PRACTICAL URINE TESTING:

A GUIDE

TO OFFICE AND BEDSIDE URINE ANALYSIS,
FOR PHYSICIANS AND STUDENTS.

BY

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PREFACE.

The importance of urine testing at the bedside for the immediate detection of pathological conditions and for watching the progress of disease is now recognized, and reagents for the detection of sugar, albumin, etc., form a necessary part of a physician's armamentarium. The recent investigations in this department of chemistry have brought forward convenient and accurate methods of urine analysis which enable the physician to obtain in a minimum of time all the information which is of any value to him. It is the aim of this little volume to give concise directions for office and bedside testing, embodying all the latest advances that have proved to be of value.

Particular attention has been given to the qualitative and quantitative tests which from their cleanliness and ease of application, and the simplicity of apparatus required, commend themselves to the practicing physician.

Part I is devoted to a brief consideration of the chemistry of the urine in health and disease,

and concisely discusses the relative utility of various methods of testing for normal and pathological ingredients.

Part II presents a systematic scheme for urine analysis unencumbered by physiological or pathological data; a chapter on the microscopical examination, one on the analysis of calculi, and one on apparatus and reagents.

Much of the subject matter has been compiled from various sources, but the author has condensed and arranged it in a manner which, in his judgment, is best suited to the purpose in view.

It was thought not best to burden the text with too many references; in addition to those given, the author acknowledges indebtedness especially to Charles' "Physiological and Pathological Chemistry," Witthaus' "Manual," Ralfe's "Clinical Chemistry," Oliver's "Bedside Urine Testing," and Tyson's "Practical Examination of Urine."

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PART I.

Physiology and Pathology of the Urine

CHAPTER I.

PHYSICAL CHARACTERS.

Quantity. The average healthy adult man passes from 35 to 50 ozs. (1000—1500 cc.) in 24 hours. The adult woman from 30 to 40 ozs. (900 to 1200 cc.)

The quantity is **increased**—

Physiologically by—

Increase of general blood pressure;
Increase of the pressure within area of renal artery;
Copious drinking;
Contraction of the cutaneous vessels;
The action of diuretic foods and drugs.

Pathologically—

In diabetes insipidus and mellitus;
In granular kidney with cardiac hypertrophy;
In the early stages of waxy kidney;
After the absorption of œdematous fluids or exudates;
In convalescence from fevers;
In hysteria, chorea and epilepsy.

The quantity is **diminished**—

Physiologically by—

Decrease of general or local blood pressure;
Profuse sweating;
Non-nitrogenous food.

Pathologically in—
Weakened heart action;
Active and passive congestion of the kidneys;
All acute inflammatory diseases and fevers;
Diarrhœa, enteritis and cholera;
Mechanical compression or closure of ureters;
The last stage of all forms of Bright's disease;
Cirrhosis of the liver.

Transient variations in quantity are of little significance; persistent variations always demand investigation.

Color. Normal urine varies from a pale straw color to a deep amber. The color is **changed—**

Physiologically by—
Variations in concentration;
The ingestion of certain foods and drugs. (Rhubarb, logwood, indigo, madder, etc., their distinctive color; santonin, yellow, bile-like color; carbolic acid and creosote, olive green.)

Pathologically it is *paled* by—
Hysteria and other paroxysmal nervous diseases;
Diabetes mellitus and insipidus;
Chronic Bright's disease;
Convalescence from acute diseases.

It is *darkened* by—
Disorders of the liver;
Fevers and acute inflammatory diseases;
Diarrhœal disorders;
Admixture with blood (according to the degree of decomposition of the hæmoglo-

bin it is red, dark brownish-red or smoky);
Bile-pigments (deep, yellowish-brown with intense yellow froth).

Odor. The characteristic not unpleasant odor of normal, freshly-passed urine is well known. Concentrated urines have a strong odor. Old urines develop a putrescent and ammoniacal odor. In newly-passed urine this is indicative of chronic organic disease of the urinary tract. Various drugs and articles of food, *e. g.*, turpentine, asparagus, impart peculiar odors to healthy urine.

Transparency. Perfectly normal urine is clear when passed, although slight disturbances of the chemistry of the body, not manifested by symptoms, may give rise to some turbidity due to earthy phosphates or mixed urates. Many pathological urines are perfectly clear.

Pathological turbidity may be due to—
Urates;
Phosphates;
Pus;
Mucus;
Chylous urine;
Granular and fatty debris of epithelium in Bright's disease;
Blood.

Specific gravity. The average specific gravity of normal urine is about 1020. It varies much within physiological limits. As the specific gravity depends upon the proportion of water to the dissolved solids, conditions that disturb these relations affect the specific gravity

A healthy man of average weight, 140 pounds, should excrete about 50 ozs. (1500 cc.) of urine in 24 hours, of a specific gravity of 1020. This urine will contain 4 per cent. of solid matter, or about 20 grains to the ounce, or 1000 grains in 24 hours.

From the specific gravity an approximate quantitative estimation of the urinary solids may be made. In general, the amount of total solids is a measure, (1) of the activity of tissue change; (2) of renal integrity; (3) of abnormal constituents in the urine. Estimation of solids from the specific gravity is a ready method of obtaining important information.

Hygienic conditions favoring increased metabolism, as abundant food, active exercise, etc., *increase*, and the opposite conditions *decrease* the solid matter in the urine.

Pathologically the urinary solids are **deficient**—

(1) With the urine *normal* or *sub-normal* in amount—

(a) From *defective and enfeebled metabolism*, as—

Senility;
Anæmia;
The cachexias of syphilis, cancer, etc.;
Chronic alcoholism;
Functional or organic diseases of the liver.

(b) From *renal failure*, as in—

Acute nephritis;
Acute exacerbations of chronic renal disease;
The close of Bright's disease;

The early stage of Bright's disease (sometimes);
Venous congestion of the kidneys (cardiac disease, etc.).

(2) With the urine *increased* in amount—
In diabetes insipidus;
Interstitial nephritis (often);
Amyloid disease of the kidney (often);
Chronic parenchymatous nephritis.

The urinary solids are **increased**—

(1) With the quantity *not increased* in—
Fevers;
Lithæmia;
Some forms of dyspepsia.

(3) With the quantity *increased* in—
Diabetes;
Phosphaturia (phosphatic diabetes);
Azoturia (excessive secretion of urea).

The urinometer is generally used to determine the specific gravity. A specific gravity bead, however, made to float at 1.005 offers many advantages over it. The bead is cheap, portable, not easily broken, and with it the specific gravity of very small quantities of urine may be taken. The bead must be very carefully tested, as any inaccuracies are magnified by the dilution of the urine that is necessary.

Reaction. The reaction of fresh normal urine is usually acid. Some urines show what is termed the *amphoteric reaction*, that is, give both the acid and alkaline reaction to test paper. The acidity is due to the presence of acid sodium phosphate, NaH_2PO_4, and also, perhaps, to some extent to minute quantities of free carbonic, uric and hippuric acids. It must be admitted, how-

ever, that little or no free acid can be detected by sodium hyposulphite. The amount of acidity in the total urine of 24 hours is equivalent to 30 to 60 grains (2 to 4 grams) of oxalic acid.

Physiologically there is **increased acidity**—

During the night;
With a flesh diet;
After strong muscular exertion;
During the intervals of gastric digestion;
After the ingestion of mineral acids.

Pathologically—

In fevers;
In rheumatism;
After asthmatic attacks;
In emphysema, pneumonia, pleuritis.

Physiologically the urine is **less acid** or **alkaline**—

During gastric digestion;
After hot or prolonged cold baths;
After profuse sweating;
After copious ingestion of vegetable acids and their salts.

Pathologically—

In acute and chronic inflammation of the urinary tract, as cystitis, pyalitis;
In decomposition of the urine in the bladder in retention;
In some cerebral and nervous diseases;
In anæmia, chlorosis, general debility.

Acid fermentation. When urine is set aside in a cool place it gradually becomes more acid. This is called the *acid fermentation.* To what it is due is a matter of dispute. Landois and Sterling think it results from the development of a special microbe. The process is ac-

companied by the deposition of uric acid, acid sodium urate and calcium oxalate. The fungus and the bladder mucus decompose part of the urine pigment into lactic and acetic acids, and the latter sets free uric acid from neutral sodium urate; a part of the neutral sodium urate is changed to the acid urate.

Alkaline fermentation. After longer exposure to a warm atmosphere the urine becomes neutral, and finally strongly alkaline in reaction. It becomes turbid, has an ammoniacal odor, and deposits triple phosphate, ammonium urate and great numbers of microbes. An iridescent film containing triple phosphate crystals covers its surface. This *alkaline fermentation* is due to the transformation of the urea into ammonia and carbon di-oxide $CO(NH_2)_2+H_2O=2NH_3+CO_2$ under the influence of a microbe which appears in the form of free globules, of articulated filaments or of chaplets. It has received the name of *micrococcus ureæ*. This ferment is conveyed through the air, like other microbes of fermentation. So long as the urine remains acid it does not exist in the bladder. It, however, is common around the orifice of the urethra, and sometimes gains entrance to the bladder through the medium of a sound or catheter. Experiments have shown this microbe to be the true cause of the ammoniacal fermentation of the urine. Sternberg has demonstrated that only the microbes of the air or those about the urethral orifice can produce it. Urine guarded against the introduction of these organisms may be preserved in a sterilized vessel for an indefinite time without undergoing any change.

Consistence. Normal urine is perfectly aqueous.

Pathologically it may be thick or glutinous from—

Mucus;
Decomposed pus;
Molecular fat (chyluria).

CHAPTER II.

NORMAL CONSTITUENTS.

Urea. ($C\ O\ N_2H_4$.) Urea is the principal constituent of the urine, this fluid containing from 2 to 4 per cent., or an average mean of 2.5 to 3.2 per cent. It forms nearly one-half the total solids of the urine.

It is the end product in the decomposition of the proteids forming the tissues of the body and ingested in the food. The change takes place in the liver, spleen and tissues generally. According to Oliver, urea is chiefly formed by the disintegration of the red blood cells in the liver. The mean amount excreted in 24 hours by a healthy man is 525 grains (35 grams); by a woman 385 grains (25 grams). The amount varies greatly within the limits of health.

Physiologically the urea is **increased** by—

Large eating; nitrogenous food;
Copious ingestion of water;
Exercise and muscular vigor.

It is **decreased** by—

Fasting or spare feeding;
Non-nitrogenous food;
Reduction of water in the diet;
Alcoholic beverages, tea or coffee;
Indolence of mind and body.

Pathologically the urea varies with the total solids. In disease the activity of metabolism and the integrity of the kidneys may be deter-

mined by the quantitative estimation of the urea. For ordinary clinical work the specific gravity may be utilized for this purpose, and it gives fairly approximate results. Often, however, it may be of great value to determine the amount by a more accurate method.

Uric Acid. ($C_5H_4N_4O_3$.) This body occurs *free* in normal urine only in the most minute quantity (soluble in 18000 parts of cold, and 15000 parts of boiling water). From 7 to 10 grains (.5 to .7 grams) are excreted daily in the form of acid urates of sodium and potassium. It is a less oxidized metabolic product than urea, but it is not proven that it is a precursor of urea.

Physiologically it is **increased** and **diminished** *pari passu* with urea.

Pathologically it is **increased** by—

Indigestion;
Acute dropsies, rheumatic and catarrhal inflammations;
After attacks of gout;
In cancer of the liver (Harley);
In leukæmia;
All disturbances of the circulation and respiration.

It is **decreased**—

In chronic maladies in general;
Diabetes and polyuria;
Before paroxysms of gout, and during chronic gout;
Anæmias;
Chronic rheumatism;
Chronic disease of spinal cord.

Urine Pigments. What the urinary pigments are is still a subject of controversy.

Urobilin (hydrobilirubin) is the chief urinary pigment. The red blood corpuscles are decomposed in the liver into bile pigment and urea. Bile pigment is converted in the small intestines by the action of free hydrogen into urobiline, a small portion of which is absorbed and excreted in the urine. Conditions that increase the destruction of red blood corpuscles, therefore, increase the intensity of the color of the urine. Chemical tests for variations in the quantity of this body are imperfect, and for clinical purposes valueless.

Urine Indican. (Uroxanthin.) $C_{52}\,H_{62}\,N_2\,O_{34}$. The presence of this pigmentary body is fairly well determined. It is colorless, but is transformed into indigo blue by various reagents. It is present in but small quantity in normal urine, but subject to much variation.

The *pathological* significance of increase has not yet been fairly determined. It has been found to be **decreased** in

Derangements of the nervous system ;
During reaction from cholera ?
Cancer of the stomach and abdomen ;
Addison's disease ;
Cirrhosis of the liver ;
All diseases attended by intestinal obstruction :
Some forms of diarrhœa ;
Typhoid fever, peritonitis, phthisis.

Hippuric Acid, kreatinine, phenol-sulphuric acid and some other complex organic compounds are more or less constant constituents of normal and pathological urine, but they are of interest only to the physiologist.

INORGANIC CONSTITUENTS.

These chiefly consist of sodium, potassium, ammonium, calcium, magnesium and iron, combined with hydrochloric, phosphoric and sulphuric acids. The determination of the presence and amount of these substances is often of physiological interest, and may sometimes furnish valuable evidence of disease and its progress. In ordinary examinations of urine, however, their determination may be omitted.

Chlorides. Next to urea the chlorides form the chief portion of the urinary solids. Sodium chloride is by far the most abundant. Daily 150 to 185 grains (9.7 to 12 grams) are excreted.

The chlorides are **increased** *physiologically—*

After the ingestion of salt foods and much water ;
Mental and physical activity ;
During pregnancy ; and,

Pathologically—

After the crises of fevers ;
After the absorption of exudates ;
In diabetes (occasionally).

The chlorides are **decreased** *pathologically—*

In all acute fevers ;
Pneumonia (often entirely absent during hight of disease) ;
In cholera ;
In most chronic diseases.

An increase, or the re-establishment of the excretion of chlorides in disease is generally a

favorable sign. In pneumonia it is a precursor of the crisis, and may often take place before other symptoms reveal the favorable change.

Phosphates. Phosphoric acid occurs in the urine combined with sodium and potassium (*alkaline phosphates*) and calcium and magnesium (*earthy phosphates*). From 70 to 90 grains (4.7 to 5.8 grams) are excreted in 34 hours.

Physiologically variations in the amount are caused chiefly by the character of the food.

Pathologically the phosphates are **increased**—

In rickets ;
Osteomalacia ;
Chronic rheumatism ;
Diseases of the nerve centers ;
After great mental strain and worry.

Sulphates. Sulphates of sodium and potassium are excreted in the urine, the quantity varying from 45 to 60 grains (3. to 4. grams).

Physiologically, the sulphates are **increased**—

By the ingestion of sulphur and its compounds ;
Nitrogenous food ;
Conditions of increased metabolism.

CHAPTER III.

ABNORMAL CONSTITUENTS.

PROTEIDS.

The proteids found in the urine under various conditions are *serum albumin*, *globulin*, *albuminates*, *peptones*, *fibrin* and *mucin*.

Serum Albumin. Albuminuria is a *symptom* of many pathological conditions, and occasionally occurs in persons apparently healthy.

Amount. The amount of albumin in pathological urine varies from $\frac{1}{20}$ per cent. or less to $2\frac{1}{2}$ or 3 per cent. It may rise to 4 per cent. The average amount is $\frac{1}{10}$ to $\frac{1}{2}$ per cent. In 24 hours 60 to 150 grains (4 to 10 grams) are ordinarily excreted. The amount may be so high as 400 grains (26 grams).

Functional Albuminuria. By delicate testing minute traces of albumin may at times be demonstrated in the urine of a majority of healthy persons. Chateaubourg of Paris found traces of albumin in the urine of 321 soldiers out of 423 examined. Of 142 healthy children the urine of 111 contained albumin. The observations of Senator and Laube in Germany, of Oliver in England, and Purdy in this country, show similar results. My own experience, also, is the same.

Probably no individual ever lives for any length of time with the body in a perfectly

physiological condition—with every function perfectly performed; with waste and repair, ingestion and exercise, assimilation and excretion perfectly balanced. The vicissitudes of climate and weather, diatetic errors, slight digestive disturbances, mental and muscular exertions, to which the average man is constantly exposed, are sufficient to determine the imperfections in the delicate chemistry of nutrition that give rise to this symptom. It is very necessary for the observer to be familiar with the reaction which the urine of healthy persons will sometimes give, and he should carefully note it in a series of specimens. The most sensitive tests are necessary, as heat after acidulation, picric acid or potassio-mercuric iodide, and the most delicate manipulation.

Albumin in easily recognizable quantity is not infrequently found in the urine, especially of young adults, without there being any attendant great disturbance of bodily health or recognizable renal disease. Many of these individuals appear perfectly healthy, others are anæmic or suffering from some constitutional taint, as syphilis, scrofula, rheumatism, etc. This condition has been described by various writers as "intermittent albuminuria," "cyclical albuminuria," "albuminuria of digestion," "albuminuria of adolescents," etc., and has recently attracted considerable attention. A careful study of these non-dangerous albuminurias is important.

The conditions which have been found to be attended by this symptom are—

Severe muscular exercise, or any exercise.

Errors in diet, diet rich in proteids, or simply the ingestion of any food (dietetic albuminuria).

Mental emotion, exercise or worry.

The albuminuria may be paroxysmal, intermittent, remittent or, more rarely, persistent. The quantity of albumin discharged is small, $\frac{1}{10}$ to $\frac{1}{20}$ per cent. or less. The urine is dark colored, of normal or high specific gravity, contains the normal or an excessive quantity of urea, and the bile salts are usually increased. Casts are absent.

