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A GUIDE

TO THE

PRACTICAL EXAMINATION

OF

URINE.

FOR THE USE OF PHYSICIANS AND STUDENTS.

BY

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PREFACE TO THE SECOND EDITION.

ADVANTAGE has been taken of the occasion for a new edition of this little work, to carefully correct the previous one, as well as to improve it by incorporating such additions of new facts and processes as seemed consistent with its original purpose, without, however, increasing the size of the book. This has been accomplished by slightly increasing the amount of matter on each page.

It is hoped that it may prove worthy of the same kindly reception accorded its predecessor.

1506, SPRUCE STREET,
Sept. 1, 1878.

PREFACE TO THE FIRST EDITION.

DOUBTLESS it will be thought by some that there is no present necessity for an additional volume on the subject which the title of this pretends to cover. Such was, indeed, the writer's own impression, when urged, a few months ago, to prepare it. Some reflection, however, convinced him that, while there were quite a number of comprehensive works of great value, and a smaller number of manuals or guides for the examination of urine, the latter seemed altogether too limited, while the former are too bulky to be convenient for daily use. It was further thought that an experience of several years in almost daily microscopical and chemical examinations of urine for others and himself, as well as in teaching the subject in the University of Pennsylvania, had given the author such familiarity with the practical wants of the physician, as would appear to justify his attempting to supply them in a convenient shape.

Pains have been taken to secure a completeness of

illustration not usual in the smaller works, while the methods for the most exact quantitative, as well as approximate analysis, have been included, without too much increasing the size of the volume.

The modes of approximate estimation so commonly used in the German laboratories, it is believed are here published for the first time in English. For the details of these the writer is indebted to the admirable practical treatise of Hoffmann and Ultzmann, so often referred to in the text. To Messrs. Lindsay & Blakiston acknowledgment is due for the privilege of using electrotypes of certain cuts in the American edition of Dr. George Harley's work "On the Urine and its Derangements," and to Dr. C. B. Nancrede for assistance in drawing and coloring.

PRACTICAL EXAMINATION OF URINE.

SECRETION OF URINE.

The theory which explains the secretion of urine most consistently with the facts, is one which, while it makes it mainly physical, admits something also of the nature of elaboration in the acts of the kidney. Nothing can be more beautiful at first thought than the theory of Ludwig, according to whom the process is a purely physical one—partly a transudation and partly a diffusion or osmosis. He correctly states that in the capillaries of the malpighian bodies there is a greatly increased blood pressure caused by the resistance to the exit of the blood through the efferent vessel. As the result of this, a transudation of the watery constituents of the blood, with some dissolved salts, takes place into the malpighian capsule. Thus the blood is greatly thickened when it reaches the second capillary system surrounding the convoluted tubules which contain the thin aqueous transudation from the malpighian bodies. Here we have, then, the essential elements of a complete osmometer—an animal membrane formed by the thin wall of the capillary and the delicate basement-membrane of the tubule, with a dense fluid (the blood) on one side, and a thin saline solution on the other. An interchange now takes place, as the result of which a current

sets in, of the water from the tubules to the blood, and of the products of regressive metamorphosis, urea, etc. and salts to the tubules, concentrating the fluid in the latter, making it, in other words, urine; while the albuminous constituents of the blood are retained there because of their well-known resistance to osmosis.

One important fact, however, remains unaccounted for by this theory, beautifully simple as it is. This is, that, if the tubules are stripped of their epithelium, as they often are in disease, urea and other products of regressive metamorphosis are no longer so freely removed, but accumulate in the blood, producing the phenomena of *uræmia*, so called. We must therefore admit some elaborating action on the part of the epithelium through which these results are obtained. Doubtless, however, the larger proportion of the act is a physical one—a process of transudation or filtration and of diffusion or osmosis.

The objection formerly made to the physical nature of the act of secretion of urine, on the ground that we cannot by this method account for the formation of an *acid* fluid from an *alkaline* one, no longer holds, since Dr. Ralfe, of London, has shown this to be quite possible. Into one limb of a small U-shaped tube, fitted with a membranous diaphragm at the bend, he introduced an alkaline solution of sodium bicarbonate, and into the other limb a solution of neutral sodium phosphate. He then passed a weak electric current through the solutions. In a short time the fluid in the limb connected with the positive pole became acid from the formation of acid sodium phosphate, the substance which is the chief agent in producing the acid reaction of the urine, while the fluid in the limb connected with the negative pole increased in

alkalinity. The changes are represented by the following formula :—

Sodium bicarbonate.	Neutral sodium phosphate.	Sodium carbonate.	Acid sodium phosphate.
$NaHCO_3$	$+ Na_2HPO_4 =$	Na_2CO_3	$+ NaH_2PO_4$*

REAGENTS AND APPARATUS REQUIRED FOR QUALITATIVE AND APPROXIMATE ANALYSIS.†

It is not a matter of very great importance in what form of bottle *Reagents* are kept. They should hold enough—four ounces is a convenient quantity—and be provided with ground-glass stoppers for the acids, but the alkalies are better kept in bottles with rubber stoppers. Those required are as follows :—

1. Pure colorless nitric acid (HNO_3).
2. Nitroso-nitric acid, the brown fuming nitrous acid of commerce, really nitric acid containing nitrogen tetroxide ($HNO_3+N_2O_4$ or NO_2).
3. Pure hydrochloric acid (HCl).
4. Pure colorless sulphuric acid (H_2SO_4).
5. Pure acetic acid ($C_2H_4O_2$).
6. Liquor potassæ, U. S. P. The sp. gr. is 1065, and it contains $5\frac{3}{10}$ per cent. of potassium hydroxide (HKO).
7. Solution of caustic potash, or caustic soda, 1 part to 2 of distilled water, sp. gr. 1330+, to be spoken of in the text as the "stronger solution of potash." It is the ætzkalilauge (or ætznatronlauge if soda) of the German Pharmacopœia, and contains from .30 to .31 of the hydrate of potassium (or of sodium).
8. Solution of sodium carbonate, 1 part water and 3 parts of the crystallized salt.

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* Medical News and Library, Oct. 1871, from London Lancet, July 1, 1871.

† All reagents and apparatus suitable for urinary analysis may be obtained of Bullock & Crenshaw, 528 Arch Street, Philadelphia.

9. Solution of barium chloride, 4 parts crystallized barium chloride, 16 of distilled water, and one of hydrochloric acid.
10. Liquor ammoniæ, U. S. P.
11. *The magnesian fluid*, containing of magnesium sulphate and pure ammonium chloride, each 1 part, distilled water 8 parts, and pure liquor ammoniæ 1 part.
12. Solution of copper sulphate, say 1 gramme to 30 c. c. or 15 grs. to f℥j.
13. Pavy's or Fehling's copper solutions, made as directed under volumetric analysis for sugar.
14. Solution of silver nitrate, 1 part to 8 of distilled water.
15. Solution of lead acetate (sugar of lead), 1 part to 4 of distilled water.
16. Solution of basic lead acetate, 1 part to 4 distilled water.
17. Distilled water, a litre or a quart.
18. Alcohol, 95 per cent., a half litre or a pint.

Other solutions as required.

Apparatus.

A note and drawing-book.

1 dozen test-tubes, assorted sizes, some narrow. (Some test-tubes, with bases, so that they may stand on a shelf or mantel, are convenient and desirable; see Fig. 4). A couple of these may be graduated in decimetre and centimetre divisions, and thus serve as fluid measures, and at the same time be used to measure the proportion of a sediment, or of albumen after the heat test and subsidence.

Test-tube, rack, and drainer.

4 conical glasses. (Observe that they taper toward a point, and that there is not a convexity at the bottom.)

2 or 3 smooth wineglasses, with broad bottoms, of the kind sometimes known as "collamore" wineglasses.

Red and blue litmus-paper; filtering-paper.

Urinometer and urinometer glass.

4 ground-glass covers, assorted sizes.

Spirit-lamp.

3 porcelain capsules.

6 beaker glasses, small and medium sizes.

½ dozen watch-glasses.

3 glass funnels, assorted sizes.
Glass stirring-rods and dropping-tubes.
1 large receiving-glass to measure twenty-four hours' urine, with capacity of 2000 cubic centimetres or more.
1 graduated measuring-glass holding 500 c. c.
1 wash-bottle with distilled water.
1 retort stand; water-bath.
1 or 2 sheet-iron tripods with wire gauze to cover.
1 100-minim pipette; 1 volume pipette for 5 c. c., another for 10 c. c.
Platinum spoon.
Blowpipe.
Swabs for cleaning test-tubes, etc.
A microscope with two object-glasses, a $\frac{1}{4}$ or $\frac{1}{5}$ inch, and a 1 inch or $\frac{8}{10}$ inch; stage micrometer: camera lucida for drawing; glass slides, thin covers, *shallow cells;* test-bottles with capillary stoppers; plain glass pipettes.

For volumetric analysis are required in addition—

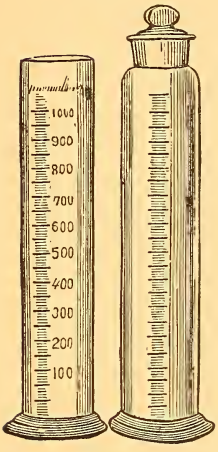
A full set of volume pipettes, 5, 10, 15, 20, 30, 50 c. c.
1 graduated dropping pipette, 20 c. c.
2 burettes of 50 c. c. capacity.
A half-litre flask.
Volumetric solutions as directed under volumetric analysis.

If the solutions are made by the student himself, as they may be, he should be provided with a balance which will turn with a milligramme, or with $\frac{1}{50}$th of a grain if the English system is used.

SELECTING A SPECIMEN OF URINE.

In obtaining a specimen of urine for examination, it should, as far as possible, be a part of the whole twenty-four hours' urine, as the specific gravity, reaction, and other properties are well known to vary during the twenty-four

FIG. 1.



hours, and the only accurate method is therefore to take a part of the total. But as this is not always possible, a portion of that passed in the morning before breakfast is generally most suitable. And yet this is not always the case. Thus, when a small quantity of albumen is present in urine, it is often increased after a meal, and sometimes when there is no trace apparent in the morning urine, a little will be found detectable after a meal. The same is true of sugar. In Fig. 1 are represented forms of glass vessels used for measuring large quantities of urine.

GENERAL PHYSICAL AND CHEMICAL CHARACTERS OF THE URINE.

Normal urine may be described as a transparent, aqueous fluid, of a pale yellow (or amber) hue, acid reaction, specific gravity of about 1020 when passed in the average quantity of 1500 cubic centimetres (50 ounces) in the twenty-four hours, and possessing an odor which can only be described as "characteristic" or "urinous." The odor is sometimes spoken of as "aromatic."

Each one of these characters is, however, liable to some variation within the limits of health, as well as disease, and with these variations we should be thoroughly familiar before interpreting a given specimen.

I. *As to Transparency.*—This, although quite constant,

can scarcely be considered an essential character of normal urine, while, on the other hand, it by no means follows that because a given specimen of urine is transparent, it is therefore normal.

Causes of Diminished Transparency.—Diminished transparency may be due to one of *three* causes. 1. Even urine which is apparently perfectly transparent when passed, commonly exhibits, a few minutes after standing, a faint cloud floating somewhere between the top and bottom, which is composed of *mucus* derived from the genito-urinary tract. Mucus itself is also transparent, but becomes visible through the presence of so-called mucus-corpuscles and epithelium in different stages of growth, discoverable by microscopic examination. In the urine of females, this cloud is apt to be more distinctly visible in consequence of the increased amount of epithelium from the vagina, and general increased area of the mucus-surfaces in this sex. There is nothing abnormal in the presence of such an amount of mucus as is covered by the above description. The effect of alkalies, heat, and strong acids is to leave the appearance unchanged, but acetic acid *may* produce a slight increase of the opacity by coagulating the *mucin*.

2. Normal acid urine may be partially opaque at the moment when passed by reason of the presence of the *earthy phosphates of lime and magnesia*. These shortly after passing begin to subside, and within half an hour present an appearance not unlike that of mucus—that of a flocculent mass floating somewhere between the top and bottom of the vessel. But still later, generally within an hour, it has approached the bottom and become a sediment, cloudy and bulky, but leaving a transparent supernatant fluid. The *test* of its nature is the addition of a few drops of any acid, as nitric,

which will cause a prompt disappearance of the sediment, if it be the earthy phosphate, while the application of heat will increase it, such increase being also rapidly dissipated by the action of acid.

The more or less constant presence of the earthy phosphates above mentioned cannot be considered abnormal. Requiring an acid urine to keep them in solution, a diminution of the degree of acidity may result in their precipitation, which is further increased by an alkaline reaction. Such diminished acidity and substitution of alkalinity always takes place during digestion, and the deposit is therefore at such time commonly observed.

3. Urine is sometimes rendered turbid by the presence of the so-called mixed *urates* of soda, potash, lime, and magnesia. The most frequent cause of this precipitation in normal urine, is a reduction in the temperature of the urine after being passed. Although highly soluble in water at the temperature of the body, the urates are promptly precipitated from a cold urine, such as would prevail in a room without fire on a winter's morning.

As in the case of earthy phosphates, such opacity soon diminishes by subsidence of the disseminated urates, which become a white or pink *deposit*, occupying less bulk than phosphates; they are also apt to be precipitated on the *sides* of the vessel. The *test* of its nature is the application of heat, which quickly causes its dissipation, while a deposit of phosphates is increased by heat.

Pathologically, urine may be opaque or semi-opaque from abnormal degrees of the above conditions, or from the presence of *pus*, which also subsides with a rapidity inversely as the quantity of mucus. If the latter is absent, or present in small quantity, the subsidence is rapid; if, on the other

hand, it is large, subsidence is slow, often requiring several hours. The opacity of such urine is *increased* by the application of heat and acids, in consequence of the precipitation of the albumen which is always a constituent of *liquor puris*.

II. *As to Consistence.*—In health, urine is never anything else but aqueous, that is, dropping and flowing readily.

Pathologically, it often becomes viscid, glutinous, and with difficulty or not at all separable into drops. Such state may be due to the presence of an excess of pure mucus, or of a mixture of mucus and pus, and very frequently it is caused by the action upon pus of an alkalinity due to the presence of ammonium carbonate, to be again alluded to.

In the so-called chylous urine of tropical countries, also sometimes met here, there is an addition of molecular fat, giving a chylous appearance to the urine, and an increased consistence.

III. *As to Color.*—While normal urine may be characterized in general terms as *pale yellow*, or *amber hued*, there may be considerable variation in health. Due to the presence in solution of the normal coloring matters, it is deeper or paler according to the proportion of water dissolving them. After copious libations of beer or water, the quantity of urine discharged being large, the color is very pale. On the other hand, circumstances which diminish the proportion of water within the limits of health deepen the color. The complemental relation of the skin and kidneys is well known. Under the influence of warmth, therefore, when the skin is acting freely, the quantity of urine is smaller, and it is darker. In winter, the skin being less active, the quantity of urine is larger, and its color less deep. In persons from whom the respiratory exhalation is greater, the urine is likewise less abundant, darker, and *vice versa*.

Pathologically, the color of urine may be altered by increase or diminution of the normal coloring matters, or by the addition of abnormal ones.

1. The former is also generally due to a change in the proportion of the coloring matters to the watery constituents. Thus we have almost an absence of color in the copious urines of diabetes, hysteria, and convulsions, while we have a high color in the urine of fevers and febrile states, chiefly because the quantity of water is diminished, but in the latter instance also because of the addition of an abnormal coloring matter, known as *uroerythrin*.

2. The addition of abnormal coloring matters is seen in the instance just mentioned (fevers), in urines containing blood or blood-coloring matters and bile-pigment; and in the *blue* and *brown* urines, of which several instances have been reported.

3. The urine is also colored after the ingestion of certain vegetable matters eliminated by the kidneys, as santonin, which imparts a yellow color.

IV. The *Reaction* of normal *mixed* urine, that is, the urine of the entire twenty-four hours, is always acid. And, generally, specimens of urine passed at any time of day exhibit this reaction, though there is a difference in its degree, while after a meal the urine may become neutral or even alkaline.

The cause of this change in the reaction is still disputed. Roberts believes that it is due to an admixture with the blood, of the elements of food, which are largely alkaline, and that the resulting increased alkalinity affects the reaction of the urine secreted. Bence Jones contends, that it is the demand made on the blood for the elements of the acid gastric juice, which thus affects the reaction of the urine secreted during digestion. While neither explanation is

altogether satisfactory, the former seems more likely to be correct.

The cause of the acid reaction of the urine is usually ascribed to *acid sodic phosphate*, though it is probably also slightly contributed to by other acid constituents, as *uric* and *hippuric* acids, and under certain circumstances, also by lactic and acetic acids.

There is often observed in urine which has been standing for a short time, especially at a moderate temperature, an *increased* degree of acidity, which sometimes results in a decomposition of urates, and a precipitation, first of acid urates, and later of uric acid crystals. This has been ascribed by Scherer to an *acid fermentation*, in which, the mucus acting as the ferment, lactic and acetic acids are formed by the decomposition of the coloring matters of the urine. This has not been altogether satisfactorily proven, while the increased acidity is by no means constant.

It is certain, however, that acid urine which has stood for some time, and more rapidly in hot weather, exhibits an ammoniacal odor, and becomes alkaline in its reaction; attending this change of reaction results a semi-opacity with a precipitation of a white amorphous and crystalline sediment, and often also with the formation of an iridescent pellicle on the surface. The cause of these changes has been well determined, and has already been alluded to. Through the action of mucus and other organic matters acting in their decomposition as a *ferment*, the urea is converted into ammonium carbonate by the addition of two equivalents of water. Thus:—

$$CH_4N_2O + 2H_2O = (NH_4)_2CO_3,$$

which gives the odor of ammonia and the alkaline reaction.

The opacity and deposits are due to the precipitation of

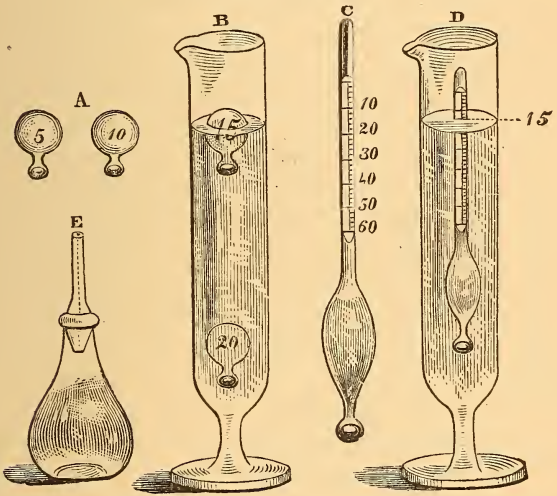
the crystalline triple phosphate of ammonium and magnesium, the amorphous phosphate of lime, urate of ammonium, and to living vegetable organisms known as bacteria.

V. The *Specific Gravity* as stated may be put down at 1020 for an average amount of 1500 c. c. (50 oz.) in the twenty-four hours. But as this amount is by no means fixed, while the amount of solid matter remains about the same, the specific gravity must vary accordingly. Under the influence of cold, when the skin is not acting, and after copious use of water and diuretics, the specific gravity may descend to 1010 and even lower, within the limits of health. But, where perspiration is copious, or a drain of water from the economy takes place through some other channel, the urine becomes concentrated, and may be 1025 or more in specific gravity.

Pathologically, the specific gravity of urine is increased or diminished, but to be entirely reliable, conclusions should be based upon observations made on the entire quantity passed in the twenty-four hours. The specific gravity is increased in *diabetes mellitus*, where it sometimes reaches 1050. A specific gravity of more than 1028, if it attend a copious urine, should excite suspicion of diabetes, and calls for sugar tests. In a single instance which came under my observation, a specific gravity of 1020, in a specimen of urine, was attended by the evident presence of sugar, easily shown by all the tests. The case was that of a medical practitioner aged forty-five. On a selected diet, the sugar disappeared altogether, while the specific gravity descended to 1018; proving that it is not safe to infer, from a low specific gravity alone, the absence of sugar, although I have never found it in urine having a lower specific gravity than 1020.

The specific gravity is also increased in the first stage of the *acute fevers*, in consequence of the increased amount of solid matters excreted; and in the *first stage* of acute Bright's disease, from the presence of *blood*, the higher specific gravity of the latter raising that of the mixed fluid. The specific gravity is diminished in *hysterical* and *spasmodic* hydruria, though here it attends a proportionate increase of water and is not of much practical significance. In all forms of *Bright's disease*, except the stage of acute nephritis

FIG. 2. (From Harley.)



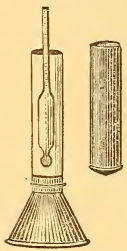
referred to, there is a *tendency* to lowering of specific gravity from the diminished proportion of urea. Particularly is such reduction of specific gravity significant when it attends a diminished quantity of urine. In a general way, the presence of albumen and sugar being eliminated, variations in

the specific gravity of urine point to variations in the amount of urea present; *lower specific gravity of mixed urine* generally *means less urea.*

To determine specific gravity, the so-called *urinometer* is almost invariably used, and though less accurate than the picnometer (E, Fig. 2) and balance, is still sufficiently so when carefully constructed. Every urinometer should first be tested with distilled water at 60° F. (15.54° C.), into which it should sink to the mark 0 or 1000. In their graduation the lines indicating the degrees should gradually approach each other as the bulb is reached, because allowance must be made for the weight of the stem above water.

The English-made urinometers, about 5 inches long (Fig. 2 C), are generally accurate, but the short German instruments (3 inch) are very convenient for small quantities of urine. In the little urinometer of Heller (Fig. 3), much used in Vienna, in which the "sink" consists of leaden shot, the graduation of Baumé is retained, where one degree corresponds with *seven* of the ordinary scale. Thus 1001 = 1007, 1002 = 1014, and so on. Especial care should be taken in testing these instruments, as a slight variation in them indicates a large one by the ordinary scale. The writer has in his possession an instrument of this kind which recorded the specific gravity of a given specimen of urine 1004, that is, 1028 by the ordinary scale, of which the specific gravity by a long-tried English instrument was found to be 1019. And on testing the former with distilled water, it was found to sink, not to 1000, but to 1001+, proving its inaccuracy. More recently a urinometer has been imported from Germany even slightly shorter

FIG. 3.



than the original of Heller, in which the ordinary scale is retained on an ivory stem within the tube, and the "sink" contains mercury instead of shot, apparently altogether more carefully made. These, so far as tested by myself, have been found accurate.

The cylindrical glass vessel usually supplied with the urinometer, or a sufficiently large test-tube, should be about three-fourths filled, the urinometer introduced, and when at rest, the specific gravity read off. The cylinder or test-tube should not be too small in relation to the urinometer, lest, in consequence of the capillary attraction between the latter and the walls of the cylinder, the urinometer should not sink as low as it ought. For the same reason the urinometer should not be allowed to impinge against one side of the glass. *If the quantity of urine be too small* sufficiently to fill the cylinder, it may be diluted with a quantity of distilled water sufficient to fill the cylinder to the required height. From the sp. gr. of this mixture may be calculated that of the urine. Thus, suppose it is necessary to add four times as much water as urine to enable us to use the urinometer, that is, to make five volumes, and the specific gravity of the mixed fluid is 1004, then that of the urine would be $1000+(4\times5)=1020$.

VI. *Quantity.*—The average amount of urine in the twenty-four hours is put down at 1500 c. c., or about 50 fluidounces. But enough has already been said to allow the inference that there is also much variation within the limits of health. All that has been said of color and specific gravity in this respect is true of the quantity of urine, though in an inverse ratio. That is, in health, *diminished* intensity of color and *diminished* specific gravity correspond with *increased* quantity of urine. It is with regard to quan-

tity that the complemental relation so well known to exist between the skin and kidneys most palpably shows itself, the increased action of the former causing diminished quantity of water separation by the latter, and *vice versa.* In deranged conditions, it is the absence of this relation of color and specific gravity to quantity which gives significance to either.

Pathologically, the quantity of urine is increased in diabetes, and hysterical and convulsive conditions, in the former, however, with increased specific gravity, and in the latter with diminished. In cardiac hypertrophy, in common with all conditions of increased blood-pressure, in which we include ingestion of large amounts of water, the peripheral action of cold, etc., there is an increase of water, and a corresponding reduction in specific gravity and color.

In all forms of Bright's disease, except in the cirrhotic and albuminoid kidneys, there is a *tendency* to diminished secretion of urine. Towards the fatal termination, however, it is diminished even in these affections. Any marked diminution of urine in these affections, particularly if it be attended by a low specific gravity, which means diminished urea, becomes a grave symptom.

In acute fevers and inflammatory affections, the quantity of urine is very constantly diminished until convalescence sets in, when there is generally observed a marked increase in the secretion of urine, which, in common with the profuse perspiration often observed at the same time, was long ago characterized by the word "critical."

VII. Of the *Odor*, little more can be said than that it is "peculiar" or "characteristic" in health. It is by some spoken of as "aromatic." There is, however, appreciable difference in its intensity, as most have observed in their

own cases. Concentrated urines always exhibit what is described in common language as "strong odor." This is undoubtedly due to urea, though the peculiar odor of urine is not ascribed to urea, but rather to the minute quantities of phenylic, taurylic, and damoluric acid which are found in it.

Urine which has been standing exposed in warm weather acquires an odor which is at once putrescent and ammoniacal, the former from decomposition of mucus and other organic matters, the latter from the ammonium carbonate derived from the urea. The former is predominant when a large amount of organic matter is present, and is often observed in destructive disease of the kidney or its pelvis, and especially of the bladder.

The odor of urine is very promptly influenced by that of substances separated by the kidney from the blood, illustrated by the well-known phenomenon of the odor of violets in the urine of persons taking turpentine. The odor of cubebs, copaiba, and sandalwood oil is promptly communicated to the urine of persons taking them. So, too, the use of certain vegetable foods promptly influences the odor of the urine. Among these asparagus is prominent.

In *disease*, except the increased intensity of the characteristic odor in concentrated urines, the *putridity* alluded to, and a *sweetish* smell which often attends the presence of sugar in the urine, there seem to be no modifications of this "characteristic" odor of urine.

To Determine the amount of Solid Matters in the Twenty-four hours' Urine.

Knowing the quantity of urine passed in the twenty-four hours, and its specific gravity, an approximation to the

quantity of solid matters, and thence that of water, may be readily obtained by multiplying the last two figures of the sp. gr. by what is known as Trapp's coefficient—2.33. This will give approximately the number of the grammes in the 1000 c. c. (33.8 f.oz.).

Thus, suppose the twenty-four hours' urine to be 1200 c. c. and the sp. gr. to be 1022, then

$$22 \times 2.33 = 51.26 \text{ grms. in } 1000 \text{ c. c.}$$

But the total quantity of urine in twenty-four hours is 1200 c. c., therefore it will contain more than 1000 c. c. contain. Hence,

$$1000 : 1200 :: 51.26 : x = \frac{51.26 \times 1200}{1000} = 61.51 \text{ grms. (948.09 grs.)}$$

Now the normal amount of solid matters in the twenty-four hours is about 70 grammes (1080.1 grs.), showing that in this instance rather less than the normal quantity was separated. In this manner valuable information bearing upon diagnosis and prognosis may be obtained in a few seconds. The most striking variations are observed in diabetes and Bright's disease, the former of increase in solids by addition of sugar, the latter in diminution by loss of urea.

