URINALYSIS,

A GUIDE FOR THE BUSY PRACTITIONER.
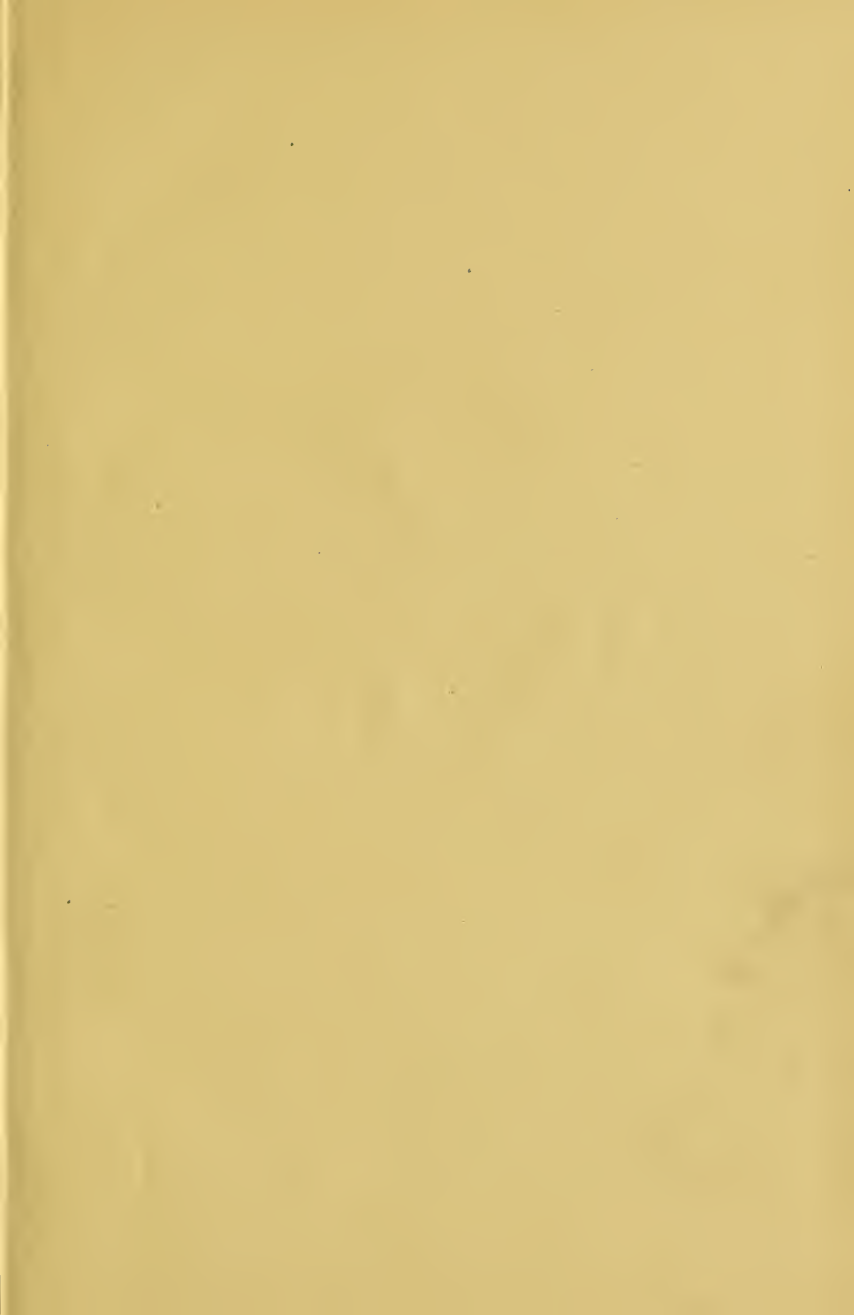
HEINRICH STERN, Ph. D., M.D.

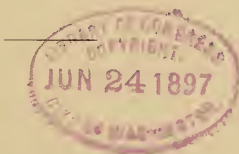# URINALYSIS,

A GUIDE

FOR THE BUSY PRACTITIONER

BY

HEINRICH STERN, Ph.D., M.D.

E. R. PELTON,
129 FIFTH AVENUE, NEW YORK.
1897.

The purport of this little book—thoroughly practical and concise in its scope—is to aid the busy practitioner in his routine work. For theoretical and protracted explanations the physician must naturally resort to the more exhaustive treatises upon the same subject.

H. S.

The Physician's Laboratory.

A medium-sized table and a few shelvings answer well for a physician's laboratory. The table should be covered, if possible, with a plate of stout glass.

Apparatus necessary for urinalysis:

One alcohol lamp, or one Bunsen burner, with rubber tubing.

Twelve test tubes, assorted sizes.

One test tube holder.

One test tube rack.

One test tube brush.

One 2 oz. graduate.

One porcelain evaporating dish.

Two glass funnels, with holders.

One glass stirring rod.

Six glass evaporating dishes, or watch crystals.

Two pipettes.

One Mohr's burette.

Four beaker glasses.

One pair pincers.

One pack white filter paper.

One sheet platinum foil, ¾ in. square.

Two screw-capped vials, containing blue and red litmus paper respectively.

One urinometer.

One albumenometer.

One ureometer.

One saccharometer.

One microscope, and accessories.

For reagents and formulæ of test solutions, see Part II.

Introduction.

Clinical medicine of the day has profited greatly by the advancement of physiological chemistry and by the general and rational use of the microscope. The exact determination of the composition of urine especially furnished us many a clue as to the physiological processes within the organism, and has made us understand the true nature of a variety of pathological changes, which, but a short time since, were neither definitely described nor, in most instances, at all recognized. Urinalysis has become an important factor in investigating and determining disease, and although not all bodily afflictions can be diagnosticated directly by the urine, there is no serious ailment which in some way or other does not cause changes in the condition of the urine.

General Characteristics of Normal Urine.

Quantity of Urine.—The quantity of urine passed by a healthy individual, in twenty-four hours, varies greatly, and is always dependent upon the amount of food and fluids taken into the system and upon the activity of the lungs and the skin. The average amount of urine voided for an adult is estimated at from 1,200 to 1,500 cubic centimetres (40–50 fl. oz.) per diem.

Color.—When freshly voided, the urine of a healthy person is a clear, straw-colored fluid, but as it is in most instances dependent upon the degree of its concentration, it may present all shades of color, from a watery appearance to a deep brown.

Odor.—Normal, freshly voided urine has a peculiar aromatic (urinous) odor, which may be due to the presence in minute quantities of damolic, damoluric, phenylic and taurylic acids. Upon standing, the urine decomposes and acquires a putrid odor, in which ammonia is especially conspicuous.

Consistency.—Normal urine is always aqueous, and flows like water.

Reaction.—Normal, fresh urine is generally more or less acid. This is due to acid sodium phosphate, and not to free acids. The degree of acidity of urine varies at different hours of the day. After meals the pronounced acidity decreases, but it is never perfectly neutral. Occasionally, when voided during the process of digestion, the urine is perceptibly alkaline.

After standing for some time at an ordinary temperature, the urea present is decomposed into ammonium carbonate, thus rendering the urine conspicuously ammoniacal in odor as well as in reaction.

Specific Gravity.—The density of normal

urine varies greatly—it averages between 1,015 and 1,025. Variations therefrom are consistent with perfect health, and depend largely upon the character and quantity of the food taken.

Urinometers are instruments for determining the density of urine. They are small hydrometers, graduated from 1.000 to 1.060, to read specific gravity directly, but are often inaccurate. Dr. Squibb's urinometer is probably the best.

Fig. 1.—Squibb's Urinometer.