Opinions differ as to the conditions which immediately give rise to this form of albuminuria. They may be—

Dilatation of the vessels in the renal area;

The formation of more diffusible proteids during digestion;

Excess of saline constituents in the blood;

Increased hæmolysis;

A combination of two or more of these conditions.

Dr. C. H. Ralfe believes all functional albuminurias to have one etiological factor, namely, abnormally increased hæmolysis, and he considers functional albuminuria and hæmoglobinuria to be intimately related—the albuminuria being simply a minor manifestation of hæmoglobinuria. In health the effete hæmoglobin is decomposed in the liver into pigment and urea. In disease the hæmolytic action is so increased that some of the albumin or hæmoglobin escapes transformation, passes into the general circulation and is excreted by the kidneys.

Ralfe* expresses the gradations of hæmolytic action and their results thus:

* London Lancet, Am. Reprint, Dec., 1886.

Ordinary hæmolysis,	Urinary pigment, Urea.	Normal urine.
Active hæmolysis,	Increase of urinary pigment, Increase of urea.	Urine of digestion.
Increased hæmolysis,	Increase of urinary pigment, Appearance of bile pigment, Increase of urea, Albumin in urine.	Functional albuminuria.
Extraordinary hæmolysis,	Hæmoglobin in urine, Increase of urinary and bile pigment, Increase of urea, Albumin in urine.	Hæmoglobinuria.

As causes of the increased hæmolysis he suggests increased irritability of the vaso-motor reflex center and the formation, probably owing to disorder of the blood-forming organs, of corpuscles unable to withstand unusual disintegrating influences.

Classification of Albuminurias.

(1) *Renal affections.* The kidneys have undergone structural change, and the albumin filters into the urine because of inflammatory and degenerative changes in the epithelium of the Malpighian capsules and the tubes. The changes in the inflammatory and specific fevers are vaso-motor paralysis, mild tubular catarrh, swelling and proliferation of the epithelium.

(a) *Diseases primarily affecting the kidneys—*

Acute congestion (a chill, action of medicinal irritant);

Acute nephritis;

The different forms of chronic Bright's disease;
Renal (tubular) concretions.

(b) *Diseases secondarily affecting the kidneys*—
Retention of urine from obstructed ureters;
Last stage of diabetes;
The exanthemata;
Diphtheria;
Typhus and typhoid fevers;
Cholera;
Pyæmia;
Pneumonia;
Peritonitis.

(2) *Disturbed renal circulation* from extra-renal cause—reduction or increase of blood pressure. Whether the blood pressure is increased or diminished is often difficult to determine. The renal epithelium remains healthy.

Compression of renal arteries or veins by tumors, etc.;
Pregnancy and other abdominal tumors;
Compression of aorta above renal vessels;
Diseases of the heart;
Cirrhosis of the liver;
Pleuritic effusion;
Chronic bronchitis, pneumonia, phthisis;
Great reduction of temperature;
Epilepsy, tetanus, lead colic.

(3) *Disturbed innervation.* The albuminuria is caused by changes in the diameter of the blood vessels, and sometimes perhaps by trophic changes in the renal epithelium.

Organic lesions of different parts of brain and spinal cord;
Mental strain and worry;
Exophthalmic goitre;

Delirium tremens;
Cerebral hemorrhage.

(4) *Alterations in the constitution of the blood.* The diminished blood pressure and degenerative changes in the epithelium permit the filtration of albumin into the urine.

Anæmia, chlorosis;
Scurvy, purpura;
Gout;
Syphilis;
Tuberculosis;
Poisoning.

(5) *Admixture with albuminous fluids, as—*

Blood;
Pus;
Semen;
Vaginal secretions.

Many times a combination of two or more of the above general conditions are present. In acute nephritis, for example, destruction of renal epithelium, disturbed circulation and admixture with blood all contribute to the albuminuria.

Tests for Albumin in the order of their delicacy.

Potassio-mercuric iodide. Tanret's reagent. May be used in solution, tablet or test paper.

Bodies precipitated. Albumin, globulin, albuminates, peptones, alkaloids, mucin.

Delicacy. Detects 1 part albumin in 20.000.

Precautions. When a reaction occurs the solution must be heated. Peptones, urates, alkaloids and mucin dissolve. When the reagent is used in solution a mucin reaction sometimes occurs that closely simulates albumin, the concen-

trated reagent and acid preventing the solution of the precipitate by heat. According to Dr. Oliver this source of fallacy may be avoided by using the reagent in the form of test paper. The test paper or tablet is dissolved in 60 minims (4 cc.) of water in a test tube and 15 minims (1 cc.) of the urine added. The faint precipitate of mucin is redissolved by heat. The behavior of this reagent with mucin and other urine constituents should be very carefully studied before it is used as an albumin test.

Remarks. This reagent detects the most minute traces of albumin. Many urines of healthy persons give a reaction. This delicacy makes the reagent a very valuable one, but it must be used with caution, and its indications must be confirmed by other tests. Its great value is as a general test for proteids and as a reagent to quickly and certainly exclude albumin. A urine that gives no precipitate with potassio-mercuric iodide, or one that dissolves by heat, is absolutely albumin-free; further testing is superfluous. The faint opacity which many healthy urines give will never, after a little observation, be mistaken for pathological albuminuria. The very fact that it precipitates so many bodies is a source of security rather than weakness. The observer will find so many urines that give a precipitate with this reagent which clears up by heat that he will soon mechanically correct it. A reagent with a source of occasional error, like heat, is a much more dangerous one.

Sodium Tungstate. Used in saturated solution, tablet or test paper with citric acid. It may be used by the contact method.

Bodies precipitated. Serum albumin, globulin, albuminates, peptones.

Delicacy. Detects 1 part albumin in 20.000.

Precautions. When reaction occurs solution must be heated. Peptones dissolve.

Remarks. It will be noted that alkaloids are not thrown down by this reagent, and it thus serves to distinguish between peptones and alkaloids. The solution is clear, and it is a very delicate and reliable test.

Picric Acid. Advocated by Dr. George Johnson. Used in saturated solution, powder, tablet or test paper without acidulation.

Bodies precipitated. Serum albumin, globulin, albuminates, peptones, alkaloids. After some time (crystalline) uric acid and kreatinine.

Delicacy. Detects 1 part albumin in 20.000.

Precautions. The reagent must always be used in excess. When reaction occurs boil the solution; peptones and alkaloids dissolve.

Remarks. A very delicate and reliable test. It is particularly valuable as a pocket reagent, as it is also an excellent test for glucose. The intense yellow color may prove to some a slight hindrance to the detection of minute quantities of albumin.

Heat. A temperature of from 164° F. to 167° F. coagulates serum albumin. The most delicate and reliable method of use is to acidify a 3 or 4 inch column of urine by a drop of acetic acid and heat the upper half. By comparison with the lower clear portion the slightest haze may be detected.

Bodies precipitated. Serum albumin, globulin, earthy phosphates.

Delicacy. When carefully applied it has almost the delicacy of the above tests.

Precautions. The precipitation of the earthy phosphates is ordinarily prevented by the acidulation, but to certainly exclude this source of error a drop or two of nitric acid must be added after boiling. Any remaining precipitate or opacity is albumin. Care in acidulation is absolutely necessary. The native albumins are readily converted by the slow action of acids and alkalies into albuminates, which do not precipitate by heat. Albumin in this state, even when present in large quantity, may escape detection by the heat test. The reaction of the urine will be the guide to the amount of acid necessary. Many highly acid urines, as those that deposit urates or uric acid, require no previous acidification, while a highly alkaline one may require 3 or 4 drops of acetic acid. This point demands judgment and some experience.

Remarks. The heat test is, perhaps, the most frequently used of all the albumin detecting methods. It is open to the objection that the greatest care is necessary to exclude occasional erroneous results. It should never be alone relied upon. As peptones and albuminates escape detection by heat, it cannot be used as a general test for proteids.

Potassium Ferrocyanide. Used in saturated solution, tablet or test paper with acetic or citric acid.

Bodies precipitated. Serum albumin, globulin, albuminates; very rarely urates (Oliver). I have as yet never seen this reagent precipitate urates even with concentrated solutions.

Delicacy. Detects 1 part albumin in 10.000 (Oliver).

Precautions. This reagent must be used *cold.* Boiling decomposes the ferrocyanide with the formation of a white precipitate.

Remarks. It will be noted that this reagent does not precipitate alkaloids or peptones. It is almost entirely free from sources of error, does not require boiling for correction, is portable, and not too delicate. It therefore forms one of the readiest applied and most reliable albumin reagents. If the physician wishes to use but one test in his routine work this one should be selected. The reaction takes place rather slowly, and my own experience does not give it a much greater delicacy than nitric acid.

Acidulated Brine, Introduced by Dr. Roberts of England. It may be applied by the contact method.

Bodies precipitated. Serum albumin, globulin, albuminates, peptones, urates.

Delicacy. Detects 1 part albumin in about 8.000.

Precautions. The solution must be heated. Peptones and urates dissolve.

Remarks. I have found this to be a most satisfactory test. The solution is colorless, and does not give a color reaction like nitric acid to obscure a delicate ring.

Nitric Acid. This reagent should be used only by the contact or Heller's method (page 58). The simple addition of nitric acid to urine is coarse and inaccurate.

Bodies precipitated. Serum albumin, globu-

lin, albuminates. Rarely oleo-resins, urates and excess of urea give a hazy ring.

Delicacy. Detects about 1 part of albumin in 6000.

Precautions. Sometimes oleo-resins, urates and urea give a ring as above noted, but it is diffuse, situated *above* the point of contact, and is readily dissipated by heat. Urines containing these substances with albumin give two rings—the sharply defined albumin ring at the point of contact and the hazy ring above it.

Remarks. Although within its limits nitric acid is a very reliable test, it is an intensely corrosive agent, there are other equally reliable, cleanly and portable tests of about the same range of albumin detecting power that can replace nitric acid. I never use it except for purposes of comparison and study.

Globulin. Serum globulin is found in the urine along with serum albumin in some forms of renal disease. Werner reports a case of nephritis in which it was the only proteid found.

It is thrown down by heat and all the other albumin precipitants. It differs from serum albumin in being insoluble in water. It is readily converted into albuminates. It is soluble in saline solutions, and is thus held in solution in the urine. When present it may be detected by adding water to the urine until it has a specific gravity of 1002 or 1003; the globulin forms a cloudy precipitate.

It has been found in the urine in—

Vesical catarrh;
Acute nephritis (early stage);
Advanced chronic renal disease;
Waxy kidney (most abundant).

Albuminates. Serum albumin, and particularly globulin, when subjected to the action of acids or alkalis, are transformed into *albuminates* or *derived albumins.* They may be regarded as acid and alkali combinations of neutralization precipitates. Solutions of albuminates precipitate by neutralization but *not by heat.* Conditions favoring the formation of albuminates are found when the urine is alkaline, or when an excess of acid has been added to acidify. Careful neutralization of a urine containing one of these bodies causes a precipitate. These important modifications of albumin may always be detected by the use of potassio-mercuric iodide, sodium tungstate, potassium ferrocyanide, etc., as albumin tests.

Peptones. These products of the digestion of proteids occur not infrequently in the urine in disease. Their presence is always a pathological occurrence. A number of peptones have been identified, representing successive steps in the gastric and pancreatic digestion of albumin. Whether one or more of these find their way into pathological urine has not yet been determined.

A product intermediate between albumin and peptone — *Hemialbumin* or *Propeptone* — has been found in the urine in two cases of osteomalacia. It differs somewhat in its reactions from both albumin and peptone, but is thrown down by the ordinary precipitants for these bodies.

Peptone may be the only proteid found in a specimen of urine, or it may accompany albuminuria. It often precedes albuminuria. I have found but few urines giving the peptone reac-

tion. Just what pathological changes or condition give rise to peptonuria have not been determined. It has been noted in :—

(1) *General diseases*, as—

Diphtheria ;
Small-pox ;
Typhus, typhoid and malarial fevers ;
Cerebro-spinal meningitis ;
Puerperal fever ;
Septicæmia ;
Acute phosphorus poisoning.

In these diseases it is sometimes indicative of profound tissue changes.

(2) *Local inflammations*—

Croupous pneumonia (frequently) ;
Pleurisy ;
Acute nephritis ;
Acute rheumatism ;
Abscess ;
During absorption of purulent exudates.

It is especially liable to accompany inflammations tending to the formation of pus, and in obscure cases of suspected suppuration it may be a valuable diagnostic sign.

(3) *Hepatic disorders.*

Dr. Oliver considers peptonuria to be caused by some defect in the constructive assimilation of the products of tryptic digestion. A portion of the peptone, absorbed from the intestine, passes through the liver into the general circulation, and is excreted by the kidneys. It is well known that proteids are converted into peptone by prolonged contact with animal tissues, and by the fermentative action of bacteria. Urine peptones may occasionally have such a source.

Detection. Of the reagents used for the detection of albumin, peptone is *precipitated* by—

Potassio-mercuric iodide ;
Sodium tungstate ;
Picric acid ;
Acidulated brine.

The precipitates by these reagents are soluble by heat.

It is *not precipitated* by—

Potassium ferrocyanide, nitric acid or heat.

The precipitates by potassium iodide and picric acid are not distinguishable from those of alkaloids. Sodium tungstate gives a precipitate soluble upon heating, but it does not precipitate alkaloids. This reagent, then, forms a presumptive test for peptones. Ralfe's modification of the biuret test is a ready clinical method ; the reaction, however, is not very apparent with small amounts of peptone. The phosphor-tungstate and biuret tests are the most accurate.

Fibrin is met with in chylous urine, from which it is separated in a light gelatinous clot. It is recognized by its power of decomposing hydrogen peroxide with effervescence.

Mucin. This proteid is a more or less constant constituent of normal urine. The hazy cloud which collects in the middle of a vessel of urine is mucus, made visible by the entangled epithelium, crystals and debris. It is particularly abundant in catarrhal inflammations of the genito-urinary tract. It is precipitated by alcohol, dilute mineral acids and organic acids. Acetic or citric acid used by the contact method forms a convenient test for this proteid. Pus decomposed by alkalies forms a thick, glairy de-

posit in urine, which is not infrequently mistaken for mucus.

The chief point of interest that attends the presence of mucin in the urine is its reaction to albumin precipitants. With some of these reagents it reacts similarly to albumin, and the observer should become familiar with these sources of fallacy in albumin testing.

Dr. Oliver gives the following method of studying the mucin reaction: The clear saliva and a solution of salt (say 20 grains to the ounce) should be mixed together in equal parts, and 1 drop of acetic acid or a citric paper should be added to a 4-inch column, which should then be thoroughly boiled, when the milkiness produced by a trace of albumin will appear. This highly muciferous solution is now added to albumin free urine—in such proportion as the observer may wish to charge it with mucin, *e. g.*, 1 to 1 or 1 to 2. In any case the urine will then become more highly muciferous than is likely to be met with in the course of practice. Filtration may be dispensed with—being slow—if observation be checked by some of the untreated fluid, held by the side of that experimented on. A citric and a mercuric test paper added to 90 minims produces an opacity exactly like that induced by a small quantity of albumin; but it differs from it in completely vanishing when heated. The opacity returns as the temperature of the solution falls, and in the cold it greatly exceeds the original amount. Heat will again disperse it as before. The characteristic feature of the reaction is the great increase of the opacity which follows the clearing up by heat; just in fact what occurs with normal urine, and also with urine which contains an excess of mucin. No doubt the observer, taking into account the highly muciferous character of the urine, will be surprised by the slightness of the reaction, after dropping in the test papers; and he will moreover find that 10 minims of it, when added to the 60 minim solution prepared from the test papers (see page 121), gives the faintest tinge of milkiness, which heat, far short of boiling, completely removes. If now a trace of albumin be communicated to the mucin-charged urine—as by adding a little albuminous urine—the test papers will produce an opacity which heat will clear up only to a certain degree, that which remains over being due to the albumin.

GLUCOSE AND ALLIED BODIES.

Glucose. $C_6H_{12}O_6$. Glucose exists in the blood in from .81 to 1.231 parts per thousand. In diabetes it may rise to 5.0 parts per thousand. In health, with a diet not too rich in starchy and saccharine food, it does not appear in the urine. The quantity excreted in the urine varies from 3 grains per ounce (8 grams per 1000 cc.) in physiological glycosuria, to 40 or 50 grains per ounce (80 to 100 grams per 1000 cc.) in diabetes. The average quantity excreted in diabetes is 20 grains per ounce (41 grams per 1000 cc.) The elimination of 6 ounces (192 grams) in 24 hours is common. One case is recorded in which 45 ounces (1350 grams) were discharged in one day.

The reducing action of normal urine. With the indigo-carmine, copper, picric acid and other sugar tests, normal urine has a reducing action equivalent to from .5 to .7 grains per ounce (1.1 grams per 1000 cc.) of glucose. The nature of the reducing agent has been a matter of much controversy. Many hold the opinion that a trace of glucose is a normal constituent of urine, and to it is due this reducing action; while others believe inosite or some other member of the glucose group to be the reducing agent. Uric acid reduces the salts of copper, and to it many attribute this action of normal urine. Very recent experiments by Dr. Geo. Johnson seem to prove that *kreatinin* is the body sought. He also finds that the urine during the ingestion of salicylic acid has a reducing action equal to one or two grains of glucose per ounce. It is well known that the administration of chloral has the same

effect. Sugar, in quantity detectable by the ordinary tests, is found in the urine—

Physiologically—

During pregnancy and lactation ;
Of infants under 2 months old ;
Of old persons 70 to 80 years of age ;
Of persons living largely upon starchy and saccharine food.

Pathologically—

In diabetes mellitus :
In impeded respiration from pulmonary diseases ;
In impeded hepatic circulation (functional and organic diseases of the liver) ;
In diseases of the central nervous system (general paresis, epilepsy, dementia, puncture of fourth ventricle) ;
In intermittent and typhus fevers ;
By the action of certain poisons, as carbon monoxide, arsenic, chloroform and curare ;
In abnormally stout persons.

