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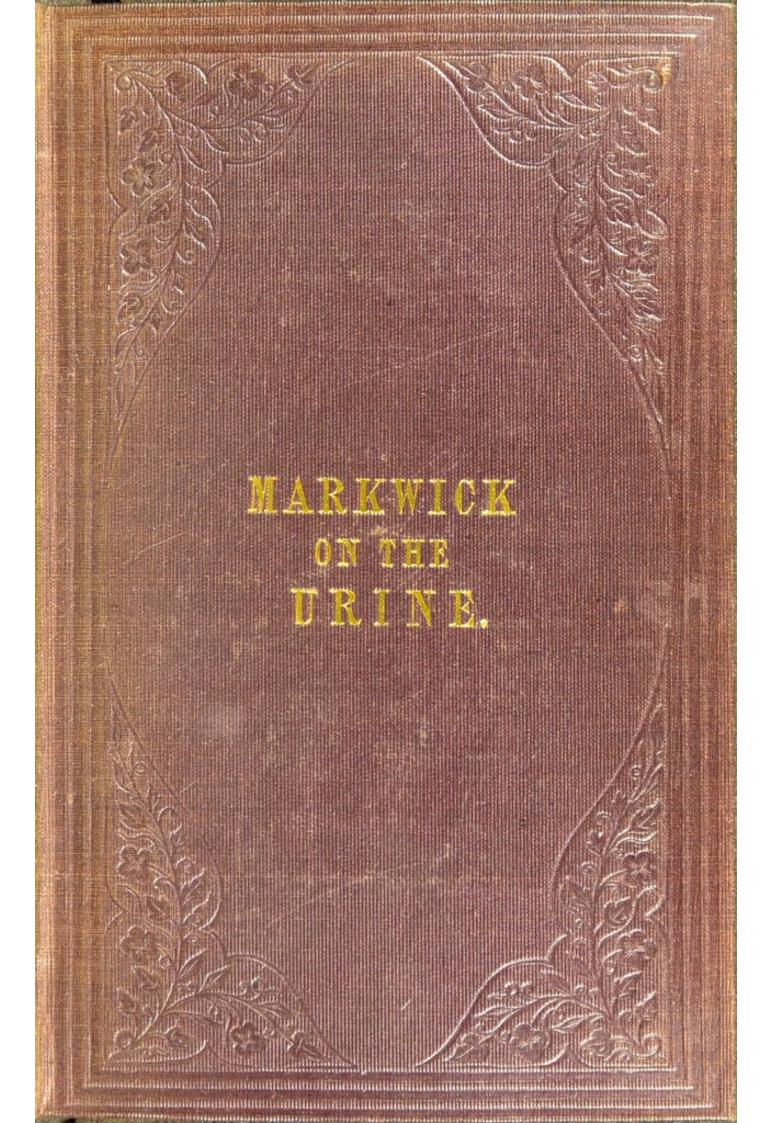
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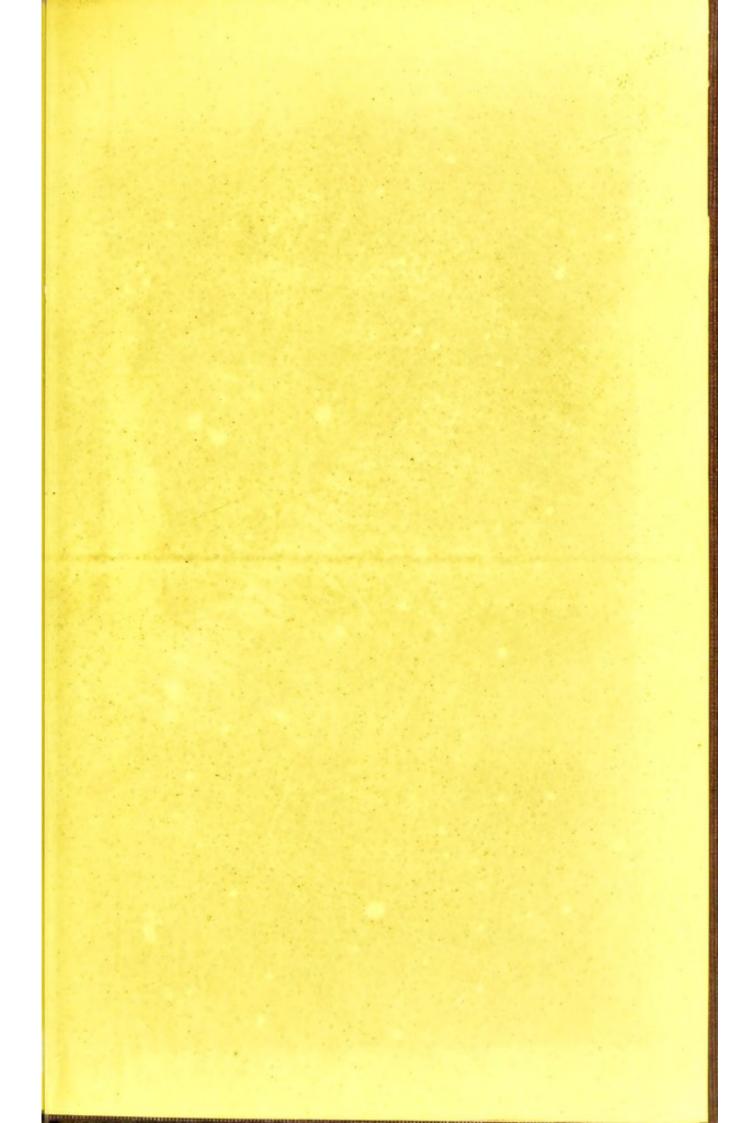


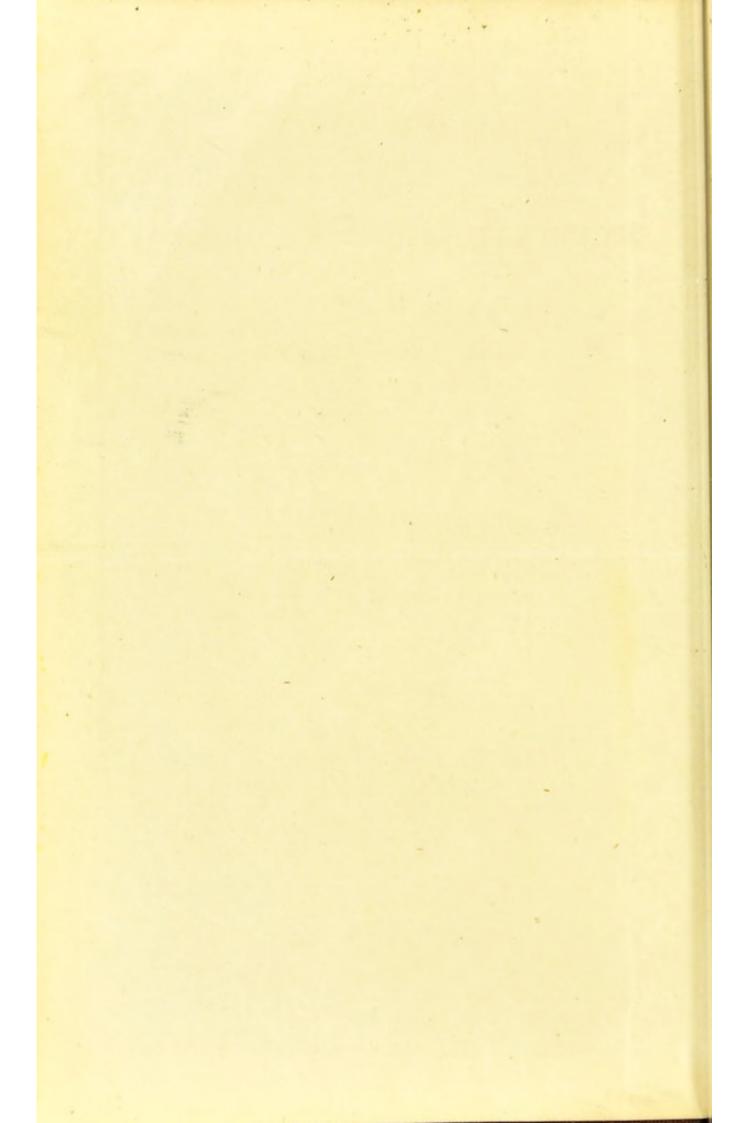
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## A GUIDE

TO THE

## EXAMINATION OF THE URINE

IN

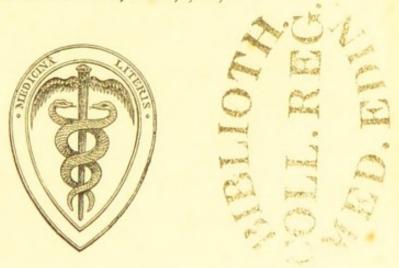
## HEALTH AND DISEASE,

FOR

THE USE OF STUDENTS.

#### By ALFRED MARKWICK,

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#### PREFACE.

The great impulse that has lately been given to the study of Chemical Pathology has thrown considerable light on many obscure subjects, and effected the solution of various difficult, and hitherto uncomprehended problems. Yet, however important the knowledge thus gained may be, there still remains a great deal to be obtained.

The names of Prout, Bird, Bright, Willis, Percy, Day, Jones, &c., in our own country, and of Berzelius, Liebig, Lecanu, Rayer, Becquerel, Simon, and Lehmann, on the Continent, will ever be remembered by those interested in chemico-pathological investigations, and need only to be mentioned to bring others into this daily increasing field of interesting research.

The urinary secretion is the chief, and at the same time, the most important subject of attention in this branch of science. I have, therefore,

endeavoured in the following pages, to give a clear as well as correct description of its composition, both in Health and Disease, and of the various modes of detecting its several normal and abnormal ingredients, with a view to present the Student with a Manual or Pocket Companion that may be useful to him while prosecuting his Hospital Studies. I have strenuously avoided all discussion, preferring to confine myself simply to the narration of such facts, relative to this very important fluid, as it will then be necessary for him to be possessed of, leaving him to refer to other and more elaborate treatises for more detailed information on urinary diseases. Should I succeed in my object, my labour will be fully repaid by the satisfaction, the knowledge of having done so will be to me.

19, LANGHAM PLACE, September, 1847.

## CHAPTER I.

1. Two very important actions are continually taking place in the body. They are, First, the Destruction or Metamorphosis of the different tissues of which it is composed; and, Secondly, the Deposit of fresh materials for their nutrition and repair. Both are admirably effected by the blood, a fluid which takes up the different decomposed and waste matters, and carries to every part its requisite nutritive materials; the former act constituting the second or destructive stage of the secondary assimmilating process of Dr. Prout, or in the words of Professor Liebig, the metamorphosis of the tissues, and the latter the primary or formative stage of the same process. In order, therefore, that the blood may be fitted for its purposes, it is evident that fresh blood must be continually formed in order to make up for the loss it sustains, and that it requires to be continually purified. This we find to be accomplished by digestion and respiration, the one separating and rearranging the nutritive matters of our food, the other, through the influence of the atmosphere, converting them into blood; and lastly, by the various secreting and excreting organs which remove from it the various matters with which it becomes impregnated during the destructive processes, some of these being perfectly effete or excrementitious, answering no further purpose in the economy, but which, if retained in the system, produce very serious, and even fatal consequences.

The excreting organs are of two kinds; first those which separate from the blood, its superabundant carbon and hydrogen, namely, the liver, the lungs, and the skin; the first in the shape of bile, and the two last as carbonic acid and water; and, secondly, those which remove from it its highly azotised compounds, such as the urea and lithic acid, namely, the kidneys. To the latter, and to the skin, too much attention cannot be paid, as it is upon the due and proper performance of their respective functions that our health may be said in a great measure to depend. In fact, how frequently we are called to cases which have entirely arisen either from the suppression, or imperfect excretion of the perspiration or of the urine; and was it not for the wise provisions of nature (which we can but admire) in enabling one excreting organ to antagonise, or, in other words, to compensate for, the deficient action of another, we should, considering the great and frequent changes to which these two excretions

are liable, both as to quantity and quality, from various and constantly occurring causes, be continually the subjects of disease.

It will be seen, therefore, that the relations or sympathies, if I may so term them, that exist between the different excreting organs, are of the utmost importance in preventing the imperfect performance of their respective functions, from frequently giving rise to some morbid condition of the system. Thus, when the functions of the skin are impeded those of the kidneys are increased, and vice versâ, and when the powers of respiration are diminished they are replaced by an increased activity of the liver; and lastly, when the latter is sluggish, the kidneys make up for the deficiency, by excreting a larger quantity of carbonised matter. Unfortunately, however, this compensating effect does not always take place; hence it is that when an organ has been previously diseased and consequently weakened and rendered susceptible of, or predisposed to, further morbid action, it is almost sure to suffer, when, from any cause, it is called upon for increased Numerous examples of this fact are exertion. presented to us by the kidneys, than which, there is, I should say, no organ more susceptible of derangement, or whose secretion is subject to so much variation, both in health and disease, and from the slightest causes; and this cannot be wondered at when we consider that these organs

are the emunctaries by which not only a considerable portion of the waste matter that is of no further use to the system is got rid of, but also large quantities of fluid with which the blood becomes overcharged after copious draughts of liquid, and various other matters which have entered the circulation after a repast. It is evidently therefore very essential that we should be thoroughly acquainted with the normal composition and character of the urinary excretion, and at the same time able, not only to discover any deviation from the healthy standard, but also correctly to ascertain in what that deviation consists. And this has of late years become the more necessary in consequence of the valuable researches, on this subject, of Prout, Becquerel, Bird, Liebig, Simon, and others, who have thus rendered the study of urinary diseases extremely interesting and useful. In fact, as Dr. Bird has remarked "Med. Gaz. for Feb. 10, 1843:" "the examination of the urine in disease is now regarded as one of the most important aids in diagnosis, and which it would be alike injurious to the welfare of the patient, as to the credit and reputation of the practitioner to avoid."

I propose then, first, to speak of the properties and composition of healthy urine and the various modifications it is liable to undergo, both in health and disease, and afterwards to describe the mode of analysing it.

## CHAPTER II.

2. The urine is a fluid composed of certain effete, animal, and saline matters, which have been separated from the blood by the kidneys.\* In health, immediately on being passed, it is in adults, transparent, of an amber colour, something like that of Sherry wine, and of a temperature varying between 95 degs. and 100 degs. Farhn. It has a bitter, disagreeable, saltish taste, which is more or less marked according as the urine is more or less concentrated; an acid reaction on litmus, and a peculiar somewhat aromatic odour, which is said to resemble that of violets. This on cooling goes off, and becomes replaced by one, sui-generis, to which the term urinous has been applied; this also disappears in a few days, but may be restored by heating the

The urine was formerly supposed to be secreted from arterial blood. Mr. Bowman has, however, attempted to prove in a paper, published in the Philosophical Transactions for 1842; also Med. Gaz. vol. xxx, "On the Structure and use of the Malpighian bodies," that it is like the bile separated from venous blood.

fluid, and is succeeded by one resembling sour milk, and lastly by one of a fetid ammoniaco-alcaline character. The urine of infants on the contrary, is almost colourless and without smell when passed, but evolves an odour on standing resembling that of veal broth. It has scarcely any reaction on test paper, and is very low in density.

- 3. The odour, however, is liable to be greatly altered by certain articles of food, such as asparagus, onions, garlic, &c., and by some kinds of medicine, as turpentine, copaiba, assafætida, and the essential oil of the juniper berry, each of which imparts to the urine its peculiar characteristic fragrant principles. It is likewise considerably influenced by disease. Thus it is particularly strong in all cases of fever and inflammation, for instance, and slight or even entirely wanting in those of anæmia and hysteria; while in diabetes immediately the urine is voided, it resembles that of whey, and subsequently, when fermentation commences, is of an alcoholic nature.
- 4. The colour also varies and depends in a great measure on the degree of concentration of the secretion. Hence it is generally darker in summer than in winter, owing to the solid contents of the urine being relatively increased at this season. It is, generally speaking, somewhat darker in men than in women, owing, I fancy, in a great measure, to their more active exertion, causing an increase

of the cutaneous exhalation, and thereby diminishing the amount of fluid in the urine. It is also greatly modified by particular states of the system, by certain articles of food, and by some medicines. Thus, it is deep in febrile affections, pale in nervous diseases, anæmia, &c., and yellowish or of a dirty brown in bilious disorders. It is of a more or less deep brown in proportion to the animal diet of the person, and when chimaphila or the pareira brava have been administered; reddish after the ingrestion of beet-root, the prickly pear (Cactus Opuntia); and hæmatoxylon, and yellowish when rhubarb has been taken. Rayer also states that the urine of an epileptic patient had a light green tint after a few day's use of sulphate of indigo, in doses of from one to three drachms in the course of twenty-four hours; and De Velseu gives an instance of an old man affected with chronic inflammation of the bladder in whom it became of a deep violet colour after the use of lime water mixed with milk.\* Drs. Prout and Simon have also met with cases in which it was of a dark blue owing to the presence of indigo which in all probability had become generated in the system. It is likewise much altered by foreign substances, as blood, pus and bile, the former renders it of a dirty red, brown, or black, the second of

<sup>\*</sup> Quoted in the Med. Gaz. for August 8th, 1845, from Heller's Archiv, Heft 1, 1844.

a dirty yellowish white, and the last of a more or less deep yellow, sometimes approaching to a dark brown, or even black.

5. Dr. Prout is of opinion that the colour of the urine is due to the presence of two colouring principles, one of which is closely allied to lithic acid and lithate of ammonia, and gives them their yellow colour, and the other to some modification of the colouring matter of the bile; and he believes both to be intimately connected one with the other from the circumstance that lithic acid and the biliary colouring principle are similarly affected by nitric acid. Simon believed the first to be identical with the yellowish brown matter, viz. the hæmaphäeîn that is extracted from the dried serum of the blood by ether and alcohol.\* Becquerel also supposes the colouring matters of the urine to be composed of two others; one of a greenish and the other of a reddish colour, and he states that the latter generally predominates when the urinary secretion is high coloured and loaded with uric acid and organic matters. This is perfectly in accordance with Dr. Prout's statement. Berzelius has applied the term halophyle to the yellow colouring matter of the urine, in consequence of the great difficulty of separating it from the saline principles of the secretion. Heller, on the other hand, has

<sup>\*</sup> Simon's Handbuch, b. 1. s. 328.

given it the name of uroxanthin, which he says "occurs in solution in very small proportion in healthy urine, but is much increased in certain forms of disease."\*

6. Some discrepancy of opinion exists respecting the pigment which gives to the urine and its lithic deposits that peculiar rose and purple tint in certain cases of derangement of the portal circulation. Dr. Prout considers it to be the purpurate of ammonia, the murexid of Liebig. Dr. Bird believes it to be a principle very different to this, and to which he has given the name of Purpurine. His reasons for differing from Dr. Prout are founded on the different behaviour of the two substances towards certain reagents; and on the latter being soluble and the former insoluble in alcohol; while M. Rayer thinks it is the rosacic acid of Vauquelin. Simon describes a principle closely allied to it under the name of uroerethrin; and Heller states that the yellow pigment of the urine, which he has termed wroxanthin, "possesses the property of being converted by oxidation, (either spontaneously or artificially), into two other pigments, one of which is of a rubyred tint, urrhodin," and no doubt identical with the purpurine of Dr. Bird, "while the other is of the colour of ultramarine, (uroglaucin)." They both "occur in diseases different in most of their characters, but similar in one—the presence

Simon's Animal Chemistry, by Day, vol. ii. p. 522.

of an excess of urea in the blood: thus they are found in Bright's disease, in cholera, and in suppression of urine. Further, when these products occur in considerable quantity, (especially when the blue sediment is spontaneously formed,) there, is always much carbonate of ammonia, and very little urea (perhaps mere traces) in the urine, as is often the case in Bright's disease. Finally, Heller has observed the blue tint developed by nitrate of urea artifically prepared and kept moist, and has likewise produced it by adding nitric acid to an old solution of urea, partially converted into carbonate of ammonia,"\* and hence they are in all probability, together with the uroxanthin, derived from urea.

Scherer states as the results of his experiments that the colouring matter of urine is allied to both that of the blood and bile and he is led to believe that it is formed from the hæmatin of arterial blood, and that its formation is analagous to that of the urea and lithic acid. He states its composition to be as follows:—

Carbon		58.43
Hydrogen		5.16
Nitrogen		8.83
Oxygen		27.58
	-	
		100.00

<sup>\*</sup> Simon's Chemistry.

In those diseases accompanied by an inactive state of the lungs and of the liver, and by rapid metamorphosis of the tissues, the two first elements become remarkably increased. The opinion therefore expressed by Dr. Bird, namely: that an excess of this matter in the urine may be considered as an evidence of the kidneys performing a compensating function for the lungs and liver receives very strong corroboration; and the great similarity that is found to exist between the composition of the normal colouring matter of the urine as given above, and that of purpurine, of the bile pigment, and of the urinary colouring matter in jaundice, still more confirms it.

The following are the respective compositions of these principles according to Dr. Bird:—

	Urinary colour- ing matter of jaundice,	Urinary colour ing matter in organic disease of the liver,	Bile Pigment from urine.
Carbon	60.19	65.76	68.182
Hydrogen		6.01	7.437
Nitrogen Oxygen	} 34.25	} 28.23	$ \begin{cases} 7.074 \\ 17.261 \end{cases} $

A non-nitrogenized diet has likewise the effect of increasing, although not in equal proportions, the quantity of carbon and hydrogen passed with the urine, even when there is no alteration in the amount of exercise taken or of oxygen absorbed. An ex-

cessive secretion of this principle for any length of time, gives rise, according to Scherer, to anæmia and emaciation.

- 7. The quantity of urine passed in twenty-four hours has been differently stated by different authors. Thus, Haller estimated it at 49 ounces; Simon at 45; Bostock and Rye at 40; Venables considered it to average between 40 and 50; Rayer between 21 and 57; Becquerel about 46, and Dr Prout between 30 and 40 ounces. Becquerel also states that it may range within the limits of health between 28 and 53 ounces. Dr. Prout's estimate will I think on the whole, for this country at least, be found the most correct. It appears to be somewhat less in men than in women, according to Becquerel; although the contrary is stated to be the case by Dumas and Burdach.
- 8. The quantity, however, is much influenced by various circumstances. It is generally found to be increased in cold and damp weather; by a vegetable diet, and according to Mr. Erichsen, \* during the process of digestion, a short time after its commencement, and by exercise; + by certain medicines, as

<sup>\*</sup> Med. Gaz. July 4, 1845.