Transparency.— Normal, freshly voided urine is always clear, although never perfectly transparent ; upon standing, a slight mucus cloud can be noticed, which remains unchanged when subjected to heat, alkalies or mineral acids.

Solid Matter.—Normal urine contains, when voided in quantities from 1.200 to 1.500 c.c., about 4–6% of solid matter, of which more than half is organic.

A quick, and for all practical purposes sufficient, method to determine the solids of the urine, is the following one : Multiply the last
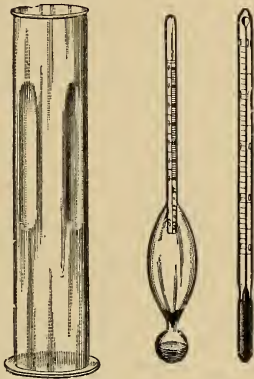
two figures of the specific gravity of the urine by the co-efficient of Häser, which is 2.33. This indicates, in an approximate way, the amount of grammes of solid matter in each 1.000 c. c. of the urine, as for example :   The amount of urine voided in 24 hours being 1.600 c. c., the specific gravity 1.015, with Häser's co-efficient we have

$15 \times 2.33 = 34.95$ grammes in 1.000 c. c. of urine; therefore $\dfrac{34.95 \times 1.600}{1.000} = 55.92$ grammes of solids.

II.

Chemical Analysis.

a. *Normal Constituents of Urine.*

The urine contains about 95% of water ; its composition is very complex ; it contains

Urea, $(NH_2)_2$ CO,
Uric acid, $C_5 H_4 N_4 O_3$,
Kreatinin, $C_4 H_7 N_3 O$,
Kreatin, $C_4 H_9 N_3 O_2$,
Xanthin, $C_5 H_4 N_4 O_2$,   } Organic matter.
Mucin,
Hippuric acid, $C_9 H_9 NO_3$,
Oxalic acid, $C_2 H_2 O_4$,

Urabilin,
Urochrom,   } Coloring matter.
Indican,

Sulphuric acid, $H_2 SO_4$, ⎫
Phosphoric acid, $H_3 PO_4$, ⎪
Chlorine, ⎪
Potassium, ⎪   Inorganic con-
Sodium, ⎬   stituents.
Calcium, ⎪
Magnesium, ⎪
Iron, ⎭

Carbon Dioxide, ⎫
Nitrogen, ⎬ Gases.
Oxygen, ⎭

Detection and Determination of the Normal Constituents of Urine.

Urea.—Normal quantity in the urine, about 2%.

DETECTION :

By hypobromite of sodium.

Add to the urine in a test tube an equal quantity of hypobromite of sodium solution. If urea be present, bubbles appear rapidly.

DETERMINATION :

By hypobromite method.

(Preparation of Knop's test fluid :

250 c. c. distilled water.

+ 100 grms. caustic soda.

+ (after cooling) 25 c. c. bromine.

The solution does not keep well ; it is therefore advisable to prepare it always fresh, thus : 10 c. c. sodium hydroxid sol.

+ 1 c. c. bromine (sol. 1 to 10).

After alkali and bromine are completely mixed, add equal volume of water.)

The ureometer is devised to carry out this method. The most simple and practical instrument is Dr. Doremus's.
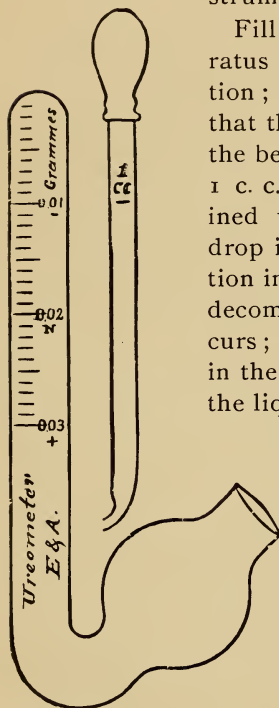
Fill the bulb of the apparatus with the testing solution; incline instrument so that the long arm is filled to the bend at the bulb. Take 1 c. c. of urine to be examined with the pipette and drop it slowly into the solution in the long arm. Rapid decomposition of urine occurs; nitrogen bubbles rise in the long arm of the tube; the liquid flows back into the bulb. In 15 minutes the urea is completely decomposed. The graduation indicates the quantity of urea in the volume of urine examined. If you wish to know percentage of urea instead of grammes per c. c., remove decimal point two figures to the right, for instance :

FIG. 2.—DOREMUS'S URE-
OMETER.

0.02 gramme to the c. c is 2% of urea ; 0.015 gramme is 1.5%.

Uric Acid.—Normal quantity excreted per diem about 0.5 gramme (8 grains).

DETECTION :

By murexide test. Reagents : Conc. nitric acid and diluted ammonia.

Place some urine in an evaporating dish ; evaporate to dryness. Add to the residue 1 or 2 drops of concentrated nitric acid. Evaporate again to dryness. Add 1 or 2 drops of diluted ammonia. Notice the striking purple-red color, which turns violet when potash is added.

Kreatinin.—Normal quantity excreted per diem from 0.75 to 1 gramme (10–16 grains).

DETECTION :

By

Reagents : Nitric acid and phospho-molybdic acid.

Place some urine into a test tube ; add a few drops of nitric acid ; heat gently and add some phospho-molybdic acid. Notice the yellow crystalline precipitate, which dissolves in hot nitric acid.

Xanthin.—Occurs in exceedingly minute quantities ; analysis not practicable. (Neubauer found 1 gramme in 300 litres of normal urine.)

Mucin.—Always present in very small quantities.

DETECTION :

By
Reagents : Acetic acid and liquor iodi comp.

Add to the urine in a test tube a few drops of acetic acid and a few drops of liquor iodi comp.   Notice threads and bands of mucin. If nitric acid is added these are dissolved again.

Hippuric Acid.—Normal quantity excreted per diem about 0.75 gramme (10 grains).

DETECTION :

Reagent :   Nitric acid.

Evaporate urine with nitric acid, heat residue in dry test tube. If hippuric acid be present, an odor like that of bitter almonds is perceivable, due to the development of nitrobenzol.

Oxalic Acid.—Never occurs in the urine in a free state, always as oxalate of lime. Amount excreted per diem about 0.1 gramme (1½ grains).

DETECTION :

As oxalate of lime crystals by microscope.

Sulphates.—Quantity excreted per diem about 2 grammes (30 grains).

DETECTION :

By acidulated barium chloride solution.

Formula of Reagent :

Acid hydrochloric,	-	-	-	1 part.
Baric chloride,	-	-	-	-	4 parts.
Distilled water,	-	-	-	-	16 parts.

Add to 10 c. c. of urine, in a test tube, 3 c. c. of the reagent. Notice the immediate appearance of a white, milky precipitate, indicating the presence of sulphates.

Phosphates.—EARTHY PHOSPHATES excreted per diem about 1 to 1.5 grammes (16–24 grs.)

ALKALINE PHOSPHATES excreted per diem about 2 to 4 grammes (32–64 grs.)

DETECTION :

Of earthy phosphates.

Make the urine alkaline with ammonium, sodium or potassium, and heat. Notice whitish cloud, which soon precipitates white or gray. The latter is dissolved when acetic acid is added.

Of alkaline phosphates.

By magnesium fluid.

Preparation of Reagent :

Liquor ammonium,	-	-	-	1 part.
Ammonium chloride,	-	-	-	1 part.
Magnesium sulphate,	-	-	-	1 part.
Distilled water,	-	-	-	8 parts.

Filter off the precipitated earthy phosphates, and add to the filtrated urine one-third its volume of the reagent. Notice

snowy deposit—precipitated alkaline phos-
phates.