The persistent excretion of easily recognizable quantities of sugar constitutes true diabetes. The quantity of urine in diabetes in 24 hours is generally increased, often enormously so. The specific gravity is high, varying from 1025 to 1050. It may, however, not be above normal; exceptionally it is below. The elimination during 24 hours is increased.

Tests for Glucose. The particular property of glucose which is utilized for its detection is its action as a reducing agent—its disposition

to absorb oxygen. In this property it differs strikingly from sucrose or common sugar.

The Copper test. If a little copper sulphate and an excess of liquor potassa be added to a solution of glucose, a clear blue solution results. Without the glucose the alkali would precipitate the pale blue cupric hydrate, CuH_2O_2; and if the mixture were boiled this blue precipitate would be reduced to a black precipitate of cupric oxide, CuO_2. The clear blue solution containing glucose, however, when boiled, changes from transparent blue to opaque yellow, and speedily deposits a yellow, ultimately red precipitate of cuprous oxide CuO. When the quantity of sugar is large the change is immediate. When small the reaction takes two or three minutes for its completion.

This is *Trommer's test:* It is convenient, but open to the objection that, with small quantities of sugar, the reaction is liable to be obscured by a precipitate of cupric oxide. To avoid this difficulty, Rochelle salt is added to the copper solution, the tartaric acid of which prevents the precipitation of the cupric hydrate upon the addition of an alkali.

Fehling's solution is thus prepared, and is the most convenient modification of the copper test. It is of definite composition, and is intended for a quantitative as well as a qualitative test. This solution readily decomposes. This may be obviated to a considerable extent by having two solutions, one containing the cupric sulphate, and the other Rochelle salt and soda. The formula of Dr. A. B. Lyons of Detroit is an excellent one. Prof. W. S. Wayne proposed the substitution of

glycerine for the Rochelle salt. It produces a solution similar to Fehling's, but quite permanent. It is an excellent modification. Care must be used to select glycerin free from glucose.

Precautions. A number of constant and occasional constituents of the urine interfere with the copper test. Albumin must be removed. Uric acid and inosite reduce the copper solution, but without the precipitation of the oxide; the blue color is merely changed to green. Kreatinine and ammonia tend to prevent the precipitation of cuprous oxide in urine containing sugar.

Remarks. With careful regard for possible fallacies the copper test forms a sufficiently delicate and reliable test for glucose. It is not practicable, however, for a bedside test.

The Bismuth test. The principle of the test is the same as the copper test. The glucose reduces the salt of bismuth in the presence of an alkali.

Precautions. The same as for the copper test.

Remarks. The sources of fallacy are not so marked as in the copper test. It is a convenient bedside reagent. Sodium carbonate may be substituted for the potassium hydrate.

Moore's test. In this test the urine is boiled with potassium hydrate. If sugar be present the color changes to yellow or brown; the intensity of the color being proportionate to the amount of sugar.

Precaution. Albumin must be removed.

Remarks. It detects, with certainty, large quantities of sugar in the urine, and may be used as a rough quantitative test.

The Picric Acid test. Advocated by Dr. Geo. Johnson. A little picric acid and an alkali are added to the urine and boiled one minute. If sugar be present, the solution becomes garnet red or deep brown, due to the formation of picramic acid, $HC_6H_2NH_2(NO_2)_2O$.

Precautions. The kreatinine in normal urine gives a color change equal to .5 to .7 grains of sugar per ounce. (.15 to .20 grams per 1000 cc.) With this exception, there are no fallacies. The presence of albumin is of no consequence.

Remarks. This is an exceedingly valuable test. On account of the kreatinine reaction it cannot be used to detect minute quantities of sugar, but for all quantities above 1 grain per ounce (2.07 grams per 1000 cc.), it is characteristic and accurate. It is a convenient bedside test, and Dr. Johnson has elaborated a fairly accurate and easily applied method of quantitative testing.

The Fermentation test. Yeast added to a saccharine urine decomposes the glucose with the formation of carbon dioxide. The generation of gas under these circumstances proves the presence of sugar.

Precautions. The yeast must be fresh, and the temperature at which the experiment is performed must be high enough to favor the growth of the fungus (Torula cerevisiæ). The proper temperature is from 68°to 75° F. (20° to 24° C.)

Remarks. This is the most conclusive of the sugar tests. Its great disadvantage lies in the fact that it requires several hours to complete the experiment. It forms one of the most convenient quantitative methods.

Indigo-carmine (*Mulder's test*). Revived and strongly advocated by Dr. Oliver. If a solution of indigo-carmine of a distinctly blue tint, with a little sodium carbonate, be boiled with a trace of glucose, the blue color will change to purple, amethyst, red, and finally fade to pale yellow. With very minute quantities of sugar the color change is not complete; it stops at the purple or red. As the oxygen of the air reaches the cooling solution the blue color is restored; passing in reverse order through the same shades as in fading. The blue color may be restored by agitation, and bleached by rest if the fluid be kept hot.

Precautions. Only one or, at most, two minims of the urine should be employed—at least in the first test. Normal urine will discharge the color of indigo if added in sufficiently large quantity—generally 5 minims of nominal urine are necessary to produce any change in 30 minims of a pale blue solution.

Remarks. This test leaves but little to be desired. It is as delicate as Fehling's solution. When properly used, it is not affected by the presence of albumin, uric acid, or kreatinin. Of the many substances found in the urine of patients undergoing medication, only tannic acid and the salts of iron reduce indigo. It is a convenient pocket reagent, and keeps indefinitely. In the form of tablet, it has great advantages over every other glucose test. For nearly two years I have used it almost exclusively, reverting to the other tests only to confirm the indications of this. The test must be used in tablet form or test paper, as the proportion of pigment to soda must be always the same.

Inosite, or muscle sugar, is occasionally found in the urine. Unlike glucose, it does not undergo vinous fermentation. It readily takes on lactic fermentation. The olive-green color which is sometimes produced with the copper test for glucose is thought to be due to the presence of inosite.

This body has been detected in the urine in—

Diabetes mellitus (sometimes, especially during convalescence, replacing glucose.)
Typhus fever;
Syphilis;
Phthisis.

Lactose. Sugar of milk has been found in the urine of young infants and nursing women. Lævulose, or fruit sugar, occasionally attends glucose in diabetes mellitus.

Acetone. $CO(CH_3)_2$. Normal urine does not contain this body.

Pathologically it has been observed in—

Diabetes;
Infectious diseases;
Febrile conditions in general;
Various cachexias;
Some functional brain diseases.

It is particularly in diabetes that acetonuria occurs. The relation of the overloading of the blood with acetone, acetonæmia, to diabetic coma, has been a matter of much discussion. It was formerly thought to be the cause of the coma. Human beings, however, tolerate larger doses of acetone, and the view is gaining ground that diabetic coma is the result of various conditions.

Diacetic Acid. Diaceturia, a pathological occurrence, sometimes is seen in—

Diabetes;
Mental disease with excitement;
Carcinoma;
Certain convulsive attacks in children (V. Jaksch).

To this body also diabetic coma has been attributed. Both diacetic acid and acetone are probably decomposition products of glucose, and from the evidence we have up to this time it would appear that diabetic coma is sometimes the direct result of the formation and retention of large quantities of these compounds in the blood.

BLOOD

Is often a constituent of the urine of disease. Hæmoglobin and the corpuscles may be present —*hæmaturia;* or hæmoglobin without the corpuscles—*hæmoglobinuria.*

Hæmaturia. Urine containing blood is red, brown or smoky, and deposits a red or brown sediment on standing. The color depends upon the alterations which the corpuscles and hæmoglobin have undergone during their stay in the urine. Prolonged contact with the urine changes the bright red hæmoglobin to *methæmoglobin.* This body imparts to the urine a brown, blackish-brown or blackish-green color.

Blood from the urethra, bladder or ureters, or if exuded from large vessels in the pelvis of the kidney or the kidney itself, is often but little changed, and is sometimes passed in clots. In capillary hæmorrhage from the kidneys, the color is dark, and the blood thoroughly diffused in the urine. Small clots may be present.

Hæmaturia may have its *source* in—

(1) *The kidneys* due to—
- Injuries;
- Acute nephritis;
- Acute exacerbation of chronic nephritis;
- Diseases of renal vessel (embolism, thrombosis, aneurism, stasis);
- Amyloid kidney (very rarely);
- Infective fevers (small-pox, scarlatina, typhoid fever, etc.);
- Certain blood diseases (scurvy, purpura, hæmophilia);
- Parasitic diseases (echinococcus).

(2) *The pelvis and ureters*, due to—
- Renal calculi;
- Tuberculosis;
- Rupture of neighboring abscesses;
- Parasites.

(3) *The bladder*, due to—
- Calculi;
- Cancer and other tumors;
- Diphtheritic cystitis;
- Varicose veins;
- Injuries.

(4) *The urethra*, due to—
- Injury (catheterization, impaction of calculi, etc.).

(5) *Extraneous discharges*, as—
- The menstrual flow, etc.

Hæmoglobinuria. In this condition the bloody color is owing to the presence of dissolved blood pigment. The condition is produced when large numbers of blood corpuscles undergo dissolution within the vessels, since the kidneys very soon excrete the hæmoglobin. For the relation of

hæmoglobin to certain forms of albuminuria, see page 24.

Hæmoglobinuria has been observed—

In severe infectious diseases (typhoid fever, scarlatina, etc.);

In conditions of blood dissolution (scurvy, purpura, etc.);

In skin burns, sunstroke;

As an independent disease (paroxysmal hæmoglobinuria—page 24);

After transfusion of lamb's blood.

BILE.

In a number of pathological conditions the elements of the bile are excreted in the urine. The bile pigments, *bilirubin* and *biliverdin*, may occur along with the bile salts, sodium glycocholate and taurocholate, or the bile salts alone may be present.

Urine containing the bile pigments is colored yellow, brown or brownish-green. It forms an intense yellow froth on agitation. It stains paper or linen a permanent yellow.

The *bile pigments* are found in jaundice from whatever cause.

The significance and modes of detection of the *bile salts* in the urine have been the subjects of much speculation and controversy. Most authorities had come to look upon the methods of detection of these salts as too complicated and unsatisfactory to be of any clinical value.

Dr. Oliver, in a recent original study of the subject, has brought out a ready test for these bodies, and has greatly enlarged our knowledge of the conditions which give rise to their secretion.

According to Dr. Oliver, the bile salts, in small quantities, are constantly excreted in the urine in health. Hygienic changes, as meteorological variations, changes in diet, etc., cause variations in their quantity.

He has observed the quantity to be *increased*—

During the daily periods of fasting;

After exercise.

Pathologically he found the bile salts *increased* in—

Jaundice;

Functional disorders of the liver (acute and chronic biliousness);

Organic diseases of the liver apart from jaundice (carcinoma, amyloid disease, cirrhosis);

Diseases of the spleen;

Fever;

Hæmolytic diseases (anæmia, leucocythæmia and scurvy).

Tests for bile salts. Pettenkofer's test for bile salts has proven useless for clinical purposes. With rare exceptions the bile salts, if present in urine, must be isolated before the reaction will take place. This difficulty has led to the abandonment of search for them. Dr. Oliver has recently brought forward a test, which can be readily applied, and which opens up a new field of clinical observation.

In health the products of gastric digestion, peptone and parapeptone, leave the stomach in acid solution, meet the bile in the duodenum, and are precipitated in a tenacious layer over the whole mucous membrane. Upon this physiological fact is founded Dr. Oliver's test. He uses an antiseptic, acidified solution of peptone.

With this reagent the bile salts in the urine are precipitated in the form of a milky opacity, the intensity of which depends upon the amount of bile salts present. The test is very delicate, detecting 1 part of the bile salts in 18.000 to 20.000 parts of a solution of sodium chloride. Dr. Oliver's observations show that the bile salts are constituents of normal urine, and that variations in the amount present take place under a variety of physiological and pathological conditions.

LEUCIN AND TYROSIN.

These bodies, products of tryptic digestion and the decomposition of proteids, occur associated together in the urine in certain pathological conditions. They are symptomatic chiefly of grave destructive diseases of the liver, as—

Acute yellow atrophy;
Acute phosphorus poisoning.

They may present themselves in—

Severe typhus;
Severe variola;
Leucocythemia;
After epileptic fits and brain injuries.

When present they form a deposit, and may be detected by the microscope.

FAT.

Fat in a state of microscopic subdivision occurs in the urine in a variety of conditions. Two forms of fatty urine are recognized, *chyluria* and *adiposuria*.

Chyluria. In this form of fatty urine the fat is in a chylous state. It occurs chiefly as a symptom of the presence of the embryos of the nematoid worm *filiaria sanguinis hominis* in the

blood. The chyluria in these cases is supposed to be due to the blocking up of the lymph vessels above the kidneys by masses of the embryonic worms, and the consequent escape of the chyle into the urine. The same condition occurs also in other diseases, in which it is probable that some communication is opened up between the lymph vessels and the urinary tract.

Adiposuria may be present with or without renal disease. Fat may escape into the urine through a perfectly healthy kidney. It has been observed—

After the ingestion of fats and oils;
During the union of fractures;
In diseases of the pancreas;
In a case of acute diabetic coma (Ralfe).
In cases of poisoning by phosphorus and carbon dioxide;
In acute yellow atrophy of the liver;
In yellow fever;
During pregnancy;
During chronic parenchymatous nephritis (from fatty degeneration of the renal epithelium).

PART II.

Practical Urine Analysis.

CHAPTER I.

SYSTEMATIC SCHEME FOR QUALITATIVE ANALYSIS.

Selection of a Specimen of Urine. Whenever possible a sample of the whole urine passed in 24 hours should be examined, as the composition varies to quite a degree at different periods of the day. Erroneous conclusions may be drawn from the analysis of an isolated specimen. When a sample of the whole day's urine cannot conveniently be obtained, the first and second morning evacuations mixed together form an approximately average specimen.

1. **Make a note** of the **quantity** passed in 24 hours, the **color,** the **odor,** the **transparency,** and the **consistence.**

2. **Determine the specific gravity.**

(*a*). *With the urinometer.* Fill the cylinder to within an inch of the top with the urine. Bring the urine to the temperature for which the urinometer is graduated, by immersing the cylinder in hot or cold water, as may be necessary. Float the urinometer in the fluid, and then completely fill the cylinder. Take the reading at the highest point, where the surface of the liquid comes in contact with the stem.

Urinometers are usually graduated for a temperature of 60° F. When the temperature at which the observation is taken is above this point,

add, and when below, subtract, 1 degree of specific gravity for every 6 degrees F. of temperature for approximate correction. Correct accurately by Dr. A. B. Lyons' table, as follows:

Temperature. Fahr.	Correction. Subtract from reading of Urinometer.	Temperature. Fahr.	Correction. Add to reading of Urinometer.	Temperature. Fahr.	Correction. Add to reading of Urinometer.
50°	1.05	61°	0.11	79°	2.49
51	0 95	62	0.22	80	2.63
52	0.84	63	0.34	81	2.78
53	0.74	64	0.45	82	2.94
54	0.64	65	0.57	83	3.10
55	0.53	66	0.69	84	3.26
56	0.43	67	0.82	85	3.42
57	0.32	68	0.95	86	3.58
58	0.22	69	1.08	87	3.75
59	0.11	70	1.22	88	3.91
60	0.00	71	1.35	89	4.08
		72	1.49	90	4.24
		73	1.62	91	4.40
		74	1.76	92	4.57
		75	1.90	93	4.74
		76	2.04	94	4.91
		77	2.19	95	5.09
		78	2.34		

If the quantity of urine be too small to fill the cylinder use the specific gravity bead; or, dilute with one, two or more volumes of pure water. From the specific gravity of this mixture, taken with the urinometer, calculate that of the urine.

EXAMPLE.

Urine, 1 volume.
Water, 3 volumes.
Specific gravity of mixture 1.004.
$1.000+(4\times4)=1.016$

(*b*) *With the specific gravity bead—*

The bead just floats in fluid of a specific gravity of 1.005.

Drop the bead into a small test tube and add 25 minims of urine. If the bead float, the specific gravity is below 1.005. If the bead sink, cautiously add water, 25 minims at a

time, and mix it thoroughly with the urine. Watch for a tendency of the bead to rise. When this time approaches add the water, 5 minims at a time, until the bead is just suspended in the fluid, neither rising nor falling. Calculate the result. Each five minims of water added equals one "degree" (.001) of specific gravity.

EXAMPLE.

Urine, 25 minims.
Water added, 85 minims.

$$5\overline{)110}$$
$$22$$

Specific gravity=1.022.

Urine of very high specific gravity, 1.030 or above, may be diluted one-half, and the result multiplied by two.

3. **Determine the Reaction.** Dip a red and a blue litmus paper in the urine. If the blue turns red the reaction is *acid;* if the red turns blue the reaction is *alkaline;* if no change take place in either the reaction is *neutral.*

If the reaction be alkaline dry the test paper. If the blue color be permanent the alkalinity is due to *fixed alkali*, soda or potassa ; if the blue color disappear the alkalinity is due to *volatile alkali*, ammonia.

4. **Test the Specimen for Proteids.** If the urine be not perfectly clear, filter. Turbidity from urates may be dissipated by heat; from phosphates, by a few drops of acetic acid.

If the turbidity be due to amorphous phosphate and microbes, as in old alkaline urines, and the urine be not rendered perfectly clear by ordinary filtration, add about one-fourth its volume of solution of potassa, warm and filter. If the filtrate still be turbid add a few drops of the

magnesian fluid, warm again and filter. The urine will then be clear. When this process is necessary heat cannot be used as a test.

