HELLER'S

PATHOLOGICAL CHEMISTRY OF THE URINE,

WITH SHORT AND EASY

DIRECTIONS FOR ITS EXAMINATION:

TO WHICH IS APPENDED A BRIEF ACCOUNT OF SOME OF THE OTHER EXCRETIONS, AND OF THE BLOOD AND MILK.

By LUDVIG DAHL, Cand. Med.

TRANSLATED FROM THE NORWEGIAN BY

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PREFACE.

HAVING been for many years constantly engaged in the examination of the urine and other animal fluids, both in their healthy and morbid conditions, I became impressed with the idea that a concise manual, which should enable the practical physician, without undue expenditure of time or labor, to ascertain for himself their leading features, was a desideratum in our medical literature. This observation applies in a more especial manner to the renal secretion, to the examination of which so much attention has of late years been justly directed in the investigation of disease; and the changes in the composition of which in many instances so largely influence the practitioner in the formation both of his diagnosis and prognosis, as well as in the selection of the therapeutical measures he is to employ.

While recently perusing a number of the *Norwegian Magazine of Medical Science*, it appeared to me that I had met the materials of such a manual, in a clear and concise history of the chemistry and pathology of the urine, by Dr. Ludvig Dahl, entitled, " Communications from the Chemico-Pathological Laboratory in Vienna,*" and I hoped that an English translation of the essay, which I now venture to lay before the profession, would prove acceptable, especially to the medical man engaged in active practice.

Dr. Dahl's paper contains a faithful epitome of the views of the distinguished pathological chemist of Vienna, Dr. Joh. Florian Heller, apparently the fruits of observation during personal attendance in the laboratory of that eminent professor ; accordingly, it does not follow the order in which Dr.

* *Meddelelser fra det chemisk pathologiske Laboratorium i Wien*, published in the *Norsk Magazin for Lægevidenskaben*, 1854, viii. Bind, 6 Hefte. Christiania : Feilberg & Landmark.

Heller has himself put forward his opinions at much greater length, and with vastly more minuteness of detail, in a series of papers in his *Archiv für Physiologische und Pathologische Chemie und Mikroskopie ;* but having had an opportunity lately of perusing these papers, I can bear testimony to the accuracy and fidelity with which his views have been condensed. Dr. Dahl's paper is in the original illustrated by a lithographic plate, representing some of the most important matters met with in the microscopic examination of urinary deposits ; I have thought it more advantageous to exhibit these in the form of woodcuts, interspersed through the pages of the book, in direct connection with the subjects treated of. For the style in which they are executed I am indebted to Mr. Oldham of this city. I have introduced between brackets additional matter, including among other things the results of some experiments of my own. In conclusion, I venture to hope that I shall not be proved to have rashly added to the number of books in our language on the subject of which the following pages treat; but that while others are found valuable by those who can devote their time and talents to the engrossing study of animal chemistry in its minute details, this manual may be awarded the merit, to use the language of the author, "of having so simplified and made easy the processes and agents employed in chemical investigations, as to enable the practising physician to avail himself, without disproportionate loss of labour and time, of the assistance afforded by pathological chemistry."

WILLIAM D. MOORE.

7, South Anne-street, Dublin,
May 24th, 1855.

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PATHOLOGICAL CHEMISTRY OF THE URINE.

ERRATA.

Page 19, line 8, for *free from carbon*, read *rich in carbon*.

Page 70, *note*, for 1854, read 1852.

very important chemical peculiarities are not to be recognized by external signs. In this way very different conditions of the fluids examined have been confounded, some similar have been dissevered, and some very important have been entirely overlooked. Even, therefore, if the co-existent state of the body had been correctly estimated, the signs derived from the fluids should have been quite wrong ; but as, in addition, the other branches of pathological knowledge were defective and full of error, the most of what was stated as to the signs to be derived from the fluids must be rejected from a more perfect and more scientific method of investigation.

Pathological chemistry is still but little developed, and it may be doubted how often it may be of essential benefit to the practical physician ; but its undoubted merit is, that it has overthrown the former superficial mode of investigation, and the incorrect, and, for the patients, often fatal conclusions built upon it : for example, the repeated bleedings, supposed to be indicated by the inflammatory crust.

However, pathological chemistry gives the physician such important points of support, if not in a therapeutic, at least in a diagnostic and prognostic sense, that we should by no means despise the assistance it affords ; and the difficulty of the practitioner consists only in being able to profit by it, without disproportionate labour and loss of time. In this respect, the professor in the chemico-pathological laboratories of Vienna, Dr. Heller, has the merit of having simplified and made easy the processes and agents employed in chemical investigations.

Since, according to Heller, every, even the least, abnormity in the blood, which may have its origin either in the process of nutrition or in the influence of the nervous system, makes itself known by a chemical change in the urine, and this excretion, which is almost always accessible, is besides best suited to an easy and rapid examination, he recommends the practical physician to direct his attention to it, not only in diseases of the organs which are most nearly connected with its elimination, but in all the more important morbid conditions of the system. But it is not sufficient to employ a few simple re-actions on certain substances ; we must both qualitatively examine and approximately determine the quantities of all the more important matters demonstrable in the urine, and in this manner obtain a survey, a sketch of this fluid ; which cannot, indeed, always lead to a special or affirmative diagnosis,—this is sometimes only general, sometimes merely exclusive,—yet still, while it gives information about the morbid process, yields important contributions both to diagnosis and prognosis.

In the following pages, I shall first describe the mode of proceeding adopted by Heller in the examination of the urine, and afterwards the interpretation which, according to his experience, may be applied to its results. I shall finally give a short review of the more important of the other secretions and excretions, so far as the practical physician may derive advantage from their consideration.

THAT a fluid is really urine, or at least contains urine, may be ascertained by heating a drop of it on a piece of platina foil. The combustion of the urophæin gives rise to the peculiar urinous odour, which is quite distinct from that of ammonia.

As a general rule, it may be observed that the urine ought to be recently voided and as concentrated as possible ; consequently it should not be selected after the ingestion of much drink (urina potûs) ; on the contrary, that passed in the morning or after copious perspiration should be chosen. If it is to be kept or sent to a distance, a small flask should be completely filled with it, closely corked, and kept cool.

If the urine deposits a sediment, the latter must be carefully removed with it. The entire should be poured into a cylindrical glass vessel, and the supernatant fluid and sediment should subsequently be examined separately.

In examining the urine the following scheme should be employed, so that nothing may be forgotten; and it will be found advisable immediately to write down the result of each re-action, which may be thus abbreviated: N [*normal*]; +; *slightly* +; *strongly* +; —; *slightly* —; *strongly* —; O.

PHYSICAL PROPERTIES.

Colour.	Specific gravity.	Sediment ?
Smell.	Re-action on litmus.	

CHEMICAL INGREDIENTS.

NORMAL.

Urophæin (Up.)	Chlorides (Cd.)
Uroxanthin (Ur.)	Sulphates (St.)
Urea ($\bar{U}$.)	Earthy phosphates (Ep.)
Uric acid (U.)	Alkaline phosphates (Ap.)

ABNORMAL.

In solution.	Sediment.

CHAPTER II.

PHYSICAL PROPERTIES OF THE URINE.

Colour.—Normal urine has a wine or amber yellow colour. This depends essentially on the urophæin, and diminishes and increases in intensity with the quantity of this principle. The less concentrated the urine is, the less urophæin is present, and the lighter the colour; thus the colour also bears a relation to the specific gravity. Where this is not the case (as in lighter urine with increase of density) there is reason to suspect the presence of a foreign substance (sugar, albumen). Blood and other coloured matters give the urine various shades, but conclusions must not be drawn too quickly from the appearance alone. Bile pigment makes its foam yellow.

The *Smell* is faintly urinous, from the urophæin; the other ingredients are inodorous. The smell of ammonia, the ammoniaco-urinous odour, does not occur until decomposition has commenced. Sulphuretted hydrogen is sometimes present in freshly voided urine. The cause of a mouldy smell, which often does not become evident until after the addition of concentrated sulphuric acid, is unknown. According to Heller, it is a bad prognostic.

The *specific gravity* may be taken in a little cylinder, with the aid of Heller's urometer.* This is a small areometer, 0° of which corresponds to 1,000 specific gravity (water), 1 to 1,007; 2 to 1,014; 3 to 1,021; 4 to 1,028; 5 to 1,035; 6 to 1,043; 7 to 1,050; 8 to 1,058; which is the highest specific gravity any animal fluid has. Of the normal ingredients, urea and the chlorides have most influence on the specific gravity; of the abnormal, albumen and sugar.

Reaction on litmus.—This should be tried as quickly as possible, and by holding the paper for a couple of seconds in the fluid. Heller admits three kinds, acid, alkaline, and amphigenous. The acid reaction is derived from the urophæin (only in a slight degree from the uroxanthin, and not from the uric acid). The more concentrated the urine is, the stronger is the acid reaction. When the urine is highly coloured (by urophæin), and the

* This, together with all the apparatus necessary for these investigations, may be procured for from 5 to 7 dollars from Luhme and Company, Kurstrasse, no. 51, Berlin.

reaction on litmus is notwithstanding but weakly acid, it may be inferred that a substance is present which affects the reaction in an opposite direction. An alkaline reaction proceeds either from carbonate of ammonia or carbonate of soda. As the former is volatile, an alkaline reaction which remains after boiling proceeds from carbonate of soda. This becomes even stronger after boiling. According to Heller, urine never gives a neutral reaction when the test paper is good. In other words, he states that with slightly coloured litmus paper he can in such cases demonstrate both reactions, and this is what he calls amphigenous reaction. This he explains by considering urophæin as not properly an acid, but merely an animal pigment with an acid reaction; which does not combine with ammonia, and does not expel carbonic acid from its union with the same; and which may consequently exist in a state of mechanical mixture with carbonate of ammonia.

Sediment.—In normal urine, we observe after the lapse of one or two hours a whitish cloud in the middle or nearer the bottom of the vessel, which consists of mucus from the urinary passages. Whether the opacity occurs more superficially (cremor), or more deeply in the vessel (enæorema), or as a proper precipitate (hypostasis—sediment in a limited sense), or, lastly, generally diffused (jumentosa), cannot lead to important chemical inferences. On the contrary, the colour has more significance; as the more red or yellowish shade, where blood is not present, generally depends on the precipitation of urates, while the whitish is more frequently connected with deposition of the earthy phosphates. The chemical constitution of calculi cannot with certainty be inferred solely from their physical properties.

CHAPTER III.

CHEMICAL INGREDIENTS OF THE URINE.

Of these we must be able not merely to demonstrate the presence, but also approximately to estimate their relative quantity. The practical physician cannot, however, employ tedious methods in the attainment of this object; he cannot spare time to weigh or measure, and must therefore depend upon his sight alone. But in order that he may be able to base a correct opinion upon inspection alone, it will be quite necessary that he shall constantly adopt exactly the same mode of proceeding, and that he shall always use a similar apparatus, and reagents of the same degree of concentration. It will not be possible with certainty to estimate quantities in the ordinary slender test-tubes; the old-fashioned round wine-glass (*Dramglas*) is best suited for this purpose, on account of its wide diameter; and it is always used in Vienna when there is no occasion to resort to ebullition. Repeated practice with normal urine will be necessary to enable the experimenter to estimate the relative proportions of the several constituents. But if the conditions I have pointed out be attended to, he will with some practice acquire the power of performing the entire investigation in a few minutes with sufficient accuracy.