Chlorides. —
$\left\{\begin{array}{l}\text{Chloride of sodium (common salt).}\\ \text{``\qquad`` potassium.}\\ \text{``\qquad`` ammonium.}\end{array}\right.$

Quantity excreted per diem 15 grammes (℥ hs).

DETECTION AND APPROXIMATE DETERMINA-
TION :

By nitrate of silver solution (strength 1 to 8).

Acidify half a test tube full of urine with
a few drops of nitric acid, then add 1 or 2
drops of the nitrate of silver solution.
Note changes ! If rather heavy, either curdy
or lumpy, quickly sinking precipitate,—chlo-
rides are present in the average quantity,
about 0.75%.

If urine only becomes cloudy or milky,
chlorides present are diminished to about
0.1%.

If urine remains unaffected, no chlorides
are present.

———

b. *The Principal Abnormal Constituents of Urine.*

———

Proteids.—
$\left\{\begin{array}{l}\text{Serum albumin,}\\ \text{Serum globulin, hæmoglobin,}\\ \text{Albuminates,}\\ \text{Proteoses or albumoses,}\\ \text{Peptones,}\\ \text{Mucin.}\end{array}\right.$

Dextrose (glucose, grape sugar), $C_6 H_{12} O_6$,

Acetone, $C_3 H_6 O$,

Pus,

Bile acids,

Bile pigments.

Detection and Determination of Abnormal Con-
stituents of Urine.

While for all practical purposes one single test is sufficient to detect or to determine a normal constituent of urine, two or more tests should invariably be applied for the detection or determination of a suspected *abnormal constituent*.

Until recently the proteids occurring in the urine were all classed together as "albumin." There are, at least, six proteid substances which may appear in urine—each of a different significance. The one proteid body interesting us mostly is serum albumin. As tests 1, 2 and 3 are apt to precipitate other proteids than serum albumin, I recommend tests 4, 5 and 6 as trustworthy in detecting serum albumin.

Serum Albumin.— Occurs in urine, mostly together with paraglobulin, and in very minute quantities, rarely over 1–2% by actual weight.

Its presence may depend upon :

1. Pathological conditions of the kidney.
2. Excess of albumin in the blood, and changes of the latter's constitution.
3. Disturbances of circulation.

In many cases albumin is not constantly present; the quantity differs often. The urine may be free from albumin just after rising, when an hour or two later, especially after walking or manual labor, it will be present again.

The occurrence of albumin in the urine, although *per se* an abnormal condition, does not indicate renal changes, unless accompanied by such pathological products in the urine as casts, epithelium, etc., which are the result of kidney disease.

DETECTION :

1. By heat and acetic acid.

Fill a test tube ¾ full of urine. If alkàline, add a few drops of acetic acid. If urine be acid, do not add anything. Boil upper part of urine and examine carefully while holding it against a dark background. If urine, where it was heated, looks turbid, let it cool for a few minutes, and add afterwards a few drops of diluted nitric acid. If turbidity remains or is increased, albumin is present.

2. By heat and nitric acid.

Place about 8 grammes of urine (2 drachms) into a test tube and boil. If precipitate occurs it consists either of earthy phosphates or albumin. To differentiate, add a few drops of nitric acid. If precipitate disappears, it is due to the presence of

earthy phosphates ; if it remains, it is caused by albumin.

3. By nitric acid test (Heller's).

Place about an inch of pure nitric acid into a test tube, and drop the urine to the same amount gently along the inside of the tube while you hold this in an inclined position. This is absolutely necessary, as the urine must lay on top of the acid, and must not mix with it. Notice opalescent zone at the point of contact if albumin be present. If only *small traces* of albumin are present, the ring of coagulated albumin will appear about half an hour later. Therefore, set the tube always aside, if no ring is formed, and re-examine later.

When this test is applied a brownish turbidity may appear, which may be taken for albumin. This is caused by precipitation of urates, *and never appears at the point of contact between the acid and the urine, but in the urine itself*. When heated a little the precipitated urates disappear again.

If mucin be present in excess, a light turbidity may appear near the surface of the urine, when this test is applied.

4. By Purdy's test.

Reagents : Solution of chloride of sodium, saturated and filtered, and acetic acid.

Raise first specific gravity of urine about 10 to 15 degrees by the addition of sodium-

chloride solution.   Fill test tube two-thirds
with this urine, add 1–2 drops of strong
acetic acid, and boil upper part of urine for
about half a minute.   Examine in good
light, and if albumin be present it will ap-
pear in the upper boiled portion of the
urine as a milk-like turbidity, more or less
pronounced according to the amount of
albumin present, while the lower, unboiled
portion remains perfectly clear.   This test
avoids the mucin reaction.

<div align="center">5. By ferrocyanide test.</div>

<div align="center">Reagents : Solution of potassium ferrocyanide 1 to 20 ;
and acetic acid.</div>

Fill test tube half full of urine, add 1
drachm (4 grammes) of potass. ferrocyanide
solution.   Shake well and add 10 to 15 drops
of acetic acid.   If albumin be present it will
be precipitated throughout the urine as a
milk-like flocculency—more or less pro-
nounced according to amount of albumin
present. *Never add acetic acid before the alka-
line potass. ferrocyanide solution* is mingled
with the urine, on account of precipitation of
mucous.   This test is a most trustworthy one.

6. By Tanret's reagent, the potassio-mercuric-iodide
test.   Modification by Elliott, of Chicago.

<div align="center">Preparation of Reagent :</div>

Iodide of potassium, - -	3.32 grammes.
Bichloride of mercury, -	1.35 grammes.
Acetic acid, - - - -	20 c. c.
Distilled water, - - -	64 c. c.

(Dissolve iodide of potass. and bichlor. of merc. separately in water, and mix the solutions. Then add the acetic acid, and filter.)

Fill test tube half full of urine, add 5 to 10 drops of acetic acid and 4 grammes (℥ i) of the reagent. If albumin be present, even in the smallest amount, a precipitate will occur. If there be no reaction, it may be concluded that the urine is free from all proteid substances, and all further tests for them may safely be abandoned.

If precipitate occurs, heat; if caused by peptones or proteoses, it will disappear or will diminish; if caused by serum albumin or by mucin, it will remain unaltered or will be intensified.

If precipitate persists after heating, submit fresh urine to the ferrocyanide of potassium test (No. 5). If positive reaction follows, serum albumin is present. Negative result shows the substance present to be mucin.

If heating causes disappearance of original precipitate, indication is that either peptones or proteoses are present. Apply again potassio-mercuric-iodide test to some fresh urine, and shake precipitate with ether. If due to peptones or proteoses it is not dissolved. Differentiate between these two by sulphate of ammonium test.

FIG. 3.
ESBACH'S
ALBUMINOM-
ETER.

DETERMINATION :

By Esbach's method.

Reagent :

Picric acid,	-	10 grammes.
Citric acid,	-	20 "
Distilled water,		q. s. 1000 c. c.

This test is made with the albuminometer, a standard graduated glass tube.

Fill albuminometer with urine to letter *U.*, add reagent to *R.*, close tube with stopper and shake until urine and reagent are thoroughly mixed. Put the tube aside for 24 hours, and then read off number of grammes of albumin to the litre (1000 c. c.), which will be indicated by number on side of the albuminometer on a level where albumin settles. If, instead of number of grammes of albumin per 1000 c. c., *percentage* of albumin be desired to be known, remove decimal point one figure to the left ; for instance, 3 grammes per litre would be 0.3% of albumin. Esbach's albuminometer is graduated to 7 grammes per litre, 0.7% of albumin. If urine be very rich in albumin, it should be diluted with one or two volumes of water

before testing, and result multiplied by 2 or 3, according to degree of dilution.

