorless. If a solution of cystine be placed in a shallow dish with a little ammonia, evâporation will cause a deposit of the pure crystals. (Fig. 15.)

Fig. 15.



Cystine.

**Keistine.**—It was at one time thought that the urine of pregnant women offered peculiarities by which the pregnant state could be diagnosed. It was stated that there would form upon the surface of such urine a layer of cheesy matter unlike any appearance presented when the subject was not pregnant. The name keistine (cheesy) was given to this formation. The results of observation, however, have been so conflicting that the profession, to-day, reject the matter, and attribute the phenomenon as one and the same thing as the alkaline fermentation, which is hastened in pregnancy by the presence of an increased amount of animal matter, such as epithelium and mucus from the vagina and bladder.

## VEGETABLE FUNGI.

There are several microscopic vegetable growths which invade the urine. The most important are the *Penicilium glaucum*, or common mould; the *Torula cerevisiæ*, and *Saccharomyces cerevisiæ*, or sugar fungus.

**Penicilium Glaucum.**—This fungus will appear in any urine kept any length of time at an elevated temperature. In warm weather, it sometimes makes its appearance at the end of twenty-four or forty-eight hours.

There may or may not be any very visible deposit; this depends upon the growth of the fungus. But it is often encountered under the microscope, when not seen in the urine by the unassisted eye.

There is a vegetable part, the mycelium, and a fructifying part, the spores. The mycelium is nothing but an irregular ramification and interlacement of fibres, some of which shoot upward toward the surface of the fluid, and on reaching it, develop upon their extremities the spores. And it is simply by the arrangement of these spores that we are able to distinguish most of the different varieties of mould. In the

Fig. 16.

Penicilium glaucum.

penicilium glaucum, the spores are arranged in projecting rows upon the stem. (Fig. 16.) They ripen and fall, or are blown away to other quarters; but in either case, they immediately begin to elongate, and then to branch, until a mycilium of new growth is formed. We must see the spores while yet on the stem, in order to judge of the variety of the fungus, for they so closely resemble other spores, that it would be a difficult matter to recognize them when once dislodged and separated.

**Torula Cerevisiæ.**—This fungus was formerly supposed to be the true sugar-mould, and its growth in a solution considered a pretty sure evidence of the presence of sugar.

But it is now known that it will show itself in fluids where the most delicate chemical tests fail to detect sugar.

It is very similar in appearance to the penicilium just described, but can be distinguished by the arrangements of its spores, they being arranged in *spheres*, upon the end of the stem.

**Saccharomyces Cerevisiæ.**—This is the growth which we will find in saccharine solutions, and more particularly concerns us, as its presence may determine whether a specimen of urine contains sugar in those instances where chemical tests are not very definite.

In order to become perfectly familiar with the appearances of this fungus, I advise every one to do the simple thing of making a solution of a little egg albumen, honey, and water, and keep at a temperature of about 100° F. for twelve hours, and examine the sediment under a microscope.

We shall discover numerous round or ovoid bodies of a brown color. Some will contain distinct nuclei. Some will have *budded*, and appear as two or three cells fused together. By careful examination, every stage of this growth or budding will be seen, instances where the new shoot is just appearing, and again a distinct row of full-grown cells. (Fig. 17.)

Fig. 17.

Saccharomyces cerivisiæ.

**Vibriones.** — These are microscopic objects, and are almost the lowest order of the infusorial animalcules. They appear in decomposing animal infusions, and are common to urine during the alkaline fermentation. They are about $\frac{1}{3000}$ of an inch in length, and are in constant motion. (Fig. 14, *b*.) They are propelled by a spiral or corkscrew-like movement.

# PART IV.

## ACCIDENTAL INGREDIENTS WHICH DO NOT FORM DEPOSITS.

There are certain abnormal substances which are frequently present in urine, but are in such perfect solution as to afford no evidence of their presence by way of a deposit, and may have little or no effect upon the natural color (with the exception of *bile*).

Such are *albumen*, *sugar*, and *bile*. (I shall not consider those matters which, taken by the mouth, as food or medicine, subsequently appear in the urine.)