While this method of arriving at the solids is not sufficiently accurate for scientific use, it answers for ordinary clinical purposes.

THE STUDY OF THE DIFFERENT CONSTITUENTS OF URINE IN HEALTH AND DISEASE.

In the examination of a specimen of urine, the following are the steps which will be found most convenient in actual practice. Observe—

I. The quantity passed in twenty-four hours.
II. Color and transparency.
III. Odor.
IV. Reaction.
V. Specific gravity.
VI. Presence or absence of sediment, its quantity, and characters.

In all cases, whether the sediment be appreciable or not, a portion of the fluid should be set aside in a conical glass vessel for twelve hours, with a view to collecting the sediment for *microscopical* examination. The remaining or supernatant fluid, *filtered if necessary*, should then be further examined.

Organic Constituents.

VII. Presence or absence of albumen.
VIII. Presence or absence of sugar.
IX. Coloring matters { Normal. / Abnormal.

These three are made to precede, because they should form a part of *every* examination.

X. The biliary acids.
XI. Leucin and tyrosin.
XII. Urea.
XIII. Uric acid.

Inorganic Constituents.

XIV. Chlorides.

XV. Phosphates { *a.* Earthy phosphates. *b.* Alkaline "

XVI. Sulphates.

Examination of Sediment Microscopically and Chemically.

I. Unorganized deposits, including crystals and amorphous deposits.

II. Organized deposits, including anatomical elements, such as casts, epithelium, pus, blood-corpuscles, etc.

III. Other morphological elements, as fungi, pigmentary particles, granular matter, extraneous substances, etc.

Nos. I, II, III, IV, V, VI require no further explanation than is involved in the consideration of the "general physical and chemical characters."

Organic Constituents.

VII. To Detect the Presence of Albumen.

In all instances where the urine used for testing is not perfectly clear, it should be filtered before applying the tests. This may be done in a few minutes by means of filtering-paper and a funnel.

(a) *The test by Heat.*—A test-tube is filled to $\frac{1}{4}$ to $\frac{1}{3}$ its depth with clear urine, to which, if it be not of distinctly acid reaction, a few drops of acetic acid are added, and the fluid boiled over a spirit-lamp. If an opacity result, the slightest degree of which becomes visible in a clear urine held in a good light, it is due either to *albumen* or *earthy phosphates*. If the latter, it promptly disappears on the ad-

dition of a few drops of nitric acid; if *albumen, it is permanent.* If further confirmation is desired, to the boiling urine quickly add half as much of the stronger potash solution (7, p. 15), when the albumen is dissolved, and the earthy phosphates again separate in flocculi.

If the urine has not been filtered, and is opaque from the presence of amorphous urates, the first effect of the application of heat is to clear up the fluid, and as the temperature is increased, the albumen, if present, is precipitated.

Acetic acid is preferred to nitric for acidulating the urine, because if the quantity of albumen is small it may be held in solution by nitric acid; but if the precaution be observed of adding only a single drop or two, nitric acid answers as well.

(b) *The Nitric Acid test* is best applied according to Heller's method. Upon a convenient quantity of pure, colorless nitric acid in a *small* test tube (one of those with a foot, seen in Fig. 4, is most suitable), allow to trickle from a pipette down the side of the inclined glass an equal amount of *clear* urine, which will thus overlie the acid. If albumen is present, there appears at the point of contact, between the urine and nitric acid, *a sharp white band or zone* of varying thickness, according to the quantity of albumen present.

The urine may be put into the glass first, if preferred, and the acid may then be allowed to pass down the side and under the urine. The result is the same, but I think the former is somewhat more easily practised.

Precautions.—1. Much difficulty is often experienced in causing the urine to flow from the pipette sufficiently slowly —that is, it will either not flow at all, or the finger, in the effort to cause it to flow, is suddenly raised so much as to permit a sudden flow of the urine into the acid, which interferes with the success of the test. This difficulty is readily over-

come by rotating the pipette covered by the end of the index-finger, between the middle finger and the thumb, whereby the flow may be easily controlled; the process is further facilitated if the upper end of the pipette is slightly *roughened.*

FIG. 4.

Testing for albumen by nitric acid.

2. A somewhat similar white zone is formed by the action of nitric acid on the mixed urates if present in excess, by which the more insoluble acid urates are thrown down. This zone might be mistaken for that of albumen; but the acid urates begin to appear, not so much at the border between the urine and acid as higher up; nor is the zone on the upper surface so sharply defined, but more irregular, or in "cloudy streaks." By Hoffmann and Ultzmann the appearance is

compared to the "cloudlike curling of rising smoke." Further, this layer if caused by urates is easily dissipated on the application of heat, although some care is necessary in this application lest in ebullition the ring be commingled with the entire mass of fluid and thus lost to view, although not actually dissolved. After some hours have elapsed these amorphous acid urates are completely decomposed by a further action of the nitric acid, and uric acid is then deposited as a characteristic crystalline sediment. Further difficulty arises where, as is occasionally the case in very severe cases of fever, a small quantity of albumen coexists with an excess of acid urates. In these cases the urine is of high specific gravity, and the line of albumen, lying immediately on the acid, may be obscured by the broader band and cloud of urates. But even here, if the method laid down on page 41 is carefully followed out, a mistake is scarcely possible.

It should be added that Thudicum considers this "cloud" of acid urates here referred to, to be not urates but hydrate of uric acid.*

3. This method obviates the possibility of two further sources of error pointed out by Bence Jones: first, that, if albuminous urine be acidified by a small quantity of acid, as a drop or two, no precipitation of albumen takes place, while if too large a quantity, as an equal bulk, of acid be added, the mixture in like manner remains perfectly clear. Roberts says he has known the latter fallacy to cause the concealment of albumen in the urine for months in a case of Bright's disease.

4. Occasionally, also, it happens that a urine is so highly concentrated—so highly charged with urea—that the simple

* Thudicum, J. L. W., Pathology of the Urine, 2d Ed., London, 1877, p. 377.

addition of nitric acid causes a precipitation of crystals of nitrate of urea. But these are readily distinguished from albumen by their solubility by heat, and by their appearance under the microscope, which exhibits them made up of six-sided rhombic tablets. Such urine is always of high specific gravity, while albuminous urine, except in cases of acute Bright's disease, is apt to be of low specific gravity.

5. If carbonic acid be abundantly present in urine, either free, or combined with ammonium as in the alkaline fermentation, or with sodium or potash, during the administration of alkaline carbonates or salts of the vegetable acids, the addition of an acid liberates it with effervescence. Under ordinary circumstances, this does not interfere with the test; but if the quantity of carbonate of ammonium be *very* large, as is the case in some old urines, and the quantity of albumen small, the effervescence is so great as to make the nitric acid test impossible; while the amount of acetic acid required to secure an acidity sufficient to permit the use of the heat test may be so great as to completely hold in solution the small quantity of albumen. Such difficulty is further increased by the fact that these alkaline urines are always more or less cloudy, from the presence of amorphous phosphates and of bacteria, and cannot be cleared up by ordinary filtration. Under these circumstances, boil the urine with a fourth part of its volume of the stronger solution of caustic potash (p. 15, 7), and filter. If the filtrate is still not quite clear, add one or two drops of the magnesian fluid; warm again, and filter. The fluid is then always clear and transparent, and, after being carefully acidulated with acetic acid, will show the smallest trace of albumen. But it can be made even more apparent; if to the fluid acidulated with acetic acid, a few drops of a solution of yellow prussiate of

potash be added, the mixture shaken and allowed to stand for a few minutes, white flakes of separated albumen will soon be seen at the bottom (Hoffmann and Ultzmann).

When nitric acid is thus allowed to underlie *normal* urine, there appears between the urine and the acid a *brown* ring which grows in intensity on standing, and is due to the action of the acid on the coloring matters. In consequence of this fact, when the urine is highly charged with coloring matters, as it often is in fever cases, the albumen precipitated at the same place is similarly tinted. If there is much indican present in the urine, a rose-red or violet tint may be communicated to the albumen; if much blood-coloring matter, a brownish-red, and if undecomposed biliary coloring matters, a green hue.

Other Tests for Albumen.—Nothing is said of the numerous other tests for albumen, such as carbolic acid, picric acid, corrosive sublimate, sulphate of copper, alcohol, etc., because they are either inapplicable, or less accurate than the methods described. With regard to M. Gallipe's method,* by picric acid, however, which has been much lauded, I have experimentally determined that the heat and nitric acid tests show smaller quantities of albumen in urine than it does, while my friend, Prof. H. P. Bowditch of Boston, has arrived at the same results, by experimenting with carefully prepared solutions of egg albumen of known strength.†

* Brown-Séquard's Archives, March, 1873, p. 281; and Edinburgh Monthly Med. Journal, August, 1873.

† The method of using picric acid is to make a saturated watery solution (water takes up a very small quantity), place some of the solution in a test-tube, and allow the urine to fall into it drop by drop, when each drop as it passes through the solution is followed by

Quantitative Estimation of Albumen.

It is a matter of extreme importance in the course of Bright's disease that we should be able to compare the quantity of albumen contained in the urine from day to day. The only accurate method is by precipitation by acetic acid and boiling, separation by filtration, drying and weighing by delicately accurate balances, the weight of the filter having been previously determined. This, however, involves too much time for the busy practitioner, and we must fall back on one of the approximative methods. The best known of these is to boil a given quantity of urine in a test-tube, add a few drops of nitric acid, and set aside for at least twelve hours. The proportion of bulk occupied—one-fourth, one-eighth, a trace, etc., is used to indicate the quantity of albumen. Greater accuracy is obtained by previously filtering the urine of urates, epithelium, or extraneous matter, which might unduly increase the bulk of deposit on standing.

More definite but perhaps scarcely more accurate is the approximative quantitative estimation by means of Heller's nitric acid method as given by Hoffmann and Ultzmann. According to them, if the white zone of albumen has the depth of a crow-quill, is delicate and faintly white in color,

an opaque white cloud. The test is very striking and beautiful, when the quantity of albumen is sufficient to permit its application.

The carbolic acid test in the alcoholic and acetic acid mixture recommended by Mehu, has not been satisfactory in my hands, the milkiness which occurs when carbolic acid is mixed with water or non-albuminous urine obscuring the results. With the mixture of equal parts of acetic and carbolic acids, recommended in the *London Medical Times and Gazette*, of September 26, 1874, I have had no experience.

has no granular appearance, and appears clearly defined only when placed against a dark background, the quantity is *less than half of one per cent.* If, however, the zone of albumen appears granular and flocculent, and sinks in more or less lumpy masses to the bottom, and when by stirring the albumen by means of a glass rod the mixture assumes the consistence and appearance of sour cream, then the quantity is very large, *one to two per cent.*

Roberts's Quantitative Method for Albumen.

Dr. William Roberts, of Manchester, England, suggests * a method for clinical purposes which consists in progressively diluting the urine, and testing from time to time with nitric acid until the opacity caused by the acid, becoming fainter and fainter, finally does not appear. This point is reached when the urine contains less than about 0.0014 per cent. of albumen. As it is impossible to fix the vanishing point of the reaction with accuracy, Dr. Roberts draws the line at a reaction appearing midway between 30 and 45 seconds after the addition of the acid ; that is, he dilutes the urine until it gives no reaction for 30 seconds after the contact of the acid, but becomes distinctly opalescent at the 45th. Each dilution by a volume of water equivalent to the original unit-volume of urine employed, is counted 1 degree on the scale, so that a urine requiring 40 volumes of water to reach the 0 reaction, may be said to possess 40 degrees of albumen. Ascertaining the degrees of albumen by the dilution method, and then estimating it by the weighing method, each degree on the dilution scale was found to correspond to .0034 p. c. The proportion of albumen in urine is then obtained by multiplying the degrees of albumen by the co-efficient .0034. Thus a urine which possesses 250 degrees

* American Journal of the Medical Sciences, January, 1878, p. 209 ; from the Medico-Chirurgical Transactions, vol. xli., 1876.

of albumen contains $250 \times .0034 = .85$, whence it is easy to calculate from the 24 hours' urine the total 24 hours' loss. Thus, if the patient pass 900 c. c. in 24 hours, and a given quantity shows 250 degrees of albumen, or .85 per cent., then $900 \times .85 = 765$ centigrammes, or 7.65 grms. loss in 24 hours.

Dr. Roberts says that the dilution method compares favorably with the weighing process, even in urines selected for their suitability to the latter; but it is vastly more convenient and brief, and is more generally applicable to all grades of albuminous urines.

Remarks on Testing for Small Quantities of Albumen, with the Author's Method.

To determine the presence of albumen in urine when it is abundantly present, is a very simple matter. The application of heat will throw down albumen even from an alkaline solution if highly charged with it, while the addition of a few drops of acid removes all possibility of error. But it is well known that small quantities of albumen, the significance of which in diagnosis and prognosis is often more important than that of large amounts, often escape detection; and it is with a view to pointing out the way to avoid such errors that the following paragraphs are introduced.

Under all ordinary circumstances by far the most distinctive test for small quantities of albumen is that form of the nitric acid test described as Heller's (p. 33), and in the majority of cases, this test, carefully carried out, even in the hands of the inexperienced, will exhibit the presence of albumen when it would have been overlooked in the ordinary mode of application of the heat and nitric acid test. But in the course of an experience involving almost daily examinations of urine, I have met several instances in which it failed to give satisfactory evidence of the presence of albumen, when

the ordinary heat and acid test, applied in the manner to be described, proved it conclusively.

Many, who have often tested urine for albumen by the ordinary heat and acid test, will have observed that after boiling the clear urine and adding a few drops of nitric acid, the resulting fluid will be apparently clear; but upon setting aside the urine thus treated, say for twelve hours, or until the next morning, there will sometimes be found a small deposit. Supposing the urine before testing to have been *carefully filtered*, this deposit is either, 1st, acid urates; 2d, urid acid; 3d, nitrate of urea; or 4th, albumen. The *first* result from a partial decomposition of the neutral urates by the nitric acid added; the *second* by a further action of the acid upon the acid urates, and a resulting complete separation of the uric acid from the sodium, potassium, etc., with which it was combined; the *third* is found only when the urine happens to be highly concentrated and contains an unusual proportion of urea. The *second* and *third* have well-known forms of crystallization by which they can be easily recognized under the microscope, but the acid urates and albumen are both amorphous and cannot therefore be thus distinguished. *All*, however, *except albumen*, disappear on the reapplication of heat. In all instances, therefore, urine which has been tried by heat and nitric acid, *should be boiled again* after cooling and standing from six to twelve hours, and if the sediment is not dissolved after such ebullition, it is albumen.

The Author's Method.—My own method, therefore, of examining a specimen of urine for albumen is invariably as follows:—

I. Unless *perfectly* clear it is first filtered, and if not rendered clear by filtration, it is clarified by strong alkalies, or

the magnesian fluid, according to directions on page 36. A portion of the filtered fluid is then taken, and, if not acid, it is cautiously acidulated, and then boiled, being carefully watched in a *good light* for detection of the least diminution of transparency. A drop or two of nitric acid are then added, and if a turbidity which has ensued upon the action of the heat disappears, it is caused by phosphates of lime and magnesia, and not albumen. If any degree of turbidity remains it is caused by albumen, and the test may end here—although it is well to put the tube aside, in order that the albumen may subside and be approximately estimated. If, however, there is the least doubt about the presence of albumen, the tube must be set away, carefully protected from dust, for six to twelve hours, in order that any appreciable sediment may subside, and be subsequently again tried with heat.

II. A test-tube is now filled to the depth of half an inch with colorless nitric acid. About as much urine is then allowed to fall gently upon it in the manner described on page 33, and the point of junction of the two fluids carefully examined for the white line. This is best observed by holding the tube in front of a dark ground, furnished by a book or pamphlet, just below the upper edge of the latter, so that the light may fall obliquely upon the line of junction of the two fluids, while at the same time it is seen against the dark ground.

When this double test is carefully applied as above described, it is scarcely possible to err with regard to the presence of albumen. Where it is abundantly present, it is, of course, unnecessary to use either the modified heat and acid test, or the Heller's test, although the latter is always useful in that it affords one means of approximately estimating the amount of albumen.*

* I was, for a time, under the impression that the precaution above described with regard to the heat and acid test, was identical

VIII. To Detect the Presence of Sugar, $C_6H_{12}O_6$.

Of the large number of tests extant for the presence of sugar, only those will be given which have borne the trial of

with one suggested by Dr. C. E. Brown-Séquard, in the first number of his *Archives of Scientific and Practical Medicine* (1873), but on looking up the matter find that he there says: "If we first test by heat urine containing albumen (after having ascertained that it is naturally acid), we may not find the least precipitate; and if we add nitric acid to it after it has boiled and become somewhat cold, we may yet not find precipitation of albumen. *But if we boil a second* time that now acidified urine, the solidification *of albumen quickly takes place, and a precipitate soon appears.*" A comparison of this with the above test will show the difference. Although Brown-Séquard says "this is certainly what we see in almost all cases," I must confess never having witnessed such precipitate under the precise circumstances he describes—that is, immediately after the second boiling.

While on the subject, it may be well to add what he further says in the same connection. "In three cases in which the microscope showed tubular casts in the urine, the albumen contained by this fluid was so modified by the heat that if the urine (which was naturally acid) was boiled *first*, the addition of nitric acid in small or in large quantity at a low temperature or at the degree of boiling, produces no solidification of that protein substance. But when I added either a small or large quantity of nitric acid to the fresh *unboiled* urine and then boiled it, the ordinary coagulation took place, and after some time of rest, the ordinary precipitate appeared. It is evident, therefore, that there is sometimes in the urine a kind of albumen which loses its coagulability by boiling."

The lesson from these facts is that it would seem necessary to apply the heat and acid tests *both ways*, that is, the acid should first be added to the urine and the mixture then boiled, as well as that the urine should be first boiled and the acid then added. I believe, however, that, if the method above described is carefully carried out, albumen cannot be overlooked.

experience, and it is suggested that for practical purposes the student should select some one of these and accustom himself to its use, and to the modifications in results to which all are more or less subject. I am confident that much of the difference of opinion with regard to the reliability of the different tests is due to the fact, that those claiming it have had more experience with the particular test which they recommend. Thus, in Germany, Moore's test is evidently the favorite one, while in my own hands, the old Trommer's test gives great satisfaction, simply, perhaps, because I have become accustomed to its use. But it is necessary to be familiar with more than one test, because cases of doubt constantly arise where the evidence of one is insufficient. Although Brücke has shown that sugar is present in very minute quantity in normal urines, yet the amount is so slight as to escape detection by the ordinary tests.

Specific Gravity and Quantity as a Test.—The specific gravity alone, when 1030 or more, affords a presumption of the presence of sugar, and if at the same time the urine is very pale, and far exceeds 1500 c. c. (50 fl. oz.) in twenty-four hours, the probabilities are much increased. These facts at least call for the use of other tests to determine the question. Further, if the quantity of sugar is very large, a sweetish odor and taste is communicated to the urine. (See case referred to on p. 24.)

In using any of the following tests, if albumen is at all abundantly present, it should first be removed by boiling and filtration.

Moore's Test.—Moore's test depends upon the fact that grape-sugar, with which diabetic sugar is identical, becomes oxidized when boiled in contact with caustic alkali, taking the oxygen from the atmosphere.

To a small quantity of urine in a test-tube, add half as much liquor potassa or liquor soda, and boil. If sugar is present, a yellowish-brown color soon makes its appearance, which becomes more intense as the boiling is continued, and which will be the deeper the larger the proportion of sugar, becoming finally almost black if the quantity is very large. The coloration is due to the formation, first, of glucic, and finally of melassic acid, both of which remain in solution. The flaky precipitate which is observed after the addition of the alkali, and is increased on the application of heat, is made up of the earthy phosphates, which may be filtered off before the heat is applied if very abundant.

If now to the colored fluid a few drops of nitric acid be added, the brown coloration disappears, and the odor of burnt molasses is developed, and in this we have Heller's modification of Moore's test.

Precautions.—1. Solutions of soda and potash are liable to become impregnated with lead, either from being kept in flint-glass bottles, or from the glazed earthenware vessels in which, during preparation, they are evaporated. Such contamination always causes the production of a brown and black color when boiled with organic matter containing sulphur, due to the formation of sulphuret of lead. This error may be avoided by first ascertaining the purity of the alkaline solutions, and afterwards keeping them in green glass bottles.

2. If the urine exhibits already a high color, which is, however, very rare with diabetic urines, the coloring matters may be precipitated by solution of acetate (sugar) of lead, which does not at all interfere with the sugar, although the *sub*acetate of lead throws down also a small quantity of sugar.

3. The coloring matters of bile in urine, either when pure, or decomposed (that is, when they respond neither to Gmelin's nor Heller's test), produce a *brown* color with liquor potassa or soda *without the application of heat.*

4. Bödeker found in the urine of an adult a substance which he calls *alkapton*, which when strong solutions of alkali are added produces a brown discoloration from above downward. This, according to him, also reduces the salts of copper, but does not affect the bismuth salts.

The Copper Tests. Trommer's Test.—The copper tests depend upon the power which grape-sugar possesses of reducing the oxide of copper in common with other metallic oxides, as silver, gold, etc., to a lower state of oxidation. In *Trommer's test*, the oxide of copper is set free at the time of its application by liquor potassæ or soda in excess.

1. A drop or two of a (preferably weak—say 1 to 30) solution of cupric sulphate is added to the suspected urine, and then liquor potassæ or sodæ equal to half the total volume. On first adding the alkali there is immediately liberated, in addition to the earthy phosphates, a blue precipitate of hydrated cupric protoxide, *which, if sugar is present, is redissolved on adding more alkali*, producing a beautiful blue transparent liquid. If, on the other hand, no sugar is present, the fluid will not be thus blue after the addition of the copper and alkali, but exhibit rather a turbid greenish hue. This, however, is not alone relied upon, but the *mixture is boiled*, and if sugar is present, a copious yellow precipitate of *hydrated* cupric suboxide takes place. This subsequently loses its water and becomes the *red suboxide* which falls to the bottom or sides of the test-tube, to which it often closely adheres.

2. A second similarly prepared mixture of these ingredients should be made and set aside without the addition of

heat for from 1 to 24 hours. If sugar is present a similar precipitate of suboxide of copper will take place. This repetition of the test is very important, since Neubauer says that the other organic substances which reduce the salts of copper do so only after long boiling.

Precautions.—1. Albumen, if present, must always be removed, as it interferes with the reduction of the copper.

2. Too much or too strong a solution of cupric sulphate should not be used, lest the blue color of the unreduced copper should obscure the yellow or red of the reduced.

3. While the fluid must be made to boil for perhaps half a minute, the precipitate should take place *without prolonged boiling*, as numerous organic substances other than sugar will reduce the salts of copper by prolonged boiling.

4. The flocculent precipitate of earthy phosphates should not be mistaken for the suboxide of copper; it is either transparent or of a pale greenish hue. On the other hand, *a mere change of color is not sufficient.* There must be an actual yellow or red precipitate. If it be desired to eliminate this source of error altogether, it may be done by adding the potash solution, and filtering before adding the copper.

5. As already stated, cupric protoxide is sometimes reduced by other organic matters found in urine, as uric acid, indican, etc. So also a small amount of sugar may even be present in urine and fail to reduce the oxide in the presence of certain other substances. Dr. Beale* has shown that ammonium chloride, ammonium urate, and other ammoniacal compounds have this latter effect, and Neubauer† tells us that creatinin acts similarly. Recently Dr. George Hay,‡

* Kidney Diseases and Urinary Deposits, p. 246.

† Analyse des Harns, p. 76.

‡ Philadelphia Medical Times, vol. vii., 1877, p. 489, and vol. viii., 1878, p. 28.

of Pittsburg, Pa., has reaffirmed both of these sources of error with such force as to throw a good deal of discredit on Trommer's test. While I have long been in the habit of using this test very frequently, and have grown to rely upon it in my own hands as second to none except the fermentation test, I strongly insist upon the use of some other in addition, wherever there is the least doubt, and always that the elements of Trommer's test shall be added to a portion of the same urine and allowed to stand twenty-four hours without the addition of heat. This is less troublesome than the fermentation test, the elements of which are not always at hand, although it occupies as much time. Attention should be paid to the specific gravity, to the fact that a precipitate of the phosphates always takes place which must not be mistaken for the suboxide, and that the disappearance of the blue color and the substitution of a yellowish tinge is also not to be mistaken for a precipitate. This yellowish color, however, is apt to indicate either a partial reduction by some other organic substance, or by the sugar itself, and demands that the urine should be subjected to the bismuth or fermentation test, or to both.

Other Copper Test Solutions. Fehling's and Pavy's Fluids.—It has been stated that when an alkali is added to a solution of sulphate of copper an abundant precipitate of hydrated cupric protoxide is thrown down. This is not dissolved by any excess of alkali added, but if some organic matter is added or happens to be present, an excess of alkali dissolves the protoxide. It is for this reason, that if sugar happens to be present in a suspected fluid to which these have been added, the precipitated protoxide is dissolved and a clear blue fluid results.

These facts enable us to construct a fluid which will hold the protoxide of copper in solution; but, in selecting an organic substance, one must be chosen which will not reduce the oxide of copper as does sugar, else it will make our test inoperative. Such a substance is *tartaric acid*, which is usually employed.

Of the numerous test fluids employed, only Fehling's, and Dr. Pavy's modification of it, are given, since these are most convenient in practice, and serve also for quantitative estimation. The one or the other may be used, as it is preferred to work with the English or metric system.

Fehling's Solution.—34.639 grammes (534.479 grains) pure crystallized sulphate of copper are dissolved in about 200 grammes (3086 grains) distilled water; 173 grammes (2669.39 grains) chemically pure crystallized neutral tartrate of soda are dissolved in 500 to 600 grammes (7715 to 9258 grains) solution of caustic soda of specific gravity 1.12, and into this basic solution, the copper solution is poured, a little at a time. The clear mixed fluid is diluted to 1 litre (2.1 pints).

10 c. c. (162 minims) of this solution will be reduced by .05 gramme, or 50 milligrammes (.7715 grain), diabetic sugar. If the copper solution is to be kept some time, it is absolutely essential that it should be placed in smaller (40–80 grammes) bottles, sealed, and kept in the cellar.

Pavy's Solution consists of—

Cupric sulphate	320 grains.
Neutral potassic tartrate . .	640 grains.
Caustic potash	1280 grains.
Distilled water	20 fluidounces.

The solution is made in the same manner as Fehling's, and 100 minims correspond to $\frac{1}{2}$ grain grape-sugar, the for-

mula for grape-sugar being here taken $C_6H_{14}O_7$, while by Fehling it is taken $C_6H_{12}O_6$.*

These solutions serve equally well for qualitative and volumetric testing, but if it is simply desired to have a solution for the former purpose, it may be made by pounding together 5 grains (.324 gramme) cupric sulphate, 10 grains (.648 gramme) neutral potassic tartrate, and dissolving in 2 drachms (7.4 c. c.) liquor potassæ. The usual blue fluid results.

