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URINARY DEPOSITS,

THEIR

DIAGNOSIS, PATHOLOGY,

AND

THERAPEUTICAL INDICATIONS.

BY

GOLDING BIRD, A.M., M.D., F.R.S.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS,

Assistant Physician to, and Lecturer on Materia Medica at, Guy's Hospital; Vice-President of the Medical Society of London; Late President of the Westminster Medical Society; Fellow of the Linnean Society of London; Corresponding Member of the Philosophical Institute of Basle, of the Philosophical Society of St. Andrews, of the Medical Society of Hamburg, &c., &c.

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Fürwahr nur skizzenweise.

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PREFACE

TO THE SECOND EDITION.

THE favourable manner in which this work has been received by the profession has rendered it necessary to prepare a new edition. As two years have scarcely elapsed since the publication of the first, my labours have been directed rather to revising and improving the whole work than in adding much novel matter. In doing this, I have freely availed myself of the suggestions and criticism of my professional brethren.

I would beg especially to recommend to all interested in the subjects treated of in this volume, the study of Dr. Day's excellent translation, or rather new edition, of Simon's Animal Chemistry, published under the auspices of the Sydenham Society, an institution to which the profession is already deeply indebted for many important works.

I cannot avoid in this place expressing my thanks to the editors of the British and American medical journals, who have accorded to this work an amount of approbation which I could have wished it to have better deserved, and of which I have laboured to make this edition more worthy.

19, *Myddelton Square, September,* 1846.

PREFACE

TO THE FIRST EDITION.

In the early part of last year, I delivered, to the pupils of Guy's Hospital, a short course of lectures on the diagnosis and pathology of urinary sediments, which were reported in the London Medical Gazette. I have been repeatedly requested to arrange them for publication in a separate form, but from pressure of other engagements, I was unable to turn my attention seriously to the subject, until a few months ago, and had not proceeded far with my task when I received from Vienna a translation into German of the lectures reported in the Gazette collated into a volume* with my papers in

* Die Harnsedimente in diagnostischer, pathogenetischer und therapeutischer Beziehung, von Dr. Golding Bird.—Wien, 1844; and Vorselungen über die physikalischen, pathologischen, und semiotischen Charaktere der Harnsedimente, von Dr. Golding Bird, Redakt. v. Dr. F. L. Behrend, Liepzic, 1845.

Guy's Hospital Reports, by Dr. Sigismund Eckstein. The perusal of this, induced me much to extend, indeed, nearly to re-write the whole subject, and now I venture to place this work before my professional brethren, as the result of many years' close observation, in the field of public experience which I have been fortunate enough to have at my command.

In coming in contact with pupils in the course of my duties as a teacher of my profession, and in mixing with medical men in practice, I have often found them in want of some work which would enable them readily to discover the nature of a deposit in the urine, and succintly to point out its pathological and therapeutical indications. To be of use, it was necessary that such a work should not exceed the size of a small manual, and its contents be so arranged as to admit of ready reference, and thus be more fitted to act in the humble office of pioneer to more elaborate, and more diffused sources of information.

Anxious to avoid all topics unconnected with the practical bearing of the subject, everything partaking of a controversial character has been omitted, wherever it could be done.

It has been a subject of deep regret to me to be obliged, in some instances, to dissent from the ingenious and beautiful hypothetical views of one of the greatest chemists of the present age, the illustrious Liebig—I should personally have felt better pleased if the results of observation at the bed-side had enabled me to have supported the view of this philosopher in regard to chemical pathology. For I feel convinced that had Prof. Liebig any time or opportunity for acquiring a knowledge of the phenomena of disease, so as to test the accuracy of many of the opinions suggested by his fertile mind, he could not fail to confer discoveries of the utmost importance upon medical science.

The objection often urged against the possibility of a minute acquaintance with urinary deposits being available in practice, on the plea of the time required for their investigation, no longer exists, since the re-introduction* of the microscope for their examination; a minute or two being sufficient for the observer to learn the nature of any variety of sediment.

Whilst endeavouring to describe the diagnosis and pathology of urinary deposits as minutely as appeared necessary, the consideration of their treatment has been dismissed in a briefer manner, as the valuable volumes of Dr. Prout and Sir Benjamin Brodie must render any

* It is not generally known that Van Swieten, the celebrated commentator on Boerhaave, applied the microscope nearly a century ago to the examination of calculous deposits; he minutely described an uric acid sediment as composed of crystals "having the figure of a rhombus, whose opposite angles are obtuse and equal, other parallelopiped molecules ran between them, redder and larger than the former." (Commentaries, 1776, Edinburgh, vol. xvi. page 81.) Even long prior to this, De Peiresc, born in 1580, described the same deposit as resembling under the microscope, a "heap of rhomboidal bricks." This observation is recorded by the celebrated Gassendi, in his biography of De Peiresc, and is quoted by Van Swieten. An excellent microscopic drawing of uric acid lozenges exists in Hook's Micrographia, published in 1665.

more minute account of the special treatment of calculous affections unnecessary. The only exception to this, has been in the instance of oxalate of lime, and I have felt it necessary to enlarge particularly on the pathology and treatment of cases of this disease in consequence of the scanty amount of information to be found elsewhere. The chapter upon the therapeutical employment of remedies intended to influence the function of the kidneys, is, I am conscious, very imperfect; I, however, felt anxious to allude to this important subject, in the hope of drawing the attention of the practitioner to its careful consideration.

For minute chemical details connected with the contents of this volume, I beg to refer the reader to the excellent manual on the "Analysis of Blood and Urine in Health and Disease," by my friend and colleague Dr. G. Owen Rees, whose investigations, in connexion with animal chemistry, have gained for him a deservedly high reputation. The "Practical Manual" of Dr. Griffith contains some most accurate microscopical drawings of the different deposits. Whilst for an account of the chemical discrimination of calculi, the translation of Professor Scharling's work, by Dr. Hoskins of Guernsey, will prove a safe and excellent guide.

In conclusion, I may venture to indulge a hope that this work may be of service to the practitioner, in removing any difficulties which may have prevented his interpreting into intelligible language, the invaluable indications furnished by deposits in the urine.

Myddelton Square, October, 1844.

DEDICATION

TO THE FIRST EDITION.

TO

DR. ADDISON,

SENIOR PHYSICIAN TO GUY'S HOSPITAL, &c.

MY DEAR SIR,

IT is now thirteen years since I first found myself within the walls of Guy's Hospital, a stranger and unknown. In a short time, my admiration and respect were excited for your profound knowledge and experience as a physician, and for your zeal as a teacher. But I soon experienced another feeling, that of gratitude, for numerous acts of the most disinterested friendship; and for which I must ever remain your debtor.

I cannot look back upon my past career, so far as it has extended, without gratefully acknowledging how much I owe to your example, and to the exertion of your friendly influence, from the time I took my seat upon the pupils' benches, until I had the high honour of being appointed your colleague.

That your health may be preserved, so that our profession may, through a long series of years, possess you as an ornament; and Guy's Hospital long enjoy your assistance as its distinguished physician and teacher; is the sincere wish of

Your obliged and grateful friend,

GOLDING BIRD.

Myddelton Square, October 20th, 1844.

ANALYTICAL INDEX.

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CHAPTER III.

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APPENDIX.

NOTE.

In the following pages, the figures included in the parentheses, refer to the numbered paragraphs, the smaller ones to the table of authorities at page 341

LIST OF THE MICROSCOPIC VIEWS OF DEPOSITS.

The reader is requested to correct the following erratum with his pen.

Page 39, column 6 of the Table, *for* 35.746, *read* 34.746.

URINARY DEPOSITS,

THEIR

DIAGNOSIS, PATHOLOGY, &c.

CHAPTER I.

PRELIMINARY DETAILS CONNECTED WITH THE CHEMISTRY OF THE URINE.

1. As it is probable that many practitioners into whose hands this volume may fall, may not be well versed in the chemistry of urine, nor more than acquainted by name with its chief constituents, I have thought the following introductory remarks might not be unacceptable. It is indeed

quite essential that every one, who purposes making himself acquainted with the important bearings of urinary pathology on the practice of his profession, should be at least acquainted with the characteristics of the most important constituents of the secretion. I would therefore advise the student to carefully repeat the processes described in the following paragraphs (2—11) before proceeding further, with the assurance that his subsequent researches will be thereby much facilitated, and the whole subject rendered much more intelligible.

Demonstration of the chief constituents of the urine.

2. In the following directions for enabling the reader to become personally acquainted with the most important ingredients of the healthy urine, I am anxious to be regarded as addressing those who are complete novices in chemical manipulations. Directions of this kind are of course quite useless to the adept. By the plan now suggested, any one can satisfy himself of the existence of the most important elements of the urine with the slightest amount of expenditure of time and trouble, and no greater amount of chemical knowledge than necessarily falls to the lot of every practitioner of medicine.

The urine chosen for examination should be some passed into a glass vessel immediately on rising from bed.

3. Examine the urine by holding it between the eye and the light, a delicate cloud of *mucus* (248) will be observed floating in its centre. On passing the urine through a filter, the mucus will be left upon it in a thin varnish-like layer.

4. Gently warm about an ounce of the urine, and pour it into a conical wine-glass in which a few drops of hydrochloric acid have been previously placed, and set it aside. In a few hours a thin crystalline pellicle of a reddish brown, or even darker hue, will be observed on the surface; this on agitation breaks up and falls in minute crystals to the bottom of the vessel. A drop of the fluid containing these crystals should be placed on a slip of glass and examined by the microscope. The fascicular and laminar crystals of *uric acid* will at once be recognized. (Fig. 1.)

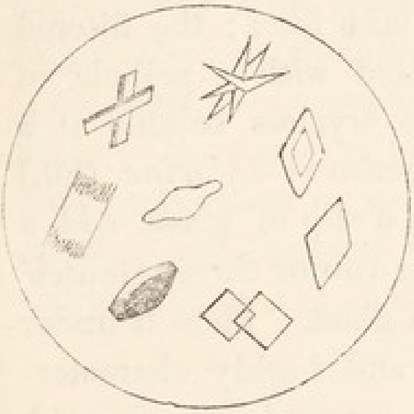


Fig. 1.

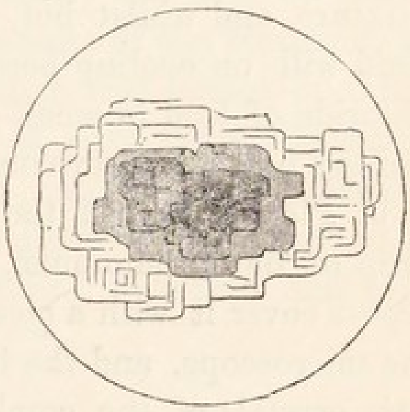


Fig. 2.

5. Place about a tea-spoonful of urine in a watch-glass, and evaporate it to about one-third its bulk by the heat of a lamp, or by placing it on the hob of a fire-place. When cold, add an equal bulk of colorless nitric acid; in a few seconds crystals of nitrate of *urea* will fill the vessel. If they be collected on blotting-paper and dried by pressure, they will present a fine satin-like lustre resembling, under a lens, laminæ of mother o' pearl. (Fig. 2.)