(*a*) **General Test for Proteids.** To about 60 minims (4 cc.) of urine in a small test tube add a few drops of potassio-mercuric iodide. Or, dissolve a mercuric and a citric acid tablet in 60 minims (4 cc.) of water, and add 15 minims (1 cc.) of the urine.

No precipitate. *Proteids are absent.* Pass to (5).

A precipitate. *Albumin*, *globulin peptones*, *alkaloids* (*urates*, *mucin*).

Boil. The precipitate remains. *Albumin.* Confirm by heat, or one or more of the other special albumin tests. Search for serum globulin, which behaves like albumin, by special tests, if the presence of this body be suspected or its recognition desired.

The precipitate dissolves. *Peptones*, *alkaloids* (*urates*, *mucin*).

To distinguish between these bodies add a few drops of the sodium tungstate solution to 60 minims (4 cc.) of the urine. Or, dissolve a tungstate and a citric acid tablet in 60 minims (4 cc.) of water, and add 15 minims (1 cc.) of the urine.

A precipitate. *Peptones* (*urates*, *mucin*). Confirm the presence of peptones by special tests.

No precipitate. *Alkaloids.*

(*b*) **Special tests for Serum Albumin.**

Heat. If not already markedly acid add a drop of acetic acid or a citric acid tablet to 3 or 4 drachms of the urine in a test tube. Hold the bottom of the tube between the thumb and finger,

and heat the upper half to the boiling point. Any precipitate or cloudiness is *albumin*.

Potassium Ferrocyanide. Strongly acidify a dram of the urine with acetic acid and add a few drops of the ferrocyanide solution. Or, dissolve a ferrocyanide and a citric acid tablet in 60 minims (4 cc.) of water and add 15 minims (1 cc.) of the urine.

Any precipitate is *albumin*.

Picric Acid. Add to 60 minims (4 cc.) of urine an equal volume of the picric acid solution, and heat to near the boiling point. Or, dissolve a picric acid tablet in 60 minims (4 cc.) of water and add 15 minims (1 cc.) of urine and heat to boiling.

Any remaining precipitate is *albumin*.

Sodium Tungstate. Add a few drops of the acidified sodium tungstate solution to 60 minims (4 cc.) of the urine and heat to near the boiling point. Or, dissolve a sodium tungstate and a citric acid tablet in 60 minims (4 cc.) of water and add 15 minims (1 cc.) of the urine and heat to boiling.

Any remaining precipitate is *albumin*.

Nitric Acid. Pour about 30 minims (2 cc.) of pure, colorless nitric acid into a test tube. Incline the tube at an angle of about 45°, and allow about 60 minims (4 cc.) of the urine to slowly trickle down the side of the tube from a small pointed pipette and overlie the acid. (See page 122.)

A white ring *at the point of contact* is *albumin*.

Caution. (1) Urates sometimes form a hazy ring, but *above* the point of contact. (2) Urines highly charged with urea may give a crystalline ring of nitrate of urea. Both these rings are dispelled by the application of a gentle heat. To

apply heat without disturbing the ring, immerse the tube in hot water. (3) The urines of persons taking the oleo-resins may precipitate with nitric acid. This ring is dissolved by alcohol. (4) Urines highly charged with normal pigments, or those containing bile pigment, give a colored ring which may obscure a delicate ring of albumin.

This mode of applying the nitric acid test is termed *the contact or Heller's method.* It is an excellent method of using a number of reagents, and is frequently spoken of in the text.

(*c*) **Special Tests for Peptone.** *Ralfe's Test.* Place 30 or 40 minims (2 or 3 cc.) of Fehling's solution in a test tube and gently overlay it with the urine. At the point of contact a zone of phosphates appears. Above this, if peptones be present, a rose-colored halo will develop. If albumin be present with peptones the color will be mauve; if albumin alone, purple.

Phosphor-Tungstate Test. Free from mucin and decolorize an ounce or two of the urine by adding to it solution of neutral lead acetate until the precipitate no longer increases; filter. Acidify the filtrate with acetic acid and add a few drops of solution of potassium ferrocyanide. Any precipitate is due to albumin. To remove the albumin continue the addition of the ferrocyanide so long as a precipitate occurs, and filter.

To this albumin-free filtrate add one-fifth its bulk of acetic acid and then an acid solution of sodium phosphor-tungstate. Any cloudiness is *peptone.* (The formation of the precipitate may be delayed ten minutes or more.)

(*d*) **Special Test for Serum Globulin.** If necessary, slightly acidify the urine

with acetic acid, filter, and dilute with clear water to a specific gravity of 1.002. A cloudiness indicates *serum globulin.*

For a more delicate test pass carbon dioxide through this diluted urine. Serum globulin gives a cloudiness.

(*e*) **Special Test for Mucin.** Place 30 minims (2 cc.) of acetic acid in a test tube and overlay it with the urine. A cloud appearing, usually after some minutes, above the point of contact of the two fluids, insoluble by heat, indicates *mucin.*

(5) **Test the Specimen for Glucose.** The urine should be fresh. No test for glucose can be trusted with decomposing urines. Uric acid, kreatinine, albumin, pus, or other ordinary physiological or pathological constituents of urine do not interfere with the indigo-carmine, picric acid or fermentation tests. Before using any of the other tests, however, remove albumin, if it be present, by boiling and filtration.

The Indigo-Carmine Test. Add 60 minims (4 cc.) of distilled or rain water to an indigo-carmine tablet or an indigo-carmine and half a sodium carbonate test paper and boil.

Add *one drop* of the urine to the solution and keep it at the boiling point without agitation.

If no color change take place by the end of two minutes *glucose is absent.* Pass to (6).

If glucose be present, a beautiful violet tint suddenly breaks out in the blue solution; the color quickly changes to purple, red, orange, and finally becomes straw-colored. Now shake the tube and the colors return in the inverse order in which they appeared. The rapidity with which the color changes develop depends upon the amount

of glucose present. If glucose be present in very minute quantity the color change may be arrested before the yellow is reached.

Confirm the presence of sugar by one or more of the following tests:

The Copper Test. Pour 60 minims (4 cc.) of Fehling's solution, or one of its modifications, into a test tube and heat to boiling. If any turbidity or change of color take place in the solution it is unfit for use and *must be rejected.* If it remain clear, add a drop of the urine (which must be freed from albumin, if present), and heat gently. If a large quantity of sugar be present a yellow precipitate, turning red, will be formed. If no precipitate appear add a drop or two more urine, and so on until a bulk equal to the amount of the Fehling's solution used has been added. If no precipitate then appear, *sugar is absent.*

In typical glucosuria the precipitation of the cuprous oxide is too marked to be mistaken. With very minute quantities of glucose, however, the reaction may be so faint as to cause confusion. It is then greenish-yellow and indistinct. After standing a short time a few grains of cuprous oxide will deposit at the bottom and along the sides of the tube.

Inosite gives a greenish coloration, but no precipitate.

Excess of uric acid, as we have seen, has a slight reducing action on the salts of copper, and a reaction by this compound may simulate that of glucose. To decide this question, add to the urine solution of neutral lead acetate, filter, and test the filtrate with the copper solution. If no reaction now result the former reaction was due to uric acid.

The Fermentation Test. For the most convenient apparatus for making the fermentation test see page 82.

Moore's Test. To 60 minims (4 cc.) of the urine add 30 minims of solution of soda or potassa. A flaky precipitate of phosphates appears. Boil the solution. If glucose be present a yellow color quickly appears, darkening to brown as the boiling is continued. The intensity of the color varies with the amount of glucose. If the quantity be large the color becomes almost black. Now add a few drops of nitric acid; the color disappears and the odor of burnt molasses is developed.

Picric Acid Test. To 60 minims (4 cc.) of the urine add an equal bulk of saturated solution of picric acid; albumin, if present, will precipitate. Add about 20 minims (1.4 cc.) of solution of potassa and apply heat. A deep red-brown color, developing gradually, indicates *glucose.* The intensity of the color varies with the amount of glucose present.

Caution. Nearly all urines treated in this way become darker in color, a color about the same as that produced by a solution of glucose of .4 to .7 grains per ounce. The reaction of normal urine should be studied before this test is used.

The Bismuth Test. To 30 minims (2 cc.) of the urine add an equal bulk of solution of potassa and a pinch of bismuth sub-nitrate, and boil for a minute or two. If sugar be present black metallic bismuth deposits.

(6) **Test the Specimen for Indican.** Into 60 minims (4 cc.) of hydrochloric acid contained in a small beaker, wine glass or large test tube, let fall about 20 drops (1.5 cc.) of the urine. Stir the fluid.

A pale *yellowish-red color* develops.
The indican is *normal* in amount.
The fluid becomes *violet* or *blue.*
The indican is in *excess.*

The intensity of the color is directly proportionate to the amount of indican present.

(7) **Test the Specimen for Blood Pigment.** *Heller's Test for Hæmatin.* Precipitate the earthy phosphates from a drachm or two of urine by caustic potash and a gentle heat.

If the phosphates appear *blood-red* or *dichroic*, blood pigment is present.

If the urine is alkaline and a precipitate does not form upon the addition of the potash, add one or two drops of the magnesian fluid and heat gently.

The preparation of crystals of Hæmin (*hydrochlorate of hæmatin*). Collect the blood-colored phosphates upon a filter, transfer the precipitate to a glass slide, and carefully warm until it is perfectly dry. Thoroughly mix a small crystal of sodium chloride with the phosphates, remove excess of salt, add a drop of glacial acetic acid and cover with a thin glass. Warm the slide carefully till bubbles begin to form. Cool the slide and examine under the microscope with a $\frac{1}{4}$ or $\frac{1}{6}$ objective. Hæmin crystals appear. (Fig. 1.)

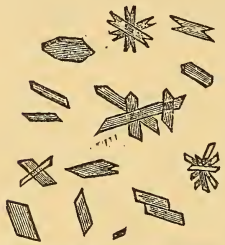


Fig. 1. Hæmin Crystals.

Alemen's Test. Shake together equal parts of oil of turpentine and tincture of guaiac, add drop by drop about the same quantity of urine. Allow the emulsion to separate. Blood gives a blue or greenish-blue color to the upper layer.

(8) **Test the Specimen for Bile.**

(*a*) **Bile Pigments.** *Gmelin's Test.* Dilute very dark urines with water. Underlay 60 minims of urine with fuming nitric acid. At the point of contact of the fluids, if bile pigment be present, a set of colors will slowly develop. Uppermost will be *green*, and following downward in order will be *blue*, *violet*, *red* and *yellow*. Often one or more colors are absent. The green is, however, necessary to prove the presence of bile.

Or, place a few drops of urine and the fuming acid near each other on a white plate and allow them gradually to approach and commingle. The same play of colors appears.

Or, drop a little of the urine and the fuming acid on a piece of white blotting paper and then allow them to come in contact.

Fleicht's method. This is more delicate than Gmelin's method. Mix thoroughly equal quantities of pure colorless nitric acid and the urine, and underlay this mixture with concentrated sulphuric acid. The colors appear at the point of contact.

Heller's method. Add to 60 minims (4 cc.) of hydrochloric acid, drop by drop, just enough urine to color it. Underlay the mixture with pure nitric acid. The colors appear at the point of contact.

To detect a very small quantity of pigment, shake two ounces of urine with a drachm of chloroform and allow the chloroform to settle to the bottom. Withdraw the chloroform with a pipette, wash it in water, and pour it into a beaker containing a drachm or two of hydrochloric acid. Shake the beaker, and while shaking add nitric

acid. The changes of color can be observed in the chloroform.

(*b*) **Bile Salts.** *Dr. Oliver's Peptone Test.* If necessary make the urine clear by filtration, boil and filter if bloody, make normally acid if it be alkaline, and reduce it by dilution with pure water to a specific gravity of 1008. (The object of this dilution is to have such uniformity as to admit of quantitative comparison, and to reduce the possibility of errors which might occur with concentrated urines.) Add 20 minims (1.4 cc.) of the diluted urine to 60 minims (4 cc.) of the peptone solution. (See page 122.)

No immediate reaction is produced, but in a little while a slight milkiness appears. The bile salts are *normal* in amount.

A distinct milkiness promptly appears, becoming more intense in a minute or two. The bile salts are in *excess*.

The degree of opacity is directly proportionate to the amount of bile derivatives.

Or, overlay 60 minims (4 cc.) of the diluted urine in a test tube with the peptone solution.

There is no response, or a delicate threadlike line slowly appears. The bile salts are *normal*.

An immediate and marked reaction takes place. The bile salts are in *excess*.

This precipitate of the bile salts with peptone is diminished by boiling and dissolved by acetic acid.

Pettenkofer's Test. As morphine, albumin and other occasional constituents of urine react to Pettenkofer's test in the same manner as the bile salts, it is necessary in testing for these bodies first to isolate them.

To accomplish this, evaporate about 2 ounces (60 cc.) of the suspected urine to dryness over a water bath. Extract the residue with about 90 minims (6 cc.) of alcohol, filter and mix with about 2 ounces (60 cc.) of ether. Collect the precipitate which is formed on a small filter, wash it with ether, and dissolve in 15 to 30 minims (1 to 2 cc.) of distilled water. This fluid contains the bile salts in solution.

Now apply Pettenkofer's test. To the solution obtained as above add 1 drop of a solution of cane sugar (1 to 3). Underlay this mixture with a little sulphuric acid. If bile be present a purple-red zone forms at the junction of the two fluids, which gradually diffuses throughout the mixture, forming after a few hours a homogeneous dark red liquid.

(9) **Test the Specimen for Chlorides.** To 60 minims (4 cc.) of the urine add a few drops of pure nitric acid, to hold phosphates in solution, and a drop or two of solution of silver nitrate. The chlorides give a heavy white precipitate, falling in cheesy lumps if the chlorides are normal in amount. If greatly decreased a cloudiness only is produced.

(10) **Test the Specimen for Phosphates.** To 60 minims of the urine add a few drops of the magnesian fluid and heat gently. The phosphates separate in a cloudy precipitate.

(11) **Test the Specimen for Sulphates.** To 60 minims of the urine add a few drops of hydrochloric acid, to hold phosphates in solution, and then add a few drops of barium sulphate. The sulphates form an opaque milky cloudiness.

(12) **Test the Specimen for Acetone** or the acetone producing body, when this substance is suspected to be present. To 60 minims (4 cc.) of the urine in a test tube add a little solution of ferricchloride. A deep red coloration is produced, which is destroyed by hydrochloric acid.

Ralfe's test. Boil together in a test tube 60 minims of liquor potassæ and 20 grains of potassium iodide. Carefully float upon the surface 60 minims of the suspected urine. A ring of phosphates forms, which after a few moments, if the acetone or its allies be present, becomes yellow, and studded with yellow points of iodoform. In time these will sink through the phosphates to the bottom of the tube.

CHAPTER II.

QUANTITATIVE ANALYSIS.

(1) **Estimation of the total Urinary Solids.** *Approximate method.* The specific gravity of urine varies with the total dissolved solids. The amount of solid urine may therefore be estimated from the specific gravity. Either of the two following methods, which give about the same results, may be used. The first is the more convenient:

(*a*) Multiply the last two figures of the specific gravity by the number of ounces of urine discharged in 24 hours. The product will be the number of grains of solid matter.

EXAMPLE.

Specific gravity of urine, 1.018.
Number of ounces, 42.
18×42=756 grains in 24 hours.

(*b*) Multiply the last two figures of the specific gravity by 2.33, the coefficient of Hæser. The product will be the number of grams of solid matter in 1,000 cc. (33.8 oz.) of urine.

EXAMPLE.

Quantity in 24 hours, 1,200 cc.
Specific gravity of urine, 1.024.
24×2.33=55.92 grams in 1,000 cc.

Calculate the amount in the 24 hours' urine as follows:

$$1000 : 1200 :: 55.92 : x \qquad x = \frac{55.92 \times 1200}{1000} = 67.10 \text{ grams.}$$

These methods give results sufficiently accurate for all clinical purposes.

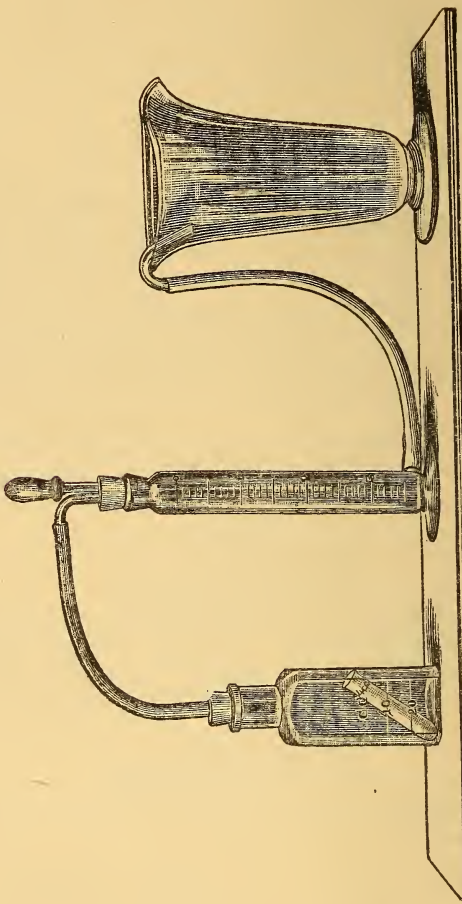


Fig. 2. Ureometer (Lyons'), giving results directly in percentages of Urea.

(2) **Estimation of Urea.** Variation in the amount of urea from the standard mean is so great that even rough approximate methods of estimation often serve well for clinical purposes. The approximate estimation from the specific gravity is a ready means of selecting, in the preliminary examination, particular urines for more accurate analysis.

For accurate estimation some modification of the hypobromite process is the most convenient.

The Hypobromite process. Principle. Urea is decomposed by a hypobromite (or a hypochlorite) into nitrogen, carbon dioxide and water.