<sup>†</sup> Exercise has generally been supposed to diminish the secretion of urine; but I think when we consider that any thing which accelerates the circulation must tend to stimulate the secreting organs, we should have been perfectly justified in supposing the contrary, as now proved to be the case by the investigations of Mr. Erichsen.

squills, digitalis, colchicum, and various resinous and saline compounds, particularly the salts of soda, &c., and by the ingestion of large quantities of watery and aërated fluids. In order, however, that liquid potations may have the effect of increasing the quantity of the urinary secretion it is necessary, as Professor Liebig, has proved, that their density should be less than that of the blood, othewise instead of being absorbed into the circulation they attract water from the blood on the principle of exosmosis, causing the sensation of thirst, and eventually become discharged by the bowels. Hence it follows that to ensure the action of a diuretic salt it should be given in a very diluted state. It is diminished in hot and dry weather: and when the cutaneous and pulmonary exhalation, and the alvine excretions are augmented; and according to Bouchardat by alcoholics. It also varies considerably in certain morbid conditions of the system; thus it is increased in Diabetes, Polydipsia, Hysteria, and other nervous affections, and likewise by fear, mental emotions and grief; and is diminished in cases of fever and inflammation, rheumatism, disease of the liver, and hepatic and cardiac dropsies.

9. The natural transparency of healthy urine is liable to be disturbed whenever the proper relative proportions of its constituents are altered, or when it contains some preter-natural or foreign matter. Hence it is that urine frequently becomes turbid from the

presence of mucus, pus, or blood; from an excess of lithic acid or lithate of ammonia; from the superabundance of the phosphates, or in consequence of the decomposition which the fluid undergoes in disease, or by keeping. Some of these form a kind of scum on the surface of the urine, and constitute what is termed a pellicle; others float in it near the surface, and form a cloud; while others again become precipitated to the bottom of the containing vessel and give rise to a sediment. Dr. Bird has included the whole under the term of urinary deposits, which he has divided, into the four following classes.

Class 1.—Deposits composed essentially of ingredients formed directly or indirectly from the metamorphosis of tissues, or from the inorganic elements of food capable of assuming a crystalline form.

Uric Acid and Urates.
Uric Oxides.
Oxalate of lime.
Cystine.

Class 2.—Deposits composed of ingredients of inorganic origin; including:—

Phosphate of lime.

Ammonio-phosphate of magnesia.

Carbonate of lime.

Silicic Acid.

Class 3.—Highly coloured deposits (black or blue) of doubtful origin:—

Cyanourine.

Melanourine.

Indigo.

Prussian Blue.

Class 4.—Deposits consisting of non-crystalline organic products; including:—

A. Organised.

Blood.

Pus.

Mucus.

Organic Globules.

Epithelium.

Spermatozoa.

Torulæ.

Vibriones.

B. Non-Organised.

Milk.

Fatty Matter.

Stearolith.

10. Its consistence varies with its density, and with the presence of foreign matters. Thus the greater the specific gravity, the more consistent the urine, and vice versâ. It is also increased by mucus, blood, pus, albumen, sugar, and oxalate of lime, and by an excess of lithic acid.

11. The specific gravity is subject to much variation. Like the consistence it depends on the degree of concentration of the urine, and on the presence of foreign matters, and has been stated by different authors to oscillate between 1.010 and 1.020. Thus M. Becquerel gives 1.018 as the mean in men, and 1.015 in women; Simon places the average at 1.012.6; Lecanu at between 1.020 and 1.030; Dumas at between 1.015 and 1.030, and Aldridge at 1.015; while Dr. Prout thinks 1.020 will be a more correct average for this country.

12. The specific gravity however differs, according to the specimen of urine examined, whether it be that passed on rising in the morning, or that excreted after copious liquid potations, or that voided after a meal. Hence, and from the particular source from which each is derived, the division of the urine into three different kinds. URINA SANGUINIS, the urine of the blood, or morning urine. 2. The URINA POTUS, and 3. The URINA CHYLI, or of digestion. The first which may be considered as the urine par excellence, varies in density from 1015 to 1025; the second being oftentimes excessively dilute is of extremely low weight, and in some cases indeed little heavier than distilled water; while of the third, or the urine from food, the specific gravity is generally considerably increased both in health and disease, and may be said to range between 1020 and 1030.

13. Dr. Schweig states that there is a constant rate of increase and decrease in the density of the urine throughout the day, and that, cæteris paribus, it varies in the morning from 1.017 to 1.022; in the afternoon from 1.023 to 1.028; in the evening from 1.019 to 1.028; and in the night from 1.022 to 1.025. Moreover, that the specific gravity of the night urine passes through certain limits in a cycle of six days, attaining a minimum twice in that period. The following table represents the average density of twenty such periods.

Nights of th	he Cycle.	Density of the Urine.
1		1.022
2		1.017
3		1.019
4		1.020
5		1.019
6		1.017

From this it appears that the specific gravity is higher on the first night and lower on the second and sixth than on any other. According to Dr. Schweig five of these cycles occur in each lunar revolution, the night previous to the new moon being counted as the second day of one of the cycles.\*

14. In consequence therefore of this variation in the density of the urine at different times of the day, it is necessary, in order to avoid error, and for

<sup>\*</sup> See Dr. Bird's work on Urinary deposits, Second Edition, page 32.

the sake of perfect accuracy, that three things should be attended to. The first is to collect the whole of the urine evacuated in twenty-four hours, otherwise we may be led to suppose from the low density of a given specimen of urine, that the amount of solids excreted in twenty-four hours is much below the healthy standard, whereas it may not only not be at all diminished, but on the contrary, somewhat increased. In fact so important is this in disease that were we to neglect it we should be frequently liable to error, as an excess of the solid constituents of the urine, relatively to the quantity of water it contains may be present in a particular sample voided at a certain time, when the amount excreted in the twenty-four hours does not exceed, or perhaps is not so great as that in health, and vice versâ. The second is to ascertain the quantity of its watery portion; for in proportion as this is increased or diminished, so will the density, cæteris peribus, be decreased or augmented. Consequently if the quantity of urine passed during the day be not greatly above or below the normal standard and its specific gravity is very low, we may conclude that the proportion of its solid ingredients has considerably diminished; but, if on the other hand, we find the amount of urine is much greater than natural, then we may fattribute the diminution in density to the proper relative proportions that normaly exist between the solid and fluid portions

of the urine having become destroyed. And we must not, as I have just now alluded to, suppose that the decrease of specific gravity from this cause is the criterion of the urine of a given time containing a less amount of solid matter than it should do, as the very reverse will, in all probability, be found to be the case. Again if the amount excreted in the twenty-four hours be normal or even greatly augmented, and the specific gravity high, we may confidently assert that the alteration is due either to an excess of urea or to the presence of some extraneous matter such as sugar. The third is to examine its temperature; for Simon found that urine of specific gravity, 1020.75, at 59 degs. Farh., became reduced to 1019.85 when the temperature was increased to 64 degs. and increased to 1021.46 when it was lowered to 53 degs. Farh.

15. It often happens that we are unable to collect the whole of the twenty-four hours urine, either from the patient being ignorant of its importance, and in consequence unwilling to strictly attend to the requisite precautions, or from his inability to suppress the evacuation of the bladder when unloading the bowels. In this case we must be content with the average density presented by the urine that is passed after a night's rest, and by that excreted after digestion on going to bed, which will be generally sufficiently accurate for all practical purposes.

optical properties which have been taken advantage of as a means of diagnosis. They have been employed principally in the detection of saccharine diabetes, in which disease, as also in albuminuria, the urine has the power of producing the circular polarization of a polarized beam of light. The obstacles and difficulties, however, attending this method, are such as will, in all probability, prevent its ever coming into general use,\* notwithstanding all that has been said in its favour by Bouchardat and Biot; and moreover Dr. Leeson has proved that it is by no means to be depended on.+

17. Various analyses have been given of the urine. According to Berzelius 1000 parts consist of 933 of water and 67 of solid ingredients, 30.10 of which represent urea and 1 uric acid; the remaining 35.90 being constituted by 17.14 of organic matters, such as the lactic acid, the lactate of ammonia and colouring principles, &c., by 18.41 of alkaline and earthy salts, as the sulphates of potash and soda, the phosphates of soda, ammonia, lime and magnesia, the muriates of soda and ammonia, and a trace of fluate of lime, and by 0.32 of vesical mucus, and .03 of silex.

It is much to be regretted, however, that this distinguished chemist has not informed us either of

<sup>\*</sup> See a translation of Bell on Diabetes by the author, page 17.

<sup>+</sup> See part vii. of the Memoirs of the Chemical Society.

the kind or the density of the urine he examined; but we have every reason to believe, from the large proportion of solids it contained, that it was a specimen much above the normal standard, and therefore cannot be considered as a type, with which all calculations and investigations both in health and disease are to be compared.

18. Becquerel's analysis, as modified and arranged for this country by Dr. Prout, has been generally considered as more approaching the truth, and is given in the following table.

#### TABLE I.

Which shows the average Normal Quantity Specific Gravity, and Composition of the Urine in this country.

Quantity, Specific Gravity, and Composition of the Urine.	Urine in 24 hours,	Composition of 1000 parts.
Quantity of Urine	35 fld. oz.	1000
Specific Gravity	1.020	Control of the contro
General Water	14807 grs.	967
Composition & Solid Matters	505	33
(Water	14807 grs,	967.
Urea	226.802	14.230
Lithic Acid		.468
Organic (Lactic Acid)		0.00
matters in-   Lactate Ammonia		
separable { Colouring matters}	146.467	10.167
from each   Extractive matters		
other Muriate Ammonia		
Fixedsalts Chlorides Lime		
posible at Phospha- Soda Potash	a 124.541	b 8.135
a red heat Sulphates Magnesia		
	15010.000	1000 000
	(15312.000	1000.000

Jetails of Analysis

Composition of the entire quality of Fixed Salts voided in 24 hours; and in a 1000 parts of urine.

(a) Fixed Salts vo 24 hours.	ided in	(b) Fixed Salts in parts.	1000
Chlorine	9.04	Chlorine	.591
Sulphuric Acid	15.39	Sulphuric Acid	1.006
Phosphoric Acid	5.72	Phosphoric Acid	.373
Potash	23.40	Potash	1.529
Soda		Soda	
Lime >	70.99	Lime	4.638
Magnesia		Magnesia	
	10454		0.104
	124.54		8.137
		-	

Here the solid matters are represented in the proportion of only 33 instead of 67 in 1000 parts of urine, the specific gravity being 1020; an amount which will be seen to but little exceed the proportion of urea, and to be not quite one half that of the whole of the solids stated by Berzelius to be present in the same quantity.

19. This amount however appears to be much too small from the researches of Dr. Day, \* who has proved the formula  $\Delta \times 2.33$  of Dr. Christison† to be more accurate than that of either Dr. Henry or Dr. Becquerel, which are  $\Delta \times 2.58$  and  $\Delta \times 1.65$  respectively; the average error from using it being

<sup>\*</sup> Lancet vol. i. 1844, p. 373.

<sup>+</sup> Library of Medicine vol. iv. p. 248

only .47 in 1000 parts, while the mean error of Dr. Henry's formula is 7.71 and that of Dr. Becquerel, 21.92.

The following table has therefore been constructed for the purpose of showing the *probable* composition of the urine according to Dr. Christison's formula.

TABLE II.

Quantity, Specific Gravity and composition of the Urine.	Urine in 24 hours.	Composition of 1000 parts.
Quantity of Urine	35 fl. oz. 1.020	1000
Urea	304.550 9.999	19.889 0.653
Peculiar Azotised principle (Pet-)	76.600	5.000
Hippuric Acid	7.365	0.481
Organic matters in- separable from each other.  Colouring matters  Extractive matters  Muriate Ammonia	140.929	9.206
FixedSalts Chlorides Lime  Phospha-Soda  posible at a red heat  Sulphates Magnesia	a 174.118	b 11.371
Total amount of Solids	713.561 14598.939	46.600 953.400
Total amount of Urine	15312.500	1 000.000

Composition of the entire quantity of Fixed Salts voided in 24 hours; and in 1000 parts of urine.

(a) Fixed Salts voided in 24 hours.	n (b) Fixed Salts in 1000 parts.
Chlorine	2       Sulphuric Acid
Soda Lime Magnesia \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	$\left\{\begin{array}{c} \operatorname{Soda} \\ \operatorname{Lime} \\ \operatorname{Magnesia} \end{array}\right\} \dots \qquad 6.482$
174.1	11.372

20. Lehmann states the average amount of solid ingredients to be as follows:

After	a mixed Diet	1.047.000
,,	an Animal Diet	1.349.898
	a Vegetable Diet	914.541
	a non-nitrogenous diet	643.455

and Lecanu informs us that the composition of the urine will be found to vary but little in the same individual at stated times, but that very great differences will be found in the secretion of different persons.

21. Its solid contents however generally become diminished in debilitated states of the system, and when the blood corpuscles are decreased in number, although in land scurvy Heller detected a slight increase. The proportion in this disease was in one case 50.72, the specific gravity being 1.021.

M. Chambert, in a memoir presented to the Academie des Sciences, on the 2nd June, 1845, deduces as the results of his investigations, 1st. That the urine of the food contains more saline matter than that of the blood; 2nd. That the inorganic principles are in a direct ratio with the quantity of salts introduced with the food. 3rd. That the saline ingredients are more abundant in the urine of the blood in proportion as they exist in larger quantity in that of digestion. 4th. That there is no relation between the saline matter and the specific gravity of the urine, or between them and the organic principles.

22. The ingredients held in solution in healthy urine may with Dr. Bird be arranged under the three following heads.

#### I. ORGANIC PRODUCTS.

1st. Ingredients characteristic of the secretion produced by the colouring and ododestructive assimilation of tissues, > rous principles, and a and separated from the blood by | crystalline nitrogenithe kidneys ..... J sed body.

Urea, Uric acid,

2nd. Ingredients developed prin- \( \) Hippuric acid, laccipally from the food during the \( \) tic acid? and acciprocess of assimilation . . . . . . . dental constituents.

#### II. SALINE PRODUCTS.

3rd. Saline combinations sepa-7 rated from the blood, and chiefly hosphates, Chloderived from the food ..... Phosphates, Chloderived from the food .....

4th. Saline combinations chiefly generated during the process of > destructive assimilation ......

Sulphates.

# III. INGREDIENTS DERIVED FROM THE URINARY PASSAGES.

5th. Mucus of the bladder. 6th. Debris of epithelium.

Under the *first* head are placed those elements which are destined to be secreted by the kidueys from the blood, and to the presence of which in the urine, the characteristic properties of the latter are due. Under the *second* are classed several saline compounds most of which are present in the various other secretions, the sulphates alone appearing to be peculiar to the urine; while under the *third* head we find certain matters common to all secretions passing over mucous membranes.

## I. Organic Products.

23. Urea enters more largely than any other substance into the composition of the urine. It is described by Dr. Prout as assuming the form of four sided prismatic, colourless, transparent crystals, of a pearly lustre, which leave a sense of coldness on the tongue like nitre. It has a faint and peculiar, but not urinous, smell, is neither acid, nor alkaline; undergoes no change on exposure to the air, except in very damp weather, when it slightly deliquesces, but does not seem to be decomposed. Pulverized and mixed with salts containing water of crystalization it separates the latter, and the mass becomes either soft or perfectly liquid according to the quan-

also has a singular effect on the crystallization of particular salts. Thus it converts the natural cubical form of chloride of sodium (common salt) into the octahedral, and the charactistic octahedral shape of hydrochlorate of ammonia into the cuboid. Its specific gravity is 1.35; is soluble in its own weight in cold and in any proportion of hot water; and in four and a half parts of cold, and about two parts of boiling alcohol, from which latter it separates in a delicately crystalized form on cooling. Urea has no neutralizing power but combines with acids, especially the nitric and the oxalic.

24. The nitrate of urea is represented by Drs. Prout and Lehmann as being composed according to their analyses of one equivalent of nitric acid and one equiv. of urea. Regnault, and more lately Heintz, on the other hand, have found it to contain one equiv. of water in addition. The following is the composition of 100 parts of this salt as given by different chemists.

	Prout.		Lecanu.	. A	Tarchand.
Nitric Acid	47.375	-	47.00	-	66.11
Urea	52.625	-	53.00	-	33.89
	100.000	-	100.00	-	100.00
I	Regnault &	Be	ecquerel.	He	eintz.
Nitric Acid	43.	781	-	44.	.14
Urea				48	86
Water	7	28]	-	7.	.00
	100	000		100.0	000

Oxalate of urea contains in 100 parts according to Berzelius,

Oxalic Acid Urea	$37.436 \\ 62.564$
	100.000

25. In the opinion of M. M. Cap and Henry, urea exists in the urine, partly in combination with lactic acid. This however is doubted by Pelouze, Lecanu, Liebig, and Dumas; the latter indeed seems more inclined to believe that it is present in a free state, but nevertheless believes it possible that it may exist in combination with sal ammoniac and chloride of sodium\* to a greater or less extent.

26. Dr. Prout from his analysis gives the composition of urea as follows:

Wöhler and Liebig represent it as being composed of

Carbon...... 20.02 Hydrogen .... 6.71 Nitrogen .... 46.73 Oxygen .... 26.541

Med. Times vol. 16. p. 29.

<sup>†</sup> Thomson's Annals, vol. xi. p. 353.

<sup>‡</sup> Poggend. Ann., xx. p. 375.

27. Its formula is C<sub>2</sub>, O<sub>2</sub>, H<sub>4</sub>, N<sub>2</sub>. Hence it will be seen to represent either one atom of Cyanogen, two of water, and one of Amidogen thus:

c. N. H. 0.  

$$2+1$$
 = one atom cyanogen.  
 $2+2$  = two atoms water.  
 $1+2$  = one atom amidogen.  
 $2+2+4+2$  = one atom urea.

Or two atoms of carbonic oxide and two of amidogen thus:

C. N. H. O.  

$$2 = \text{two atoms carbonic oxide.}$$
  
 $2+4 = \text{two atoms amidogen.}$   
 $2+2+4+2 = \text{one atom urea.}$ 

28. Its formula also readily explains the formation of the cyanate and carbonate of ammonia, and oxalic acid in the urine. For by abstracting one equivalent of water from one of urea we have the composition of one atom of cyanate of ammonia.

c. N. H. o. 
$$2+2+4+2=$$
 one atom urea.  $1+1=$  one atom water. gives  $2+2+3+1=$  one atom cyanate ammo-[nia.

and if we add two equivalents of water to one of

urea we have the composition either of two atoms of carbonate of ammonia as follows:

C. N. H. O. 
$$2+2+4+2=$$
 one atom urea. plus.  $2+2=$  two atoms water. gives.  $2+2+6+4$  which is equal to  $2+6=$  two atoms carbonic acid  $2+6=$  two atoms ammonia.  $2+2+6+4$ 

Or of one equivalent of oxalic acid, two of ammonia and one of oxygen, thus:

plus. 
$$2+2+6+4$$
 which is equal to  $2+6$  = two atoms ammonia.  $2+6$  = two atoms ammonia.  $2+6$  = two atoms ammonia.  $2+6+6+4$ 

Another probable source of the oxalic acid occasionally met with in the urine will be alluded to under the head of uric acid, (32.). The above is Dr. Bird's hypothesis.\*

<sup>·</sup> Guy's Hosp. Reports for April, 1842.

29. The conversion of the urea into carbonate of ammonia occurs much more rapidly, generally speaking, in warm weather than in cold; and also when the urine contains a good deal of mucus, which, in that case, by undergoing putrefaction may, according to Dumas, act as a ferment. But in order that putrefaction may take place in the healthy secretion it is essential, as proved by the researches of Guy-Lussac, that the atmospheric air, or rather the oxygen contained in it, should have free access to the fluid. For it appears that so long as this is excluded from the air by being confined in well stoppered bottles, its odour, transparency, and natural acid reaction remain unaltered, uric acid being alone deposited; whereas if placed in contact with the air, the oxygen of the latter becomes absorbed and may, by combining with the nitrogenous extractive principles of the urine, in the opinion of M. Dumas and Dr. Aldridge, and with the colouring matter as believed by Liebig, probably transform these substances into nitrogenized ferments which are thrown down in an insoluble state, and the urea into carbonate of ammonia, which, by rendering the urine alkaline, causes the phosphate of lime and triple phosphate to be also precipitated. Still it not unfrequently happens, however, that this change, namely the conversion of urea into carbonate of ammonia, takes place in the bladder, into which no air is ever admitted; and I have no doubt, even in

some cases, although it has been stated to the contrary, previous to secretion, the urine being under those circumstances passed in an alkaline condition. I shall have occasion to refer more particularly to this important fact bye and bye.

30. Moreover it would appear from the late investigations of Drs. Sutherland and Rigby, that this metamorphosis is very prone to take place during certain forms of mental derangement. Thus they found that in dementia the urine effervesced on the addition of an acid in 34.37 per cent; in melancholia 30, and in mania, 16, 67 per cent; and that in the first mentioned affection, the urine when passed in an acid condition, has a tendency to very speedily become alkaline.\* Dr. Erlenmeyer however states that the urine of maniacs, which he says is generally pale and deficient in solid constituents, particularly lithic acid and its compounds, is more disposed to be alkaline than that of melancholics; and he considers that in proportion as there is a greater disposition in the latter class of cases for the urine to assume an alkaline reaction, without there being any accompanying organic affection either of the brain or spinal marrow, the more liable are they to become worse, and pass into mania.+

<sup>\*</sup> Med. Gaz. vol. 36. p. p. 235, 229.

<sup>†</sup> Med. Times, vol. xvi. p. 237.