1. NORMAL CONSTITUENTS.

Urophæin and *Uroxanthin* are two colouring matters, free from carbon, first demonstrated by Heller, and which do not occur except in urine.

Urophæin is the principle on which the colour, smell, and reaction of normal urine depend. It is always present in solution. When heated, it gives rise to a strongly urinous odour. Its presence is demonstrated by means of concentrated sulphuric acid in the following manner: sulphuric acid is first poured into a wineglass to less than a third of the capacity of the glass, and on it about half as much urine is poured from a certain height, and shaken about or stirred with a glass rod. A strongly brown coloration then ensues. As the quantity of urophæin is to be estimated from the intensity of this latter, it is evident how necessary it is that an idea of the normal condition should first have been formed from practice. The proceeding is not scientific, but it is very practical. Where urophæin largely abounds, the fluid becomes perfectly opaque.

Uroxanthin also contributes, though in but a slight degree, to the colour and acid reaction of the urine. Highly concentrated hydrochloric acid (free from excess of chlorine, but strongly fuming) is taken in the same manner as sulphuric acid in the previous experiment, and twenty or thirty drops of urine (not more, as otherwise the acid would be rendered too dilute) are gradually dropped in and agitated with it. After some time, the acid effects a decomposition of the uroxanthin into urrhodin (red), and uroglaucin (blue.) Normal urine affords merely a reddish coloration, with a very slight tinge of violet ; where, on the contrary, the quantity of uroxanthin is increased, a violet of greater or less intensity, up to a blue coloration, occurs. Where the urophæin is diminished, even sulphuric acid may be observed to produce this decomposition, as it gives rise to a violet colour, the intensity of which is proportionate to the amount of uroxanthin present. In strongly ammoniacal urine, this decomposition sometimes takes place spontaneously, and a violet and blue sediment, formerly called cyanurin, is formed. On filtration, these matters remain on the filter ; the urrhodin is soluble in ether and cold alcohol, the uroglaucin in boiling alcohol. We sometimes find urinary concretions having layers of a bluish colour from uroglaucin. Blue sediment does not occur in acid urine.*

When uroerythrin and biliphæin are present, or where urophæin is in excess, they may mask the reaction of uroxanthin. We then precipitate with acetate of lead, filter, and apply the test for uroxanthin to the filtered fluid. A diminished quantity of uroxanthin seldom occurs, and is difficult to demonstrate.

Urea and *uric acid* are the most important nitrogenous constituents of urine. They exist already formed in the blood, and are merely separated through the kidneys.

Urea constitutes more than half the solid matter of the urine. It always occurs in solution, and has the greatest influence on the specific gravity of the excretion ; from the latter we consequently most frequently infer the proportion of urea, due regard being at the same time had to the other constituents, and especially as to whether sugar or albumen is present. Under the influence of mucus, and par-

* A knowledge of this fact led Heller to detect three cases in which sulphate of indigo had been mixed with urine for the purpose of imposture.—*Archiv*, 1852, page 126, note.—*Tr.*

ticularly of vesical mucus, it is easily decomposed, even in the bladder, into carbonate of ammonia ($N^2 H^4 C^2 O^2 + 2 HO = 2 CO^2 NH^3$). When it is present in great quantity we may, by adding nitric acid, precipitate it as nitrate of urea (by cooling the test tube in cold water or snow, and setting it aside, the entire may stiffen with crystals.) Or these crystals may be formed in the following manner :—a small porcelain capsule is filled with urine, and the latter evaporated until a little remains still in the fluid state. The capsule is perfectly cooled in cold water, and pure (not yellow) nitric acid is dropped into it, on which the entire solidifies, and small crystals of nitrate of urea (fig. 1) having a mother of pearl lustre,

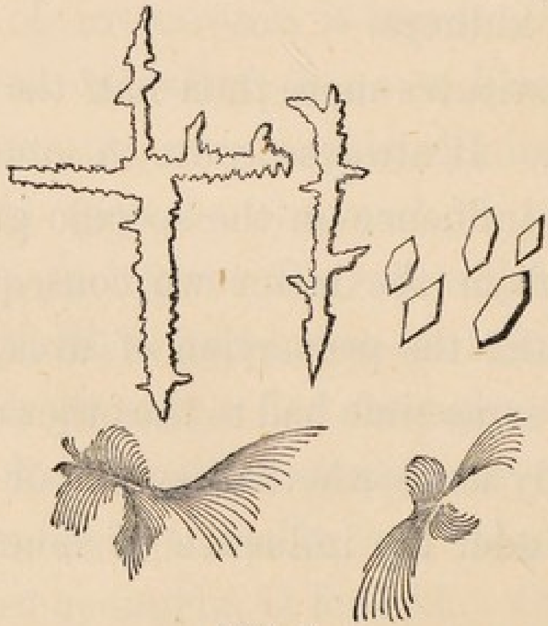


FIG. 1.

appear. In order to judge of the quantity, the experimenter must first have tried normal urine, and must always use the same capsule and the same quantity of urine. But this trouble is often avoided, and the proportion is deduced from the specific gravity alone.*

Uric acid constitutes but a thousandth part of the urine. It occurs either in solution, and has then no influence on the physical properties of the urine, (not even on the reaction.—*Heller*), or as a sediment, either alone or in combination with ammonia or soda. Its solvent is basic phosphate of soda. Where the latter is present in relatively too small proportion (for example after a hearty meal or excessive drinking) the acid is precipitated. The precipitation frequently does not take place until the urine has cooled after having been voided. Sulphuric and hydrochloric acids convert the phosphate into the acid salt, and so throw down the uric acid. Uric acid is obtained in the following manner :—Hydrochloric acid is first introduced

* Dr. E. W. Davy has recently proposed a simple and very accurate mode of determining the proportion of urea in urine, and one the manipulation of which requires but two or three minutes. It is based on the fact that urea is very readily decomposed by the hypochlorite of soda, potash, or lime, the constituent nitrogen being evolved in the gaseous state. As 0·3098 parts of a cubic inch of the gas at 60° F. 30″ Bar. correspond to a fifth of a grain of urea, the proportion of the latter can be easily deduced by calculation.—*London, Edinburgh, and Dublin Philosophical Magazine* for June, 1854.—*Tr.*

to about a finger's height into a small cylinder. Uroxanthin may first be sought for (to save the acid), and the cylinder having been then filled with urine, is covered with a piece of paper and agitated. When uric acid is present in large quantity, it deposits rapidly in crystals on the surface, sides, and bottom of the fluid; when the quantity is less, this takes place very slowly. Sometimes the separation does not occur until after the lapse of twelve hours. If the urine is ammoniacal, this test is not applicable ($\overline{U}$. NH^3.) Uric acid is recognised either under the microscope (fig. 2),

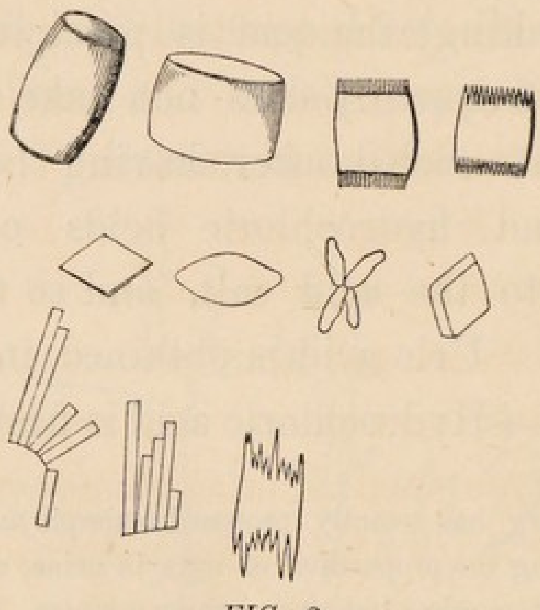


FIG. 2.

or chemically (in extraneous mixtures) by the murexid test: a little is introduced into a porcelain capsule; some distilled water and a few drops of nitric acid are added, and the entire is evaporated nearly to dryness. A few drops of water of ammonia then produce a beautiful purple-red color (murexid). This test is very sensitive, and discovers even very small quantities. The following is an easy test for the presence of uric acid in a sediment : a small portion is heated on a piece of platina foil with a couple of drops of nitric acid, avoiding complete combusttion, when a red coloration will be produced. A sediment of uric acid is distinguished from those of urate of ammonia or soda by not being dissolved on ebullition, unless ammonia be present. Uric acid is insoluble in alcohol and ether (by which it is distinguished from hippuric acid) ; it is soluble in alkalies, from its solution in which it again crystallizes on the addition of sulphuric acid.

Hippuric acid occurs only in extremely small quantity in healthy men who lead a regular life. Neither have we as yet been able to establish its constant occurrence in any particular diseases or stages of disease, and I shall therefore not dwell further upon it. The same remark applies to *kreatin* and *kreatinin* ; they occur in the flesh of muscle, and are urophanous, that is, they pass directly into the urine.

Small quantities of *fat* and *mucus* occur in normal urine. The proportion of fat may be determined by evaporating the urine and agitating with ether, in the cases in which it occurs free and visible (collapse). Sometimes it occurs in combination, very finely divided—perhaps by means of albumen, and invisible even under the microscope ; in this case, the urine is not to be previously evaporated, but should be immediately agitated with ether, (diseases of the kidneys and peritonitis.) Of mucus I shall speak more particularly when treating of pus.

The *Salts of the urine* must be specially determined, as they bear no fixed mutual relation to one another. They constitute about twelve parts in a thousand of the urine, of which the chlorides form about the half, the alkaline phosphates about four or five in a thousand, next to these are the earthy phosphates, and lastly the sulphates.

The *chlorides* (chiefly chloride of sodium,—the amount of chloride of potassium is insignificant) are determined as follows : a wine-glass is filled to about one-third with urine ; nitric acid perfectly free from hydrochloric acid is added ; this at the same time tests the fluid for albumen, as will be stated hereafter : but where much albumen is present, it is unfit for testing for chlorides, and must be filtered ; the mixture is then agitated, and the glass vessel placed on the table. A single drop of a solution of one part of nitrate of silver in eight of distilled water is now dropped in. If the chlorides are not diminished, a white spot appears on the surface, and from it a white, dense, distinctly lumpy precipitate descends when the vessel is shaken. But if the chlorides are diminished, the precipitate is finely divided ; where the quantity is still less, there is only a light cloud, and sometimes scarcely any precipitate is observed. A greater quantity of chlorides than usual has no special signification.

Sulphates (almost entirely sulphate of potash.)— To the usual quantity of urine a couple of drops of nitric acid are added, and subsequently about fifteen drops of a saturated solution of chloride of barium. As usual, the amount of precipitate is estimated by comparison with normal urine.

The *phosphates* are not all similarly circumstanced ; in diseases, for example, the alkaline phosphates are usually in direct proportion to the sulphates, and often bear an inverse ratio to the earthy phosphates ; hence, no common test for their acid will be sufficient.

The *earthy phosphates* (lime and magnesia).— The glass is half filled with urine (not to a third only, as with the other tests); three drops of water of ammonia are added, which immediately produce an opacity, and after some minutes a precipitate (of ammoniaco-magnesian phosphate) with a clear supernatant fluid. For more accurately determining the amount, graduated glasses would in this case be useful.