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

The carbon dioxide is absorbed by the alkali and the volume of the disengaged nitrogen measures the amount of urea. Several forms of apparatus have been devised to decompose the urea and measure the amount of gas. The ureometer designed by Dr. A. B. Lyons of Detroit, and manufactured by Parke, Davis & Co., is cheap, accurate and convenient.

The apparatus (Fig. 2) consists of—

1. A bottle, provided with perforated rubber cork and delivery tube; in this the decomposition of the urea is effected.

2. A small test tube to contain the urine, graduated to hold 4 cc., the quantity employed in each experiment.

3. A graduated jar for measuring the gas evolved. This jar is provided at the bottom with an "overflow" tube, and at the top with a vent tube closed with a rubber cap, to secure accurate adjustment of the level of the fluid in the jar at the commencement of the experiment.

This receiver is graduated in such a way that the results are read off directly in percentages of urea.

The solution of sodium hypobromite is difficult to prepare and does not keep. These facts make the method with this reagent an inconvenient one. In the place of the hypobromite, the U. S. P. solution of chlorinated soda (Labarraque's solution) may be used. Dr. Lyons has found, however, that the amount of gas generated when the chlorinated soda is used is considerably less than that evolved by hypobromite solution. Further, the gas is evolved much more slowly, and the reaction does not appear to be complete even when a large excess of the reagent is employed.

Dr. Lyons overcomes this difficulty by changing *the hypochlorite into hypobromite* extemporaneously. He simply adds to the solution of clorinated soda, of which 25 cc. should be sufficient to decompose the urea in 4 cc. of urine, 5 cc. of a 20 per cent. solution of potassium bromide a few minutes before the urine is introduced. With this modification he obtains results identical with those reached by the hypobromite process.

Process. Put into the bottle 25 cc. (7 fluidrachms) of solution of chlorinated soda and 5 cc. (75 minims) of the 20 per cent. solution of potassium bromide. Fill the test tube exactly to the mark (4 cc.) with the urine to be examined, and lower it into the bottle by means of a thread, or by the aid of a pair of dressing forceps, taking care that none of its contents are spilled in the operation. Fill the graduated jar with water, which must be of the same temperature as the air

of the room, to a point a little above the zero mark of the scale, supporting the extremity of the overflow tube so that no water can escape. Remove the rubber cap from the vent tube and connect the apparatus, pressing in the rubber corks firmly so as to make the joints air-tight. Finally put on the rubber cap, drawing it down so as to force a little water out of the overflow tube, and bring the level of the water remaining exactly to the zero mark, the orifice of the overflow tube being on the same level. A little practice will make this easy.

To make sure that the connections are all perfectly air-tight, lower the end of the overflow tube a few inches; a few drops of water will escape from diminished pressure, but if the joints are perfect there will be no further dropping. If there is any leakage, the defective joint must be found and the difficulty corrected before proceeding further with the experiment. Having made sure that the connections are perfect, catch the curved end of the overflow tube over the edge of a measuring graduate, as shown in the illustration (an ordinary bottle or any other receiver may be used in place of the graduate). Now, by canting the bottle, cause the urine to flow out of the test tube and mix with the hypobromite solution. Effervescence is at once produced, and the gas evolved forces a corresponding volume of water out of the overflow tube. Shake the bottle occasionally to promote the escape of the gas. When the action appears to be at an end, pour into the measuring graduate water enough to reach above the opening of the overflow tube, in order that cooling of the gas evolved, which is at first quite warm, may

not draw air into the apparatus. Let the apparatus stand 15 or 20 minutes to cool, then shake the bottle containing the urine once more and proceed to read off the result. To do this, it is necessary to bring the opening at the end of the overflow tube just to the same level as that of the fluid remaining in the graduated cylinder, since raising or lowering the tube slightly affects the volume of the gas to be measured. The percentage of urea is read off without need of any calculation from the scale of the instrument.

If desired, calculate from the percentage the quantity in grains in one fluid ounce by the following table:

Per cent. of urea by ureometer.	Quantity of urea in grains in 1 fluidounce.	Per cent. of urea by ureometer.	Quantity of urea in grains in 1 fluidounce.
0.1	.456	1.9	8.658
0.2	.911	2.0	9.114
0.3	1.367	2.1	9.570
0.4	1.823	2.2	10.025
0.5	2.279	2.3	10.481
0.6	2.734	2.4	10.937
0.7	3.190	2.5	11.393
0.8	3.646	2.6	11.849
0.9	4.101	2.7	12.304
1.0	4.557	2.8	12.760
1.1	5.013	2.9	13.215
1.2	5.468	3.0	13.671
1.3	5.924	3.1	14.126
1.4	6.380	3.2	14.582
1.5	6.836	3.3	15.038
1.6	7.291	3.4	15.494
1.7	7.747	3.5	15.950
1.8	8.203		

Fowler's method. Principle. The difference in the specific gravity of urine, before and after its decomposition by the hypochlorites, bears a definite relation to the quantity of urea present. Every degree of specific gravity lost corresponds to .77 of 1 per cent. of urea, or about 3½ grains per ounce. Squibb's solution of chlorinated soda—Labarraque's solution—is employed;

7 parts of the solution will decompose the urea in 1 part of urine.

Process. Take the specific gravity of the urine and of some chlorinated soda solution at the same temperature. Add 1 volume of the urine to 7 volumes of the hypochlorite solution. Effervescence due to the liberation of nitrogen takes place. Shake the mixture at intervals during an hour. Now take the specific gravity of the mixture at the same temperature at which the other observations were made. Add once the specific gravity of the urine to seven times the specific gravity of the soda solution, and divide the sum by eight. From the quotient subtract the specific gravity of the mixture after decomposition, and multiply the difference by .7791. The product is the amount of urea in grams in 100 cc. of urine. Determine amount in 24 hours by multiplying this result by $\frac{1}{100}$ of the quantity excreted in 24 hours.

EXAMPLE.

Quantity of urine in 24 hours, 1400 cc.
Specific gravity of hypochlorite solution, 1048.
Specific gravity of urine, 1018.

$$\text{Specific gravity of mixture before decomposition,} \left\{ \frac{1048\times7+1018}{8} \right\} = 1044.25$$

Specific gravity of mixture after decomposition, 1041.25.
1044.25—1041.25=3.
.7791×3×14.00=32.72 grams in 24 hours.

(3) **Estimation of Uric Acid.** The amount of uric acid may be determined directly by separating and weighing it.

Process. To 200 cc. of urine add 20 cc. of hydrochloric acid and set aside in a cool place for 24 hours. Uric acid crystals form and collect on the bottom and sides of the vessel. Collect the uric acid on a weighed filter and wash thoroughly

with water. Dry the filter and the uric acid at a temperature of 212 F. (100 C.) and weigh them. The weight of the two minus the weight of the filter will be the amount of uric acid in 200 cc. of urine. From this calculate the amount in 24 hours. (See page 123.)

(4) **Estimation of Chlorides.** *Approximate clinical method.* Add to the urine a few drops of nitric acid and a *single* drop of silver nitrate solution. If the precipitate fall in firm cheesy lumps the chlorides are *normal* ($\frac{1}{2}$ to 1 per cent.) If the silver produce but a milky cloudiness the chlorides are diminished, $\frac{1}{10}$ per cent. or less.

Mohr's method. Principle. If silver nitrate be added to a solution containing sodium chloride, neutral potassium chromate, and an alkaline phosphate, the chloride is first precipitated, then the chromate, and lastly the phosphate. The formation of the red silver chromate indicates the complete precipitation of the chloride.

Solutions required—

1. Standard solution of silver nitrate.
   Fused silver nitrate 29.075 grams.
   Distilled water to make 1000 cc.
   1 cc.=0.01 NaCl.
2. Saturated solution neutral potassium chromate.
   Neutral potassium chromate 10 grams.
   Distilled water 100 cc.

Process. (*a*) The urine is not high colored, and is free from albumin or excess of uric acid or mucus. Dilute 10 cc. of the urine with 100 cc. distilled water and add a few drops of the

chromate solution. Fill a burette with the silver solution to the zero mark. Drop it slowly into the urine, stir it well and watch for the first trace of orange color. Make sure that the precipitation of the chloride is complete by adding another drop. Read off the amount of silver solution used and calculate the result.

EXAMPLE.

Quantity of urine in 24 hours, 1250 cc.
Silver solution used 7.5 cc.
1 cc. silver solution=.01 sodium chloride.

$$\frac{.01\times7.5}{10}\times1{,}250=9.475 \text{ grams.}$$

(*b*) The urine is high colored, and contains albumin, or excess of uric acid or mucus. These compounds must be removed. To do this measure 10 cc. of the urine into a platinum capsule, add 2 grains of pure potassium nitrate, evaporate to dryness, and ignite at a dull red heat to destroy organic matter. When cool, treat the residue with hot water and filter; acidulate the filtrate with dilute nitric acid, neutralize with carbonate of lime and proceed as in (*a*).

(5) **Estimation of Phosphates.** *Teissier's approximate method.* Pour 50 cc. of urine (made distinctly acid if necessary by a few drops of nitric acid) into a graduated cylinder, and saturate it with the magnesian fluid. All the phosphoric acid is precipitated as triple phosphate. Shake well, and set aside for 24 hours. Read off the hight of the settled precipitate in the graduated cylinder. 1 cc. of precipitate equals .30 grams of phosphoric acid per litre, about .60 to .70 grams of phosphate. From this calculate the total quantity in 24 hours.

This method is easy of application, and gives results accurate enough for all clinical purposes.

Volumetric method. Principle. (a) A solution of nitrate or acetate of uranium precipitates all the phosphoric acid from an acidified solution of a phosphate as uranium phosphate. (b) Potassium ferrocyanide gives a reddish-brown precipitate with a uranic salt. This compound is therefore used to indicate the termination of the reaction.

Solutions required—

(1) Solution of uranium acetate.*
Prepared so that 20 cc.=0.1 gram phosphoric anhydride P_2O_5.

(2) Solution of sodium acetate.
Sodium acetate 100 grams.
Acetic acid 100 cc.
Distilled water to make 1000 cc.

(3) Solution of potassium ferrocyanide.
Potassium ferrocyanide 5 grams.
Distilled water 100 cc.

Process. (*a*) To obtain the total phosphoric acid, fill the burette with the uranium solution. Add 25 cc. of the urine, 5 cc. of the sodium acetate solution, and heat to boiling. From the burette run in the uranium solution, 1 cc. at a time, into the urine kept at the boiling point. After each addition stir well and test the mixture by placing a drop on a white plate and adding to it a drop of the ferrocyanide solution. When a brown color appears add 25 cc. more of urine, run in uranium solution, 1 cc. less than the amount already added, heat to boiling, test a

* This solution, as all those used in quantitative work, should be prepared by a competent chemist, as perfectly pure chemicals and accurate weighing are absolutely necessary.

drop of the mixture with potassium ferrocyanide. Continue to add the uranium solution, 0.1 cc. at a time, until a drop of the mixture gives with the ferrocyanide a faint tinge of color, indicating that the precipitation of the phosphates is complete. Boil the whole mixture again, stirring well, and repeat the ferrocyanide test. To be accurate two determinations must be made. Read off the amount of uranic solution used in the titration and calculate the result. Each cc. uranic solution=0.005 gram $P_2 O_5$.

EXAMPLE.

Urine in 24 hours, 1400 cc.
Uranic solution used, 22.5 cc.
50 cc. urine contain $22.5 \times 0.005 = 0.1125$ grams $P_2 O_5$.
1400 cc. contain 3.1500 grams.

(*b*) To estimate the phosphoric acid combined with the alkaline earths, make 200 cc. of the filtered urine alkaline with ammonia and set aside for 12 hours. This precipitates the earthy phosphates. Collect the precipitated earthy phosphates on a filter and wash with ammoniacal water. Make a hole in the filter and wash the precipitate through with water acidified with a few drops of acetic acid. Completely dissolve the phosphates with the aid of a little acetic acid and heat. Add 5 cc. of the sodium acetate solution, bring the volume up to 50 cc. with water and titrate as in (*a*).

In calculating remember that this result gives the phosphoric acid in 200 cc. of urine instead of 50 cc.

(*c*) To estimate the phosphoric acid of the alkaline phosphates. Subtract the phosphoric acid combined as earthy phosphates from the total phosphoric acid, and the difference will be equal to the acid combined with the alkalis.

(6) **Estimation of Albumin.** Of the approximate methods of estimating the quantity of albumin in the urine, the bulk of the deposit after acidulation and boiling is the one most frequently used by physicians. It serves a useful purpose, but is exceedingly inaccurate, and gives not even an approximate idea of the percentage of albumin. Oliver's method of comparing the opacity produced by precipitation of the albumin with potassio-mercuric iodide is a very convenient clinical method. Ranking far above all other approximate methods, both in ease of application and accuracy, is Esbach's, with the instrument which he terms an albuminometer. As will be seen below it can be applied in a moment, and the result read off in percentage in a few hours.

The only accurate method of estimating albumin is the gravimetric, which takes too much time to be available to the physician.

Approximate estimation by boiling. Nearly fill a test tube, 6 inches long and $\frac{3}{4}$ inch in diameter, with filtered urine, boil and add a few drops of nitric acid. Set aside for 12 hours, agitating once or twice in that time to insure close deposit of the precipitate. The height of the deposit as compared with the column of urine —one-half, one-fourth, etc.—is used to indicate the amount of albumin. In expressing the amount of albumin estimated by this method, the terms "one-half deposit," "one-fourth deposit," etc., should be used; not 50 per cent., 25 per cent., etc.

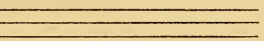
Oliver's method. Apparatus required.

(1) A permanent standard of opacity representing $\frac{1}{10}$ per cent. of albumin precipitated by the mercuric or ferrocyanide tablet or test paper.

The best form of permanent opacity standard is provided by a sealed tube of alumina precipitated by ammonia. The tube containing the alumina must be of the same diameter as the tube used for testing.

(2) A graduated flattened tube of definite diameter.

(3) Printed lines



to determine the depth of the opacity.

Process. If the urine be highly albuminous dilute with one, two or three times its bulk of water and multiply the result accordingly.

Pour 50 minims of the urine—or the diluted urine—into the flattened tube. Drop in a mercuric or a ferrocyanide, along with a citric acid tablet or test paper, and thoroughly shake the tube. Remove the exhausted papers, if test papers have been used. Place the card bearing the printed lines behind the tube and the opacity standard, placed side by side, and if the opalescence of the precipitated albumin is seen to exceed that of the standard, add water and shake the tube until the two are exactly equalized. Add the water with care, 10 minims at a time if the opacity only slightly exceeds that of the standard.

When the opacities in the standard and the testing tube are equal, calculate the percentage of albumin by multiplying the number of minims of fluid by two, and pointing off three decimal places. For example, when it is necessary to dilute the 50 minims of urine to 230 minims, the amount of albumin is .460 per cent.

Esbach's method. The albuminometer is a tube 1.5 centimeters in diameter and 15 centimeters long, and graduated into lines which represent 1 gram of albumin in 1 litre of urine. The graduations marked U and R represent the amounts of urine and reagent respectively which are used in the process.

The test solution consists of—

10 grams picric acid (to coagulate the albumin).

20 grams citric acid (to keep the phosphates in solution).

Water to make one litre.

Process. Fill the albuminometer to the mark U with urine, and to the mark R with the test-solution. Mix thoroughly, close the tube with a rubber stopper and set aside for 24 hours. Shake once or twice in that time to insure deposition of the albumin. Read off the result. Each main line of division represents 1 gram of albumin to 1 litre of urine, or .1 per cent.

Urines very heavily loaded with albumin require dilution. If diluted to double its volume multiply the result obtained by two, if to three times its volume by three, and so on.

Sherer's method. Place 100 cc. of clear urine in a beaker of 200 cc. capacity and acidify with a few drops of acetic acid, unless it be already markedly acid. Heat in a water bath for a half-hour, or until the precipitate settles. Collect the precipitate upon a small filter which has been dried at 110° F. and weighed. Wash the precipitate first with water rendered ammoniacal to remove uric acid and urates, then with hot water till the filtrate gives no reaction for chlorides, then with alcohol, and lastly with ether.

Dry the filter and precipitate at 110° F. and weigh. The difference in the weight of the filter before and after the addition of the precipitate equals the albumin in 100 cc. of urine.

(7) **Estimation of Glucose.** The most convenient way to approximately estimate glucose in the urine is by the fermentation method. Dr. Roberts' method of determining the amount of glucose by the loss in specific gravity after fermentation, requires no especial apparatus, and gives roughly approximate results. Dr. Max Einhorn,* of New York, has, however, perfected the fermentation method, and has made it possible for every physician to estimate in a moment's time, the quantity of glucose in urine with sufficient accuracy for all clinical purposes. The great value of the fermentation method lies in the fact that it forms an absolutely confirmative qualitative test. A number of compounds other than glucose reduce the other sugar tests, but none respond to fermentation. I have used the method for several months with perfect satisfaction.

The picric acid method of Dr. Geo. Johnson is not much easier of application than the accurate method of Fehling. Some modification of Fehling's method is used for all accurate estimations. Pavy's modification is a favorite with many chemists.

Dr. Roberts' method. Principle. A saccharine urine loses after complete fermentation one degree of specific gravity for each grain of sugar per fluid ounce.

Process. Carefully determine the specific gravity of the urine. Put 4 ounces in a 12

* N. Y. Med. Record, Jan. 28, 1887.

ounce bottle, add a lump of yeast as large as a walnut (½ of a cake of Fleischmann's yeast), shake thoroughly, cover with a nicked cork, and set aside for 24 hours. Decant the clear urine and take the specific gravity. Subtract the specific gravity of the urine *after* fermentation from the specific gravity *before* fermentation. Each degree of specific gravity lost equals 1 grain of sugar per fluid ounce.