**Albumen.**—Albumen frequently constitutes an ingredient of the urine. As such, it is derived from the blood, and, in fact, is a portion of it. It may be the fluid albumen of the blood plasma which has exuded through the renal circulation from congestion or over-distention of the vessels; or it may be the albuminoid corpuscles themselves which have been mingled with the urine as a result of a hemorrhage somewhere in the tract.

Almost all the congestive diseases are accompanied by albuminuria, and any interference in the return flow of blood from the kidneys for any length of time will almost surely be followed by albuminous urine. Diseases affording this interference are pneumonia, scarlet fever, and inflammatory affections generally. The pressure of the pregnant uterus or any tumor upon the renal veins is a common cause of albumen in the urine. And most important of all are the affections of the kidneys themselves, whereby they lose the power of eliminating the urine alone, but allow constituents of the blood to escape at the same time. We judge of the condition which produces albuminuria very much by the presence or absence of casts, and by the kind of cast which accompanies the condition (see "Casts"), for casts and albumen almost always exist together. Urine containing albumen is apt to be of less specific gravity than normal. Albuminous urine froths on pouring from one vessel to another, and this fact is the first, oftentimes, to attract the attention of a patient.

Tests.—Albumen is precipitated by heat, the mineral acids and their salts. But two of these are necessary—heat and nitric acid. If heat is to be applied, first see that the urine is acid; if it is not, add a drop or two of acetic acid. Now boil, and if a precipitate come down, it can be nothing else but albumen. On the other hand, if an alkaline urine is subjected to boiling, the earthy phosphates are precipitated and might lead to error. However, a drop of any acid added to such a precipitate would quickly decide the point. If it be phosphates, the acid will dissolve them; if albumen, it will not. (See "Phosphates.") It is best to have another test tube of the same size filled with the unboiled urine for comparison, when any delicacy is necessary. Nitric acid is the most delicate test. Incline the test-tube containing the suspected urine, and allow a drop of nitric acid to run down the side and gain the bottom.

It will appear there as a perfectly clear layer, and if albumen be present, a white stratum will be seen just above it where the urine comes in contact with it.

An easy method to estimate the amount of albumen is to coagulate it by heat or nitric acid, and allow the coagulum to settle to the bottom of the test-tube. The amount compared with the quantity of urine present, as $\frac{1}{4}$, $\frac{1}{2}$, etc., will enable us to detect any change from day to day.

**Sugar.**—There is a pathological condition marked by the excretion of an enormous quantity of urine of high specific gravity—1030–1060, and containing sugar. The disease is diabetes melitus.

It is an established physiological fact that the liver produces sugar entirely independent of any starchy or saccharine substances used as food; but it is by no means established that the liver is the origin of the sugar found in the urine.

The color of diabetic urine is most always light, the specific gravity high. Albumen is frequently present.

Tests.—If saccharine urine be boiled with liquor potassæ, it will assume a dark brown or molasses color. This is known as *Moore's Test.* It is unreliable in that any urine of high specific gravity will give the same result.

If a little yeast be added to urine containing sugar, *fermentation* will ensue, whereby carbonic acid gas and alcohol will be produced. The gas escaping in bubbles can be collected and tested. This is a good test, but not very convenient. It is rarely resorted to, because we possess another, easier and entirely satisfactory, namely :

**Trommer's Test.**—This method of determining the presence of sugar in a solution is based upon the fact that sugar possesses the property of reducing the salts of copper in an alkaline solution at the boiling-point.

The usual mode of applying this test is to add two or three drops of a solution of sulphate of copper to a quantity of the suspected fluid in a test-tube, and then pour in an excess of liquor potassæ. The whole now assumes a deep, transparent blue color. Now boil, and if sugar be present, the suboxide of copper will be thrown down as a bright yellow precipitate (in some cases an orange red). When this change occurs, the blue color disappears entirely, and the mixture becomes perfectly opaque.