6. Fill a test-tube one-third full of urine, boil it over a lamp, and add immediately one-fourth its bulk of

hydrochloric acid. The production of a fine pink color will at once demonstrate the existence of the peculiar coloring matter of the urine. (75.)

7. Acidulate some urine in a test-tube, by means of dilute nitric acid. Add a solution of nitrate of baryta, a white precipitate of sulphate of baryta will fall, thus indicating the presence of *sulphuric acid.*

8. Add to a tube half full of urine a solution of acetate of lead, a dense precipitate will fall, consisting of combinations of chlorine, phosphoric, sulphuric, uric, hippuric acids, and organic matter with lead. Boil the mixture, and whilst hot, throw it on a filter; the filtered fluid will on cooling become covered with a pellicle of chloride of lead in small prismatic crystals soluble at a boiling heat, thus proving the presence of *chlorine.* (86.)

9. Place a drop of the urine on a slip of glass, add a drop of liquor ammoniæ, and after two or three minutes' repose cover it with a piece of thin glass. Place it under the microscope, and the beautiful and highly characteristic crystals of the combinations with *phosphoric acid,* with *magnesia,* and ammonia, in elegant stellæ, (Fig. 3,) will at once indicate the existence of the two former substances. (80.)

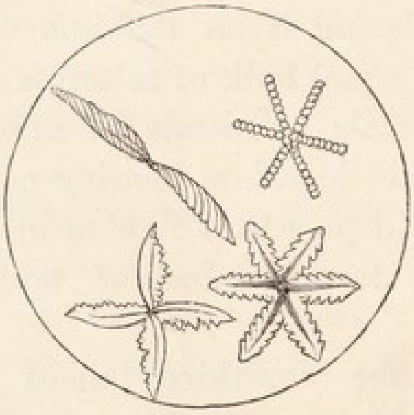


Fig. 3.

10. Place a drop of urine, as before, on a piece of glass, add a drop of a solution of oxalate of ammonia. A cloud will immediately form from the precipitation of oxalate of *lime*, and on examining this under the microscope, (using an object glass of one-fourth inch focus,) it will be found to be composed of infinitely minute cohering crystals, each presenting a square outline.

11. Place a few drops of urine carefully in the centre of a slip of glass, and evaporate it to dryness. When nearly dry, examine it under the microscope, and little octahedra of *chloride of sodium* will be visible. The urine passed after breakfast is usually the best for exhibiting the crystallization of the salts of the secretion, as it contains less organic matter than that passed at other times of the day. A few drops of such urine examined after evaporation on a glass plate exhibits very beautiful cresslets and daggers, variously modified, of chloride of sodium, (Fig. 4); mixed with these, dendritic and plu-

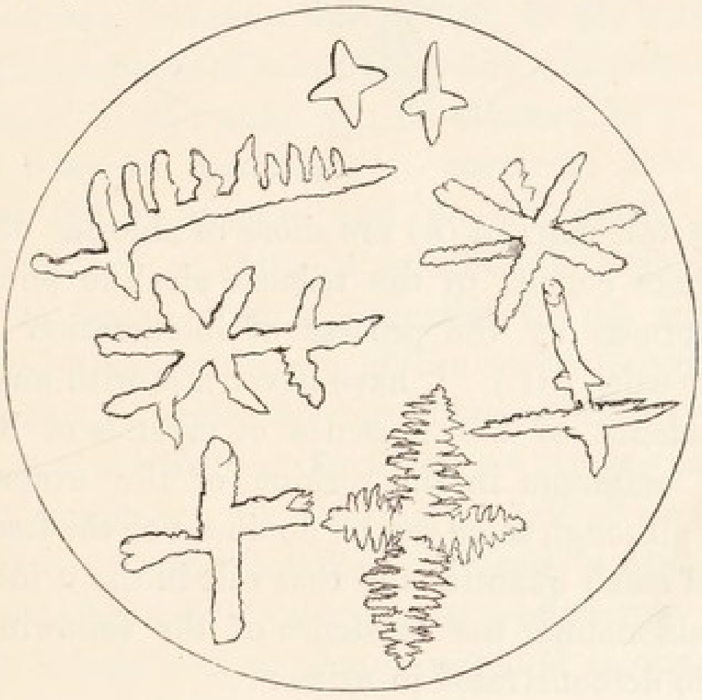


Fig. 4.

mose crystals of *phosphate of soda* are frequently visible. Some of these have been described as consisting of hydrochlorate of ammonia; but as they can easily be obtained from a solution of the ashes of urine, they cannot possibly be composed of this salt. In Fig. 5 is a microscopic representation of the crystals left by the evaporation of a drop of the watery solution of the ashes of urine.

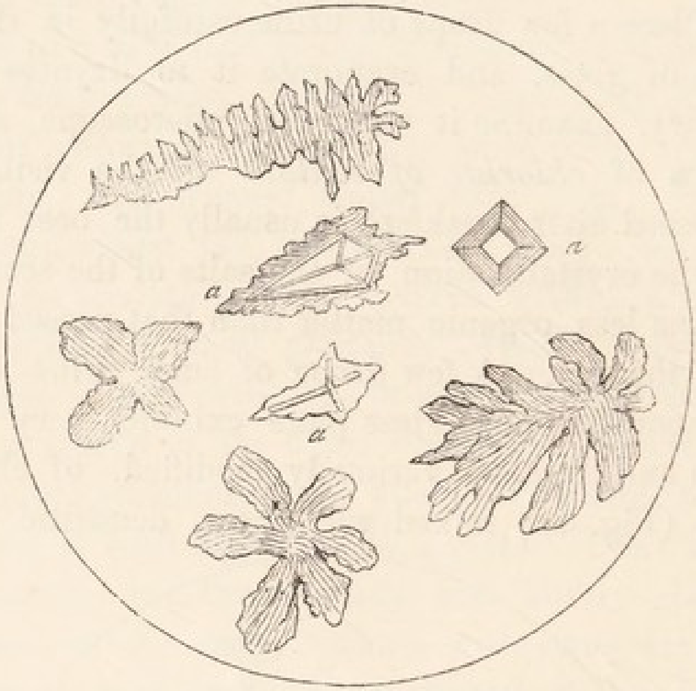


Fig. 5.

The crystals marked (*a*) are those of chloride of sodium; the others consist of the tribasic alcaline phosphate of soda, formed by the process of incineration from the rhombic salt. (81.) I have never met with any satisfactory evidence of the presence of crystals of hydrochlorate of ammonia in the residue of the evaporation of urine; although there can be no doubt of the frequent presence of small quantities of that salt in the urine.

In this manner the existence of the following constituents is demonstrated in urine:

Urea	by experiment	5
Uric acid		4
Coloring matter, rich in carbon		6
Mucus		3
Chlorine		8
Sulphuric acid		7
Phosphoric acid		9.11
Lime		10
Magnesia		9
Chloride of sodium		8.11
Phosphate of soda		11

B. *General analysis of urine containing no abnormal ingredients.*

12. An accurate analysis of the urine constitutes one of the most difficult problems in chemistry, and can only be undertaken with any approach to accuracy in the results, by the experienced chemist. A minute investigation of this kind is too frequently impracticable, from its involving an expenditure of time and attention wholly out of the reach of those who are actively engaged in practice. It is, however, fortunate that almost all the really useful information capable of being yielded by a knowledge of the composition of the urine, can be attained by a mode of analysis easy in performance, requiring merely common care for its success, and no considerable amount of chemical tact or skill, or sacrifice of time. This is effected by limiting the examination to the isolation of those ingredients which are of the most recognized pathological importance, rejecting those which exist in small quantities, and which, so far as we yet know, present no practical bearings. By availing himself of processes of this kind, every practitioner could readily contribute most important additions to the present meagre state of chemical pathology with an almost nominal amount of trouble and chemical skill.

13. Presuming that the practitioner possesses no chemical apparatus, it will be very necessary for him to procure the following, which will require the outlay only of a few shillings.

Griffin's earthen ware lamp-furnace.*

A glass funnel and good filtering paper of firm texture.

A Berlin porcelain crucible holding about an ounce.

A couple of Berlin evaporating dishes fitting the opening of the water-bath of the furnace.

A conical precipitating glass, or plain wine glass.

A few watch-glasses and test-tubes.

A small gravimeter for taking specific quantities.

The balance required need not be an expensive one. One turning readily with a quarter of a grain, when loaded with an ounce, will be sufficiently delicate.

14. Place the urine in a cylindrical glass, and immerse the gravimeter; the specific gravity thus discovered will, by a reference to the tables, (42, 46,) show the weight of a fluid ounce in grains, and the proportion of solid matter in that quantity, as well as in 1000 parts. Where great accuracy is desired, it will be proper to check this information by evaporating a fluid ounce of the urine to as near dryness as possible by means of a water-bath, (15), and weighing the residue. This process, simple as it appears, is really one of extreme difficulty, and so obstinately are the last portions of water retained, that it can be scarcely satisfactorily effected without the aid afforded by an air-pump, so as to complete the operation by drying the residual mass in vacuo over sulphuric acid or quick lime.

* This and the other procès of apparatus can be procured of any of the agents of Messrs. Griffiin, of Glasgow. In London they may be obtained readily from Mr. Ward, Bishopsgate-street Within, or Mr. Button, Holborn Bars.

15. Place a carefully measured fluid ounce of the urine in a porcelain capsule *a* fitting into the opening of an earthenware water-bath *b* about half full of hot water. Place this apparatus on the top of the earthen cylinder *c* of Griffin's lamp furnace. A lighted spirit or oil-lamp being introduced into the latter, the water in the bath will soon boil, and its vapour condensing on the bottom of the capsule *a*, will cause its contents to evaporate without risk of loss by the production of violent ebullition or burning. When the urine has evaporated to about a fluid drachm, lift the capsule from the bath, and allow it to cool. While cooling, it will become opake from the deposition of the earthy phosphates and urate of ammonia. When cold, fill the water bath with water, containing some pieces of ice, or, if the ice is not at hand, a mixture of three drachms of finely powdered nitrate of potass, and as much hydrochlorate of ammonia stirred into the water as a substitute for the ice. Care must be taken that enough water is present to reach the bottom of the capsule containing the inspissated urine, when fitted to the aperture of the bath. Having then replaced the capsule, carefully add half a fluid drachm of cold colourless nitric acid, stirring the mixture with a glass rod; only a slight effervescence will occur, if the apparatus be kept sufficiently cool, and the whole will become nearly solid, from the formation of crystalline scales of nitrate of urea. Empty the whole mass on a funnel provided with a properly folded filter of fine bibulous paper, and gently drop on the mass a very small quantity of ice-cold water in a very slender stream. When nearly drained, carefully raise the filter from the funnel,

Fig. 6.

and gently opening it, place it on the smooth surface of a porous brick. In a few hours the nitrate of urea will be found nearly dry in a slightly cohering mass, capable of being easily detached from the paper. It should be carefully removed into a capacious watch-glass, and after being kept for an hour in a warm place, it should, before becoming quite cold, be carefully weighed. 100 grains of the impure nitrate thus procured indicate nearly exactly 48 grains of urea.