Dr. Max Einhorn's method.

Principle. The amount of gas (principally carbon dioxide) given off during the fermentation of a solution of glucose measures the quantity of glucose present.

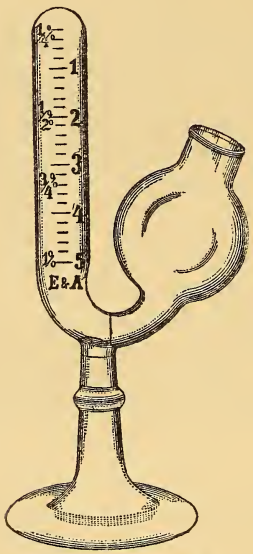


Fig. 3. Dr. Einhorn's Fermentation Saccharometer.

Apparatus. The "fermentation saccharometer," (Fig. 3) as the instrument is named by Dr. Einhorn, consists of a U shaped tube, one limb of which is a cylinder closed at the top, and the other dilated into an open bulb. The cylinder is graduated into cubic centimetres, and also marked to permit the reading of the amount of sugar in percentage. The tubes are sold in pairs, accompanied by a test tube graduated to 10 cc.

Process. Take 1 gram of fresh commercial

compressed yeast (or $\frac{1}{16}$ of a cake of Fleischmann's yeast), shake thoroughly in the graduated test tube with 10 cc. of the urine to be examined. Then pour the mixture into the bulb of the saccharometer. By inclining the apparatus the mixture will easily flow into the cylinder, thereby forcing out the air. Atmospheric pressure prevents it from flowing back.

Leave the apparatus undisturbed for 20 to 24 hours in a room of ordinary temperature.

If the urine contain sugar, the alcoholic fermentation begins in about 20 to 30 minutes. The evolved carbon dioxide gathers on the top of the cylinder, forcing the fluid back into the bulb.

On the following day the upper part of the cylinder is filled with gas. The changed level of the fluid in the cylinder shows that the sugar reaction has taken place, and indicates by the numbers the approximate quantity of sugar present.

If the urine contain more than 1 per cent. of sugar, then it must be diluted with water before being tested.

Diabetic urines of straw color and a specific gravity of 1018–1022 may be diluted twice; of 1022–1028, five times; 1028–1038, ten times.

The original (not diluted) urine contains in proportion to the dilution two, five or ten times more sugar than the diluted urine.

In carrying out the fermentation test, a normal specimen should be tested at the same time.

The mixture of the normal urine with yeast will have on the following day only a small bubble on the top of the cylinder. That proves at once the efficacy and purity of the yeast.

If there is likewise in the suspected urine a

small bubble on the top of the cylinder, then no sugar is present, but if there is a much larger gas volume, then we are sure that the urine contains sugar.

Oliver's method with indigo-carmine. In making a quantitative test with indigo-carmine much more care must be used in every detail than in qualitative testing. Select daylight for the experiment, and place a white object, as a sheet of paper, close behind so that the color changes may be accurately noted. Place an open watch on the table. Dissolve an indigo tablet or test paper in 60 minims of distilled water in a half-inch test tube, and boil the solution till the coloring matter is completely dissolved. Note accurately the time and add *one drop* of the urine to the boiling indigo solution. Keep the solution at the boiling point without agitation, and note the color at the end of 30, 60, 90 and 120 seconds.

(*a*) *The reaction is incomplete.* When the final color-change—pale yellow—is not developed at the end of two minutes there is less than 5 grains of glucose per ounce—under 1 per cent.

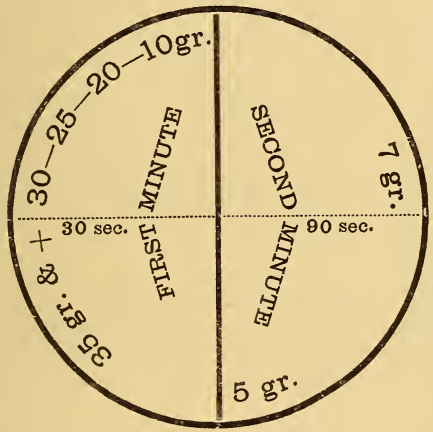
If sugar be present in smaller quantity than 5 grains per ounce, the color of the solution at the end of two minutes represents definite quantities as follows:

Violet	= 1 grain per ounce.
Purple	= 2 grains per ounce.
Red	= 3 grains per ounce.
Reddish-yellow	= 4 grains per ounce.

(*b*) *The reaction is complete.* The time required for the full development of all the colors is determined by the amount of sugar. When straw color is reached in—

½ minute, there are 35 grains or more per ounce;
1 minute, there are 10 grains per ounce;
2 minutes, there are 5 grains per ounce.

This is graphically represented in Dr. Oliver's diagram:



Urines containing more than 10 grains of sugar to the ounce must be diluted one, two, three or more times before an accurate estimation can be made.

Dr. Johnson's method with Picric Acid. Principle. Urine containing glucose boiled with picric acid and solution of potassa changes to a dark mahogany-red color, due to the development of picramic acid, the intensity of the color varying with the amount of glucose.

To prepare the standard solution. Add together in a large boiling tube marked to 4 drachms, 1 drachm of a solution of glucose, 1 grain to the ounce, ½ drachm of solution of potassa and

40 minims saturated solution of picric acid ; dilute the whole to 4 drachms. Boil the liquid for 60 seconds ; a beautiful dark red color develops.

Cool the tube by cautiously immersing in cold water, and if the level of the fluid be below 4 drachms add water to the 4-drachm mark.

This color is the standard, and represents 1 grain of glucose to the ounce four times diluted, or, $\frac{1}{4}$ grain per ounce. The color of this solution is not permanent, however. It may be exactly imitated by a solution of ferric acetate, prepared as follows:

Solution of iron chloride, sp. grav. 1.44 ʒi.
Solution of ammonium acetate, ʒiv.
Glacial acetic acid, sp. grav. 1.065, ʒiv.

Mix, and add,

Solution of ammonia, ʒi.

Dilute with distilled water to ℥iv.

The ingredients are all of the standard of the British pharmacopœia. This solution, corresponding to $\frac{1}{4}$ grain of glucose per ounce, is permanent.

Process. Test a drachm of the urine as in the preparation of the standard solution. Into the picro-saccharometer (Fig. 4)—which consists of a stoppered tube 12 inches long and $\frac{3}{4}$ of an inch in diameter graduated into 100 equal divisions, and by the side of this tube and held in place by an S-shaped band of metal is a stoppered tube of equal diameter and about 6 inches long, containing the standard iron solution—pour sufficient of the dark saccharine liquid to occupy exactly 10 divisions of the graduated tube. If the color be darker than the standard, cautiously dilute with water until they are of the same shade.

Note the dilution necessary and calculate the

result. If the two agree in color without dilution the urine will contain exactly 1 grain per ounce. If it be necessary to raise the fluid from the 10-mark to the 20-mark to make the colors correspond, the urine contains 2 grains per ounce; if to the 35-mark 3.5 grains, etc.

In the analysis picric acid must be added in proportion to the sugar present. If as high as 6 grains per ounce, 1 drachm of the picric acid solution is necessary. If the urine contain more than this quantity, as determined by the first experiment, repeat the experiment with urine diluted two or more times, as may be necessary. In computing the result bear in mind the dilution.

Fig. 4. Dr. Johnson's Picro-saccharometer.

Fehling's Test. Solution. Fehling's solution, or the modification in which the copper and the Rochelle salt are kept in separate solutions, may be used. In the process given below the latter has been used. 1 cc. of the solution equals .005 gram glucose.

Process. Measure 5 cc. of each of the solutions into a thin white porcelain capsule, add 40 cc. of water. Dilute 10 cc. of urine with 90 cc. of pure water, and fill the burette to the zero point with the mixture. (This dilution of 10 to 90 is to be made only when the urine is highly saccharine; urines containing but small quantities of glucose should be diluted 10 to 40, or less. The degree of dilution is determined by the energy of the reaction in the qualitative testing.)

Heat the copper solution quickly to boiling.

No change of color should take place in a minute or two. (If it do change, reject the solution as unfit for use.) Now run the urine mixtur efrom the burette into the boiling copper solution, quickly at first, then slowly until the blue color of the solution is just discharged. To determine this point, incline the capsule and observe the color against the white porcelain background.

Now read off the amount of urine used in the titration and confirm the accuracy of the observation by a second experiment. Accept the result of the second experiment.

EXAMPLE.

Urine in 24 hours, 2000 cc.
Urine diluted, 10 cc. urine to 40 cc. water.
Reading of burette, 26 cc.

$\frac{26}{5}$ = 5.2 cc. urine contain .050 gram glucose.

5.2 : .05 :: 2000 : 19.9 grams in 24 hours.

Pavy's method. Dr. Pavy avoids the troublesome precipitation of cuprous oxide by employing an ammoniacal copper solution, the ammonia of which holds the oxide in solution.

Process. Place in a 5 or 6 ounce flask 10 cc. of the copper solution. Provide the flask with a cork having two perforations, through one of which passes the point of a Mohr's burette, the other being fitted with a short glass tube to carry off the ammoniacal vapors. (An *open* flask cannot be used in this experiment, since oxygen absorbed from the air will vitiate the result.)

Dilute the urine 1 to 10, 1 to 20, or 1 to 40, according to the amount of sugar present, as approximately determined by the qualitative tests. It should be diluted so that 4 to 8 cc. of the mixture will reduce the copper solution. Fill the burette with the diluted urine.

Heat the contents of the flask to boiling, and run in the urine from the burette. Reduce the flow as the reaction reaches an end, which is announced by the complete disappearance of the blue color.

Take the burette reading and calculate the result.

1 cc. Pavy's solution=.0005 glucose.

The 10 cc. used in the titration=.005 glucose.

Determine the result as in the use of Fehling's solution.

(8) **Estimation of Bile-Salts** by Dr. Oliver's method. A permanent standard of opacity is required to represent the average discharge of bile-salts in healthy urine. Dr. Oliver uses a standard made by a precipitate of alumina in a sealed tube. A standard may be extemporaneously prepared by mixing together 60 minims (4 cc.) each of healthy urine, reduced to specific gravity of 1008, and of the peptone test solution.

Process. To 60 minims of the peptone test solution, the urine of sp. gr. 1008 is added—in ordinary cases 10 or 20 minims at a time, and allowing a minute to elapse after each addition—until the opacity induced is seen to be exactly equal to, or to slightly overstep, that of the standard—the tubes being held to the light, *shaded by a dark background*, such as that of the coat-sleeve.

If 50 or 60 minims of the urine bring up the opacity merely to that of the standard, the proportion of bile-salts is not outside the normal range—in the direction of increase. But any smaller quantity of urine required indicates an excess of the biliary derivatives over the physio-

logical variations. The smaller the amount of urine needed, the larger the proportion of bile-salts present—according to the following table*:

Minims of urine required.	Percentage increase of bile-salts over the normal standard.
55	5
50	10
45	17
40	25
35	36
30	50
25	70
20	100
15	150
10	250
5	550
4	700
3	950
2	1,450
1	2,950

*Calculated expressly for this work. The figures given in Oliver's Bedside Urine Testing are wide of the truth.

CHAPTER III.

MICROSCOPICAL EXAMINATION.

Perfectly normal urine, at the time of evacuation and for some hours after, contains all of its constituents in solution. A light cloudy deposit after a few hours is normal. It consists of mucus entangling a few epithelial cells. After from twelve to twenty-four hours, the time depending upon the temperature, the changes described in Part 1, and known as the *acid* and *alkaline fermentations* take place. By these fermentations the chemical characters of the constituents of the urine are so changed that precipitation of various compounds takes place. During the acid fermentation, acid sodium and potassium urates and uric acid deposit; during the alkaline fermentation, ammonium urate, amorphous calcium phosphate and triple phosphate. On account of the liability of these changes to occur *deposits should be examined early.*

To examine a deposit, put an ounce or two of the urine in a cylindrical vessel, a test tube on foot or a cylindrical graduate, and set aside in a moderately cool place for a few hours.

In general we may expect to find in *an acid urine*, urates, uric acid, tyrosin, cystin; in *an alkaline urine*, ammonium urate, calcium phosphate, triple phosphate, calcium carbonate; in a nearly neutral urine, calcium oxalate. Organized sediments may occur in acid, neutral or alkaline urines.

Take up a few drops of the sediment in a nipple pipette and deposit a drop of it on a clean glass slide, and drop over it a thin cover glass. If the sediment be very light concentrate it by taking the lower stratum from the cylinder and allowing it to settle again in a small test tube. Concentration can be very neatly done also by taking the sediment up in a nipple pipette and setting that aside. When searching for casts add to the drop of urine a drop of a nuclear staining fluid, as ammonio-carmine, and set aside for a few minutes. The casts and epithelium take the stain and contrast strongly with the unstained crystals and other objects. Without staining delicate hyaline casts often escape detection. As a further aid in identifying doubtful objects, have the object in view under the microscope and move the cover glass very gently with the tips of the fingers or with the point of a dissecting needle. By this little manœuvre the shape and all sides of an object may be subjected to scrutiny. Examine the sediment with a $\frac{1}{2}$-inch or a $\frac{1}{4}$-inch objective. The $\frac{1}{4}$-inch or higher is often necessary to resolve small crystals.

Classification. Deposits may be classified into

The unorganized—

Uric acid;

Urates { Acid sodium urate; Acid potassium urate; Acid calcium urate; Acid ammonium urate;

Calcium oxalate;

Ammonio-magnesian phosphate;

Calcium phosphate;

Calcium carbonate ;
Tyrosin ;
Leucin ;
Cystin ;
Oil globules.

The organized—

Epithelium ;
Mucus ;
Pus ;
Blood ;
Casts ;
Spermatozoa ;
Microbes ;
Elements of morbid growths.

UNORGANIZED DEPOSITS.

Uric Acid. *Microscopical characters.* Uric acid assumes a multitude of crystalline forms. (Fig. 5.) The most frequently observed

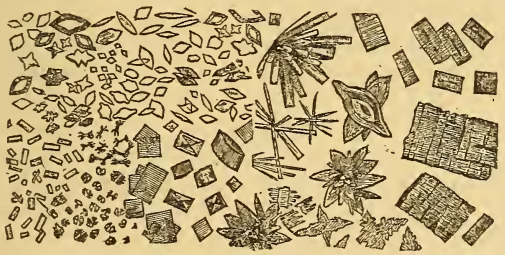


Fig. 5. Uric Acid. ×120.

forms are rhombic, often with two obtuse angles rounded. Whetstone or lozenge shaped, dumb bell and comb-shaped crystals are common. The crystals may be very minute in size, or large enough to be easily visible with the naked eye.

When of large size they form the "red pepper" grains or gravel so often spoken of by patients. These large grains are made up of rosette-shaped masses of crystals. Uric acid is nearly always colored from light yellow to dark red. Every red, brown, or yellow crystalline deposit is uric acid.

Chemical characters. Insoluble in hot or cold water. Soluble in alkalies. Responds to the murexid test.

Murexid test. Place a few grains of uric acid on a porcelain plate, add a few drops of nitric acid, and heat gently until the fluid has all evaporated. Moisten the yellow residue which results with a drop of ammonia. A beautiful purple red color appears, due to the formation of ammonium purpurate $C_8H_4(NH_4)N_2O_6$.

Occurrence. The urine of healthy persons often deposits uric acid 10 or 20 hours after emission. Such an event is normal. A deposit formed 3 or 4 hours after passing is not normal. Persons otherwise healthy not infrequently pass urine which shows a deposit. Slight disturbances of the chemistry of the body not manifested by symptoms may determine it. When occasional and transient the occurrence is of no consequence; when persistent it requires treatment. A highly acid state of the urine is most influential in producing the precipitate, the acid of the urine decomposing the soluble neutral urates and liberating the very insoluble uric acid. A deposit of uric acid does not always mean *excess*. Changed chemical characters in the urine may determine a deposit when the amount of uric acid is below normal. The significance of the various forms of crystals is as yet unknown. The pathological

conditions in which uric acid deposits are frequent are—

Convalescence from febrile diseases;
Chronic pulmonary diseases;
Pneumonia;
Acute rheumatism;
Chorea;
Functional and organic liver diseases;
Acute inflammation of the kidneys;
Eczema and some other skin diseases;
Gout;
Diabetes;
Lithæmia.

Urates. Uric acid occurs in the urine in combination with sodium, potassium and ammonium, rarely with calcium. The urates form a bulky, sometimes colorless, often yellow or red deposit. It is often termed a "brick-dust" or "lateritious" sediment.

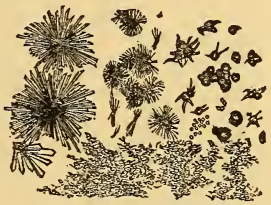


Fig. 6. Crystalline and Amorphous Urates. ×200.

Microscopical characters. Sodium urate forms an amorphous deposit, composed of minute particles which show no crystalline form even under high powers. The particles are massed together in groups often assuming various forms. Rolled masses of urates sometimes resemble casts. Sodium urate sometimes crystallizes in prisms arranged in rosettes or stellate bundles. Potassium urate closely resembles the sodium salt. *Ammonium urate* occurs only in alkaline urines. It appears in the form of dark

spheres and globular masses, the spheres often being armed with little spicules. (Fig. 6.)

Chemical characters. Urates are soluble in hot water, so that any deposit that disappears on the application of heat is composed of urates. They respond to the murexid test.

Calcium Oxalate. Oxalic acid in very minute quantity in combination with sodium and ammonium is a constant constituent of all urines. Under several physiological and pathological circumstances it appears as the insoluble calcium oxalate and forms one of the urinary sediments. It may be found in acid, neutral or alkaline urines.

Fig. 7. Calcium Oxalate. (After Charles.) ×250.