The *alkaline phosphates.*—The above fluid having been previously filtered is mixed with a saturated solution of sulphate of magnesia; to this are now added some hydrochloric acid and a sufficient quantity of ammonia to produce an alkaline reaction.

2. DISSOLVED ABNORMAL MATTERS.

Albumen may occur either independently, or as an ingredient of blood or pus. It is specifically heavier than water, and when therefore albuminous urine, as is often the case, has a diminished specific gravity, this generally proceeds from a deficiency of urea. Albuminous urine putrefies more rapidly than normal.

It very commonly happens that the tests for albumen are applied without sufficient precaution, and that incorrect conclusions are consequently drawn. Great accuracy is required in order to avoid mistakes as to its existence. If we confine ourselves to the unmethodical addition of nitric acid, we are liable to be deceived by a precipitation of uric acid which may take place under certain circumstances ;* while ammoniacal earthy phosphates are, when they are present, as will be mentioned hereafter, also precipitated by simple ebullition ; and no certainty is attained by the employment of the ordinary test, first adding nitric acid and afterwards boiling, as not only the urates but also coagulated albumen may be dissolved by boiling with an excess of nitric acid.

Two methods may be adopted, and for security it will be well to employ both.

1. With nitric acid, the usual quantity ($\frac{1}{3}$) of urine is taken in a glass (the test tube should not be used for this purpose), which is held with the left hand inclined at an angle of about 45°, and twenty drops of nitric acid are now poured in, in an even gentle stream, which is allowed to flow down the side of the glass. This forms, if the glass be held steadily, a layer at the bottom, and immediately above it we see the coagulated albumen, the separation of which from the urine above is

* Microscopic examination will generally at once show the nature of the precipitate of uric acid. It is surprising how instantaneously perfect crystals of uric acid are occasionally formed on the addition of the nitric acid.—*Tr.*

again accurately defined. If the precipitate is derived from urates, it is not sharply defined, but forms a streaky cloud which approaches the surface. If both albumen and urates are present, four very distinct layers are formed. At the bottom we have the nitric acid, over it the coagulated albumen, next a layer of urine, in which the acid is still so concentrated that it retains the urates in solution, while it is too dilute to coagulate the albumen [Heller], and above that again the cloudy urates. In case the experimenter is not quite satisfied with the result of this examination, which, however, to a practised hand, is both certain and quick, he tries the next mode. From what I have already stated, it will be understood that when the acid is diffused through the fluid by agitation, the specimen may be examined for chlorides.

2.—Albumen is not precipitated in alkaline urine by ebullition; the urine must therefore first be acidified with acetic acid [even a small quantity of nitric acid will hinder the precipitation of the albumen.—Heller.] In an acid urine, ebullition can only precipitate albumen and ammoniacal earthy phosphates. Two or three drops of acetic acid are sufficient to dissolve the latter;

much acetic acid is capable of dissolving albumen in boiling water.

When albumen is present in large quantity, it hinders many of the foregoing reactions. The specific gravity, reaction on litmus, urophæin, uroxanthin, and earthy phosphates may, however, be examined in urine which is very rich in albumen. For the application of the other tests it would be necessary that such urine should first be boiled and filtered through paper and linen.

[According to some experiments which I made a few years ago at the request of Dr. Mc Clintock, the present master of the Dublin Lying-in Hospital, the urine of the human fœtus would appear to be normally albuminous.* Eight specimens which I then examined were all highly so. In one instance only was the urine obtained in sufficient quantity to enable me to take the specific gravity, which was 1·0085. The reaction of two of the specimens is noted as having been acid, and one neutral. Five were examined for urea, but in none could any be discovered. It has recently been stated by Bernard that the fœtal urine is saccharine. I have not had an opportunity since I

* *Dublin Quarterly Journal of Medical Science*, new series, vol. 7. p. 46 et seq.

saw this statement of investigating the point ; but I may observe that the low specific gravity of the specimen mentioned above, and of another in which some years before I had found it so low as 1·003, is presumptive evidence against the presence of any considerable quantity of sugar. The saccharine condition referred to, is attributed to the fact that the sugar, which, as is well known, is generated in the fœtal liver, is but imperfectly destroyed, there being no respiration, and the process of oxidation in the fœtus being consequently indirect and deficient in energy.*

In connexion with the absence of urea in the fœtal urine, my attention was drawn to a statement which has been made, that "infants secrete scarcely a trace of urea." I examined the urine of an infant aged six months, nourished exclusively at the breast ; of another at the same age, fed artificially ; and also that of a child aged ten months, labouring under dysentery and fed artificially. "In each instance the quantity of urea present was pretty considerable, fully proportionate to the specific gravity of the fluid operated on."†]

The occurrence of blood and pus in the urine is spoken of under the head of sediments.

* Heller's *Archiv*, 1852 ; p. 74. † *Dub. Q. J.*, vol. 7, p. 49.

Combinations of ammonia.—The primary form is the carbonate; after the carbonic acid is expelled we may have sulphuret of ammonium, urate of ammonia, and ammoniaco-magnesian phosphate.

Carbonate of ammonia.—The physical properties of urine do not always disclose the presence of small quantities of this salt. Even the reaction may continue to be acid, as I have already observed in speaking of urophæin. Larger quantities produce an alkaline reaction, an ammoniacal smell and turbidity, in consequence of the formation of urate and phosphate of ammonia. Its presence is demonstrated by boiling the urine in a flask accurately fitted with a cork traversed by a glass tube. In the latter is placed a roll of reddened litmus paper moistened with distilled water, which, if ammonia be present, acquires a blue colour from below. If the urine contains albumen the flask must, during the ebullition, be kept in motion over the flame, to prevent burning of the albumen, and the consequent development of ammonia. This experiment is tried in a rougher way by boiling the urine in a porcelain capsule, and holding moistened litmus paper over it.

Sulphuret of ammonium.—Carbonate of ammonia is always present at the same time. The sulphuret is recognised by its peculiar smell, and by passing two glass tubes through the cork of the flask, in one of which is placed litmus paper as in the foregoing experiment, and in the other filtering paper moistened with a solution of a salt of silver: this acquires, when the liquor is boiled, first a brownish and subsequently a black colour, and, if a large quantity of sulphuret be present, a metallic lustre.

Urate of ammonia may occur in solution, or suspended in the urine without being deposited, or as a well-defined sediment (fig. 3*). Of the action

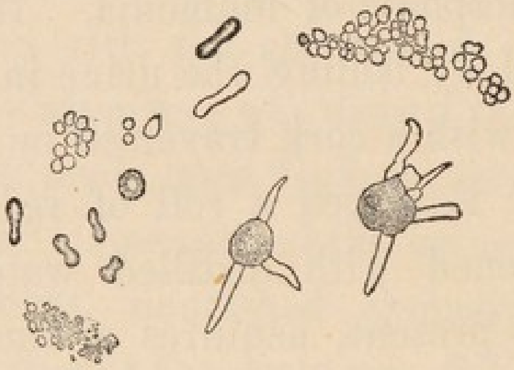


FIG. 3.

of the dissolved urate I have spoken when treating of albumen. The suspended urate is dissolved on the application of heat; but if ammoniacal earthy phosphates or albumen be present, a precipitate again immediately occurs. It also dissolves on the addition of ammonia, which is not the case with

* The portions projecting from the spheres are urate of soda.

urate of soda; but in this instance also a precipitate of phosphates immediately follows. The deposited sediment may be suspended by agitation and examined in the same manner. The more colouring matter (especially uroerythrin) there is combined with it, the more amorphous it is, and it then forms a pulverulent, irregular, rose-red coating on the sides of the vessel (sedimentum lateritium).

Ammoniaco-magnesian phosphate may also occur in solution, and it is precipitated together with basic phosphate of lime and a little carbonate of lime, as the so called earthy phosphates or bone-earth. These are distinguished from the other phosphates by being precipitated not merely by ammonia but also by heat, in consequence of which they may be mistaken for albumen; as was mentioned in speaking of the latter, they are distinguished from it by the addition of a couple of drops of acetic acid. The ammoniaco-magnesian phosphate may, according to Heller, also occur in urine which has an acid reaction; in alkaline (from ammonia) it *must* be present. Like uric acid, it often attaches itself to the sides of the glass, but is distinguished therefrom by its crystals being transparent and perfectly colourless (uric acid is yellow or brick-red), and soluble in acetic acid. Lastly, by examination under the microscope (fig. 4).

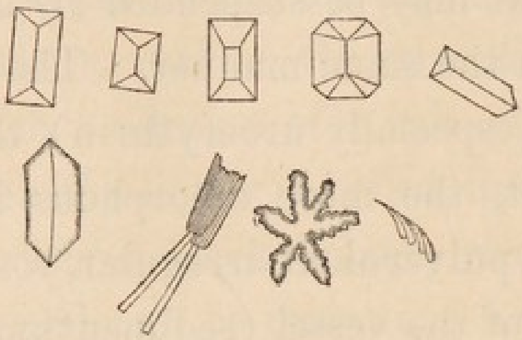


FIG. 4.

Constituents of the Bile : *Biliphæin and Bilin.*—These when they occur in the urine are always in a state of solution. They do not necessarily occur together ; sometimes we find much Biliphæin without Bilin, sometimes Bilin without Biliphæin.

Biliphæin (Bp.) when present in large quantity in the urine causes a yellow foam on agitation. A similar effect may be owing to the presence of the colouring matters of senna and rhubarb, but in such cases ammonia produces a beautiful red colour.

When Biliphæin is exposed to the action of oxydizing substances, its colour changes from yellow to green, blue, violet, red, and finally to yellow again. On this circumstance the tests of its presence are founded. Where the quantity of Biliphæin is very small, these shades of colour do not all distinctly appear. Normally, Biliphæin becomes of a yellowish red on the addition of hydrochloric acid ; if its decomposition has already commenced, it becomes green. The tests are two :

1. Simon's test.—Concentrated nitric acid is added with the same precautions as in testing for albumen. We thus obtain the transitions of colour, so that we have the strongest action nearest the bottom and the nitric acid, the oxidation gradually proceeding upwards. This test is not applicable to albuminous urine.

2. Heller's test.—We first take concentrated fuming hydrochloric acid, and to it add some drops of urine, which produces either a hyacinth-red or a greenish colour. Nitric acid is then added as in testing for albumen. In the first case, all the shades of colour occur ; in the latter, only those which follow green. Uroxanthin may produce a violet colour, but this does not pass into the other tints. This test is also employed for other secretions and excretions.

Bilin is, according to Pettinkofer, sought for as follows : a very small portion of fluid is taken in a test-tube ; to it is added a solution of cane sugar, and subsequently and gradually a large quantity of concentrated sulphuric acid. To avoid the brown combinations produced by the action of sulphuric acid on sugar, Heller recommends that the tube shall be cooled in cold water. On standing, the fluid assumes a yellowish red colour, which, to prove the presence of Bilin, must subsequently pass into a beautiful crimson. This test is applicable in all fluids.

Sugar when present in large quantity considerably increases the specific gravity of the urine. When there is an unusually abundant flow of urine of light colour and high specific gravity, it should always be tested for sugar. Such urine on standing rapidly becomes turbid in consequence of fermentation. The reaction, which was originally acid, then becomes alkaline, and after some time again changes to acidity from continued fermentation.