- 31. According to Berzelius's analysis we find urea to exist in the urine in the proportion of 30.10 to 1000, but Becquerel, who has made several apparently very careful examinations of the urinary excretion, considers this much too great. He states it to be between 10 and 14 parts only in 1000 and the quantity passed in 24 hours to vary between 15 and 18 grammes,\* or 231.570 and 277.884 grains; the minimum specific gravity being 1015 and the maximum 1018.
- 32. M. Lecanu found the proportion to be much greater than this in adult men and women and less in old men and children. The following shows the results he obtained from 120 analyses.

	Min,	Ma x.	Mean.
In adult men	154.237	437.003	295.112
	61.072	189.342	125.202
	161.759	254.171	207.965

Still the amount excreted by the same individual in a given space of time was always much the same. It is not present however in the urine of children at the breast according to Lecanu, Rayer, Guibourt and others.

33. The quantity moreover appears from the experiments of M. Lehmann on himself to be con-

<sup>\*</sup> A Gramme is equal to about 15.438 grs

siderably modified by different kinds of diet; thus, from his urine of 24 hours he obtained,

After a non-nitrogenous diet	237.909 grains.
After a vegetable diet	347.061
After an animal diet	821.270 ,,
And after a mixed diet	501.704 ,,

Bouchardat also states it to be discisshed by alcoholics, and Lehmann, Simon, and Percy have found it to be augmented by violent bodily exertion.

34. It is also much affected by disease, but an absolute excess in a given time is, according to Becquerel, of rare occurrence; the general rule being an absolute diminution. According to the researches of Mr. Stuart Cooper, there appears to be no proportionate diminution between this and the other elements contained in the urine; for he frequently found the urea to be considerably reduced in quantity and yet no very great decrease in the amount of the other organic and inorganic It is very abundant in plethoric states of the body, and remarkably scanty in anæmia; its quantity apparently coinciding in a direct ratio with the globules in the blood, for whatever increases or diminishes the latter, tends to augment the former (Andral).\* In cases of fever, rheumatism, and other inflammatory diseases, &c. the urine in twenty-four hours also contains a less amount of

Med. Times vol. 15. p. 285.

urea, although a given specimen may indicate an This is owing to the scantiness of the urine. It is likewise diminished in cirrhosis and hepatic dropsy, in various chronic and neuralgic affections, and in albuminuria or granular degeneration of the kidneys, while in diabetes it was thought that the saccharine matter had taken its place. This has however been proved by more recent analysis not to be the case. In fact, Mr. Macgregor was led to believe that patients labouring under this disease excreted "in twenty-four hours a much greater quantity of urea, than a person in health does in the same space of time,"\* although a given specimen of diabetic urine contains a less proportion than the same quantity of the healthy secretion. Drs. Kane and Bouchardat consider the quantity to be the same as in health, while Drs. Prout and Henry estimate it at something less. Judging, however from the animal diet that must necessarily be employed in this disease we should have been inclined to believe that the urea would be rather in excess than otherwise. It is also stated by Bouchardat to be considerably diminished in a disease of which one of the principal features is the presence of a large quantity of hippuric acid in the urine, and hence termed by him hippuria.+ The greatest decrease observed by Bec-

<sup>\*</sup> Bell's Essay on Diabetes, p. 21.

<sup>†</sup> Annuaire de Thérapeutique for 1842, p. 285.

querel in twenty-four hours was in those cases in which there was great debility accompanied by slight febrile action; the average quantity here being only 75.924. It however frequently happens that in a given specimen of urine the amount of urea appears more abundant than natural in consequence of the water having diminished much more rapidly than it; and hence has arisen the erroneous idea that in fever, &c. it was actually increased in a given time. Two cases only were met with by Becquerel in which there was an increase in the normal quantity in 1000 parts. One was a case of milk fever, the other of sanguineous apoplexy. In the former it was in the proportion of 18.842 and in the latter of 16.452; 14, being the maximum in health according to this author. The amount excreted in twenty-four hours was only 133.492 and 190.076 grains respectively; thus showing that although there was a very considerable relative increase there was not only no augmentation in the natural quantity in the time specified, but, on the contrary, an actual diminution.

The importance therefore of accurately ascertaining the actual amount of urine passed in the twenty-four hours before we can positively state that an increased excretion of the solid ingredients of the urine has taken place in the same period, at once becomes apparent. Still if a greater amount of urine than natural continue to be passed, then the

quantity of urea may increase likewise, although M. Becquerel states that he has never met with it, and is of opinion that it is an exceedingly rare L'Héritier however mentions a case in which during the commencement of an attack of gout, he obtained from the urine of twenty-four hours, 23.160 grammes, or about 357.454 grains. The specific gravity was 1028.315 and the quantity of water 44 fluid ounces. And Dr. Prout has long since described two distinct kinds of cases characterised by an excess of urea, one with diuresis the other without. Instances of the latter, he says, are not uncommon in certain forms of dyspepsia. It is evident therefore, that as in examining the specific gravity, so also in ascertaining the quantity of urea three things must be considered. First, the quantity of water; Secondly, the age and sex of the individual, and Thirdly, the kind of food he has been taking, for as we have seen from the researches of M. M. Lecanu (32) and Lehmann (33) it is subject to great variations in these respects. However we may generally calculate with a tolerable degree of certainty on an excess of this element whenever the specific gravity of the urine is above 1030\*

35. According to Dr. Prout urea appears to be generated from the gelatinous tissues during the

<sup>\*</sup> Prout on Urinary Diseases, p. 99. Fourth Edit.

destructive stage of the secondary assimilating processes. Dumas states it to be "manifestly derived from the oxidation of the azotised materials of the blood," which he says "have a tendency to pass into cyanic acid and oxide of ammonia." And in order to avoid any unnecessary expenditure of oxygen, nature wisely checks "the combustion of the azotised matter so soon as they are converted into cyanate of ammonia," which thus, immediately on its production, becomes transformed by an izomeric change of its elements, into urea.\* Dr. Aldridge considers it, and in fact all the more essential elements of the urinary secretion, to be "derived from the combustion of the non eliminated secretions, and not directly from the decomposition of the tissues."+ It exists in healthy blood only in very minute proportion owing to its being removed from it by the kidneys as soon as formed. Therefore anything which interferes with the elimentating action of these organs will cause the urea to be retained in the blood, from which on analysis it can be readily separated. Prevost and Dumas removed the kidneys of different animals and found in five ounces of the blood of the dog above twenty grains of urea, and ten grains of it in two ounces of cat's blood.

Urea is the first organic substance that has

<sup>\*</sup> Med. Times, vol. xv. p. 258.

<sup>+</sup> Lectures on the Urine, p. 21.

been formed artificially. Dr. Prout made several unsuccessful attempts to form it, but the honour of doing so was reserved for Wöhler a German chemist. (70)

36. Uric or lithic acid is one of the most important constituents of the urine. It has neither taste nor smell, and when pure is perfectly white, and crystallizes generally in rhomboid scales. It is insoluble in alcohol and ether, and but very sparingly soluble in water, requiring, according to Liebig, 15000 parts of cold and 1932 of hot; and according to Dr. Prout, 10,000 parts at 60 degs. for its solution. It is soluble however in caustic potash and nitric acid, and on evaporating the acid solution we obtain transparent almost colourless crystals of the erythric acid of Brugnatelli, the alloxan of Liebig, which assume a deep purple colour on the addition of ammonia, and constitute the purpurate of ammonia of Dr. Prout, the murexid of Liebig, and the purpurine of Dr. Bird. It is converted by heat into hydrocyanic acid, urea, carbonate of ammonia, and an empyreumatic oil. Exposed to the blow-pipe it turns black, and becomes dissipated with the evolution of a very peculiar animal odour. It has but feebly acid powers, and its salts are readily decomposed by all acids. Its crystals, as they are met with in the urine, are always somewhat tinged by the colouring matters present in the secretion.

37. According to Liebig and Mitscherlich it is composed of:

38. Its formula is C<sub>10</sub>, N<sub>4</sub>, H<sub>4</sub>, O<sub>6</sub>, which may be said to represent four atoms of cyanogen, two of carbonic oxide, and four of water thus:

Or, from the fact of its being decomposed into oxalic acid, all antoin and urea when boiled in water with peroxide of lead, as shown in the following diagram,

1 atom uric acid..... = 
$$10 + 4 + 4 + 6$$
  
+2 ,, oxygen .... =  $2$   
+3 ,, water .... =  $3+3$   

$$10 + 4 + 7 + 11$$
Equal to
1 atom urea .... =  $2+2+4+2$ 
2 ,, oxalic acid .. =  $4$ 
1 ,, allantoin ... =  $4+2+3+3$   

$$10 + 4 + 7 + 11$$

<sup>\*</sup> Ann. der Pharm., vol. x., p. 47.

<sup>†</sup> Poggend. Ann., vol. xxxiii. p. 335.

of Giessen, as consisting of one atom of the compound radical 'called *Urile*, (composed of two atoms of cyanogen and four of carbonic oxide,) and one atom of urea. The composition of uric acid will then be represented as follows:

1 atom uric acid..... = 
$$\begin{array}{c}
C. & N. & H. & 0. \\
10 + 4 + 4 + 6
\end{array}$$
Equal to

1 atom of urile..... =  $\begin{array}{c}
8 + 2 \\
2 + 2 + 4 + 2
\end{array}$ 
 $\begin{array}{c}
4 \\
10 + 4 + 4 + 6
\end{array}$ 

Now inasmuch as urile differs from oxalic acid only in having two atoms of cyanogen in the place of two atoms of oxygen, and as it requires merely the addition of two atoms of water to be converted into this acid and also the hydrocyanic, we can, with Dr. Aldridge, easily explain the formation of both these acids as well as the formic acid and ammonia in the urine. For

But as immediate reaction takes place between the hydrocianic acid thus formed and water, there is then produced, by an interchange of elements formic acid and ammonia: or in other words formate of ammonia.

39. Liebig states that when uric acid is acted on by oxygen, it is converted first into alloxan and urea, and subsequently by the further action of oxygen on the alloxan into either the oxalic or carbonic acid and urea.

The formation of alloxan and urea may be represented as follows:

1 atom uric acid ..... = 
$$10 + 4 + 4 + 6$$
  
plus 4 ,, water ..... =  $4 + 4$   
plus 2 ,, oxygen .... =  $10 + 4 + 8 + 12$   
Equal to

1 atom alloxan .... =  $8 + 2 + 4 + 10$   
1 ,, urea .... =  $2 + 2 + 4 + 10$   
 $1 + 4 + 8 + 12$ 

That of oxalic acid and urea from alloxan thus:

plus 1 atom alloxan ..... 
$$\equiv$$
  $8+2+4+10$   $8+2+4+11$   $\equiv$   $8+2+4+11$   $\equiv$   $8+2+4+11$   $\equiv$   $8+2+4+11$   $\equiv$   $8+2+4+11$ 

And that of carbonic acid and urea from alloxan, thus:

Or the fomation of the oxalic and the carbonic acids may be explained by the direct action of oxygen on uric acid itself; thus if we add

and 3 ,, of oxygen.. = 
$$3$$
 to 1 ,, of uric acid =  $10 + 4 + 4 + 6$ 

we have the formula Equal to  $10 + 4 + 8 + 13$ 

Equal to  $10 + 4 + 8 + 4$ 
 $10 + 4 + 8 + 4$ 
 $10 + 4 + 8 + 13$ 

And if we add three equivalents more of oxygen, we have then the composition of 2 atoms of urea and six of carbonic acid, thus:

4 atoms of water ... = 
$$0.5$$
 N. H. 0.  $0.5$  Plus 6 ,, oxygen .. =  $0.5$  M. H. 0.  $0.5$  Plus 3 ,, uric acid .. =  $0.5$   $0.5$  Plus 3 ,, uric acid .. =  $0.5$  Plus 3 ,, uric acid .. =  $0.5$  Plus 3 ,, uric acid .. =  $0.5$  Plus 4 + 4 + 6 Plus 4 + 6 Plus 6 ,, carbonic acid .. =  $0.5$  Plus 6 ,, carbonic acid .. =  $0.5$  Plus 6 ,  $0.5$  Plus 7 ,  $0.5$  Plus 8 ,  $0.5$  Plus 8 ,  $0.5$  Plus 8 ,  $0.5$  Plus 9 ,  $0.5$  Plus 9

Hence then we have two probable sources of the oxalic and carbonic acids in the urine, one from the rearrangement of the elements of urea (Bird,) (28,) the other from the oxidation of uric acid (Liebig). A third may also be mentioned as being equally probable, namely, the perverted or mal-assimilation of the saccharine matter, (Prout), (66 m.).

- 40. Lithic acid is supposed by Dr. Prout to be the result of the re-arrangement of the elements of the albuminous tissues.
- 41. According to Becquerel, about 8.1 grains are excreted in the course of twenty-four hours. In Table 2 we have stated the quantity at 9.999 grains. It exists in the urine, in all probability (as Dr. Prout has stated) in combination with ammonia, an opinion which appears to be greatly favoured by the com-

parative insolubility (36) of the acid, and by the fact that it is precipitated when any weak acid is added to the urine. Dr. Bird believes that it separates the ammonia from the double phosphate of soda and ammonia, a natural constituent of the healthy secretion, and by this means sets free phosphoric acid, which thus produces the natural acid, re-action of urine, and which requires for saturation about 15 grains of carbonate of soda.

42. From the investigations of M. M. Lecanu and Lehmann however, we learn that the quantity, like that of urea, varies considerably according to the age, sex, diet, and exercise of the individual; but that in the same person, in a given time, but little variation is found to take place. Thus, M. Lecanu states the average in twenty-four hours to be

while M. Lehmann ascertained that his urine in the same time contained 18.25 grains after a mixed diet of animal and vegetable food; 22.70 when he restricted himself entirely to an animal diet; 15.76, after eating nothing but vegetables, and 11.26 when he confined himself to food perfectly free from nitrogen. Moreover, it has been found to be increased by alcoholic drinks (Bouchardat), and diminished by much bodily exertion, (Lehmann).

43. It is augmented when the cutaneous exhalation is impeded, and is also increased both absolutely and relatively in all cases of fever; in rheumatism and gout, and in diseases of the heart, lungs, and liver, being, according to professor Andral, in cirrhosis, together with dropsy, an almost positive sign of the hepatic affection;\* but is diminished in chlorosis, ancemia, and other diseases, accompanied by great debility. This is decidedly opposed to the statement of Liebig that the uric acid disappears in proportion to the accelerated state of the circulation, and the amount of oxygen taken into the system.

44. "Excluding all abstract theories," says Dr. Bird,† "whenever an excess of uric acid or its combination with bases occurs in the urine, a normal quantity of water being present (30 to 40 ounces in twenty-four hours), it may safely be inferred that one or other of the following states exist.

A. Waste of tissue more rapid than the supply of nitrogenized nourishment, as in .....

Fever, acute inflammation, rheumatic inflammation, phthisis.

B. Supply of nitrogen in the food greater than is required for the reparation and supply of tissue, as in Excessive indulgence in animal food, or the quantity of food remaining the same, with too little bodily exercise.

C. Supply of the nitrogenized food not being in excess, but the digestive functions unable to assimilate it.

All the grades of dyspepsia.

<sup>\*</sup> Med. Times, vol. 16. p. 156

<sup>†</sup> Urinary deposits, p. 110.

D. The cutaneous outlet for nitrogenized excreta being obstructed, the kidneys are called upon to compensate for the deficient function...

All or most stages of diseases attended with arrest of perspiration.

- E. Congestion of the kidneys produced by local causes he loins, diseases of the genital apparatus."
- 45. When it exists in excess in the urine, it either becomes deposited as the fluid cools, or on the addition of an acid (63.). The urine is also of a deeper colour than natural, contains in many cases a greater amount of urea, is somewhat increased in specific gravity, and has always an acid reaction on litmus. The urine of suckling infants, however, which not unfrequently contains an abundance of this element, has not these qualities; but is very pale, of exceedingly low weight, and, as we have seen, contains no urea.
- 46. Lithic acid is met with in the urine either combined with ammonia in the form of an amorphous sediment of a whitish, yellow, pink, purple or red colour, according as it is mixed with the yellow colouring matter of the urine, with purpurine, or with both; or as a crystallized deposit constituting the red and yellow gravel, and also the variously coloured amorphous and pisiform concretions that have descended from the kidneys.
- 47. Urine containing an excess of lithate of ammonia presents the following varieties. Thus it is

either (a) of a very pale colour reduced in density, and turbid in consequence of a whitish lithate being dispersed through it; or, (b) of a light amber hue, somewhat lower in density than natural, and depositing a yellowish or pale drab coloured sediment; or, (c) it is very high coloured, increased in specific gravity and with a reddish brown or brick-dust deposit; or, (d) lastly it may have a peculiar copper coloured, purple or crimson tint, owing to the presence of purpurine (6); the deposits in these cases having always the same hue.

- 48. In gouty and rheumatic subjects lithic acid is frequently found united with soda, and the urate of soda thus formed is sometimes produced in such abundance that it not only renders the urine perfectly white, but also cannot be entirely got rid of from the system by the urinary secretion. It is therefore retained in it and eventually becomes deposited in and round the joints giving rise to those peculiar and characteristic, and often painful swellings called chalk stones.
- 49. The natural acidity of healthy urine has lately been accounted for by Liebig and Bird by the uric and hippuric acids acting on the alcaline phosphates, and either setting free a portion of their acid or converting them into acid salts. (46)
- 50. Hippuric acid, so called from being present in large quantities in the urine of the horse, was formerly supposed to be peculiar to the urine of

herbivorous animals. Lehmann, Wittstock, Ambrosiani, Muller, and Simon however, have ascertained its presence in that of diabetic patients; and Scheele, Proust, Fourcroy and Renard, in that of young infants; and Professor Liebig has lately proved it to constitute a natural ingredient of the healthy human excretion, in which he says it exists in nearly the same proportion as uric acid in combination with soda. Its composition is, according to Liebig, Dumas, Mitscherlich, and Bird, as follows:

Liebig.\* Dumas.+ Mitscherlich.+ Bird.5 Carbon.... 60.742 -60.5 - 60.63 4.959 Hydrogen... 4.9 4.98 4.64 Nitrogen... 7.816 7.7 7.90 8.21 26.483 -26.9 -26.4923.22Oxygen....

And its formula C<sub>18</sub>, N<sub>1</sub>, H<sub>8</sub>, O<sub>5</sub>, + H. O. Liebig states it, as well as the uric acid, to exist in the urine in solution with the phosphates of soda and potash; and he ascribes the fact, that these salts no longer possess in the urine, the alkaline reaction, peculiar to them when contained in the blood, to the presence of these two acids, and partly to the formation of a small portion of sulphuric acid as the result of the combustion of the sulphuric compounds contained in the system.

Ann. der Pharm., vol. xii. p. 20.

<sup>+</sup> Ann. de Chimie et de Physique, vol. lvii., p. 327.

<sup>‡</sup> Poggend. Ann., vol. xxxiii. p. 335.

<sup>§</sup> Urinary Deposits, p. 51.

- 51. Hippuric acid crystallizes in long semitransparent four-sided prisms, with dihedral summits, and has a somewhat bitter taste and a powerful acid reaction on litmus. It is soluble in about 400 parts of cold water, more soluble in boiling water, and still more abundantly in alcohol, by which therefore it can be readily separated from uric acid, which, as I have said, is insoluble in this menstrum; but is comparatively insoluble in ether. It becomes transformed into benzoic acid during the decomposition of the urine. It is also converted by nitric acid into the benzoic, and by sulphuric acid, with the addition of heat into the benzoic and carbonic acids and ammonia. Hydro-chloric acid dissolves it but does not decompose it. The addition of perchloride of iron to its aqueous solution produces a yellow colour. It is fused by a strong heat, and eventually becomes converted into a reddish coloured oil having an odour like that of Tonquin beans, ammonia, benzoic acid, and a black carbonaceous mass, and eventually into hydrocyanic acid with the evolution of its peculiar odour.
- 52. Dr. Bird believes that the quantity represented by Liebig, as normally present in the urine, is not constant, but always much less than he has stated. He is of opinion, however, that hippuric acid, considering the abundance of carbon it contains, may possibly be one of the means by which this element may be eliminated, in large quantities, from the

system by the kidneys, and that these organs may in those cases, where the lungs and liver, the proper emunctories of the carbon, do not effectually perform their functions, in some measure compensate for the deficiency, by excreting a larger quantity of hippuric acid. This is a subject well worthy of investigation. Mr. Stuart Cooper, in a memoir which gained the Corvizart prize for 1845, states the quantity to be in an inverse ratio with that of urea.

53. I know of only three well authenticated cases in which there was an excess of this acid in the urine. The first is described by M. Bouchardat under the title of hippuria,\* a disease characterized by excessive thirst, a harsh dry skin and an abundant secretion of watery urine, having an odour of whey, which contained only fourteen parts per 1000 of solid matters, 2.23 of which were hippuric acid, and no uric acid. The second is recorded by Dr. Garrod who obtained from about six ounces of urine as much as half a drachm of the acid, and this for several days together. A remarkable feature in this case is that this excess was met with during the administration of small doses of muriate of morphia for a superabundance of urea, and a deposition of the triple phosphate of ammonia and magnesia, which had been previously met with in the urinary

secretion of the patient. The uric acid in this case was not in the least diminished in quantity. The third occurred in a young female aged thirteen affected with chorea, who had lived for some time on nothing but bread and water and apples. M. Pettenkofer examined her urine which was of a limpid yellow colour, and states that it contained as much as 1.2286 per cent of hippuric acid.\*

.54. According to Liebig hippuric acid is derived from the non-nitrogenized elements of food; and we learn from the experiments of Wöhler, Ure, and Keller, that benzoic acid when administered internally becomes converted into the hippuric with the disappearance of the urea, and, according to Dr. Ure, of the uric acid, also. Dr. Garrod has, however, proved this to be a mistake, and in this statement he is confirmed by the researches of Dr. James Booth and M. H. Boyè of Philadelphia, from which it results; First, That the uric acid suffers no alteration, either in quantity, or in its external properties, by the exhibition of benzoic acid and its subsequent metamorphosis into the hippuric. Secondly, That this metamorphosis is apparent in the urine in from twenty to forty minutes after the benzoic acid has been taken, and continues to be so for eight hours; Thirdly, That the quantity of hippuric acid obtained from the urine exceeds

<sup>\*</sup> See Liebig and Wöhler's Annalen, vol. 50.

by about one third, that of the benzoic acid taken; Fourthly, That the hippuricacid is not combined with the urea in the urine, but that, Fifthly, it is united with and kept in solution by ammonia,\* and not soda as has been stated by Liebig. Dr. Bird explains the conversion of the benzoic into the hippuric acid by supposing four atoms of the former and one of urea to act on 48 of oxygen and become converted into two atoms of the latter, 44 of carbonic acid, and 8 of water. Drs. Liebig and Garrod give a different explanation; they account for the transformation by supposing two atoms of benzoic acid to act on the elements of one atom of lactate of urea and produce two atoms of the acid in question.