Globulin.—Is nearly always associated with albumin in the urine.

DETECTION :

Fill a test tube with water and drop into it some large drops of urine. If globulin be present, each falling drop is followed by a milky streak, which, when 15 or 20 drops have fallen, give the water a slight milky appearance. The addition of acetic acid clears the water again.

Hæmoglobin.—

DETECTION :

Fill test tube one-half of urine and boil. If hæmoglobin be present, a mottled precipitate of albumin and hæmatin will appear. Add caustic potash to the boiling urine. Note resulting clearness of urine, which turns green when examined in thin layers.

Peptones.—Occur often in combination with *albumoses*, and closely resemble each other.

Halliburton differentiates between the two :

Pepton.	*Deutero-albumose.*
1. No precipitate with nitric acid.	No precip. with H N O$_3$, unless considerable amount of Na Cl be added. This precip. disappears on heating and reappears on cooling.
2. Is not precipitated by saturation with ammonium sulphate.	Is precipitated by saturation with ammonium sulphate.

DETECTION :

By ammonium sulphate.

Saturate slightly acidified urine with ammonium sulphate, and filter out any precipitate, which may consist of albumin, globulin and albumose. Proteid remaining may be precipitated by potassio-mercuric-iodide, and can only be the peptone.

Mucin.—Occurs in normal and abnormal urines. It is considered abnormal when found in unusual large quantities.

(See under "Normal Constituents," page 15.)

Dextrose (glucose, grape sugar).—Occurs in urine as a result of temporary conditions, and is persistently present in diabetes mellitus.

Urine which is light in color, of a spe-

cific gravity above 1028, should always
be tested for dextrose.

DETECTION :

1. By bismuth test (Boettger's).
Reagents: Liquor potassæ and basic nitrate of bis-
muth.
Remove albumin before applying this test !

Place 5 c. c. of urine into a test tube and
add the same amount of liq. potass., and
also a little nitrate of bismuth. Boil gently.
Note, if glucose be present, gray or black
color of precipitate. The darker the color
the greater the amount of sugar present.

2. By Fehling's solution.
Formula of Reagent :
Crystallized cupric sulphate, 34,639 grammes.
Sol. of sodium hydroxid,   -   500 c. c.
Neutral sodium tartrate, - -   173 grammes.

(Dissolve sulphate of copper in 100 c. c.
of distilled water ; then dissolve neutral
sodium tartrate in sodium hydroxid solu-
tion, and add slowly and in intervals the
copper solution, and bring finally the vol-
ume of the whole up to 1000 c. c. with
distilled water.

The solution decomposes readily. It is
best to have it always prepared freshly in
just the quantity needed. The pellet form,
devised by Pavy, in which the salts for the
solution are kept separately, does not re-
tard decomposition either.

If testing with *Fehling's solution* or with *any other copper test, do not boil urine longer* than for about *half a minute.*)

Fill test tube with about 5 c. c. of the test solution and boil. If test solution remains clear blue, add 3 or 4 drops of urine to be examined, and keep boiling. Note, if much sugar be present, after a short time, dense yellow color, and later a yellowish-red sediment falling to the bottom of the tube.

If no reaction occurs continue adding urine to test solution, *but the urine's volume must never exceed that of the test fluid.*

3. By Haines's test.

Formula of Reagent :

Copper sulphate, - -	30 grains (2 grms).
Distilled water, - -	℥ hs. (15 grms).
Make a perfect solution and add	
Pure glycerin, - -	℥ hs. (15 grms.)
Mix thoroughly and add	
Liquor potass., - -	℥ v. (150 grms.)

Solution remains stable and is always trustworthy for testing.

Fill 5 c. c. of the test fluid into a tube and boil gently. Then add from 6 to 8 drops—*never more*—of the suspected urine, and boil again. If sugar be present a yellow or yellowish-red precipitate is thrown down. If no such precipitate occurs sugar is absent.

4. By phenil-hydrazin test.

Reagents: Phenil-hydrazin hydrochloride, sodium acetate and distilled water.

(CAUTION.—Be careful in handling phenil-hydrazin hydrochloride as it may produce, if brought in contact with the skin, a nasty eczema.)

Add to 25 c. c. of urine 1 gramme of phenil-hydrazin hydrochloride, 0.75 gramme of sodium acetate and 10 c. c. of distilled water. Place the whole in a water-bath after having it put into a suitable vessel, and warm it for about one hour. Remove then the vessel and allow it to cool ; if sugar
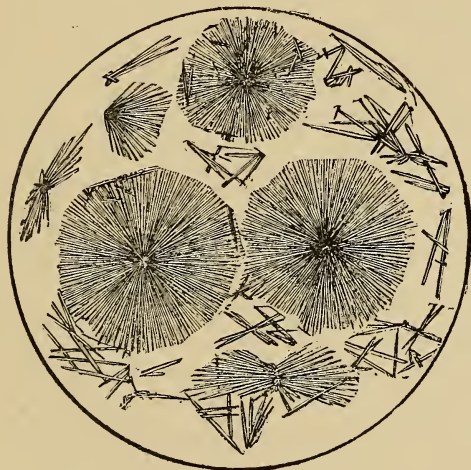

FIG. 4.—CRYSTALS OF PHENYLGLUCOSAZONE.
(After von Iaksch.)

be present—if even only in traces—a yellowish precipitate will form, which may appear amorphous macroscopically, but which when examined microscopically will be seen to contain fine bright-yellow, needle-like crystals, either single or arranged in stars,—phenylglucosazone.

This test is very trustworthy and can be highly recommended, as it gives no reaction with any other substances of the urine than grape sugar.

DETERMINATION :

1. By fermentation.

Take *two* specimens of about 100 grammes each from the 24 hours urine and add to one a little German yeast. Perforate stopper of bottle where yeast is contained, and keep the other bottle tightly corked. Set both bottles in a warm place—about 70 to 80° Fahrenheit—and allow to ferment. In about 24 hours fermentation of sugar is completed. Next take specific gravity of both specimens. The degrees of density lost indicate the number of grains of sugar in each fluid ounce of the tested urine. For instance, if specific gravity of urine be 1.045 *before* fermentation and 1.020 *after* fermentation, 25 grains of sugar were contained in the urine.

To determine amount of sugar in per cents., approximately, multiply number of

lost degrees by *0.23*. If metric system is used, each degree of specific gravity lost will correspond to .2196 grammes of sugar in every 100 c. c. of urine.

2. By Fehling's solution.

Place 10 c. c. of the solution into a porcelain capsule and dilute with 40 c. c. of water. Dilute urine with *nine times* its volume of water, and fill a Mohr's burette with the same. Slowly bring diluted solution to boiling point and add the urine from the burette in small portions to the boiling solution until the blue color has completely disappeared. Gently boil after each addition from the burette and let the mixture stand for a few seconds, after which examine carefully if it contains any blue color.

When blue color has disappeared entirely, read off from the burette the quantity of diluted urine employed for the test, and as it takes just 0.05 gramme of grape sugar to remove blue color in the 10 c. c. of Fehling's solution, the percentage of the sugar may be readily determined.

3. By Whitney's reagent.

Formula of Reagent (parts by weight):

			GRAMMES.
Ammonii sulphatis (C. P.),	-	-	1.2738
Cupri sulphatis (C. P.),	-	-	2.5587
Potassii hydroxid (C. P.), -	-	-	19.1620
Aquæ ammon. (sp. gr. 8.80),	-	-	312.2222
Glycerini (C. P.),	-	-	60.
Aquæ (dest.),	-	-	q. s.