Tests for Sugar.—Trommer's test is founded on the fact, that the blue hydrated oxide of copper is reduced by the presence of potash and sugar to the state of the yellow hydrated oxide. It is very difficult to hit upon the right proportion of potash and copper, and it will therefore be advisable always to employ a compound proposed by Dr. Kletzinsky, one of the assistants in the laboratory at Vienna. According to Trommer's directions, a solution of sulphate of copper is added to the urine in a test-tube, until an intensely green colour is obtained, on which a solution of caustic potash or soda is added until the green colour is changed to a deep blue. The mixture is now boiled for a minute or two : if the fluid contains sugar, it becomes first brownish, then of an intense yellow, and a yellowish brown precipitate quickly collects at the bottom. If no sugar is present, the fluid itself becomes green with streaks of dark green. Kletzinsky's fluid is composed of 4 parts of a saturated solution of sulphate of copper, 6 of glycerin, and 8 of potash. Sulphate of potash crystallizes, and is separated by filtration ; the urine is boiled with some of the filtered solution, by which the reduction of the copper is effected. This test is particularly suited to unpractised experimenters. By using an excess of potash the copper may be reduced to the metallic state, in which case it produces on standing a coppery lustre on the glass.

Heller's test consists in boiling urine with a piece of caustic potash, or at least with a very concentrated solution of potash, by which when sugar is present a dark brownish red colour is produced. If a little nitric acid be now added and the solution be heated, a smell of burnt sugar is evolved. This test is sufficiently delicate for such large quantities of sugar as usually occur in diabetes. If rhubarb or senna be present, they also give rise to a reddish brown colour on the addition of caustic potash, but the change in this case takes place at the ordinary temperature. Racemic acid and chloroform have the same effect on Trommer's test as sugar, but not on Heller's.*

It should be observed that cane sugar is not affected by these tests until it has been treated with nitric acid, and so transformed into grape sugar (diabetic sugar). The sugar may be directly extracted by evaporating the urine to the consistence of syrup, treating with dilute alcohol, and evaporating.

Carbonate of Soda (fig. 5).—The mode of de-

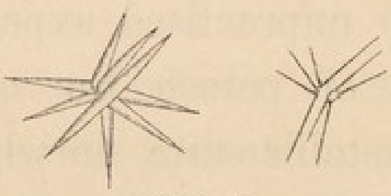


FIG. 5.

monstrating the presence of this salt has been

* The merit of bringing the above described reaction of potash prominently forward as a test for sugar belongs not to Professor Heller, but to Mr. Moore, of the Queen's Hospital, Birmingham, after whom it is usually called Moore's test. See, *inter alia*, *Simon's Animal Chemistry*, Sydenham Society's Translation, London, 1845, vol. 1, p. 68. Mr.

spoken of in the section on the reaction of urine on litmus.

Uroerythrin communicates to the urine a more or less intensely yellowish red colour. It unites very obstinately to the uric sediments, and without it the urates would be whitish. On the addition of a solution of acetate of lead, the precipitate assumes a tinge of crimson when uroerythrin is present; but when, on the contrary, urophæin or hematosin is the cause of the reddish colour of the urine, the precipitate is white or dirty white. When hematosin is present, albumen must of course accompany it; the latter is otherwise but rarely found to occur along with uroerythrin. That uroerythrin, and not hematosin, is the cause of a red colour in the deposits is shown by dissolving them by ebullition with a couple of drops of ammonia, and again precipitating with acetate of lead. If their red colour should proceed from urrhodin, the sediment must have formed in an alkaline urine, and will, when agitated with ether, impart its red colour to the latter. Biliphæin is precipitated yellow by lead.

Moore's original paper may be found in the *Lancet* for September, 1844, p. 751.—*Tr.*

CHAPTER IV.

SEDIMENTS AND CONCRETIONS.

THE sediments, which may also occur in a state of solution, have already been partially described. We may divide them all into organised, organic, and inorganic.

The *organised* are best distinguished under the microscope.

The discrimination of *pus* and *mucus* is important, and is effected both chemically and microscopically. The chemical test depends on the fact of pus being converted by the action of an alkali into a viscid gelatinous mass, capable of being drawn into threads; while mucus under similar treatment remains more fluid and lumpy. The test is applied by adding potash or ammonia to the fluid in a wine-glass, stirring it with a glass rod, and examining the nature of the mass by holding the vessel inverted over another. In alkaline urine pus will already have undergone this change. Where pus is present, albumen will also be found, which is not necessarily the case with mucus.

Under the microscope the distinction is not so certain ; the mucus-cells appear more marked than the pus-cells. When acetic acid is added, the envelopes disappear more rapidly in the pus-cells, and their granulations vanish, while the latter are permanent in the mucus cells. In a group of mucus cells the individual cells cover one another, while the pus-cells lie side by side.

Blood may occur in urine either exosmotically or after hemorrhage. In the former case, we find only albumen and hematosin. It has already been stated, in speaking of uroerythrin, how it may be ascertained whether the latter or hematosin is the cause of the red colour of clear urine, and of sediments. After hemorrhage we can either demonstrate fibrinous coagula or blood corpuscles in the sediment, or the blood globules may be dissolved in urine of a very low degree of concentration (low specific gravity), or the blood may already have putrefied, and then forms a dark mass at the bottom of the vessel. The coagula of fibrin are red when they are mixed with blood corpuscles ; when washed, they are white, and appear amorphous under the microscope.

The so-called compound inflammatory globules occur tolerably frequently in the sediments, sometimes in immense quantity. They are usually confounded with pus ; the urine is at the same time invariably albuminous, but they do not give with an alkali the reactions of pus, and they are distinguished under the microscope by their peculiar appearance.

Bellinian epithelial cylinders (fig. 6), cancer

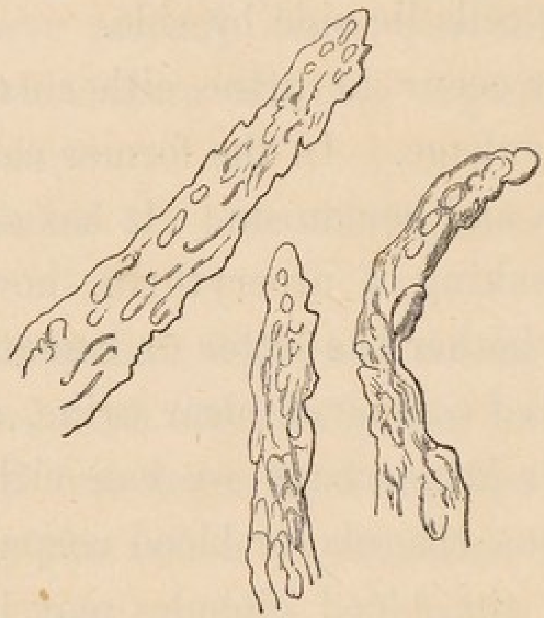
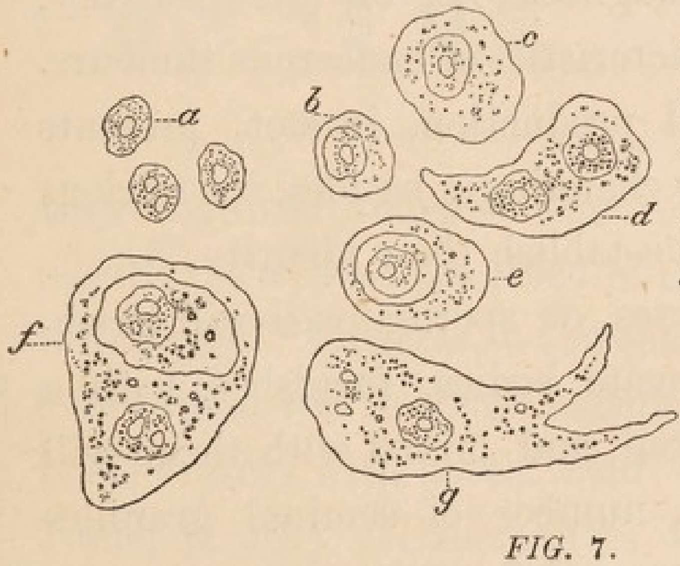


FIG. 6.

cells, spermatophytes, fermentation fungi, sarcina ventriculi (discovered in the urine by Heller before Virchow demonstrated it in the gastric juice), are all recognised under the microscope.

[The following observations, bearing on the subject of cancer cells, contained in a paper on cancerous tumours by Dr. Paul Broca, may not be out of place here :—

"The fundamental and characteristic element of cancer, he remarks, is the nucleus. This is sometimes free, sometimes included in a cell. The free nuclei are never absent; sometimes they exist alone and constitute nuclear cancer. The free nuclei are, moreover, exactly similar to those which are contained in the cells. They are remarkable for their magnitude, their uniformity, and the largeness of their nucleoli. There are in general but one or two nucleoli in each nucleus, but there may be three (fig. 7.)



a. Free nuclei.
b. Small cancer cell.
c. Larger cell.
d. Cell with two nuclei.
e. Mother cell.
f. Mother cell, enclosing a simple nucleus and a nucleated cell.
g. Large irregular and bifurcated cancer-cell.
(Magnified 460 diameters.)

FIG. 7.

"The cells contrast, by their diversity, with the uniformity of the nuclei. Some are small and regular enough; sometimes they preserve their regularity while they acquire a greater size; but sometimes also they assume the most fantastic shapes. The majority of the cells include but a single nucleus ; but it is not uncommon to find two or more nuclei in the same cell. Finally, we tolerably frequently observe large cells which include one or more nucleated cells, and which have received the name of mother cells. This extreme variety presented by cancer cells has been considered as tending to prove that these cells have nothing specific. This is perfectly true ; the nucleus alone is specific ; but the capricious diversity of the cells, far from constituting a source of embarrassment in diagnosis, is, on the contrary, one of the best characteristics of cancerous tumours. No other accidental production, in fact, presents itself under forms so changing ; besides, the nucleus is always present to establish their identity."*

The spermatophytes or spermatozoa will be observed as minute ovate bodies, furnished with a delicate bristle-like tail, and mixed with them will generally be seen a number of seminal granules under the form of rounded fine granular corpuscles of $\frac{1}{300}$ — $\frac{1}{400}$ of a line in diameter. The sarcina ventriculi was first observed by Mr. Goodsir in the fluid ejected from the stomach in pyrosis, and presents itself in the form of square or slightly oblong trans-

* *Moniteur des Hopitaux*, 9th December, 1854, page 1163.

parent plates of a pale yellow or brown colour, varying in size from the 800th to the 1,000th of an inch. They exhibit the appearance of a wool pack, or of a soft bundle bound with cord, crossing it four times at right angles and at equal distances, whence their name.*]

Organic sediments, which never occur in solution, are oxalate of lime (fig. 8) and cystin (fig. 9). They

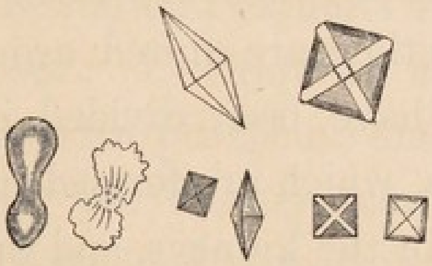


FIG. 8.