Unfortunately, when applied to the urine after the above manner, these phenomena do not present themselves. Having added the copper and potassæ, there will appear the usual transparent blue color. Now boil the solution, and almost invariably we fail to see any thing like a yellow or red precipitate. Either the blue color is entirely destroyed, and a dark, transparent, molasses color appears, or there is a dirty green precipitate.

Considerable has been written concerning the inapplicability of Trommer's test to the urine, the explanation being that the organic constituents, urea, coloring matter, etc., interfere with the reduction of the suboxide of copper. Directions have therefore been given to get rid of these matters by filtration through finely-powdered animal charcoal.

This process is an efficient, but, as a general rule, not a convenient one to the practicing physician. Therefore, as a result of some recent investigations on the subject, I submit the following hints and rules for the application of Trommer's test to the urine as being a perfectly simple and reliable method:

In the first place, *it is necessary to have a great excess of the test*, because if *the urine be in too great quantity, the precipitate is dissolved*, and on this fact depends my method.

Judge by the specific gravity of the urine and the history of the case whether there is much sugar present.

If the evidence is in favor of a considerable amount, take about ten drops of the urine in a test-tube, and add two drops of a solution of sulphate of copper (strength, 1 ʒ – ℥). If very little sugar is suspected, take about ten drops and one drop of copper solution. Now, add liquor potassæ until the mixture assumes a perfectly clear blue color. If the addition of the potassæ in excess induces a permanent milkiness instead of a transparent blue, it is apt to be due to too much copper having been added. Now, subject the solution to boiling, and

*If no sugar be present*, a flocculent green precipitate comes down, leaving the liquid colorless.

*If sugar be present*, an orange red or yellow precipitate will appear.

(When the sugar is in excess, the color of the precipitate is yellow. When the copper is in about proper proportion, the color of the precipitate is orange or red.)

When the copper is in excess, the precipitate is greenish yellow, but soon changes to orange. If no change occur immediately, set the test-tube aside and wait.

If a dark, molasses, transparent color manifest itself, there is very probably sugar present, but too much urine was used, and has dissolved the copper precipitate; therefore take the same quantity of urine as before, and add four or five drops of the copper solution.

Do not mistake the flocculi of the phosphates, thrown down by the alkaline test fluid, for a precipitate of the suboxide of copper. This latter is dark red or yellow, and soon subsides to the bottom of the test-tube, and is seen there as a compact little mass.

The main points of the foregoing method for the application of Trommer's test to the urine are that, 1*st. I have found the urine capable of dissolving the copper precipitate.* 2*d. A certain quantity can only dissolve a certain quantity of said precipitate.* 3*d. Therefore take a very little urine to begin with, for if we use much urine, we have to put in copper enough to allow for the dissolving power of that amount of urine and some over for the sugar to attack. Now, before we could produce a clear blue color by the addition of potash solution, the test-tube would overflow.*

The test with Fehling's Solution (for composition, see p. 60) is based upon the same principle as the foregoing, and if we have the solution, it is a very easy and reliable test. But it has to be made, and when kept for any length of time, is liable to undergo changes which unfit it for further use.

The way to use it is to take a test-tube a quarter full and boil it. To this add a drop of the suspected urine if much sugar is present; if little, add ten or fifteen drops.

Here we have the same principle as advised with Trommer's test—namely, a small quantity of urine and a great excess of the test fluid.

If any change occurs in the Fehling liquor when boiled alone, it is unfit for use.

**Bile.**—The coloring matter of the bile is frequently excreted with the urine, imparting to it a more or less greenish-brown color.

It occurs in jaundice even before the skin has become perceptibly colored, and continues a little while after the natural color is restored.

The biliary salts, glykocholate and taurocholate of soda, sometimes are present also, and it is frequently important to know whether the bile is represented in the urine solely by its coloring matter, or whether these more important ingredients are there too.

TESTS.—The coloring matter of bile can be detected by pouring a little of the urine into a white plate, and allowing it to come in contact with a few drops of nitric acid. As the two mingle, a play of colors will be observed, varying from a violet to a green. Any oxidizing agent, tincture of iodine, or the atmosphere, will produce a grass-green color.