Accuracy, stability, simplicity, reliability and perfect end reaction are claimed for this reagent. The Lewis Chemical Company, No. 1300 Broadway, New York City, keeps this reagent, accurately compounded, in stock. In order to save trouble and annoyance in preparing it, it would be best to procure the reagent from that firm.

For practical testing with Whitney's reagent *ten minims of urine* only are used.

Heat 4 grammes (℥ i) of the reagent in a test tube to boiling ; add urine slowly, drop by drop, until the blue color begins to fade; then more slowly, boiling three to five seconds after each drop, until the reagent be *perfectly colorless*, *like water*, or until ten drops only are added.

Dr. Whitney has prepared the following table :

If reduced by	It contains to the Ounce	Percentage
1 minim	16. grains or more	3.33
2 minims	8. "	1.67
3 "	5.33 "	1.11
4 "	4. "	0.83
5 "	3.20 "	0.67
6 "	2.67 "	0.56
7 "	2.29 "	0.48
8 "	2. "	0.42
9 "	1.78 "	0.37
10 "	1.60 "	0.33

Reagent, after reduction, will turn blue again on cooling. This should not be as-

cribed to imperfect reduction or defect in the reagent.

If urine contains a large amount of albumin, reduction proceeds as usual, but reagent presents a yellowish tint, more or less pronounced according to amount of albumin. If urine contains too much sugar, dilute with one to ten volumes of water.

Acetone.—A product of albumin decomposition ; occurs in the course of a variety of pathological conditions, especially in the advanced stages of diabetes mellitus.

DETECTION :

1. By Chautard's test.

Reagent : Aqueous sol. of magenta decolorized by sulphurous acid.

To 5 c. c. of urine add *one* drop of the reagent. If acetone be present in quantities over 0.01 per cent., a violet color will appear in five minutes.

2. By Lieben's test.

Reagents : Potassium iodide and liquor potassæ.

Distill small quantity of urine, if possible. Take into a test tube 4 c. c. (℥ i) of liq. potassi, add 1.35 grammes (20 grains) of potassium iodide and boil ; next float the urine (a distillate if possible) upon the test solution. Note at the point of contact precipitation of phosphates, which becomes

yellow and filled with molecules of iodoform
if acetone be present.

Pus.—Occurs in urine as the result of inflam-
mation and lesion in some part of the
urinary tract. On account of its tur-
bidity and sediment, urine containing
pus often resembles urine rich in gran-
ular urates, and its deposit often closely
resembles that due to earthy phos-
phates. *Heat* clears urine containing
urates, while it increases turbidity of
pus containing urine; addition of *an
acid* dissolves phosphates, while turbid-
ity of pus containing urine is increased.

DETECTION :

By Donnes's test.

Let sediment settle, pour off supernatant
urine, and add liquor potassæ. If sediment
be pus, it is immediately converted into a
substance of gelatinous-like consistency,
which sticks to the glass, and pours like a
heavy syrup.

Bile Acids.—Occur in urine in a variety of
pathological conditions, especially in
malaria and hepatic congestion. They
are very toxic.

DETECTION :

By Pettenkofer's test.
Reagents : Concentrated sulphuric acid and cane
sugar.

Take some urine into a porcelain capsule, add some cane sugar, and dissolve the latter ; then add slowly, drop by drop, concentrated sulphuric acid, and stir continually with a glass rod, taking care all the time that the temperature does not rise above 70° Celsius. The solution turns to a cherry red and then changes to purple afterwards, if bile acids be present.

As albuminous substances (when subjected to the same treatment) give the same color, in order to make this test for the bile acids a trustworthy one, spectroscopical examination for the two characteristic bands should be made, if possible.

Bile Pigments.—Occur in urine in jaundice, phosphorous poisoning, and a number of pathological conditions of the liver. The urine under such circumstances is always of a brownish or greenish hue.

DETECTION :

1. By Ultzmann's test.

Reagents :   Satur. caustic potash sol. and hydrochloric acid.

Place 10 c. c. of the urine into a test tube, add 3 c. c. of satur. caustic potash sol., and acidify with hydrochloric acid. Note beautiful green color of urine if bile pigments be present.

2. By Gmelin's test.

Reagent: Nitric acid and nitrous acid of commerce
$(HNO_3 + NO_2)$.

Place a few drops of urine on a white
porcelain capsule and allow a drop of nitric
acid, yellow with nitrous acid fumes, to run
into it. Note, if bile pigments be present,
appearance of rainbow-like play of colors—
green, blue, violet, red and yellow.

The same test may be applied as follows:

Place some concentrated nitric acid, con-
taining a little yellow nitrous acid, into a
test tube, and add thereto some urine, while
you hold the tube in an inclined position.
If bile pigments be present there will appear
in the zone between the fluids from below
upward the colors green, blue, violet, red
and yellow.

III.

Microscopical Examination.

The microscope[1] is a very valuable adjuvant
in urinalysis, and this can never be called
complete unless the sediments of the urine
have been subjected to a rigid microscopical
examination.

The sediment is usually obtained by allow-

[1] The necessary technique and practical knowledge for micro-
scopical work may be acquired best by practical instruction. A
few lessons from one experienced with the work will generally
suffice.

ing the urine to settle for a number of hours—
from 18 to 24—in a conical glass, at the bottom
of which it generally collects.

The more modern method of obtaining
urinary sediments is by means of the centrifu-
gal separator. Its advantages over the old
method are principally—*permittance of an im-
mediate microscopical examination; examination
may be made of freshly voided urine before any
changes occur in it.*

Urinary sediments may be divided into two
classes, viz., *chemical bodies* and *anatomical
bodies.*

a. *Chemical Bodies.*

The chemical bodies as found in urinary
sediments may be subdivided again into :

1. Sediments in acid urine :—
    Uric acid, urates, calcium oxalate, cal-
    cium sulphate, hippuric acid, and into :
2. Sediments in alkaline urine :—
    Triple phosphates, calcium phosphate,
    ammonium urate, calcium carbonate,
    leucin and tyrosin, and cystin.

1. *Sediments in Acid Urine.*

Uric Acid.—Occurs mostly as a reddish sedi-
    ment, and is readily perceptible by the
    naked eye. The crystals are usually
    quite large, and often concrete together,
    appearing like red sand or gravel at the
    bottom or along the sides of the vessel

containing the urine ; they differ from all other urinary sediments in their color ; they may appear occasionally pale yellow, but they are never colorless.

Under the microscope the crystals present various forms, viz.:

Rhombic prisms, cubes, quadrangular plates, circles, long pointed crystals, which are often united at one end, thus forming beautiful figures, as stars, rosettes, etc.
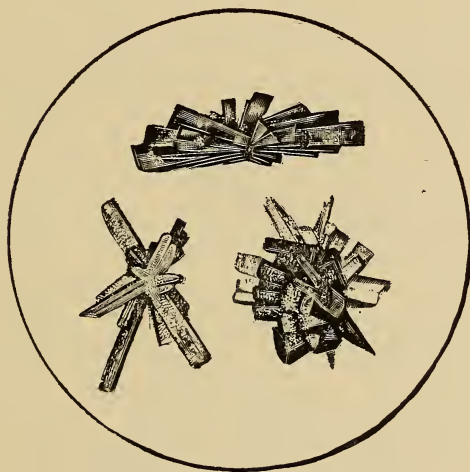

FIG. 5.—URIC ACID CRYSTALS.

Uric acid crystals are of clinical and pathological importance when deposit occurs soon after the urine is voided. Normal urine

generally precipitates its uric acid crystals after standing ten or more hours. If uric acid be thrown down soon after cooling of urine, it may be concluded that the same is liable to happen *before* it is voided, thus causing formation of gravel and calculi.