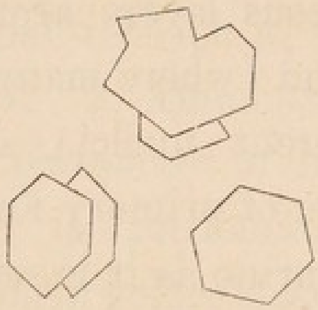


FIG. 9.

are recognized under the microscope, and also chemically, as will be described in the Analytical Table.

Inorganic sediment.—Carbonate of lime is never found dissolved in urine except as the bicarbonate. It effervesces with acetic acid (see the Analytical Table, p. 50.) Uroerythrin does not precipitate with calcareous deposits ; the colour of the latter is therefore white.

The *concretions* consist of the constituents of the urine which have already been described. Their

* See *Dr. Golding Bird on Urinary Deposits*, and *Simon's Animal Chemistry*, Sydenham Society's Edition.—*Tr.*

composition cannot be inferred from their physical properties ; calculi of oxalate of lime have indeed most frequently a surface which appears to be composed of a number of little globes, and are then called mulberry calculi ; but uric acid calculi may also present this form, and calculi of oxalate of lime may be perfectly smooth. Besides the division into simple (formation of homogeneous layers around a single nucleus) and compound (where many concretions are united around different nuclei), calculi have been divided into those of primary formation, which are formed from the urine as it is secreted in the kidneys, and those of secondary formation, which consist of such components of the urine as are subsequently developed. When, for example, a calculus in the bladder gives rise to cystitis, and the mucus so produced effects a decomposition of the urine, causing the development of ammonia, the calculus acquires a coating of urate of ammonia and earthy phosphates, which are consequently of secondary formation. If uric acid ceases to be found externally, and only earthy phosphates exist there, it may be inferred that the affection of the bladder has given rise to renal disease, in consequence of which uric acid is no longer excreted.

The urine has an acid reaction with calculi of uric acid, urate of ammonia, oxalate of lime, xanthin,* and fibrin (in hematuria, however, the reaction varies) ; it is amphigenous in cystitis, with urostealith,* and fibrin ; and ammoniacal with carbonate of lime and the ammoniacal earthy phosphates.

The hardness of the several varieties is not always the same, but the following series (from the softer to the harder) exhibits their usual relation in this respect : 1. Urate of ammonia. 2. Ammoniaco-magnesian phosphate and basic phosphate of lime, when the former constituent is predominant. 3. Cystin. 4. Urostealith and fibrin (more elastic.) 5. Uric acid. 6. Oxalate of lime. 7. Carbonate of lime. 8. Basic phosphate of lime.

The following table will be found useful in the chemical examination of sediments and concretions. The experiments should be performed on a little powder scraped off the calculi, or with the sediments collected on a filter :—

* Xanthin and urostealith occur in the urine only in the form of concretions, and as such extremely rarely. [I am indebted to Dr. Robert Adams of Dublin and Dr. Little of Sligo for two opportunities of examining the latter interesting substance, first described by Professor Heller; I have given some account of it in the *Dublin Quarterly Journal of Medical Science*, vol. xvii. p. 473.—*Tr.*]

SCHEME OF THE ANALYSIS OF URINARY SEDIMENTS AND CONCRETIONS.

Combustible (on platina foil)	Combustible without flame.	Murexid test with positive result.	Cold ammonia test (potash and moist litmus paper.)	positive result :	URATE OF AMMONIA.
				negative result :	URIC ACID.
		Murexid test with negative result			XANTHIN.
	Combustible with flame.	Blue, very faint flame, with a smell of sulphur and fat			CYSTIN.
		Yellow, clear bright flame, with a smell of perfumed shell-lac			UROSTEALITH.
		Yellow flame, emitting an odour of burnt hair			FIBRIN.
Not combustible. (N.B.—A small portion is always combustible.)	Effervescence on the addition of concentrated hydrochloric acid to a fresh portion of the original powder				CARBONATE OF LIME.
	No effervescence	Effervescence on the addition of concentrated hydrochloric acid to the powder after having been ignited at a *low* heat and subsequently cooled. . .			OXALATE OF LIME.
		No effervescence.	Cold ammonia test.	positive result . .	AMMONIACO-MAGNESIAN PHOSPHATE WITH BASIC PHOSHHATE OF LIME.
				negative result. .	BASIC PHOSPHATE OF LIME.*

* Only agglomerated calculi from the walls of the bladder.

CHAPTER V.

PATHOLOGY OF THE URINE.

In drawing conclusions from the results obtained in the examination of the urine, the diet and regimen of the patient, with the medicines administered, must be taken into consideration. This must be especially attended to in reference to matters which are directly dependent on the ingesta (urophanous substances).

Urophæin and Uroxanthin.—These two principles often bear an inverse ratio to one another, so that an excess of one is usually attended with a diminution of the other. Still we may also find an excess of urophæin co-existent with an excess of uroxanthin.

The quantity of urophæin is increased in acute diseases with fever : the urine becomes darker. We therefore find this condition to exist in all acute inflammations, especially those of the thoracic organs ; in diseases of the heart, acute rheumatism, in typhus, and lastly, in a high degree in affections of the liver. On the contrary, it is diminished in nervous diseases,* epilepsy, chronic affections of the spine, and hysteria. Further, in simple anæmia, in debilitated individuals, and in secondary syphilis; in these cases without a simultaneously increased quantity of uroxanthin. The amount of urophæin is generally in direct proportion to that of the uric acid and earthy phosphates.

The uroxanthin is increased in all neuroses: epilepsy, spinal affections, hysteria, neuralgia, also after direct nervous influences, depressing emotions of the mind, as fear; after frequent coitus, in spermatorrhœa and onanism (so constantly that Heller thinks he can recommend it as a diagnostic in suspected cases); after severe pain, beatings, falls, or shocks upon the back; in all renal affections, especially in chronic Bright's disease, diabetes mellitus, and after the use of excitants of the kidneys. The increase of uroxanthin during pregnancy, in dropsy, ceasing after paracentesis and beginning again when the accumulation is renewed, and in excessive tympanitis, is attributed

* [Heller considers that the extremely pale colour of hysterical urine is owing not merely to its dilution but to the relative as well as absolute diminution of the urophæin.—*Archiv* for 1852. The sudden diminution of this principle in consequence of violent mental emotions, such as terror, is also remarkable, and Heller is of opinion that the amount of urophæin present may assist in the diagnosis between rheumatism and neuralgia.—*Tr.*]

by Heller to the pressure on the kidneys. In cholera the uroxanthin is increased in the highest degree. In diseases of the bladder it is not increased until after a renal affection has been superinduced. It is sometimes increased in rheumatism and gout of very long standing, where we find the urophæin and uric acid simultaneously diminished ; in acute rheumatism the reverse is the case. After the exhibition of narcotics, of strychnia, of musk, and, to a moderate extent, after the use of strong coffee and tea. There is some increase in pyemia ; in inflammation of the abdominal organs (peritonitis), and in typhus the uroxanthin is sometimes but not invariably increased. Its diminution is rare, but sometimes occurs in inflammations, especially in acute rheumatism. At the close of the stages of effusion and in the stage of absorption we most frequently find even some increase. As its quantity in normal urine is but small, and as in the diseases in which it is diminished we have better positive uroscopic signs, the diminution of uroxanthin is of little diagnostic value ; while its increase is very important ; for example, in the diagnosis of neuralgic and rheumatic pains (prosopalgia), regard being at the same time had to the earthy phosphates, to which, as well as to uric acid, it usually bears an inverse ratio.

Urea and uric acid.—Both these nitrogenous components of the urine are products of the metamorphosis of the constituents of the body which contain protein. Like urophæin and the alkaline phosphates and sulphates (sulphur and phosphorus being components of the modifications of protein), they are increased during a more rapid metamorphosis in the capillaries and in the lungs ; and when the kidneys are not morbidly altered, the excretion of these substances is reciprocally proportionate.

Physiologically, they are excreted in increased quantity during full living, especially on animal food, in connexion with moderate exercise. Pathologically they are increased in acute diseases, particularly inflammations, in acute rheumatism, in which, especially when accompanied by endocarditis, the uric acid is increased in the greatest degree, and in the first stage of typhus. The striking quantity of urea in meningitis is particularly remarkable. Diminution takes place chiefly in spinal neuroses and in chronic renal affections, in which the uric acid may be even entirely absent; moreover, in chlorosis and in hectic. In the latter stages of typhus the quantity of urea is considerably diminished (diagnosis from meningitis); the uric acid also diminishes, as in the latter stages of other acute diseases, but is rarely under the normal amount.

A secondary diminution of urea takes place in the bladder itself, when, either in consequence of obstacles to its evacuation, or of affections of the vesical mucous membrane (cystitis, lithiasis), it is resolved into carbonate of ammonia.

In chronic rheumatism and gout we in most cases find the quantity of uric acid diminished; sometimes we find it crystallized in the sediment, without its being increased in the urine itself.

We very often find oxalate of lime occurring periodically in the sediments, accompanied by a diminution of the uric acid. Such an interchange of these two substances is also exhibited in their alternating layers in calculi in gouty individuals. In other respects too, we find in old inveterate forms of gout and rheumatism, urine of a more neuralgic character; for example, with excess of uroxanthin.

Heller has often observed a total absence of uric acid in chronic affections of the spinal marrow, ramollissement, &c. in renal diseases of long standing, as the second and third stages of Bright's disease, abscess and atrophy of the kidneys; lastly periodically in gout.

Heller has not been able to establish any constant variations in the occurrence of hippuric acid in disease. It is only when the disease has led to the exclusive use of vegetable food, that this substance will with certainty be found to increase.

Salts—It is very important, in estimating the value of the quantity of salts in the urine, to ascertain their proportion to the ingesta. Chloride of sodium (like the other haloid salts) passes rapidly into the urine. It is only during the occurrence of effusions that this does not take place. We may allow patients labouring under pneumonia and typhus to use strongly salted herrings and soups without increasing the chlorides in the urine. This is true only of the stage of effusion; in the other stages, as well as in other diseases, the normal condition obtains.

The *chlorides* are often suddenly diminished to an extreme degree, even to their total disappearance, in the stage of effusion in acute diseases, particularly in pneumonia. After pneumonia, pleuritis is the disease in which this diminution is most considerable. In typhus the diminution occurs gradually, and goes off in the same manner, while in pneumonia their return also often occurs very suddenly. In meningitis, and in acute tuberculosis, they are seldom considerably lessened. In pyemia and cholera they almost wholly disappear. In puerperal fever the diminution may last several weeks. In acute rheumatism, even with effusion into the joints, the diminution is less considerable and is not constant; on the other hand, it is considerable when endocarditis and especially when pericarditis is superadded. As the diminution and disappearance of the chlorides are proportionate to the degree of effusion, their return becomes of great prognostic signification; the more complete and persistent their disappearance is, the more unfavourable is the prognosis.

In the blood, under these circumstances, we find the chlorides in disproportionately large quantity.

In effused fluids the proportion of the chlorides to the albumen is always greater than in the serum of the blood.

An increase of the chlorides in the urine is not important; in neuroses we find it coincident with an excess of uroxanthin.