To detect the biliary salts, we must resort to Pettenkofer's test, as follows: Make a watery solution of the urine, if the color be very marked, and pour about ʒ ii of it into a test-tube. To this add a few drops of a solution of cane-sugar (one part to four of water). Then very gradually drop in sulphuric acid. The mixture becomes heated by the action of the acid, but must be kept below 50° F. Very soon, if the biliary salts are present, and care is taken not to agitate the mixture, a red color will appear at the bottom of the test-tube. Now, cease adding the acid. The red gradually changes to a crimson, and finally a beautiful claret pervades the whole.

It is this play of colors which constitutes the most characteristic feature of the test.

# PART V.

## QUANTITATIVE ANALYSIS.

### SUGAR—UREA.

There are only two substances of which the medical man will be often called upon to estimate the quantity in the urine—they are sugar and urea.

**Sugar.**—The quantitative analysis of sugar in the urine is performed with Fehling's solution, which has the following composition:

Sulphate of copper, . . 90½ grains.
Neutral tartrate of potash, . 364 "
Solution of caustic soda (sp. gr. 1.12), 4 fluid ounces.

Add water to make exactly six fluid ounces.

The following apparatus is necessary: 200 grain measure; burette graduated to grains; 8 ℥ flask; spirit-lamp and stand upon which to place the flask to boil its contents.

Fehling's solution contains a definite amount of sulphate of copper in an alkaline solution. The graduation in the above formula is such that 200 grains of the solution correspond, or are decomposed by 1 grain of sugar; and when this decomposition has taken place, of course the blue color of the *sulphate* of copper is gone.

So, proceed as follows: Diabetic urine usually contains so much sugar that it is best to dilute it in this analysis: as much as one in ten, if sugar be very abundant; one in five or pure urine, if in small proportion. Suppose we wish to dilute it as much as one in ten: take $4\frac{1}{2}$ ounces of water and $\frac{1}{2}$ ounce of the urine and mix well. Now, measure out 200 grains of the copper solution and pour it into the flask. This had also better be diluted with twice its bulk of water, then set it to boil. Then, if you have a burette, fill it up with the diluted urine to the O mark. If a burette is not at hand, measure out a certain quantity, and remember it, for you will wish to know how much of the diluted urine has been used. By this time, the blue liquid in the flask is boiling. Now, very carefully add drop by drop the urine from the burette or what you have measured, and watch the result. As the saccharine urine comes in contact with the copper solution, some of the latter is decomposed, and appears as a red powder. Let it boil after each addition of the urine.

A time will at length arrive when all the blue color will have disappeared, and a red, insoluble powder taken its place.

Cease the whole operation every little while, and let this red oxide of copper settle, when it will be easier to determine whether any blue color yet remains in the supernatent liquid. During the last part of the operation, proceed very carefully, for there is great danger of adding too much sugar, and then immediately the whole experiment is spoiled. The mixture, under these circumstances, will turn suddenly of a molasses color, the result of the action of a boiling alkali upon the sugar.

Having been cautious then, suppose you have added diluted urine until the blue color has entirely disappeared. Now, then, refer to your burette or measured quantity which you poured out to commence with. How much of the diluted urine has been used? Say 250 grains. But this is only one tenth urine; we have therefore only used 25.0 grains pure urine. These 25.0 grains of the pure urine contain one grain of sugar, because it has reduced the copper in 200 grains of the standard Fehling's solution. Divide 25 into 100, and we have the percentage of sugar in the specimen of urine, or 4 per cent.

Fehling's solution is liable to undergo spontaneous decomposition, as has been before mentioned, and it should always be boiled thoroughly before using; if perfect, no change in color is induced by boiling.