The great majority of stones is entirely or chiefly composed of uric acid—from 75% to 90%. Uric acid calculi are quite large, very hard and dense.

Acid Urates.—

Acid Urate of Sodium forms a sediment which is most always granular or amorphous. It ranges in color from light pink

FIG. 6.—ACID URATE OF SODIUM CRYSTALS.

to red-brown and may occur in a crystalline form, star or fan shaped.

Acid Urate of Potassium occurs only in amorphous form, and is, like acid urate of sodium, a constituent of the mixed urate deposit or " brick dust."

Acid Urate of Calcium may also occur as a urinary precipitate.

With uric acid the urates (the principal constituent of which is the *alkaline urate of ammonium*) form calculi often met with in children ; with *calcium oxalate* urates form rather often occurring calculi. Urate calculi attain very seldom a greater diameter than one centimeter, and are neither very hard nor dense.

Calcium Oxalate.—The crystals of calcium oxalate in the urine belong to two distinct varieties. The most common and most characteristic shape is that of octahedra, with high refracting powers. They are soon recognized under the microscope, as squares or rectangles, colorless and with diagonal lines, the whole resembling an envelope. The second form met with are the " hour-glass" and " dumb-bell " crystals ; they are really oval-shaped bodies.

These crystals are much smaller than uric acid crystals and do not dissolve in alkalies,

water, alcohol, ether or acetic acid, but are readily soluble in hydrochloric or other mineral acids.

FIG. 7.—CALCIUM OXALATE CRYSTALS.

Calcium oxalate is not infrequently found in the deposit of urine after a vegetable diet, as for instance, asparagus or rhubarb. The oxalate of lime or "mulberry calculi" most always occur as large and rough con-· cretions, which are very hard and brittle. Pure calcium oxalate calculi occur often, but they frequently occur in combination with uric acid.
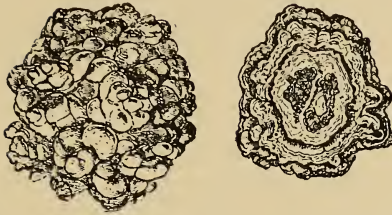
FIG. 8.—MULBERRY CALCULUS, ITS SECTION.

Calcium Sulphate Crystals occur occasionally in the deposit of urine in the form of radiating needles, but seem to bear no special significance.

Hippuric Acid.—Is excreted in large amounts by herbiverous animals, but occurs only in small amounts in human urine, and then especially after the prolonged use of certain vegetables and fruits. The crystals of hippuric acid occur usually as colorless prisms with well defined ends, and vary considerably in size.

2. *Sediments in Alkaline Urine.*

On standing for some hours the urine becomes alkaline. This is due to the formation of carbonate of ammonia, and then a new class of urinary sediments appear, which are all soluble in dilute acids.

These deposits consist to the greater part of the earthy phosphates—the triple phosphate and the calcium phosphate.

Triple Phosphate, or **Ammonio-Magnesium Phosphate,** $Mg\ NH_4\ PO_4.\ 6\ H_2O.$ —Occurs always in fermenting ammoniacal urine, and is only of clinical interest when occurring in the urine at the instant it is voided.

There are two principal forms of crystals of triple phosphate. The star-shaped, feathery variety, occurring but rarely in urine, and the " coffin-shaped " variety—rectangular prisms with beveled ends, ranging in size from the most minute crystals to great transparent masses.

FIG. 9.—TRIPLE PHOSPHATE CRYSTALS.

Calcium Phosphate or **Phosphate of Lime,**
$Ca_3(PO_4)_2$.—Occurs not only in alkaline,
but also in its crystalline form, in slight-
ly acid, to ammoniacal decomposition
tending urines, and forms mostly amor-
phous deposits, which may be mistaken
by the naked eye for pus or other or-
ganic substances.   Under the micro-
scope the amorphous sediment presents
itself as small, colorless granules.

The crystalline variety of phosphate of
lime is not often met with as a deposit of
urine. The wedge-like, prismatic crystals

FIG. 10.—CALCIUM PHOSPHATE CRYSTALS.

vary greatly in size and shape, and often form stars or rosettes, the points of the wedges turned towards the centre.

Urine, which is already alkaline when voided, throws down the triple phosphates at once. The ammoniacal decomposition of urine occurs in these cases *within* the organism, in the urinary organs, and then mucus and pus are regularly present.

Calcium phosphate calculi do not occur frequently. They may be of a dense or spongy structure, and appear in two forms— the round or oval-shaped, ranging in size from a bean to a hen's egg, and chalky in appearance and to the touch, and the irregular shaped, which are of a more grayish color and of a dense structure.

Calcium phosphate and triple phosphate often concrete. The concretion has been termed "fusible calculus," and attains often a large size. This calculus is rather spongy, of a grayish-white color, insoluble in water and alkalies but very soluble in mineral acids. They are invariably caused by ammoniacal urine.

Ammonium Urate.—Occurs in sediment of urine associated with the phosphates, presenting characteristic yellow or brownish spheres, to which spikes or projections are generally attached. They

vary greatly in shape and are often called "thorn apple" shaped crystals. The smaller ammonium urate crystals often occur without spikes.

FIG. 11.—AMMONIUM URATE CRYSTALS.

Calcium Carbonate.—Occurs but rarely in urine. It forms little spheres, which evolve carbon dioxide when treated with acetic acid. Concretions of calcium carbonate are small and smooth, and are often of a great density. They occur rarely.

Leucin and Tyrosin.—Most always occur together, also in urine. They are the final products of tryptic digestion of certain proteid substances, and are met with in the urine during the course of certain pathological conditions of the liver and in acute phosphorus poisoning.

Leucin, $C_6 H_{13} NO_2$.—Crystallizes in white, glistening plates and also in little clusters of fine needles, branching out from a centre. In the deposit of urine, it is often impure, and appears yellowish, hardly showing any crystalline structure and resembling minute drops of oil.

Leucin has a greasy feeling but is *insoluble* in *ether*—the mode of differentiation from oil particles. It is soluble in heated alcohol and in alkalies. Its nature may be confirmed by Scherer's test. When fused with nitric acid on platinum foil leucin leaves a colorless residue, which on being heated with potassium hydrate yields an oil-like substance not adhering to the platinum foil.

Tyrosin, $C_9 H_{11} No_3$. — Crystallizes in sheaves of very fine, snow-white, radiating crystals. It dissolves with difficulty in cold water, dissolves readily in hot water and hot alcohol, in acids and alkalies. Tyrosin responds readily to Millon's reaction.
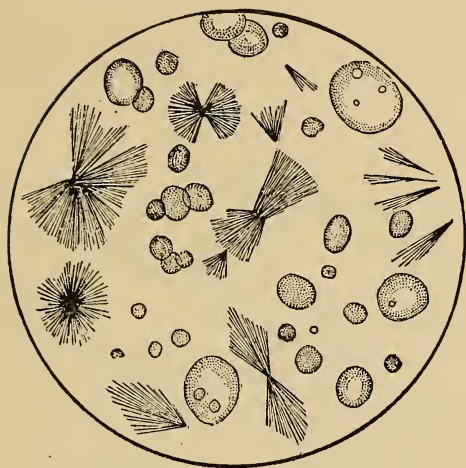
FIG. 12.—LEUCIN AND TYROSIN CRYSTALS.

Cystin, $C_3 H_7 NSO_2$.—Occurs rarely in the urine. It is found in two forms: 1—as six-sided plates of "mother-of-pearl" appearance, and 2—as four-sided square prisms, with high refractive power and laying singly or in star clusters.