16. A fluid ounce of the urine should be gently warmed and poured into a conical glass, in which about 30 drops of hydrochloric acid have been previously placed. The mixture being stirred with a glass rod, and covered with a piece of paper to exclude the dust, must be then set aside for 12 hours. The uric acid will be found partly floating in a pellicle on the surface, and partly precipitated on the sides of the glass in dark coloured grains. The whole is to be well stirred with a glass rod, so as to excite a vortiginous motion in the fluid, aided by which all the uric acid will in a few moments fall to the bottom of the glass. The supernatant fluid should be decanted and replaced by distilled water. After repeating this process three or four times, the precipitated acid may be washed with a few drops of water into a watch-glass, glass dried, and weighed. We thus learn the amount of uric acid existing in a fluid ounce of urine.

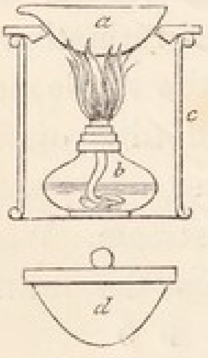


Fig. 7.

17. Evaporate an ounce of urine in a capsule *a* over a spirit lamp *b* without the interposition of the vapor-bath, and when reduced to about a teaspoonful pour it into a porcelain crucible *d*, washing the capsule in which the

evaporation is performed with a few drops of water, which are to be added to the contents of the crucible. By aid of the spirit-lamp, heat is to be applied until the contents of the crucible are dry and beginning to char. It should then be carefully placed in a little space made for it in the centre of a clear, smokeless, and flameless fire. Allow the crucible to remain at a bright red heat for ten minutes, then carefully remove the lid, taking care that no dust falls into the vessel, and in three or four minutes remove the crucible itself. It should be allowed to cool on a brick, or on sand, to avoid its fracturing by too sudden change of temperature. When cold a nearly white fused mass will be found, consisting of the combinations of sulphuric acid, phosphoric acid, and chlorine, with lime, magnesia, and soda, or potass, or both. The weight of these salts can thus be determined. If it be desired to calculate the proportion of earthy and alcaline salts, it can be easily effected by reducing the fused mass to powder and digesting it in water, by which the chloride of sodium and tribasic phosphate of soda, with any alcaline sulphate will be dissolved, and the phosphates of magnesia and lime will be left. The weight of the latter, when quite dry, subtracted from the weight of the fused mass, will of course give the proportion of alcaline salts present.

By the above process we have learned

The aggregate amount of solids	14	In a fluid ounce of urine.
——— of urea	15	
——— of uric acid	16	
——— of inorganic salts . .	17	

By deducting the aggregate weight of the urea, uric acid, and salts, from that of the total quantity of solids the weight of the mixture of what has been denominated extractive matters may be learnt. This so called extractive matter contains the peculiar colouring matter (of which, indeed, it is probably principally composed) hippuric acid, the nitrogenised substance of Pettenkofer, with lactic acid (if really existing in urine,) and perhaps combinations of ammonia.

On multiplying the quantities thus obtained by the number of ounces of urine secreted in 24 hours, the proportion of the different matters separated in that time by the kidneys, will of course be learnt.

I venture to hope that the process for analysis thus detailed is sufficiently simple and easy of execution to induce practitioners to make themselves conversant with it. How much valuable information would be collected in a few years if every member of the profession would thus examine, every second or third day, the urine of but one patient during the entire course of any well-marked ailment, as fever, the exanthems, rheumatism, &c.

C.—*On the clinical examination of Urine.*

19. The following observations may be of service to the practitioner, both as a guide to his proceedings in the superficial examination of the urine, the most important part of which can be readily performed in a few moments in the sick-room; and as a reference to the contents of this volume, which will direct him to the completion of his investigations when at leisure. Premising that the urine presented for inspection is either an average specimen of that passed in the preceding twenty-four hours (36), or at least that resulting from the first act of emission after a night's rest (38), unless the

urine secreted at other times of the day be specially required.

A.—Urine without any visible deposit, or decanted from the sediments.

20. A piece of litmus paper should be immersed in the urine, which if acid, will change the blue colour of the paper to red. Should no change occur, a piece of reddened litmus paper must be dipped in, and if the secretion be alcaline, its blue colour will be restored: but if its tint remains unchanged, the urine is neutral.

Some of the urine should then be heated in a polished metallic spoon over a candle, or what is preferable, in a test-tube over a spirit-lamp (237), and if a white deposit occurs, albumen or an excess of the earthy phosphates are present; the former, if a drop of nitric acid does not re-dissolve the deposit (236), the latter if it does (189).

If the urine be very highly coloured, and not rendered opake by boiling, the colouring matters of bile, or purpurine are present. To determine which, pour a thin layer of urine on the back of a white plate, and allow a few drops of nitric acid to fall in the centre; an immediate and rapidly ending play of colours, from blueish-green to red, will be observed if bile (47), but no such change will be observed if purpurine (76,139) alone exists. Should the highly coloured urine alter in colour or transparency by heat, the presence of blood must be suspected (238).

If the addition of nitric acid to deep red urine, unaffected by heat, produces a brown deposit, an excess of uric acid exists. If a specimen of urine be pale, immerse the gravimeter, and if the specific gravity be below 1.012, there is a considerable excess of water, but if above 1.025, the presence of sugar, or a superabundance of urea is indicated. To determine the existence of either of these conditions, place a few drops of the urine in a watch-glass, add an equal quantity of nitric acid, and allow the glass to float on some cold water; crystals of nitrate of urea will appear in two or three minutes, if the latter exists in excess (56). Should this change not occur, the urine must be examined specially for sugar, which, it must be remembered, may exist in small quantities, without raising the specific gravity of the fluid. For this purpose boil a small portion with an equal bulk of liquor potassæ in a test-tube, and the development of a brown colour will at once afford evidence of the almost certain existence of sugar (264-5). An excess of colouring matter, rich in carbon, should always be sought after, on account of its pathological importance. This is readily done by boiling some urine in a tube, and, whilst hot, adding a few drops of hydrochloric acid. If an average proportion of the pigment exist, a faint red or lilac colour will be produced; but if an excess is present, it will be indicated by the dark red, or even purple tint assumed by the mixture (76).

Should the urine be alcaline, add a drop of nitric acid; if a white deposit occurs, albumen is present (236); if brisk effervescence follows the addition of the acid, the urea has been converted into carbonate of ammonia (59).

B.—Examination of the sediment deposited.

21. If the deposit is flocculent, easily diffused on agitation, and scanty, not disappearing on the addition of nitric acid, it is chiefly made up of healthy mucus (248), epthelial debris (256), or occasionally, in women, of secretions from the vagina, leucorrhœal discharge (245), &c.

If the deposit is ropy and apparently viscid, add a drop of nitric acid; if it wholly or partly dissolves, it is composed of phosphates (188), if but slightly affected, of mucus (249). If the deposit falls like a creamy layer to the bottom of the vessel, the supernatant urine being coagulable by heat, it consists of pus (245).

If the deposit is white, it may consist of urate of ammonia, phosphates, or cystine; the first disappears on heating the urine (95), the second on the addition of a drop of diluted nitric acid (184), whilst the third dissolves in ammonia (146), and the urine generally evolves an aromatic odour like the sweet-briar, less frequently being fœtid.

If the deposit be coloured, it may consist of red particles of blood, uric acid, or urate of ammonia, stained with purpurine. If the first, the urine becomes opake by heat 238); if the second, the deposit is in visible crystals (92); if the third, the deposit is amorphous, and dissolves on heating the fluid (95).

Oxalate of lime is often present diffused through urine, without forming a visible deposit; if this be suspected, a drop of the urine examined microscopically will detect the characteristic crystals (165).

If the urine be opake like milk, by repose, allowing a cream-like layer to form on the surface, an emulsion of fat with albumen is probably present. Agitate some of the urine with half its bulk of ether, in a test-tube, and after a few minutes repose, a yellow ethereal solution of fat will float on the surface of the urine,—a tremulous coagulum of albumen generally forming beneath it (279).

22. Much of the little time required for the investiga-

tion thus sketched out, may be saved by remembering the following facts.

If the deposit be white, and the urine acid, it in the great majority of cases consists of urate of ammonia ; but should it not disappear by heat, it is phosphatic.

If a deposit be of any colour inclining to yellow, drab, pink, or red, it is almost sure to be urate of ammonia, unless visibly crystalline, in which case it consists of uric acid.

23. the following tables briefly point out the readiest mode for the examination of crystalline deposits, both by chemical tests and by microscopic examination. The latter mode is of course preferable to all others, both for the accuracy and extent of the information it affords as well as for economy of time.

A. Table for discovering the nature of urinary Deposits by chemical Re-agents.

1.	Deposit white..............................	2
	—— coloured....................	5
2.	—— dissolves by heat	— Urate of ammonia.
	—— insoluble by heat............	3
3.	—— soluble in liquor ammoniæ. ..	— Cystine.
	—— insoluble in —————....	4
4.	—— soluble in acetic acid..........	— Earthy phosphates.
	—— insoluble....................	— Oxalate of lime.
5.	—— visibly crystalline............	— Uric acid.
	—— amorphous..................	6
6.	—— pale, readily soluble by heat...	— Urates.
	—— deeply coloured, slowly soluble by heat..................	— Do. stained by purpurine.

B.—Table for the microscopic examination of crystalline Deposits.

1.	Deposits white	2
	—— coloured	5
2.	—— amorphous { insoluble by heat	— Phosphate of lime.
	—— amorphous { soluble	— Urate of ammonia.
	—— in defined crystals	3
3.	—— in prismatic crystals	— Triple phosphate.
	—— in octahedral or tabular crystals	4
4.	—— in octahedra	— Oxalate of lime.
	—— in simple or compound tables	— Cystine.
5.	—— in transparent crystals	— Uric acid.
	—— amorphous, or in spherical masses	— Urate of ammonia.

The microscope used in all these researches must be provided with a good achromatic object-glass of one half-inch focus, which will be sufficient for most observations connected with the pathology of the urine, with the exception of those which form the subject of chapter 12,—for which an objective of at least one-fourth of an inch is necessary.

NOTE.

The most economical and efficient microscope of sufficient power for observations of this kind, with which I am acquainted, is one made by Mr. Powell, of Clarendon-street, Somers Town, for about £7. Mr. Prichard, of Fleet-street, supplies a very excellent one, having but a single object-glass of one-third of an inch, for £5. A most useful and portable instrument is sold under the name of "Microscope pour l'Hospice," by Georges Oberhäuser, Place Dauphiné, Paris, for 60 francs.

CHAPTER II.

PHYSIOLOGICAL ORIGIN AND PHYSICAL PROPERTIES OF URINE.

Indications of the urine, 24—Proximate source of, 25—Metamorphosis of tissue, 26—Three species of urine, 27—Stages of the assimilative processes, 28—Liebig's theory of the destruction of tissue, 29—Mulder's researches on protein, 30—illustrated in muscle, 31—Relation of urine to other secretions, 32—Physical characters—Density, 33-35—Variations of density, 36—Schweig's speculations, 37—Influence of fluid potations, 38—Average density, 39—Average bulk, 40—Formulæ for solids in urine, 41—Table of ratio between density and solids in 1000 grains, 43—Weight of a pint of urine of different densities, 44—Table of solids in a fluid ounce, 46—Colour, 47—Consistence, 48—Circular polarising power, 49—Applied to diabetic urine, 50, 51.