To Use.—In using either of the above solutions for qualitative testing, a small quantity should be placed in a test-tube and boiled alone for a few seconds. If the solution remains clear on thus boiling, add immediately the suspected urine drop by drop. If sugar is present in any quantity, the first few drops will usually cause the yellow precipitate, but the dropping may be continued until an equal volume of the urine has been added, when the mixture is again boiled. If no precipitate occurs, sugar is absent.

If a precipitate occurs on boiling the *test fluid alone*, a new supply may be obtained, or a little more soda or potash may be added, the fluid filtered, and it is again ready for use. The precipitate referred to is a suboxide of copper, the result of a spontaneous reduction of the protoxide which sometimes occurs when Fehling's or Pavy's solutions are kept for some time. Boiling causes its precipitation, and hence the necessity of boiling a solution which has been kept for any length of time, before adding the suspected fluid. All possibility of such source of error may be avoided by keeping the solution of copper separate from that of the

* This should be remembered, as, in consequence of it, the same urine in the hands of different observers would yield slightly different results, according as one or the other solution is used.

potash and potassic tartrate, and mixing them at the moment they are required for use.

The same precautions laid down with regard to Trommer's test are here to be observed.

To obviate the uncertainty of Trommer's tests and the inconvenience of Fehling's, Dr. H. G. Piffard* has suggested the following—

New Test for Sugar.

Take of—

Sulphate of copper (chemically pure), 1 part.
Crystallized tartrate of soda and potassa, 5 parts.
Sodic hydrate (chemically pure), 2 parts.

Mix *thoroughly* in a mortar.

The result will be a pasty mass, which can be transferred to a wide-mouthed bottle, and kept till wanted *To use it*, take of the mass a piece about the size of a small pea, put it in a test tube, and add about two fluidrachms of water, boil till the mass is dissolved, and the solution has a uniform, pale, and rather dirty blue color; then add two or three drops of the suspected urine, and boil again for a moment. If sugar be present, the usual reaction will be manifest.

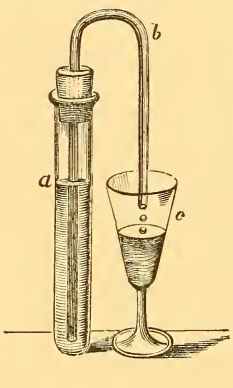
Bœtger's Bismuth Test consists in adding to urine in a test-tube an equal volume of liquor potassæ or sodæ, then a pinch of the ordinary subnitrate of bismuth, shaking and boiling for a couple of minutes. The sugar possesses the power of reducing the salts of bismuth, and, if sugar is present, the black metallic bismuth will shortly be deposited on the side of the test-tube. If the quantity of sugar is small, the bismuth will assume a grayish hue; hence, when this is the case, a very small amount of bismuth should be used in making the test.

* New York Medical Record, March 23, 1878.

This is an excellent test, and the one I usually employ to confirm the results of the copper test. With the exception named below, no other substance than sugar is supposed to reduce bismuth salts.

*Brücke's Modification of the Bismuth Test.**—Professor Brücke finds, that, while Bœtger's bismuth test has many advantages over Trommer's test, it may lead under certain conditions to false results, since sulphur occasionally present in the urine will cause the same reaction as glucose; hence he recommends that the urine, if it contain a sulphur compound, be faintly acidulated with hydrochloric acid, then treated with a solution of iodide of bismuth and potassium, which completely removes the sulphur, while it does not affect the glucose in the slightest. After a few minutes the solution is filtered, and boiled for a few minutes with an excess of a concentrated solution of caustic potash; if the solution is now colored gray or black, or such a precipitate is formed, the presence of sugar is proven beyond a doubt.

FIG. 5. (After Harley.)



Precaution.—For the same reason all albumen must be removed from the urine to be tested by bismuth, since it affords a source for sulphur, which in like manner will precipitate the sulphide of bismuth.

The Fermentation Test.—The most reliable of all tests for the presence of sugar is the fermentation test, but, being somewhat troublesome, it is less suitable for the practitioner as an everyday test. The most convenient

* Proceedings of American Pharmaceutical Assoc., 1877, p. 287.

method of its application is as follows: A test-tube of large size is provided with a tightly fitting perforated cork, through which one limb of a bent glass-tube long enough to reach nearly to the bottom is passed. A small quantity of ordinary baker's or brewer's yeast (about a fluidrachm, or 3 to 4 c. c.) is placed in the tube, which is then filled with urine, tightly corked, allowing no air to remain, and placed in a vessel which may be filled with tepid water, in a room at a temperature of 15–25° C. (59–77° F.). If sugar is present, evidences of fermentation will present themselves generally within twelve hours in the formation of carbonic acid, which will force the fluid out of the bent tube into the glass vessel arranged for its reception. *If carefully performed, this test is thoroughly reliable.*

Quantitative Estimation of Sugar.

So important is a knowledge of the daily change in the quantity of sugar in the urine of a case of diabetes, that it may be laid down that some kind of quantitative estimation from day to day is absolutely necessary.

1. *Approximative Estimation.*—While the specific gravity determined from the twenty-four hours' urine may serve to give a general idea of the increase or diminution of the amount of sugar, in consequence of the complex composition of the urine it cannot be relied upon even for approximate estimation, as it might be in a simple watery solution of sugar.

(a) To those who habituate themselves to Moore's test, the method of Vogel recommends itself by its simplicity and brevity. As the result of trial, Vogel has determined that solutions of grape-sugar, when boiled with half their bulk of liquor potassæ, exhibit the following changes of color: A 1

per cent. solution becomes *canary yellow;* a 2 *per cent.* a *dark amber;* a 5 *per cent.* a *dark Jamaica rum* (?); and a 10 *per cent.* a *dark black-brown*, and *opaque*, while all solutions of a less percentage are more or less transparent.

With a pale urine, in the hands of one accustomed to this test, if the specific gravity be also regarded, tolerable accuracy may be obtained. It should certainly be employed rather than none at all.

(b) *Roberts's Fermentation Test* is based on the fact that diabetic urine loses in specific gravity after fermentation is completed. Dr. Roberts has shown by careful experiments that every "degree" in specific gravity lost in fermentation corresponds to *one grain of sugar per fluidounce.* Thus, if before fermentation the specific gravity of a given specimen is 1050, and after fermentation it is 1020, it will have contained 30 grains to the fluidounce. The method recommended by Dr. Roberts is as follows: Four ounces of the saccharine urine are put in a 12-ounce bottle, and a lump of German yeast,* as large as a small walnut, is added. The bottle is then covered with a nicked cork to permit the escape of the carbonic acid, and set aside on a mantelpiece or other warm place. Beside it is placed a tightly corked 4-ounce vial, filled with the same urine, but without any yeast. In eighteen to twenty-four hours fermentation will be complete, and the scum cleared off or subsided. The specific gravity of the decanted fermented urine is then taken; at the same time, that of the unfermented urine, and a comparison made. While some time is here required to complete the fermentation, yet, as Dr. Roberts says, the preparations can be made by the patient himself or friends, and each day,

* The so-called Vienna yeast, now well known in this country, is the same thing. But the ordinary liquid yeast answers as well.

when the physician makes his visit, he has only to make the comparison.

2. *Volumetric Process.*—*The exact quantitative methods* are those by Fehling's or Pavy's solutions. That recommended by Pavy is by far the most convenient in practice, requiring a hundred-minim graduated pipette,* a measuring glass, spirit-lamp and stand, and porcelain capsule.

In an ordinary case of diabetes, the urine contains too much sugar to be tried, unless diluted with a known quantity of water. Generally it suffices to dilute it with two to four times its bulk of water, according to the amount of sugar suggested by the specific gravity.

One hundred minims of Pavy's solution (p. 49), equivalent to half a grain of sugar, are now measured out into a porcelain capsule. Into this a fragment of caustic potash, about twice the size of a pea, is dropped, for the purpose of causing the reduced oxide to fall in a denser form, so that the liquid may remain clear, and allow the change of color to be more readily seen. The capsule is then placed over the flame of a spirit-lamp or gas, on a retort stand, or better, on a piece of iron gauze, adapted to the top of a stoneware cylinder, as arranged in the cut, Fig. 6. The cylinder protects the flame from draught, and the gauze distributes and regulates the heat.

The one-hundred-minim pipette is now filled with the *mixture of urine and water*, and, as soon as the fluid in the capsule begins to boil, the contents of the pipette are allowed to fall drop by drop into the test solution in the capsule,

* For some time it was impossible for me to get a minim pipette in this city. Finally I found they were to be had of W. H. Pile, northwest corner of Passyunk Avenue and Catharine Street, who prepares them with great care.

which must be kept boiling, and moved about by tilting with a glass rod, until all the blue color is gone. All trace of blue should be removed, and a little experience will enable even the beginner to note the exact point. If the deposit

Fig. 6. (From Pavy.)

falls slowly, the process may be stopped for a few minutes until it has subsided, when by tilting the capsule a thin layer of the fluid may be examined over the pure white porcelain, and thus any remaining coloration detected. We then note how many minims of the urine mixture have been used to decolorize the one hundred minims of test solution, thence the number of minims of pure urine, and thence the quantity in the whole twenty-four hours.

Thus, suppose the quantity of urine in twenty-four hours to be 100 ounces, some of which was diluted four times—that is, of 100 minims of the mixture 20 were urine; sup-

pose, further, that 80 minims of this mixture exactly reduced the 100 minims of solution representing the half grain of sugar. Then one-fifth only being urine, we have learned that 16 minims of urine contain half a grain of sugar, and from this that an ounce contains 15 grains, and 100 ounces, or the twenty-four hours' urine, $15 \times 100 = 1500$ grains.

Fehling's solution may be used in precisely the same manner, using, however, the metric system of measurement and operation, and obtaining results in the same system. Either solution may be dropped from a burette in a manner to be described in the volumetric analysis for urea, etc.

IX. Coloring Matters.

The pathological significance of all the coloring matters has not as yet been determined. Many of them are, however, of such importance that their consideration commands interest next to that of albumen and sugar.

I. *Normal Coloring Matters.*—Notwithstanding the very considerable attention which has been given to this subject of late years, there is still some confusion as regards the normal coloring matters. Thus, perhaps most recently, Hoffmann and Ultzmann,* describing Scherer's method of obtaining his urohæmatin, state that it does not contain iron, while the urohæmatin of Harley and the urophain of Heller do. Further, they make the *urohæmatin* of Harley identical with the *uroerythrin* of Heller, an abnormal coloring matter. Thudicum† makes a single coloring matter

* Anleitung zur Untersuchung des Harns, etc. Wien, 1871.

† Thudicum, A Treatise on the Pathology of the Urine, 2d Edition, London, 1877.

which he calls *urochrome*, in the composition of which he does not appear to admit iron.

The fact is, that, while it is probable that the true coloring matter of the urine has not been precisely determined, the urohæmatin of Scherer and Harley are identical, Scherer* admitting that urohæmatin contains iron, and approving of the use of the term by Harley for his coloring matter. The urophain of Heller is doubtless practically the same thing. It will at any rate here be so considered. So would seem to be the urochrome of Thudicum. Upon the presence of indican (Heller's uroxanthin) in most normal urines, all are agreed, although Thudicum prefers not to consider it a coloring matter, but a *chromogen* or color generator. For the present I shall retain it among the normal coloring matters, making therefore two, viz. :—

1. Urohæmatin (Harley and Scherer) or urophain (Heller); urochrome (Thudicum).
2. Indican or the uroxanthin of Heller.

1. *Urophain—Urohæmatin—Urochrome.*

Heller's test for urophain is as follows: About 2 c. c. (32.4 minims) of colorless sulphuric acid are poured into a small beaker-glass, or better a "collamore" wineglass (p. 16), and upon it in a fine stream from a height of about four inches, two parts of urine are allowed to fall. The urine mingles itself intimately with the sulphuric acid, and in normal urine, of which the specific gravity is 1020 and the quantity 1500 c. c. in the twenty-four hours, produces a *deep garnet-red coloration.*

* Harley, The Urine and its Derangements, Philadelphia, 1872, from London Edition, 1871.

If the coloring matter is increased, the coloration is no longer garnet-red, but is *black* and *opaque;* whereas, if the coloring matter is diminished, the mixture appears *pale garnet-red* and transparent.

Precautions.—Unfortunately, other conditions than that of increased amount of coloring matter produce the increased intensity of the urophain-reaction. Thus diabetic urine produces the same dark opacity through carbonization of the sugar by the sulphuric acid. In like manner, urine containing blood, biliary coloring matters, and uroerythrin (an abnormal coloring matter), gives the same reaction with sulphuric acid. Before relying, therefore, upon this reaction, the above substances must be carefully excluded.

Dr. Harley's test for urohæmatin is as follows: Dilute the twenty-four hours' urine with water till it measures 60 ounces (1800 c. c.), or, if the quantity exceeds 60 ounces, concentrate it to this amount; then add to about 2 drachms (7.4 c. c.) of it, in a test-tube, half a drachm (1.8 c. c.) of pure nitric acid, and allow the mixture to stand for some minutes. If the quantity of urohæmatin is normal, the mixture will alter but slightly in tint; whereas, if there be an excess, it will become pink, red, crimson, or purple according to the amount present. Heating the mixture hastens the change in color, but it is better to do this experiment in the cold, and, if necessary, allow plenty of time for the change to take place.

The acid is added to liberate the coloring matter, which may be so thoroughly concealed that a *pale urine often contains a large amount of urohæmatin.*

He gives a second method, also easy of application, of determining its excess in cases of destructive diseases of the blood. Boil 4 ounces (120 c. c.) of urine, and add nitric

acid to set the coloring matter free. When cool, put the urine in a six-ounce bottle along with an ounce of ether. Cork the bottle, thoroughly shake it, and place aside for twenty-four hours. At the end of that time the ether will be found to be like a red, tremulous jelly. Such a case, however, he admits to be a bad one. He further says, that "in some of the worst cases of urohæmaturia the urine is neutral, or even alkaline, and the *fons et origo mali* is to be looked for in the spinal cord."

Dr. Harley, apparently with good reason, considers that urohæmatin arises from the disintegration of the red blood-corpuscles, and that it fluctuates, therefore, with the rate of destruction of these.

Urochrome of Thudicum.—Thudicum terms the substance, to which he considers the whole or greater part of the yellow color of the urine is due, urochrome. It is an alkaloid, but not of pronounced basic properties. It has been isolated, but not finally analyzed. Its principal characteristic is, that on chemolysis with acids it is split up into several bodies of smaller atomic weight, one of which—uromelanine—seems to be derived from the coloring ingredient of the blood. Urochrome does not show any specific absorption band before the spectroscope when strongly acidified, but by chemolysis probably gives rise to two or three substances having distinct spectral phenomena which greatly aid in their diagnosis. It is not the chromogen of urobilin.

Thudicum gives (op. citat.) several methods of isolating urochrome, the briefest of which consists in precipitating fresh urine with neutral and basic lead acetate, decomposing the precipitate with sulphuric acid, and precipitating the urochrome (and some xanthine-like body) from the filtrate by phosphomolybdic acid.

Clinical Significance of the Increased Urohæmatin or Urophain Reaction.

An increase of the urophain (urohæmatin) reaction has been observed under the following circumstances.

1. In concentrated urines.
2. In fever urines.
3. In the urine of icterus and in chronic diseases of the liver. In the latter, and biliary obstructions, an increase of the urophain reaction may show itself, even when Gmelin's or Heller's test for the coloring matters of bile does not respond; since the products of their decomposition may be present when the proper biliary coloring matters themselves, bilirubin and bilifuscin, are wanting.
4. In diabetic urine containing abundant sugar.
5. In urine rich in the coloring matters of blood.
6. A large amount of indican in the urine may also give a strong urophain reaction. So marked an increase in indican alone very seldom occurs, but it often happens that the blue color is recognized at the first moment of the test, and gradually passes over into the black; but by dilution with water the blue may again be made to appear. Hofmann and Ultzmann.

2. *Indican; Uroxanthin of Heller; Indigogen of Thudicum*

Indican or uroxanthin itself is a colorless substance as is indigo at first, separable from urine in the shape of a clear brown syrup easily soluble in water, alcohol, and ether. It has a bitter taste, and is easily converted by treatment with acids under warmth into *indigo-blue* (the uroglaucin of

Heller), a red coloring matter (urrhodin of Heller), said by Kletzinsky to be identical with indigo-red, but denied by Thudicum, and indigo-*glucin*, a saccharine substance which is said to respond to Trommer's test, but not to the fermentation test. According to Thudicum, *urrhodin* is the result of chemolysis by acids, of a separate chromogen which he calls *urrhodinogen*.

Heller's Test for Indican is performed as follows: 3 or 4 c. c. (48.6 to 64.8 minims) of pure hydrochloric acid are poured into a smooth wine- or a small beaker-glass, and into the same while stirring 10 to 20 drops of urine are dropped. Under normal conditions indican is present in urine in so small quantity that the acid to which the urine is added is colored *pale yellowish-red*. If indican is present in larger quantities, the coloration is *violet* or *blue*. The more abundant the indican the more rapid does the violet or blue discoloration take place, and often 1–2 drops of urine are sufficient to color 4 c. c. (64.8 minims) hydrochloric acid. The blue color does not always make its appearance immediately. It is well then to wait 10 or 15 minutes. If it is desired to test urine containing the biliary coloring matters for indican, the former must be precipitated by solution of acetate (sugar) of lead, and filtered out.

Dr. Harley believes that all the various colored urine pigments are but different grades of oxidation of urohæmatin,* and thus accounts for the various cases of blue, green, brown, and black urines which have been at different times reported, a most important fact with regard to which is that they never exhibit these colors at the moment the urine is passed, but acquire them after exposure to the air or the action of chemical reagents. He believes these changes which occur

* Op. citat., p. 110.

in urohæmatin out of the body are primarily due to its constitution in the body having been altered by disease.

He admits, however, in common with others, that some portion of the coloring matter of the urine comes from the food, chiefly vegetable food.*

Senator's Method for Indican† is more striking in its results, and is even approximately quantitative. To 10 or 15 c. c. (2.7 or 3.24 f℥) of urine in a large test tube add an equal amount of hydrochloric acid, and then, with constant shaking, a saturated solution of calcic hypochlorite (chloride of lime) drop by drop, until the greatest intensity of the blue color is reached. This is then shaken with chloroform, which readily dissolves the freshly formed indigo, and separates from the aqueous solution as a blue fluid, the color being more or less deep according to the amount of indican present. In pale urines, often very rich in indican, this method will serve to determine its amount with sufficient accuracy for clinical purposes. Dark urines, whose other coloring matters are also decomposed by hydrochloric acid and calcic hypochlorite, should first be decolorized by a solution of the basic acetate of lead, avoiding a great excess of the latter, when, if indican is present, a good indigo extract can be obtained in this way.

Albumen must always be separated before performing the analysis.

* Op. citat., p. 101, ad fin.

† E. S. Wood, M.D., in Boston Medical and Surgical Journal, February 7th, p. 170, from Centralblatt für Wiss. Med., No. 20, 1877, p. 357.

Clinical Significance of Indican in the Urine.

An increase of indican is found in renal diseases, especially the acute, in pyelitis, diseases of the spinal cord and its membranes, and especially derangements of the entire central and peripheral nervous system, in urina spastica, and after coitus. It is also especially abundant in the urine secreted during the reaction from cholera.

It has been found by Neftel in cases of cancer of the liver, and its presence in large quantities, in persons affected with malignant tumors, he considered pathognomic of cancer of the liver; by Hoppe-Seyler, in a case of melanotic cancer of the orbit. Jaffé finds indican increased in all diseases attended by intestinal obstruction, cancer of the stomach, lymphoma and lympho-sarcoma in the abdomen, purulent peritonitis, certain forms of diarrhœa, and in various diseases where the latter is a symptom. Rosenstein found indican increased eleven to twelve times in Addison's disease.

From these facts it is evident that it is difficult to associate it pathognomonically with any disease. But recent physiological observations afford a rational explanation for its increase which is strikingly confirmed by the clinical observations above noted. It was discovered by Kühne (Virchow's Archiv., vol. xxxix.) that, during the artificial fermentation of albumen in the presence of minced pancreas, a substance known as *indol*, first discovered by Baeyer, was produced. Jaffe suggested that the indol thus produced during digestion is absorbed and oxidized in the blood to indigo-blue, combined with sugar and excreted as the glucoside *indican*. Now it is supposed that in ordinary normal intestinal digestion very little indol is produced; but wherever digestion is interfered with or delayed, as is evidently likely to be the

case in almost all of the conditions above instanced, more is produced, absorbed, oxidized, and excreted as indican, thus accounting for its presence in increased amount under the circumstances.

II. *Abnormal Coloring Matters.*

Under abnormal coloring matters are included those which never enter into the composition of normal urine, whether found elsewhere in the body or not.

They include *a*, *the coloring matters of blood*, hæmoglobin, methæmoglobin, and hæmatin. Hæmatin is a deoxygenated hæmoglobin, into which and a coagulated albuminous substance, hæmoglobin is converted by the action of heat. Methæmoglobin is an intermediate condition, approaching, however, nearer to hæmatin, and giving the same absorption band, in the yellow of the spectrum between Fraunhofer's lines C and D, but nearer to D, while hæmoglobin gives two bands in the yellow and green between D and E. *b*, the *uroerythrin* of Heller. *c*, *vegetable coloring matters*. *d*, *biliary coloring matters*.

a. The coloring matters of the blood, hæmoglobin, and *methæmoglobin,* and *hæmatin.*

These substances can enter the urine either by direct transudation, or arise from the dissolution of blood corpuscles themselves, which have entered the urine in different ways. They may be present in urine in very small quantities without being accompanied by albumen, as was first shown by Dr. F. A. Mahomed.*

* Transactions of the Royal Medico-Chirurgical Soc. of London, vol. lvii., 1874, p. 196.

The color of the urine is different according as it contains more hæmoglobin or methæmoglobin, the former being brighter, the latter darker, brownish-red. Hemorrhages from the larger vessels produce more hæmoglobin; capillary hemorrhages, on the other hand, more methæmoglobin. Heller proposes to account for the difference in the fact that in the hemorrhages which take place from the capillaries in the course of renal diseases, the blood is much more intimately and more slowly commingled with the urine, and therefore longer retained with the urine at the normal temperature of the body. Temperature, the presence of carbonic acid, and the absence of oxygen, may favor the passage of hæmoglobin to methæmoglobin.

Detection of Blood Coloring Matters.

1. *Of small quantities of Hæmoglobin unaccompanied by Albumen.*—Dr. Mahomed (*Op. citat.*) directs as follows:—One end of a small slip of white blotting paper is dipped in the urine and dried over the flame of a spirit lamp; by this means the dilute solution of the crystalloid is concentrated by evaporation; two drops of the tincture of guiacum are then dropped on the paper, and, after a minute or so allowed for the spirit to evaporate, a single drop of ozonic ether* is let fall in the centre of the guiacum stain. A *blue* color appears if hæmoglobin is present. Some time, perhaps a quarter of an hour will elapse before the reaction becomes visible, especially if it be slight; when it appears it is not permanent;

* Ozonic ether may be obtained in this city of L. Wolff, apothecary, N. W. cor. 12th and Chestnut. Both it and the tincture of guiacum should be freshly prepared.

it will begin to fade in a few hours, and will have disappeared in a day or two.

The advantage of this test lies in the fact that the physician can carry a few slips of blotting paper in his pocket-book, dip one in the urine during his visit, allow it to dry and make the test at home.

Dr. Stevenson's modification of Dr. Mahomed's Test, acknowledged by the latter to be far more brilliant, is as follows:—To a drop or two of urine in a small test tube, add one drop of the tincture of guiacum and a few drops of ozonized ether; agitate and allow the ether to collect at the top, forming an upper layer of fluid. If hæmoglobin be present, the ether carries up with it the blue color that is produced, leaving the urine colorless below. In this method the blotting paper, which is somehow the source of fallacy, is not required.

Precautions.—Saliva, nasal mucus, and a salt of iodine (as happens when the patient is taking iodide of potassium) all strike a blue color with tincture of guiacum, some without and some after the addition of ozonic ether.

Application.—By this test, according to Dr. Mahomed, infinitesimal traces of hæmoglobin can be detected in urine, which to the naked eye, the microscope, the spectroscope, and even to the nitric acid test for albumen, affords no indication whatever of abnormality. Indeed the presence of albumen in any quantity interferes with the test, and it is in the *prealbuminuric* stage of scarlatina, or just after it has disappeared and where there is a high state of vascular tension, that it is serviceable. It will respond in chronic albuminuria also, where minute traces of blood are present. Where the response precedes the appearance of albuminuria, it fades

when the albumen becomes copious, and reappears again as it diminishes or after it disappears.

The most useful application of the test, if Dr. Mahomed's views are sustained, will be in the prealbuminuric stage of scarlatina, where it will give us information of a state of affairs in the kidney previous to actual inflammation of the organ, when a brisk purge or copious sweat may avert more serious mischief. In cases of albuminuria produced by intense fever and due to venous congestion, as in enteric fever, pneumonia, and sometimes in the febrile stage of scarlatina, when the fever is intense and the albuminuria only slight, no reaction showing the transudation of the hæmoglobin can be obtained.

2. *Heller's Hæmatin Test* is as follows: Precipitate from urine in a test-tube the earthy phosphates by caustic potash and gentle heat over a flame. The earthy phosphates carry with them as they sink the blood-coloring matters, and appear therefore not white as in normal urine, but *blood-red.* When the quantity of coloring matter in urine is very small the earthy phosphates appear dichroic. If the urine is already alkaline, and no precipitate of earthy phosphate appears on the addition of liquor potassæ and heat, a precipitate can be artificially produced by the addition of one or two drops of the magnesian fluid, which, with the application of heat, carries down the coloring matters, whence it is possible

To Prepare Hæmin Crystals.—If the precipitated earthy phosphates are filtered out and placed on an object-glass, and carefully warmed until the phosphates are completely dry, Teichmann's hæmin crystals can be produced therefrom. For this purpose a minute granule of common salt is carried on the point of a knife to the dried hæmatin and earthy

phosphate, and thoroughly mixed with it. Any excess of salt is then removed, the mixture is covered with a thin glass cover, a hair interposed, and a drop or two of glacial acetic acid allowed to pass under. The slide is then carefully warmed until bubbles begin to make their appearance. After cooling, hæmin crystals can be seen by aid of the microscope, which, though often very small and incompletely crystallized, are easily recognizable by sufficient amplification.

Precautions.—Care must, however, be taken to apply only a gentle heat in precipitating the earthy phosphate with caustic potash solution, and to filter quickly, else the hæmatin may be decomposed.

It sometimes happens also that vesicles develop under the thin glass cover, after the addition of acetic acid, even before heat has been applied. These are carbonic acid which has developed out of the earthy phosphates. These should be allowed to pass away, and then the slide warmed until the formation of vesicles, that is, to the boiling-point of acetic acid.

3. *Test for Hæmatin by Precipitation of Albumen, etc.*—The blood coloring matters in urine may also be demonstrated by coagulating the albumen by boiling, filtering off the brown coagulum, drying and treating it with alcohol containing sulphuric acid. This alcoholic solution contains the hæmatin, and if the alcohol be evaporated, hæmatin crystals can be obtained from the residue in the manner above described.