55. The presence of Lactic acid and its compounds in the urine has been disproved by Liebig, who on repeating the experiments of Berzelius, discovered a particular crystallizable substance, that had not been previously described, and which he believes to have been mistaken for them. This new matter appears to be very rich in carbon and nitrogen, and therefore it is the more to be wondered at that it should have been confounded with lactic acid, a compound entirely free from the latter element.

56. The normal proportion of this acid in 1000 parts of healthy urine cannot, I think, be considered

Med. Gaz. for Nov. 21, 1845, p. 1286.

as decided even supposing it to exist there. Becquerel believes it to constitute the greater portion of what he terms the inseparable organic matters, which according to him, vary between 7 and 10 parts in 1000, and to exist partly in a free state and partly in combination with ammonia, soda, and urea. M. Lehmann states the average amount of free lactic acid to be 1.525, and that of combined lactic acid 1.160, making a total of 2.685 parts in the quantity stated. The mean daily quantity of free lactic acid discharged, according to the same observer was:

After a mixed Diet		grains.
" an Animal Diet	33.45	,,
" a Vegetable Diet	18.35	,,
While that of combined lactic ac	eid was	:
After a mixed Diet	18.12 21.16	grains.
57. The composition of this acid	l is:	
Carbon	4	4 90
Hydrogen		6.11
Oxygen		8.99

And its formula C<sub>6</sub>, H<sub>5</sub>, O<sub>5</sub>. It is therefore greatly allied to

 $C_{12}$ ,  $H_{10}$ ,  $O_{10}$ , = Starch.  $C_{12}$ ,  $H_{11}$ ,  $O_{11}$ , = Gum.  $C_{24}$ ,  $H_{24}$ ,  $O_{24}$ , = Sugar of Milk.  $C_{12}$ ,  $H_{14}$ ,  $O_{14}$ , = Grape Sugar.

 $C_{12}$ ,  $H_{11}$ ,  $O_{11}$ , = Cane Sugar.

Liebig's Animal Chemistry, p. 309.

58. Peculiar azotised principle. This is a neutral substance lately discovered in the urine by Pettenkofer. It has a sharp bitter saline taste, and is easily dissolved both by water and alcohol. From its watery solution it is thrown down by chloride of zinc. When heated on platinum foil it first melts and subsequently enters into slow combustion, at the same time giving off an odour of urine and ammonia. It is said to contain 54.02 per cent of nitrogen, and to exist in the urine in the proportion of five grains to 1000. Its formula is Cs, N3, H8 O3, which, according to Dr. Bird, "differs only in the proportions of the elements of water from that of uramil, a product of the decomposition of uric acid, and which may be regarded as uric acid in which the elements of urea are replaced by those of ammonia and water." Thus, on comparing the two formulæ together, we shall find that of uramil which is Cs, N3, H5, O6, contains three equivalents less of hydrogen and three equivalents more of oxygen than does the new principle of Pettenkofer. Dr. Bird moreover, suggests, that it is "a transition formation between uric acid and urea," and there seems some probability of such being the case, from the fact that when uric acid is acted on by oxygen, it is, as I have already stated (39), converted into alloxan and urea, to the former of which Pettenkofer's formula may be considered to somewhat approach.

The following is Dr. Bird's explanation of his views:

Its composition may be represented as follows:

Carbon										39.37
Nitrogen										33.63
Hydrogen										6.79
Oxygen										20.21

59. Extractive Matters.—These are certain organic nitrogenous principles, combined, in the opinion of Dr. Aldridge, with some substance resembling sugar or dextrine, which remain in combination with the saline constituents of the urine after the urea and lithic acid have been removed. They consist principally of the colouring matter already described (6), and which is considered by Scherer to be analogous to both that of the bile and blood; are entirely dissolved by water, less so by rectified spirit, and still less by alcohol; hence their division by the last named writer, into the water extract,

the spirit extract, and the alcohol extract. They are composed of carbon, hydrogen, oxygen, nitrogen, and sulphur. Their watery solution very speedily undergoes the putrefactive fermentation, a very fœtid disagreeable odour being then evolved, and a large quantity of acetic acid generated. During this process the presence of sulphur is manifested by the glass vessel in which it is allowed to take place, becoming blackened. On burning the extract in a test tube over a spirit lamp fumes of ammonia are disengaged, and may be detected in the usual way, namely, by holding a glass rod dipped in strong hydrochloric acid, or the wetted stopper of the bottle containing it, over the mouth of the tube, a black carbonaceous mass being left behind. The spirit extract also generates acetic acid in considerable quantity during its putrefaction, and on being heated gives off, according to Dr. Aldridge,\* a pyroligneous oil, water, carbonate of ammonia, and leaves a porous charcoal. The alcohol extract, on the other hand, that is, that portion of the extractive matters, which in the words of Dr. Aldridge is "precipitable in white flocks from a concentrated watery solution by the addition of anhydrous alcohol," does not produce any acetic acid by putrefaction. Thus then we are now able to explain the cause of the decomposition which always takes place in the urine by keeping, and

<sup>\*</sup> Lectures on the Urine, p. 11.

the origin of the acetic acid which is frequently found in it. Proust it is true some years ago proved its existence in the secretion by distilling the latter with sulphuric acid;\* and Liebig has more lately ascribed its presence to the putrefaction of the colouring matters of the urine, which, he says, become converted by this process into the acid in question and a brown resinuous highly azotised substance.† But, thanks to the labours of Scherer, we now know what particular portions of the urinary extractive it is that becomes transformed by decomposition into the acetic acid.

60. In Table 2, I have represented the quantity of extractive and colouring matter with muriate of ammonia passed in the twenty-four hours to be 140.929 grains. The amount was found by Lehmann to be considerably influenced by diet, the greatest proportion being excreted after vegetable food. The following are the results of his investigations:

The quantity is also considerably diminished by exercise, the mean daily amount during a pedestrian tour, being 130.528 grains according to the last named author.

<sup>\*</sup> Annales de Physique et de chimie, vol. 14, p, 260.

<sup>†</sup> Lancet, June, 1, 1844.

61. The quantity of Fixed saline matters in healthy urine is stated by Becquerel to average about 140 grains in the 24 hours. This is hardly enough for this country at least; that given in the table I have constructed from Dr. Christison's formula will probably be found more correct. Lecanu found the quantity to fluctuate between 75 and 378 grains, the following are the results of his analysis:

	Max.	Mean.	Min,
In Men	378	265	153 grains.
Women	302	234	166 ,,
Children of about 8 years	168	160	152 ,,
Old men	151	122	94 ,,

Becquerel gives 7.695 grains as the mean amount he obtained from 1000 parts of urine from four healthy men, and 6.143 grains from the same quantity from four healthy women; while the mean result of six analyses of the morning urine of a healthy man made by Dr. Day was 9.27 in 1000 parts.

62. These saline matters are derived partly from the food and partly from the metamorphoses constantly taking place in the tissues. Thus the alkalies, potash and soda, are furnished by the blood and the albuminous tissues, and the earths lime and magnesia by the fibrinous and muscular structures. The hydro-chloric acid appears to be derived principally from the common salt we eat, and the

sulphuric and phosphoric acids in great part from the oxidation of the sulphur and phosphorus contained in the albuminous and fibrinous tissues; the former in the proportions of 0.68 and 0.36, and the latter of 0.33 and 0.33 respectively. The presence of sulphuric acid in the urine may likewise be partly ascribed to the oxidation of the sulphur recently discovered by Professor Redtenbacher in taurine, a substance obtained by the decomposition of the choleic acid of the bile, in the proportion of nearly twenty-six per cent, -25.70. It exists in the urine in combination with potash and soda, in the proportion, according to Professor Dumas,\* of from 30.7 to 57.6; while the phosphoric acid is found united with both the earths and the alkalies; the earthy phosphates varying from one fourth to one eighteenth and the alkaline phosphates from three-fourths to seventeen eighteenths. (Dr. Bence Jones).

It is evident, therefore, that these salts must be subject to considerable variation in quantity both in health, in consequence of the difference in the composition of the various articles of food we take, and also in disease. In the latter they are generally absolutely diminished and to this Becquerel appears to have met with but one well marked exception. It was in the case of a girl convalescent from chlorosis accompanied by pulmonary emphysema, in which it was 32.759 grains above his highest normal standard.

Med. Times, voi. xvi p. 71.

In this instance, however, it had increased conjointly with the water which amounted to upwards of 32 ounces. A relative increase, however, is by no means uncommon, especially in febrile and inflammatory infections. Independant of the alteration in the quantity of these saline matters taken together, variations in their relative proportions to each other also frequently occur. The greatest differences have been observed in the earthy phosphates; Lecanu indeed found them to oscilate between 0.56 and 30.2 grains. Some very interesting researches have lately been made by Dr. Bence Jones relative to this subject. Thus it appears from the results of his investigations, that the urine passed soon after eating a meal, no matter whether it consists of animal food or only of bread, contains a much larger quantity of the earthy phosphates than that voided at other times; whereas the proportion contained in that excreted after long fasting, is greatly diminished. The alkaline phosphates on the contrary, become very remarkably decreased in quantity after a purely meat diet, and augmented in the greatest degree when bread alone is taken. Exercise, on the other hand, he found not to affect the earthy phosphates, but to occasion an increase of the alkaline phosphates to the extent of nearly one third. A considerable augmentation in the amount of the earthy phosphates is also occasioned by the exhibition of the chloride of calcium and the carbonate and sulphate of magnesia. The same author also ascertained a remarkable difference in the quantity of phosphates excreted with the urine during certain diseases of the brain. For instance, in inflammation of the brain he found the quantity to be much greater than in delirium tremens; the average in three cases of the former being 8.26 per 1000 urine sp. gr. 1.025,3, and in three cases of the latter only 0,67 per 1000, sp. gr. 1.020.4. Great mental exertion tends likewise very materialy to increase the amount of phosphates. The average amounts of the earthy phosphates obtained by Lehmann in the 24 hours were as follows:

After an animal diet............ 34.990 grains., a mixed diet............ 17.444 ,,

The quantity of chloride of sodium also varies remarkably in adult men and women. Thus, while in the former it may be stated to average between 30 and 70 grains, in the latter, and likewise in old men, it scarcely ever reaches above 10 or 11 grains, and has been found even as low as 0.26 grains. From the urine of dying persons, it is according to Proust, almost entirely absent. Lecanu found it to fluctuate between 0,26 and 116 grains in 24 hours in different individuals.

63. According to Berzelius sulphur exists in the urine not only as sulphuric acid, but also in some particular state of combination not yet defined; and Mr. John T. Barry has, by repeating and modi-

fying the experiments of the Swedish chemist, detected a very tolerable proportion of it. Dr. Bird also states, on the authority of Dr. Edmund Ronalds, that from three to five grains of sulphur in a compound form are excreted with all urine in the course of twenty-four hours. According to Dr. Ronalds the sulphuric acid bore to the non-oxydised sulphur, in five different specimens of healthy urine the following proportions:

1.06:0.17 - 1.46:0.18 - 1.42:0.18 - 2.44:0.1531.32:0.165

64. The quantity of Mucus contained in healthy urine is generally very small, and from its transparency, invisible. In some cases, however, as the excretion cools it becomes slightly opaque and forms a distinct cloud near the base of the containing vessel, constituting what is termed an eneorema. In females during the menstrual period it is more abundant, and from being somewhat altered in its properties, by having lost its natural transparency, can always be distinctly observed. Lecanu found it to vary in six different individuals (male) from 4.6 to 26.5 grains, and from 3.3 to 5.68 grains in various women and old men. In certain diseases it becomes considerably increased in quantity as will be more particularly alluded to hereafter. (118) When examined under the microscope it has a nucleolo granular appearance and is found to contain several exfoliated epithelial scales.

65. Butyric acid is a compound which Berzelius

states may be procured in small quantities from urine when it is distilled with sulphuric acid. Dr. Prout, however, appears from the following passage at page 568 of his celebrated work "neither if we except the lactic acid does any form of the saccharine principle exist in healthy urine" to doubt its existence in the normal secretion, and is of opinion that it is only present during some particular derangement in the assimulation of the saccharine matters. It may therefore, I think, be considered as intermediary between the preceding healthy constitutents of the urine and the abnormal ingredients frequently present in it during certain morbid states of the system; and which now remain to be described. M. Lehmann found it to exist in rather large quantities during the first week after labour, in the urine of a female who did not suckle her child.

66. The Abnormal ingredients may be divided into two classes. The first contains those matters resulting from the various alterations or decompositions which take place in the renal secretion; and the second those of an organic and inorganic nature which have either been secreted with the urine, or which have entered it in consequence of some pathological change having taken place in some part of the urinary passages. They may be conveniently arranged in the following

CLASS 1.  CLASS 1.  CLASS 2.  CLASS 3.  CLASS 3.  CLASS 3.  CLASS 3.  CLASS 3.  CLASS 3.  CLASS 4.  CLASS	a. Persyanise of long 2 producing symmetr of among, and the presence of long in the unite.  a. Melanomies, cases Unknown.  * No Its Res's work, p. 150.
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## CHAPTER III.

- 67. Having spoken, in the foregoing pages, of the composition of healthy urine and of the various modifications it is liable to undergo both in health and disease, it now remains for me to describe the mode of obtaining this information, or in other words, the process by which the nature of the different natural and unnatural urinary constituents can be ascertained. This will form the subject of the present chapter.
- 68. From what has been already said, it is evident that in examining the urine, it is always necessary to previously discover when it was passed, and then to commence by noticing its physical properties and its acid or alkaline reaction; for by this means we become possessed of certain facts by which we are better enabled to regulate our subsequent analytic researches.
- 69. We should begin then by making ourselves acquainted with the colour, odour, transparency, and consistence of the urine, and then with its

density, quantity, and chemical reaction on test paper. By its colour (4) we judge, First, of its degree of concentration or dilution and consequently of the amount of solid ingredients; Secondly, of the presence of certain foreign matters, and Thirdly, of certain morbid states of the system. By its odour, (3), we not only ascertain whether decomposition has taken place or whether some foreign odoriferous principles are present, but we are also enabled to suspect the existence of certain diseases. By a deviation from its natural transparency (9), we discover either that some of its natural constistuents are in excess; that it contains some abnormal element, or that some change has taken place in it by decomposition. By an increase in its consistence, (10) we detect the presence of mucus, pus, albumen, sugar, and even in some cases of oxalate of lime. By its density (11) and quantity, (7) we are not only enabled to ascertain the amount of solid matters present in a given specimen, and the quantity excreted in a certain time, but are also led to infer either that certain elements are diminished or in excess, or that some abnormal ingredient is present, or even the existence of some particular malady. Thus (by way of illustration), two distinct classes of cases may present themselves. In the first the urine is low in density, and either normal, diminished, or increased in quantity. If it be normal or diminished we have positive proof that the amount of its con-

stituents is reduced; the extent of the reduction being exactly in proportion to the decrease in the quantity and specific gravity; while, if it be increased, no such reduction may have taken place, but on the contrary, the actual quantity of solid matter excreted may be perfectly normal, in fact, augmented. In the second class, the urine is of high specific gravity, and its quantity either natural decreased or augmented. If it be natural it is a certain sign that a greater amount of solid matter is held in solution. If it be decreased, which is most commonly the case, it shows that the quantity of solids has either remained unaltered, or that it has not diminished in the same proportion as their solvent. If it be augmented, it is a certain criterion that a much larger amount of solid is excreted than natural, and affords us a valuable means for ascertaining the cause of the emaciation that occurs in some cases. Lastly, by its acid neutral, or alkaline reaction, (2, 41, 29.), our former suspicions respecting the cause of the change in its colour, odour, transparency, and consistence, become in a great measure confirmed. For instance, suppose we find the urine thick or turbid, strong smelling, and high coloured, with a reddish or pinkish coloured deposit and acid, we know immediately that there is an excess of the lithates in combination with purpurine, (6, 46, 47;) while if it be pale, opaque, covered with a pellicle presenting numerous

colours like the surface of a soap bubble, and alkaline, or perhaps, somewhat acid, we then strongly suspect an excess of the phosphates, more especially if the urine is alkaline, has a feetid ammoniacal odour, or contains a large quantity of mucus, (29), which, as I have before said, is liable to act as a ferment, and by thus effecting the decomposition of the urea causes a deposit of the earthy phosphates.

The valuable information that is thus derived from the examination of the physical properties and chemical reaction of the urine is obtained in a very short time and with little trouble.

- 70. To ascertain the chemical reaction of the urine, blue and red litmus paper should be employed. The former will be changed to red if the urine be acid and the latter to blue if it be alkaline, but if it be neutral neither will be acted on. These test papers are now conveniently arranged in small books by Griffin of Glasgow.
- 71. The density may be obtained in two ways, either with the specific gravity bottle,\* which is the most correct; or with, what is more commonly used, the urinometer, an instrument consisting of a stem graduated from 0 to 60 degrees and two bulbs, the lower one being, partially or quite filled with mercury in order to increase the weight of the instrument. It may be purchased at any Philosophical

<sup>\*</sup> The specific gravity bottle holds exactly 1000 grains of distilled water, therefore the density of any other fluid will be represented by the increase above 1000.

Instrument Makers, conveniently arranged in a case, containing a cylindrical glass vessel in which the urine to be examined is intended to be placed, a test tube, a bottle for nitric acid, a watch glass, and test paper.

In using it, all that is required to be done is to place it in the urine contained in the glass vessel just alluded to, and then to carefully note the figure corresponding to the surface of the fluid which will be the density of the latter; or, as Dr. Bird recommends, the degree *immediately below it* in order "to compensate for the errors arising from capillary adhesion of the urine to the glass."

72. In estimating, however, the specific gravity,

and free from impurities; therefore, when turbid, either from the presence of foreign bodies, or from the precipitation of some of its natural constituents, these must be previously removed by filtration; and it behoves us also at all times, as I have before said, to pay strict attention, both to the temperature, (which should be about 60 degs. Farnh.) and the quantity of the excretion in twenty-four hours; (7.14) and when it is desirable to come to some correct conclusion with respect to the nature of the urine in that time, we must always endeavour to collect, if possible, the whole that is passed, and then to submit a portion of the mixture to examination; for it is evident that the results that are otherwise

obtained can have reference only to the particular specimen examined. Another source of fallacy also requires to be avoided, viz., the sinking of the instrument too rapidly in the fluid, for if any of this collect on the stem above the degree corresponding to its density, it will cause the instrument to descend so much lower, and consequently indicate a less specific gravity than the fluid in reality possesses.

73. Various tables have been constructed by different authors, by which it is proposed to calculate the amount of solid matter contained in a given quantity of urine, from the specific gravity of the secretion. These tables are all based on the now well-known fact that the proportion of the solid contents of one thousand parts of urine is equal to the excess of its density over that of water multiplied by a given number; this number being, according to Dr. Henry, 2.58; according to M. Becquerel, 1.65, and according to Dr. Christison, 2.33. Now it must be evident to every one, from the great difference existing between these three amounts that fallacy must exist somewhere. Dr. Day has, however, proved, by numerous experiments, that the formula of Dr. Christison, viz.  $\Delta \times 2.33$ , in which  $\triangle$  represents the difference betwen 1000 grains and the density, is far more accurate than either of the others.

I have therefore from it, formed the following tables which, as they prove each other, may be relied on for their accuracy.

TABLE III.

Showing the amount of water and the proportion of solids in a fluid ounce at different densities.

	Specific Gravity	Amount of water in one fluid oz. in grains.	Weight of solids in 1 fluid oz. in grains.	Specific Gravity.	Amount of water in one fluid oz. in grains.	Weight of solids in 1 fluid oz. in grains.
	1000	437.50		1029	407.92	29.58
ì	1001	436.48	1.02	1030	406.90	30.60
1	1002	435.46	2.04	1031	405.88	31.62
1	1003	434.44	3.06	1032	404.86	32.64
	1004	433.42	4.08	1033	403.84	33.66
1	1005	432.40	5.10	1034	402.82	34.68
	1006	431.38	6.12	1035	401.80	35.70
	1007	430.36	7.14	1036	400.78	36.72
1	1008	429.34	8 16	1037	399.76	37.74
1	1009	428.32	9.18	1038	398.74	38.76
1	1010	427.30	10.20	1039	397.72	39.78
	1011	426.28	11.22	1040	396.70	40.80
	1012	425.26	12.24	1041	395.68	41.82
1	1013	424.24	13.26	1042	394.66	42.84
1	1014	423.22	14.28	1043	393.64	43.86
1	1015	422.20	15.30	1044	392.62	44.88
1	1016	421.18	16.32	1045	391.60	45.90
1	1017	420.16	17.34	1046	390.58	46.92
1	1018	419.14	18.36	1047	389.56	47.94
١	1019	418.12	19.38	1048	388.54	48.96
1	1020	417.10	20.40	1049	387.52	49.98
1	1021	416.08	21.42	1050	386.50	51.00
1	1022	415 06	22.44	1051	385.48	52.02
	1023	414.04	23.46	1052	384.46	53.04
	1024	413.02	24.48	1053	383.44	54.06
	1025	412.00	25.50	1054	382-42	55.08
	1026	410.98	26 52	1055	381.40	56.10
	1027	409.96	27.54	1056	380.38	57.12
1	1028	408.94	28.56	1057	379.36	58.14
-	1					-

## TABLE IV.

Showing the amount of water and the quantity of solid matter contained in one pint of wrine at different densities.