24. In availing himself of the phenomena presented by the urine in disease, it is essential that the practitioner should not fall into the error of regarding a knowledge of the morbid condition of the secretion as alone essential in directing his treatment; nor must he commit the equally serious mistake of regarding every deviation from the natural conditions of the urine as constituting a disease *per se*. The only view that can be legitimately taken of such conditions is to regard them, not as constituting entities of morbid action, but as one of a series of pathological changes going on in the system, and more valuable than others as an index

of disease, in consequence of the facility with which they can be detected. Hence every abnormal state of the secretion in question should be regarded rather as an indication of some particular phase of morbid action than as constituting the ailment itself.

It is true, that those pathological states of the urine which are accompanied by the formation of deposits, or gravel, as they are popularly termed, may, and frequently do acquire so serious a character as to lead to the formation of the much-dreaded stone or calculus; and thus have a claim, from their importance, to be regarded as definite and independent diseases. Still, both in their pathological and therapeutical relations, although frequently called upon, from the irritation they produce, to make the deposit or calculus the primary objects of attention, yet we must never lose sight of the fact, that these are but effects, not causes; the last links of a chain, of which it should be the endeavour of the physician to grasp the first.

25. In a physiological sense, the urine must be regarded as arising from three several sources, each acting alike in preserving the equilibrium of the delicately adjusted balance of the secreting functions of the body. The effects of copious aqueous potations in producing a free discharge of pale urine, at once indicates one source of the great bulk of the urinary secretion, and demonstrates one of the most important functions of the kidneys in their pumping off any excess of fluid which may enter the circulation. A second great duty of these organs is shown in the physical and chemical characters of their secretion after the digestion of food is completed. Here it is no uncommon circumstance

to detect the presence of some traces of the elements of an imperfectly digested previous meal; and in unhealthy and irritable states of the digestive functions, to discover some abnormal constituent in the urine, arising from the primary mal-assimilation of the food. Of the former of these states, the peculiar odour and colour of the urine after the ingestion of asparagus and some other bodies affords an example; and a good illustration of the latter condition is met with in the copious elimination of oxalic acid from the blood shortly after a meal in cases of irritative dyspepsia. Hence the kidneys have the duty of removing from the system any crude or indigested elements of the food which had been absorbed whilst traversing the small intestines and entered the circulating mass; and of excreting the often noxious results of imperfect or unhealty assimilation. To effect this process, it is essential that the substance to be removed should be soluble, or at least capable of being readily metamorphosed into a body soluble in the water of the urine; as nothing can be excreted from the kidneys without breach of surface unless in a state of solution (269). The third function performed by the kidney is its serving as an outlet to evolve from the animal organism those elements of the disorganisation of tissues which cannot perform any ulterior process in the economy, nor be got rid of by the lungs or skin. The disorganisation of tissues here alluded to, is a necessary result of the conditions for the growth and reparation of the body.

26. It is now generally admitted, that during each moment of our existence, every atom of the frame is undergoing some change or other; the old matter is absorbed and thrown off at one or other of the excreting outlets of the

body, and new matter is deposited from the blood to supply its place. The old and effete atoms of the animal structure are not excreted in the form of dead tissue, but their elements become re-arranged; one series of combinations thus produced, rich in nitrogen, is excreted by the kidneys, whilst those products which contain a preponderance of the inflammable elements, carbon, hydrogen, and, according to some late researches, sulphur, are called upon to perform, chiefly through the medium of the liver, an important office previous to their final elimination from the system.

27. It is therefore necessary to recognise three distinct varieties of the urinary secretion in every case under investigation: Firstly, that passed some little time after drinking freely of fluids, generally pale, and of low specific gravity (1.003—1.009), *urina potus*. Secondly, that secreted after the digestion of a full meal, varying much in physical characters and of considerable density (1.020—1.028 or even 1.030), *urina chyli vel cibi*. Thirdly, that secreted from the blood independently of the immediate stimulus of food and drink, as that passed after a night's rest, *urina sanguinis;* this is usually of average density (1.015—1.025), and presents in perfection the essential characters of urine.

28. As the elements of urine are thus assumed to owe their origin to a proeess by which the effete elements of the body are removed, it may be useful to inquire how far we are enabled to trace the exhausted tissue through its several changes until it disappears as a fluid excretion. This, as well as many other portions of chymical physiology, has been invested with a peculiar charm by the bold inductions of Professor Liebig, who has, with

great apparent success, endeavoured to trace the different stages of metamorphosis of tissue through the various secondary offices the secreted products are called upon to perform in the economy, until their final separation as effete and useless matter.

Food is taken into the stomach, and undergoes certain changes by which such of its constituents as are capable of forming albumen, as the protein elements of all animal and vegetable ingesta, are separated unchanged, and portions of its saccharine and amylaceous elements are converted into fatty or oily matters. This act constitutes the first stage of what has been aptly termed by Dr. Prout[1] *primary assimilation*. The elements of food thus separated or re-arranged by this process, being absorbed by the lacteals, reach the right side of the heart, and being exposed to the influence of the air in the lungs, become converted into blood. This act constitutes the second stage of primary assimilation. From the blood all the tissues of the body are formed, and the waste of the animal structures supplied; a process forming the first stage of secondary assimilation. The old and exhausted material has then to be removed, to make room for the deposition of new matter by a process referred to the second or destructive stage of the secondary assimilation of Dr. Prout, the metamorphosis of tissue of Professor Liebig [2]

Dr. Prout has expressed an opinion, that the elements of the albuminous tissues of the body are, during the process of metamorphosis, so arranged as to be converted into uric acid, or urate of ammonia, and the atoms not entering into the composition of these bodies, are so combined as to form " certain ill-defined principles." [3]

The ulterior changes which the gelatinous tissues undergo in the act of destructive or metamorphic assimilation, are supposed by this distinguished physician to be intimately connected with their conversion into urea, and some saccharine principle, or its close ally, the lactic acid. These opinions do not admit of positive proof, and hence can only be regarded as conventially correct.

29. Professor Liebig has, in following the track thus pointed out by our illustrious countryman, with a boldness which at least excites our admiration, endeavoured to express in numbers the changes occurring during the stage of destructive assimilation. He has assumed that the ultimate composition of animal flesh, as a muscle, and of blood, can be expressed by the same formula, and are consequently chemically identical. When, therefore, animal fibre is taken into the stomach, it undergoes a kind of imperfect solution, and reaches the circulation, possessing nearly the same chemical composition as the blood with which it becomes mixed. It then undergoes certain changes in the lungs, assuming probably a more highly vitalised condition connected essentially with the conversion of its albumen into self-coagulating fibrin; bodies, however different in their physical and molecular arrangement, nearly identical in composition. Reaching in their course the nutrient capillaries, the elements of the food are deposited in the substance of a tissue, as a muscle, whose waste they thus supply. Ere these new molecules can be deposited, room must be made for them by the removal of old matter, and then the following beautiful results of vital chemistry are supposed to come into play. The exhausted atoms of the muscle cannot be removed as fibres (26), but their elements must be re-arranged, so

as to enter the circulation and be carried to other organs. They therefore undergo metamorphosis; water and oxygen are conveyed to the muscle, the former in the fluid of the blood, the latter in the red particles, and the result is the re-arrangement of elements, which, whilst it enables the old tissue to be removed with facility, furnishes the pabulum for other and important secretions.

30. The late researches of Professor Mulder[4] of Utrecht on the combinations of protein with oxygen, have thrown much light on a very obscure part of the act of metamorphosis of tissues, and which constituted the least tenable part of Liebig's hypothesis: he having, as already stated, assumed that oxygen is conveyed to the capillaries in the arterial blood-corpuscules, combined with iron, as sesqui-oxide—which giving up part of its oxygen, reaches the venous blood as protoxide. This idea can be only regarded as an ingenious assumption, for which no proof is offered by its talented author. All the elements of our food capable of being organised into albuminous tissues, consist chiefly of a substance which, from the important functions it fulfils, is called Protein,* a compound of carbon, nitrogen, hydrogen, and oxygen, (C_{48}. N_{36}. H_6. O_{14}.) combined with varying proportions of sulphur and phosphorus. Professor Mulder has discovered two oxides of protein, a binoxide and tritoxide, both of which are formed in the animal economy, and constitute, when combined with fatter matter, the buffy coat of inflamed blood. He believes that the protein of the food reaches the right side of the heart, circulates through the lungs, and combines with oxygen, forming oxy-protein (binoxide, tritoxide, or

* Πρωτεύω.—I am first.

both); this reaches the nutrient capillaries, and all or part is decomposed; the oxygen being employed for the disorganisation of worn-out tissue, the protein thus deoxidised being deposited to supply its place. If more protein is set free than is required for the growth of tissue it passes unchanged into the veins, to be again oxidised in the lungs. The tritoxide of protein being soluble in water, is better enabled to traverse the minutest capillaries than if it existed merely diffused through the fluid containing it.

31. On Liebig's hypothesis, the elements of muscular tissue are carried into the circulation, combined with water and oxygen, the latter by its union with the carbon of the effete tissue, is supposed to aid the conservation of the temperature of the body. On reaching the glandular structure of the liver, 50 atoms of carbon, 1 of nitrogen, 45 of hydrogen, and 10 of oxygen, with an unascertained but considerable proportion of sulphur, are supposed to be filtered of from the portal blood, in the form of bile, a secretion which has to play an important part in the animal economy, prior to its final elimination. The more highly nitrogenised portions of the metamorphosed tissue are separated by the kidneys from the blood conveyed to them by the renal arteries chiefly in the form of urea and uric acid, whilst the carbonic acid formed by the slow combustion in the capillaries of the carbon of the original atoms of muscle, is exhaled from the surface of the skin or pulmonary membrane. In this mode, by a wonderful influence of vital chemistry, the exhausted fibre is ultimately expelled from the animal structure.

An analogous explanation to the above, may be applied to the destructive assimilation of all the other animal tissues.

32. The following example will afford a good illustration of the results flowing from these views. According to Becquerel's researches,[5] the average proportion of uric acid and urea excreted in 24 hours by a healthy adult amounts to 8·1 grains of the former, and 255 of the latter, being in the ratio of one atom of the acid to 82 atoms of urea. From the accurate experiments of Allen and Pepys, it appears that 18,612 grains of carbonic acid gas are exhaled by an adult man in 24 hours; a quantity, as compared to the uric acid and urea, equivalent to about 800 atoms of carbon and 1600 of oxygen.

The average proportions of the bile cannot be determined with satisfactory accuracy, but from the lowest assumed quantity secreted by a man in 24 hours, 9,640 grains may be regarded as near the truth. As bile contains about 90 per cent. of water, the amount of solids secreted in the bile during 24 hours will amount to 964 grains. Dried human bile contains about 69 per cent. of carbon, and hence 964 grains may be represented by about 14 atoms of solid bile, according to the provisional formula suggested by Dr. Kemp.[6]

For the purpose of yielding these products about 35 atoms of muscular tissue must be acted upon by at least 1783 atoms of oxygen. The heat evolved by this slow combustion aids in keeping up the temperature of the body; and the products of this oxidation of exhausted tissue will be—

14 atoms of solid bile, excreted by the liver.
82 ——— of urea }
1 ——— of uric acid } excreted by the kidneys.

800 atoms carbonic acid excreted chiefly by the lungs
403 —— water, diffused through all the excretions.