The *earthy phosphates* are not increased by medicines or ingesta, unless, perhaps, by the very abundant use of animal food. We find them greatly increased in rheumatism, both acute and chronic; also in acute and chronic diseases of the brain. They are diminished in all chronic affections of the spinal marrow (below the fourth ventricle). In hemiplegia the earthy phosphates are in excess, in paraplegia they are diminished; likewise in chronic affections of the kidney, and cholera. When the chlorides suddenly and largely diminish, the earthy phosphates also will be found somewhat diminished. In diseases of the osseous system we seldom find their proportion in the urine altered; it is in the fæces we must, in such cases, look for them.

The *alkaline phosphates* are increased in the urine after the use of phosphoric acid, of soluble phosphates, of eggs, and after poisoning with lucifer matches. They are in general proportionate to the sulphates.

The *sulphates* are increased in the urine by all the preparations of sulphur, as for example the acid mixture in typhus.

In inflammatory processes a rapid decomposition of protein compounds combined with wasting of the body takes place; carbonic acid, water, and azotized substances are formed; sulphur and phosphorus are oxidized, and deprive the blood of alkalies ; the fibrin, increased in the inflammatory blood thus loses its solvent, and exudes more easily, while the alkaline phosphates and sulphates are voided in increased quantity with the urine. Even the most ancient physicians in such cases gave weakly alkaline drinks. It is in meningitis and acute rheumatism that we find the greatest quantities of alkaline phosphates and sulphates. In typhus they are increased only in the commencement, particularly the sulphates, so long as the specific gravity is increased ; afterwards they diminish ; while in meningitis they continue increased.

Diminution of these salts usually attends that of the urea and uric acid in neuroses, &c.

Albuminuria is not synonimous with renal disease ; there may be albuminuria without renal disease and *vice versa.* The conditions which are capable of producing albuminuria may be arranged in three principal classes :—

1. A diluted state of the serum, enabling it to filter through the renal blood vessels without morbid alteration of the latter, as in hydremia, and in chlorosis with co-existent dropsy. Affections of the

heart and liver, too, ague, puerperal fever, and many other diseases may in this manner cause albuminuria.

2. When, without such a condition of the blood, there is increased porosity of the walls of the blood vessels of the kidneys as well as of other organs, and a transudation consequently becomes possible, as in hyperemia, with increased sanguineous pressure ; therefore in acute diseases, in the stage of effusion in pneumonia, pleurisy, pericarditis, meningitis, &c. That such a condition cannot be demonstrated in the kidneys after death is no argument against its having existed, as, in consequence of the return of the blood, we never find the kidneys so congested as they probably have been during life (*Engel*).

3. Diseases of the kidney, particularly those attended with disorganisation : Bright's disease ; in the commencement, so long as the morbid process has not extended far, there is often very little albumen (in pneumonia there is frequently more). In tuberculosis, cancer, and after the use of stimulants of the kidneys. When deficiency of albumen occurs in the blood, it produces the condition mentioned under No. 1, and increases the albuminuria.

From what has preceded, it would appear that in hydremia and dropsy dependent thereon, not diuretics but diaphoretics are indicated, as the latter tend to produce concentration of the urine ; the use of substances calculated to reproduce albumen, as white meat, eggs, &c., should also be prescribed.

Bellinian epithelial cylinders are pathognomonic of Bright's disease.

Blood may be derived from the kidneys, the bladder, the ureters, the prostate gland, or the urethra. In the kidneys, Bright's disease, calculi and morbid degenerations of the organ may produce hemorrhage. In such cases we find the other changes in the urine incidental to renal affections : diminution of the urea and uric acid, increase of uroxanthin, diminution of the earthy phosphates, more albumen than is proportionate to the amount of blood present, and acid reaction. If the blood proceeds from the bladder, we have almost invariably the conditions of the urine which accompany cystitis ; alkaline reaction and much mucus. We may almost entirely exclude the so-called vesical hemorrhoids, and refer the symptoms to affections of the kidneys, as the derangements of digestion and pains in the back which so generally accompany the latter have led to the assumption of hemorrhoids. The ureters are seldom the source of the hemorrhage ; when the blood is derived from the prostate and the urethra, this can be generally ascertained by local examination.

Pus may either proceed from the uropoietic system itself, or from the neighbouring organs. If it comes from the kidneys, the urine will exhibit the changes peculiar to renal disease. If from the bladder, it will be found in combination with much mucus, and the urine will be ammoniacal. By attending to the accompanying pathological phenomena, and by excluding the two foregoing sources, we may arrive at the other possible causes of its presence.

[The possibility of the occurrence of pyuria by metastasis has been doubted by some. Dr. Lees lately mentioned to me a case which seems to bear upon this point. It was that of a lady suffering from mammary abscess, which appeared suddenly. The patient stated, that from the day on which the abscess was observed the urine was turbid. On the fourth day it was ascertained to be purulent ; on the sixth the tumour was opened, the discharge was small in quantity ; and the urine continued purulent for some days.

Soon after Dr. Lees informed me of the foregoing, I observed in the *Gazette Médicale de Paris* a notice of a case of abscess of the forearm, which, when apparently on the point of maturity, suddenly subsided, its subsidence being immediately followed by the appearance in the urine of a large quantity of purulent matter.*

Dr. Lees, in the course of some observations on purulent urine, has adverted to the first-mentioned case,† and he thinks himself justified in concluding, that in it " there occurred from some part of the genito-urinary apparatus, probably the kidneys, what is termed a vicarious secretion of pus ;" conceiving, though the absorption of unaltered pus through the capillaries is hardly admissible upon physical grounds, that either the nuclei of ruptured pus globules were carried into the general circulation, or that there occurred absorption of the serum of the pus either into the lymphatics or into the blood vessels communicating by their capillaries with the abscess, which was then eliminated from the system through the kidneys ; and he suggests that in every case of pyemia the urine should be examined for pus, as its occurrence in that fluid

* *Gazette Médicale de Paris*, 9th December, 1854, page 758.

† *Dublin Hospital Gazette*, vol. 2, March 1, 1855, page 39.

would be favourable, just as the appearance of cholic acid in the urine in certain cases of jaundice tends to allay our apprehension of the terrible cerebral symptoms which result from the absorption of bile into the system, and as the presence of urea in the urine in albuminuria renders the case less serious.]

Mucus, on the whole, occurs in greater quantity in women, partly normally, partly in consequence of leucorrhœa. The influence of vesical mucus on urea has already been alluded to.

Compound inflammatory globules are found with especial frequency in degenerations of the kidneys, also in cases of calculi with hematuria.

Heller has found *Sarcina ventriculi* only in spinal affections ; in one case he found a considerable sediment entirely composed of them.

The *smell of mould and yeast* occurs in putrefying albuminous urine. In freshly voided urine in typhus, spinal affections, and puerperal fever, it affords a bad prognosis.

Ammonia.—Heller has proved, in opposition to Liebig, that any occurrence of ammonia in freshly voided urine is abnormal. The original form in which it occurs is always the following.

Carbonate of ammonia.—This may be formed primarily, that is, it may be separated as such from the blood, or it may be generated by the decomposition of urea. Where there is no cystitis, with its attendant increased secretion of mucus, it may be looked on as of primary formation. It may then be formed in the blood itself, in typhus, uremia (according to Frerichs, by the decomposition of urea), or during the absorption of effusions; consequently we may find it in the stage of absorption in inflammatory diseases (pneumonia, pleuritis), and in convalescence from rheumatism. In the first case it is a bad sign, and then occurs with diminution of the chlorides; in the latter case it has no evil signification. When it is formed in disease of the bladder, the urine ought of course to be voided as often as possible, and the bladder should be washed out with injections, to prevent the continued action of the ammonia aggravating the morbid condition.

Sulphuret of Ammonium may occur in small quantity without being of any importance in diseases of the kidney and bladder. It occurs most frequently during the absorption of effusions, especially of the pleuræ, but only for a very short time, and is then of favorable import. In gangrene and cavernous excavation of the lung, on the contrary, its occurrence is unfavorable.

Urate of Ammonia, especially in the stage of absorption in inflammatory diseases, accompanies the return of the chlorides constituting critical urine, which is usually dense, the urate of ammonia forming a sediment suspended in it. In typhus, on the contrary, where the ammonia has a different signification, such urine is not critical. The cessation of the sediments of urate of ammonia in the course of an affection of the bladder is not a good sign; it indicates the occurrence of renal disease, preventing the secretion of uric acid.

The *ammoniacal earthy phosphates* partake of the indications both of ammonia and of the earthy phosphates. They occur chiefly in rheumatism.

Constituents of the Bile.—These indicate a derangement of the hepatic functions.

Biliphæin may be present in the blood without occurring in the urine, not *vice versa*. It may disappear from the blood without being separated either through the urine or the skin, (when the urine contains Biliphæin, jaundice is always present); it must then pass off by the lungs as carbonic acid and water. Heller states that when Biliphæin occurs in the blood without being present in the urine, it does not depend on an affection of the liver. This is usually the case during a spasmodic condition.

Heller has always found that when *Bilin* is present in the blood, it also occurs in the urine. It occurs in the urine more rarely than biliphæin, and not in any constant proportion to the latter. It is most frequently found when tuberculosis and nutmeg liver coexist.

Sugar.—During the exclusive use of cane sugar, glucose is formed in the urine. On the contrary, if a solution of cane sugar be injected into a vein, it occurs as such in the urine. By puncturing into the fourth ventricle, between the hypoglossal and vagi nerves, sugar is produced in the urine. It can also be demonstrated in the urine of children at the breast. The diseases in which the urine is essentially saccharine are diabetes mellitus, affections of the brain and of the female breasts. In the first-named disease the urine is usually clear ; a little albumen is commonly present in all the three classes mentioned. The other characters of the urine in diabetes are : excess of uroxanthin, diminution of urophæin, diminution or absence of urea, chlorides normal or in excess ; their diminution is rare and is of evil import ; diminution of earthy phosphates, sulphates normal ; such urine without sugar we find in diabetes insipidus (purely neuralgic urine). In cerebral affections we usually find coexistent a normal amount or excess of urophæin, uroxanthin slightly in excess, excess of uric acid, diminution of chlorides, excess of earthy phosphates and of sulphates. In cases of lacteal congestion we have urophæin in considerable excess, uroxanthin normal, uric acid in excess, decided diminution of chlorides, earthy phosphates normal, sulphates in great excess.

Small quantities of sugar may also occur in cases of convulsions and neuralgia.

[M. Dechambre some time ago brought forward a statement, based on the results of his investigations, that sugar is an habitual ingredient in the urine of the aged.* These investigations were suggested to him by the perusal of M. Reynoso's theory, that when the respiratory process is impeded, sugar is excreted with the urine, and as in old people the respiratory functions are notably diminished in activity, M. Dechambre inferred that in them the urine ought to be saccharine. With a view of determining this point for myself, I examined, in the month of December, 1852, the urine of twelve men and women whose ages varied from 60 to 83.

* *Archives Générales de Médecine*, 1852, tom xxix, p. 338.

Two or three of the specimens, when previously very much concentrated, boiled with an equal portion of liquor potassæ, gave doubtfully some indication of the presence of a minute trace of sugar; but not one of the twelve gave any such indication when the test was applied in the ordinary way, viz. by boiling a given portion of the urine with an equal quantity of liquor potassæ; and the urines of the two oldest individuals examined, aged respectively 83 and 81 years, exhibited, even when previously concentrated, no trace of sugar. I hence infer that the statement of the invariable presence of this principle in the urine of old people is incorrect, or that the saccharine matter exists in it in so small quantity as not to be indicated by the liquor potassæ test applied in the ordinary way, and that it may consequently for practical purposes be disregarded. I may add that of the twelve specimens I examined two were alkaline and slightly albuminous; of these, one gave, as above mentioned, doubtful indications of the presence of a trace of sugar, the other did not. The remaining ten were acid when subjected to examination.