Cystin is *insoluble* in alcohol, ether, acetic acid, cold and hot water, and in solutions of ammonium carbonate, but is *soluble* in caustic alkalies and strong acids.

Cystin crystals somewhat resemble those of uric acid, and may be readily distinguished from the latter by different methods. The most simple method consists in treating

crystals with hydrochloric acid—cystin crystals are dissolved while those of uric acid remain unaffected.
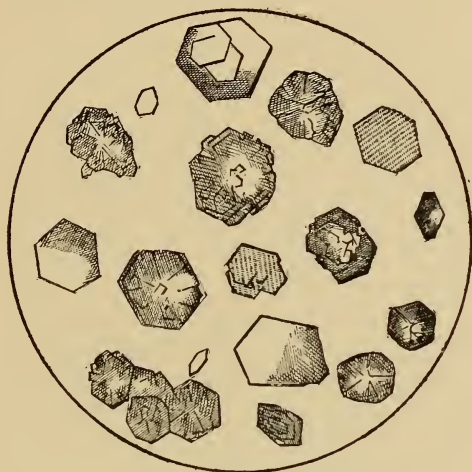
FIG. 13.—CYSTIN CRYSTALS.

Cystin contains about 25% of sulphur and differs on this account from most organic substances of the body. Cystin concretions do not occur frequently in the bladder. They are mostly of a round or cylindrical form, medium-sized and compressible.

b. *Anatomical Bodies.*

The anatomical bodies in urinary sediments may consist of, or contain :

Blood, Pus, Epithelial Cells, Casts, Fungi and Bacteria, and Spermatozoa.

Blood.—As a sediment in urine may come from any part of the genito-urinary tract. In hæmorrhages from the *kidney*, the urine usually presents a reddish-brown color, a lowered specific gravity, an acid reaction, and contains renal epithelium and casts. Hæmaturia may be caused by the so-called Bright's disease, by amyloid and tubercular renal disease, by malignant growths of the kidney, by renal calculus, -abscess, -embolism, -cysts, etc., by the action of certain drugs, as cantharidis, etc., and as a result of injuries to the kidneys.

In hæmaturia of *vesical origin* the urine is very often alkaline in reaction, especially so if chronic cystitis be present. Triple phosphates, mucus and pus are usually in the train of vesical hæmaturia. The blood is brighter than in hæmaturia of renal origin. The causes of vesical hæmaturia are principally : stone in the bladder, cys-titis, carcinoma, neoplasms, etc.

Hæmaturia of *urethral origin* may be diagnosed by the hæmorrhage occurring be-fore the urine is voided. It is caused by acute urethritis, blenorrhœa, chancre or cutting of strictures. The microscopical characteristics of blood corpuscles are so well known, that I refrain from giving them here again. In urine, though, after they
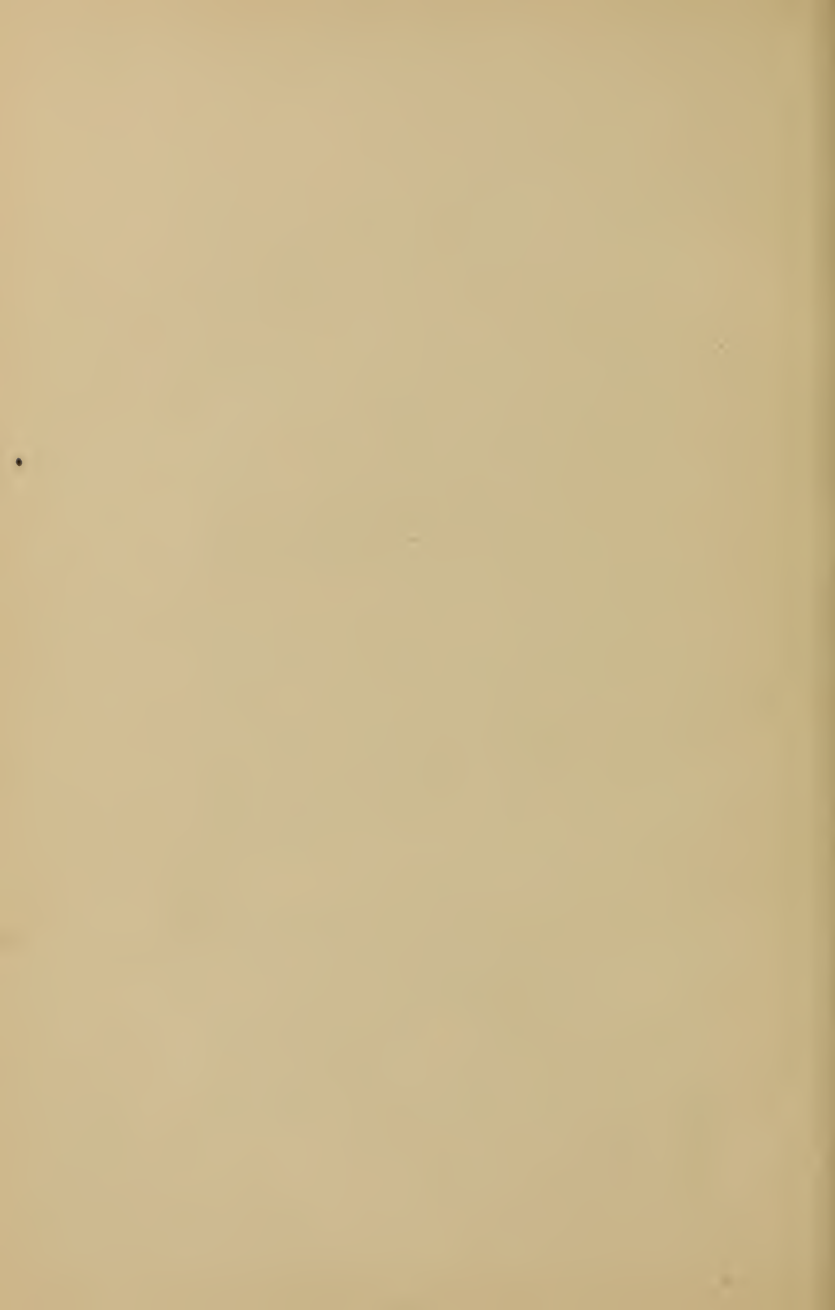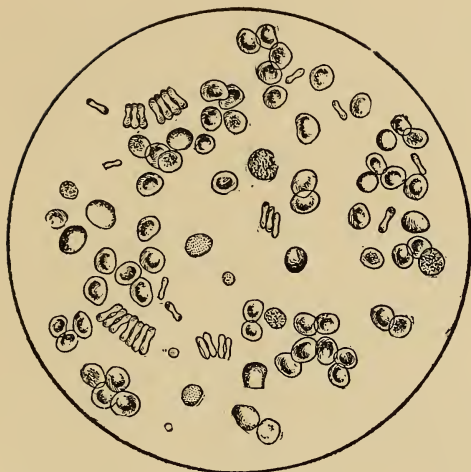
FIG. 14.—HUMAN BLOOD CORPUSCLES.

have soaked for any length of time, espe-
cially if a decomposition takes place, they
lose their sharp, clear, round outline, and
become rather shapeless and more or less
granular, so that they may be mistaken for
pus corpuscles. They may, however, be
distinguished from the latter by the absence
of visible nuclei.