Specific Gravity.	Amount of water in one pint.	Weight of solids in one pint in grains.	Specific Gravity.	Amount of water in one pint.	Weight of solids in one pint in grains.
1000	8750.000		1029	8158.400	591.600
1001	8729.600	20.400	1030	8138.000	612.000
1002	8709.200	40.800	1031	8117.600	632.400
1003	8688.800	61.200	1032	8097.200	652.800
1004	8668.400	81.600	1033	8076.800	673.200
1005	8648.000	102.000	1034	8056.400	693.600
1006	8627.600	122.400	1035	8036.000	714.000
1007	8607.200	142.800	1036	8015.600	734.400
1008	8586.800	163,200	1037	7995.200	754.800
1009	8566.400	183.600	1038	7974.800	775.200
1010	8546.000	204.000	1039	7954.400	795.600
1011	8525.600	224.400	1040	7934.000	816.000
1012	8505.200	244.800	1041	7913.600	836.400
1013	8484.800	265.200	1042	7893.200	856.800
1014	8464.400	285.600	1043	7872.800	877.200
1015	8444.000	306.000	1044	7852.400	897.600
1016	8423.600	326.400	1045	7832.000	918.000
1017	8403.200	346.800	1046	7811.600	938.400
1018	8382.800	367.200	1047	7791.200	958.800
1719	8362.400	387.600	1048	7770.800	979.200
1020	8342.000	408.000	1049	7750.400	999.600
1021	8321.600	428.400	1050	7730.000	1020.000
1022	8301.200	448.800	1051	7709.600	1040.400
1023	8280.800	469.200	1052	7689.200	1060.800
1024	8260.400	489,600	1053	7668.800	1081.200
1025	8240.000	510.000	1054	7648.400	1101.600
1026	8219.600	530.400	1055	7628.000	1122.000
1027	8199.200	550.800	1056	7607.600	1142 400
1028	8178.800	571.200	1057	7587.200	1162.800

TABLE V.

Showing the proportion of fluid and solid in 1000 grains of the secretion at various specific gravities.

1					
Specific Gravity.	Amount of water in 1000 grains.	Amount of Solids in 1000 grains.	Specific Gravity.	Amount of water in 1000 grains.	Amount of solids in 1000 grains.
1001	997.67	2.33	1029	932.43	67.57
1002	995.34	4.66	1030	930.10	69.90
1003	993.01	6.99	1031	927.77	72.23
1004	990.68	9.32	1032	925.44	74.56
1005	988.35	11.65	1033	923.11	76.89
1006	986.02	13.98	1034	920.78	99.22
1007	983.69	16.31	1035	918.45	81.51
1008	981.36	18.64	1036	916.12	83.88
1009	979.03	20.97	1037	913.79	86.21
1010	976.70	23.30	1038	911.46	88.54
1011	974.37	25.63	1039	909.13	90.87
1012	972.02	27.96	1040	906.80	93.20
1013	969.71	30.29	1041	904.47	95.53
1014	967.38	32.62	1042	902.14	97.86
1015	965.05	34.95	1043	899.81	100.19
1016	962.72	37.28	1044	897.48	102.52
1017	960.39	39.61	1045	895.15	104.85
1018	958.06	41.94	1046	892.82	107.18
1019	955.73	44.27	1047	890.49	109.51
1020	953.40	46.60	1048	888.16	111.84
1021	951.07	48.93	1049	885.83	114.17
1022	948.74	51.26	1050	883.50	116.50
1023	946.41	53.59	1051	881.17	118.83
1024	944.18	55.92	1052	878.84	121.16
1525	941.75	58.25	1053	876.51	123.49
1026	939.42	60.58	1054	874.18	125.82
1027	937.09	62.91	1055	871.85	128.15
1028	934.76	65.24	1056	869.52	130.48
			1		

74. Having obtained then the specific gravity in the manner above recommended, we refer at once to Tables 3 or 4 for instance, and we there find corresponding to it, the amount of solids contained either in an ounce or a pint of the urine, and then by a simple multiplication we can readily discover the actual quantity excreted in the twentyfour hours. To illustrate this, let us suppose the urine to be healthy, that is of specific gravity 1020 and about 35 fluid ounces in quantity. By looking at the tables we find at this density, one fluid ounce contains 20.40 grains, and a pint 408 grains of solids. If then we multiply 20.40 by 35, or add to 408, the result that will be obtained by multiplying 20.40 by 15, the surplus above a pint, the quotient will be the amount sought for, thus: -

$$20.40 \times 35 = 714$$
 grains in 35 fl. ounces.  $20.40 \times 15 + 408 = 714$ 

Dr. Bird has constructed a Table \* by which he proposes to calculate to amount of solids contained in a pint of urine by multiplying the weight of the latter by the quantity of solid matter found by Table V., to exist in 1000 grains, and these dividing by 1000. But the results obtained from it do not coincide with those given in the preceding Tables.

75. In consequence, however, of the various densities of the different elements of the urine, of the various relative proportions in which they exist in it, and also of the foreign matters with which it is frequently contaminated, Tables thus constructed can never do more than give an approximation to the truth. Still they are sufficient for practical purposes. When, therefore, greater accuracy is required, another mode of proceeding must be adopted, which consists in the evaporation of the urine. For this purpose Simon recommends us first to ascertain its specific gravity at the temperature of 60 Farhn., and then to evaporate about 25 grains of it over a steam bath to the consistence of a thin extract in a prieviously weighed light porcelain dish or capsule, the edges of which must be perfectly even, so that when covered by a piece of glass (the weight of which should be known) all air may be excluded. The dish with the residue thus obtained, is then to be placed in the vacuum of an air pump over strong sulphuric acid, and allowed to remain for a period of from thirty-six to fortyeight hours, when it is to be removed, care being taken to cover it directly with the piece of glass above mentioned, in order to prevent the dry mass which remains from absorbing moisture from the surrounding atmosphere. The capsule is now to be weighed, and the increase above its known weight and that of the glass will represent the amount of

solid in the quantity of urine examined. We have then only to multiply this by  $17\frac{1}{2}$  to ascertain how much is contained in an ounce, and the product obtained multiplied by the number of ounces voided in the twenty-four hours will give the actual quantity, excreted in that time.

76. Having now made ourselves acquainted with the density, and formed, with the assistance of the Table, a tolerably correct idea of the amount of solid matters contained in the urine, our next step is to ascertain the quality of the secretion. can generally be sufficiently effected for practical purposes, by means of heat and nitric acid. Heat will throw down any albumen that may be present, provided the urine is not alkaline, and likewise the phosphates when in excess. The latter are distinguished from the former by being re-dissolved by a few drops of nitric acid. Heat, when raised to the boiling point, will even precipitate the phosphates when not increased in quantity, as has been observed by Dr. Rees, and more recently by Dr. Schaffner who explains the circumstance by the fact that at this temperature they, that is the earthy phosphates, become decomposed into subphosphates which are deposited. It will also dissolve a deposit of the lithates, but not of lithic acid or of the phosphates. It also alters the unnatural colour given to the urine by blood and disturbs the transparency of the secretion by coagulating the albuminous matter. Nitric acid will precipitate the lithic acid if it exist in excess, and detect a superabundance of urea. (78) It will throw down albumen, dissolve the phosphatic deposits, and also the lithates with the deposition of the lithic acid in a crystallized state, and detect the presence of bile by producing a rapid and interesting display of colours in a thin layer of the urine containing it, but will not affect the purulent or mucous sediments. It sometimes happens, however, that the urine not only contains albumen, but is at the same time turbid from the deposit of phosphates; and, as in this case, the disappearance of the latter, when nitric acid is added, is frequently marked by the coagulation of the former by the same re-agent, it follows that an error in diagnosis would in consequence very frequently result, especially if, from the alkaline condition of the urine heat had no power in solidifying the albumen, were we not aware of the possibility of such an occurrence, and likewise of the best means of detecting it. When, therefore, urine of this description is presented to us, a little acetic acid should first be added; this will restore the transparency by dissolving the phosphates, and we can then have recourse to the usual tests for albumen, namely heat and nitric acid.

Again, albuminous urine may be turbid from a deposit of lithates, and the disappearance of these not perceptible owing to the coagulation of the albumen. Under such circumstances the best plan

to be adopted is to place some of the urine in a conical glass vessel for the sediment to subside; we can then pour from it the supernatant fluid and apply the several tests to each.

To discover the proportion of the various natural constituents of the secretion, and the nature of any abnormal ingredients that may be contained in it recourse must be had to a more elaborate process.

77. We have seen that healthy urine is composed of certain organic and inorganic elements, and that in disease it frequently becomes impregnated with others. I propose, therefore, to consider the whole analytically under two heads: 1st. The normal and abnormal Organic Elements, and 2ndly. The normal and abnormal Inorganic Elements.

## 1. ORGANIC ELEMENTS.

## (A) Normal.

78. Urea.—To detect an excess of urea, (34). Pour a small quantity of the suspected urine into a watch glass, and gradually add to it an equal volume of nitric acid. Slight effervescence first takes place and afterwards a crystalline deposit of nitrate of urea. The rapidity of the crystallization being in proportion to the amount of the urea. This operation requires the mixture to be kept at a low temperature.

When it is desirous to know the exact quantity

of urea we must adopt one or other of the following processes.

79. I. Dr. Prout recommends us to evaporate the urine to the consistence of a thick syrup and then add to it when cold, concentrated nitric acid until it becomes a crystallized mass of a dark colour. This is then to be repeatedly washed with distilled water and the acid neutralized with a solution of carbonate of potash or soda. The nitrate thus formed must be removed by crystallization, and the supernatant liquor, containing the urea and a portion of the nitrate, made into a paste with powdered charcoal and allowed to remain for a few hours. Distilled water is then to be added to it, to dissolve the urea and nitrate, and the solution, after having been filtered, evaporated to dryness. If the residuum thus obtained is now heated with boiling alcohol, the urea will be dissolved away from the nitrate of potash orsoda, and can be obtained from the alcholic solution almost in a state of purity by evaporation and crystallization.\*

II. Or the nitric acid may be saturated with carbonate of lead, and the alcholic solution afterwards obtained as above, and heated with sulphuretted hydrogen and animal charcoal to remove any remaining particles of lead and colouring matter. The urea will thus be obtained n a crystallizied form, and nearly pure by subsequent solution and evaporation.

<sup>\*</sup> Med. Chir. Trans. vol. viii.

III. Evaporate fresh urine in a water bath to about 1-12th or 1-14th of its volume, allow it to cool, and then filter; to the residue of every pint of urine employed, add slowly, with continual agitation, a solution of half an ounce of oxalic acid in twice its weight of hot water, and an abundant buff-coloured precipitate of oxalate of urea will be the result. Collect this on a calico filter, wash it with a cold solution of oxalic acid and separate the mother water by pressure. Then dissolve it in hot water in a large vessel and neutralize the acid by means of chalk; filter the solution so as to remove the oxalate of lime, and digest it with animal charcoal, again filter and evaporate. Brown coloured crystals of urea will then be obtained and can be procured perfectly colourless and inodorous by repeated solution in warm water and digestion with animal charcoal.\*

IV. Evaporate the urine to the consistence of syrup, taking care that the temperature be not raised too high so as to decompose the urea; then for every pint of urine employed add to it about five ounces of alcohol, which will take up the urea the extractive and colouring matters, and leave the lithic acid and its compounds, together with the various alkaline and earthy salts behind. Separate these by filtration, and wash them with alcohol to remove any remaining portion of urea. Mix the

<sup>\*</sup> Graham's Chemistry, p. 993.

two solutions, evaporate them to a syrupy consistence, and then treat the residue with an equal weight of pure nitric acid, when the nitrate of urea will be formed in such abundance as to constitute a solid crystalline mass, containing an excess of nitric acid, the organic matters, and a portion of the mother water. From these it must be separated by squeezing it in a fine linen cloth, and frequently rinsing it while contained in the latter in ice-cold water. It is then to be compressed between sheets of blotting paper, dried by a gentle heat and weighed. The nitrate of urea thus obtained is slightly coloured and contains a certain portion of organic matter, while the weight of urea present in it may be ascertained from its composition. (Lecanu.)

V. Berzelius's method consists in evaporating the urine to dryness over a water bath and treating the solid mass with alcohol in order to separate those matters soluble in it. The alcoholic solution thus obtained is then submitted to distillation and the yellow residue dissolved in a little water and digested with animal charcoal. The liquor is then filtered, heated to 122 degs. and saturated with oxalic acid; oxalate of urea is formed which becomes deposited in colourless crystals as the solution cools. The mother water must be evaporated, and a fresh portion of oxalic acid added to it, in order to obtain more crystals of the oxylate of urea. The

whole of the crystals are now to be washed in ice-cold water and afterwards dissolved in boiling water mixed with a little animal charcoal. This is then to be separated by filtration, and the liquor saturated with carbonate of lime; effervescence takes place, oxalate of lime is precipitated, and the urea remains in solution from which it is to be procured by evaporation. It may be obtained perfectly free from impurities by repeated solution in pure anhydrous alcohol and distillation.

VI. Mix the urine with basic acetate of lead, and add sufficient sulphuric acid to convert the acetates into sulphates. Then filter the solution through animal charcoal, evaporate it, and tolerably pure crystals of urea will be obtained. (O. Henry.)

VII. Ragsky proposes to determine the amount of urea from the products of its decomposition. For this purpose he mixes in a flask one part of urine with three or four of strong sulphuric acid, and raises the temperature of the mixture to nearly 572 degs. The urea begins to be decomposed at 383 degs. Carbonic acid gas is disengaged and is evolved in great abundance at 393 degs., while the ammonia, which is also formed, unites with the sulphuric acid. He then determines the amount of ammonia in the form of the ammonio-chloride of platinum, from which he afterwards calculates the quantity of urea. By this process he found that 4.03 grains of urea yielded 29.8 grains of ammonio-

chloride of platinum which corresponds to 4.01 grains of urea; and that 4.84 grains of urea yielded 35.7 grains of the double platinous salt corresponding to 4.81 grains of urea.\*

VIII. Heintz also recommends a similar process it is as follows: "A weighed quantity of urine, 6-8 grammes, is treated with about thirty drops of muriatic acid, and set aside in a cool place for twentyfour hours, then filtered through a very small filter into a large platinum or porcelain crucible; the filter and glass are washed with a small quantity of water; the filtrate is treated with about six grammes of sulphuric acid, and the liquid evaporated over a small spirit-lamp, taking care that it does not boil, until the evolution of carbonic acid commences. The crucible is then covered with a watch glass and heated until the evolution of carbonic acid ceases, the temperature not being allowed to exceed 180 degs. The contents of the crucible are then filtered into a porcelain dish, the crucible and the watch glass are well washed, and the filtrate is evaporated until almost all the water has passed off. About twenty drops of muriatic acid are then added to the residue, a sufficient quantity of chloride of platinum and alcohol mixed with æther being then added. If the liquid from which the precipitate has subsided is of a very pale colour, more chloride of platinum must be added. After

Liebig's and Wöhler's Annalen for October, 1845.

8-10 hours the precipitate is separated by filtration, washed, dried, and heated to redness in a crucible, which is at first covered but subsequently open. The residue is treated with boiling dilute muriatic acid, the solution filtered, and this is repeated until the liquid which drops from the filter leaves no residue when evaporated upon platinumfoil; the crucible and filter are dried at a gentle heat; the latter is burnt in the former and weighed. Thus the amount of platinum, which corresponds to that of the potash, ammonia, and urea, is obtained.

Another weighed quantity of the fresh urine is treated once with chloride of platinum, three volumes of alcohol, and one of ether; at the end of ten or twelve hours the mixture is filtered, and the precipitate heated to redness in a well-covered and weighed platinum crucible. The residue is treated as above with dilute muriatic acid, the filter is burned and weighed. We thus obtain the weight of platinum which corresponds to the potash and ammonia contained in the urine; its per-centage is calculated and then deducted from that obtained in the first experiment; the difference gives the amount of platinum which corresponds to the urea."\*

80. The urea, as we have seen, (34), is also liable to be deficient in quantity, both absolutely and rela-

<sup>\*</sup> Chemical Gazette, vol. iv. p.p. 19, 20.

tively. When there is an absolute deficiency, it may take place in common with a diminution of the other solid constituents of the urine, and of the water; or of the solid constituents alone, the amount of water remaining normal. In both these cases the actual decrease can only be ascertained by one or other of the preceding processes, (79.) When a deficiency of urea is suspected, it has been recommended to evaporate the urine to about one half, and then to add to a portion thus concentrated and placed in a watch glass, an equal quantity of strong nitric acid or a saturated solution of oxalic acid; when, if no crystallization takes place, the urea is to be considered as deficient. It is obvious, however, that this method cannot be relied upon; the detection of any deficiency requiring in fact, as Dr. Prout has stated, "a more elaborate process."

81. Should albumen be present in large quantities in the urine it must be previously thrown down by means of alcohol, collected on a filter, and washed with the spirit. The washings are then to be mixed with the alcoholic solution obtained as above directed, and from which the urea is to be procured. M. Heintz's method consists in boiling a carefully weighed portion of the albuminous urine with the bichloride of mercury in a large open dish, collecting the precipitate that is formed on a filter, breaking it up and washing it with water. Then passing a stream of sulphuretted hydrogen slowly through

the filtered liquid, and removing from it by filtration, the sulphuret of mercury that is produced. The filtrate has now to be evaporated mixed with sulphuric acid, until the whole of the urea is decomposed, which may be known by the cessation of effervescence as pointed out by Ragsky, and the fluid which remains, treated, as already described (viii). It now remains to calculate the amount of potash and ammonia. This is done by throwing down the albumen from a second portion of the urine, (also weighed), by means of bichloride of mercury, and heating the filtered fluid with bichloride of platinum and ether, when the quantity of platinum obtained from the precipitate will indicate the proportion of the alkalies. This method is applicable to urine containing blood, milk, or bile, and in the opinion of Heintz, even to Diabetic urine.

Dr. Griffith recommends the alcoholic solution of the residue that is left on evaporating albuminous urine to dryness, to be evaporated, and the extract dissolved in distilled water, the solution then reduced to the consistence of syrup and mixed with half its bulk of pure nitric acid. The formation of crystals of the nitrate having been promoted by placing the mixture in ice, the supernatant liquid is to be poured off, and the crystals then washed in ice-cold water, and subsequently dried in an open steam bath.

- 81.\* To obtain the urea from Diabetic urine M. Bouchardat proceeds by taking the residue left after the evaporation and crystallization of the urine, and dividing it into several portions, and treating each successively with alcoholated sulphuric ether. He then mixes the several solutions, evaporates them at a gentle heat, and dissolves the residue in a sufficient quantity of water, from which, when filtered, and a few drops of weak nitric acid have been added, he obtains the urea in the form of nitrate.\* Dr. Christison merely evaporates the urine quickly over a steam bath at a temperature of about 200 Farn. to about one-sixth of its volume, then adds to this one-fourth of its amount of pure nitric acid diluted with an equal weight of water, and exposes the mixture to a moderate degree of cold. Some have recommended to previously destroy the sugar by fermentation, but it is doubtful whether the transformation of the urea into carbonate of ammonia is not more likely by this process to be occasioned.
- 82. Urea may be artificially prepared by well mixing twenty-eight parts of dry ferrocyanuret of potassium with fourteen of peroxide of manganese both in fine powder and heating the mixture, placed on a smooth iron plate to a dull red heat, at which temperature it inflames, and must be kept stirred so as to allow of a free access of air and prevent agglu-

tination. When cold the mass is to be treated by repeated portions of water, and twenty and a half parts of sulphate of ammonia, are to be added to the solution, from which a copious deposit of sulphate of potash then takes place. The supernatant liquor containing the cyanate of ammonia must afterwards be decanted off and evaporated in order to separate still more of the sulphate, and this process repeated until the whole of it is removed, when the last decanted liquor is to be evaporated to dryness, and boiling alcohol of from eighty to ninety per cent added to the residue. This takes up the urea, which is obtained as the solution cools, or by evaporation, in beautiful colourless crystals. One pound of ferrocyanuret of potassium will yield about four ounces of urea.

83. Lithic Acid. This is frequently met with in the urine in the form of a crystalline deposit, varying in colour from a light fawn to a deep brown or brownish red, which is owing either to its being in excess (44,45) and consequently no longer entirely retained in solution, when the fluid cools, by the double phosphate of soda and ammonia, (41), or to the presence in the secretion of some free acid, (45), by which the lithate of ammonia becomes decomposed.

84. To ascertain whether a particular deposit be lithic acid, place the urine in a tall conical glass vessel, and when it has stood some time, and the

sediment has subsided, decant nearly the whole of the supernatant liquor and pour a small quantity of the turbid remainder, containing the deposit, into a watch glass. Then if uric acid be present it will be known by its remaining undissolved when the urine is heated over a spirit lamp; by being precipitated in combination with ammonia from its solution in liquor potassæ by hydroclorate of ammonia; by its not being acted on either by hydrochloric or acetic acid; by its being soluble in nitric acid with the disengagement of equal volumes of nitrogen and carbonic acid gases, and also in sulphuric acid from which it is again precipitated by water; by the pink coloured residue (the erythric acid of Brugnatelli), left after the evaporation of the acid solution, being changed to a beautiful purple when exposed to the vapours of ammonia, owing to the formation of murexid, and lastly by its yielding urea and evolving an odour of prussic acid when burnt, and leaving a white substance composed principally of phosphate of soda and lime.