	Carbon.	Nitrogen.	Hydrogen.	Oxygen.
35 atoms of muscular tissue.	1680	210	1365	525
1788 ——— oxygen................	....	....	....	1788
	1680	210	1365	2313
14 atoms of solid matter of bile.	700	14	630	140
82 ——— urea..................	164	164	328	164
1 ——— uric acid	10	4	4	6
800 ——— carbonic acid	800	....	....	1600
403 ——— water..................	....	....	403	403
	1674	182	1365	2313
In excess....	6	28		
	160	210	1365	2313

The 6 atoms of carbon and 28 of nitrogen here unaccounted for, are probably eliminated in combination with the constituents of water, forming some of the less defined elements of the excretion—as compounds of ammonia, fatty, colouring, and odorous principles, &c.

The sulphur existing in the blood and its educt, the bile, has not here been taken into consideration, as experiments are still wanting to show in what proportion it exists in the latter.

Theories of this kind, notwithstanding the seductive interest with which they are invested, must be admitted with extreme caution, and as in every case in which we endeavour to explain vital phenomena, by the physical or chemical laws governing dead matter, be admitted as only provisionally correct. Their minute, and even general details being liable to partial or complete alteration on the detection of a comparatively slight error in the analysis, or even on a mere difference of opinion regarding an atomic weight. It will be difficult to make the physiologist believe that the laws which regulate the phenomena presented by inert matter in the laboratory, retain their supremacy as completely in that complex and wonderful structure in which Life is the presiding chemist.

33. The physiological relations borne by the urine to other secretions both in regard to quantity and quality, are exceedingly interesting. The fact of this fluid constituting the stream by which a host of noxious ingredients either formed within the body or derived from without, is washed away, has been already alluded to (25). But there is another very important function which it performs in common with other secretions, depending upon the power possessed by the kidneys, of temporarily compensating the deficient action of other secreting organs. Thus, so long as the function of the skin and the kidney bear a normal relation to each other, all goes on as in health, a limpid secretion from the one and insensible exudation from the other, announce that a just balance obtains between the two functions. But if the energy of the cutaneous function be increased so that more than a normal amount of fluid escapes from the skin, the kidneys compensate for this great loss by secreting a smaller quantity of fluid, so that the urine becomes concentrated and its specific gravity is increased; and conversely, the bulk of the urine is often greatly increased when the skin is imperspirable. In this way the balance is for a time preserved, and no greater amount of fluid is drawn from the body than is consistent with health. Again, if the function of the liver be impaired, either from mechanical or organic causes, highly carbonised products are elimi-

nated in the urine (141), the kidneys performing temporarily the function of separating some or all of the elements of bile from the blood, as every case of jaundice teaches us. In these and many other analogous modes (36, 38, 55) the quantity and quality of the urine may become so modified as to lead to serious errors; and to induce a suspicion of the presence of renal disease where none really exists. The fact of an excessive or diminished secretion of urine existing in any particular case cannot *per se* be regarded as indicative of disease of the kidney, any more than the excessive sweating so frequent in rheumatism or phthisis, or the diminished perspiration in fever, can be regarded as implicating the existence of disease of the skin.

34. In the investigation of urine in connexion with diagnosis, it is important to notice its physical properties, especially its *density or specific gravity, colour, consistence,* and in some particular cases its optical properties.

Almost every one is familiar with the modes of discovering the density of the urine. This may be most readily accomplished by pouring some of the fluid into a cylindrical glass vessel, and immersing in it, the little instrument known as the hydrometer, gravimeter, or urinometer (Fig.8). This is generally made of glass or metal, and consists of two bulbs *a b*, and a narrow stem *e f*. The instrument is made sufficiently heavy to cause it to sink to *e*, when placed in distilled water. Then, as all bodies immersed in fluid displace a bulk equal to themselves, it follows that in a fluid denser than water the instrument will not sink so deeply, and less of the stem will be immersed.[7] The space *e* to *f* is graduated

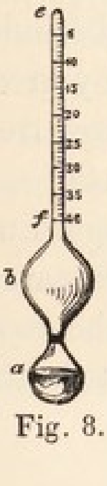


Fig. 8.

into degrees corresponding to different densities. When such an instrument is allowed to float in a vessel of urine the number on the stem corresponding to the level of the fluid, will indicate very nearly its specific gravity. Thus if the degree 18 be on the surface of the urine, its specific gravity is said to be 1018, (the number 1000 being always added to the number on the stem). This shown that a vessel holding when quite full 1000 grains of distilled water, will contain just 1018 grains of the urine or other fluid under examination.

35. If a gravimeter be not at hand, any small and thin stoppered phial may be substituted. For this purpose counterpoise the empty bottle and stopper in a tolerably good balance, with shot or sand. Then fill it with distilled water, insert the stopper, and carefully ascertain the weight of the water it contains. Empty the bottle, fill is with urine, and again weigh it; the specific gravity of the fluid will be readily found by merely dividing the weight of the urine by that of the water.

As an example, if the carefully counterpoised phial hold 478 grains of distilled water, and 498 of urine, the specific gravity of the latter will be 1.0418, for $\frac{498}{478}=1.0418$. This process affords much more accurate results than can be obtained by the urinometer or gravimeter just described. Still as the error necessarily involved in the indications of the latter are not sufficient to be of any great practical importance, this instrument is generally preferred on account of the very great facility attending its use.

36. Much difference of opinion has existed regarding the average density of healthy urine (39), a discrepancy admitting of ready explanation by a reference to the state of health of the individual by whom it was secreted, the

period of the day at which it was passed, the bulk of fluid drank in the course of the day, and the character of the previous ingesta.

Nothing can be more absurd than attempting to determine the state of the average density of the urine by the examination of specimens voided at different periods of the day. So seriously is the state of this secretion affected by comparatively slight causes, that from a neglect of this caution, a patient told only to "bring his water," might be supposed one day, from its density, to be suffering from diabetes, and on the following he may surprise his medical attendant by presenting him with a specimen as light as spring water (38). In all cases where any approach to accuracy is required, an average sample from the urine passed in 24 hours into the same vessel must be selected: as this is, however, not always practicable, it is better to request the patient to furnish specimens of the urine passed immediately before going to bed, (urina chyli,) and of that voided on rising in the morning, (urina sanguinis). The average density of these two specimens will give a near approach to the truth.

37. The law of the density of the morning urine being less than that passed at night, holds good in disease, certainly in the majority of cases. A remarkable exception, however, occurs in some neuralgic and hysterical affections, in which, immediately after a paroxysm of the disease, the urine falls to its minimum of density at whatever period of the day it is secreted, often after an hysteric fit being scarcely heavier than pure water. The following table shows the results of some observations on the respective densities of night and morning urine in different diseases:

Density of urine passed at		Disease.
Night, Urina Chyli.	Morning, Ur. Sanguinis.	
1.027	1.022	Irritable Bladder.
1.026	1.022	Hæmoptysis.
1.026	1.020	Dyspepsia.
1.024	1.024	Dyspepsia.
1.024	1.014	Dyspepsia.
1.022	1.016	Phthisis.
1.021	1.019	Oxaluria.
1.005	1.015	Hysteria.
1.020	1.018	Healthy.

A very curious statement has been made in Germany by Dr. Schweig,[11] that the density of urine presents a constant rate of increase and decrease during the day, and that *cæteris paribus* it ranges from 1.017 to 1.022 in the forenoon, 1.023 to 1.028 in the afternoon, 1.019 to 1.028 in the evening, and 1.012 to 1.025 during the night. Taking the night urine alone, he states its density to vary through certain limits in a cycle of six days, so that twice in this period its density attains a minimum; on the third and fourth night being higher than on the fifth and second, but then being lower than on the first. Five of these cycles occur, according to Dr. Schweig, in each lunar revolution, counting the night before the new moon as the second day of one of his cycles. The following is the density of night urine taken from an average of 20 such periods:

Nights of the cycle.	Density of the urine.
1	1.022
2	1.017
3	1.019
4	1.020
5	1.019
6	1.017

38. It is quite impossible to assign any limits within which the specific gravity of the urine secreted at different periods of the twenty-four hours may possibly range. In addition to the bulk of water eliminated from the circulation by the kidneys in a given time being materially affected by the state of surface (33) and other causes, the amount of fluids drank will exert an important effect in modifying the density and bulk of the urine. In many persons mere mental anxiety, or the ingestion of a few cups of tea, a glass or two of hock, or a goblet of soda-water, will at once determine the secretion of urine of a density as low as 1.002 or 1.003. The free use of aqueous diluents will also greatly increase the bulk, and in a corresponding degree diminish the density of the urine. And from some recent observations of Professor Liebig[21] it appears probable that the purer the water the more freely is it absorbed into the blood and eliminated by the kidneys, the presence of small quantities of saline matter considerably retarding its absorption and subsequent excretion (271).

It was observed by Becquerel[13] that a man whose normal average of urine in 24 hours was 30 ounces, passed 56 ounces after swallowing about a quart of water in the day. In another case the natural average, or 32 ounces, was raised to 87 ounces after the imbibition of half a gallon of water in the 24 hours.

Severe mental emotion, especially a paroxysm of hysteria, will also obtermine the secretion of pale aqueous urine, of low density (37). A young woman who naturally passed in 24 hours about 35 ounces of urine, voided 86 ounces after the occurrence of a hysteric fit in the course of the day.

39. Dr. Prout's experience has led him to assign 1.020 as the average specific gravity of healthy urine, and this completely agrees with my own observations. From a number of careful observations made by Becquerel, it appears that the mean density of all the urine passed in 24 hours, and examined by him, is in men 1.0189, and in women 1.0151, the mean in the two sexes being 1.017.

40. The average quantity of urine secreted in 24 hours in this country varies from 30 to 40 ounces; this is Dr. Prout's estimate, and is certainly the most correct. It is, however, capable of varying from at least 20 to 50 ounces without exceeding the possible limits of health, the quantity excreted in summer being as a general rule less than during winter, on account of the greater activity of the functions of the skin in warm weather.

M. Becquerel regards 43 ounces in men and 47 in women, as the most accurate expression of the average quantity of urine. The habitual use of weak subacid wines in France will from their diuretic influence sufficiently explain the discrepancy existing between the remarks of English observers and those of Becquerel.

41. Presuming that in any given class of affections the several ingredients existing in the urine preserve nearly their normal ratio, it is obvious that if by any means we could appreciate with tolerable accuracy the quantity of solids or "real urine" excreted in a certain time, we should be able to learn, not only to what extent the kidneys are performing their great and important function of depuration; but should slso obtain data by which it would be possible to measure, within certain limits, not only the amount of nourishment acquired from ingesta, but of the

rapidity of the destruction of the effete tissues of the body under the influence of the oxygen of the arterial blood. In this manner we may recognise the existence of a series of causes influencing the condition of our patients, the detection of which would otherwise have been scarcely possible.

The first element in an inquiry of this kind will be, to obtain a tolerably accurate measure of the quantity of urine secreted in twenty-four hours. Simple as this appears, it in practice is attended with no small difficulty. Not only is it no easy matter to make our patients quite understand what we require, but the loss of urine generally voided during the action of the bowels, will frequently prove no small obstacle to our learning the exact quantity secreted. The patient should be told to pass water at noon, and, rejecting the portion then excreted, to collect all that he passes up to the same time the next day, when he will take care to empty his bladder completely.