In order to obviate this disadvantage of the decomposition of Fehling's solution, Professor Chandler recommends the following method, and to those familiar with the French system of weights and measures, it is superior to any other:

Take 34.639 grammes of copper sulphate, and dissolve in 1 litre of water; 10 cubic centimetres of this correspond to .05 grammes of sugar; 10 c.c. of this copper solution, therefore, are placed in a flask and diluted with about four times as much water. Now, put in a pinch of tartaric acid (to prevent the precipitation of the hydrate of copper when the potash is added). Shake the mixture, and then pour in a solution of potassic hydrate until the whole assumes a clear blue color. Now, proceed exactly as directed in the other case, except that instead of grains of urine, we measure out cubic centimetres. That is, take 2 c.c. of urine, if the sugar present be in large proportion, and dilute it with 18 c.c. of water. Now, the mixture consists of one tenth urine. (This dilution is resorted to in order that we may add the sugar more gradually, and not overadd it.)

Suppose, then, we have used 20 c.c. of the diluted urine; but this only contains one tenth, or 2 c.c. of pure urine. Therefore : 2 c.c. : .05 grammes of sugar :: 100 : quantity of sugar = 2.5 per cent.

The advantage of this method depends upon the fact that the copper, tartaric acid, and potash are not mixed until we wish to perform the analysis, and therefore do not deteriorate by keeping.

**Urea.**—The daily quantity of urea excreted frequently becomes of importance, and various methods of estimating it have been advised. None are so simple as the one proposed by Dr. Davy, of England.* Doubts having arisen as to its accuracy, I undertook a series of experiments in order to ascertain if they were well founded.† The results of these experiments led me to the conclusion that the method was in every respect sufficiently accurate for practical purposes, and I therefore introduce it here as the one best adapted to the physician who wishes to perform the analysis himself.

The analysis depends upon the decomposition

* Philosophical Mag. 1854. † New-York Med. Jour., Sept. 1872.

which ensues when urea is brought in contact with the hypochlorite of soda, potash, or lime.

Nitrogen gas is evolved, and being collected and measured, the amount of urea originally present is estimated. The following are Dr. Davy's directions:

"A strong glass tube, about twelve or fourteen inches long, closed at one end, and its open extremity ground smooth, and having the bore not larger than the thumb can conveniently cover, holding from two to three cubic inches, each divided into tenths and hundredths by graduation on the glass, is filled more than a third full of mercury, to which afterward a measured quantity of urine to be examined is poured, which may be from a quarter of a drachm to a drachm or upward, according to the capacity of the tube. Then, holding the tube in one hand, near its open extremity, and having the thumb in readiness to cover the aperture, the operator fills it completely full with a solution of the hypochlorite of soda (taking care not to overflow the tube), and then instantly covers the opening tightly with the thumb, and having rapidly inverted the tube once or twice, to mix the urine with the hypochlorite, he finally opens the tube under a saturated solution of common salt and water, contained in a steady cup or mortar. The mercury then flows out, and the solution of salt takes its place, and the mixture of urine and hypochlorite being lighter than the solution of salt, will remain in the upper part of the tube, and will therefore be prevented from descending and mixing with the fluid in the cup. A rapid disengagement of minute bubbles of gas soon takes place in the mixture in the upper part of the tube, and the gas is there retained and collected. The tube is then left in the upright position till there is no further appearance of minute globules of gas being formed, the time being dependent upon the strength of the hypochlorite and the quantity of urea present. But the decomposition is usually completed in from three to four hours; it may, however, be left much longer, even for a day if convenient, and having set the experiment going, it requires no further attention; and when the decomposition is completed, it is only necessary to read the quantity of gas produced off the scale on the tube. In cases where great accuracy is required, due attention must be paid to the temperature and atmospheric pressure, and certain corrections made if these should deviate from the usual standards of comparison, at the time of reading off the volume of gas; but in most cases, sufficiently near approximation to accuracy may be obtained without reference to those particulars."

It has been found by calculation that one cubic inch of gas corresponds to .64 of a grain of urea. Therefore, multiply the amount of gas by .64, and the product will be the amount of urea in the mixture. According to the volume of urine employed, it is an easy matter to determine how much an ounce of the urine would contain, and from this, the total excretion of urea per day.