85. When examined under the microscope uric acid is seen to crystallize in rhomboidal prisms, or in some modification of this form; the particular shape of the crystals appearing to depend on the rapidity of their crystallization, on the quantity of colouring matter contained in them, and on the nature of the precipitating agent. The forms most

frequently observed are the rhomboid and the quadrilateral tables, which, in some cases, appear nucleated by being marked all round at a short distance from their borders. Occasionally, however, we meet with them of a spindle shape, at other times they appear like so many flattened cylinders which are in reality "thick lozenges lying on their sides," (Bird) and require to be made to roll over, either by agitation or by the addition of a few drops of alcohol, in order that their true shape may be detected. Sometimes, when the urine is very acid for instance, the surface of the quadrilateral tables are either entirely or partially covered with numerous dark straight lines, their extremities, in consequence, having a serrated appearance. In those cases where they are only partially striated, the plane part frequently presents two concentric lines placed with their convexities towards each other. Or the striæ may be so arranged as to leave between them two clear triangular spots united at their apices. When the deposit is of a deep orange or red colour, the crystals are generally found adhering together in clusters having the appearance either of thick rhombic prisms collected together in bundles, or placed across or parallel to each other; or of spinous or striated masses of cohering lozenges.

86. Before examining the deposit it is however always better to previously dissolve the urate of

ammonia with which it is frequently combined, by heating the urine and then to remove the latter with a pipette and replace it with a little distilled water.

87. To detect an excess of uric acid (41, 44, 45,) for a deposit is no proof of it, Dr. Bird recommends the whole of the urine voided in twenty-four hours to be collected and well shaken, and about an ounce of it gently warmed and mixed in a conical glass vessel with about half a drachm of hydrochloric acid. By allowing the mixture to stand for six or eight hours, the sides of the glass will become covered with a copious deposit of crystals of uric acid. The urine is now to be poured off and replaced by cold distilled water, and the crystals detached with a feather or a spatula, and collected at the bottom of the vessel. The water is then to be decanted and the acid placed in a watch glass, the weight of which is known, dried and weighed. This process also enables us to ascertain, by simple multiplication, the actual quantity excreted in the twentyfour hours; but as hippuric acid is obtained at the same time it should be removed by means of boiling alcohol previous to drying the precipitate in order to avoid error in calculation. (51.)

An excess of lithic acid, when it does not constitute a deposit, as is sometimes the case, can also be detected by nitric acid, when added to a high coloured urine, producing a brown precipitate possessed of the preceding chemical and microscopic properties.

88. The amount of lithic acid contained in the urine may also be discovered by proceeding as for urea, viz. by evaporating the secretion to the consistence of syrup, and then treating it with alcohol. This will throw down the uric acid in combination with some of the colouring and animal matters and the alkaline and earthy salts. The supernatant liquor containing the urea and hippuric acid in solution, is then to be poured off and the precipitate washed with alcohol and allowed to dry. Cold hydrochloric acid is afterwards added to dissolve the saline matters and decompose the urates, when the uric acid will be left tolerably pure, and requires only to be dried and weighed.

In having recourse to this test it is necessary that the urine should be perfectly limpid, that is, free from viscidity, for if any mucus for instance, be present it will prevent the uric acid from being precipitated; therefore when it is not so, it had always better be previously filtered.

89. Another mode consists in taking the residue, (composed of lithic acid, and vesical mucus, the extractive and colouring matters, the alkaline and earthy phosphates, and silex,) that is left when alcohol is added to the urine reduced to a syrupy

consistence, for the purpose of separating the urea, and washing it with water in order to remove the alkaline salts, then drying and weighing it and afterwards incinerating it in a platinum or porcelain capsule. By this means we get rid of the organic matters, viz. the uric acid and mucus, and obtain as a residue, the earthy phosphates in combination with silex if any be present in the urine. We have now only to weigh this when we at once ascertain the quantity of uric acid and vesical mucus, by the loss that has been sustained by incineration. The mucus, however, being as we have seen, (64) in such exceedingly minute proportion, may be neglected in the calculation.

90. Urate of Ammonia.—Deposits of this substance never occur in the urine in a crystallized form, therefore are not likely to be confounded with uric acid, (85) but generally in an amorphous state, of a yellow, red, pink, or purple colour, and sometimes nearly white. Occasionally, however, they have a ropy appearance, and are dispersed through the fluid like mucus or muco-pus (47a). They are known by being dissolved on the application of heat and by the addition of a solution of ammonia or potash. The hydrochloric and acetic acid, also dissolve them with decomposition setting free the uric acid which becomes deposited, and may be recognized by its various chemical and microscopic properties above described. (85).

- 91. They not unfrequently exist in combination with the lithate of soda and occasionally also with that of lime. When this is the case the deposit is not entirely dissipated by heat, the soda and lime remaining behind as a white ash at the bottom of the capsule, when they may be detected by the usual tests. Thus by adding to their solution in hydrochloric acid a little oxalate of ammonia, the lime if present becomes precipitated as an insoluble oxalate, and the supernatant liquid will yield on evaporation crystals of chloride of sodium (common salt) if it contain soda. Moreover soda gives a rich yellow colour, and lime a dull brown to the flame of a blow-pipe.
- 92. A positive proof of a deposit consisting of lithate of ammonia is its disappearing when the urine is heated, and its being replaced by crystals of uric acid when a few drops of acetic acid are added to it in a watch glass. It occasionally happens, as when the lithate is mixed either with the earthy phosphates or with mucus, that the urine does not become perfectly transparent by heat. If this be owing to the presence of the phosphates they will be dissolved by acetic or hydrochloric acid, but if to mucus no such change will take place. In order to avoid error from the latter ingredient, the urine ought always to be filtered before it is warmed. It also sometimes occurs that the urine after it has been rendered clear by being

submitted to a gentle heat, becomes again turbid by the further application of heat. This is owing to the presence of albumen.

- 93. To determine its quantity, collect the whole of the urine of twenty-four hours, ascertain its specific gravity and divide it into two portions. Evaporate the one in order to obtain the amount of solid constituents, and collect the sediment from the other; mixed, as the case may be, with lithic acid, the earthy phosphates or mucus on a filter, the weight of which is known. Wash it in ice cold water, dry and weigh it, and its proportion to the solid matters and to the urine will be obtained. Then place it in a test tube and boil it with a little of the urine. Afterwards filter it, wash the residue with hot water and stand the clear fluid that passes through in a freezing mixture, to promote the separation of the lithate. When this has taken place it can be collected, dried, and weighed, and its absolute and relative proportion ascertained.
- 94. The most frequent appearance presented by lithate of ammonia under the microscope is that of very small globules arranged together in rows. Occasionally, however, particularly in albuminous urine, the globules are considerably larger, and distinct, some of them having sharp or obtuse processes attached to them. Both varieties are generally mixed with crystals of uric acid.
  - 95. Hippuric acid. I have already alluded to

two modes by which hippuric acid may be obtained (87, 88,). Another, that recommended by Liebig, consists in evaporating the urine in a water-bath to the consistence of syrup, then mixing it with hydrochloric acid, and agitating it with its own volume of ether. This will, in all probability, remain enclosed by the fluid like froth, and require to be separated after a short time, by the addition of one twentieth of its volume of alcohol, which will at the same time remove the froth and cause a separation of the fluid into two layers. The upper layer containing the hippuric acid and urea in solution, must now be removed with a pipette and treated with several small portions of water, in order to wash away the alcohol and urea and leave the hippuric acid dissolved in the ether. By then evaporating the etherial solution, the acid will be obtained in the crystallized form\*. From this statement we should suppose hipphuric acid to be soluble in ether, but we have already seen that this is not the case, or at least to a very slight extent only.(84.)

The best method for detecting this acid is to add to the urine, reduced to the consistence of syrup, an excess of hydrochloric acid. By this means the hippuric acid will be thrown down together with the lithic, from which, after some little time, when the supernatant liquor has been poured off, it can be

<sup>\*</sup> Lancet for June 1, 1844.

separated by boiling the precipitate in alcohol, in which lithic acid is insoluble. The alcoholic solution thus obtained, will then yield on evaporation, crystals of hippuric acid, to be recognized by their chemical and microscopic characters already described (51).

96. Dr. Day recommends the following process: "Evaporate the urine till there is a copious deposition of salts. Add strong alcohol and place the mixture in a stoppered bottle. With the aid of a gentle heat (for instance, by placing the bottle in warm water), we ensure the solution of the urea, the lactates, (if any are present), and the hippurates in the alcohol, whilst the urates remain with the insoluble constituents. When the supernatant fluid is perfectly clear it must be decanted, evaporated nearly to dryness, and re-dissolved in hot water. If a stream of hot water be passed through the aqueous solution, the urea is destroyed; and, by gradual concentration, and the addition of a little free mineral acid, we obtain crystals of hippuric acid.

97. When an excess of hippuric acid is suspected in the urine, place some of the latter in a large watch glass, and evaporate it nearly to dryness over a spirit lamp, then add about half its bulk of hydrochloric acid which will cause the mixture to assume a bright pink colour, and give off a powerful odour somewhat similar to that of new hay. Set the mixture aside, and after a few hours, provided

the acid is in excess, crystals of a peculiar linear shape will make their appearance." (Bird.)

In order to purify hippuric acid Dr. A. Bensch has recourse to the following process. Having precipitated the acid from the urine by means of hydrochloric acid, he collects it on a strainer, well presses it, and treats it with ten times its weight of boiling water and an excess of milk of lime. He then filters the mixture, presses the precipitate, treats the fluid with a solution of alum as long as it has any alkaline reaction, allows it to cool to 104 degs. Farnh., saturates with a solution of bicarbonate of soda, again strains and presses, and lastly adds hydrochloric acid to throw down the hippuric. This is afterwards washed, pressed, and dissolved in boiling water: an ounce of animal charcoal is then added to every pound of the moist acid, and the boiling liquid filtered through paper, when perfectly white hippuric acid will be obtained.\*

## (B.) Abnormal.

## a Crystalline.

98. Uric or Xanthic Oxide, (66), has been but very rarely met with. It has a great resemblance to uric acid which is very liable to be mistaken for it. When, therefore, its presence is suspected in a

<sup>\*</sup> Chem. Gaz. for Nov. 16, 1846.

deposit, Dr. Bird recommends the latter to be treated with a weak solution of carbonate of potash, which will separate the uric acid and leave the oxide undissolved. The principal features by which it is distinguished are the fleshy colour of its external surface; the brownish-red, or cinnamon hue it presents when broken; the waxy appearance it assumes on being rubbed, and also its different actions towards various reagents. Thus it dissolves but slowly in nitric acid and without effervescence, and leaves a yellow, not a pink residue like uric acid (36), on the evaporation of the acid solution. It is not precipitated by water from its solution in strong sulphuric acid, nor from its solution in liquor potassæ by hydrochlorate of ammonia. It is insoluble in a solution of carbonate of potash and yields no urea or bitter almond odour like lithic acid when When examined under the microscope it has not been found to have any distinct crystalline form, even when precipitated from its solution in liquor potassæ.

99. Oxalate of Lime, (66.) Crystalline deposits of this substance were formerly supposed to be of exceedingly rare occurrence, but this has been entirely disproved by the late researches of Dr. Bird\*, who, from his experience, is led to the conviction that "in the cases of disease occurring in the

<sup>\*</sup> See Med. Gaz. for 1842.

metropolis, the oxalate is of far more frequent occurrence in the urine than the deposits of earthy phosphates," an opinion which is fully corroborated by Dr. Shearman of Rotherham, who states as the result of his observation, that, next to the urates, small quantities of the oxalate are most commonly met with in the secretion.\*

It appears to be intimately connected with that particular state of the system characterized by great nervous irritability. The urine in these cases has its natural amber colour, but is generally somewhat darker than in health, and has only been met with by Dr. Bird of the citron yellow or greenish hue described by Dr. Prout as being peculiar to the oxalic acid diathesis, when blood corpuscles have been present in the secretion. It is likewise acid in the great majority of instances, and subject to very great variation in its specific gravity. Thus it has been observed by Dr. Bird as low as 1.009 and as high as 1.030. "It increases with the quantity of urea," of which the urine, generally in these cases, contains an excess, sometimes even to a very considerable extent, so that crystallization takes place immediately nitric acid is added; the abundance and size of the crystals of the oxalate appearing also to be in a direct ratio with its amount. It may, however, be said to range generally speaking, between 1.015 and 1.025.

<sup>\*</sup> Urinary Deposits, p. 165.

I have already alluded (66) to the various sources to which the existence of oxalate of lime in the urine is to be ascribed, namely, slight deoxidation of the elements of urea and water, oxidation of uric acid, certain articles of food, and the mal-assimmilation of saccharine matters. With reference to the last, and considering the great importance of the subject, the following interesting remarks may with considerable advantage be quoted from one great authority on Oxaluria Dr. Bird. "It is scarcely possible," says he\* " to avoid being impressed with the very probable physiological relation between oxalic acid and sugar: we know that the latter substance forms a considerable item in our list of aliments; we know that the great majority of farinaceous matters are partially converted into this element during the act of digestion.+ It is indisputable that, under certain circumstances, it finds its way into the blood, and is eliminated by the kidneys; even when artificially introduced it is thus thrown out of the system. I have in my possession fine crystals of sugar prepared by my friend, Dr. Percy of Birmingham, from the urine of a dog, into whose veins he had previously injected a solution of that substance. Lastly, we know that, under certain morbid influences, the great proportion of our food

Loc. Cit. p. 175.

<sup>+</sup> Gmelin and Tiedemann, Recherches expérimentales sur la Digestion.—Paris, 1827, p. 202. [Also Papers, by the Author, in the Med. Times, vol. xv., from the French of M. Bouchardat relative to this subject.]

may, whilst in the stomach, become converted into sugar, which becoming absorbed, rapidly passes through the circulation, and is thrown out of the system by the kidneys as an effete matter, with the effect of producing more or less rapid emaciation, and in most cases leading to fatal marasmus. Dr. Aldridge\* of Dublin, has even lately suggested the probability of a substance analogous to sugar, [59] capable of undergoing acetous fermentation, being a normal element of the urine. Then, recollecting the facility with which sugar and its chemical allies, as starch, gum, and wood fibre, are, under the influence of oxydizing agents, converted into oxalic acid, and having sufficient amount of evidence to prove that when oxalic acid is really found in the urine, symptoms bearing no distant relation to those of a diabetic character are met with, we are almost inevitably led to draw the induction that the oxalate of lime found in the secretion owes its origin to sugar, and to locate the fons et origo mali in the digestive organs. This appears to be nearly the view adopted by that very excellent authority in these matters, Dr. Prout." And he goes on to state that his experience has led him "to the following conclusions regarding the circumstances under which oxalate of lime occurs in the urine.

I. That in the urine under examination oxalate

<sup>\*</sup> Lectures on Urine.

of lime is present, diffused through the fluid, and in a crystalline form.

11. That in rather more than one-third of the cases, uric acid or urates existed in large excess, forming the greater bulk of the existing deposit.

III. That in all, there exists a greater proportion of urea than in natural and healthy urine of the same density; and in nearly 30 per cent of the cases so large a quantity of urea was present, that the fluid crystallized into a nearly solid mass on the addition of nitric acid.

IV. That the urate of ammonia found in the deposits of oxalic urine is occasionally tinted of a pink hue.

v. That an excess of phosphates frequently accompanies the oxalate.

vi. That the existence of free sugar in the specimens I have examined, is the exception to the rule."

100. Deposits of oxalate of lime, independent of numerous epithelial scales with which they are almost always found combined, generally occur alone in the urine. They have, however, been sometimes found mixed with lithic acid and lithate of ammonia, and occasionally with the triple phosphate.

101. In order to detect the presence of this salt in the urine, a portion of the latter, passed a few hours after a meal, is recommended by Dr.

Bird to be set aside in a tall glass vessel for a short time, the upper 6-7ths then poured off and a little of the remainder placed in a watch glass and gently heated over a spirit lamp so as to dissolve any urate of ammonia that may have become deposited (a circumstance of frequent occurrence in winter), and to promote the subsidence of the crystals of the oxalate, which have the very remarkable tendency to remain diffused through the urine, even when present in it in considerable quantity. By then giving the fluid a slight rotatory motion, they will be collected together at the bottom of the capsule. The urine is now to be almost entirely removed from them with a pipette and replaced with a little distilled water, when a white, often brilliant powder will make its appearance, which with the aid of a microscope, furnished with a half-inch object glass, will be seen to consist of transparent, well defined, octahedral crystals of oxalate of lime. Examined when dry, they are found to have a quadrilateral shape, and appear to be composed of two squares, one within the other, the central one being transparent and the outer one dark, and so arranged that the sides of the former correspond to the angles of the latter. Sometimes they are somewhat of a dumb-bell shape, or resemble that presented by two kidneys united together at their fissures.

102. Deposits of oxalate of lime may also be

recognized by their solubility in the nitric and hydrochloric acids; by their remaining undissolved when boiled in liquor potassæ or acetic acid; by yielding on incineration first carbonate of lime and afterwards the oxide of the metal, and by their being decomposed when boiled in a solution of carbonate of potash, with the formation of carbonate of lime and oxalate of potash; the former being precipitated while the latter remains in solution.

108. Cystic oxide or Cystine, (66), constitutes rather a rare deposit. In the opinions of Drs. Prout and Bird, it is to be met with in the urine more frequently than has been imagined. When present in the urine, the latter is always turbid when passed, and lets fall a very abundant sediment. It is of a pale or greenish-yellow, or honey colour, and generally somewhat reduced in specific gravity. When fresh, it has, in the greater number of cases, no reaction on test paper, occasionally, however, it is acid, and if kept, soon becomes alkaline. Its odour on emission resembles that of sweet-briar, and assumes a peculiar fœtid character when putrefaction takes place, owing probably to the disengagement of sulphuretted hydrogen. On standing it also becomes coated with a grey looking pellicle, which has been found to consist of crystals of the substance under examination and the triple phosphate.

104. Deposits of cystine are characterized by the following properties. They are of a pale or light fawn colour; are not affected by heating the urine; are insoluble in alcohol; but slowly dissolved by nitric or hydrochloric acid, which readily distinguish them from the lithates (90) and phosphates, (153 to 156), and are decomposed by an excess of the former, a brown residue being left. They are also soluble in the sulphuric, phosphoric, and acetic acids, in solutions of the volatile and of the fixed alkalies, and also of the carbonates of the latter, but not in the carbonate of ammonia or in the vegetable acids. When burnt they give a greenish blue tint to the flame, and emit a disagreeable acid but characteristic odour.

105. To examine the microscopical characters of cystine, first remove any lithate of ammonia that may be present by boiling the sediment in water, and afterwards dissolve the oxide in a little liquor ammoniæ, and allow the ammoniacal solution to slowly evaporate on a slip of glass; then place this under the field of the microscope, and crystals will be observed, either of a well-defined hexagono-laminated shape, perfectly transparent or with opaque centres; or in round masses, dark in the centre, with serrated or notched borders resembling rosettes, and numerous markings on their surface, an appearance which seems to be due to several plates having become placed one above the other. Or the compound deposit, consisting of a mixture of cystine with either the urates or the phosphates, may be

treated at the onset with a little liquor ammoniæ, the cystic solution then evaporated, and the residue examined under the microscope.

## b. Organised

106. Blood.—The presence of blood in the urine is owing, as we have seen, (66a), to very various causes, and is sometimes so abundant as to give it a dark red, or port-wine, or even black appearance; while in others it exists in such a minute proportion as to be almost imperceptible. Its existence in large quantities in the urine may be suspected from the dark colour just alluded to of the latter; from the large black masses resembling coagula, contained in the secretion; and, together with these, from the alkaline reaction of the urine on test paper. In those cases where the blood is less abundant, the urine instead of assuming the dark colour abovementioned, has a dirty aspect, is without coagula, and lets fall a reddish sediment.

107. When urine, contaminated with blood, is boiled, it becomes turbid, owing to the coagulation of the albumen, and changed to a dirty brown colour, and, when nitric acid is added to it, deposits an albuminous precipitate, more or less copious in proportion to the quantity of blood present in it.

108. To detect its presence, one or other of the following processes may be resorted to:

I. Boil the urine, previously saturated with nitric

acid, if it be alkaline, collect the coagulum that is formed, on a filter and treat it with alcohol, accidulated with sulphuric acid in order to remove its colouring principle. Evaporate the brown coloured liquid thus obtained, and which is changed to a bright red on the addition of ammonia, and the colouring matter will collect on the surface as a black resinous looking mass, soluble in acetic ether and ammoniated alcohol. To the latter fluid it communicates a red colour, which is converted to a yellow by hydrochloric acid; a blue precipitate being also subsequently formed when ferrocyanate of potash is added to the yellow solution, (Lecanu).

II. Boil the urine, collect the coagula on a filter, and pour over them liquor potassæ; add hydrochloric acid to the greenish fluid that passes through, and white coagula consisting of protein will be formed (Pariset Journal de Chimie, 1840, p. 68.)

109. The most speedy and certain mode, however, of ascertaining the presence of blood in the urine is by means of the microscope. Place a little of the suspected dark coloured urine in a watch glass under the field of this instrument, and if blood be present it will be detected by its characteristic corpuscles, which are more or less altered in shape in proportion to the length of time they have been acted on by the secretion. They are generally distinct and appear flatter than natural, owing to exosmosis, and have sometimes fringed or serrated borders. Occa-

sionally, when the urine is examined very shortly after its admixture with blood, they are met with in their normal condition, namely, as flattened vesicles with bright central spots adhering together in rouleaux.

When the quantity of blood is so small as to scarcely tinge the urine, then a portion of the coloured deposit which mostly subsides, or of the lowermost stratum of the fluid must be examined. It sometimes happens, however, that in these cases the blood corpuscles have become dissolved, and then the microscope is of no avail. Our only ressource then left is to ascertain if the fluid becomes coagulated or opaque, and if its colour disappears by boiling.

Having detected the presence of blood it becomes highly necessary to discover from what part of the urinary apparatus it has arisen, whether from the kidneys, the ureters, the bladder, or the urethra. This is not at all times an easy matter and requires several circumstances to be considered before we can arrive at just and true conclusions.

110. When it proceeds from the kidneys, there will generally be some symptoms referrible to these organs, caused either by an injury to the loins or by some morbid condition of the glands themselves, as inflammation or congestion, or tubercular or cancerous degeneration, or by the presence of a calculus. The urine, moreover, will be tolerably uniform in colour,

and when the blood is very abundant, will contain dark elongated coagula. This is more particularly the case when the hæmorrhage has been occasioned by a violent blow, or by a penetrating wound in the lumbar region, or by the presence of a stone.