Having thus measured the amount of urine secreted in a given period, we are yet far from having any satisfactory information as to the proportion of work done by the kidneys in that time, as far as their depurating functions are concerned. The amount of fluid in the renal secretions being liable to serious variations, according to the quantity of fluids drank, the action of the skin, &c. Thus, a person may, under peculiar circumstances, void, in twenty-four hours, forty ounces of urine, and on the next day but twenty, and yet the amount of depurating duty performed by the kidneys be the same; for the former bulk of urine, if of a density of 1·015, will contain about as much solid matters as half that quantity if of a specific gravity of 1·030.

42. The amount of solid matters existing in the urine, can, of course, be discovered by the evaporation of a given quantity to as dry an extract as can be obtained. The practical difficulties attending this process are familiar to every one who has ever performed the task; and moreover, the time required for its performance would preclude its being had recourse to sufficiently frequently to be of any real service.

It has, therefore, been proposed to calculate the quantity of solid matter present in the urine from its specific gravity; and for this purpose the following different formulæ have been proposed by the late Dr. Henry, Dr. E. Becquerel,[8] and Dr. Christison.[9] If D= the density or specific gravity of the urine, and $\Delta =$ the difference between 1000 and its density,

The quantity of solids in 1000 grs. is, according to Dr. Henry, $\Delta \times 2{\cdot}58$
- - - - - Dr. Christison, $\Delta \times 2{\cdot}33$
- - - - Dr. Becquerel, $\Delta \times 1{\cdot}65$

Although by formulæ of this kind only an approximation to the truth can be gained, in consequence not only of the different densities of the various elements of the urine, but from their not always existing in the same proportion, they are of great value in the investigation of disease at the bedside, as affording an approach to an accurate knowledge of the solids removed from the system in a given time. Of these three formulæ that of Dr. Christison has been shown by the researches of Dr. Day[10] to be the most exact, and to afford results generally sufficiently accurate for the guidance of the practitioner.

43. The following table, calculated from Dr. Christison's formula, shows at a glance the quantity of solids

and fluid existing in 1000 grains of urine of different densities.

TABLE 1.

Specific gravity.	Solids.	Water.	Specific gravity.	Solids.	Water.
1001	2.33	997.67	1021	48.93	951.07
1002	4.66	995.34	1022	51.26	948.74
1003	6.99	993.01	1023	53.59	946.41
1004	9.32	990.68	1024	55.92	944.18
1005	11.65	988.35	1025	58.25	941.75
1006	13.98	986.02	1026	60.58	939.42
1007	16.31	983.69	1027	62.91	937.09
1008	18.64	981.36	1028	65.24	934.76
1009	20.97	979.03	1029	67.57	932.43
1010	23.30	976.70	1030	69.90	930.10
1011	25.63	974.37	1031	72.23	927.77
1012	27.96	972.04	1032	74.56	925.44
1013	30.29	969.71	1033	76.89	923.11
1014	32.62	967.38	1034	79.22	920.78
1015	34.95	965.05	1035	81.55	918.45
1016	37.28	962.72	1036	83.88	916.12
1017	39.61	960.39	1037	86.21	913.79
1018	41.94	958.06	1038	88.54	911.46
1019	44.27	955.73	1039	90.87	909.13
1020	46.60	953.40	1040	93.20	906.80

The mode of using this table is exceedingly simple; for having discovered the density of the urine passed in 24 hours by means of the gravimeter or specific gravity bottle, a single glance at the table will be sufficient to show the proportion of solid matter and water in 1000 grains of the urine. Then by weighing the whole quantity of urine passed in 24 hours, the weight of solids secreted by the kidneys may be calculated by a simple rule of proportion.

44. As it is much easier to obtain the measure than

the weight of urine passed in a given time, the following table becomes of use in enabling us to calculate the weight of the urine (in grains) from its bulk. A pint of distilled water weighing 8750 grains.

TABLE 2.

Specific gravity.	Weight of one pint.	Specific gravity.	Weight of one pint.
	Grains.		*Grains.*
1.010	8837	1.023	8951
1.011	8846	1.024	8960
1.012	8855	1.025	8968
1.013	8863	1.026	8977
1.014	8872	1.027	8986
1.015	8881	1.028	8995
1.016	8890	1.029	9003
1.017	8898	1.030	9012
1.018	8907	1.031	9021
1.019	8916	1.032	9030
1.020	8925	1.033	9038
1.021	8933	1.034	9047
1.022	8942	1.035	9056

45. The following example will be sufficient to point out the mode of using the preceding tables.

Ex.: A patient passes in 24 hours $2\frac{1}{2}$ pints of urine of the specific gravity 1.020, what is the weight of solid matter thus excreted by the kidneys?

1000 grains of urine, specific gravity 1.020, hold dissolved 46.6 grains of solids (Table 1) and a pint will weigh 8925 grains (Table 2); then,

$$\frac{8925 \times 46.6}{1000} = 415.9 \text{ grains of solids in a pint;}$$

and $415.9 \times 2\frac{1}{2} = 1039.72$ grains, being the total quantity present in urine of 24 hours.

46. Since the publication of the first edition of this work, I have calculated another table from Dr. Christison's formula ($\Delta \times 2{\cdot}33$), which is exceedingly convenient from its showing at a glance the number of grains of solids in, and the weight of, a fluid ounce of urine, of every density from 1·010 to 1·040.

TABLE 3.

Specific gravity.	Weight of one fluid oz.	Solids in f℥j.—grs.	Specific gravity.	Weight of one fluid oz.	Solids in f℥j.—grs.
1010	441.8	10.283	1025	448.4	26.119
1011	442.3	11.336	1026	448.8	27.188
1012	442.7	12.377	1027	449.3	28.265
1013	443.1	13.421	1028	449.7	29.338
1014	443.6	14.470	1029	450.1	30.413
1015	444.	15.517	1030	450.6	31.496
1016	444.5	16.570	1031	451.0	32.575
1017	444.9	17.622	1032	451.5	33.663
1018	445.3	18.671	1033	451.9	35.746
1019	445.8	19.735	1034	452.3	35.831
1020	446.2	20.792	1035	452.8	36.925
1021	446.6	21.852	1036	453.2	38.014
1022	447.1	22.918	1037	453.6	39.104
1023	447.5	23.981	1038	454.1	40.206
1024	448.0	25.051	1039	454.5	41.300

A glance at these figures presents us with a mode of recollecting the quantity of solids existing in urine of different specific gravities, when the table is not at hand for reference; depending upon the curious coincidence existing between the figures expressing the densities and the weight of solid present. Thus, if the specific gravity of any specimen of urine be expressed in four figures, the two last will indicate the quantity of solids in a fluid ounce of the urine, within an error of little more than a grain, when the density does not exceed 1·030; above that number the error is a little greater. To illustrate this, let us suppose we are called to a patient, the integrity of the depurating functions of whose kidneys we are anxious to learn. The quantity of the urine excreted in 24 hours amounts, we will suppose, to three pints or sixty ounces, and the density of the mixed specimens passed in the time alluded to is 1·020; now we merely have to multiply the number of ounces of urine by the two last figures of the specific gravity, to learn the quantity of solids excreted; or $60 \times 20 = 1200$ grains of solids. If the table were at hand, the calculation would be more rigid, for we should multiply 60 by 20.79, instead of 20; the product, 1247 grains, shows that by the former mode an error of 47 grains has been committed; an amount not sufficient to interfere materially with drawing our inductions by the bedside, and of course capable of immediate correction by referring to the table at our leisure.

From a large number of observations, it appears that the average amount of work performed by the kidneys in the adult, may be regarded as effecting the secretion of from 600 to 700 grains of solids in twenty-four hours. Although certain peculiarities connected with muscular exercise, regimen, and diet, as well as certain idiosyncracies of the patient, may influence this, yet if we regard 650 as the average expression of the number of grains of effete matter excreted in twenty-four hours by the kidneys, we shall not commit any very serious error. In calculations of this kind much latitude must be allowed, and it ought at least to be assumed that the kidneys may excrete fifty grains more or less than the assumed average, without exceeding or falling short of their proper duty.

47. Among the physical characters of urine, the tints not unfrequently present in different maladies are of great importance, and worthy of being carefully studied. Whatever may be the nature of the colouring ingredients of healthy urine, it is pretty evident that they are capable of generating but a small series of tints; varying according to the degree of dilution from nearly colourless, to the usual pale amber colour, and up to deep brown. When much diluted, urine presents a faint greenish tint, as in the urine of early infancy, and in that of chlorosis and hysteria. If bile or blood be present, a variety of colours varying from red to brown, blackish-green, or apple-green are produced, the latter hue being occasionally indicative of the presence of cystine (146.) It is often of great importance to distinguish between the substances causing some of the various colours possessed by the urine. The following table will be found of use for this purpose.

Colour.	Cause of colour.	Chemical and Physical characters.	Pathological indications.
Red A.	Purpurine.	Nitric acid produces a deposit of uric acid almost immediately—No change by heat—Alcohol digested on the extract, acquires a fine crimson colour—Density moderate.	Portal congestion; it is generally connected with organic mischief of liver or spleen.
B.	Blood.	Becomes turbid by heat and nitric acid, its colour changing to brown.—The microscope discovers floating blood-discs.	Hæmorrhage in some part of the urinary passages.
Brown C.	Concentration.	Nitric acid precipitates uric acid readily—Density high—The addition of hydrochloric acid to some of the urine previously warmed, produces a crimson colour.	Fever.
D.	Blood.	See B, coagulation by heat, and nitric acid less marked.	Obstruction to the escape of bile from the liver or gall bladder; and the presence of some or all the elements of bile in the circulation.
E.	Bile.	A drop of nitric acid allowed to fall in the centre of a thin layer of urine on a white plate, produces a transient play of colours, in which green and pink predominate.	
Greenish-brown F.	Blood.	See B; occurring in alcaline urine.	
G.	Bile.	See E; occurring in very acid urine.	
Grass-green. H.	Excess of Sulphur.	Unchanged by heat or nitric acid.	Presence of cystine.

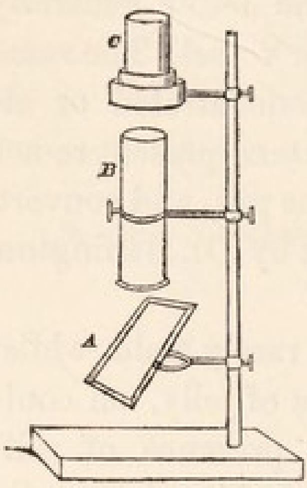
48. Urine occasionally varies in *consistence*, and instead of being fluid, as is generally the case, acquires a considerable amount of viscidity. This is sometimes only to be detected by the readiness with which it froths on agitation, and the length of time the bubbles are retained, as in diabetes mellitus. In other cases the urine may be so viscid as to allow of being drawn into threads from the presence of mucus (248), although the latter generally forms a dense layer at the bottom of the vessel. The same thing happens if pus occurs in rather concentrated or alcaline urine, as the alcali or saline matters present re-act upon the albuminous constituents of the pus, and convert it into a mucous magma, as pointed out by Dr. Babington and myself.[14] (249.)