There are one or two sources of error to be avoided. Ammonia and uric acid will give rise to nitrogen gas, and thereby increase the apparent amount of urea. It is the ammonia which is most likely to exist in quantities sufficient to cause confusion, and we must get rid of it by "gently heating the urine with a certain quantity of baryta-water as long as the odor of ammonia is disengaged, and then filter the solution."

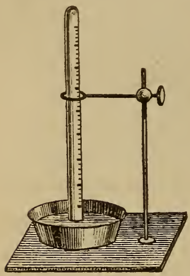


Fig. 18.

The apparatus necessary to perform this analysis is shown in Fig. 18. The graduated tube can be procured of Benjamin & Co., No. 10 Barclay street.

The hypochlorite of soda is preferable to either that of lime or potash, because it is easily procured, being an article in general use under the name "Liquor Sodæ Chlorinatæ," or Labarraque's Solution. But there are various preparations of this solution, both foreign and domestic, which do not correspond in strength, and are not universally kept on sale. Therefore, I used in my experiments, a preparation of reliable manufacture, and the one most generally sold in the United States, namely, "Squibb's Liquor Sodæ Chlorinatæ," and I advise its use in connection with this analysis.

# PART VI.

## CALCULI AND GRAVEL.

We have seen that the urine is subject to a variety of deposits. Now, some of these are precipitated within the urinary passages under certain conditions, in a manner to form solid masses of considerable size.

When the masses are small enough to be voided by the urethra, or pass from the kidney to the bladder, they are called *gravel.* During their passage, they frequently cause excessive pain, and by the irritation to the urethra or ureter, induce spasmodic contractions of those canals, and subsequent severe inflammation.

It is important to be aware that the conditions which give rise to these small concretions are the same which favor the formation of larger ones, or calculi.

Also gravel is in most cases the *cause* of larger concretions, as we will presently see.

**Calculi.**—By a urinary calculus or stone, we mean those solid concretions found in the bladder and kidney, and which vary in size from that of a pea to a hen's egg. They differ in composition as well as in general form and texture.

As regards composition, the most common are as follows: *uric acid*, *oxalate of lime*, *urates*, *phosphatic*, and *cystine.*

There are several other extremely rare varieties, as *urostealith*, *xanthine*, and *carbonate of lime*.

*A stone is very rarely composed of one substance alone; but is made up of alternating and varying concentric layers of different deposits.* This happens as follows: A few crystals of uric acid, of oxalate of lime, or a mass of mucus, a clot of blood, or some foreign substance accidentally introduced into the bladder, serves as a nucleus. Then the necessary conditions prevailing, we get a deposit of a layer, either of uric acid or something else; and thus the stone grows until finally its presence is irritating, and it begins to act as a foreign body; and if it be removed at this stage, we shall have a pretty pure stone of uric acid, or whatever the predominating deposit up to this time has been. Inflammation follows, whereby the mucous membrane throws off an extra quantity of mucus, which, mingling with the urine, induces fermentation. As a result of this, the urea is decomposed, and carbonate of ammonia appears, to render the urine alkaline; and then, of course, the earthy phosphates are precitated and add another layer to the stone. And so the very presence of the calculus conduces to its own growth.

As before stated, we are not likely to have a stone made up of one material; yet this may be the case, or, at any rate, one particular substance may predominate and thereby impart its characters to a stone.

**Uric Acid.**—Uric acid is the most common of all deposits going to form calculi. The nucleus of almost every stone is composed of crystals of this substance, and not unfrequently we see it constituting a stone almost entirely, especially if it be removed before the alkaline fermentation ensues.

When this is the case, the size rarely exceeds that of a pigeon's egg. The color ranges from a brick-dust red to a fawn, and the surface is generally covered with little tubercles. If, however, there were more than one stone in the bladder, friction of their surfaces would tend to make them smooth.

They are usually spherical, and slightly flattened. When sawed in half, their concentric laminæ are very distinctly seen.

When a stone of this composition exists in the bladder, the urine is acid.