- 111. When it proceeds from the ureters, it is almost always produced by a calculus, which may be readily detected by the symptoms it gives rise to, namely: sudden and severe, but intermitting pain, extending round the loins downwards towards the testicles, rendering these spasmodically painful and forcibly retracted, and giving rise to distressing nausea, vomiting and even faintness.
- 112. If it proceeds from the bladder it may generally be readily discovered by the accompanying symptoms being principally referred to this viscus; the kidneys and ureters remaining unaffected. The symptoms however will vary considerably, according to the cause which has given rise to them, (See Tabular view,) and in some cases, indeed, will be entirely wanting, as when the hæmorrhage is vicarious to some periodical discharge of blood, such as the menses, and in some cases to the hæmorrhoidal flux, &c.
- 113. If the urethra be the seat of the hæmorrhage, it will be easily detected by the escape of pure blood, free from urine, both previous to and after the evacuation of the bladder, and by the first portion of urine passed being slightly tinged, while

the remainder is perfectly clear and of its natural colour. There are likewise no symptoms referrible, either to the bladder or the kidneys. It sometimes happens however, that the blood has passed backwards into the bladder; in that case the whole of the urine will be coloured in proportion to the quantity of blood that has retrograded. The true seat of the hæmorrhage may, nevertheless, be generally detected by the accompanying symptoms.

114. Pus (66 b). Urine containing pus is always more or less turbid when passed. On standing, it becomes somewhat clearer, but never perfectly transparent. This is owing to the subsidence of the purulent matter, which then has the appearance of a thick sediment of a pale yellowish-green, or dirty white colour, and is easily disturbed by the slightest motion of the fluid. The urine is mostly acid or neutral when voided, and but slowly undergoes decomposition. The ammonia, however, which is formed when this change does take place, not only renders the secretion alkaline, but also completely alters the nature of the deposit by making it tenacious and viscid.

115. To ascertain whether a sediment consists of pus, pour from it the clear supernatant fluid, and test it for albumen with heat and nitric acid; then collect the suspected deposit and add to a part of it an equal volume of liquor potassæ, and to another portion some ether, and place the remainder under

the field of the microscope. Then, if coagulation or an opacity takes place in the first; gelatinization or coagulation in the second; and yellow fat globules are left by the evaporation of the third; while, in the fourth, granular and opaque globules are observed floating in an albuminous fluid—the liquor puris—we have positive proof of the purulent nature of the morbid deposit.

- 116. Pus globules are distinguished from blood corpuscles or discs (109) by being larger, granulated, and less transparent, and by their external membrane becoming dissolved, and the nuclei which they contain, thereby rendered distinctly visible, when acetic acid is added to them.
- 117. Purulent deposits are liable to be mistaken for mucus or the phosphates. The former may be diagnosticated by its characteristic features, (119) while the phosphates may be known by their being dissolved by an acid.
- 118. Mucus (66 c.)—Urine containing mucus in excess is always more or less turbid, and frequently is so consistent and viscid as to have the appearance of a gelatinous mass. It is remarkably prone to decomposition, the mucus in all probability acting as a ferment (29), and has, when this takes place, a remarkably feetid, disagreeable odour, and an alkaline re-action on test paper. If the decomposition commence previous to its excretion, it then acquires irritating qualities, and by acting on the lining

membrane of the bladder, causes an increased formation of mucus. The mucus therefore must be considered as both the cause and effect of the putrefactive change which the urinary secretion undergoes. Mucus, when present in the urine in large quantities, always falls in great part to the bottom of the vessel in which the secretion is placed, from which it rises, when the fluid is shaken, in large stringy or ropy masses.

- deposit, and those which distinguish it from pus, are its ropy or stringy appearance; its not perfectly separating from the urine as a homogeneous yellowish substance, but always remaining somewhat suspended in it in the form of long stringy masses; its being coagulated by acetic acid; its yielding very few, if any, fat globules to ether, and its not rendering the urine albuminous. Another distinguishing feature between mucous and purulent urine is that the former is alkaline and the latter mostly acid or neutral; the one being prone to putrefaction while the other undergoes that change but very slowly.
- 120. The microscopic characters of mucus are much the same as those of pus, and therefore are of no avail in diagnosis.
- 121. It not unfrequently happens that both pus and mucus are contained in the urine at the same time. In that case the secretion will present more

or less of the characteristic appearances above described as peculiar to each substance. The whitish ropy deposit of lithate of ammonia (90), is liable to be mistaken for the sediment occurring under these circumstances. It may, however, be distinguished by disappearing when the urine is heated.

122. Urine voided in an alkaline state may be owing, (and I have had frequent opportunities of verifying the fact) to its having undergone some change or decomposition in the bladder in consequence of some morbid or inflammatory condition of this viscus, either originating in it or the result of some derangement of the parts anterior to it, as stricture of the urethra, for instance, and enlarged prostate; or to its having been secreted in that state, and constituting then, according to Rayer, a symptom of chronic nephritis.

It is of the utmost importance, therefore, to distinguish between these two classes of cases, and the only way of doing so is to draw off the urine, then to wash out the bladder, and examine the fluid that is next secreted.

123. Besides the pus and mucus globules already described, the urine occasionally contains others for which Dr. Bird has proposed the name of Organic Globules. They are of two kinds, the large and small. The former differ from the pus and mucus particles only in the fluid in which they float not possessing the albuminous properties of the Liquor

Puris or the viscid or glairy nature of the Liquor Muci. They seldom constitute an actual deposit but are generally diffused through the urine. They are met with in cases of ardor urinæ, and in the latter months of pregnancy, but are most numerous in confirmed cases of Bright's disease.

The SMALL ORGANIC GLOBULES are of more rare occurrence. They differ from the larger ones, in always forming a distinct deposit, in having a smooth non-granular surface, and in being devoid, to all appearance, of nuclei.

124. EPITHELIUM SCALES may be recognized by their flattened cellulo-nucleated aspect under the microscope. They are occasionally met with in very large quantities, especially during the occurrence of the oxalate of lime deposits. Dr. Johnson has lately discovered fat globules in them, an appearance which, in his opinion, is characteristic of Bright's disease.

125. Spermatozoæ (66). The only way to detect the existence of these animalcules is to submit to microscopic examination a few drops of the lowest stratum of the suspected urine, or a little of the deposit that may have formed, when they will be observed as small oblong bodies with delicate tapering tails.

126. Torulæ (66), are only met with in saccharine urine, while it is undergoing the alcoholic fermentation. Their true nature can only be detected with the microscope. When first examined with this

instrument, they are found to consist of small oval vesicles containing in their interior minute granular corpuscles. At length, by the gradual increase in size of these granules, the vesicles expand, become tubular, and finally put forth small granular, budlike projections, which enlarge and undergo the same change as their parent cells, so that the fungoid, or confervoid vegetation has then a beaded or jointed appearance, and constitutes a thin pellicle on the surface of the fluid. Occasionally, however, these fungi appear to increase in a different manner, namely, by the bursting of the parent vesicles and the escape of the contained granular bodies, which eventually form themselves into fresh cells.

When the vesicles have remained on the surface united together in the manner above described, for some little time, they separate and fall to the bottom in their original distinct state.

127. Vibriones, (66), have been met with in the pale, light urine of cachectic and debilitated persons. They are excessively small linear bodies, having an oscilating motion, but without any distinguishable organization.

## g. Non-Organized.

129. Albumen, (66), is by no means an unfrequent abnormal ingredient in urine, and in some cases is present in it in great abundance.

It admits, generally speaking, of easy detection.

The principle tests are heat, nitric acid, and the ferrocyanide of potassium with the addition of a few drops of acetic acid. The appearances presented by the urine after the application of these tests will be a good criterion of the quantity of albumen present in it, as in some cases it is merely rendered a little turbid, while in others it becomes almost a solid mass.

129. If heat occasion an opacity or a deposit, we must not be too hasty in attributing it to the presence of albumen, as it may be owing to the precipitation of the phosphates. This, however, may be readily discovered if the precipitate is dissolved by the addition of a few drops of nitric acid.

Dr. Griffith, however, has stated in a communication to the Medical Gazette for Oct. 21, 1842, that the albumen, when in small quantity, may also be dissolved by a few drops of this acid; but that there is this difference between the two substances, that the latter (albumen) is precipitated, while the phosphates remain dissolved when the acid is added in excess.

- 130. If the urine be alkaline no coagulation or opacity may take place. Nitric acid must be used in this case either alone, or what is better, in combination with heat.
- 131. If nitric acid alone renders the urine turbid, ascertain whether the patient has been taking copaiba or cubebs; for according to Dr. G. O. Rees,

such an effect is liable to be the result of the administration of these medicines. This statement has been confirmed by Simon, who states that the precipitate consists of small oil vesicles. No turbidity or deposit is produced in these cases by heat.

It will be seen, therefore, by the preceding remarks, that the effects of both heat and nitric acid require investigation before they can be received as evidence of the presence of albumen, and in fact that each test necessitates the confirmation of the other.

132. To ascertain the amount of albumen it must be precipitated by boiling a given weight of urine, then collected on a filter, dried, and weighed, and the quantity contained in the whole of the urine voided in twenty-four hours, calculated from that obtained from the portion examined. Or we may adopt the process recommended by Heller,\* which is as follows: Take a given quantity of urine, say from ten to twenty grains, and determine the percentage of solid matters contained in it; then rapidly raise another portion of equal weight to the boiling point in a small narrow-mouthed flask. Set this by with its mouth closed, and when the fluid is cold, filter it through a tolerably fine linen cloth, and the albumen will collect upon it. If the addition

<sup>\*</sup> Quoted by Dr. Day in Simon's Chemistry, from vol. i. p. 192, of the Archis für phys, und Patholog Chimie und Mikroskopie.

of nitric acid causes no further precipitation of albumen we may be sure that the whole has been separated. The difference between the amount of solid residue left by the strained fluid on evaporation, and that from the first specimen examined, will represent the quantity of albumen.

133. "There is a class of cases," says Vogel in his Erläuterungstafeln zur Pathologischen Histologié,\* in which the urine-sometimes bloody, sometimes of its natural colour, but always turbid at the commencement-when allowed to remain at rest, lets fall a yellowish white sediment, whereby it becomes clear and transparent. This sediment is not mucous; on agitation it readily mixes with the urine, whereby this latter is rendered turbid for the time, but becomes clear again, as soon as the precipitate is again deposited. The urine sometimes contains a large quantity of albumen, which coagulates on boiling; at other times it contains but little, rarely none at all. Under the microscope this sediment appears to consist of colourless coagula, of a cylindrical form, the diameter and shape of which correspond exactly to the tubuli uriniferi of the kidneys. Like the uriniferous tubules of healthy kidneys they contain, inclosed within them, portions of epithelium, and now and then, rusty coloured granules (altered blood). These coagula readily

<sup>\*</sup> Translated by Mr. Kirkes in the Medical Gazette, for May 2, 1845.

dissolve in caustic potash, with difficulty in acetic acid; but by this latter re-agent the epithelial cells contained within the coagula are rendered very distinct.

There seems hardly a doubt that these cylindrical masses are fibrinous coagula, which are formed in the uriniferous tubes, and that during their coagulations portions of the epithelium of these tubes become entangled within them, and the whole substance is then discharged together with the urine, from which the several masses are afterwards precipitated, still preserving the shape of the canals in which they were formed. They vary in length, often measuring several lines: their transverse diameter corresponds with that of the tubules, varying from  $\frac{1}{90}$  to  $\frac{1}{200}$  of a line. Moreover, there are sometimes a large quantity of pus corpuscles present in these cylindrical masses; probably in those cases in which the inflammation has extended to the pelvis of the kidneys and to the ureter."

Dr. George Johnson, of King's College, also states that oil globules, or epithelial cells containing fatty matter, are likewise frequently met with adhering to these tubular fibrinous masses, and that he considers them, when in large numbers, an alarming symptom of Bright's disease, of which they are, in his opinion, pathognomonic.

134. Bile (66,) when present in the urine, communicates to it an unnatural tint varying from that

of a saffron-yellow to a dark brown, similar to that produced by blood.

135. It may be detected by the following processes:—

I. Dip a piece of clean linen in the suspected urine, and if bile be present it will be changed to a yellow colour, which will be converted to a green by hydrochloric acid.

II. Pour a little of the urine on any flat white surface, as the bottom of a plate for instance, and gradually add to it a few drops of nitric acid. A rapid display of colours will be exhibited, in which the green, blue, violet, pink, and red will be observed.

III. Add basic acetate of lead to the urine, and a yellowish precipitate, soluble, with the production of a green colour, in alcohol acidulated with sulphuric acid, will be thrown down. (Schwertfeger in Day's Simon's Chemistry).

IV. Gradually add to a little of the urine, previously deprived of any admixture of albumen, contained in the test tube, two thirds of its volume of sulphuric acid perfectly free from sulphurous acid, and then shake the mixture, kept below 144 degrees, with two or three drops of a solution of cane sugar, made in the proportion of five parts of water to one of sugar, when a more or less distinct violet-red colour, in proportion to the amount of bile present in the secretion, will make its appearance. (Pettenkofer).

This test, however, cannot be safely relied on, owing to the action of the sulphuric acid on the the sugar employed.

v. Treat the urine, previously deprived by filtration of the mucus and lithic acid that may have become deposited, with chloride of barium; collect the precipitate that is formed on a filter, and wash it with distilled water. Then boil it in water with carbonate of soda, and separate the biliary colouring matter from the yellow solution thus obtained, by hydrochloric acid. Collect it on a filter, dissolve it in a mixture of two parts of alcohol and one of ether, and evaporate the resulting green solution, when the colouring matter will be left in the form of a dark green mass. Or the barytes precipitate above alluded to, may be at once decomposed by digesting it with alcohol and hydrochloric acid at a moderate heat, the alcoholic solution then evaporated and the residue washed with distilled water, and afterwards dissolved in the alcoholic ethereal mixture and again evaporated. (Scherer Ann. der Chimie und Pharm, March 1845. Lancet, May 24, 1845.)

When dried, this colouring matter may be reduced to a powder, which has a very beautiful dark green colour. It is very sparingly soluble in water and ether, but very soluble in alcohol and liquor potassæ, to the latter of which it communicates a brownish hue. Hydrochloric acid converts it to a blackish brown.

vi. Add the white of an egg, or any other albuminous fluid to the suspected urine, and afterwards separate it by means of nitric acid. If bile be present in the secretion, the coagulated albumen will have a blueish, or perfectly blue or greenish colour. But if there be no biliary matter, the precipitate will be white, being gradually, however, tinged yellow by nitric acid. (Heller). This test is stated by its author to be extremely delicate, the most minute quantity of bile being detected by it; a thing impossible with nitric acid alone.

136. The colouring matter of bile has been found by Heller to suffer considerable modification in certain diseases, particularly cholera, and in this state not to give its characteristic reaction with nitric acid, a red instead of a green colour, being in fact produced when this acid is added. In these cases he considers ammonia to be the best test. It is to be dropped into the suspected urine in small quantity, when, if bile be present, a bright red colour, which passes to a brownish red on the addition of more ammonia, will be produced.\*\*

137. If MILK (66f) be present in the urine, the latter will let fall a precipitate consisting of casein,

<sup>\*</sup> Med. Gaz. October 17th, 1845.

when acetic acid is added to it, and will exhibit fat globules when examined under the microscope.

138. Kiestien, (66g).—This substance is principally met with in the urine of pregnant women, in the form of a greasy fat-like pellicle, which, after having remained stationary for three or four days, breaks up and gradually falls to the bottom of the cylindrical vessel in which the urine has been placed. It has been supposed to consist principally of caseine owing to its occurring in combination with butyric acid. M. Regnault is of a different opinion. According to him it is composed only of very minute microscopic animalculæ and phosphatic crystals, and therefore he considers that the deposit under consideration is not due to the spontaneous coagulation of a substance primitively existing in the urine, but rather to the decomposition of a nitrogenized matter secreted by the kidneys in excess during gestation, which by acting as a ferment in the urine, promotes the conversion of urea into carbonate of ammonia and occasions the peculiar appearance presented by the secretion in these cases.\*

139. According to Dr. Golding Bird, its formation is prevented by an inflammatory state of the system, a statement which has lately been corroborated by M. Möller,†

Med. Times, vol. xvi. p. 176.

<sup>+</sup> See Med. Gaz. June 5, 1846.

Suppressed perspiration has also been stated by Dr. Bird to be a cause of the non-appearance of this peculiar pellicle. This, however, does not appear always to be the case, M. Möller having met with an instance to the contrary in a young female in the eighth month of her pregnancy, who, from long continued mental emotion, had become attacked with severe hectic and profuse sweats, without there being apparently any local affection present which could have given rise to them. In this patient's urine not a trace of kiestien could be detected during the whole of the febrile attack, but the moment the hectic disappeared it was found to exist in it in large quantities.

140. Lehmann treated it with ether, evaporated the solution obtained, and procured a fatty matter resembling butter, which yielded butyric acid on the addition of sulphuric acid after being saponified with potash; and Dr. Rees informs us in the last edition of his work, that he has discovered in it globules exactly similar to the fat globules contained in milk. Möller, after he had evaporated the etherial solution at a gentle temperature, removed the phosphates by means of diluted hydrochloric acid, neutralized any excess of the latter with ammonia, and expelled any remaining portion by the application of a moderate heat, procured it in a pulverulent form, without taste or odour, and of a whitish or yellowish colour, insoluble either in alcohol, ether,

or water. Urine from which pellicles of kiestien have formed appears to contain no albumen, and but very rarely casein. It is generally neutral or alkaline and occasionally acid; while the pellicle itself is stated never to become mouldy.

141. Fatty matter, (66h,) occasionally met with in the urine, may also be detected with the microscope, and by its characteristic globules; and likewise by the yellow solution that collects on the surface of the urine when ether is added to it, and which yields fat globules on evaporation.

142. Urostealith.—This is the name given by Dr. F. Heller, to a peculiar concretion that was passed by a patient while suffering from symptoms of calculus in the bladder, and which he found to consist of a particular kind of fatty matter. These concretions, when first passed are soft, but become hard by drying. They are then brittle, have somewhat the appearance of wax, and a greenish yellow hue when viewed by transmitted light. When heated they melt, then swell and burn with a characteristic pungent odour, something like that of gum benzoin, leaving an abundant ash. Urostealith is soluble in ether, from which it can be obtained by evaporation, but is insoluble in water, and nearly so in alcohol. It is also soluble in nitric acid with effervescence, a colourless substance being formed; and combines readily with alkalies, which will separate it from its etherial solution.

143. Sugar, (66 i.k.).—The presence of saccharine matter in the urine constitutes diabates mellitus, an interesting disease characterized by the excretion of an extremely limpid urine "of a pale greenish straw colour, of a peculiar odour deprived of the urinous character; sometimes resembling that of whey, of a sweet taste, of considerable specific gravity and generally acid;" and which, "when left standing by itself in the vessel for some time, becomes somewhat turbid, loses its greenish tint, and undergoes spontaneously the alcoholic fermentation, if the weather be hot."\*

144. Sugar may generally be detected by the sweet taste it gives to the secretion; occasionally, however, this is completely masked by the other constituents of the urine. (Bouchardat).

The following are the various tests that have been proposed for it.

1. "The most convenient means of ascertaining the presence of saccharine matter in diabetic urine, is to add to it some yeast, which gives rise to vinous fermentation, a most delicate test, as it can detect one part of it in a thousand parts of urine.† Every cubic inch of gas given off nearly corresponds in round numbers with one grain of sugar—forty-seven of gas to forty-five of sugar.";

Bell's Essay, by the Author, p. 12.

<sup>+</sup> Christison's Lib. Pract. Med vol. iv. 249.

<sup>‡</sup> Bell's Essay, p. 16.

The amount of gas may also be ascertained by the increased weight of Liebig's bulb apparatus.

In healthy urine no change takes place on the addition of yeast, with the exception of the disengagement of a small quantity of carbonic acid necessarily present in the latter.

II. Another equally delicate test is the growth of Torulæ. These spores or fungoid vegetations make their appearance in the urine whenever saccharine matter is present in it in however minute proportions. They may be recognized by their peculiar characters. (126).

the supposed diabetic urine contained in a test tube. Slight opacity will take place owing to the formation of phosphate of copper which is precipitated. Then add an excess of liquor potassæ and a deposit of the hydrated oxide of copper will be formed, which will be re-dissolved by an excess of the alkali if sugar be present, with the production of a blue solution similar to that of the ammoniuret of copper. By gently raising the mixture to a boiling point, the copper will be deposited as a red suboxide if it contain any saccharine matter, and as a black oxide if it does not. (Trommer.)

Dr. Bird evidently gives the preference to this test, as being the most delicate of all those hither-to proposed for the detection of sugar in the urine, and in fact, one which "will readily detect it in

diabetic urine, even when very largely diluted, provided "no more of the solution of sulphate of copper be used than is sufficient to afford a decided precipitate on the addition of the liquor potassa." \*

rv. Add to the suspected urine, contained in a conical glass vessel, a small quantity of the hydrated oxide of copper, and an excess of liquor potassæ. The fluid, if it contain sugar, will then become of a reddish colour, and the deposited oxide will gradually assume a yellow hue. (Capezzuoli.)

v. Evaporate a little of the urine at a gentle heat in a shallow porcelain dish, and drop upon the dry warm residue a few drops of sulphuric acid diluted with six parts of water, when, if it contain sugar, it will assume a dark brown, or even black colour. (Runge.)

This test, it is said, will detect as much as one part in two thousand; but as similar results will be obtained, according to Dr. Bird, if albumen be present, this must be previously removed before it is had recourse to.

vi. Treat the urine, reduced to the consistence of syrup, with alcohol, and add to the solution obtained a little of an alcoholic solution of potash. A white precipitate, if saccharine matter be present, will then be formed, consisting of a compound of sugar and potash. Wash it in alcohol and dissolve in

Med. Gaz. for May 24, 1844.

water; a saccharine solution will thus be obtained, from which the amount of sugar may be determined. (Lowig, quoted in the *Lancet* for Sept. 6, 1845, from part 2, vol. 38 of Buchner's Repert.).

vii. Boil the suspected urine in a test tube with an excess of *liquor potassæ*, and if it contain sugar it will assume an orange-yellow, or brown, or claret colour, in proportion to the quantity present, owing to the conversion of the diabetic saccharine matter into melassic acid. (Moore).