Occurrence.—Hæmatinuria, that is the direct passage of the coloring matters alone from the blood into the urine, occurs in certain general diseases, as scurvy, purpura, scarlatina, etc. Hæmaturic or bloody urine occurs, of course, from a variety of causes which require no special mention.

b. Uroerythrin.

Heller ascribes the well-known *dark reddish-yellow* or "high" color of all fever urines to the presence of a substance which he calls uroerythrin, as well as to an increase of the normal coloring matters. Except that it contains iron little else that is certain is known with regard to uroerythrin. To it he ascribes the reddish color which so often characterizes the deposits of urates known as "lateritious;" if the supernatant urine in such cases be treated with solution of neutral acetate of lead, the precipitate presents a similar "rosy red" or "flesh color," which he attributes to the same substance. It is doubtless a modified hæmatin, being found especially in diseases where there is evident blood dyscrasia, as in low fevers, septic conditions, etc. It so far at least corresponds with the urohæmatin of Harley that it is a measure of the destruction of the blood-corpuscles, though it will be remembered that the urohæmatin of Harley is looked upon as a normal constituent of urine which may be abnormally increased, while uroerythrin, although a modified hæmatin, is still not considered identical by its discoverer.

Detection.—Uroerythrin is known to be present by its pink coloration of the "lateritious" sediment, or by its precipitation by solution of neutral acetate of lead. Too much lead solution must not be added lest the precipitate be too abundant, and therefore the coloring matter be rendered less distinct by its being disseminated over a large amount of deposit. If the urine contains hæmatin or the coloring matter of blood, it must first be removed.

Precautions.—1. The froth of a urine highly charged with uroerythrin may appear yellow, as that of urine containing biliary coloring matter, but the precipitate of the

latter by acetate of lead is also yellow and not pink as with uroerythrin.

2. The earthy phosphates which are precipitated on heating the urine with caustic potash, are dirty gray when the urine contains uroerythrin, while in urine containing hæmatin they are "blood red" or dichroic. The absence of albumen from the urine, the gray coloration of the earthy phosphates, and the red precipitate with solutions of lead, serve as points in the differential diagnosis between uroerythrin and the coloring matter of the blood.

Clinical Significance.—Uroerythrin is found in the urine in all febrile affections, even the slightest catarrh; especially in pyæmia, diseases of the liver, and lead colic. All urine, according to Heller, which contains uroerythrin must be abnormal.

c. Vegetable Coloring Matters.

The coloring matter of plants, especially chrysophanic acid found in rhubarb and senna leaves, contributes to alkaline urine a reddish-yellow to a deep red color. It can be recognized by the fact that the red alkaline urine by the addition of an acid becomes yellow, and by the addition of an excess of ammonia again takes on the red color.

Precautions. — Such precipitation by heat and potash solution might possibly be taken for blood coloring matters. But the absence of albumen from the urine, the production of the red color by addition of an excess of ammonia, and its paling on the further addition of an excess of acid, serve to distinguish this vegetable coloring matter from blood coloring matter and uroerythrin.

Numerous other vegetable matters color the urine, among which *santonin* is conspicuous for the bright yellow color it

produces in acid urine, while the staining of linen by it closely resembles that of biliary coloring matter. Dr. W. G. Smith (Dub. Quar. Jr. Med. Sci., Nov. 1870) has investigated the subject, and found that the addition of an alkali causes the development of a *fine red cherry or crimson color*, according to the amount of santonin present; but it will be observed that this reaction is that of the vegetable coloring matters generally, as above described.

Madder, gamboge, rhubarb, logwood, carrots, whortleberries, etc., give to urine more or less of their peculiar color.

d. Biliary Coloring Matters.—The Detection of Bile in the Urine.

When bile is abundantly present in urine, the yellow color of the fluid, and especially of the froth or foam produced by shaking, is sufficient to excite suspicion. Further, if a piece of filtering-paper or a piece of linen be moistened with such urine, it retains a permanent yellow color on drying.

The only positive proof of the presence of the coloring matters of bile in the urine is found in Gmelin's or Heller's test for the unaltered coloring matters.

Gmelin's Nitrous Acid Test is performed in two ways :—

First. A quantity of urine is placed in a test-tube, and a small quantity of fuming nitric acid (nitrous acid of commerce) is allowed to pass carefully down the sides of the test-tube to underlie the urine as described in Heller's test for albumen. If biliary coloring matters are present, at the point of union between the urine and the acid will very soon be seen a set of colors which, if typical, should be *green*, *blue*, *violet-red*, and *yellow*, or yellowish-green again in the order named from above downward. Often, however, one or more

colors are wanting. The green is most constant, and the *first* green *indispensable* to prove the presence of bile, but violet shading into red and yellow is also very constantly seen.

Second. Equally satisfactory is the test if a few drops of the urine are placed upon a porcelain plate, and as much of the fuming acid placed adjacent and allowed gradually to approach the urine. The same play of colors occurs.

E. Fleischl (Boston Med. and Surg. Journal, Jan. 13, 1876, from Centralblatt für die Medicinischen Wissenschaften, 1875, No. 34) recommends a modification of Gmelin's test by which it is made more delicate. Instead of having impure nitric acid added in such a way that it will form a separate layer at the bottom, the urine should be thoroughly mixed with pure nitric acid, or still better, with a solution of the nitrate of sodium, and then concentrated sulphuric acid should be carefully added so as to form a separate layer at the bottom. The play of colors forms at the junction of the urine and sulphuric acid. The advantage of this modification is that the pigment is not oxidized so rapidly, and therefore the color is not changed so quickly and is not so liable to be overlooked.

Heller's Test for Bile Pigment.—Pour into a test-tube about 6 c.c. (1.6 f℥) of pure hydrochloric acid, and add to it, drop by drop, just sufficient urine to distinctly color it. The two are mixed and "underlaid" as before with pure nitric acid, and at the point of contact between the mixture and the colorless nitric acid, a handsome play of colors appears. If the "underlaid" nitric acid is now stirred with a glass rod, the set of colors which were superimposed upon one another now appear alongside of each other in the entire mixture, and should be studied by transmitted light. Heller further

says, if the hydrochloric acid on addition of the biliary urine is colored *reddish-yellow*, the coloring matter is *bilirubin;* on the other hand, if it is colored *green* it is biliverdin.

If the amount of coloring matter is very small, a large quantity of urine should be shaken with chloroform; the chloroform allowed to separate at the bottom of the vessel in large drops. The yellow-colored chloroform is then removed by means of a pipette, washed with distilled water, and poured into a beaker-glass containing hydrochloric acid. The yellow drops of chloroform sink to the bottom. If now while diligently shaking the glass, nitric acid is added, the changes of color can be distinctly observed in the chloroform. In consequence of the slower action of the acid upon the coloring matters dissolved in the urine and the consequent slower transition of colors, this method is peculiarly adapted for demonstration.

Precautions.—1. With neither test should too dark-hued a urine be employed, but it should first be diluted with water.

2. Should albumen be present, the opaque zone at the point of contact between the urine and acid imbibing the coloring matters will exhibit a green coloration, and so in no way interfere with the test.

3. Urine *rich in indican* may, however, deceive, forming at the point of contact a blue layer of indigo, which, along with the yellow urine in reflected light, may appear green. In these doubtful cases the chloroform modification of the test should be used, or the urine may be precipitated with solution of acetate of lead, and the filtrate examined for indican.

4. The earthy phosphates, precipitated from biliary urine by liquor potassæ and heat, exhibit a brown coloration.

Test for Decomposed Biliary Coloring Matters.—Should the urine contain only altered biliary coloring matters which respond neither to Gmelin's or Heller's test, it may be tried as follows :—

A piece of white linen or filtering-paper is immersed in the suspected urine, and allowed to dry, when it will appear colored brown. A further confirmation that the decomposed coloring matters are present will be found in a low specific gravity and a dark urophain reaction. If, moreover, the urine be treated with liquor potassæ and heat, to precipitate the earthy phosphates, it becomes darker than before and the phosphates are precipitated brown.

Bile pigments have a property of adhering to precipitates much more powerfully than other pigments, and therefore sometimes cannot be detected in fluid urine when they may be in precipitates. Hence Dr. J. F. Tarchanoff (Centralblatt für die Medicinischen Wissenschaften, 1875, No. 6) recommends, in order to separate with certainty the biliary from the urinary pigments, precipitating the urine with milk of lime, freeing from excess of lime by a current of carbonic acid gas, allowing the whole to stand a few hours, filtering, and washing the precipitate with water. The bile pigments are contained in the precipitate, while the indican, hæmogloben, and methæmogloben are in the filtrate. The precipitate is then dissolved in acetic acid and tested by Gmelin's test.

X. The Biliary Acids.

From a perusal of almost all of the existing text-books on physiology, and even of numerous manuals on the examination of urine, the student is led to suppose that the detection of bile acids, if present in urine, by means of what is called Pettenkofer's test, is one of the easiest possible. On the other hand, nothing is farther from the truth, and the fact is that *such detection by the direct application of the elements of Pettenkofer's test in urine, or any other animal fluid, is practically impossible, even if the bile acids are present in considerable amount.* Nor have any of the modifications of Pettenkofer's test, recently announced as clinically available, proved such in my hands, even where the elements of bile have been added to the urine, except where inspissated ox-bile has been used. The results of a complete investigation of this subject in its practical bearings will be found in a clinical lecture by the writer, in the Philadelphia Medical Times, for July 5, 1873, "On a case of Jaundice, with remarks on the availability of Pettenkofer's Test," to which the student is referred. In these experiments the simplest method of obtaining the biliary acids was found to be as follows: Six or eight ounces (180–240 c. c.) of the suspected urine are evaporated to dryness over a water-bath. The residue thus obtained is treated with an excess of absolute alcohol, filtered, and the filtrate treated with an excess of ether (12 to 24 times its bulk), by which the bile-acids, if present, are precipitated. These are then removed by filtration and re-dissolved in distilled water. The solution is then decolorized by passing through animal charcoal the resulting colorless fluid, tried by Pettenkofer's test as fol-

lows: A single drop of a 20 per cent. solution of cane-sugar (simple syrup of the Pharmacopœia is many times too strong) is then added to a drachm or two (3.7–7.4 c. c.) in a test-tube or porcelain capsule. Sulphuric acid is then added drop by drop, while the test-tube is kept in a vessel of cold water, to prevent too great a rise in temperature, which should not exceed 50°–70° C. (122°–158° F.). As the quantity added approaches a bulk equal to that of the fluid tested, a beautiful *cherry-red*, or *purple-violet* color should make its appearance. So soon as a yellow color makes its appearance, then the sulphuric acid is acting on the sugar, and the cherry-red can no longer be looked for. This carbonizing of the sugar is obviated by keeping the temperature down to the degree mentioned.

Even this method involves more time than is often available to the active practitioner, but there is none more simple, and there is really rarely any necessity for any other than the color test, for the presence of the biliary acids, although undoubtedly occurring, is very rare, and the circumstances under which they occur are illy determined. It is not true, as was once supposed, that they are always present in the urine in cases of *obstruction*, and consequent *reabsorption* of bile, and absent in cases of *suppression*, else would the determination of their presence be of real value in diagnosis. The only circumstances under which they are undoubtedly present in the urine are as *rapidly* destructive diseases of the liver, as acute yellow atrophy, and phosphorus poisoning.

XI. Leucin and Tyrosin.

Leucin and tyrosin, products of a retrograde metamorphosis of nitrogenous substances, are found physiologically only in certain fetid secretions, as those of the axilla and between the toes, but can be produced by chemical means from some glands, as the liver, pancreas, and spleen, where they also occur in certain pathological states. They are found in the urine chiefly, in rapidly destructive diseases of the liver, as acute yellow atrophy, or phosphorus poisoning, but occasionally also in typhus and smallpox. They always accompany a large amount of biliary coloring matter, and the presence of albumen. When at all abundant, as they generally are in acute yellow atrophy, they are deposited from the urine and are found in the sediment, the former in the shape of centrically marked spheres, arranged in warty masses, or druses, the latter in needles. (Fig. 18.)

Schultzen has shown* that in animals poisoned by phosphorus, "urea disappears from the urine, and is replaced by leucin and tyrosin, which in the healthy organism are converted into urea." A similar substitution takes place, in cases of acute atrophy of the liver, the retained urea accounting for the convulsive attacks which usually precede death in these cases.

Detection.—If the crystals, to be more fully described in treating of sediments, do not present themselves in the spontaneous deposit of such cases, the evaporation of a small quantity of the urine will generally promptly display them.

* Boston Medical and Surgical Journal, July 23, 1874, from Zeitschrift für Biologie, viii, 124, and Berliner Wochenschrift, 1872, p. 417.

If they are not sufficiently abundant to be thus demonstrated, the method of Frerichs must be pursued to separate them. A large amount of urine is precipitated with basic acetate of lead, filtered, the excess of lead removed from the filtrate by sulphuretted hydrogen, and the clear fluid evaporated over a water-bath to a small volume. In twenty-four hours tyrosin needles will be found to have crystallized out, but leucin spheres will not appear until later, on account of their greater solubility.*

XII. Urea. CN_2H_4O.

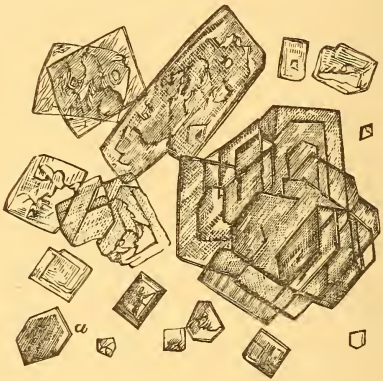
The chief organic constituent of the urine and the index of nitrogenous excretion, the quantity of urea fluctuates with changes in the quantity and composition of ingesta, and with the rapidity of tissue metamorphosis in health and disease. A range of from 20 to 40 grammes (308.6 to 617.2 grains) must at least be admitted in adults.

Detection and Estimation.—The odor of urine highly charged with urea, may be said to be characteristic, but certain evidence of its presence can only be obtained by treating the solution suspected to contain it with nitric or oxalic acid. Though crystallizing itself in glistening needles, it is too soluble to permit of easy detection by its own form. If it be desired to detect its presence in a suspected fluid, a drop or two is placed upon a glass slide, a drop of nitric acid added, the slide carefully warmed over a spirit lamp, and placed aside to crystallize. If urea is present, the micro-

* Leucin and tyrosin are more fully treated by the writer in the American Journal of the Medical Sciences for January, 1872. The above is believed to be sufficient for practical purposes.

scope will reveal singly or in plates six-sided and quadrilateral crystals of nitrate of urea, Fig. 7. The crystals have acute angles measuring about 82°, and are so characteristic as to be easily recognizable; the plates often overlap each other like the shingles of a roof.

FIG. 7. (After Beale.)



Crystals of nitrate of urea.

Solution of oxalic acid produces similar but less regular crystals of oxalate of urea.

In ordinary healthy urine, this crystallization does not take place unless the urine is concentrated by evaporation. But in some urines highly charged with urea, it is simply necessary to add nitric acid to produce the crystals, and thus is arrived at a rough quantitative estimation for urea.

As urea is by far the most abundant solid constituent of the urine, it follows that the specific gravity may become a means of approximately estimating its amount, especially when there is no sugar present, if the quantity of albumen is

small, and that of the chlorides is normal. A specimen of urine, containing neither albumen or sugar, a normal proportion of chlorides, and a specific gravity of 1020–4 to a quantity of 1500 c. c. (50 oz.), in twenty-four hours may be taken as a standard normal specimen containing 2 per cent. to $2\frac{1}{2}$ per cent. of urea. These conditions being observed, a higher specific gravity would indicate an increased proportion of urea, and a lower diminished proportion. Under these circumstances, a specific gravity of 1014 indicates about 1 per cent. of urea, and of 1028 to 1030 about 3 per cent.

But the chlorides fluctuate markedly in some diseases, and by far the largest proportion of urines, in which a knowledge of the amount of urea is important, contain albumen. Next to urea, supposing albumen and sugar absent, the chlorides most affect the specific gravity, being separated to the amount of 10 to 16 grammes (154 to 247 grains), or $\frac{2}{3}$ to 1 per cent. in the 24 hours. If these are totally absent, as they often are in pneumonia and other febrile diseases, characterized by an increase in the elimination of urea, then must a specific gravity of 1020 indicate more than $2\frac{1}{2}$ per cent. of urea, or if the percentage of chloride replaced by urea be added, $3\frac{1}{2}$ per cent. This is supposing, of course, as is the case, that the remaining constituents, uric acid, creatinin, phosphates, sulphates, etc., have little influence on the specific gravity.

If albumen is present in small quantity, not exceeding $\frac{2}{10}$ per cent. as determined by the approximative method given for albumen, it has little effect, and it can be thrown out of the question. If, however, the albumen be more abundant, 1 to 2 per cent., it must first be removed by coagulation and filtration, and the approximate estimation be made from the

specific gravity of the filtrate after cooling. Care must of course be taken to wash the coagulum by further addition of water until the quantity of fluid originally operated with is restored. After such removal of albumen, if not before it, the specific gravity will generally be found diminished, showing what volumetric analysis has determined more precisely, that in chronic albuminuria, at least, the quantity of urea is generally diminished.

Where sugar is present the percentage of urea is also generally less, though with increased specific gravity, while the large total quantity of urine in the twenty-four hours may show an increase in the total urea for the day. There is no way of allowing here for the increased specific gravity due to the presence of sugar, and the only way to arrive at a knowledge of the amount of urea is by volumetric analysis.

Volumetric Analysis for Urea.

Under any circumstances, when an accurate estimation of urea is required, we must have recourse to volumetric analysis. Several methods of volumetric analysis for urea have been suggested, of which that of Liebig, with the nitrate of mercury solution, seems most to combine accuracy and convenience. Davy's method, with the sodium hypochlorite and pure mercury, is, in some respects, more simple, but it is also more liable to error, and really takes more time for its completion, while Liebig's process is carried out with surprising celerity, after even a little experience, not more than fifteen minutes being required to complete it if the solutions are at hand.

Liebig's process is based upon the fact that urea produces an insoluble precipitate with mercuric nitrate.

The following test-solutions are required:

1. *The Baryta Solution*, consisting of one volume of cold saturated solution of barium nitrate, with two volumes of cold saturated solution of caustic baryta (baryum hydrate).

2. A saturated solution of sodium carbonate.

3. *A standard solution of mercuric nitrate* of such strength that 1 c. c. is precisely equivalent to .010 gramme, or 10 milligrammes of urea (.15 grain).

To Prepare the standard Solution of Mercuric Nitrate. 1. Dissolve about 75 grammes (1157.25 grs.) of pure mercury in pure boiling nitric acid. The acid fluid is concentrated by evaporating over a water-bath to a syrupy consistence, and then diluted to the volume of a litre (2.1 pints) of distilled water. Unless a great excess of acid remains after evaporation, a white precipitate of basic nitrate of mercury will fall, which must be removed by filtration; previously, however, a few drops of nitric acid should be added which will dissolve the greater part of the precipitate without making the solution too acid. The solution requires to be graduated by

2. *The standard Solution of Urea.* Two grammes (30.86 grs.) of pure urea should now be dissolved in 100 c. c. (27 f3) of distilled water, of which 10 c. c. (2.7 f3) will then contain 0.2 gramme (3.08 grs.) or 200 milligrammes.

Ten c. c. of this standard solution containing 200 milligrammes of urea are now placed in a beaker-glass. A burette is then filled to 0 with the solution of mercuric nitrate (taking care that the lower edge of the meniscus which forms the upper surface of the liquid corresponds with the arrow on the burette), which is then allowed to drop into the beaker, where it will quickly form a dense precipitate. When the precipitation seems nearly complete, a drop of the fluid containing it is allowed to fall on a drop of the solution of sodium carbonate of which several are previously ready on a piece of glass on a dark ground. If the urea is not completely precipitated, no change of color takes place. The cautious addition of the

mercuric nitrate is continued, and the process of testing with the Na_2CO_3, until finally a yellow color appears. This proves that the mercuric nitrate has been added in excess,—consumed all the urea in combination and left some mercuric nitrate to react with the sodic carbonate, which it does by forming sodic nitrate and the yellow oxide of mercury.

The number of cubic centimetres consumed in reaching the point as read off on the burette, indicates the quantity of mercuric nitrate which is equivalent to 200 milligrammes of urea. Whence it is easy to calculate how much further the solution should be diluted to make 10 c. c. = 100 milligrammes of urea or 1 c. c. = .010 gramme (10 milligrammes).

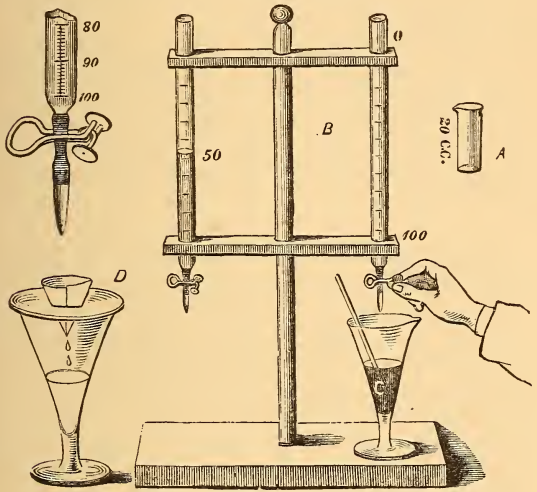
Thus suppose that 17.3 c. c. (4.67 f℥) of the solution of mercuric nitrate are required to precipitate the .200 gramme of urea; then if 2.7 c. c. (.73 f℥) water are added to this quantity, we will have 20 c. c. = .200 gramme or 10 c. c. = .100 gramme or 1 c. c. = .010 gramme or 10 milligrammes as required.

It is scarcely necessary to say that the quantity (75 gms.) of mercury originally taken is selected, because it is known that that amount treated as above and diluted to a litre will give very nearly the proportion required.

Process.—Take 40 c. c. (10.8 f℥) urine and 20 c. c. (5.4 f℥) of the baryta solution, and throw them into a beaker-glass. By this means the phosphates, sulphates, and carbonates are precipitated. They are removed by filtration through a *dry* filter, and if the filtrate happen not to be quite clear, it may be passed through a second time. While this is taking place, the burette is filled to 0 with the mercuric nitric solution, and 15 c. c. (4.05 f℥) of the filtrate from the mixed baryta fluid and urine, containing of course 10 c. c. (2.7 f℥) of pure urine, are measured off into a small beaker-glass. Into this the mercuric nitrate solution is allowed to fall from the burette, first, a number of cubic

centimetres approaching the last two figures of the specific gravity (that is, if the specific gravity is 1017, drop say 15 c. c.) before testing with the soda solution. If no yel-

Fig. 8. (After Harley.)



low coloration appears, then proceed cautiously, a cubic centimetre or two at a time, testing with the Na_2CO_3 until the yellow coloration is struck. When that point is reached, read off the number of cubic centimetres employed.* The

* The tinge of yellow at which we cease the titration must of course be the same as that at which in originally testing the nitrate of mercury solution the titration was stopped. It is evident that ceasing the titration now at a slight tinge, and again at a marked yellow coloration, must give rise to an error, which practice will soon teach the student to avoid.

number of cubic centimetres of mercury solution thus used, minus 2, multiplied by .010 gramme, gives the amount of urea in fractions of a gramme contained in 10 c. c. (2.7 f℥) of the urine, when the latter is of average composition,—that is, when it contains no abnormal constituent, and the amount of chlorides is nearly normal.

The two cubic centimetres are first subtracted because it takes about this quantity to decompose the chlorides which first form a *soluble* precipitate with the mercuric nitrate, and until they are all thrown down, the combination with the urea does not begin. Hence this amount must first be subtracted.

If, however, the chlorides are not of average amount, but diminished or increased, and we wish to be accurate, we must first estimate the amount of chlorides calculated as NaCl in 10 c. c. of the urine, by the process to be explained under chlorides, and from a fresh quantity of urine remove the whole of the chlorides by a standard solution of silver nitrate. For this purpose a solution of nitrate of silver is required of such strength that 1 c.c. will precipitate 10 milligrammes sodium chloride. 29.075 grammes (448.62 grs.) of fused nitrate of silver, dissolved in distilled water, and diluted to a litre, will be such a fluid.

In 10 c. c. (2.7 f℥) of the original urine we determine with the nitrate of silver solution the chloride of sodium by the method for the determination of the chlorides, p. 96. Suppose there are required for this 17.5 c. c. of the silver solution, this indicates 175 milligrammes sodium chloride.

Take now 30 c. c. (containing 20 c. c. of urine) of the filtrate from the mixture of baryta fluid and urine, add a drop of nitric acid, and then 17.5×2 c. c. $= 35$ c. c. of the nitrate of silver solution. This will precipitate all the chlorides, which should be removed by filtration, and the filtrate may be now estimated for urea. It is important always to bear in mind the exact amount of urine operated with after adding the nitrate of silver

solution to a mixture of baryta solution and urine, of which only two-thirds are urine. Thus if 35 c. c. of the silver solution are added to 30 c. c. of the filtered mixture of urine and baryta fluid, of the resulting 65 c. c., only 20 would be urine minus the chlorine, or out of 32.5 c. c., 10 would be urine minus the chlorine.

If the case be one of inflammation, as pneumonia, where there is a total or almost total absence of chlorides, they may be thrown out of the question altogether.

Further correction.—If the number of cubic centimetres of mercury solution added to 15 c. c. of the mixture of urine and baryta fluid exceeds 30—that is, if the amount of urea exceeds 2 per cent.—we must for the number of c. c. of the mercurial solution above 30 add half the number of c. c. of water before testing with carbonate of sodium.

If the urine contains less than 2 per cent of urea, for every 5 c. c. of the test solution used below 30, there should be deducted .1 c. c. from the entire number of cubic centimetres of the mercurial solution used.

For the reasons for these corrections the student is referred to the larger works, as Neubauer and Vogel or Thudicum.

Estimation of Urea by the Hypobromite Process.—The principle on which this process is based—that urea, when brought into contact with hypochlorite of calcium, is decomposed into nitrogen, carbonic anhydride, and water—was suggested many years ago by Davy. Recently Messrs. Russell and West* have again directed attention to the subject, substituting a solution of hypobromite of sodium and caustic soda, which yields similar products; the carbonic anhydride being absorbed by the caustic alkali. The following is the reaction :—

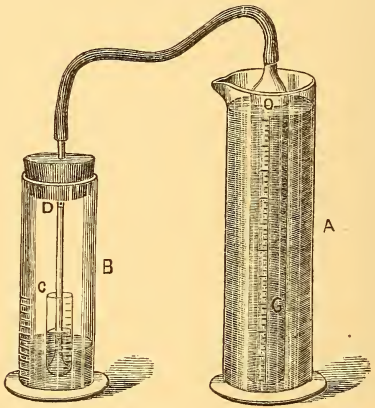
$$CON_2H_4 + 3(NaBrO) = 3(NaBr) + CO_2 + 2H_2O + N_2.$$

* Journal of the Chemical Soc. (London), August, 1874.

The volume of nitrogen disengaged being the measure of the urea.