Tests.—The murexid test is the most direct and characteristic. Place a fragment of the stone in a clean porcelain capsule, and add one or two drops of nitric acid; now evaporate the acid by gentle heat over the flame of a spirit-lamp, and a pink color will appear, which changes to a purple when a little ammonia is dropped in.

Uric acid is soluble in an alkali.

Under the blow-pipe, it is consumed, being of organic origin, and a black ash remains.

**Urates.**—Stones composed wholly of the urates are rare, though this deposit frequently alternates with others.

When pure, they are small, and are apt to originate in the kidneys. Most frequently these calculi are met with in children.

The urine will have an acid reaction where these concretions exist.

They are more or less of a red or brick-dust color.

TESTS.—The fact of their solubility in warm water will prove the presence of the urates.

**Oxalate of Lime.**—Like other deposits, the oxalate of lime more frequently forms a stone by alternation, especially with uric acid. The nucleus may be uric acid or oxalate of lime. When the latter exists alone or predominates, the stone is exceedingly hard and rough; in fact, it has been called the *mulberry calculus*, from its warty and irregular surface.

When the concretions of this formation are small enough to be classed as gravel, and are voided with the urine, they may be smooth. Here, however, there is a mixture of the urates, and the formation has probably taken place in the kidneys, and by their number the surfaces are worn.

In color, these stones are sometimes dark brown or even black, and again almost white.

Most mixed calculi contain layers of oxalate of lime.

The urine will be strongly acid.

TESTS.—Oxalate of lime is soluble in the mineral acids. Under the blow-pipe, it is reduced to a dark ash, and when this ash is touched with moistened red litmus-paper, it turns it blue—caustic lime being the residue of the combustion.

## PHOSPHATES.

We have seen that an alkaline condition of the urine would precipitate the earthy phosphates, and that the alkalinity may be due to two causes, only one of which is concerned in the formation of phosphatic calculi. We have said that the alkalinity of the fixed salts may continue for a length of time without a stone being found; because the phosphatic precipitate will then be amorphous, and has little tendency to form concretions. But when putrefaction occurs from retention of urine, or the action of inflammatory products anywhere in the urinary passages, then we have carbonate of ammonia developed, and now *crystals* of the ammonio-magnesian or triple phosphate are thrown down, as well as the amorphous phosphate of lime.

It is the ammoniacal decomposition, then, which most influences the formation of phosphatic calculi.

Sometimes, after prolonged administration of alkaline medicines, and as a result of high living where the urine is kept alkaline by the fixed salts, we have a *phosphate of lime calculus* formed.

These stones are light colored, easily broken, and present an earthy fracture. They rarely alternate with other forms.

Tests.—Phosphate of lime is insoluble in water; soluble in a weak acid, and is practically infusible under the blow-pipe.

**Mixed or Triple Phosphates.**—Deposits of this nature are the result of the ammoniacal decomposition of urine, and consist of the crystalline ammonio-magnesian phosphate with the amorphous phosphate of lime. They rarely constitute the whole or interior of a stone, but are generally added as the result of the presence of a pre-existing calculus, the irritation of which has induced the decomposition just mentioned. And it is a fact, that almost every stone, if it remains long enough in the bladder, will be encrusted with several layers of the mixed phosphates.

So long as the ammoniacal decomposition continues, there will be no more layers of uric acid, urates, or of oxalate of lime; so that the interior of a stone may present a variety of deposits, while the crust is composed entirely of the phosphates.

Accordingly, stones of this description sometimes attain to enormous dimensions.

These calculi are chalk-colored, and have a glistening appearance on account of the presence of the crystals of the triple phosphates on their surface.

Tests.—Under the blow-pipe, the mixed phosphates readily fuse into a white enamel (and they have therefore been sometimes called the *fusible calculi*), and give off ammonia and water. They are soluble in weak acids.

**Cystine.**—This substance sometimes forms calculi and gravel. The number of cases is very limited, and very few specimens of the concretion exist. The stone is quite small, not larger than an almond, and of a dirty brown or greenish color. There appear to be no distinct laminæ, but rather a radiating structure. The pathology is obscure.