Heller, who seems to have recommended this test about the same time as Mr. Moore, (see Archiv für phys. und Path. Chem. und Mikrosk., 1844, 2 S. 212), states that "if an excess of nitric acid be now added, a strong odour will be developed by the sugar. If a drop of diabetic urine be diluted with ten drops, or even more of water, the presence of sugar will be shown by the above test."\*

In having recourse to this test we must be careful that the liquor potassæ contains no lead, (which it may do if it has been kept in a white glass bottle) and the urine no albumen, otherwise, the sulphur contained in the latter, by acting on the lead would produce a sulphuret of this metal, which would give rise to a dark colour similar to that occasioned by sugar. This source of fallacy

<sup>\*</sup> Quoted in Pharmaceutical Journal, vol. v. p. 188.

has been lately pointed out by Dr. Rees, who recommends that no liquor potassæ should be employed but what has been kept in green glass vessels.
The presence of lead in the liquor potassæ may
be easily detected by means of the hydrosulphuret
of ammonia.

M. Bouchardat prefers milk of lime to the solution of potash; first, because in the country it can be more readily obtained; and, secondly, because many of the extractive matters of the urine are darkened by potash, which is not the case with milk of lime.\*

viii. Digest some cheese, previously cleansed from foreign matter, in the suspected diabetic urine for a few hours, and then add to it some acetate of zinc; a white precipitate will be formed if sugar be present owing to a portion of it being converted by the casein into lactic acid. (Ross.)

IX. "The urine is to be evaporated to dryness, the residue is then treated with alcohol, which dissolves the sugar, and all the extractiform matters soluble in this menstruum. By slowly evaporating the solution, the sugar crystallizes in small grain-like crystals, similar to the sugar of grapes." (Bell's Essay on Diabetes).

x. Add diacetate of lead to the urine, filter, remove the lead by means of sulphuretted hydro-

<sup>\*</sup> See a translated paper by the Author, in the Med. Times, for March 6, 1847.

gen; filter a second time and evaporate to a syrup; treat this with alcohol and allow the solution obtained to spontaneously evaporate. The saccharine matter will then be procured in the crystallized form.

xI. Mix together sulphuric acid and bile until the precipitated choleic acid is redissolved, then add to the mixture a few drops of the urine to be examined, when, if sugar be present, a violet colour will be immediately produced. Should any albumen be contained in the secretion, it must be previously removed by ebulition. (Pettenkofer).

144.\*Some of these tests it will be seen only enable us to ascertain the presence of sugar in the urine while the others admit of our calculating its quantity.

For the precise determination of the proportion of saccharine matter contained in a quart of urine, M. Bouchardat,\* gives the preference to M. Biot's polarizing apparatus, and has proposed the following formula for this purpose. If the length of the tube in millemetres, in which the diabetic urine is examined, be represented by L, and the deviation measured with the naked eye, corresponding to the violet blue tint that is observed immediately preceding the appearance of the yellowish red—by a, then by multiplying 2353.6 by the latter, and dividing the product by the former, the quotient

<sup>•</sup> Med. Times, March 1847.

will be the amount of the sugar contained in a quart of this urine in grammes. Thus

Crystallized diabetic sugar contains two atoms of water, and is represented by the following formula:

$$C_{12}$$
,  $H_{12}$ ,  $O_{12}$ ,  $+ 2 H O$ .

"On saturating diabetic urine with common salt, and leaving it to spontaneous evaporation, crystals, three-fourths of an inch in diameter, may be obtained. They are not very regular in their form, but most of them are six-sided double pyramids. These crystals are hard, easily pulverizable, transparent, of a combined saltish and saccharine taste, and dissolve in about 3-7 parts of cold water and slightly in alcohol. The formula for this combination is:

 $C_{12}$ ,  $H_{12}$ ,  $O_{12}$ , 2 11 0 +  $C_{12}$ ,  $H_{12}$ ,  $O_{12}$ , Na Cl."\*

145. To obtain the Extractive Matters evaporate a given quantity of urine to dryness over a waterbath, treat the residue with alcohol of 0.83, and the water extract will be precipitated in combination with the phosphates and sulphates. Collect the

Day in Simon's Chemistry, vol. i. p. 66.

deposit on a weighed filter, wash it with alcohol of the same degree of strength and dry it, and its amount will be represented by the increase in the known weight of the filter. The proportion of water-extract contained in it can then be ascertained by the loss it sustains by incineration.

Mix the spirituous solution with the washings of the contents of the filter, evaporate the mixture to the consistence of an extract, and treat this when cold, with anhydrous alcohol. The spirit-extract together with the chlorides of sodium and potassium and a portion of the alkaline lactates will then be thrown down. When the supernatant alcoholic liquid is no longer rendered turbid by any further addition of anhydrous alcohol, it must be poured off from the residue, and this washed with pure alcohol; afterwards carefully dried on the water bath and weighed, and the spirit-extract estimated by the loss occasioned by incineration.

To determine the alcohol-extract and the ammonia salts, Simon proceeds in the following manner: the alcoholic fluid obtained from the precipitation of the spirit-extract, is evaporated on the water bath to the consistence of a thick syrup, then thoroughly dried over strong sulphuric acid in a receiver and weighed. Theresidue is dissolved in a little water, and free bary-ta gradually added, a gentle warmth being kept up as long as it continues to dissolve, and as long as ammonia is perceptibly evolved. This point being attained

extract, and moistened with a little alcohol of 0.83; a large quantity of anhydrous alcohol is then added, and the whole allowed to clear itself. Their remain undissolved, chloride of barium, a compound of baryta with extractive matter, and the greater part of the free baryta, which has probably been added in excess. Dissolved in the alcohol are urea, lactate of baryta and a small quantity of free baryta. The undissolved portion is burnt in a platinum crucible, the residue incinerated, and the ash digested in water. The solution is then filtered, slightly acidulated with nitric acid, and the chlorine precipitated by nitrate of silver, when the chloride of ammonium can be calculated from it.

The alcoholic solution must be evaporated, the residue dissolved in water, the solution filtered, and a current of carbonic acid passed through it, until the free baryta is precipitated: it must then be again filtred, acidulated with nitric acid and the baryta of the lactate of baryta precipitated by sulphuric acid. The lactate of baryta is estimated from the residual sulphate.

By substracting from the solid residue of the alcohol extract the weight of the urea, of the free lactic acid, of the lactate of ammonia, and chloride of ammonium, we obtain the quantity of the alcohol-extract.

146. To detect an excess of the extractive matters boil a little of the suspected urine in a test tube, with a small portion of hydrochloric acid, when if the quantity be increased, the fluid will assume a dark hue, and will deposit a sediment of a brownish, or blackish, or even of an indigo blue tint, readily soluble in alcohol, to which it imparts a peculiar colour.

147. According to Heller "the existence of a large quantity of uroxanthin (6) in urine is indicated:

1. By the clear, light yellow colour of the urine when that secretion is acid, as in cholera, and sometimes in Bright's disease.

II. By the presence of the products of its oxidation, uroglaucin and urrhodin, which, either of themselves, form a violet coloured sediment, or communicate that tint to a sediment already formed.

On allowing urine abounding in uroxanthin to stand for some time, it is observed that after the formation of the sediment has ceased, the fluid from the surface downwards, assumes a violet tint, and this change of colour takes place with a rapidity proportional to the amount of carbonate of ammonia produced by the decomposition of urea.

Hence, on keeping such urine in a high cylindrical glass, three distinct strata are observed; lowermost, a violet sediment; in the middle, yellow and nearly clear urine; and superiorly, a violet or purple turbid layer.

On shaking the glass, the whole urine assumes a blueish-green tint, because the urrhodin, formed principally at the surface, becomes converted, by agitation, with a full supply of atmospheric air, into uroglaucin, which, mixing with the central yellow layer of urine, develops a green tint. The uroglaucin thus formed, ultimately settles as a blue powder on the sides, and at the bottom of the vessel. Hence there is obviously no fixed proportion between the quantities of uroglaucin and urrhodin.

III. If much uroxanthin is present, the crystals of uric acid (separated spontaneously, or by the addition of an acid) have a beautiful blue or amethyst tint.

iv. Lastly, if much uroxanthin is present, it may be recognized by the addition of concentrated nitric acid, (ten drops to half an ounce of urine,) which at once communicates a brilliant violet colour to the fluid: if a smaller amount is present, the change of colour is developed more slowly.

The nitric acid oxydizes the uroxanthin, and converts it into uroglaucin and urrhodin. Sulphuric and hydrochloric acids act similarly, but with less activity. If albumen is present in urine treated in this manner, it is either precipitated blue at once, or assumes that tint gradually, according to the amount

of uroxanthin. This is constantly noticed in Bright's disease on treating urine abounding in uroxanthin with an acid, and allowing it to stand for a couple of days; uroglaucin separates in dark blue crystalline groups, visible to the naked eye, partly on the surface and partly at the bottom at the vessel. On taking a drop from the surface, and examining it under the microscope, uroglaucin [has the appearance of a dark central spot, from which proceed numerous lengthy tentaculæ].

To separate the two products of oxidation of uroxanthin, we collect on a filter the sediment thrown down by nitric acid, and agitate it with cold spirit of .830, which takes up the urrhodin, (as also does ether;) the residue is boiled for some time with spirit of the same strength, until the fluid becomes somewhat concentrated; we thus get a bright blue solution of uroglaucin.

To exhibit these substances in normal urine, the fluid must be so far evaporated as just to remain liquid. On adding concentrated nitric acid to the cold residue, a crystalline magma of nitrate of urea is at once formed; on adding to this a few more drops of nitric acid (and sometimes even this is unnecessary) it assumes a violet tint. If the cyrstalline mass is allowed to stand for some time, and is then dissolved in the smallest possible quantity of distilled water, after being left at rest for some time, it deposits a sediment in which urrhodin and uroglau-

cin may be detected either by the microscope or by extraction with cold, and then with boiling spirit.

The action of nitrate of silver on uroxanthin is very singular. On precipitating the chlorine by an excess of nitrate of silver from urine acidulated with nitric acid, and then carefully neutralizing the filtered liquid by ammonia, there is not only a pale yellow precipitate of phosphate of silver, but the fluid assumes a brown tint, and in a short time there is likewise a brown sediment.

Heller has not yet succeeded in isolating uroxanthin. Uroglaucin associated with urrhodin, occurs in urinary sediments in Bright's disease, and in cases in which urine, abundant in uroxanthin, has become alkaline in the bladder. Heller has noticed it in these sediments forming groups of delicate prisms. It likewise assumes this form when urine abounding in uroxanthin is treated with nitric, sulphuric, or hydrochloric acid. In this case it is principally found on the surface of the fluid.

When allowed to crystallize from its cold spirituous solution, it forms groups which appear nearly black, but are blue and transparent at the edges.

Urrhodin appears to be a less oxydized product of uroxanthin than uroglaucin, and usually occurs in much larger quantity. It is most commonly observed in cases in which the urine is alkaline before emission, in consequence of containing much vesical mucus, and its developement in such cases is

hastened by the addition of nitric acid. The method of isolating it has been already described. Heller has never succeeded in obtaining it from its spirituous solution in a crystalline form. It occurs in granules, which, under the microscope, appear of a beautiful rose-colour. It is resinous in its nature, and burns with a clear flame.

On treating uric acid crystals obtained from healthy urine, with cold alcohol, the pigment formed a carmine solution, and the uric acid remained comparatively devoid of colour, being of a yellowish brown tint, from the brown pigment of the urine. The spirituous carmine solution, on exposure to the air, gradually became purple, and had all the properties of uroglaucin, previous to which it appeared to be identical with urrhodin.

On treating the red sediment common in inflammatory affections, and tinged with uroerythrin, with hot and cold alcohol and ether, the red pigment remained unaffected, unless a little acid was added. The difference of insolubility in the above menstrua is therefore sufficient to separate uroerythin from urrhodin."\*

## II. INORGANIC ELEMENTS.

## (a.) Normal.

148. The normal inorganic elements of the urine are constituted by the fixed salts, namely the

<sup>·</sup> Simon's Chemistry by Dr. Day.

sulphates and phosphates of potash, soda, lime, and magnesia, the chlorides of their metals, and by silex.

To ascertain their amount evaporate three or four ounces of urine acidulated with nitric acid, incinerate the residue and weigh the melted white ash that is obtained. Dissolve a given portion of it in water, to which a small portion of nitric acid has been added. Filter the solution and the silicic acid, if any be present, will remain on the filter probably in combination with a little carbon. Wash it, burn it with the filter, and determine its weight. Then mix the solution with the washings of the contents of the filter and add liquor ammoniæ to a slight excess. Warm the mixture and the earthy phosphates will be completely precipitated. Wash and dry them and expose them to a red heat and weigh them. To discover the proportion of lime dissolve them in very dilute nitric acid, and saturate the free acid with ammonia, then by adding oxalate of ammonia, the lime will be thrown down in the form of an oxalate. Separate it by filtration and calculate the amount of lime from its composition. Then add liquor ammoniæ to the clear fluid to precipitate the ammoniaco-magnesian phosphate. Collect the triple salt on a filter, wash it with water, dry and weigh it, and add the washings to the ammoniacal solution from which the earthy phosphates have been obtained, and supersaturate the

whole with nitric acid. Then add chloride of barium until a precipitate is no longer formed, warm the fluid to promote the separation of the sulphate of baryta; separate this by filtration, wash it, expose it to a strong heat and weigh it. The quantity of sulphuric acid must then be calculated.\* Mix the washing's of the sulphate with the solution from which it was procured, in a stoppered bottle a little larger than sufficient to contain the whole of the mixture, and add liquor ammoniæ to supersaturation, and afterwards chloride of barium as long as phosphate of baryta continues to be thrown down. Set the bottle by with the stopper in it for the salt to subside; then pour off the supernatant liquor; collect the precipitate, treat it as the sulphate and calculate the amount of acid it contains.+ Mix the ammoniacal fluid now remaining, and which contains the fixed alkalies, with the washings of the phosphate, evaporate it, treat the residue with sulphuric acid, and, after the excess of

*	Composition o	f Sul	phate	of B	aryta	:	
	Baryta						65.63
	Acid.						34.37
							100.00
+	Phosphate of	Bary	ta:				
	Baryta						68.20
	Acid	*	٠				31.80
							100.00

acid has been expelled by heat, dissolve it in water. Filter the solution and separate the sulphuric acid by means of chloride of barium; again filter, and the chlorides of potassium and sodium will be obtained by evaporation. The proportion of chlorine may be determined by dissolving a given weight of the fixed salts in water acidulated with nitric acid, and then adding nitrate of silver, so long as a precipitate is formed, to the filtered solution.\*

149. Soda may also be detected in the urine by evaporating the alcoholic solution, obtained by treating the secretion, reduced to the consistence of syrup, with this fluid; the chloride of sodium will then be left and may be distinguished under the microscope by its crystals, which, owing to their containing urea, have lost their natural cuboid shape and assumed that of octahedrons. By submitting the salt thus procured to the action of the blow-pipe a yellow flame will be produced.

The presence of soda in the urine is also indicated by the formation of the microcosmic double salt of phosphate of soda and ammonia, characterized by its rectangular prismatic crystals when the urine becomes decomposed.

• Chloride of sil	ver:			WF 00
Silver				75,33
Chlorine			٠	24.67
				100.00

150 Potash.—To detect this alkali dissolve the fixed salts in a little hydrochloric acid, extract them by alcohol, and add to the alcoholic solution of chloride of potassium some chloride of platinum which will throw down a yellow precipitate of chloride of potassium and platinum in the form of small yellow shining prismatic crystals. Potash also communicates a violet tint to the flame of a blow-pipe, and is precipitated from its aqueous solution by an excess of tartaric acid.

151. Ammonia.—Heintz demonstrates the presence of ammonia, and indeed of potash likewise, by the following process. He treats urine that has been recently passed with chloride of platinum and then adds to it a mixture of alcohol and ether, made in the proportion of three volumes of the former to one of the latter. A precipitate is thus formed which is collected on a filter, washed with etherized alcohol, dried and heated to redness. The residue is then repeatedly taken up with boiling dilute hydrochloric acid, the solution filtered and the filter afterwards burnt. The platinum which remains corresponds to the amount of ammonia and potash in the urine. By this process Heintz found the proportions of these alkalies to vary between 2.16 and 2.19, and 1.315 and 1.325 respectively in 1000 parts.

(b.) Abnormal.

152. The subcarbonates of lime and magnesia

may exist in the urine, either in solution, being retained in it in that state by an excess of carbonic acid, or as a deposit. If in solution, they will be thrown down when the acid is expelled by heat, and may be detected by their solubility in an acid with effervescence.

The presence of lime may be ascertained by the addition of oxalate of ammonia to the ammoniacal solution of the precipitate producing a deposit of oxalate of lime; while the existence of magnesia may be discovered by saturating the double carbonated salt with phosphoric acid, then setting the liquid by to crystallize, dissolving the crystals that are formed in hydrochloric acid, separating the lime in the manner just described, and adding to the supernatant liquor, solution of ammonia, when the ammoniaco-magnesian phosphates will be precipitated.

153. Neutral Phosphate of Lime.—To separate this salt from the ammoniaco-magnesian phosphate with which it is generally mixed, treat the deposit with acetic acid; this will dissolve the triple salt and leave the phosphate of lime behind in an amorphous state. It is precipitated from its solution in hydrochloric acid by liquor ammoniæ, and its acid solution, when neutralized with this alkali yields a precipitate on the addition of oxalate of ammonia.

The lime may be also separated, either from the

solution of the phosphate in hydrochloric acid, or from the compound deposit, by means of sulphuric acid as an insoluble sulphate.

The phosphate of lime is precipitated from healthy urine in combination with the ammoniaco-magnesian phosphate by caustic ammonia, and with the phosphate of magnesia by liquor potassæ.

When examined under the microscope it generally appears as an amorphous powder, but is occasionally met with in the crystallized state, as for instance, when the urine has remained long in a state of decomposition.

154. The neutral and bibasic ammoniaco-magnesian phosphates are distinguished by the following characters. They are very slightly soluble in either hot or cold water, but are soluble in acids, from which they are again precipitated by ammonia. Mixed with caustic potash and heated, ammonia is evolved; and their solution in hydrochloric acid yields on evaporation crystals of hydrochlorate of ammonia.

155. The neutral triple phosphate is the form most commonly met with. It occurs during the commencement of the decomposition of the urine, or when a small quantity of ammonia is added to the healthy secretion, and may be recognized by its prismatic crystalline appearance under the microscope. It is the only variety of the triple salt that can occur in acid urine.

156. The bibasic form is met with in urine that has been long kept and become putrescent, and may be thrown down artificially from the healthy fluid by an excess of ammonia. It crystallizes in beautiful stellæ.

Dr. Bird gives the following formula as representing the probable composition of the two salts.

Neutral or prismatic salt 
$$= (HO, NH_4O, MgO,) + P_2O_5, (dry)...$$

Basic or Stellar salt (dry) 
$$= (NH_4O, 2MgO,) + P_2O_5$$

# Inorganic Colouring Matters.

157. Cyanowrine when present in the urine communicates to it a fine blue colour and becomes deposited from it by repose. By collecting it on a filter it may be separated from any adherent matters by repeatedly washing it in water, in which it is insoluble, and then dissolving it in sulphuric acid, from which it can be thrown down by the gradual addition of magnesia. The cyanourine thus obtained has a dark blue colour, is without taste or smell, and is insoluble in cold, and but very sparingly so in boiling water. It is soluble in diluted acids which become of a brown or red colour in propor-

tion to their quantity. On evaporating its sulphuric acid solution, a carmine extract is left soluble in water with the production of a brown coloured fluid. It is soluble in the hot solutions of the alkalies and their carbonates, the former assuming a brown and the latter a red hue.

158. Indigo. As we have already seen, this substance has been discovered in the urine of persons to whom it has been administered as a remedy, and as also been met with in cases where it appears to have originated in the system; an opinion which is greatly favoured by its composition namely, C16, N H5, O2, being very similar to that of certain organic matters. Like cyanourine, it communicates a deep blue colour to the urine, from which it separates in the form of a blue powder. On collecting it by filtration it is found to be both tasteless and inodorous, insoluble in water, soluble in ether and alcohol, to which it gives a yellow colour, and also in sulphuric acid, the solution being purple. It is converted by nitric acid into the nitropicric; and is deoxidized by sulphuretted hydrogen, various sulphites, and the protoxide of iron, &c., with the addition of an alkali, and is thrown down from the alkaline solution, when this is saturated by hydrochloric acid, in a white flocculent crystallized state, to which the blue colour becomes restored on exposure to the atmosphere.

159. To detect the presence of indigo in a deposit,

place the latter in diluted alcohol, with a little grape sugar and caustic potash, and the blue colour, if due to indigo, will be replaced by a yellowish red, which on shaking the mixture, becomes converted, first into a deep blood red and then into a green; the yellowish red being at length eventually restored when the fluid is left at rest.

160. Prussian Blue has been discovered in the urine by various observers, and M. Julia Fontanelle detected it in the secretion of a boy who had swallowed ink. It forms a blue deposit characterized by its insolubility in water and alcohol, and by its being decomposed by a solution of potash with the production of peroxide of iron which is precipitated, and a yellow liquid of ferrocyanide of potassium, from which this salt may be obtained in crystals on evaporation.

FINIS.

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#### ERRATA.

Page 18, line 10 from bottom, for peribus, read paribus.

- ,, 39, line 4 from top, for 70, read 82.
- ,, 58, line 10 from top, dele s in portions.
- ,, 64, line 9 from top, for assimulation read assimmilation.
- ,, 74, line 3 from bottom, for these read then.
- ,, 81, line last, for oxylate read oxalate.
- ,, 96, line 9 from bottom, for hipphuric, read hippuric.
- ,, 10!, line 9 from top, for one read our.
- ,, 126, line 8 from top, dele first and.

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