Microscopical characters. The deposit most frequently occurs in the form of very minute octahedra. They appear as minute squares with two lines crossing each other in the centre—letter-envelope shape. When very minute they merely show a bright spot in the centre. Dumb-bell forms are sometimes seen, and modifications of dumb-bells, as peculiarly marked ovoids. (Fig. 7)

Chemical characters. Insoluble in acetic acid (distinguishing from triple phosphate), alcohol, water, and alkalies. Soluble in nitric acid.

Significance. Calcium oxalate may be derived (Ralfe)—

(1) From the food.

Directly by the ingestion of foods containing calcium oxalate, as rhubarb, sorrel, tomatoes, excess of carbonated drinks, etc.;

indirectly, by the imperfect oxidation of carbohydrates and fats, oxalic acid being one of the substances formed.

(2) From increased tissue metabolism.

Imperfect oxidation of fats, etc., is the cause of the appearance of the oxalate. Urines under these circumstances are high colored, and contain excess of urea, uric acid and phosphates. This is one of the most frequent pathological causes of a deposit.

(3) From the mucus from the urinary tract.

Meckel is of the opinion that the acid fermentation which mucus undergoes in certain catarrhal conditions gives rise to oxalate of calcium.

(4) From excess of acid in the circulation.

This condition is found in catarrhal inflammation of the small intestines. Fermentative changes generate the fatty acids in great excess, which are absorbed and but incompletely oxidized, and the intermediate acid, oxalic, is formed. This condition, often described under the term *oxaluria*, is attended by all the symptoms of intestinal indigestion, by irritation of the bladder from the presence of the sharp pointed crystals, and by great mental depression.

According to Beale, a deposit of dumb-bells of calcium oxalate is of peculiar significance. They are very liable to form the nuclei of calculi. When the oxalate assumes this form, energetic efforts should be made to keep it in solution.

Phosphates. The phosphates in the urine are held in solution by the acid present. So soon

as the urine becomes neutral or alkaline, whether the alkalinity be due to fixed or volatile alkali, the phosphates are thrown from solution and appear as a deposit; and this deposit takes place whether the phosphates are increased or diminished. A *deposit* of phosphates, then, has no necessary relation to the *amount*. The great excess found in phosphaturia does not show itself by a deposit unless the urine becomes neutral or alkaline.

Calcium Phosphate usually appears as a white deposit in urines neutral or alkaline from either fixed or volatile alkali.

Microscopical characters. The deposit is amorphous or crystalline. The amorphous granules are distinguished from a similar deposit of urates by the particles being isolated and scattered evenly over the field, while the particles of a deposit of amorphous urates adhere together and form masses of various shapes. The crystals of calcium phosphate are wedge-shaped and arranged in rosettes, their points uniting.

Fig. 8. Ammonio-Magnesian Phosphate. ×120.

Chemical characters. The deposit is increased by heat and dissolved by acids, distinguishing it from a deposit of urates.

Ammonio-magnesian phosphate — (triple phosphate) $N H_4 Mg P O_4$, occurs in urines neutral or alkaline from the presence of volatile alkali (ammonia).

Microscopical characters. The most com-

mon form is the triangular prism with obliquely truncated ends (Fig. 8). Modifications of this form and imperfect crystals are frequently seen. Sometimes beautiful stellate feathery crystals are observed; they may be artificially produced by adding ammonia to fresh urine.

Chemical characters are the same as those of calcium phosphate.

Occurrence. As has been said before, a deposit of the phosphates is indicative of a neutral or alkaline reaction of the urine rather than an excess of phosphates, and the significance of a

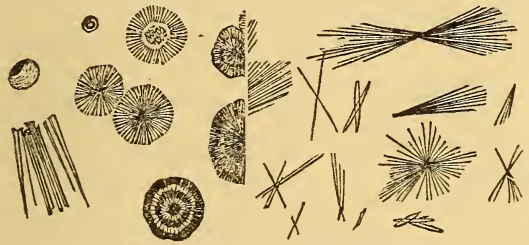


Fig. 9. Leucin and Tyrosin. ×255.

deposit will depend upon the cause, persistence, etc., of the alkalinity. It should be borne in mind that although no conclusion can be drawn from an excess of phosphates, the frequent presence of a deposit is of significance on account of a possibility of the formation of soft phosphatic concretions.

Calcium Carbonate, a very rare deposit, occurs as small spheres. It effervesces on the addition of an acid.

Tyrosin and Leucin. *Microscopic Characters.* Tyrosin appears as fine, long,

silky needles, generally arranged in sheaf-like bundles or rosettes. It sometimes appears as yellowish-green, crystalline globules, which dissolve in hot ammonia, and recrystallize on cooling in radiated groups of needles. Leucin appears as brown-tinted spherical masses, with fine radial striation and often with the appearance of concentric rings. (Fig. 9.)

Cystin. *Microscopical characters.* Cystin appears as hexagonal plates, colorless or sometimes pigmented. It is soluble in ammonia, recrystallizing on evaporation. (Fig. 10.)

Occurrence. Dr. Bence Jones thinks cystin is constantly formed in the healthy organism and immediately transformed into sulphuric acid, carbon dioxide and urea. Whenever this transformation is arrested cystin appears in the urine. It is a very rare sediment. In the majority of the cases in which it has been found the individuals have been below the standard in health. A number of cases have been observed in which a deposit of cystin persisted for years. Dr. Ralfe has met with it in the urine of strumous children, and adults with hepatic disease.

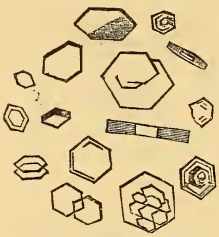


Fig. 10. Oystin. ×200.

Oil Globules in the urine appear under the microscope as highly refractive spheres and minute bright specks. They are soluble in ether.

ORGANIZED SEDIMENTS.

Epithelium (Fig. 11) from various parts of the urinary tract, from glands opening into it,

and, in women, from the vagina, frequently occur in urinary deposits, both in health and disease. In disease the appearance of the cells and their number may give important information as to the nature, location and severity of the morbid process. The varieties of epithelial cells that are to be seen are—

Round cells;
Columnar cells;
Flat cells.

Round cells. Small round cells come from the convoluted tubes of the kidney. (Fig. 14–A, 1.) Large round cells come from the pelvis of

Fig. 11. a From ureter. b From urethra. c From pelvis of kidney d From bladder. e From vagina. ×150.

the kidneys, and fundus of the bladder. They are irregularly round, granular, and contain a large single nucleus.

Columnar cells may come from the pelvis, ureters (often spindle shaped), fundus of the bladder and urethra. They are elongated, irregularly conical, and contain a single nucleus.

Flat cells are derived from the base of the bladder and from the vagina. The vaginal cells are much the larger.

Although in many instances it is possible to locate the source of the epithelium, the great similarity of the cells from different localities renders it often a matter of guess work.

The epithelium may, under different circumstances, undergo granular or fatty degeneration, maceration and disintegration, or they may be imperfectly formed.

Abundant epithelium means catarrhal inflammation.

Mucus and Pus. Mucus in small quantity is present in normal urine. It forms a light sediment near the bottom of the glass, which is visible because of the epithelium, crystals, etc., entangled in it. In disease it may be present in large quantity, and it then appears as a clear, translucent mass.

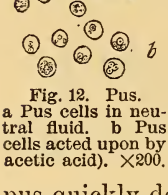


Fig. 12. Pus. a Pus cells in neutral fluid. b Pus cells acted upon by acetic acid). ×200.

Pus may be present in the urine in very small amount, or in large quantity; it then forms a bulky white deposit. The urine is turbid when passed, and the pus quickly deposits.

Microscopical characters. Pus and mucus corpuscles have the same appearance under the microscope. (Fig. 12.) They appear as small granular globules, $\frac{1}{3000}$ to $\frac{1}{2500}$ inch in diameter, and may vary somewhat in shape and character in different states of the urine. Acted upon by acetic acid, the granular appearance is destroyed, and they become clear cells with one or more distinctly visible nuclei. Abundant epithelium, croupous shreds and crystals often accompany pus deposits.

Chemical character. The mucin of mucus is precipitated by acetic acid. The pyin of pus is precipitated by mercuric chloride. These reactions serve to distinguish between these bodies.

When present together the pyin may be precipitated by mercuric chloride and filtered out, and the filtrate tested for mucin by acetic acid.

Donnè's test for pus. To the suspected deposit obtained by decanting off the supernatent fluid add a little liquor potassæ. The corpuscles quickly disappear and the pus is transformed into a thick, glairy, gelatinous mass. Mucus treated with liquor potassæ becomes thinner.

This change in pus takes place spontaneously in urine that has undergone alkaline fermentation, the ammonia formed in the decomposition acting as the reagent. Pus changed in this manner must not be mistaken for mucus.

Occurrence. Pus is present in the urine—

In inflammation from any cause, at any point along the urinary tract;

In inflammation of glands and ducts opening into the urethra;

In some forms of Bright's disease;

In renal embolism and abscess;

In abscesses opening into the urinary tract at any point;

From sources outside the urinary tract, as the admixture of a leucorrhœal discharge in women.

Pus coming from the urethra is more abundant at the beginning of urination; from the bladder, at the end of the act.

Urine containing pus coming from the kidney is usually acid; from the bladder the reaction is usually alkaline.

If blood accompany the pus the two are intimately mixed when the trouble is in the bladder; when in the kidney the blood forms a layer on top.

Urine containing pus in any quantity is albuminous. It is a question often very difficult to decide whether the albumin in a purulent specimen is derived entirely from the liquor puris or comes in part from a diseased kidney. The amount of albumin which is to be expected from the pus present is gradually learned by observation, and this point alone enables an experienced observer to reach a conclusion. Other characters of the urine, as the presence or absence of casts, and the amount of urea, offer valuable evidence.

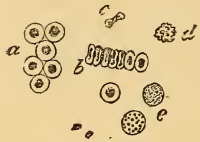


Fig. 13. Blood Corpuscles. ×200.
a Red cells seen flat. b In rouleau. c In profile. d Crenated. e White cells.

Blood. Blood corpuscles are distinguished by their characteristic bi-concave centers and yellowish color. In dilute urine the discs swell up and become round; in concentrated urine they shrink and become crenated. (Fig. 13.)

Tube casts. In diseases of the kidney, manifested by albuminuria, casts of the uriniferous tubules find their way into the urine, and can be seen with the microscope in the sediment. In some cases they are very numerous, every slide examined showing many specimens; or they may be so few that the most diligent search is necessary to discover them. Whenever they are to be sought in a scanty sediment it should be concentrated by allowing it to settle two or more times. To take the sediment up from the settling glass in a nipple pipette, and allow it to collect in the end of that is a very efficient way to concentrate.

Casts are formed of coagulable material, exuded into the lumen of the uriniferous tubules. This solidifies and entangles with it any other substances, as blood, pus, epithelium, etc., that may be present in the tubule. The casts contract and loosen from the sides of the tubule, and are washed into the pelvis of the kidney by the urine secreted above them.

The nature and origin of the coagulable material that forms the base of the cast is still a matter of dispute. The conditions under which the casts are formed admit of several explanations, and it is probable that in different pathological conditions of the tubules one of two or more processes is active, or perhaps two or more combine.

They are probably for the most part of the nature of fibrinous exudations. In the acute forms of Bright's disease, particularly, the conditions for fibrin formation are present. The exuded plasma contains the fibrinogen, and the white corpuscles the globulin and ferment. Brought in contact with the diseased epithelium the white cells disintegrate and fibrin is formed.

Beale thinks that casts are composed of a substance nearly related to mucin, and that it is formed by the protoplasm of the tubes, which under ordinary circumstances forms the outer part of the epithelial cells. Under the conditions of renal congestion and inflammation, however, it forms the transparent material of the cast.

Again, casts may be the result of coagulation necrosis of the lining epithelium of the tubules. Casts having such a source do not differ in composition from the proper fibrinous ones; the fibrinogen has the same source, while the epithe-

lium, instead of the white blood cells, furnish the fibrinoplastic matter and the ferment (Coats).

Cornil recognizes mucous tube-casts which differ from the ordinary hyaline casts in being more delicate and transparent and with less clearly defined borders. A still more important distinction is that they are not stained by carmine. I have observed these casts in cases of albuminuria after specific fevers. This difference in chemical properties makes it highly probable that the transparent base of tube-casts varies in composition.

Varieties. *Hyaline*, or *transparent casts* (fibrin cylinders), are the most common form, and are observed in all varieties of renal disease. They are mostly long and narrow cylinders, transparent and homogeneous. They may be straight, wavy or forked. Their ends may be rounded off or have the appearance of having been broken. They often have a few particles or streaks of granular matter imbedded in them.

Hyaline casts vary from $\frac{1}{1000}$ to $\frac{1}{500}$ inch in diameter. The small hyaline casts are formed in tubes the epithelium of which is firmly attached to the basement membrane. They have the diameter of the normal calibre of the tubule. The large casts are formed in tubes denuded of epithelium by disease. Their diameter is therefore equal to the diameter of the tube measured from the basement membrane. Some hyaline casts are more highly refractive and dense, and have the appearance of molten wax. These are termed *waxy casts*, and have been observed particularly in amyloid disease of the kidney. They do not respond to the test for amyloid substance. Some

hyaline casts are not stained by carmine (the mucous casts of Cornil). (Fig. 14.)

Blood casts. In diseased conditions attended by the effusion of blood into the tubules casts are formed containing few or many blood discs. Often the cast appears to be a solid mass of corpuscles, and is in reality a miniature clot.

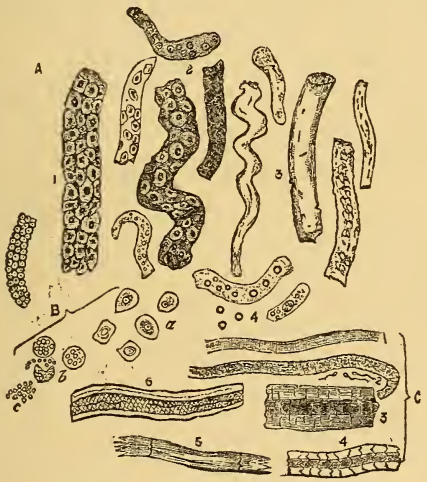


Fig. 14. Renal Casts (Charles). ×225.

A. Renal Casts—1 Epithelial casts. 2 Granular casts (the uppermost containing blood cells). 3 Large and small hyaline casts. 4 Fatty casts.

B. Renal Cells—a Normal. b Undergoing fatty degeneration. c Free fat granules.

C. Objects that may simulate renal casts—1 Mucus cast. 2 Spermatic cast. 3 Human hair. 4 Woolen hair. 5 Flax. 6 Cotton fibres.

Epithelial casts are formed when the epithelium exfoliates and becomes entangled in the coagulating material. The epithelial cells may be fairly perfect, or may have undergone granular or fatty degeneration.

Granular casts result from the imbedding

of granular matter in a forming cast. The granular matter may be the debris of degenerating epithelium or disintegrating blood cells, molecular fat, or amorphous urinary salts. They are termed highly, moderately, or faintly granular, according to the amount of granular matter present.

Fatty casts show minute oil globules scattered through the hyaline substance.

Pus casts have also been observed.

Sometimes crystals of various salts are seen imbedded in casts, or a small cast may be formed inclosed by a larger one.

Clinical significance. Casts are usually indicative of congested and inflammatory conditions of the kidney. They are found in—

Acute and chronic renal congestion ;
Acute Bright's disease ;
Chronic Bright's disease ;
Irritation from renal calculi ;
The urine of jaundice without renal disease.

If Beale's theory of the production of the base of casts be true, it is highly probable that hyaline casts may be formed during transient and insignificant catarrhal states of the renal tubules, induced by diatetic errors, exposure, or medicines, and not incompatible with a state of apparent health ; and in fact they are occasionally observed in the urine of healthy individuals. But, although they *may* be found under such circumstances, their occurrence in a urinary deposit is a matter of gravity, and with but few exceptions indicates disease of the kidney.

In addition to the value of the discovery of casts as indicative of renal disease, their number and appearance in a given case furnish most

valuable assistance in the determination of the condition of the kidney, the prognosis, and the plan of treatment to be pursued. The number of casts often bears no relation to the gravity of the case. For example, in the declining stage of acute nephritis they are often very abundant, while in grave interstitial nephritis only an occasional specimen may be found. Casts usually accompany albuminuria, but they have been observed without this symptom. Casts without albumin are probably rarer than is thought. Delicate and careful testing would, I think, almost always reveal it. Casts formed in non-albuminous urine are always hyaline. Albuminuria may occur without casts.

Hyaline casts may be seen in congestion of the kidney from any cause, and in mild and transient catarrhal states. They also may be present alone or in company with other varieties in all forms of acute and chronic Bright's disease. They are often seen in the latter stages of acute nephritis. They are about the only form observed in interstitial nephritis and amyloid kidney before the involvement of the tubules in the morbid proccess. In chronic nephritis they are also frequent. The small hyaline casts are seen when the epithelium is intact; the large casts when the epithelium is denuded. The latter are, then, in chronic disease, of much graver significance, indicating destruction of the secreting tissues. When observed in the latter part of acute nephritis the injury to the epithelium is often but temporary, and they are not so ominous.

Blood casts are significant of hemorrhage into the tubules, which may occur in intense arterial or venous congestion or acute nephritis.

Epithelial casts are particularly indicative of the early stages of nephritis. The condition of the epithelium making up the casts is significant of the changes that the tubules have undergone.

Granular casts. The nature of the granular matter making up these casts varies much, and the appearance of attendant varieties of casts gives valuable data for determining its source. In the later stages of nephritis the granular matter is usually the debris of degenerated epithelium. In fatty kidney it consists of molecular fat. Under other conditions amorphous urinary salts may give the granular appearance.