I have recently seen some observations of Dr. Kletzinsky on this subject. He says, "Without in the least wishing to dispute such cases, I must still most solemnly protest against the expression, 'almost always,' as in our investigations we could not discover such a *panglycosuria senilis.* Considering the decided distrust that is already loudly expressed with regard to Reynoso's conclusions, it would be desirable in such instances that at least the number of experiments, the individual circumstances, and the mode of testing for sugar (whether with or without tartaric acid) should be given as clearly as possible." *]

Carbonate of Soda.—It has been mentioned that the alkaline carbonates pass directly into the urine ; the combinations of the vegetable acids with alkalies also pass into the urine as carbonates ; the latter therefore occur in the urine after the use of alkaline mineral waters, &c. and after fruits. If these have been withheld, the pathological indications of carbonate of soda are very limited, and therefore of little importance : it occurs in fact only in chronic cerebral affections as hydrocephalus, tubercles, hemiplegia, in the insane (we seldom find it in acute cases).

Carbonate of Lime often accompanies the foregoing ; its indications are the same.

These two substances, in extremely variable

* Heller's *Archiv*, Band 5, 1854, p. 398.

quantity, sometimes combined with small portions of carbonate of ammonia, sugar, and excess of earthy phosphates, are the peculiarities we most frequently find in the urine of the insane.

Uroerythrin, as well as the other colouring matters of urine, appears to proceed from a metamorphosis of hematosin. It occurs with every, even the least degree of rheumatism ; moreover, where the hepatic functions are deranged (especially in granular liver), in lead colic, and acute affections of the brain. In rheumatism and cerebral diseases, it coexists with excess of earthy phosphates ; in the latter, albumen is usually also present.

Oxalic acid may be considered as a degree of oxidation of uric acid. Except after the use of aliments containing it, it only occurs where copious development of uric acid has existed, as in rheumatic and gouty diatheses, between which temperaments Heller is unable to show any difference in the urine. It accordingly commonly alternates with uric acid. It is particularly likely to be found if periostitis supervene.

From what has now been brought forward, it would be possible to deduce certain formulæ for the composition of the urine in the most important groups of diseases, and to some extent also in particular diseases and stages of disease. We must not however, calculate on always finding these to be in practice perfectly accurate ; partly because diseases are not always unmixed, and partly because individual circumstances give rise to various modifications.

CHAPTER VI.

BLOOD.—ITS NORMAL COMPOSITION.

The following tables afford a synoptical view of the composition of the Blood :—

1. Blood,
   - Liquor Sanguinis,
     - Serum,
     - Fibrin, } Coagulum.
   - Blood globules, ... } Coagulum.

2. Serum,
   - Water,
   - Solid Constituents of the serum,
     - Organic.
       - Albumen.
       - Hemaphæin (yellow colouring matter, with a trace of iron, demonstrated by *Simon*).
       - Fat.
       - Cholesterine.
       - Extractive matters in which Heller has demonstrated :
       - Urea and uric acid.
     - Inorganic.
       - All the salts occurring in the urine.
       - Alkaline carbonate (namely, of soda—hence alkaline reaction).
       - Soda in the form of albuminate.

3. Coagulum of the blood,
   - Retained serum,
   - Fibrin,
   - Blood corpuscles,
     - Globulin enveloping,
     - Hematosin, × liquor,
       - Oxide of iron,
       - × organic substance.

By evaporating the serum we obtain its solid constituents ; the water is determined by the loss. On igniting the solid matters the inorganic are left behind. The quantity of fibrin is best ascertained by washing on linen ; it is almost impossible with any accuracy to determine the proportion of blood corpuscles. The commonly received statement is, that 1000 parts of blood contain 790 of water and 210 of solid matters. Of the latter, 127 are blood corpuscles, 3 are fibrin, and 80 solid matters of the serum, of which between 60 and 70 are albumen.

In practice it may be observed, that the blood when drawn should stand covered in a room not too warm, and best in cold water, in order that the fluid part shall not evaporate. The serum is to be poured off, and its specific gravity taken, which normally is 1,027, or 1,028=4° of the urometer ; in children it is only 1,024. This depends almost solely on the albumen, the absolute but not the relative proportion of which we thus ascertain. Analbuminosis may, for example, in hydremia be combined with a deficiency of fibrin and blood corpuscles, in Bright's disease with a normal proportion of each, and the serum may, in both cases, have the same specific gravity. The specific gravity must also be borne in mind, in inferring the proportion of blood corpuscles from the size of the coagulum. When, for example, the specific gravity is low, the corpuscles imbibe fluid, swell up, no longer arrange themselves in rouleaus, and a bulky crassamentum in that case ceases to have the same signification it would have, did it occur with the normal specific gravity, when it would indicate an increase in the number of blood corpuscles. Likewise, a small coagulum with normal specific gravity would show a diminution in the number of corpuscles, (pneumonia.) From the density of the coagulum we infer the amount of fibrin ; it is tested with the aid of a glass rod let fall towards the bottom, which, in normal blood, penetrates the coagulum with tolerable facility, and rings against the bottom ; the variations are estimated according to the greater or less amount of resistance experienced.

The buffy coat depends, it is true, essentially on an excess of fibrin as compared with the corpuscles, but to the mode of coagulation on the whole we cannot attach any semeiotic value, as the entire process has not as yet been fully elucidated.

The most important changes in the composition of the blood are exhibited in the following table :—

Solid constituents of the serum, (proportional to the specific gravity.)	Fibrin.	Blood corpuscles.		
minus	minus	minus	=	HYDREMIA.
plus	plus	plus	=	PLETHORA.
normal	plus	minus	=	FIBRINOSIS.
normal	minus	plus	=	AFIBRINOSIS.
plus	normal	normal	=	ALBUMINOSIS.
minus	normal or variable	normal or variable	=	ANALBUMINOSIS.
normal	normal	plus	=	GLOBULOSIS.
normal	normal	minus	=	AGLOBULOSIS.

Fibrinosis is found to exist in pregnant women and in those recently delivered, in inflammations, in the commencement of typhus, in chronic tuberculosis, and in the cancerous diathesis (up to 17 parts in 1000).

Afibrinosis exists in typhus, albuminosis in epilepsy, analbuminosis in Bright's disease, (especially in pregnant women). The coincidence of analbuminosis and hydremia gives rise to dropsy; the serum filters through the pores.

We have aglobulosis after the loss of blood, and in the last stage of typhus, (with afibrinosis), also in many other diseases.

These conditions may again be further combined; when, for example, an epileptic individual gets an attack of pneumonia, fibrinosis becomes superadded to albuminosis: + F. + specific gravity—Blood corpuscles, &c.

We may find fibrin completely deficient in persons struck with lightning, in which case no coagula are found in the organs on dissection.

Urea and uric acid occur in increased quantity in the blood in cases of retention of urine, (cholera, &c.) and in the rheumatic and especially in the arthritic diathesis (coinciding with a deficiency of urea in the urine). Urate of lime is found in nodes and gouty concretions, and the presence of urea is occasionally demonstrated in atheromatous deposits.

ABNORMAL MATTERS IN THE BLOOD.

Carbonate of Ammonia. When larger quantities of this salt are present in the blood, the latter becomes of a darker colour, and its reaction is rendered more strongly alkaline. It is detected in the same manner as in the urine, except that the blood is first diluted with three or four times its bulk of distilled water, and the ebullition is continued longer but with great care to avoid burning the coagulated albumen. It occurs in the blood in severe cases of typhus, and in retention of urine (from decomposition of urea—gives rise to the uremic phenomena, Frerichs) ; in the latter case, together with all the other constituents of the urine.

Sugar also occurs in the normal condition in small quantities in the blood of the vena portæ and hepatic veins, and in consequence of a large consumption of sugar. Larger quantities can be demonstrated by Heller's and Trommer's test ; in detecting smaller portions, the following method is adopted, which is also used in testing for sugar in the perspiration, in vomited matters, in the fæces and sputa : the sugar is extracted by alcohol, which coagulates the albumen ; the latter having been separated by filtration, the filtered fluid is evaporated, the residuum is again dissolved in a little water, and in this solution the sugar can be easily detected by Heller's and Trommer's tests. A similar process is followed in searching for uric acid in the blood, in vomited matter or in fæces ; the residuum left after the evaporation of the alcohol is boiled with water containing a little spirit, by which a soluble urate is obtained, the solution is evaporated, and the murexid test applied. Sugar is found in the blood only in diabetes mellitus and in cases of lacteal congestion.

Biliary matters do not, according to Heller, occur in normal blood ; they are therefore first formed in the liver. Biliphæin is demonstrated by Heller's test (we must not however take too much serum), bilin by Pettinkofer's. We discover biliphæin more frequently than bilin, which is more rapidly decomposed. They occur when the excretion of bile is from any cause obstructed, in which case they also appear in the urine, or without hepatic affection during a spasmodic condition.

Emulsion globules are sometimes found in the blood, and may make its serum perfectly milk-white; they consist of fat globules, with an albuminous envelope as in milk, and therefore do not coalesce: under the microscope, they exhibit themselves as sharply defined rings. They have been found in peritonitis and in the blood of drunkards.

Pus.—In blood which contains pus the fibrin separates in a very well-defined manner, and under the buffy coat the coagulum is remarkably diffluent. Heller demonstrates pus in the blood as follows:—The greater part of the pus collects at the top of the coagulum in the layer next to the buffy coat. This part of the coagulum is washed on linen, (about one pound or somewhat more of water being used to an ounce of blood); the blood-corpuscles and pus-cells then pass through; the former dissolve in the water, while the latter collect in it as a sediment. The blood-red fluid is poured off, and the sediment is tested with potash in a smaller glass. As by this test the white corpuscles, which do not give with potash the reaction of pus, can be recognised, we possess in it a means of distinguishing pyemia and leukemia.

CHAPTER VII.

MILK.

The following tables afford a view of the composition of the milk :—

1. Milk,	Liquor,	Serum,	
		Casein,	Coagulum.
	Milk globules,		

2. Serum	Water,		
	Solid constituents of the serum,	Organic,	Sugar of milk. Extractive and Colouring matters. Fat.
		Inorganic,	All the salts of the blood, the earthy phosphates preponderating. Carbonate of soda is the solvent of the casein.

3. Coagulum,	Casein,	
	Milk globules,	Casein. Butter.

In the milk the fat and sugar constitute the respiratory, the casein and the earthy phosphates the histo-plastic principles. In the first period we find no casein [?] ; and if milk containing casein be given to the child, it is rejected, or passes through by stool. Nature at first provides especially for the respiration; in the colostrum we find chiefly fat ; afterwards we have more sugar,* and finally casein.

The presence of sugar of milk is demonstrated directly by Heller's or Trommer's tests ; casein by agitation with acetic acid, on which small white lumps become attached to the walls of the vessel. The fat globules are seen under the microscope. The salts are detected as in the urine.