Many forms of apparatus have been suggested by different experimenters, all based upon the principle that operating with 0.15 grm. of urea, the barometer being at 30 and the thermometer at 60° F. (15.5° C.), the volume of nitrogen disengaged was found to be 55 c. c., or 10 c. of gas corresponded to .0027 grm. urea.

FIG. 9.



The simplest apparatus would seem to be that of Dr. G. Noel, figured in the text and first described in the *Répertoire de Pharmacie** (1877, No. 22). It consists, 1st, of a mixing vessel, B, graduated into cubic centimetres, and a small receiver, C, similarly graduated (this graduation is not absolutely necessary, as the test fluid and urine may both be measured by a volume pipette before being intro-

* Also figured and described in *New Remedies*, March, 1878.

duced). The receiver C is provided with a central open tube, ending at D, the chief use of which is to retain it in an upright position. 2d, of a taller vessel, A, to contain water, into which is immersed an elongated bell-glass or burette, graduated in cubic centimetres. To the pointed open end of this a piece of rubber tubing is attached, connecting it with the glass tube passing through the rubber stopper of the mixing tube B.

The alkaline hypobromite solution used is made by dissolving 100 grms. of caustic soda in 250 c. c. of water, and adding 25 c. c. of bromine to the solution thus produced.

$$2NaHO + Br_2 = NaBr + H_2O + NaBrO.$$

Process.—Introduce into the receiver C, 5 c. c. urine, and into the mixing vessel 15 c. c. of the hypobromite solution, being careful not to mix the two fluids. Depress the graduated tube into the vessel A, until the zero mark coincides entirely with the surface of the water, and connect the end of the tube by means of the rubber tube with the tube perforating the stopper of the mixing vessel B, which is now *accurately* closed. The mixing tube is then inclined so as to allow the urine to mix with the hypobromite solution. Effervescence immediately sets in, and as it proceeds, the measuring tube is gradually raised to relieve the disengaged nitrogen of the hydrostatic pressure. The mixing vessel is then shaken a few times, and when the reaction appears complete, the apparatus is left for a few minutes until it has acquired the temperature of the room in which the operation has been performed. The water within and without the tube is again levelled and the cubic centimetres displaced by the gas read off. Thus suppose 10 cubic centimetres have been read off. Then 5 c. c. urine contain $.0027 \times 10 = .027$ grm.; whence can be calculated either the percentage or the 24 hours' quantity.

In experiments made by Messrs. West and Russell, Mr. Richard Apjohn, Dr. Dupré, Dr. M. Simpson, Mr. C.

O'Keefe and others with solutions containing known quantities of urea, astonishingly accurate results were obtained, quite sufficiently so for clinical purposes.

M. Depaine (*Journ. de Pharm. d'Auv.*, 1877) recommends to deduct 4.5 per cent. from the total amount of urea found, to eliminate the error caused by the simultaneous decomposition of uric acid and creatinin.

XIII. Uric Acid. $C_{10}H_4N_4O_6$.

When uric acid is spoken of as a constituent of normal urine, it is never to its free state that allusion is made, but to its combinations chiefly with potash, soda, and ammonia, but also with lime and magnesia, usually known as mixed urates. Uric acid itself is so extremely insoluble (one part requiring 14,000 of cold and 1800 of hot water to dissolve it) that it is immediately precipitated on being freed of its bases. In quantity it is found ranging .4 to .8 gramme (6.17 to 12.34 grs.) in the twenty-four hours, in health varying *pari passu* with urea of which it is a stage short in oxidation.

Detection by the Microscope.—Its presence as such is recognized by the microscopic characters of its crystals, which in their typical form may be said to be "lozenge-shaped," or as best described by the Germans, "whetstone-shaped." They are, moreover, always colored yellowish-red or red, being with their salts the only urinary deposits thus stained, so that when a sediment is seen of which the elements are thus colored, it may, without hesitation, be put down as composed of uric acid or its combinations. More will be said of these crystals in treating of sediments, where their discussion more properly belongs.

The Murexid Test.—The murexid test for uric acid and its combinations is one of extreme beauty. A small portion of sediment, or the residue after evaporation, is placed on a porcelain plate or piece of platinum, a drop or two of nitric acid added to dissolve it, and then carefully evaporated over a spirit-lamp flame. When dry, a drop or two of liquor ammonia is added, when there promptly appears a beautiful purple color, which will gradually diffuse itself as the ammonia spreads. The murexid reaction is believed to depend upon the origin of alloxan, alloxantin, and ammonia, under the action of the hot nitric acid. This reaction is also said to occur with tyrosin, hypoxanthin, and xanthoglobulin, and Schiff accordingly recommends the

Carbonate of Silver Test for Uric Acid.—This is very delicate, and is most conveniently applied as recommended by Harley. Dissolve a little uric acid in a solution of sodium or potassium carbonate, place a drop or two of the solution on paper, and add a solution of nitrate of silver. A distinct gray stain promptly occurring indicates the presence of uric acid.

Neither of the tests, however, discriminates between uric acid and urates. The microscope alone can do this.

Quantitative Estimation of Uric Acid.—To 200 c. c. (54 f℥) add 20 c. c. (5.4 f℥) of hydrochloric or nitric acid, and set aside in a cool place, as a cellar, for twenty-four hours. At the end of that time the uric acid crystals, highly colored, will be found adhering to the sides and at the bottom of the beaker. Collect the uric acid on a weighed filter, wash thoroughly with distilled water. Dry the filter and uric acid at a temperature of 100° C. (212° F.), weigh, and the weight of the two, minus the weight of the filter, will be the weight of the uric acid in 200 c. c., except the

small portion retained in the acid and washings. Neubauer advises to add to the result 0.0038 gramme uric acid for every 100 c. c. of these fluids.

XIV. Urates.

It has already been said that in health, practically all the uric acid of the urine is held in combination with potash, ammonia, soda, lime, and magnesia, of which those with potash and ammonia are most abundant according to Bence Jones. These are very soluble compounds at the temperature of the body, but are precipated in amorphous granules when the temperature of the urine is lowered, as in winter weather.

Their physiological and pathological significance depends altogether upon the uric acid they contain, but there are some points of reaction with which the student should be quite familiar. These grow out of the fact that uric acid is a bibasic acid, forming neutral and acid salts, and that *the acid salts are much less soluble than the neutral*, requiring 124 parts of boiling and 1120 parts of cold water for their solution. They form, therefore, the bulk of urate deposits, while urates, which remain in solution after such reduction of temperature as constantly takes place in an apartment, must be, if not neutral, at least less acid than those which form the sediment. And a solution remaining for some time clear under such circumstances, must contain urates of soda, etc., with a large proportion of the alkaline base.

The practical application of this fact is seen in this, that when an acid is added to such solution of neutral urate, by seizing upon a portion of the base, it leaves an *acid* urate of

soda, which, in consequence of its relative insolubility, is promptly precipitated in a finely *granular* form, producing a decided opacity. Now, this is precisely what often happens in the nitric acid test for albumen. The urine is highly charged with neutral urates which are held in solution. Nitric acid is added, and down goes a precipitate, not crystalline, but *amorphous*, which is composed of acid urate of soda. And if Heller's method is followed, an opaque zone is formed at the point of contact between the acid and urine, which may be mistaken for albumen, but which, besides presenting certain visual characters of its own, which have been described, p. 34, is readily soluble by heat. If urine presenting this reaction with acid be allowed to stand for some time, the milky opacity gradually passes away, and is substituted by a very small crystalline sediment of uric acid. By longer action of the acid, the remainder of the base is entirely withdrawn, leaving the free acid, which is deposited in crystals. It has already been stated that this precipitate by nitric acid is considered by Thudicum to be not acid urates but *hydrated uric acid.*

The remaining organic constituents of the urine, creatinin, creatin, xanthin, hippuric acid, oxalic acid, lactic acid, and phenylic acid, having little practical significance as such, require only to be mentioned in this connection.

Mucus and the crystalline combination of *oxalic acid* with lime will be further considered in treating of sediments.

Hippuric acid is interesting in forming one of the most striking connecting links between the urine of carnivora, omnivora, and herbivora, replacing in the last the uric acid of the first, while in man, who consumes a mixed diet, we have both uric acid and hippuric, that is, an intermediate state. But while hippuric acid is increased in man by a

vegetable diet, yet it is not wholly absent with animal food. It is increased in diabetes, where also it almost replaces uric acid. If 10 grains benzoic acid be taken in the evening, the next morning crystals of hippuric acid will usually be found in the urine. The typical form of these is a four-sided prism, with two or four bevelled surfaces at its ends, but from this there are deviations. In the twenty-four hours' urine of man, .5 to 1 gramme (7.7 to 15.4 grs.) are separated.

Inorganic Constituents.

XV. The Chlorides.

The chlorides found in the urine are chiefly those of sodium, with a small proportion of chloride of potassium and ammonium.

In health the chlorides are almost an exact measure of the same substances taken in with the food, and amount to 10–16 grammes (154.3 to 246.8 grs.) in the 24 hours.

Detection and approximate Estimation.—If a drop of urine be slowly evaporated on a glass slide, characteristic octahedral crystals and rhombic plates of a combination of urea and chlorine make their appearance, and may be examined by the microscope. But more available for detection and approximate estimation is

The Nitrate of Silver Test.—Nitrate of silver in solution throws down both the phosphates and chlorides from the urine. But if a few drops of nitric acid be first added, the phosphates will be held in solution, and only the chlorides will fall as opaque white chloride of silver.

From normal urine containing $\frac{1}{2}$ to 1 per cent. of chlorides,

they are precipitated by a *single* drop of a solution of nitrate of silver, 1 part to 8, in cheesy lumps, which do not further divide themselves, or make the urine more milky by moving the glass about. *If, however, the chlorides* are *diminished* to $\frac{1}{10}$ per cent. or less, the addition of a single drop of the silver solution no longer produces the white cheesy lumps, but a simple cloudiness, and the entire fluid appears equally milky. If, finally, there should be no precipitate whatever, then the chlorides are totally absent.

The presence of albumen in moderate amount does not interfere with the test, but if abundant, it must be removed.

Clinical Significance.—The chlorides are diminished in all febrile conditions, whether of local or general origin. Especially is this the case where there are any exudations, solid or fluid, by which they seem to be eliminated. In acute pneumonia, where they are often totally absent from the urine, they appear abundantly in the saliva. In this affection, and indeed, in all acute diseases, their disappearance from the urine indicates an increment in the disease, and their reappearance an improvement. In pneumonia a decline in the disease may often be detected through their return before physical or any other signs point to improvement. Hence a daily trial of the urine for them becomes important.

Volumetric Process for the Chlorides.

The volumetric process employed may be that of Liebig with solution of mercuric nitrate, or Mohr's, with silver nitrate.

Mohr's nitrate of silver method is preferred by Neubauer,*

* Neubauer and Vogel, Analyse des Harns, vi. Aufl., 1872, p. 169.

because Liebig's method, if not very exactly carried out, gives incorrect results. There are required :—

1. A cold saturated solution of neutral chromate of potash.

2. A solution of nitrate of silver, such that 1 c. c. = 10 milligrammes NaCl. This is made by dissolving 29.075 grammes (448.62 grs.) pure fused nitrate of silver in distilled water, and diluting to a litre.

Process.—Put 10 c. c. (2.7 f℥) of the urine in a platinum crucible, dissolve in it 1 or 2 grammes (15.43 or 30.86 grs.) potassium nitrate, free from chlorides, and evaporate the whole slowly to dryness. Expose the remainder first to a gentle and afterwards to a strong heat until the carbon is completely oxidized, and the residue a white molten saline mass. The entire white mass is then dissolved in a little water, placed in a beaker-glass, the platinum capsule washed off into it with the wash-bottle. Dilute nitric acid is then carefully dropped into the alkaline fluid until it is faintly acid, a small pinch of calcium carbonate is then introduced to make it neutral, and the excess of lime filtered off. To the mixture, 2 or 3 drops of the potassium chromate solution are now added, and the silver solution allowed to flow in from the burette while stirring the mixture, until a distinct red color remains. The color continues canary-yellow until all the chlorides are decomposed. As each drop falls into the urine, it must be carefully watched for the least tinge of red surrounding the precipitate of chloride of silver; the very next drop after the complete decomposition of the chlorides gives a permanent red color, due to the presence of silver chromate. The number of cubic centimetres consumed $\times .010$ grm. will give the amount of chlorides, estimated as NaCl, in 10 c. c. urine, whence the total is calculated.

XVI. Phosphates.

The phosphates of the urine are composed partly of *earthy* and partly of *alkaline* phosphates. The former are insoluble in water, but soluble in acids; they are held in solution in acid urine by free carbonic acid, and precipitable from it by alkalies. The *alkaline* phosphates are soluble in water, and not precipitated from solution by alkalies.

(a) The *earthy phosphates* are phosphates of lime and magnesia, and are contained in urine in but small quantities —1 to 1.5 gramme (15.43 to 23.14 grains) in twenty-four hours.

Detection and Approximate Estimation.—The presence of the earthy phosphates is shown by adding any alkali as caustic ammonia or potash.

Their quantity may be *approximately* estimated in the following simple way, given by Hoffmann and Ultzmann. A test-tube, 16 centimetres (6.2992 inches) long and 2 centimetres (.787 inch) wide, is filled *one-third* with clear or filtered urine, to which a few drops of caustic ammonia or caustic potash solution are added and warmed gently over a spirit-lamp until the earthy phosphates begin to separate in flakes. It is then placed aside for ten or fifteen minutes for them to subside. If the layer of sediment is one centimetre (.3937 inch) high, the earthy phosphates are present in normal amount; if they occupy 2 to 3 centimetres (.787 to 1.181 inch), they are increased; if, on the other hand, only a few flakes are visible, the earthy phosphates are diminished.

Further, in normal urine the earthy phosphates are precipitated white, but if the urine contains abnormal coloring matter, they fall variously colored. If the urine

contains blood coloring matter, the earthy phosphates appear blood-red or dicroic; if there be present vegetable coloring matters, as of rhubarb, senna, etc., they are colored rosy-red to blood-red, and by the biliary coloring matters yellowish-brown, and by uroerythrin, gray.

The earthy phosphates are deposited from alkaline urine, and a most important precaution here must be observed not to mistake such a *deposit* for an excess of phosphates. The phosphates may really be *diminished*, and yet, in consequence of the reaction of the urine, a copious *deposit* may be present. The possible *precipitation of earthy phosphates by heat alone* as a source of error in testing for albumen, has already been alluded to. This frequently occurs, and is best explained on the supposition of Dr. Brett, that the earthy phosphates are held in solution in urine by carbonic acid, which, being dissipated by heat, allows the phosphates to fall. It should be further stated, however, that Dr. Owen Rees believes the phosphates are held in solution of ammonium chloride, which would also be dissipated by heat. Dr. Bence Jones attributed this precipitation to a neutralization of the excess of free acid in the urine by an alkali or free sodium phosphate.

Clinical Significance.—The earthy phosphates are increased in the urine by diseases of the bones, especially if extensive, as in osteomalacia and rickets, in chronic rheumatoid arthritis, in diseases of the nerve-centres, and after great mental strain; but especially are the earthy phosphates increased by the food and drink, some contending that all variations in the earthy phosphates are due to this cause. In renal diseases, on the other hand, the phosphates are diminished. Earthy phosphates are often found deposited

in conditions of dyspepsia and over-work, but this may generally be traced to changes in the reaction of the urine.

(b) *The alkaline phosphates*, soluble in water and not precipitated by ammonia or alkalies, form the chief bulk of the phosphates, averaging, according to Breed, 4 grammes (61.72 grains) in the twenty-four hours, though Neubauer, by volumetric analysis, has seldom found more than two grammes (30.86 grains) in this period. Four grammes correspond to two grammes phosphoric acid. They are almost wholly made up of *acid sodium phosphate*, with possible traces of potassium phosphate. The acid sodium phosphate was believed by Liebig to be the cause of the acid reaction of the urine.

Approximate Estimation of Alkaline Phosphates.—Accurately to estimate the alkaline phosphates, it would be necessary, first, to remove the earthy phosphates, which may easily be done by precipitating them with ammonia and filtering out. For approximate estimation, however, this is not necessary, since they are in the first place present in comparatively small quantity, and, secondly, do not vary much in disease. Practically, therefore, they are disregarded, and to a suitable quantity of urine placed in a beaker-glass about *one-third* as much of the magnesian fluid (p. 16) is added. *All* of the phosphates are thrown down in the shape of a snow-white deposit composed chiefly of ammonio-magnesian phosphate and amorphous phosphate of lime. If the entire fluid present a *milk-like cloudy appearance*, the alkaline phosphates may be considered present in normal amount; if it is denser, more cream-like, there is an increase. If, on the other hand, the fluid is but slightly cloudy, transmitting light distinctly, the phosphates are diminished.

Nitrate of Silver Test.—A solution of nitrate of silver

added to urine throws down a yellow precipitate of phosphate of silver, and chloride of silver. Both are soluble in *ammonia*, the silver phosphate also in nitric acid, but not the chloride. If, therefore, a few drops of ammonia be added, they will promptly disappear. If now nitric acid, just sufficient to neutralize the ammonia, be added, the precipitate will again reappear; but the moment the nitric acid is present in excess, the silver phosphate is redissolved, but the chloride remains in suspension. If now enough ammonia be added again to neutralize the nitric acid, the phosphate of silver will again fall; but if an excess be added, the entire precipitate, including the chlorides, will be redissolved.

Clinical Significance.—The alkaline phosphates in the urine are influenced chiefly by the food, whence they are mainly derived; phosphorus is also oxidized in the economy, and a small part of the phosphates is doubtless derived from the disintegration of nervous and muscular tissues. Any increased activity of vital processes, as inflammations and fevers, would, therefore, favor their increase.

Volumetric Process for Phosphoric Acid.

This process is based upon the facts that—

1. When a solution of phosphate acidulated with acetic acid is treated with a solution of nitrate or acetate of uranium, a *precipitate* falls which is composed of uranium phosphate.

2. When a *soluble* salt of uranium is added to a solution of potassium ferrocyanide, a reddish-brown precipitate or color is developed.

The solutions required are—

1. A standard solution of sodium phosphate, made by dis-

solving 10.085 grammes (155.60 grs.) of well-crystallized sodium phosphate ($Na_2HPO_4+12H_2O$) in distilled water, and diluted to a litre (33.8 f℥); 50 c. c. (13.5 f℥) then contain .1 gramme (1.54 grs.) P_2O_5.

2. Saturated solution of potassium ferrocyanide.

3. Sodium acetate solution, made by dissolving 100 grammes (1543 grains) sodium acetate in 100 c. c. (27 f℥) pure acetic acid, and diluting with distilled water to 1000 c. c. (33.8 f℥).

4. Solution of uranium acetate, such that 1 c. c. will correspond to .005 gramme or 5 milligrammes phosphoric acid.

To Prepare the Uranium Acetic Solution. — Dissolve 20.3 grammes (313.2 grs.) of yellow uranic oxide in strong acetic acid previously diluted with distilled water to nearly a litre. To determine the strength of this solution, place 50 c. c. (13.5 oz.) of the standard solution of sodium phosphate in a beaker with 5 c. c. (1.35 f℥) of the solution of sodium acetate and heat in a water-bath to 90° to 100° C. (194° to 212° F.). The uranium solution is then allowed to run from a burette into the warm mixture until precipitation ceases. Then a drop of the mixture is carried by a glass rod into contact with a drop of the ferrocyanide of potassium solution on a white plate, or to a piece of the filtering-paper impregnated with it. If the reddish-brown of the uranium ferrocyanide does not appear, continue the cautious addition of the uranium solution until the color responds to the test. The quantity used is then read off, being that which is sufficient to decompose sodium phosphate corresponding to .1 gramme (1.54 grs.) of P_2O_5, whence is calculated the amount of distilled water to be added to make 1 c. c. correspond to .005 gramme (.077 grain) of phosphoric acid.

Process.—Take 50 c. c. (13.5 f℥) of urine; add 5 c. c. (1.35 f℥) of the sodium acetate solution, and warm in a water-bath as above. Fill the burette with the uranium

solution, and drop it into the mixture while warm, testing with the ferrocyanide solution. The number of cubic centimetres used multiplied by .005 will give the phosphoric acid in the 50 c. c. of urine, whence calculate the quantity for the twenty-four hours.

XVII. Sulphates.

The sulphates found in the urine are those of soda and potash, the former preponderating. The quantity in twenty-four hours is 3 to 4 grammes (46.29 to 61.72 grains) corresponding to 2 grammes (30.86 grains) sulphuric acid.

Detection and Approximate Estimation.—This is simple with any of the barium compounds which throw down a white precipitate of barium sulphate. A little acid, as hydrochloric, should previously be added, in order to hold in solution the barium *phosphate*, which is otherwise thrown down, or the acid may be previously added to a solution of barium chloride.

If to a small quantity of urine in a beaker-glass, one-third as much of the acidulated solution of barium chloride (1 part to 8 plus $\frac{1}{2}$ a part hydrochloric acid) is added, and there occurs an *opaque* milky cloudiness, the proportion of sulphates is normal; if the opacity is intense, and the whole mixture has the appearance and consistence of cream, the sulphates are increased; if, on the other hand, there is only a slight cloudiness, so that light is still transmitted, the sulphates are diminished.

Clinical Significance.—The sulphates are derived partly from the food and partly from the tissues, are increased by the introduction of sulphur compounds, sulphuric acid and its soluble combinations, by an animal food, and by any

causes producing increased rapidity of tissue change, as active exercise, the introduction of oxygen, febrile movements, and fevers. The greatest increase has been observed in meningitis, cerebritis, rheumatism, and affections of the muscular system. They are diminished in an exclusively vegetable diet.

The Volumetric Process for Sulphuric Acid.

This depends upon the principle that a solution of chloride of barium will throw down a precipitate from a given quantity of urine, so long as any sulphuric acid is present; and further, that in thus treating a specimen of urine acidulated with HCl, a neutral point is reached at which the filtrate will show a slight opacity as well with the sulphuric acid, as with the barium chloride solution. In such a fluid we are to suppose potassium chloride, barium chloride, and potassium sulphate, balancing each other. If now either barium chloride or potassium sulphate are added, it itself is decomposed, and barium sulphate precipitated.

The solutions required are—

1. Solution of barium chloride so concentrated that 1 c. c. will precipitate exactly 12.25 milligrammes H_2SO_4, or 10 milligrames SO_3 prepared by dissolving 30.5 grammes (470.6 grs.) dry crystallized chloride of barium, and diluting to a litre (33.8 f℥).

2. Solution of potassium sulphate such that 1 c. c. = 12.25 milligrammes H_2SO_4; or 10 milligrammes SO_3 prepared by dissolving 21.775 grammes (336.03 grs.) chemically pure powdered potassium sulphate, dried at 100° C. (212° F.), and diluting to a litre (33.8 f℥).

Process.—Place 100 c. c. (27 f℥) urine, acidulated with

20 to 30 drops hydrochloric acid, and heat it in a water-bath. When boiling, allow 5–8 c. c. of the barium solution to flow in from a burette. Remove the heat and allow the precipitate to subside. If the fluid becomes rapidly clear, allow another cubic centimetre or two of the barium solution to flow in, reapply the heat, and filter 10 to 12 drops of the urine into a small test-tube, add some of the barium solution, and observe whether there is a precipitate or not. If not, add to another portion a few drops of the potassium sulphate solution, by which we learn whether an excess of the barium solution has been added or not. If, however, the barium solution still produces a precipitate in the portion removed for testing, the latter is returned to the beaker, and more solution allowed to fall in, determining the quantity somewhat by the intensity of the reaction in the test-tube, and the process repeated until no precipitation takes place with the barium, and until a *slight* cloudiness takes place when adding the potassium sulphate to a portion of the filtered mixture. If the latter is an intense reaction, say at 12 c. c., then we know that the correct point is somewhere between 11 and 12, and the process is repeated as far as 11 c. c., when it is continued very cautiously, adding only fractions—$\frac{1}{10}$ths of a centimetre—until the right point is reached, whence the calculation is made as before.

URINARY DEPOSITS.

It has already been said that strictly normal freshly passed urine, of *acid* reaction, contains no sediment whatever, except the faint flocculi of mucus which gradually subside towards the bottom, and entangle a few mucus-corpuscles and an occasional epithelial cell. Should the urine, however, be alkaline, as is frequently the case three to four hours after a meal, it may be more or less cloudy at the moment it is passed, and quickly deposit a flocculent precipitate of *earthy* phosphates, which may occupy considerable bulk. They will be found by microscopic examination to be made up of amorphous granules, and will quickly disappear on the addition of a few drops of any acid.

But even urine which is strictly normal will, in the course of time, form deposits as the result of different reactions. These deposits differ with the stages of such reaction, and should be perfectly understood by the student before he is ready to interpret any sediment arising from other causes.

1. After normal urine, completely without sediment, has stood for a time, especially at a moderate temperature, there is often observed a precipitate of amorphous granular matter, readily soluble by heat, which is made up of acid urates of potash, soda, and ammonia, with which urates of lime and magnesia are occasionally commingled. (See lower portion of Fig. 10.) A little later they are replaced by rhombic crystals of uric acid, stained yellowish or yellowish-

red. These are often associated with octahedral crystals of the oxalate of lime.

The explanation given by Scherer of the occurrence of these deposits, is that of the so-called *acid* fermentation, in which, through the agency of the mucus of the bladder, acting as a ferment, are formed *lactic* and *acetic* acids out the coloring matters. These take away a part of the base from the neutral or alkaline urates, and produce first the more insoluble acid urates named above, which are deposited ; later they combine with the remainder of the base also, and leave the crystalline uric acid sediment.

As though favoring this so-called acid fermentation, there are also often found at this stage in urine, spores of *torula cerevisiæ*—the yeast fungus—small, oval, transparent, structureless cells, to be again referred to. Further, sufficient proof that such fermentation takes place is, however, wanting.

A much more satisfactory explanation of the occurrence of these deposits, has been offered by Voit and Hoffman,* who attribute the decomposition of the basic urates to the acid phosphate of soda, the excess of phosphoric acid playing the part of the acetic and lactic acid in the fermentation theory, and decomposing the alkaline urates in the same way and with the same results. They prove their position by an artificial production of the same results, by adding a solution of acid phosphate of soda to a solution of basic urates. The extent to which the reaction goes will depend upon the quantity of acid phosphate of soda present, and the length of time which has been permitted for the reaction to take place. It is possible also for the latter to begin at

* Neubauer and Vogel, Analyse des Harns, vi Aufl., 1872, p. 113, from Zeitschrift für Analyt. Chemie, Bd. 7, p. 397.

the moment of secretion, and to continue in the bladder, causing deposits of acid urates and uric acid to appear as "gravel" or "sand" immediately after the urine is passed. Such a condition would be pathological. According to these authors, a more rapid action of the acid sodium phosphate produces an amorphous precipitate, and a slower separates the crystalline uric acid. The more rapid reaction may be induced by a more abundant separation of the acid sodium phosphate or a greater concentration of the urine.

In the course of these changes, also, the acidity of the urine is diminished, and it may become neutral and even alkaline before the phenomena of the next stage to be described—the alkaline fermentation—set in.