Fatty casts are found during convalescence from acute nephritis, in fatty kidney, and under other circumstances. When highly fatty casts are persistent grave fatty change is indicated.

Pus casts indicate the presence of pus in the tubules from bursting of an abscess or pus formation from the inflamed epithelium.

Spermatozoa may be recognized under a $\frac{1}{5}$ inch objective by their characteristic oval head or body and the delicate tail-like cilia projecting from it. In urine they are motionless. They are found in urine under the various physiological and pathological conditions in which they are discharged into the urethra.

Microbes. In addition to the micrococcus ureæ always present in decomposing urine, various other minute organisms may be found. Although of biological interest they, with one exception, have no clinical significance. The Saccharomyces urinæ is found only in urine containing sugar.

Elements of Morbid Growths. Tumors of the bladder often reveal themselves by the appearance of minute parts of them or their individual cells in the urine. It is unnecessary to detail here the microscopical characters of such a deposit.

CHAPTER IV.

ANALYSIS OF CALCULI.

Urinary calculi occasionally consist of but one constituent. Most frequently, however, they consist of two or more, arranged in concentric layers around a nucleus composed of a small renal calculus, mass of mucus or epithelium, a clot of blood or a foreign body. A small concretion of uric acid is the most frequent nucleus.

Of the compounds that go to make up urinary calculi the most important are—

Uric acid and urates;	Calcium oxalate;
Earthy phosphates;	Xanthin;
Calcium carbonate;	Cystin.

General characters of calculi. *Uric acid* calculi are the most frequent, forming about 25 per cent. of all stones. They are hard, usually of a flattened ovoid shape, reddish or yellowish brown in color. The surface is smooth and concentric, layers crystalline in structure.

Urates are almost always combined with other compounds. Ammonium urate calculi are sometimes seen in children. They differ only in color from uric acid calculi, being of a dull white or clay color.

Calcium oxalate calculi are common, forming about 20 per cent. of all stones. They usually form around a uric acid nucleus. They are often quite large, have a very rough and irregu-

lar surface, and are brownish or dirty purple in color. From these properties they are often termed "*mulberry calculi.*" Small, smooth and often polished calcium oxalate calculi are often met with—*hemp seed* calculi. Many mixed calculi contain this salt.

Phosphates. Calcium phosphate forms a very rare calculus. They are often large, with white, friable exterior.

Ammonio-magnesian phosphate is very rarely the sole constituent of a stone. It often forms layers of mixed calculi, and in combination with calcium phosphate forms what is termed the *fusible* calculus.

Calcium carbonate calculi are occasionally met with. They are usually multiple. They are spherical, sometimes pyramidal in shape, and mostly white in color.

Xanthin calculi are extremely rare. They are yellowish brown in color, smooth, and take a polish when rubbed.

Cystin calculi are very rare. They are smooth, greenish-yellow in color, and very soft.

Concretions of fibrin, blood, fatty substance or cholestrin are sometimes seen.

To analyze a calculus. Make a section through the centre of the stone, and scrape off some of the cut surfaces. If the stone be small pulverize it. Make separate analysis of the body of the stone and the nucleus.

Examine the powder thus obtained by

WITTHAUS' SCHEME FOR ANALYSIS.

1. Heat a portion on platinum foil:
   a. It is entirely volatile 2
   b. A residue remains 5

2. Moisten a portion with nitric acid, evaporate to dryness at low heat; add ammonium hydrate:
   a. A red color is produced 3
   b. No red color is produced 4
3. Treat a portion with potassium hydrate without heating:
   a. An ammoniacal odor is observed..... *Ammonium urate.*
   b. No ammoniacal odor..... ..... *Uric acid.*
4. *a.* The nitric acid solution becomes yellow when evaporated; the yellow residue becomes reddish-yellow on addition of potassium hydrate, and, on heating with potassium hydrate, violet-red.....*Xanthin.*
   b. The nitric acid solution becomes dark brown on evaporation.....*Cystin.*
5. Moisten a portion with nitric acid; evaporate to dryness at low heat; add ammonium hydrate:
   a. A red color is produced 6
   b. No red color is produced 9
6. Heat before the blow-pipe on platinum foil:
   a. Fuses..... 7
   b. Does not fuse 8
7. Bring into blue flame on platinum wire:
   a. Colors flame yellow .....*Sodium urate.*
   b. Colors flame violet.....*Potassium urate.*
8. The residue from 6:
   a. Dissolves in dilute hydrochloric acid with effervescence; the solution forms a white ppt: with ammonium oxalate.....*Calcium urate.*
   b. Dissolves with slight effervescence in dil. sulphuric acid; the solution, neutralized with ammonium hydrate, gives a white ppt. with hydrogen disodium phosphate..... *Magnesium urate.*
9. Heat before the blow-pipe on platinum foil:
   a. It fuses.....*Ammonio-magnesian phosphate.*
   b. It does not fuse..... 10
10. The residue from 9, when moistened with water, is:
   a. Alkaline..... 11
   b. Not alkaline.....*Tricalcic phosphate.*
11. The original substance dissolves in hydrochloric acid:
   a. With effervescence.....*Calcium carbonate.*
   b. Without effervescence.....*Calcium oxalate.*

NOTE.—A fresh portion of the powdered calculus is to be taken for each operation except where otherwise stated.

CHAPTER V.

APPARATUS AND REAGENTS.

In this chapter will be enumerated the apparatus and reagents that are necessary to conduct the tests detailed in the body of the book, and which could not be conveniently spoken of in the text.

Apparatus. *Test tubes.* A dozen test tubes of assorted sizes with rack and drainer are necessary. For general testing, a test tube ½ inch in diameter and 3 inches long is the most convenient. A large tube for boiling is useful. Test tubes on foot form the best vessels for the collection of sediment. One or more graduated test tubes are very convenient.

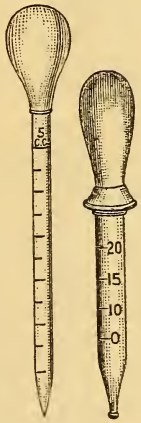


Fig. 15.
Nipple Pipette.

Pipettes. The nipple pipette (Fig. 15) is the most useful for all the manipulations in urine analysis. They may be obtained in various sizes and graduated into minims or cubic centimetres. The ordinary medicine dropper answers well when specially made instruments cannot be obtained. Volume pipettes (Fig. 16) holding 5 cc. and 10 cc. are used in quantitative analysis. Useful pipettes may be made from straight glass tubing.

Urinometers. I have found many of the urinometers on the market very inaccurate. The best instrument is the one supplied by Dr. E. R. Squibb of Brooklyn (Fig. 17). It is of the most approved shape—with the air chamber ovoid instead of cylindrical—and each instrument has been tested, and its variations at 1000, 1030 and 1060 noted. It is standardized for a temperature of 77° F. (25° C.), a temperature much more easily obtainable than 60° F. The glass cylinder has a heavy foot, and its sides are

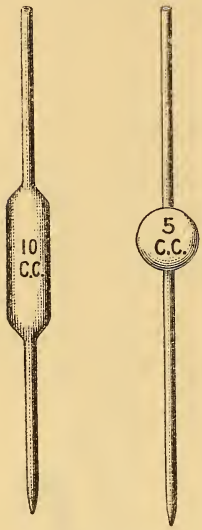


Fig. 16.
Volume Pipettes.

fluted or indented. This form of cylinder and the shape of the urinometer air chamber prevent adhesion between the two. A thermometer accompanies the instrument.

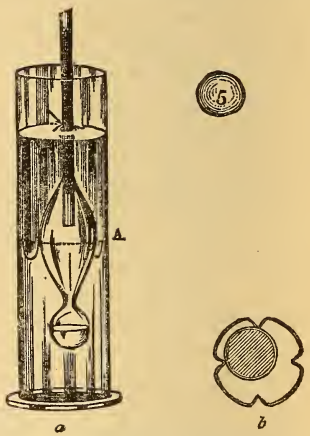


Fig. 17. Specific Gravity Bead (5) and Dr. Squibb's Urinometer.

The specific gravity bead is very convenient for either bedside or office use. The bead in Dr. Oliver's test case has a density of 1008, and is sold with a

graduated test tube for diluting the urine. It is quite accurate and convenient. A bead of a density of 1005 is, I think, to be preferred.

Dr. A. B. Lyons, in the Pharmaceutical Rec-

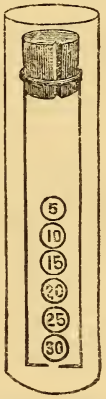


Fig. 18. Bead Urinometer.

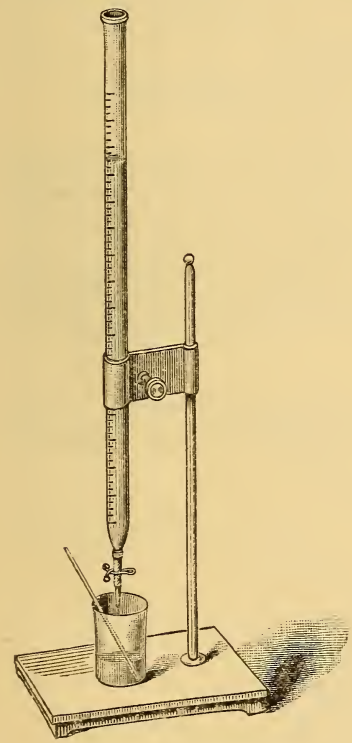


Fig. 19. Mohr's Burette.

ord, July 15, 1885, describes a very convenient and durable urinometer made with a set of specific gravity beads. The instrument (Fig. 18) consists of six beads arranged in regular order, the heaviest at the bottom, in a narrow test tube, perforated at the bottom and closed with a nicked cork.

Burettes. Two Mohr's burettes (Fig. 19) of a capacity of 50 cc. are necessary in accurate quantitative work. A burette holder is also essential.

Graduated Jars. One with a capacity of 2000 cc. for collecting and measuring the 24 hours' urine. Smaller graduated cylinders of a capacity of 100 or 200 cc.

Glass Funnels, three, assorted sizes.

Beaker Glasses, one-half dozen.

Porcelain Capsules, three.

Spirit Lamp, stirring rods, wash-bottle, blow-pipe, platinum foil, swabs for cleaning test tubes, retort stand, red and blue litmus paper, filter paper, and a microscope with accessories.

The apparatus necessary for emergency and bedside testing is conveniently put up in small compact cases, to be carried in the pocket or medicine case.

Reagents. *General reagents.* Acetic acid, nitric acid, hydrochloric acid, sulphuric acid, all chemically pure.

Fuming nitric acid.

Liquor potassæ, U. S. P. Specific gravity 1065.

Liquor ammoniæ, U. S. P.

The magnesian fluid.

Magnesium sulphate, 1 part.
Ammonium chloride, 1 part.
Solution of ammonia, 1 part.
Distilled water, 8 parts.

Solution of barium chloride.

Barium chloride, 4 parts.
Distilled water, 16 parts.
Hydrochloric acid, 1 part.

Solution of copper sulphate.

Copper sulphate, 1 part.
Distilled water, 32 parts.

Solution of silver nitrate.

Silver nitrate, 1 part,
Distilled water, 8 parts.

Solution of neutral lead acetate.

Neutral lead acetate, 1 part.
Distilled water, 4 parts.

Distilled water.
Alcohol, ether, and chloroform.

Special reagents for albumin testing.

Potassio-mercuric iodide. (Tanret's reagent.)

Potassium iodide, 3 32 grams.
Mercuric chloride, 1.35 grams.
Distilled water, 64. cc.
Acetic acid, 20 cc.

Solution of potassium ferrocyanide.

Potassium ferrocyanide, 1 part.
Distilled water, 4 parts.

Solution of picric acid.

Picric acid, 7 grains.
Distilled water, 1 ounce.
Dissolve by boiling and filter.

Solution of sodium tungstate with citric acid.

Solution sodium tungstate (1 to 4), 1 part.
Solution citric acid (10 to 6), 1 part.

Solution of acidulated brine.

Saturated solution sodium chloride, 16 parts.
Hydrochloric acid, 1 part.

Solution of phosphor-tungstic acid.

Boiling saturated solution of sodium tungstate.
Phosphoric acid to acid reaction.
Cool and make strongly acid with acetic acid.
Let stand for 24 hours and filter.

Special reagents for glucose testing.

Fehling's solution.

Copper sulphate, 34.64 grams (534.6 gr.).
Rochelle salt, 173.0 grams (6 oz. av.)
Sodium hydrate, 40. grams (617.3 gr.).
Water to make 1 litre (33.82 fl. oz.).
1 cc. (mxv)=.005 (gr. $\frac{1}{1\,8}$) glucose.

Fehling's solution in two solutions.

(1) Copper sulphate, 69.28 grams (505.9 gr.)
Sulphuric acid, 1 cc. (8 m.).
Water to make 1 litre (1 pint).

(2) Rochelle salt, 350 grams (6 oz av.).
Sodium hydrate, 100 grams (730 gr.).
Water to make 1 litre (1 pint).

These solutions mixed in equal volumes reproduce Fehling's solution.

Prof. Wayne's formula with glycerin.

Copper sulphate, 30 grains.
Caustic potassa, 15 grains.
Pnre glycerin, 2 fl. drams.
Water, 6 fl. oz.

Pavy's solution.

Copper sulphate, cryst. 4.158 grams.
Rochelle salt, recryst. 20 400 grams.
Caustic potassa, 20.400 grams.
Strong ammonia (sp. gr. 0.880) 300 cc.
Water to make 1 litre.
1 cc.=.0005 glucose.

Indigo-carmine is best used in tablet or test paper, as the quantity of the reagent and sodium carbonate must be always the same.

Special reagent for bile-salt testing.

Dr. Oliver's peptone test.

Pulverized peptone (Savory and Moore), gr. xxx.
Salicylic acid, gr. iv.
Acetic acid (B. P.) mxxx.
Distilled water to make ℥ viii.
Filter until transparent.

The nitric magnesian test.

Pure nitric acid, 1 part.
Saturated solution magnesium sulphate, 5 parts.
Filter till perfectly clear.

Miscellaneous reagents. Bismuth sub-nitrate, solution of ferric chloride, potassium bromide, potassium iodide, tincture guaiac, ozonized ether (solution of hydrogen peroxide in ether).

Tablets and Test Papers.

Dr. Geo. Oliver, of London, introduced to the profession a few years ago reagents put up in the form of test papers. They consist of strips of bibulous paper saturated with a reagent and dried. When used the reagent is dissolved out and the paper removed from the test tube. This form of reagent is exceedingly convenient, and makes bedside urine testing practicable. They have the advantage also in containing always the same quantity of reagent. This is of considerable value in albumin testing, and absolutely necessary in testing for glucose by indigo-carmine.

For a few months I have been experimenting with reagents in the form of tablet triturates, manufactured at Dr. A. B. Lyons' suggestion by Parke, Davis & Co.

The results have been highly satisfactory. In this form the reagent is quickly and completely soluble, and does not leave after solution a paper to be extracted or fibres to make the solution turbid. It has all the advantages of the paper and none of its objections.

Tablets or papers are as useful for office as for bedside testing. They are permanent, compact and cleanly, and all the reagents used in ordinary testing may be embodied in them.

The reagents that are put up in this form are—

Indigo-carmine;
Potassio-mercuric iodide;
Potassium ferrocyanide;
Picric acid;
Sodium tungstate;
Citric acid;
Sodium carbonate;
Oliver's peptone test.

Tablets with the apparatus for bedside testing are put up in small pocket cases, very convenient and compact, by Messrs. D. O. Haynes & Co.

ADDENDA.

1. **Nitric Magnesian Test for Albumin.** Dr. H. B. Millard, of New York, speaks very highly of a modification of the nitric acid test introduced lately by Dr. Roberts. He terms it the nitric magnesian test. The reagent consists of a mixture of nitric acid, one volume, with a cold saturated solution of magnesium sulphate, five volumes. (See page 121.) Pour 30 minims (2 cc.) of the reagent into a test tube, carefully overlay this with 60 minims (4 cc.) of the urine. If albumin is present a white ring forms at the plane of contact of the two fluids. The advantages of this reagent over pure nitric acid are: 1st. It is not corrosive, and does not stain the fingers, or produce a coloration with iodides. 2d. Its great density makes the reaction an exceedingly sharp one, so that the test has even greater delicacy than where pure nitric acid is used.

Dr. Millard regards this as the most satisfactory test for albumin as regards delicacy, accuracy and facility of employment. Its indications are the same as those of the nitric acid test (page 57).

2. **Estimation of Uric Acid.** **Haycroft's Volumetric Method.* *Principle.* Urate of silver is soluble in nitric acid, but insoluble in ammonia.

* This method, recently published, is the most exact yet devised.

Solutions required—

(1) Ammoniacal solution of silver nitrate.
Silver nitrate, 5 grams.
Water, 90 cc.
Ammonia sufficient to make a clear solution, and water to make 100 cc.

(2) Ammonium sulpho-cyanide centinormal.
Ammonium sulpho-cyanide, 8 grams.
Distilled water, 1 litre.
Adjust strength to centinormal silver nitrate.
1 cc. = 0.00168 gram uric acid.

(3) Saturated solution of ferric alum as an indicator.

Process. To 25 cc. of urine, freed from albumin, add 1 gram sodium bicarbonate and 2.5 cc. water of ammonia. Then add 1 to 2 cc. of the silver solution, collect the precipitate, wash with distilled water until the washings are free from silver, dissolve in a little dilute nitric acid, and estimate the silver in the solution by titration with the sulpho-cyanide solution, using the ferric alum as an indicator. Multiply the number of cc. used by .000642 ($.00168 \div 25 \times 10$) and divide the specific gravity of the specimen to obtain the uric acid. Or, multiply the number of cc. used by .00306 to find the number of grains of uric acid in each fluid ounce of urine.