[The question of the coagulability of human milk by heat and acids is one on which a remarkable difference of opinion long existed among chemists. Being anxious, if possible, to ascertain the cause of the striking discrepancy between the statements of different writers on this point, I undertook, about six years ago, some experiments, the results of which were published in the *Dublin Quarterly Journal of Medical Science*,† and which led me to the conclusion that human milk forms with most acids two sets of compounds, one of them soluble in water, the other insoluble ; the latter being formed only when the quantity of acid is large in proportion to the casein ; and I supposed that accordingly as each experimenter had formed the soluble or the

* The colostrum, however, is also rich in sugar.—*Simon's Animal Chemistry*, Sydenham Society's Edition, vol. 2, p. 50.—*Tr*.

† New Series, vol. 7, p. 275.

insoluble compound, he reported the milk on which he operated to be incapable or capable of coagulation with acids.

The colostrum, or the first milk secreted after the commencement of lactation, I found to be in every instance coagulable by heat alone in the human subject, as it is well known to be in the case of cows' milk.* The average specific gravity of twenty specimens of healthy human milk which I examined in reference to density was 1.0299; the highest being 1.033, the lowest 1.025. Of eight specimens of colostrum, the highest specific gravity was 1.034, the lowest 1.028, the average 1.0316.

The only peculiarity I found in milk examined during the period of menstruation, was a great diminution of the cream. This result agrees with the previous observations of M. Raciborski.

A fluid presenting the characters of perfect milk is occasionally secreted in the breasts of infants, and at least as frequently in those of male as of female children. In the above quoted periodical I have given the results of an examination I had an opportunity of making of a specimen of this singular secretion.†]

* Loc. cit. pp. 290 and 492. † Vol. 19, p. 186.

ABNORMAL MATTERS IN THE MILK.

In women, *Albumen* occurs in the milk only in cases of inflammation of the breast. In cows it is produced by feeding on grains. It is detected by coagulating the casein with acetic acid, filtering and testing the filtered fluid with nitric acid.

Biliphæin may occur with the most various tints according as it is more or less oxidised by the action of lactic or fatty acids. That which is reddish coloured cannot be distinguished from hematosin. It is detected by Heller's test. It is found in mastitis and in eclampsia.

Lactic acid does not occur in normal milk ; the reaction of normal milk is faintly alkaline. The causes of the development of lactic acid are unknown ; it produces coagulation of the casein, and consequent obstruction of the lactiferous ducts, distention, inflammation, and abscess. Heller advises the administration of alkaline salts with a view of dissolving the casein.

Blood and *Pus* are met with after wounds and inflammation of the breasts. They are best discovered with the aid of the microscope. The presence of pus may be also demonstrated by agitating the milk with water, and letting it stand. The pus-cells form a sediment which may be tested with potash.

CHAPTER VIII.

MATTERS DISCHARGED BY VOMITING.

According to the chemical nature of their contents we may distinguish the following varieties :—

1. *Normal Contents of the Stomach.*—These, in addition to the ingesta, consist of a mucous, transparent fluid, having a strongly acid reaction, which is a mixture of mucus and gastric juice. In the latter we find all the salts of the blood and a peculiar acid, the acid of the stomach. This possesses the energy formerly attributed to pepsin; pepsin is only a product of decomposition, developed by the action of dilute hydrochloric acid on mucus. The acid of the stomach is soluble in alcohol and in water; if we evaporate the alcohol, a viscid mass of a syrupy consistence remains behind. Free hydrochloric acid is not found in the stomach except when the chloride of sodium of the gastric juice is decomposed by acids. Lactic acid and fatty acid are derived solely from the food.

2. *Watery vomitus* is the normal contents of the stomach plus water, has an acid reaction, contains

no albumen, and must be carefully distinguished from the following :—

3. *Serous vomitus.*—In this the gastric juice has nearly disappeared; it has an alkaline reaction, and may be almost considered as a very watery serum of the blood ; it contains small quantities of albumen, alkaline carbonate, and albuminate of soda. It occurs in cases of very frequently repeated vomiting, where the effort gives rise to hyperemia and exosmosis : consequently in pregnant women, almost constantly in perforating ulcer, which has not yet produced hemorrhage, in carcinoma, &c. and in cholera.

4. *Uremic vomitus* occurs in connexion with other uremic phenomena. It has an alkaline reaction in consequence of the presence of carbonate of ammonia, which is detected as in albuminous urine ; it contains in addition albumen, urea, and sometimes uric acid and uroxanthin.

5. *Bilious vomitus.*—Chiefly in hyperemia of the liver, especially when metallic poisons become deposited in that organ, which takes place very rapidly, as in poisoning by copper and arsenic. Biliphæin is usually present in the green or blue, rarely in the yellow, modification ; in poisoning with copper, the colour is derived from it. Bile is also frequently

found mixed with the varieties of vomitus. Biliphæin is demonstrated by means of Heller's test ; bilin is decomposed so rapidly in the stomach, that it can be rarely detected.

6. *Bloody vomitus.*—We may find a fresh red colour, or it may have already become of a blackish brown ; in the first case, we shall be able to discover blood corpuscles ; in the second these will not be apparent ; in both cases we shall have albumen. To distinguish the coloured substance from berries which may have been eaten, we may burn it on a piece of platina foil ; fruits give a white ash, blood a rusty brown. The ash may be dissolved in hydrochloric acid, neutralised with ammonia, and tested for iron.

7. *Fæcal vomitus* is characterised by a yellow colour and fæcal smell, the latter being increased on the addition of concentrated sulphuric acid.

8. *Purulent vomitus* is distinguished by means of the potash test, and by testing for albumen.

CHAPTER IX.

FÆCES.

Fæces consist partly of undigested, partly of indigestible substances; their odour depends on volatile fatty acids: butyric acid, and capric acid also called fæcin. Sulphuric acid is employed as a test for fæces in cases of strangulated hernia, &c., after having first mixed them with water; the fatty acids are thus volatilized, and are then recognized by their smell. Sulphuretted and phosphuretted hydrogen are formed in the intestinal canal, and are partially absorbed by the fæces. The colour of normal fæces is yellowish brown, from caprophæin, which is a product of biliphæin. Biliphæin does not occur as such in them. Caprophæin immediately strikes a red colour with nitric acid. If the flow of bile into the intestinal tube be obstructed, the fæces assume a pale colour. Soluble salts are found only in very small quantity in the fæces; under the microscope, we observe portions of vegetable matter (spiral vessels) and from these the ashes of incinerated fæces derive their potash. The earthy phosphates are found in great quantity ; in rachitis they are so abundant, that the ashes occupy almost as much space as the fæces did before incineration. Of iron there is scarcely a trace ; the ashes are white.

The consistence of abnormal fæces may be natural, increased, or diminished.

1. In fæces of natural consistence we do not find much that is abnormal. In affections of the bones, and especially in rachitis, the earthy phosphates are present, as has been observed, in excessive quantity. After the use of ferruginous remedies, (which, however, usually produce a thinner, porridge-like consistence) and after hemorrhoidal bleeding, we observe a darker, blackish-green colour, derived from sulphuret of iron. The ashes then have a rusty brown colour, while the ashes of vegetable colouring matters are white. Analysis does not show whether the iron is derived from the chalybeate preparations which have been taken, or from blood. In thin fæces albumen may be sought for.

2. *Increased consistence* is observed after the ingestion of carbonate of lime (in spring-water, or as chalk, &c.) in abstinence from drink, in chlorotic patients, &c.

3. *Diminished consistence.*—Before examination,

the portions which are not quite fluid should be dissolved or suspended in water. We may distinguish,

(*a*) Watery Discharges.—These contain soluble salts, which do not ordinarily occur in the fæces, and usually some biliphæin; their reaction is sometimes neutral, sometimes acid; in children this is owing to the presence of lactic acid.

(*b*) Serous Discharges.—The fluid floating above the solid portions contains albumen, although the solid parts do not contain blood (in which case these portions would be of a greenish or brownish-black colour.) They have an alkaline reaction derived from carbonate of soda, sometimes also from ammonia, as in typhus, and are generally poor in caprophæin. They occur in chronic diarrhœa, dysentery, typhus, and cholera.

(*c*) Bloody Discharges.—They are either of a bright red colour, from the lowest part of the intestinal canal, and exhibit blood-corpuscles under the microscope; or are darker coloured in proportion as the effusion has taken place higher up in the tube; if they are derived from the stomach, they are black as pitch. Iron may be demonstrated in the ashes and albumen in the fluid portions.

(*d*) Bilious Discharges are sometimes pap-like, sometimes watery, sometimes serous; they usually contain biliphæin instead of caprophæin. It is detected by means of Heller's test. Great importance is often ascribed to them, as they are supposed to be connected with an affection of the liver. When diarrhœa sets in rapidly, the first motions almost always contain biliphæin; this is therefore formed after the exhibition of purgatives, in the commencement of cholera, &c. Where biliphæin is long persistent (cholorrhœa) we may infer the existence of an affection of the liver. In dysentery the excretion of bile seems somewhat increased.

The green stools which occur during the use of mineral waters often proceed from sulphuret of iron. After calomel, they proceed from sulphuret of mercury; but we should remember in both cases that biliphæin passes off in the beginning, as during the administration of other purgatives.

(*e*) and (*f*). Mucous and Purulent Discharges are not easily distinguished. The microscope exhibits no diagnostic characters. In purulent stools the fæcal serum contains albumen. Mucus is found in the mass, as transparent lumps capable of being drawn out into threads; it is also often voided in this form without any fæcal mass. Pus is more equably intermixed ; where ammonia is not present, and has not already affected the pus, the ordinary test for that secretion may be applied to these fæcal masses.

All diarrhœal discharges may become *ammoniacal ;* it is a bad sign : we find a strongly alkaline reaction, and with it invariably crystals of ammoniaco-magnesian phosphate. This condition frequently attends purulent diarrhœa in typhus and puerperal fever. In dysentery the fæces may become ammoniacal without giving rise to an unfavorable prognosis, as the development of ammonia proceeds from the decomposition of intermingled urea derived from the blood and serum.

Biliary Calculi are in general distinguished from conglomerated fæces by floating in water. They may consist of,

1. *Cholesterine*, which occurs in masses of all possible sizes, sometimes exceeding that of a pigeon's egg ; such calculi are ordinarily white, or slightly coloured with biliphæin. Ignited on platina foil, they first melt, and then burn with a yellow flame, forming much soot, and developing a smell of burning fat. They dissolve in boiling alcohol, from which the cholesterine precipitates on cooling in the form of white scales. It is by this process cholesterine is usually obtained.

2. *Cholesterine and Biliphæin.*—This is the most usual form of biliary calculi ; they are of a brownish-yellow or dark orange colour, and participate in the characters of Nos. 1 and 3.

3. *Biliphæin.*—These calculi are blackish-brown, do not fuse on platina foil, but burn with a faintly yellow flame. Extracted with solution of potash they give a dark orange-yellow solution, to which Heller's test is to be applied.

4. *Inspissated Bile.*—These are very common in the old ; are usually small, black or green, very hard, and do not fuse when heated on platina foil. They are to be extracted with solution of potash, to which Heller's test for biliphæin and Pettinkofer's test for bilin are to be subsequently applied.

5. *Carbon.*—(Demonstrated by Berzelius) ; these are rare, do not fuse, and are insoluble in all re-agents.

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