Pus.—As a sediment in urine may be caused
by inflammatory processes of any part
of the urinary tract. When the pus
cells are derived from the *kidney* they
indicate a suppurative inflammation of

that organ and are usually accompanied with considerable amount of albumin and with pus casts. The urine in these cases generally retains its acidity. When the pus cells are of *vesical origin* the urine is often ammoniacal when passed, or it very soon turns alkaline upon standing. In these cases the urine contains large quantities of mucus and its deposit is of a more syrup-like consistency and tenacity than when the pus corpuscles are derived from the kidney. Amorphous and triple phosphates and excess of bladder epithelium are usually accompanying pus cells derived from the bladder. Pus derived from affections of the *prostate* often appears in the form of threads, and pus corpuscles caused by *urethritis* are very similar, appearing as little string-like threads.

Pus cells present under the microscope a circular, quite colorless, granular disc-like appearance, and are larger than the blood corpuscles. They show distinct nuclei, which are often multiple.

When pus cells are treated with some acetic acid they lose their granular appearance, swell up, become more colorless, and their nuclei become even more visible. Hydrate of potassium and other caustic alka-

lies convert the pus corpuscles into a gelati-
nous substance.   (See Donnes's test for
pus.)

Pus cells which remain for some time in
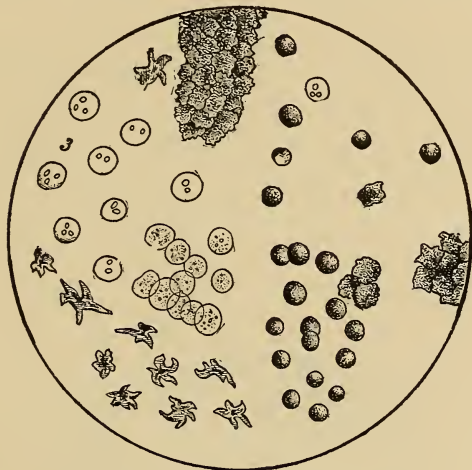alkaline urine may be similarly converted.

FIG. 15.—PUS CORPUSCLES.

Epithelium.—Epithelial cells from some part
of the urinary apparatus are to be met
with in small quantities in every urine.
In pathological conditions of the urin-
ary organs, however, the epithelium is
often thrown off in considerable quan-
tities.

The various cells are by no means char-
acteristic—as claimed by many observers—

for certain locations or lesions of the urinary tract. The epithelial cells are masses of protoplasm with single nuclei, and are most always granular in structure. They occur as a urinary deposit in three varieties.

a. Round Epithelial Cells are small and round, and show nuclei. They resemble pus cells but are somewhat larger and have a more visible, single nucleus. The round cells may originate from any part of the urinary tract, but if they predominate in a urine in which also albumin is contained, it may be concluded that they are of renal origin.

FIG. 16.—EPITHELIUM, AS FOUND IN URINARY DEPOSIT.

b. Columnar Cells are of various shapes and sizes, but are always elongated and have a distinct nucleus. They generally are thrown off in the small passages of the urinary apparatus, and it is claimed that they never originate in the kidney itself.

c. Squamous Cells, or "pavement" epithelial cells, are large and flat and have a distinct nucleus. They are usually derived from the bladder or the vagina. Those coming from the latter are most always the larger and occur often in sheets, whereby the cells overlay each other like the tiles on a roof.

Casts.—Urinary casts are of the utmost clinical importance, and when closely studied are a positive aid in diagnosis of renal disease and of its course. It seems to be generally agreed upon, that the material which forms the basis of the casts is a proteid substance, not kindred, however, to any proteids with which we are acquainted, and that they are formed of coagulated blood proteids, which pass into the tubules, thus rendering the urine albuminous. In addition thereto the urine may contain little plugs of already coagulated proteid matter. This coagulation occurs as the proteid substances are traveling

along the tubules, which may be plugged up by the coagula to such an extent, that they cannot transmit any urine. Finally, however, these clots are driven out of the tubules by the pressure of the urine—these clots are what we designate as casts.

The casts formed in this manner are diminutive, cylindrical masses with parallel sides. One end of the cast is generally rounded off—the result of the rolling around of the soft and tough material of which it is composed.

There are three classes of renal casts :

1. Those composed of morphological substances, as epithelium, blood- and pus-corpuscles.

2. Those composed of broken-down morphological substances, as seen in the granular casts and fatty casts.

3. Those clear casts, generally termed "hyaline."

Epithelial Casts are generally medium sized, and are soon discovered under the microscope. Their presence in the urine is a conclusive sign of inflammation in those parts, from whence they derive. The cells appear swollen and granular and may occur in rows or patches over the surfaces of the casts.

Blood Casts do not occur frequently in the urine, and are generally difficult to find.

Pus Casts are also of rare occurrence, but pus cells are sometimes found on the surface of granular casts.

Granular Casts occur in the urine in different variations, as highly granular, finely granular, coarsely granular, light and dark granular, etc., and differ consequently in size, shape and appearance. They are white, gray, yellowish and brown, and contain often on their surfaces epithelial cells, fat globules and leucocytes.

FIG. 17.—EPITHELIAL CASTS.

Hyaline Casts are rather colorless and transparent, and when more opaque are called *waxy casts*. They are generally of considerable length and often difficult to

detect. The so-called *narrow hyaline casts* are exceedingly transparent and non-refracting, while the *broad hyaline casts* reflect better and are more distinct in structure.

Fatty Casts are those where minute, shiny globules of fat, either unbound or in epithelial cells, are impacted in granular or hyaline casts.

Casts are hardly heavier than water, and settle very slowly in the urine. Generally an antiseptic is added to this, and about 18 hours are allowed for the precipitation. The modern centrifugal method perfects sedimentation in a few minutes.

FIG. 18.—GRANULAR CASTS.

FIG. 19.—NARROW HYALINE CASTS.

FIG. 20.—FATTY CASTS.

Fungi.—Upon standing at an ordinary temperature for some time, *normal* urine becomes filled with *micro-organisms*. *Abnormal* urine, when just voided, contains already, in most cases, micro-organisms.

In decomposing urine we find examples of the three classes of fungi—molds, yeast plants and bacteria.

Molds occur quite rarely and may appear after the urine has been exposed to the air for some time, but not when glucose is present, in which instance they will make their appearance in large quantities just after the alcoholic fermentation.

Yeast Plants occur in small quantities in nearly every specimen of decomposing urine. They consist of round or oval-shaped cells with a nucleus. These cells are generally arranged in bead-like forms, with additional cells or buds occasionally attached thereon. In diabetic urine the yeast fungi develop very rapidly and in great abundancy.

Bacteria.—Are present in all decomposing urines. The micrococcus ureæ is an organism of comparatively large size and occurs mostly in chainlike strings, but

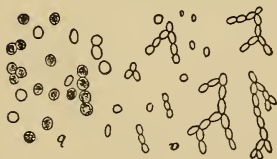FIG. 21.—YEAST FUNGI IN URINE. also as single

round bodies. The urine may also contain a great variety of other microorganisms.

Pathogenic Bacteria, so called, are said to occur in the urine in two varieties, as micrococci and bacilli. A number of micrococci and bacilli certainly do occur in the urine. In the estimation of the writer, however, they are neither pathogenic nor does their presence aid and establish a trustworthy or rational urinary diagnosis.
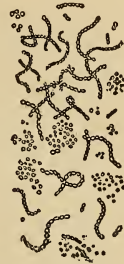

FIG. 22.
MICROCOCCUS
UREÆ.

Spermatozoa.—Are found not infrequently in normal and abnormal urine. They are very minute thread-like bodies with a head shaped like a pear, and with a long, slender, tapering, tail-like extremity. In urine spermatozoa are most always in the quiescent state, and they retain their typical form even after the urine has stood for a number of days.
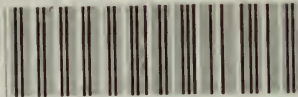
FIG. 23.—SPERMATOZOA IN SEDIMENT OF URINE.