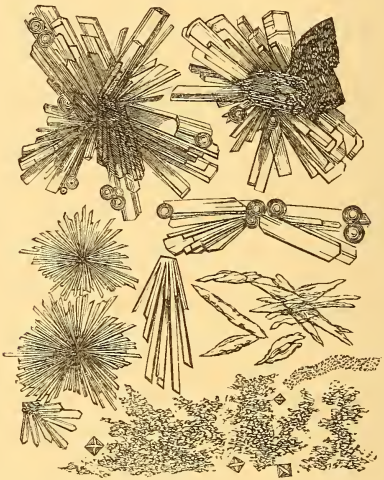
2. After a still longer but variable period, which is shorter in warm weather and longer in cold, we have the so-called *alkaline fermentation*, which is a real fermentation. This, in which decomposing mucus is also thought by some to be the ferment, is ascribed by Tieghem* to the action of a little torula, structureless, and without a cell-wall, which multiplies by budding, not at the surface but within the urine or at the bottom of the vessel, where it with the deposited salts forms a white sediment. In this fermentation we have the urea converted into carbonate of ammonia, as already explained, by the addition of two equivalents of water.† As

* Neubauer and Vogel, Analyse des Harns, vi Auflage, 1872, pp. 110 and 130.

† An explanation of the delay which sometimes occurs in the appearance of these phenomena is based on the recognition of the multiplication of these spores as the cause of the fermentation. If infusoria are simultaneously developed, the urea is more slowly converted, and if the surface of the urine happens to be covered with other plant vegetation, as is sometimes the case (mildew), the

the result of this conversion, the urine is rendered highly alkaline, and a further change in the character of the sediment takes place. At the very beginning of the reaction, when the urine may still be neutral or even weakly alkaline, the uric-acid crystals begin to dissolve and to change their

FIG. 10.



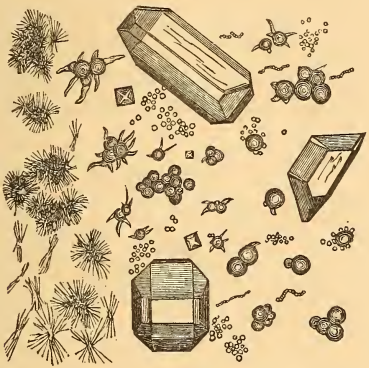
Prismatic crystals of sodium urate, spherules of ammonium urate, and amorphous urates, with octahedral crystals of oxalate of lime. (Ranke.)

form so as to become more or less unrecognizable, while on their fragments may often be seen to adhere prismatic crystals of urate of soda and dark spheres of urate of ammonia. (Fig. 10.) As the reaction becomes alkaline, the uric acid

urine may remain acid for months in consequence of the interference with the access of oxygen, on the presence of which the spore is dependent for its growth and multiplication.

altogether disappears, and the field becomes crowded with granules of amorphous phosphate of lime, beautiful triangular prisms ("coffin-lid" shaped crystals), and their modifications, of the triple phosphate of ammonium and magnesium, and opaque black balls of urate of ammonium often beset with spiculæ (Fig. 11); the spores referred to are also often pres-

FIG. 11.



Spiculated spherules of ammonium urate along with triple (ammonio-magnesium) phosphate and octahedral crystals of the oxalate of lime. (Ranke.)

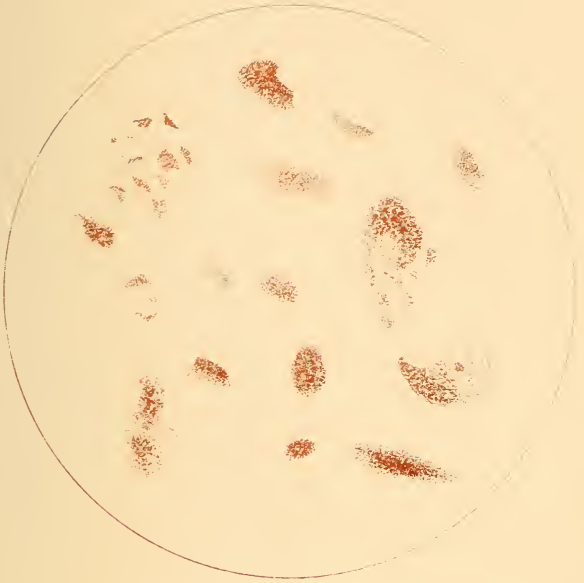
ent, while millions of bacteria vibrate slowly along, or form granular aggregations about a fragment of organic matter, and an occasional infusorium darts across the field of view with magnified celerity. Commonly, however, the intermediate stage is lost sight of, and the stage just described is the only one seen in the alkaline fermentation. Such urine has an ammoniacal and putrescent odor, is cloudy from the suspended phosphate of lime and bacteria, and exhibits to the naked eye an abundant white deposit.

Either of the above set of changes may take place within the economy, in the pelvis of the kidney or in the bladder, and as such become pathological states which are constantly met with in practice, the first in the condition of uric acid gravel or calculus with its incident suffering, and the second in the phenomena of irritation and inflammation, more particularly of the bladder, due to obstruction by stone, stricture or malignant disease. It also seems to be a matter of modern observation that the germs of the fungi above alluded to, which seem to have a very close relation to the phenomena described, either as cause or effect, may be introduced from without by the use of imperfectly cleansed catheters, sounds or similar instruments.

With this preliminary knowledge of the rationale of the causation of a large proportion of urinary deposits, we are ready to take up their detailed consideration, previous to which, however, allusion must be made to

Extraneous Substances found in Urine.—These are very various, and include indeed all substances which are liable to get into vessels containing urine. The most common among these are fibres of cotton and linen, hair of blankets, worsted, wool, human hair, cats' hair, splinters of wood, oil globules, starch corpuscles, tea-leaves, bread crumbs, etc. With the microscopical appearances of all these the student should familiarize himself before he begins the examination of urinary sediments.

Scratches and *marks* in the glass slides may also confuse, if not mislead, the beginner, and, if they become filled with coloring matters, are more likely to do so. Such error was, for a long time, occasioned by the pigmented markings often found in glass slides, which were so long and so often described by observers as *pigment flakes.* They are little depressions



or scratches in the glass which have become filled with oxide of iron used in the polishing of the glass, and can be better appreciated by a study of the annexed plate than by any description. Their true character was first pointed out by Dr. J. G. Richardson, of this city.

Classification of Urinary Deposits.

Efforts have been made to classify sediments on different bases, that is, on the ground of their external naked-eye characters as to bulk, color, weight, etc., again with regard to their nature and origin, whether organized or unorganized, crystalline or amorphous, and finally as to the reaction of the urine in which they are found.

The simplest division is into *unorganized* and *organized*. A further division of these groups into crystalline and amorphous seems to separate groups which are naturally associated, and is therefore omitted.

UNORGANIZED.

I. Uric acid (crystalline).

II. Uric acid compounds.
- *a*. Acid sodium urate (amorphous, occasionally crystalline).
- *b*. Acid potassium urate (amorphous).
- *c*. Acid calcium urate (amorphous).
- *d*. Acid ammonium urate (crystalline).

III. Oxalate of lime (crystalline).

IV. Earthy phosphates.
- *a*. Ammonio-magnesian phosphate (crystalline).
- *b*. Calcium phosphate (amorphous and crystalline).

V. Carbonate of lime (crystalline).

VI. Leucin and tyrosin (crystalline).

VII. Cystin (crystalline).

ORGANIZED.

I. Mucus and pus.
II. Epithelium.
III. Blood.
IV. Casts.
V. Spermatozoids.
VI. Fungi and infusoria.
VII. Elements of morbid growths.
VIII. Entozoa.

I. UNORGANIZED SEDIMENTS.

I. Uric Acid. *Occurrence, etc.*—Uric acid presents itself as a sediment of small bulk, sinking to the bottom, but sometimes adhering also to the sides of the glass. The individual crystals are often large enough to be seen by the naked eye, and in their aggregation often form masses so large as to be characterized by the terms "sand," "gravel," "red-pepper grains." This latter term is based upon the *red* or *yellowish-red* coloration which uric acid crystals in urine exhibit.

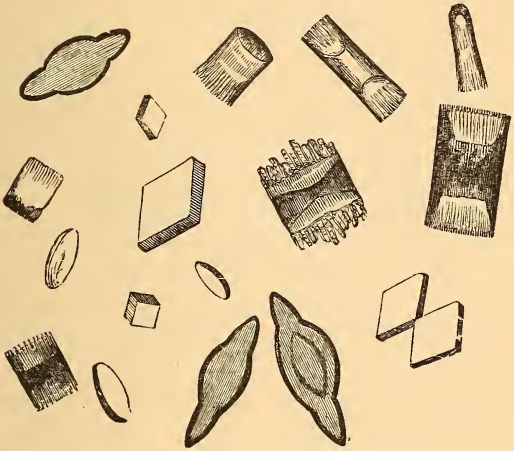
They are found perfect only in acid urine, often at the end of the so-called acid fermentation, in urine concentrated from any cause, and where there is a pathological increase in the production of uric acid due to imperfect oxidation or assimilation.

Recognition.—The typical shapes of a uric acid crystal may be said to be a *four-sided* rhomb and *six-sided* plate.

But it is comparatively seldom that the typical forms are observed, the latter shape being somewhat rare, and the angles of the former being generally so rounded off that the crystal assumes an ovoid or "whetstone" shape, of very different sizes, some being mere points with powers of 200 to 300 diameters, while others are large enough to be seen by the naked eye. Further shapes are those of sections of a barrel, envelope, spear, fan, of a comb with teeth on two

sides, quadrilateral prisms with terminal planes, dumb-bells, and even other forms. What are commonly called "dumb-bells" of uric acid may be rather compared to a tuft of hay

Fig. 12. (After Harley.)



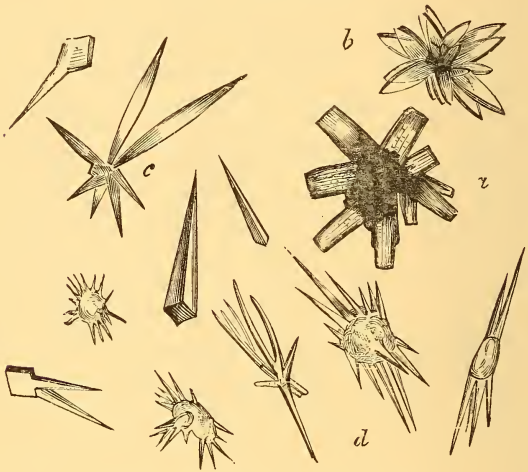
More usual forms of uric acid crystals.

constricted at its middle. These varied forms practice soon teaches one to recognize, even though they may deviate much from the typical shape. Uric acid crystals, as observed, are *almost invariably* colored, and can generally thus be distinguished from other deposits. Dr. Beale* states that two or three instances have come under his notice in which they were not colored. Uric acid crystals are met singly, but very commonly they are aggregated,

* Kidney Diseases and Urinary Deposits, Philadelphia, 1869, p. 371.

forming beautiful rosettes and other shapes of aggregation of such size as to be easily visible to the naked eye—as the "red-pepper grains" already alluded to—and to give pain in their transit through the ureter.

Fig. 13. (After Harley.)



More unusual forms of uric acid crystals.

Fig. 12 exhibits the more usual varieties of uric acid, and Fig. 13 some of the rarer forms.

Tests for Uric Acid.—Whenever a crystalline deposit is of doubtful character and suspected to be uric acid, if the latter, it will respond as follows :—

1. Insoluble in cold or hot water, it will readily dissolve in the alkalies, soda, potash, or ammonia. If then the alkaline solution be treated with an excess of acetic acid, in a few hours typical whetstone-shaped forms will crystallize out.

2. Or the sediment may be placed on a glass slide, and treated with the murexid test, as described on page 91.

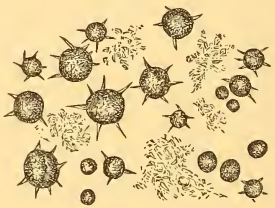
The dumb-bell crystals of uric acid occasionally met with may be distinguished from the dumb-bell crystals of the oxalate of lime, by the characteristic shape already referred to, by their larger size, their darker color, and their solubility in alkalies.

II. Uric Acid Compounds.—(a) *Sodium urate*, mainly amorphous, is sometimes crystalline. It always forms a part, and, according to Bence Jones, a predominant part in the pulverulent, heavy, variously tinted, and generally bulky deposit of the mixed urates known as "brick-dust" or "lateritious" sediment. The degree of coloration of this sediment depends upon that of the coloration of the urine whence it falls. From pale urine of low specific gravity, 1010 to 1014, an almost *white* sediment separates, falling very slowly, and producing therefore an opaque cloudy appearance in suspension, but readily disappearing on the application of heat; from urine of an amber color, and specific gravity of about 1018, the urates deposited are *fawn*-colored; and from high-colored urine of higher specific gravity, we have the true red "brick-dust" sediment. The sediment is found in acid urine, or urine in which the acid fermentation has only commenced, and has not been operating so long as completely to remove the base and cause the crystalline uric acid to be deposited. It is found also in urine concentrated from any cause, or where it has cooled down considerably below 37° C. (98½° F.), or where there is defective oxidation or assimilation, as in fevers.

Recognition.—By far most frequently do we find sodium urate in fine amorphous granules, by their shape in no wise distinguishable from other fine granular matters, requiring,

therefore, the chemical tests for their discrimination. The adhesion of these fine granules to partially coagulated shreds of mucus sometimes gives rise to an appearance resembling finely granular casts (see Fig. 10), which is readily detected by the experienced, but which may mislead the beginner. The careful application of heat, or the addition of a drop of acetic acid, will promptly dissipate the illusion. These granules of sodium urate also assume a larger size, and become little spherules sometimes provided with spicules (see Fig. 14), which are considered by some (G. Bird, Beale) to be spicules of uric acid. (See Fig. 14, from Beale, Kidney Diseases.) Other spherules are provided with pro-

FIG. 14.



Spherules and spiculated spherules of urate of ammonium (sodium?) ; amorphous granular urates.

jecting and curved processes, and are believed by Hassall (2d edition, page 75), and Thudicum (2d edition, page 81) to be composed of sodium urate throughout. That the *spines* were also urate of sodium, Thudicum considered evidenced by their solubility in water. A modified form of the latter is probably the irregularly star-shaped crystals in Dr. Beale's Fig. 110, from the urine of a patient suffering with peritonitis. But all of these forms of spherules with straight and incurved processes (thorn-apple shapes) are put down by the German observers (Neubauer and Vogel, Hoffmann and

Ultzmann) as crystalline forms of urate of *ammonium*, in which I am inclined to concur, at least with regard to those which are found at the stage of reaction intermediate between the acid and alkaline fermentations, or, perhaps, rather at the beginning of the latter, when ammonia makes its appearance, and is accompanied by the ammonio-magnesian phosphate. But any spherules which occur early in the acid reaction, or before it is possible for any ammonia to be present, are probably *sodium urate.*

The sodium urate is also rarely found in *dumb-bells* which are also striated and broad at the extremities like those of uric acid, but less disposed than the latter to break up at the extremities into individual acicles (Atlas of Hoffmann and Ultzmann, Taf. IX.). One half of one of these dumb-bells, viewed from above, would be fan-shaped.

Under the same circumstances, at the end of the acid, and at the beginning of the alkaline fermentation, do we also have the true prismatic *crystals* of acid sodium urate, arranged in star-like masses (Fig. 15, p. 118).

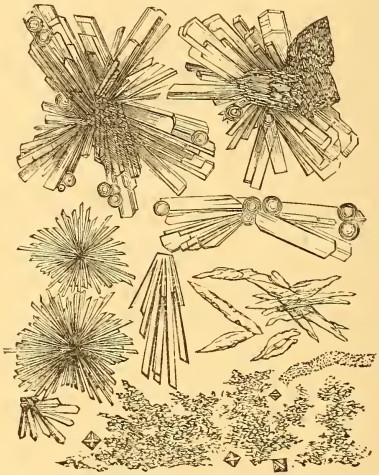
(b) *Acid potassium urate* is also amorphous, very soluble, and occurs under the same circumstances as sodium urate, as a constituent of the mixed urates.

(c) *Acid calcium urate* occurs very seldom and in small quantity, of white amorphous powder, along with the mixed urates. It is with difficulty soluble in water, and known to have lime for its base, by leaving a residue of calcium carbonate after incineration.

(d) *Acid Ammonium Urate. Occurrence.*—This is found along with amorphous earthy phosphates and crystals of the triple phosphates of ammonia and magnesia, in urine in which the alkaline fermentation has commenced. It is the only urate found in alkaline urine.

Recognition.—It is crystalline, and presents itself in the shape of smooth and characteristic "thorn-apple" spherules (Figs. 14 and 15), which serve easily to distinguish them. They are dissolved in hot water, and dissolve with the evolution of uric acid crystals, by hydrochloric or other acid. Liquor potassa, added to them, evolves the odor of ammonia, and they give the murexid reaction with nitric acid and ammonia.

FIG. 15.



Prismatic crystals of sodium urate, spherules of ammonium urate and amorphous urates with octahedral crystals of oxalate of lime. (Ranke.)

Tests.—Though the acid urates are much more insoluble than the neutral urates remaining in solution, requiring 124 parts of boiling water, and 1150 of cold, they readily dissolve on the application of heat to the slide or test-tube containing them. They are dissolved also by the alkalies,

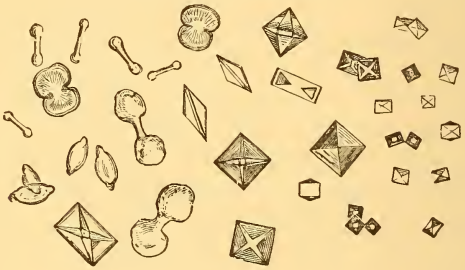
liquor potassa, or soda. Treated with nitric, hydrochloric, or acetic acids (the diluted are better on account of their slower action), they dissolve with the subsequent crystallization of uric acid. They also respond to the murexid test.

III. Oxalate of Lime. *Occurrence.*—The oxalate of lime crystals are most frequently met in acid urine, often therefore alongside of crystals of uric acid, but they may also be met in alkaline urine, along with crystals of the triple phosphate. They are particularly abundant in the urine after a meal of rhubarb plant, after the use of tomatoes, and other vegetables containing oxalic acid. There are no means by which the presence of oxalate of lime may be foretold before a microscopic examination of the urine is made. The first edition of this book contained the following: "It never forms a deposit appreciable to the naked eye, and most commonly the crystals do not descend to the bottom of the glass, but are caught as it were by the flocculi of mucus which float *towards* the bottom, rather than occupy it." Later and repeated observations have convinced me that in many instances the whole of this cloud-like mass, so much resembling mucus, is made up of oxalate of lime.

Recognition.—Two forms of calcium oxalate crystals are met, the *octahedra* and the *dumb-bell* crystals. The former appear somewhat differently according as they are seen in the longer diameter or in the shorter. They may be said to be made up of two four-sided pyramids, placed base to base, and when viewed in the longer diameter, may readily be detected as such by the microscope. When seen in the opposite direction, their characteristic appearance is that of a square, crossed obliquely by two bright lines, and if the crystal be very small, it will appear as a square with a bright point in the centre—a characteristic appearance by which

one may soon learn to detect them, even when they are very small. They are often seen in aggregations of three, four, or more, closely adherent, and forming as it were microscopic calculi.

Fig. 16. (After Harley.)



The *dumb-bells*, very much more rarely met with, are highly characteristic, and although we have spoken of dumb-bells of uric acid and of ammonium urate, neither of the latter present the typical dumb-bell appearance like those of the oxalate of lime. To these are found also allied forms, circular and oval shapes, with darker or brighter centres, and some with partial concavities at the sides, as though passing over into dumb-bells. Dumb-bells are also met with in the urine aggregated, forming microscopic calculi, which go far to explain the incipient formation of calculi.

Chemical Characters.—The form of crystals of oxalate of lime is so characteristic, that there is seldom occasion to make use of chemical tests to determine them. The only crystals which at all resemble them, are certain forms of the triple phosphate. These are small crystals, modifications of the typical triangular prism, with its bevelled ends, in which the body of the prism is exceedingly short, as if it were

almost left out, so that the two inclined triangular ends closely approach each other, and form a crystal like that of the octahedron of oxalate of lime. Their nature may, however, be suspected by the character of the larger crystals around them, for they never occur alone. Moreover, they are promptly dissolved by the addition of acetic acid, while the oxalate of lime is totally insoluble in this acid. The octahedra are highly insoluble in water, in alkalies, and in the vegetable acids, including acetic, but are soluble in the mineral acids. The dumb-bells, after a prolonged action in acetic acid, yield their crystalline matter, leaving a framework, which maintains the original shape of the crystal. This in fact explains, perhaps, the shape of the crystal. It has been shown by Mr. Rainey and others, that the presence of organic matter, as mucus, interferes with crystallization in the regular manner. The dumb-bells of oxalate of lime can readily be distinguished from the dumb-bells of uric acid or urates by the solubility of the latter in alkalies.

The acid phosphate of soda, according to Neubauer,* possesses a power of solution over the oxatate of lime, often holding it in solution, and he gives a method by which the latter may be obtained from solution in the urine by its agency, as follows: 4 to 600 c. c. (108 to 162 f℥) of the urine to be tested is treated with solution of chloride of calcium, supersaturated with ammonia, and the precipitate dissolved in acetic acid. After twenty-four hours, the precipitate then occurring, which nearly always contains uric acid, is placed on a filter, washed with water, and a few drops of hydrochloric acid poured upon it. The latter dissolves out the oxalate of lime present, and leaves the uric

* Neubauer and Vogel, op. citat. p. 174.

acid on the filter. The filtrate is then diluted in a test-tube with 15 c.c. (2.83 f3) of water, and overlaid most carefully, by means of a pipette, with very dilute ammonia in sufficient quantity. At rest, the two fluids gradually mingle, and after twenty-four hours the oxalate of lime present will have collected at the bottom, and octahedra of great beauty may be studied with the microscope.

Neubauer says he has many times, in this manner, obtained considerable quantities of oxalate of lime, where there was previously no deposit whatever. He has, however, in other instances with normal urine, obtained negative results, so that he is unable to decide whether oxalate of lime should be considered a normal or abnormal constituent of urine.

Sources of Oxalate of Lime in the Urine.—There is no doubt, that *oxalic acid* is, at times at least, secreted by the kidneys, and meeting immediately the lime salts for which it has a strong affinity, forms the crystals we are considering; for both octahedra and dumb-bells are not infrequently found in the uriniferous tubules of the kidney, and even in tube-casts. Schunck has attempted to show that the oxalate of lime is formed during the decomposition of urine from the oxalate of ammonium, but Neubauer says the oxalate of ammonium is converted into carbonate of ammonium. Others, as Owen Rees, Aldridge of Dublin, Wöhler, and Frerichs, allege that oxalate of lime is derived from a decomposition of uric acid and urates. Their experiments would seem to show this, and it is undoubtedly the case that deposits of oxalate often make their appearance in urine some time after it has been passed. Two sources must, therefore, be admitted, one within the organism and one without.

Clinical Significance.—There is no disease with which

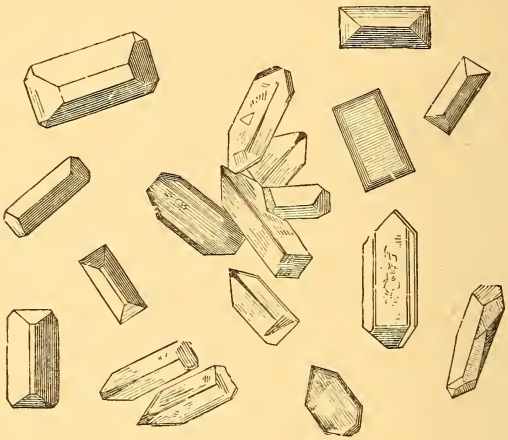
the oxalate of lime is particularly associated, nor can deposits of it be considered indicative of derangement. Abundant deposits of oxalate of lime are found in the urine of persons who are typically healthy. On the other hand, it is apt to occur where there is mal-assimilation, and hence dyspeptics are often found having oxalates in their urine, as a result rather than a cause of the affection from which they suffer.

When there is evidence of renal calculi in descent from the pelvis of the kidney, and oxalates are found in the urine, especially if they are found in the aggregations referred to, the latter may afford explanation of the nature of the stone. Unfortunately, too often there is no sediment whatever attending the descent of a calculus, and we must, therefore, determine its nature without such aid, or remain in ignorance. A careful examination should, however, always be made of the urine in nephritic colic, as valuable information is at times at least furnished by it, especially in the uric acid lithiasis where uric acid sediment is often found.

IV. Earthy Phosphates. *Occurrence.*—These deposits are found only in very feebly acid or alkaline urine, and are the more abundant, the more advanced is the stage of alkaline fermentation. They appear to the naked eye as bulky opaque white deposits, unless they are accompanied by blood, which then more or less tinges them. The urine itself is apt to be turbid from the presence of amorphous phosphate of lime in suspension, to have an ammoniacal and sometimes a fetid odor, though not necessarily. They are especially abundant in the urine of all irritative affections of the bladder, and often attend diseases of the spinal cord. The earthy phosphates are the *triple phosphate* or ammoniomagnesian phosphate and the *phosphate of lime.*

(a) *The Ammonio-magnesian Phosphate* ($MgNH_4PO_4 6H_2O$), or triple phosphate, is a crystalline deposit, of which the typical form is a triangular prism (Fig. 17) with bevelled ends, very characteristic and easily recognized.

FIG 17. (After Harley.)

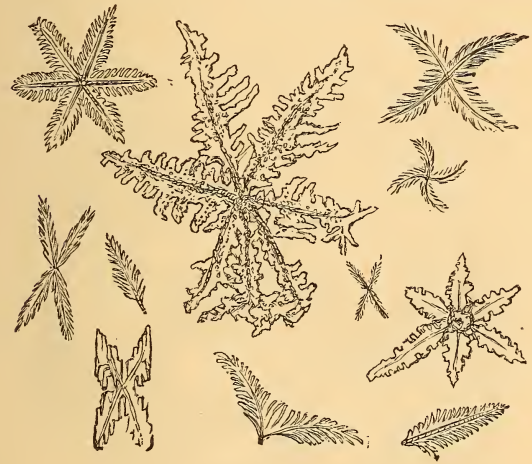


In addition to this, there is an infinite variety of modifications, with one or more corners removed, the body of the crystals variously shortened, etc. Among these forms are the small crystals already referred to as being possibly mistaken for the oxalate of lime. There are also sometimes found beautiful star-shaped (Fig. 18) crystals of triple phosphate, which gradually undergo conversion into the prisms, and between these two there are many intermediate forms.

(b) *Phosphate of Lime*, amorphous $Ca_3(PO_4)2$, crystalline $CaHPO_4$.—Phosphate of lime is most frequently found amorphous under the same circumstances under which the triple phosphate is found. It is, however, frequently de-

posited from normal urine in which it is held in solution during the acid reaction by the acid phosphate of soda, or carbonic acid, or by both. At any rate let the acid reaction be wanting, as it is three or four hours after a meal, and a copious deposit of calcium phosphate often takes place, which is increased by boiling. In other instances, a urine may be acid in its reaction, and the boiling, apparently by driving

FIG. 18. (After Harley.)