The urine is occasionally, although rarely fluid whilst warm, becoming semi-solid, like a mass of jelly, on cooling. This change depends upon the presence of self-coagulating albumen or fibrin, a state of things generally connected with severe organic mischief in the kidneys, although in some instances dependent only upon mere functional disturbance.

In a few rare instances occurring chiefly in urine loaded with oxalate of lime, I have found it quite fluid whilst cold and gelatinizing when heated, retaining, however, its transparency. This curious change is best observed when water is poured on the warmed urine, when the gelatinous mass floats for some seconds in the water before it completely dissolves.

49. The optical properties of the urine have scarcely been applied to diagnosis, with the exception of the action saccharine urine exerts on polarised light, which has been proposed by M. Biot, and applied by M.

Bouchardat[16] to the detection of diabetes mellitus. It is quite out of place to notice here the theoretical action of diabetic urine on polarised light; for an account of which I would refer the reader to works especially devoted to the investigation of physical phenomena:[17] and now simply content myself with pointing out the readiest mode of applying this property to diagnosis.



Let a mirror A, composed of half a dozen pieces of thin window glass, be fixed to an arm of a common retort-stand. A brass tube B, open at top, and closed below with a plate of glass is fixed to a second arm: this tube should be an inch in diameter, and 6 or 8 inches long. In a third arm, at C, is fined a ring of wood, supporting a doubly refracting rhomb of calcareous spar. Let the tube B, be filled with water, and allow the light of a candle, or of the clouds, to be incident on the mirror A, at an angle of 56.°45. A ray of light, polarised in a vertical plane, will consequently be reflected through the column of water in B. Then look through the crystal C, and two images of the bottom of the tube B will be visible: these images are colourless, and differ merely in the intensities of their illumination. Slowly revolve the crystal C, and one of the images will cease to be visible four times in an entire revolution. Having thus become familiar with the management of the instrument, empty the tube B, and fill it with very clear syrup. Again revolve the eye-piece C, and now, instead of two uncoloured images only being visible, two, tinted with the most vivid colours of the spectrum, will be seen. These will change their hues by revolving the crystal C. These beautiful tints are generated by a physical change produced by the solution of sugar on the transmitted plane-polarised light, giving rise to the phenomena of circular polarisation.

50. The quantity of sugar existing in the urine is never sufficient to present the beautiful phenomena in a satisfactory manner without taking very many precautions to ensure success. For this purpose the tube B should be changed for one 14 inches long, as the quantity of sugar in urine is so much smaller than in the syrup, that a larger column of fluid becomes necessary to develope the optical phenomena above described. As one effect of this is to oppose a greater obstacle to the passage of light, a more vivid beam becomes necessary. To attain this, a good light should be thrown into the tube from a concave mirror, which should be substituted for the reflecting plates A in the figure. This light should be polarised by allowing it to traverse a Nicol's single image prism, screwed into the lower end of the tube holding the urine.

If then diabetic urine, carefully filtered to render it as clear as possible, be placed in the tube, the utmost care being taken to exclude all extraneous light, the coloured images will be visible, not, however, with the vivid tints presented by the syrup, as their hues will be modified by the colour of the urine, and quantity of sugar present. *Whenever in this apparatus, two images possessing different colours, however faint, are seen simultaneously, it is certain that the fluid in the tube possesses the power of circular polarisation.* And, as in the case of urine, but two bodies have been found which produce this physical change in light, viz. sugar and albumen, it is easy to discover the nature of the substance which communicates this property to the urine. If, therefore, a specimen of urine which does not coagulate by heat, produces the coloured images when examined in the polariscope, it is certain that sugar is present.

51. The comparative increase or decrease in the quantity of sugar in the urine during the progress of treatment may be detected by observing the extent of the arc through which it is necessary to rotate the eye-piece before any particular tint reappears or disappears. The best and most constant tint to assume as an index is a dark bluish violet colour, which precedes a yellowish red and follows a deep blue, and has the advantage of being a very distinct colour easily recognised. Let us suppose the tube of the apparatus is filled with diabetic urine, and by careful examination a rotation of the eyepiece through 9° is required to develop the dark violet colour. If on a subsequent examination a column of urine of the same length requires a rotation of 18° or 27° to develop the same colour, we learn that the quantity of sugar present is doubled or tripled in quantity, whilst if a rotation of $3\frac{1}{2}$° or 6° is sufficient, it shows that the sugar has fallen to one half or two-thirds the quantity found on the first observation.

There are many serious practical difficulties in the application of the polarised power of urine to the detection of sugar, which will probably ever prevent its being generally employed. But as M. Bouchardat has lately drawn the attention of the profession to it, it was necessary to give some explanation of it.

CHAPTER III.

CHEMICAL PHYSIOLOGY OF THE URINE.

52. The chemical composition of urine has been the subject of repeated investigations during the present century, and numerous statements have from time to time been made public, respecting the elements contained in this important fluid. In a physiological point of view, the urine of health may be regarded as naturally made up of the following classes of ingredients dissolved in water.

I. ORGANIC PRODUCTS.

1st. Ingredients characteristic of the secretion, produced by the destructive assimilation of tissues, and separated from the blood by the kidneys.	Urea, uric acid, colouring and odorous principles, and a crystalline nitrogenised body.
2nd. Ingredients developed principally from the food during the process of assimilation.	Hippuric acid, lactic acid? accidental constituents.

II. SALINE PRODUCTS.

3rd. Saline combinations, separated from the blood, and chiefly derived from the food.	Phosphates, Chloride of sodium.
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.

Of these, the first class of ingredients can alone be considered as really essential to the urine, and characteristic of it as a secretion, the kidneys being the only organs which normally eliminate these elements from the blood. The saline ingredients of the second class are met with in most secretions of the body, with the exception of the sulphates, which are rarely found except in the urine. The third class of elements is met with in all fluids passing over mucous surfaces.

53. As all unnecessarily minute chemical details of the analysis of urine, are more interesting in their abstract bearings than in relation to physiology and pathology, it would be quite out of place to insert any of the very elaborate views which have been given by some writers of the composition of the secretion under consideration. I prefer adopting the analyses of M. Becquerel, as the most practically useful, especially as they are corroborated by the results of the researches of most recent and trustworthy observers. The following table presents a view of the normal average composition of the urine passed by healthy persons in the course of twenty-four hours; the weight of the constituents being expressed in grains.

	Urine of men.		Urine of women.		Mean of both.	
	In 24 hours.	In 1000 grains.	In 24 hours.	In 1000 grains.	In 24 hours.	In 1000 grains.
Weight of urine . . .	19516	1000	21124	1000	20320	1000
Specific gravity . . .	1.0189		1.0151		1.01701	
Solids	610.	31.1	526.8	24.95	568.	28.
Urea	270	12.8	240.	10.366	255.	12.
Uric acid	7.6	0.391	8.6	0.406	8.1	0.398
Fixed salts	150.	7.63	126.	6.14	138.	6.9
Organic matters and volatile saline combinations	176.	9.26	145.	8.	160.5	8.6

The organic matters mentioned in the above table consist of a mixture of a nitrogenised body lately discovered by Pettenkofer, hippuric, and according to some, lactic acid, a colouring matter rich in carbon (77), with a salt of ammonia, and probably of some other bodies in smaller quantities with whose nature we are yet unacquainted.

54. The fixed salts referred to in this table consist of combinations of chlorine, phosphoric and sulphuric acid, with lime, soda, potassa and magnesia, or their metallic bases: these substances exist normally in the following average proportions:—

	In the urine of 24 hours.	In 1000 grains.
Chlorine	10.15 grains	0.502 grains.
Sulphuric acid	17.3	0.855
Phosphoric acid	6.4	0.317
Soda, Lime, Magnesia, Potassa	106.1	5.224
	139.95	6.918

The proportions in which these several ingredients exist in the urine are liable to great temporary variations from slight causes, depending upon the nature of the food, amount of exercise, and state of general health. The amount of solids in the secretion increasing usually in a direct ratio with the amount of muscular exertion, and consequently metamorphosis of tissues, and inversely with the length of time occurring after taking food.

55. The following example will be sufficient to point out the great variation existing in the composition of urine passed at different periods of the day. I collected carefully all the urine secreted by a person in good health

during twenty-four hours: it amounted to only 22 ounces; he had previously drank very little. It was passed at the following hours: at 8 A. M., eight ounces, depositing urate of ammonia; at 1 and 5 P. M., six ounces altogether. At 11½ P. M., eight ounces; all these specimens were acid.

The first of these was passed after having been 10 hours without food, and consequently was a good specimen of *urina sanguinis;* the second was influenced by the morning meal and a slight lunch at noon; whilst the third, *urina cibi,* contained the products of the metamorphosis of food taken at dinner early in the evening. The composition of these three specimens was, in 1000 grains, as follows:—

When excreted	A. 11 A.M.	B. Noon and 5 P.M.	C. 11½ P.M.	D.	E.
Specific gravity .	1.016	1.020	1.030	——	1.018
Water	962.72	953.40	930.10	——	958.
Solids	37.28	46.60	69.90	——	41.94
Urea	14.3	15.3	24.4	180.4	11.0
Uric acid . . .	0.23	0.9	1.33	8.0	1.1
Fixed salts . . .	5.1	16.5	9.9	98.0	11.2
Organic matters and volatile saline compounds	17.9	13.9	34.27	213.0	18.6

The bulk of the urine secreted was nearly one-half the average, being but 22 ounces, and the composition of the solids existing in the whole quantity is shown in the column D of the above table. In the following twenty hours, the same person having partaken more freely of fluids, secreted 36 fluid-ounces of urine, and the composition of 1000 grains of which is shown in column E.

56. *Urea.*—Chem. Comp. C_2, N_2, H_4, O_2,=60. This very important substance constitutes the form under which a large quantity of nitrogen is expelled from the system ; 270 grains of urea, or more than half an ounce, being on an average excreted by a healthy man in the course of twenty-four hours.

Urea, in consequence of its combining with acids like a weak base, can be very readily discovered in urine. The nitric or oxalic acids may be used for its detection ; the former being the most convenient for clinical observations. For this purpose let about a dram of urine be placed in a watch-glass, and about half that quantity of colourless nitric acid be carefully added. If a normal proportion of urea exist, no change, except a darkening in tint, and the evolution of a few bubbles, will be observed, unless the weather be exceedingly cold, or the glass be placed in a freezing mixture, and then a delicate plumose crystallisation of nitrate of urea will commence at the edges of the fluid. Under ordinary circumstances, however, no crystals will appear, unless the urine be concentrated by previous evaporation to one-half its bulk or even less. In some cases, indeed, an exces of urea exists, and then a rapid formation of crystals of nitrate of urea occurs, occasionally so copiously that the mixture becomes nearly solid. It is important, whenever this is the case, to measure, and ascertain the specific gravity of the whole quantity of urine passed by the patient in twenty-four hours ; for unless this exceeds the average proportion of health, there is no proof that an actual excess of urea is excreted by the kidneys. A particular specimen of urine may appear richer in urea than natural, simply from the diminished amount of water present, as is well shown in the preceding table (55) ; in which, although the total quantity of urea present in the urine of 24 hours was much below the average, yet the proportion found in 1000 grains at these different periods of the day far exceeded it. On this account, the urine secreted shortly after a full meal, especially of animal food, as well as that voided after excessive perspiration, generally crystallizes on the addition of nitric acid.