Tests.—Cystine is soluble in the mineral acids; insoluble in water, organic acids, and carbonate of ammonia. Place a piece of the stone in contact with caustic ammonia, and allow the latter to evaporate, when the characteristic six-sided crystals of cystine will be visible under the microscope.

## SCHEME FOR EXAMINATION OF URINE.

Proceed in the following manner:

1. Odor.
2. Color.
3. Transparency.
4. Reaction to test-paper.
5. Specific gravity.
6. Daily quantity.
7. Any deposit.
8. Apply reagents.

| | PRECIPITATES. | DISSOLVES. |
|---|---|---|
| Heat. | Albumen. Phosphates. | Urates. |
| Nitric Acid. | Albumen. | Phosphates. |
| Liq. Potassæ. | Phosphates. | |

This table will be all that is necessary in the majority of cases, and for the sake of *simplicity*, I omit the various complications, such as cystine, pus, bile, chyle, etc., for which see the text.

## SCHEME NO. 2.

### NORMAL.

Urine, acid + heat gives no result.
" alkaline + heat gives earthy phosphates.
" + nitric acid gives no result except darkening the color.
" + potassa gives earthy phosphates.
" + nitrate baryta gives alkaline sulphates.
" + nitrate silver gives chlorides.

### ABNORMAL.

Urine (slightly acid) + heat gives albumen.
" + nitric acid gives albumen.

Other reactions same as normal urine.

The other abnormal ingredients, blood, pus, cystine, spermatozoa, etc., are readily recognized under the microscope.

# GENERAL DIRECTIONS.

Urine intended for examination should be placed in a conical-shaped glass vessel, such as an ordinary ale-glass, in order that any deposit which may appear shall be concentrated in a comparatively small space; for if there is a very minute quantity, we otherwise might not be able to secure a specimen for the microscope.

After the specimen has stood for six or eight hours, very gently pour off all but about half an ounce. This is done in order to prevent the deposited crystals, casts, or whatever is there, from becoming again mingled with a great quantity of urine when it is agitated by our subsequent manipulations.

Now, having provided yourself with a drop-tube, which be sure is clean, place the finger over the large end, and direct the other end to the bottom of the glass; raise the finger, and the urine ascends in the tube; replace the finger, and we have it confined there. Touch the point of the tube thus supplied upon a clean glass slide, and a drop will escape, which is all-sufficient. A thin glass cover is placed over this drop on the slide in a manner to exclude air-bubbles, as follows: place one side of the cover on the slide and allow it to come gradually down. If the cover floats, there is too much urine, which will overflow it, and obscure the lens. Under such circumstances, just absorb the surplus urine with a little blotting-paper.

We need a good $\frac{1}{4}$-inch lens for the examination of urinary deposits, and sometimes a $\frac{1}{8}$-inch in order to distinctly discern small hyaline casts.

# LIST OF APPARATUS AND REAGENTS REQUIRED.

## APPARATUS.

| | | |
|---|---|---|
| Absolutely necessary. | ½ doz. 4-inch test-tubes.<br>Test-tube rack.<br>Alcohol lamp.<br>Small glass funnel.<br>Filter-paper to fit funnel.<br>Red and blue litmus paper. | |
| | $2.60. | |
| Special apparatus. | Glass flask, 8 ℥.<br>Cubic centimetre or grain measure. | Quantitative analysis of sugar. |
| | Glass tube graduated to cubic inches. | Quantitative analysis of urea. |
| | | $2. |

## REAGENTS, IN GLASS-STOPPERED BOTTLES.

Nitric acid, 4 ℥.
Acetic acid, 4 ℥.
Sulphuric acid (pure), 4 ℥.
Solution caustic potassæ (20 gr.–1 ℥), 8 ℥.
Sol. copper sulphate (1 ʒ–1 ℥), 4 ℥.
Sol. silver nitrate (10 gr.–1 ℥), 4 ℥.
Sol. barium nitrate (10 gr.–1 ℥), 4 ℥. $4.

# INDEX.

D



E



F



G



H



K



L

M



N



O



P



Q



R



S