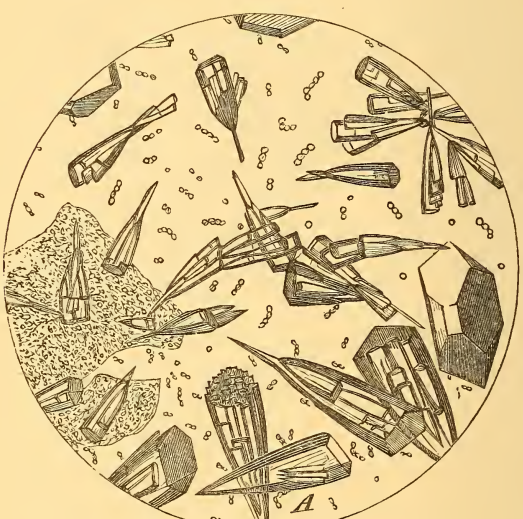


off the carbonic acid, will cause the phosphate to go down. These deposits have more than once been spoken of as possible sources of error in testing for albumen, but they promptly disappear on the addition of acids. The color of the phosphate of lime alone is not snow-white as that of the triple phosphate, but rather yellowish.

Not infrequently we meet in urinary deposits *crystalline phosphate of lime* (Fig. 19), which occurs sometimes alone

and sometimes along with the triple phosphate. It is also met in urine of a weak acid reaction, but strongly disposed to take on the alkaline fermentation. The occurrence of crystalline phosphate of lime seems peculiar to certain individuals, and Hoffmann and Ultzmann have met persons perfectly healthy, who, in the summer months, have almost daily deposits of crystalline phosphate of lime. They are frequently associated with octahedra of the oxalate of lime.

FIG. 19.



Crystalline and amorphous phosphate of lime.

Recognition.—The isolated crystals of phosphate of lime may be said to be *wedge-shaped* or even *conical*, from which form there are, however, variations. But their characteristic feature is in their arrangement, which is that of a circu-

lar rosette, in which the apices of the numerous crystals forming it all point to the centre. Phosphate of lime is also found in the shape of spherules or even *dumb-bells*. The latter are said by Dr. Beale (Kidney Diseases and Urinary Deposits, p. 357) to be deposited in decomposing mucus, not only from the urinary tract, but from other surfaces, as the gall-bladder. Dr. Beale figures such dumb-bells in his Plate xxi, Figs. 116 and 118.

Chemical Characters.—All of the phosphates are dissolved by acids, but are insoluble by alkalies and heat, whereas the uric acid salts are dissolved by both these agencies. The small triple phosphate crystals, which resemble those of oxalate of lime, dissolve quickly in acetic acid, while the octahedra are untouched by it. Uric acid itself could scarcely ever be confounded with phosphates, occurring, as it does, in urine of different reaction; but if it were necessary to discriminate them, the former are dissolved by alkalies, the latter not. Moreover, the murexid test will not respond to phosphates, but will to uric acid.

V. Carbonate of Lime is a very rare deposit in human urine, but found abundantly in horse's urine. When present, it occurs in small spheres, and is detected by its effervescence with acetic acid.

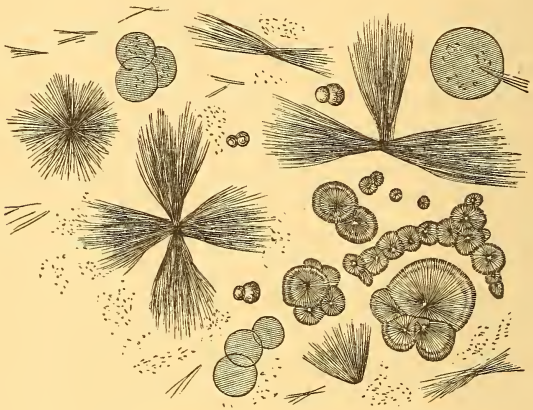
VI. Leucin and Tyrosin. *Occurrence.*—These crystalline deposits are only found in urine which is loaded with biliary coloring matters, since they attend only grave destructive diseases of the liver, especially acute yellow atrophy and phosphorus poisoning.

Recognition.—If suspected in urine presenting the above characters, it may be slightly evaporated, when the crystals will be deposited if present.

Leucin presents itself in the shape of more or less yellow-

tinged, highly refracting spheres, which may at first sight be taken for *oil-drops*. A little study will show them refracting light not quite so strongly, *i. e.*, not possessing quite so wide a dark border; and by suitable illumination, many of them will be found marked with radiating and concentric striæ. The spherules further exhibit a peculiar disposition to aggregate, appearing partially to merge where two edges come together.

FIG. 20.



Leucin spheres and tyrosin needles.

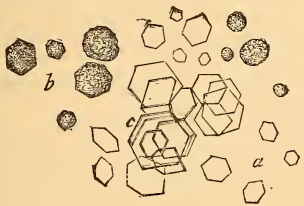
TYROSIN is found in the shape of very fine needles arranged in tufts or "*sheaf*"-like collections, often crossing each other and intersecting at their constricted central portions (Fig. 20).

Chemical Characters.—*Leucin* spheres, unlike oil-globules, are insoluble in ether, and further are soluble in caustic alkalies, but not in cold mineral acids. *Tyrosin* may be recognized by Hoffmann's test. A suspected de-

posit is boiled in an excess of water. To the boiling fluid a few drops of a solution of mercuric nitrate are added, and there asises a red precipitate, while the supernatant fluid is colored red to purple-red.

VII. Cystin ($C_3H_7NSO_2$). *Occurrence and Recognition.*—Cystin is a rare urinary sediment. Crystalline, forming a whitish or dirty yellowish-gray deposit, which on microscopic examination is found to be made up of regular six-sided tablets of different sizes, often so arranged that one of smaller size is superimposed on one of larger, and this upon a still larger, and so on; but it also occurs in irregular masses (Fig. 21). It is usually met in a pale urine, both acid and alkaline, developing in decomposition the odor of sulphuretted hydrogen, as well as that of ammonia, the former doubtless derived from the sulphur contained in the cystin. It occurs as a separate urinary deposit as well as accompanying cystin calculus, which seems sometimes to be hereditary.

Fig. 21. (After Harley.)



Chemical Characters.—It is soluble in ammonia, and, upon spontaneous evaporation of the ammoniacal solution, *the six-sided crystals reappear*, showing that it is simply dissolved in the ammonia, and not in chemical combination with it. Now if the six-sided crystals of uric acid, which

so closely resemble it, and which often accompany it, are dissolved in ammonia, and the solution allowed to evaporate, there would be formed ammonium urate, and, on evaporation of the solution, this ammonium urate would remain as an *amorphous residue*. Cystin is also insoluble in boiling water, in strong acetic and very weak hydrochloric acids; but it is readily soluble in oxalic and strong mineral acids. It is soluble in potash, and insoluble in solution of carbonate of ammonium, and therefore may be precipitated from an acid urine by the alkaline fermentation; under these circumstances it would be accompanied by amorphous phosphate of lime and crystalline phosphate of ammonia and magnesia, with neither of which is it likely to be confounded. In a mixed deposit containing six-sided crystals, the lime and triple phosphate may be dissolved out with acetic acid, while the plates of cystin will remain. They may then be treated with ammonia, as above, to distinguish them from uric acid.

Cystin contains 26 per cent. of sulphur.

ORGANIZED DEPOSITS.

I. Mucus and Pus.—Mucus, even if present in considerable amount, could not be recognized by its own properties, it is so transparent and similar to urine in its refractive index. It is visible only through the accidental morphological constituents which it more or less constantly holds in suspension. These are the so-called mucus-corpuscles and epithelium from all parts of the genito-urinary tract, as well as crystals of the oxalate of lime, granules of sodium urate, and even crystals of uric acid. In strictly normal urine the first two would alone be present, and in very minute quan-

tity. These cause mucus to appear, when present in normal amount, as a *delicate* cloud, often barely visible, floating *towards* the bottom rather than at the bottom of the vessel.

By the action of *acetic* acid, the *mucin*, an element of mucus which is comparable to albumen, though not coagulable by heat, is precipitated in the shape of delicate fibrillated bands, which are sometimes tortuous, and again appear as delicate threads known as mucin threads. If a little iodine and iodide of potassium be added to such acetic acid, they are made even more distinct. Tartaric acid and very dilute solutions of the mineral acids have the same effect, while an excess of the same will redissolve the precipitate; so, too, the mineral acids will dissolve the coagulum of acetic acid, while an excess of the latter will not dissolve it. These coagula may sometimes be found in urine to which no acids have been added, being probably produced by the action of the acids developed in the acid fermentation. Under these circumstances they are particularly apt to be studded with granular urates, which may cause them to be mistaken for granular tube-casts, but they are generally very much narrower than the latter, and the addition of a little warmth, hydrochloric acid or alkali will quickly dissolve the granules. (See Fig. 10.)

As the result of irritation of any part of the genito-urinary tract, mucus is increased in quantity, when it assumes a thicker, more ropy character, and becomes more or less opaque, but even here the opacity is due to the increased proportion of cellular element rather than to the mucus itself, which is always transparent. Under these circumstances, the opaque clouds of mucus are often enormously increased, and with them the adherent epithelial cells from the seat of irritation. When thus in excess, mucus is apt to

pervade more or less the entire mass of the urine rather than sink to the bottom, giving the entire fluid, therefore, a glairy character. Mucus, however, seldom becomes very abundant without being attended by pus, as the causes producing them are but differences of degree. So long, however, as urine containing mucus is without *albumen*, so long may pus be said to be absent, as *mucus itself contains no albumen, while pus does.*

The Mucus- and Pus-corpuscle.—The *mucus-corpuscle*, as it appears in urine, is a small, granular, spherical or nearly spherical cell, rather larger than a blood-corpuscle, that is, .008 to .010 millimetre ($\frac{1}{300}$ to $\frac{1}{250}$ of an inch) in diameter, containing one or more nuclei. In a healthy condition of mucous membrane, a mucus-corpuscle, however it originates, is nothing more nor less than a young epithelial cell which has been pushed off before it has attained the characters of such cell in its development. As such, therefore, we must not too closely restrict its size, for who shall say where the mucus-corpuscle terminates and where the epithelial cell begins? As such a young cell, without morbid impression, simply arrested in its normal development, a single nucleus is more common than it is in the *pus*-corpuscle of which the multiple nucleus may be said to be more characteristic. But here the difference ceases. For the pus-corpuscle, when young (that is, not the subject of fatty degeneration), is a cell exhibiting the same characters, and may be defined in the same way. The fact being that when a cell exhibiting the above characters, with one or multiple nuclei, is found upon a non-suppurating surface, it is called a mucus-corpuscle, while the same cell on a suppurating surface would be called a pus-corpuscle. Thus, while the two are physiologically distinct, they are anatomically the same,

the physiological difference being in this, that a pus-corpuscle is a cell too rapidly produced to be allowed to develop into the normal tissue of the part, while the mucus-corpuscle is, as it were, only accidentally arrested in its development. The same resemblance which exists between these bodies exists between them and the white corpuscles of the blood, and to the whole class of cells to which the term *leucocyte* or white cell is conveniently applied.

Fig. 22.

Mucus- and pus-corpuscles before and after the addition of acetic acid.

The Action of Reagents.—The mono-nucleated mucus-corpuscle, which may be considered an older mucus-corpuscle, or young epithelial cell thrown off at a later period, usually exhibits its single nucleus distinctly, without the addition of a reagent; but the majority of leucocytes have not their nuclei visible until acted upon by certain reagents, of which two acting similarly most interest us. These are water and dilute acetic acid.

1. *Action of Water.*—When water is added to the pus- or mucus-corpuscle, its first effect is to cause the latter to swell up, sometimes to twice the original size, next to become smooth, the granules gradually disappearing, while the nuclei come forth with great distinctness. Finally, after some time the body of the cell becomes almost, and then quite invisible, while the nuclei remain some time longer. The circumstances under which the corpuscle exists in urine are not

quite identical, because in it we have a solution of organic and inorganic matters considerably denser than water, sp. gr. 1015 to 1025, and while the action is somewhat similar, it is very much slower; and if the specific gravity of the urine should be very high, exceeding that of the fluid in the cell, there might be no effect, or a contrary one, *i. e.*, a shrinkage of the cell from an exosmosis of its contents.

2. *Acetic Acid.*—The action of dilute (20 per cent.) acetic acid is identical with that of water, except that it is very much more rapid, and the stage of distinct nuclei is reached much sooner.

3. The *caustic alkalies* have a rapidly destructive effect upon these corpuscles, destroying their morphological identity, and converting them into a gelatinous adherent mass.

Characters of Urine containing Pus.—Urine containing pus deposits an opaque white sediment, which sinks rapidly to the bottom, so long as the reaction is acid and there is no mucus present. Such urine, when shaken up, becomes more or less opaque, according to the amount of pus which it contains. The opacity, as well as the deposit, often resembles that due to the pale granular urates, from which it is distinguished by the disappearance of the latter on the application of heat, while *purulent urine deposits* albumen under the same circumstances. To a less degree does urine containing pus resemble that containing amorphous phosphate of lime, but the latter is dissipated by acids, while acids also precipitate the albumen from pus, and the microscope reveals millions of the granular cells already described as pus-cells, in many of which the nuclei are already displayed in consequence of the action of water.

Donné's test for pus is based upon the reaction referred to between the alkalies and pus. It consists in the addition of

liquor potassa to the deposit of pus after the supernatant urine is poured off. If the deposit is pus, it is promptly converted into a viscid gelatinous substance *resembling mucus*, which adheres to the bottom of the test-tube, often permitting its inversion without falling out, and which, when it is forced to flow, does so in a continuous mass as the albumen runs out of a broken egg. If a portion of this glairy mass be examined under the microscope, the pus-corpuscles will be found to have been destroyed, or, rather, converted into the substance itself. If the action has not been very long, or the proportion of alkali to the pus is small, the nuclei of the corpuscles may still be found as black dots in the mass, or a certain proportion of the corpuscles may preserve their integrity.

Changes in Urine containing Pus.—On this same reaction is based a most important change which urine containing pus undergoes after the alkaline fermentation has set in. Through the agency of the carbonate of ammonium generated, precisely the same change is wrought, and the urine contains a deposit so closely adhering to the bottom of the bottle that it is impossible to remove it with a pipette. It must be remembered that *this is not mucus*, although it so closely resembles it, and although microscopic examination may show the total absence of pus-corpuscles. These have been destroyed by the alkali. Care should be taken, therefore, to determine the reaction of the urine before a mucoid deposit is decided upon, and if it is alkaline, another of acid reaction should be obtained. The glairy product referred to will be found dotted with glistening points, which, on microscopic examination, prove to be crystals of triple phosphate, while the supernatant fluid will be found to contain albumen, which is wanting in deposits of pure mucus.

Frequently, in diseases of the bladder, these changes take place within the organ, forming a gelatinous mass, which plugs up the urethra and makes it almost impossible to evacuate the bladder, thus greatly increasing the suffering of the patient. In such cases, the only remedy is to wash out the bladder with weak acid solutions, and having cleansed it, keep it so by their daily use. Even when acid at the time of being passed, these urines become rapidly alkaline afterwards.

Sources of Pus in the Urine.—Pus in the urine may come from any part of the genito-urinary tract. When descending from the *pelvis* of the kidney, as it often does, in impacted calculus, it is less apt to be mingled with mucus, the urine retains its normal reaction, and the pus is, therefore, readily miscible with the urine, and as promptly deposited from it. When coming from the *bladder*, if the urine is not already alkaline, it is apt to become so very quickly, and we have then the phenomena described as incident to the alkaline fermentation, taking place soon after the urine is passed, if not in the bladder itself.

In diseases of the *prostate*, are apt to be found long plugs of mucus, which, appearing to the naked eye like fine threads, upon microscopic examination are found made up of aggregated pus-corpuscles, in which are sometimes found the larger round or nearly round nucleated cells peculiar to this seat. Similar plugs are found in the pus from gonorrhœa, and it is said also (Neubauer) that in this affection the mucus-corpuscles are distinguished from those derived from the bladder by their larger size, their "glass-like clearness," and diminished granulation. If there be no gonorrhœa, these plugs or threads point almost pathognomonically to inflammation or irritation of the prostate.

In females, pus is apt to obtain in the urine from leucorrhœa or other purulent discharge from the vagina. This should not be forgotten.

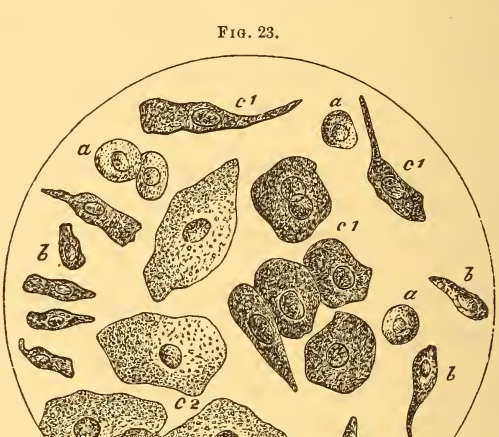
II. Epithelium.—Epithelium from all parts of the genito-urinary tract is found in the urine, but it is not very often that we are enabled to locate its site beyond the bladder and vagina, partly because of the comparatively slight differences in the epithelium from certain locations, and partly because maceration in the urine renders such feeble distinctive points even less marked.

Three varieties of epithelium may, however, be distinguished in urine, with tolerable ease: 1st, round cells; 2d, cylindrical or conical and spindle cells; and, 3d, squamous cells.

(a) *Round epithelial cells* (*a*, Fig. 23) arise from the uriniferous tubules, particularly in their convoluted portion, from the deeper layers of the mucous membrane of the pelvis of the kidney, of the bladder, and of the male urethra. Some of these cells, originally somewhat flattened by pressure, swell up in the urine, and become nearly round. They are distinguished from pus- and mucus-corpuscles by their larger size and their *single* nucleus, which is distinct without the use of reagents, while the *multiple* nucleus of the pus-cell requires the use of acetic acid to exhibit it. There is no way of distinguishing the source of these cells more precisely than as stated above, except that if the urine be albuminous, and there is evidence of renal disease, it may be right to infer them to come from the tubules of the kidney, or from the pelvis if there are symptoms of impacted calculus; otherwise from the urethra, the prostate, Cowper's or Littre's glands, but cells from the latter are rare. If the plugs already referred to, made up of pus-cells with a few

larger, nearly round, and distinctly mononucleated cells united by mucus, are present, we may infer the round cells to be from the epithelium of the prostate. The round cells from the bladder are considerably larger than those from other sources—twice the diameter of a pus-cell.

FIG. 23.



a, round epithelium from bladder.
b, columnar epithelium from ureter and urethra.
c^1, columnar and squamous epithelium from deeper layers of epithelium of bladder.
c^2, squamous epithelium from superficial layers of epithelium of vagina.

(b) *Columnar or conical and spindle cells* (*b*, Fig. 23) are derived, the *first*, from the superficial layers of the pelves of the kidney, from the ureters and urethra, the *latter* from the ureters and urethra.

(c) *The scaly epithelial cells* (*c*, Fig. 23) arise from the bladder or the vagina. These are flat, but often thicker at

the middle, contain a single nucleus, are irregularly polygonal in outline, and often folded over on themselves either completely or partially. The epithelial cells of the bladder (c^1) are not generally as large as those of the vagina (c^2) nor so flat; they are less apt to occur in layers or flakes, although also found thus. Frequently it is not safe to attempt to distinguish between the two.

In acid urine these cells remain a considerable length of time, but in alkaline urine they are gradually destroyed, becoming at first swollen and more transparent.

III. Blood-corpuscles.—These get into the urine from the tubules of the kidneys, from the pelvis, the bladder, the prostate, and from the uterus and vagina in their various physiological and pathological hemorrhages. They may be so abundant as to be easily distinguished in mass by the naked eye, or they may require the microscope for their detection. Urine containing blood in large amount, is impressed with the red color of the latter, but containing the moderate amount most frequently encountered in urine, it obtains a color depending on its reaction. If the urine is acid, it assumes a peculiar blackish-brown color which has long been described as "smoke-hued," and which is so characteristic as to enable one who is at all experienced, to decide at once as to the presence of blood. If, on the other hand, the urine is alkaline in reaction, it assumes the bright red color of blood. *Urine containing blood in any quantity, appreciable to the naked eye, is albuminous.*

If blood-corpuscles are present in numbers sufficient to produce an appreciable deposit, they form a brownish-red pulverulent mass at the bottom of the vial if they come from the kidneys or ureters. They are more apt to be found in coagula, if they come from the bladder or urethra, though

this latter is not necessarily the case; for, on the other hand, moulds of clotted blood are sometimes discharged from the ureters with all the agonies of nephritic colic.

Recognition.—Blood-corpuscles are recognized under the microscope by the optical properties due to their biconcave centres. This is the *reversal of light and shadow* which they undergo in focussing, the centre and periphery alternating in brightness or shadow, as the object-glass is approximated to the slide or removed from it. This, in connection with their evident biconcavity when seen on edge, and their yellowish color, will always serve to distinguish them, although the effects of long-continued maceration tend to interfere in different degrees with the distinctness of all of these features. If the urine is a dilute one, the corpuscles will swell up, become biconvex instead of biconcave, finally spherical, and the reversal of light and shadow no longer occurs, while the coloring matter is more or less dissolved out. Ultimately the corpuscle altogether disappears. If, on the other hand, the urine is highly concentrated, the concavity becomes more marked and more distinctive, while the corpuscle itself shrinks and becomes smaller, and soon acquires the crenated or horse-chestnut-shape (Fig. 24).

FIG. 24.

Blood-disks.

In an acid urine the blood-corpuscles maintain themselves for a long time, but in an ammoniacal urine they are soon

dissolved, being soluble in alkalies. The hæmatocrystalline and hæmatin are then dissolved in the urine, and may be tested for as already directed.

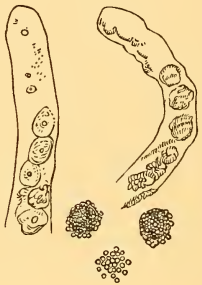
IV. Tube-casts.—Tube-casts, or "epithelial cylinders" as they are sometimes called, although it is by no means certain that they are real cylinders, are moulds of the uriniferous tubules produced by admission into the latter, by capillary rupture or otherwise, of a coagulable constituent of the blood, which there solidifies, and in this act entangles whatever it may have surrounded in its liquid state; subsequently it contracts and slips out of the tubule into the pelvis of the kidney, whence it is carried to the bladder and voided with the urine.

It should be added, however, that at least two other views as to the mode of formation of casts are entertained, according to one of which the cast is a result of the disintegration and fusion of the epithelial lining of the tubules; and, according to another, of a secretion from these same cells.

The mechanism of the production, on the supposition of an albuminoid exudation from the blood, of the different varieties of casts is very simple. Thus, suppose a tubule to be filled with detached and loosely attached epithelium at the time the fibrin is poured into it. These elements are entangled, and as the cast contracts, carried out in the shape of an "*epithelial*" cast (Fig. 25). If the tubule should happen to have contained blood, the cast entangling it is called a "*blood-cast*" (Fig. 26). Casts containing even a few blood-corpuscles are also called blood-casts. The basis substance of blood-casts is most probably the fibrin of the blood. If the epithelium be firmly attached to the basement-membrane of the tube, and remain behind when the cast passes

out, or if the tube be entirely bereft of epithelium, then is the cast a "*hyaline*" (Fig. 27), or structureless cast. In

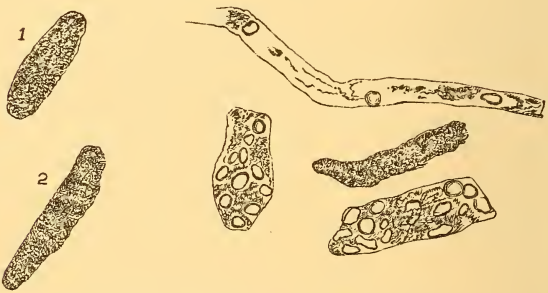
FIG. 25.



Epithelial casts and compound granule-cells.

the former instance the cast is of *smaller* diameter, and in the latter of *larger*, the diameter in the latter being that of

FIG. 26.

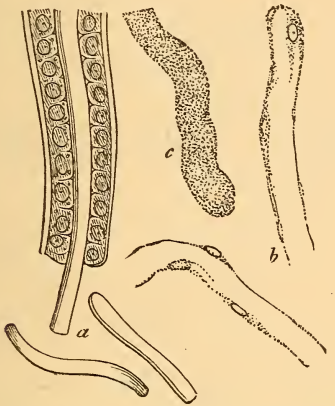


Blood-casts and highly granular cells.

the former plus twice the thickness of an epithelial cell. Fig. 27, from Rindfleisch, explains this sufficiently. From

causes like these, as well as a subsequent contraction of the cast itself, the diameter of casts may vary considerably, ranging commonly from .01 to .05 mm. ($\frac{1}{2500}$ to $\frac{1}{500}$ in.). A cast is seldom completely hyaline, generally containing a few granules and one or two glistening oil-drops, but it is

FIG. 27.

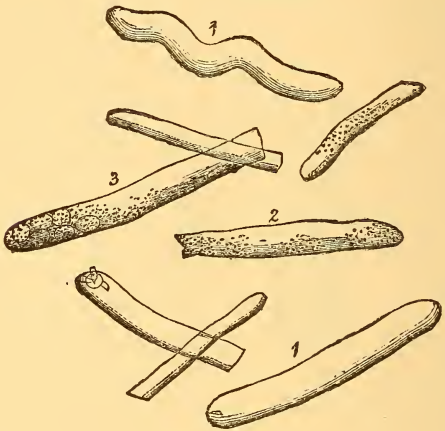


Hyaline and granular casts, illustrating the formation of the former at *a*.

still called *hyaline*. Completely hyaline casts do, however, occur. A variety of hyaline cast, more solid in appearance, and resembling molten wax, is spoken of as a "*waxy cast*" (Fig. 28, 1). Some hyaline casts are so delicate as to be overlooked, unless the light from the mirror illuminating the field of view be modified by shading with the hand or by manipulation of the mirror itself. If a cast contains granular matter, which is generally the granular débris of a degenerated epithelial lining of a tubule or of blood-corpuscles, it is called a "*granular*" cast, and *highly* granular (Figs. 26 and 27), *moderately* granular (Fig. 27, *b*), *slightly* or

delicately granular, according to the amount of granular matter present. When the material of granular casts is

FIG. 28. (After Harley.)

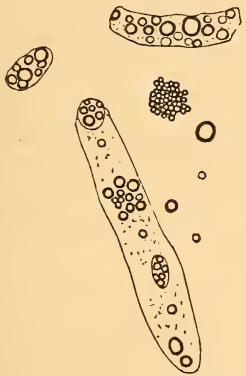


derived from broken-down blood-corpuscles, the casts appear yellow or yellowish-red. Finally, if a cast is loaded with oil-drops, either free or contained in epithelial cells, it is called an "*oil-cast*" or *fatty cast* (Fig. 29).

Casts of smaller diameter are sometimes found within those of larger, the material of the latter having been poured out around that of the former after it has undergone some contraction. This occurs usually with waxy or hyaline casts. In consequence of the mode of formation above referred to, hyaline and waxy casts vary considerably in diameter, some being as narrow as .025 millimetre ($\frac{1}{1000}$th of an inch) and even narrower, while others are as much as .05 millimetre ($\frac{1}{500}$th of an inch) wide. There is no doubt that some of these are formed in the straight or collecting tubes near

their openings on the papilla. To these a limited number of epithelial cells is sometimes attached.

Fig. 29.



Oil-casts and fatty epithelium.

In addition to the epithelial casts above described, there are found in urine under the same circumstances moulds of the uriniferous tubules made up of simple *aggregations* of the *epithelial cells themselves*—simple exfoliations of the cellular contents of the tubule, which having increased by proliferation form a compact cellular mass. In addition to these also are sometimes found epithelial casts in which the cells are seated on the outside or around the fibrinous mould.

Mucus-casts.— Casts are occasionally found, which are apparently pure *mucus-moulds* of the uriniferous tubules. Unless covered by accidental elements, as granular urates or phosphate of lime, they are smooth, hyaline or gently fibrillated moulds, especially characterized by their great

length, which is often enormous, in the course of which they divide and subdivide, diminishing in diameter as the division proceeds, showing positively that they come from the kidney. Yet there is no albumen or merely as much as could be accounted for by the presence of pus which sometimes attends them. For they are particularly apt to occur where there is irritation of the bladder, which is apparently extended through the ureters to the kidney. Under these circumstances, I have met them on two or three occasions. Dr. Beale says (*Kidney Diseases*, etc., p. 342), they are not unfrequently passed in cases where the urine has a very high specific gravity, 1030 or higher, containing an excess of urea and urates.

These casts are not identical with the bands of mucin already alluded to (p. 131), which are found in the urine of highly acid reaction, perhaps precipitated by the acids, which are often beset with granular urates, and might be mistaken for casts.

Casts of the seminal tubules are sometimes found in the urine, but their origin may be inferred from the presence of spermatozoids in them.

To Prepare Urine for Examination for Casts.—The greatest caution should be exercised in examining urine for casts. They are often so sparsely present as to furnish no deposit appreciable to the naked eye, and yet may be found by careful microscopical examination. While it is not impossible for non-albuminous urine to contain casts, yet I have never met them, except in two or three instances, where, albumen and casts having been present, in their gradual disappearance the signs of the presence of albumen disappeared before the last casts had been washed out. On the other hand the presence of albumen means casts in the vast

majority of instances, and many times I am certain they are declared absent, simply because they are not carefully sought. At present I have a case under my observation in which the urine contains $\frac{1}{4}$th its bulk of albumen, and yet by the most searching examination I fail to find casts. Not a single slide, however, should satisfy the examiner, but two or three should be carefully studied throughout their entire field. Nor is a plain slide sufficient. Urine should be examined in *shallow cells*, and as those of thin glass are generally too deep, the best are made with gum-dammar or Bell's cement, by means of a turntable and brush, since in this way they may be obtained sufficiently shallow to allow them to be penetrated by an ordinary one-fifth or one-fourth objective. After being made they should be put away for a month or more to thoroughly dry and harden, else they are washed off with the first cleaning of the slide.

Most casts from their lightness subside slowly, and the more so because the urine is albuminous. As soon as received, therefore, the bottle of urine should be shaken up, poured into a conical glass, and carefully covered. Although casts generally fall to the bottom in a shorter time, I have known twelve hours to elapse before one could be discovered, and therefore whenever it is possible, urine should be allowed to stand for this time in a conical glass, and then examined. If the urine has already been standing some time, the supernatant fluid may be removed, and only the lower strata containing the sediment turned into the conical glass, and allowed further to subside. A pipette, consisting of a plain glass-tube drawn nearly to a point, should then be carried to the bottom of the glass with the index finger firmly pressed upon the distal end. When it has reached the bottom, the finger should be raised, and immediately

returned. In this manner only the lowest drops are obtained, which are most likely to contain the casts. A drop of this fluid is allowed to fall into one of the shallow cells, covered with a thin glass cover, and carefully examined with a one-fourth or one-fifth object-glass and the No. 1 eye-piece. If these precautions are taken, and two or three slides examined, casts will either be found, or they are absent. Only the beginner need be cautioned against linen and cotton fibre, hair, or portions of deal-wood. More likely are the mucin flakes and cast-like granular aggregations of inorganic and organic matter to mislead.

V. Spermatozoids frequently occur in the sediment of urine of healthy individuals. When abundant, they form a slight flocculent cloud in the urine, but there is generally nothing in the appearance of urine whence their presence may be suspected. They require a power of 400 diameters (one-fifth with the No. 2 eye-piece) to show them well, when they may be recognized by the oval head or body and the delicate tail-like prolongation emanating from it. They no longer exhibit their vibratile movement after entering the urine. Their recognition is most interesting in connection with medico-legal cases—cases of suspected rape. Their presence in vaginal mucus soon after coition, and in stains upon linen, is easy of demonstration. In the former case a drop of mucus from within the vagina is placed upon a slide, a drop of water added if necessary, covered with a thin cover, and examined with the microscope. In the latter a simple piece of the stained linen may be soaked in water or artificial serum in a watch-glass for half an hour or an hour, and the sediment examined. Beale figures (Fig. 74) some filaments of a vegetable nature resembling spermatozoids.

VI. Fungi.—Most of the living organisms found in de-

composing urine, formerly looked upon as of animal origin, are now acknowledged to be vegetable in their nature, and are generally fungi.

The most frequent among these are *bacteria*, *penicilium glaucum*, and the *yeast fungus*. *Sarcinæ* are occasionally met with.

Fig. 30.

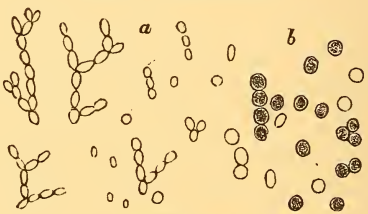
Human spermatozoids. 1. Magnified 350 diameters. 2. 800 diameters. *a*, viewed from the side. *b*, from the front.

1. *Bacteria.*—In the refined study which has of late years been given to the subject of fungi, a classification has been made of the minute objects which were formerly called bacteria or vibriones. I take from Hoffmann and Ultzmann the classification of A. Vogel, who makes of them, *a*, the *monad form*, consisting of little trembling points distinguished in their molecular movement from that of inorganic particles, by a progressive motion; *b*, *the staff-shaped* bacteria, which appear as minute lines equalling in length with moderate powers the diameter of a red blood-disk, but mere

lines in breadth, sometimes at rest, and sometimes vibrating across the field; *c*, the *vibrio form*, consisting of two or more of the staff-shaped bacteria, adherent end to end, and moving often with great rapidity, sometimes by a spiral movement, and sometimes by vibrating one extremity, as a fish propels itself; *d*, the *leptothrix form* or *chain fungus*, often extending entirely across the field of view, differing from the vibrio forms only by their length, moving seldom, and if at all very slowly; *e*, the *zooglea form*, consisting of heaps of bacteria, mostly punctiform, apparently held together by a gelatinous substance.

2. *The yeast or sugar fungus*, identical with the ordinary yeast fungus, consists in the sporule-stage of transparent oval cells, in their longer diameter about the size of a blood-disk, and of larger spherical cells, granular and nucleated, found in saccharine urine. (Fig. 31.) According to Hassall, this

FIG. 31. (After Harley.)



Yeast fungus.

is a fungus peculiar to saccharine urine, but the small oval cells of the sporule-stage at least cannot be distinguished from the similar stage of

3. *Penicilium glaucum*, which occurs in acid urine with or without albumen or sugar. The sporule-stage furnishes cells very similar to those of the yeast fungus, but, later

penicilium, by the union of its cells, forms thalli or branches which are characteristic. So, too, in the stage of aerial fructification, the penicilium multiplies by simple linear division of cells, while the spores of the sugar fungus fall from a spherical mass not unlike that on the stem of an onion "going to seed."

4. The *sarcina* is a fungus rarely met with in urine. Composed of cubes, it is capable of further separation into smaller cubes. It is similar to, but smaller than, the *sarcina ventriculi* of Goodsir.

The germs of these fungi doubtless enter the urine after it has passed from the bladder, in the vast majority of instances, one or the other form being developed according as its germs preponderate, or according to the properties the urine may possess. Decomposition seems essential to the presence of the bacteria, but not to the other forms.

VII. The Elements of Morbid Growths.—These are seldom met in the urine. Possibly *cells* may be found, and perhaps *fragments* of the growth may be broken off and passed with the urine. The former may be suspected to be of morbid origin by their large size, their multinuclear character, the large size of the nuclei, and diversity of the cell-forms. Spindle-cells, it must be remembered, may be derived from the ureter, urethra, and even the bladder, and must not, therefore, be considered abnormal.

Fragments of cancerous growths which get into the urine are generally from the villous kind, and may show the capillary vessels which make up the villus, with or without the epithelial covering. Fragments, suitable for examination, are sometimes withdrawn with the catheter.

VIII. Entozoa.—Entozoa are seldom found in the urine in this climate. Echinococcus cysts, as well as their hook-

lets, have been passed in two or three instances recorded. The eggs and ciliated embryos of *Bilharzia hæmatobia* have been found by Dr. John Harley in three patients with the endemic hæmaturia of the Cape of Good Hope, and I had the privilege, through the kindness of my friend, Dr. S. W. Gross, of examining one of the slides containing ova, sent to this country. The parasite itself is found in the vesical, mesenteric, and portal veins, causing hemorrhages into the intestines, bladder, ureters, and pelves of the kidney. The ova and parasite are figured by Beale, op., p. 402.

Distoma hæmatobium has been found in the bladder, ureters, and pelves of the kidney, especially in Egypt.

DIFFERENTIAL DIAGNOSIS OF RENAL DISEASES.

While it is quite impossible to determine with absolute certainty all of the different affections to which the kidneys are liable by a mere examination of the urine, there is nevertheless an association more or less close of signs with well-determined conditions. With such association it is important that we should be familiar, while we should as well recognize the fact that they are subject to variations and exceptions. If these truths are properly remembered, it is not likely that any one can be led far astray by observing the following:—

I. *Acute Nephritis* (*Scarlatinal Nephritis*).—The urine is scanty, dark, "smoke-hued," so long as it remains acid, but becomes red if alkalized. It is highly albuminous. Its specific gravity is not constant, but apt to be high—1025 or above—not from an increase in urea, but from the presence of blood. It contains a variable, but generally large amount of reddish-brown, pulverulent sediment, which, on microscopic examination, is found made up of large epithelial casts, blood-casts, hyaline casts of large diameter, dark-red granular casts, numerous red blood-disks, and free cells, more or less round and nucleated, twice as wide as the blood-disks, cloudy, and more granular than in health, the granules often obscuring the nucleus. Crystals of uric acid are often present. The chlorides are at first diminished, also the earthy phosphates. Hæmatin, indican, and uric acid are increased.

The patient is dropsical, much swollen about the face,

and, if a child, has had scarlet fever, or, if an adult, has been exposed to wet while perspiring.

The disease is *acute nephritis*, scarlatinal nephritis, or acute Bright's disease, and the chances for recovery are many.

II. *Chronic Tubal Nephritis* (*Parenchymatous Nephritis; Large White Kidney*).—The urine is pale, and of low specific gravity—1005–1015; its quantity, though variable, generally diminished. Albumen is diminished as compared with (I.), but is still abundant—one-quarter to one-half the bulk. It deposits an appreciable white sediment, which, by microscopic examination, is found made up of black, highly granular casts, hyaline casts, and casts containing fragments of epithelium; also compound granule-cells (Fig. 25). Probably also there are casts containing a moderate quantity of oil, and perhaps also partially fatty cells. Waxy casts are also sometimes found in this form of disease. The urea is diminished, the chlorides normal, pigment diminished. There is also œdema, more or less general, which may, however, subside, but the patient has a pale, almost characteristic waxy look. The symptoms have existed more than six weeks.

The disease is probably the large white kidney, a chronic continuation of (I.), known also as *chronic tubal nephritis*, and recovery, though possible, is not likely to occur.

III. *Yellow Fatty Kidney.*—The urine presents the same general characters as in the last case, contains rather more albumen, and a more abundant sediment, which is found made up of numerous oil-casts filled with free oil, and oil contained in epithelial cells. There are numerous free fatty cells and free oil-globules. The urea is diminished.

It is the *true yellow fatty* kidney, which, sometimes at

least, originates independently of any acute inflammation of the organ in drunkards. Dropsy is persistent. The disease is pre-eminently fatal. The patient exhibiting the peculiar cachexia mentioned under (II.) will generally perish within the year.

IV. *Secondary Contraction of the Kidney after Chronic Nephritis.*—The disease has existed for more than a year, the urine is small in amount, though pale in color, but is perhaps not so much diminished, and the specific gravity is somewhat higher than in (II.). The albumen is diminished but is still considerable. The urine deposits a more scanty sediment, made up of broad casts, some dark granules, and others contain fragments of waxy, together with a few narrow pale casts. Compound granule-cells occur, but are less numerous, and there may be some fatty epithelial cells, but the amount of oil, though distinctive, is not very large. The urea is much diminished. There is generally some dropsy, less than in (I.), (II.), and (III.), but more than in (V.).

Here the *large white kidney has probably commenced to contract*, but one must be cautious about drawing too sharp a line between these two affections. The prognosis is unfavorable, but the disease may last some time—even years.

V. *Interstitial Nephritis* (*chronically contracted Kidney*).—The urine is increased in amount, correspondingly pale, but, while micturition may be a little more frequent, it may not attract attention. The patient may have to rise once in the night. The specific gravity is little, if at all, diminished, (1018–20)—while the quantity of albumen is trifling, never exceeds one-quarter, and often is shown by a mere line of opacity in Heller's test. It deposits often no visible sediment, and at all times a trifling one. In this are found delicate hyaline and finely granular casts, often of small diameter.

Some of these contain one or two glistening oil-drops, but very minute. Here are found the casts which are at times almost invisible. The urea is generally slightly diminished.

There is no dropsy. There are often no symptoms whatever connected with the disease. If any, the patient may complain of a weak, tired feeling, and this symptom should suggest an examination of the urine always. The disease may exist for years without the knowledge of the patient, who may or may not be subject to gout. (The urine of gouty patients should be frequently examined.)

The disease is the *chronically contracted* kidney, the interstitial nephritis of the German pathologists. If exposure to cold and fatigue be avoided, the patient's life may be scarcely shortened, and yet he is constantly liable to attacks of uræmia, which may suddenly terminate his life.

VI. *Albuminoid or Amyloid Degeneration of the Kidney.*—The urine is increased in quantity, clear, of corresponding specific gravity (1007–1015), of a pale, golden color, the color of a dilute urine only, contains considerable albumen, about one-fourth to one-half; urea is diminished. There is very little or no sediment visible. Casts are often wanting, and when present include the broad dark granular as well as the hyaline and waxy, though the latter by no means always; occasionally fatty casts are found; the waxy are solid looking, and *sometimes* giving the characteristic red reaction of the albuminoid substance when treated with a *watery* solution of iodine and iodide of potassium. Here hyaline and waxy casts of large diameter are found, and sometimes within these smaller casts.

While the highly refracting waxy casts are not confined to albuminoid kidney, they always indicate chronic and deep-seated processes.

There is apt to be dropsy, sometimes persistent, but generally, except towards the termination of the case, amenable to treatment by rest and diuretics. The patient has an enlarged liver or spleen, sometimes persistent diarrhœa; he has had syphilis, or extensive disease of the bones, or has phthisis.

The disease is *albuminoid degeneration of the kidney*, and is incurable, though the patient may live many years.

VII. *Parenchymatous Degeneration of the Kidney.*— Most frequently the sole symptom is albuminuria, the most careful examination failing to discover casts. There is, as a rule, no dropsy. The quantity of albumen ($\frac{1}{10}$ to $\frac{1}{4}$ bulk) is generally less than in tubal or parenchymatous *inflammation*, or albuminoid degeneration. Such is sometimes the albuminuria of pregnancy or such grave diseases as diphtheria and acute febrile disorders.

After death, the renal epithelia are often more or less enlarged by albuminous exudation, their contents cloudy. This condition differs from parenchymatous *nephritis* in the smaller extent and diminished intensity of the morbid process. It is probably due to the pernicious influence of some poison on the minute structure of the tissue of the kidney, which may extend to all the tissues. Recovery is frequent.

The disease is called by Niemeyer *parenchymatous degeneration.*

The above is given as a general guide, and I would again refer to the fact that there are deviations from the conditions laid down. There are still many points quite disputed in the pathology of the kidney. Thus, the German pathologists contend that there is a constant relation of succession between the acute parenchymatous nephritis, the chronic

parenchymatous nephritis (large white kidney), and the contracting stage of the latter, making no distinction between the large white kidney and the fatty kidney. Both, it is true, are fatty kidneys, but while the fat in the former is molecular or granular fat, in the latter it is globular. Although these two may also, at times, be different stages, the latter being the more advanced, no fact is better determined than that the true fatty kidney *may* originate insidiously without any acute attack.

One more fact must be mentioned in this connection, and this is, that although the presence of fatty casts and fatty epithelium are unfavorable symptoms, yet it does not follow that such cases are necessarily fatal. I have, on more than one occasion, found oil-casts in the urine of patients, and yet have also found them to disappear altogether. The circumstances under which this has occurred have been, 1st, where there have been heart-disease and kidney-disease combined, and there has been some exacerbation of one or both, when the albumen has increased, and oil-casts have made their appearance, which later totally disappeared; 2d, where pregnancy has supervened on existing Bright's disease, and oil-casts have been present, which again disappeared after a successful labor.

URINARY CALCULI.

The qualitative analysis of gravel or calculi is much simpler than is generally supposed. There are but three forms of calculi which are of at all common occurrence, and which are, therefore, likely to demand analysis. These are *uric acid and compounds*, *oxalate of lime*, and the *mixed phosphates*. Calculi of *xanthine* and *cystine* are found, though very rarely.

1. *Uric acid calculi* are the most common. They are either red or some shade of red, and usually smooth, but may be tuberculated. They leave a mere trace of residue after ignition.

2. *Oxalate of lime calculi* are frequently met with. They are generally of a dark-brown or dark-gray color, and from their frequently tuberculated surface have been called mulberry calculi. They may, however, also be smooth. Considerable residue remains after ignition. The calculus is soluble in mineral acids without effervescence.

3. *Calculi of the mixed phosphates or fusible calculi* are composed of the phosphate of lime and of the triple phosphate of ammonia and magnesia. They form the external layer of many calculi of different composition, and may form entire calculi, but very seldom form the nuclei of other calculi. They are white, exceedingly brittle, fuse in the blowpipe flame, and are soluble in acids, but insoluble in alkalies.

Few calculi of large size are of the same composition throughout. Oxalate of lime is the most frequent nucleus; uric acid may also serve as a nucleus, but phosphates, as stated, almost never. Small collections of organic matter, as blood-clots, frequently form nuclei, and may often be

recognized by the odor of ammonia on ignition. It is not uncommon to find calculi made up of concentric layers of different composition.

*To Determine the Composition of Calculi.**

Heat a portion of the *powdered* calculus to redness upon platinum foil. Note whether there is a residue.

A. There is a fixed residue. To a portion of the original powder apply the murexid test (p. 91).

I. A purple color results; *uric acid* is present. Observe whether a portion of the calculus melts on being heated.

a. It melts, and communicates—

1. A strong yellow color to the flame of a spirit lamp; *sodium urate.*
2. A violet color to the flame; *potassium urate.*

b. It does not melt. Dissolve the residue after ignition in a little dilute HCl, add ammonia until alkaline, and then ammonium carbonate solution.

1. A white precipitate falls; *calcium urate.*
2. No precipitate. Add some hydric sodic phosphate solution; a white crystalline precipitate falls; *magnesium urate.*

II. No purple color results. Observe whether a portion of the calculus melts on being heated strongly.

a. It melts (fusible calculus). Treat the residue

* The processes here given are taken, with slight verbal alterations, from the last edition of Thudicum's work on the Pathology of the Urine.

with acetic acid; it dissolves. Add to the solution ammonia in excess; a white crystalline precipitate falls; *ammonio-magnesium phosphate.* In case the melted residue is insoluble in acetic acid, treat with HCl; it dissolves. Add to the solution ammonia; a white precipitate indicates *calcium phosphate.*

b. It does not melt. Moisten the residue with water, and test its reaction with litmus paper; it is not alkaline. Treat with HCl; it dissolves without effervescence. Add to the solution ammonia in excess; white precipitate; *calcium phosphate.* Treat the calculus with acetic acid; it does not dissolve. Treat the residue after heating with acetic acid; it dissolves with effervescence; *calcium oxalate.* Treat the original calculus with acetic acid; it dissolves with effervescence; *calcium carbonate.*

B. There is no fixed residue. Apply the murexid test (p. 91).

I. A purple color is developed.

a. Mix a portion of the powdered calculus with a little lime, and moisten with a little water; ammonia is evolved, and a red litmus paper suspended over the mass is turned blue; *ammonium urate.*

b. No ammonia; *uric acid.*

II. No purple color.

a. But the nitric acid solution turns yellow as it is evaporated, and leaves a residue insoluble in potassium carbonate; *xanthine.*

b. The nitric acid solution turns dark brown, and leaves a residue soluble in ammonia; *cystine.*

MODE OF RECORDING AN EXAMINATION.

To systematize and facilitate the work of urine examinations, forms of record have been devised by those working in the subject. I formerly used, with great convenience, that suggested by Prof. Austin Flint, Jr., in his manual on the Chemical Examination of Urine, but for ordinary use in hospital and private practice that of Heller recommends itself for its economy and readiness.

Heller recommends that an ordinary half-sheet of letter paper be folded in four, and marked as indicated below :—

Physical Properties.
Quantity in twenty-four hours, Color and reaction, Sp. gr., Quantity and character of sediment.
Normal Constituents.
Uph. (Urophain.) Cl. (Chlorides.) Ux. (Uroxanthin.) Eph. (Earthy phosphates.) $\overset{+}{U}$. (Urea.) Alkaline phosphates. $\overset{-}{U}$. (Uric acid.) Sulphates.
Abnormal Constituents in Solution.
Sediment.

Abbreviations for the important constituents are used as shown, and the sign "+" for *increased*, the sign "—" for *diminished*, and the letter "n" for *normal*. For *great* increase or *great* diminution, "gr. +" and "gr. —" may be used, and for *slight* increase or *slight* diminution, "sl. +" or "sl. —."

Let us suppose an examination to have been made, with the following results. The word "indican," "*ind.*" is preferred for "uroxanthin," and substituted.

PHYSICAL PROPERTIES.

Quantity in twenty-four hours, 500 c. c.
Color, very pale-yellow. Reaction, acid.
Sp. gr. 1005. Sediment, moderate, flocculent.

NORMAL CONSTITUENTS.

Uph.	gr. —	Cl.	n.
Ind.	sl. +	Eph.	—
+ U	gr. —	Aph.	—
U		Sph.	

ABNORMAL CONSTITUENTS IN SOLUTION.

Albumen, 50 per cent.

SEDIMENT.

Numerous oil-casts, free fatty cells, and free oil-globules.

Diagnosis—Fatty kidney.

TABLES

For Reducing the Metric or French System into the English, and vice versâ, as far as required in Urinarg Analysis.

Grammes to Grains.			Grains to Milligrammes.		
1	=	15.43 (+ .0022)	1	=	64.8 (—.000425)
2	=	30.86	2	=	120-6
3	=	46.29	3	=	194.4
4	=	61.72	4	=	259.2
5	=	77.15	5	=	324.0
6	=	92.58	6	=	388.8
7	=	108.01	7	=	453.6
8	=	123.44	8	=	518.4
9	=	138.87	9	=	583.2

Cubic Centimetres to Minims.			Minims to Cubic Centimetres.		
1	=	16.2 (+ .0293)	1	=	.0616
2	=	32.4	2	=	.1232
3	=	48.6	3	=	.1848
4	=	64.8	4	=	.2464
5	=	81.0	5	=	.3080
6	=	97.2	6	=	.3696
7	=	113.4	7	=	.4312
8	=	129.6	8	=	.4928
9	=	145.8	9	=	.5544

Cubic Centimetres to Fluidrachms.			Fluidrachms to Cubic Centimetres.		
1	=	.27 (+ .0005)	1	=	3.7
2	=	.54	2	=	7.4
3	=	.81	3	=	11.1
4	=	1.08	4	=	14.8
5	=	1.35	5	=	18.5
6	=	1.62	6	=	22.2
7	=	1.89	7	=	25.9
8	=	2.16	8	=	29.6
9	=	2.43	9	=	33.3

Litres to Fluidounces.

1	=	33.8 (+ .011)
2	=	67.6
3	=	101.4
4	=	135.2
5	=	169.0
6	=	202.8
7	=	236.6
8	=	270.4
9	=	304.2

Fluidounces to Cubic Centimetres.

1	=	30 (— .4238)
2	=	60
3	=	90
4	=	120
5	=	150
6	=	180
7	=	210
8	=	240
9	=	270

Litres to Pints.

1	=	2.1 (+ .013188)
2	=	4.2
3	=	6.3
4	=	8.4
5	=	10.5
6	=	12.6
7	=	14.7
8	=	16.8
9	=	18.9

Pints to Litres.

1	=	.473 (+.00022)
2	=	.946
3	=	1.419
4	=	1.892
5	=	2.365
6	=	2.838
7	=	3.311
8	=	3.784
9	=	4.257

Inches to Millimetres.

1	=	25.4 (+ .00005)
2	=	50.8
3	=	76.2
4	=	101.6
5	=	127.0
6	=	152.4
7	=	177.8
8	=	193.2
9	=	228.6

Millimetres to Inches.

1	=	.03937
2	=	.07874
3	=	.11811
4	=	.15748
5	=	.19685
6	=	.23622
7	=	.27559
8	=	.31496
9	=	.35432

Metres to Feet.			Feet to Metres.		
1	=	3.28	1	=	.3048 (+ .0000005)
2	=	6.56	2	=	.6096
3	=	9.84	3	=	.9144
4	=	13.12	4	=	1.2192
5	=	16.40	5	=	1.5240
6	=	19.68	6	=	1.8288
7	=	22.96	7	=	2.1336
8	=	26.24	8	=	2.4384
9	=	29.52	9	=	2.7432

To Convert Degrees of Fahrenheit's Thermometer to Centigrade, and vice versâ.

Centigrade to Fahrenheit.			Fahrenheit to Centigrade.		
1	=	1.8	1	=	.555 (+ .000555)
2	=	3.6	2	=	1.110
3	=	5.4	3	=	1.665
4	=	7.2	4	=	2.220
5	=	9.0	5	=	2.775
6	=	10.8	6	=	3.330
7	=	12.6	7	=	3.885
8	=	14.4	8	=	4.440
9	=	16.2	9	=	4.995

To use this table, convert the given number of degrees Centigrade into degrees Fahrenheit, and add 32°.

To use this table subtract 32° from the given number of degrees Fahrenheit, and convert the remainder into degrees Centigrade.

(*From Dr. Craig's Decimal System.*)

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