57. *Physiological origin of urea.*—This has been already traced to the destructive assimilation of the tissues of the body (3). That urea is one of the products of this important process, and that it constitutes the mode in which the greatest portion of the nitrogenised elements are excreted, is unquestionable. In man, and warm-blooded carnivorous and omnivorous mammalia, its quantity far exceeds that of uric acid ; whilst, in carnivorous birds, serpents, and insects, the latter substance predominates, and often quite replaces the urea. Dr. Prout is inclined to believe that the urea is the peculiar product of the metamorphosis of gelatinous, and uric acid of albuminous, structures.[19] Liebig, on the other hand, considers that uric acid is the immediate product of the change in all nitrogenised tissues, and that urea is the secondary product, arising from the action of oxygen and water in the uric acid.[20] The fact that in sea-birds and many insects the uric acid remains in the state of urate of ammonia, and does not become converted into urea, notwithstanding all the conditions necessary on Liebig's views for this change exist, must cause this hypothesis

to be received with great caution. The following table shows the average quantity of nitrogen and carbon evolved from the system in twenty-four hours in the form of urea and uric acid.

Quantity excreted in 24 hours.		Nitrogen existing in	Carbon existing in	Nitrogen calculated in cubic inches.
	grains.	grains.	grains.	cubic inches.
Urea	255.	118.95	50.92	391.4
Uric acid	8.1	2.52	3.23	8.3
Total	263.1	121.47	54.15	399.7

58. The influence of the composition of food on the quantity of urea, is beautifully shown by the late experiments of Dr. Lehmann[22] of Leipsic. This philosopher examined the quantity of urea secreted by his kidneys whilst living for some days on a strictly animal diet, as well as when he restricted himself to vegetable food, to a mixed diet, and to one quite free from nitrogen, consisting of starch, gum, oil, sugar, &c. The mean weight of the urea obtained from the urine of twenty-four hours, under these circumstances, is expressed below in grains.

Diet.	Animal.	Vegetable.	Mixed.	Non-nitrogenised.
Urea in the urine of 24 hours . . .	819.2	346.5	500.5	237.1

No one can avoid observing the great disproportion existing between the quantity of urea existing in Lehmann's urine, and that generally assumed as the average; the quantity secreted whilst confined to a strictly non-nitrogenised diet, nearly equalling the normal proportion (53). Still, whatever may be the idiosyncracy of the ingenious experimenter in this matter, the results of his researches prove to a demonstration, the influence of food in modifying the proportion of urea separated by the kidneys. M. Lecanu[23] has made some interesting observations on the connexion between the amount of urea secreted, and the age of the individual. The following presents the average results of his experiments on the quantity of urea and uric acid excreted in twenty-four hours at different ages.

	Urea.	Uric acid.
Adult men - - -	431.9 grains - -	13.09 grains
Adult women - - -	294.2 - - -	10.01
Very old men (84 to 86 years old)	124.8 - - -	6.77
Children (under 8 years) -	138.2 - - -	3.98

59. As urea consists of 2 at. carbon, 4 at. hydrogen, 2 at. nitrogen, 2 at. oxygen, its elements are so arranged that its composition exactly resembles that of carbonate of ammonia, minus two atoms of water.

	C. N. H. O.
2 at. carbonic acid - -	2 4
+2 at. ammonia - - -	2+6
	2+2+6+4
—2 at. water - - - -	2+2
=1 at. urea - - -	2+2+4+2

In accordance with this view, urea is decomposed by boiling with a concentrated acid, a salt of ammonia being formed, whilst carbonic acid is evolved; and, on the other hand, by ebullition with a solution of potass, ammonia is given off, and a carbonate of potass remains.

An ingenious mode of estimating the proportion of urea existing in any fluid founded on its becoming so readily converted into an ammoniacal salt, has been proposed by M. Heintz (119). The fluid being mixed with an excess of sulphuric acid, is slowly evaporated in a retort until fumes of sulphuric acid begin to rise, a sulphate of ammonia is formed, and carbonic acid given off. The quantity of ammonia in the salt estimated by precipitations by chloride of platinum; or the amount of carbonic acid evolved, becoming an index of the urea present; 22 grains of carbonic acid indicating 60 of urea. The mere act of boiling the urine is sufficient to convert a portion of urea into an ammoniacal salt, and by long keeping, even in close vessels, a similar change occurs. The rapidity with which this conversion is effected, varies remarkably in different specimens of urine. I have known urine become alkaline within an hour of its emission, and yet, in one instance, I detected urea in a specimen of urine which had been preserved in a closely-stopped bottle upwards of ten years. The presence of a mucoid body in a state of change, acting as a ferment, certainly explains the rapid conversion of urea into carbonate of ammonia in some urine (201).

The elements of urea not only are thus related to those of carbonate of ammonia, but are identical with those of cyanate of ammonia with water (229), a circumstance which explains the occasional occurrence of cyanogen-compounds in urine.

60. *Uric acid.* (Chem. Comp. C_{10}, N_4, H_4, O_6,$=168$) (Syn. Lithic or Urylic acid.) From the analysis of healthy urine, we learn that on an average 8.1 grains of this substance are excreted from the blood by the kid-

neys in twenty-four hours (53). There can be no doubt of the correctness of Dr. Prout's opinion, that the greatest proportion of the acid exists in combination with ammonia. From the accurate observations of this physician, we learn that uric acid requires 10,000 parts of water at 60° for solution, whilst there does not exist in urine quite 2500 times its weight. It is hence utterly impossible to be in a free state without supposing the existence of causes modifying its solubility, by no means justified by the present state of chemical knowledge. If, on the other hand, the acid is combined with ammonia, it must of necessity remain dissolved at ordinary temperatures. Urate of ammonia is soluble in 480 times its weight of pure water, and in the state in which it occurs in urinary deposits, requires for solution 2789 parts of urine, according to the researches of Dr. B. Jones;[24] who has also shown that the presence of a moderate quantity of saline matter increases its solubility. The 8.1 grains of uric acid normally secreted in twenty-four hours, require but 0.82 grains of ammonia for saturation, and the 8.92 grains of urate of ammonia thus formed, would be held in solution by less than half a pint of water, or about one-fourth the quantity separated from the blood by the kidneys. If healthy urine be slowly evaporated in an air-pump vacuum, it soon becomes turbid from the formation of clouds of urate of ammonia, which ultimately subside in very minute spherical masses on the sides of the vessel. The same thing occurs when urine of rather high specific gravity is exposed to cold. These facts appear conclusive in favour of Dr. Prout's opinion. The most plausible objection against this view, is the one advanced by M. Becquerel and others, viz. that a single drop of nitric acid is sufficient to precipitate all the uric acid naturally contained in a considerable quantity of urine, which, it is stated, could hardly be the case if it were combined with a base. This is an objection more apparent than real, for if it be granted that 8.92 grains of urate of ammonia are dissolved in about 40 ounces of urine, a moment's reflection will show that less than a single drop of uric acid ought to be sufficient to precipitate all the uric acid present in half a pint of urine. For the quantity of ammonia combined with the uric acid in half a pint would be about 0.2 grains, which would be exactly neutralised by 0.8 grains of nitric acid, or less than a single drop.

61. It is, of course, quite possible that uric acid may be secreted combined with ammonia from the elements of the disorganised albuminous tissues (64). It is, perhaps, more probable that the acid is first generated and subsequently unites with a base, which it meets, either in the nascent state, or in its progress through the structure of the kidneys. Late researches of Professor Liebig have thrown much light on this matter, in developing the mutual reaction of uric acid with alkaline basic phosphates. It is well known that an aqueous solution of the common or tribasic phosphate of soda exerts an alkaline action on reddened litmus paper. If uric acid be heated in such a solution, it dissolves in consequence of combining with part of the soda, and setting free part of the phosphoric acid, which probably forms a super-salt with some of the undecomposed phosphate.[25] The fluid thus becomes acid, and reddens litmus. On cooling, the phosphoric acid reacts on the urate of soda, and about one-half the uric acid is deposited in fine *prismatic* crystals,

resembling in shape some varieties of uric acid sand. These crystals are not pure uric acid, but contain, chemically combined, some phosphate of soda, of which they are not deprived either by boiling water, or hydrochloric acid. The addition of an acid to the fluid decanted from the crystals causes a deposition of *tabular* crystals of uric acid. These observations are amply sufficient to explain the natural acidity of urine, and the deposition of crystals of impure uric acid on cooling; all that is required, being to suppose that the .398 grains of uric acid, the average quantity existing in 1000 grains, are dissolved in about 2.5 grains of tribasic phosphate of soda, the proportion found by Simon in that quantity of healthy urine.

62. The deposits most frequently occurring in the urine on cooling, by evaporation in vacuo, or exposure to a freezing mixture, are, however, (97) neither crystalline nor composed of uric acid alone. They consist of urate of ammonia, more or less contaminated with colouring matter; are amorphous, and readily dissolve in warm water, which scarcely acts on uric acid. We are hence compelled to seek for another explanation of the proximate formation of these deposits; and this, I believe, is found in the action of uric acid on the microcosmic salt or double phosphate of soda or ammonia; which salt, or its elements, may be regarded as a constant constituent of healthy urine. When uric acid is mixed with a warm solution of this triple phosphate, urate of ammonia is formed, and phosphoric acid evolved, either free or combined with a base and forming an acid salt. This urate of ammonia is not decomposed on cooling, but is simply deposited in delicate microscopic needles, readily re-dissolving on the application of heat, if sufficient

water is present. On the addition of urine to a hot solution of these minute needles, they are deposited on cooling, combined with the colouring matter of urine, completely amorphous and presenting all the characters of the commonest forms of urinary deposits.[27] If, after the separation of the urate of ammonia, a fresh quantity of uric acid be heated in the supernatant fluid, more of the ammoniacal salt is formed, up to a certain point; when phosphate of soda yields, and urate of soda is generated, which on cooling is decomposed in the manner already described (61).

63. I therefore venture to propose the following, as a probable explanation of the mode in which uric acid exists in healthy urine. *Uric acid, at the moment of separation from the blood, comes in contact with the double phosphate of soda and ammonia, derived from the food, forms urate of ammonia, evolving phosphoric acid, which thus produces the natural acid reaction of urine. If the whole bulk of the urine be to the urate of ammonia formed, not less than about* 2701 *to* 1, *the secretion will, at the ordinary temperature of the air, remain clear, but if the bulk of fluid be less, an amorphous deposit of the urate will occur. On the other hand, if an excess of uric acid be separated by the kidneys, it will act on the phosphate of soda of the double salt, and hence, on cooling, the urine will deposit a crystalline sediment of uric acid sand, very probably mixed with amorphous urate of ammonia, the latter usually forming a layer above the crystals, which always sink to the bottom of the vessel.*

64. *Physiological origin of uric acid.*—It will be sufficient to merely allude to some of the more recent

opinions entertained on this subject, and the first which demands attention is that of the celebrated Liebig.[28] He believes that when, in the exhausted tissues containing protein, (i. e. albuminous structures,) the vital force is no longer able to resist the chemical action of the oxygen, which is conveyed to them in the arterial blood (29); it combines with their elements and forms products, among which uric acid is the most important. Thus, the elements of one atom of the essential ingredient of all muscular and fibrous tissues, (protein,) with 91 atoms of oxygen, produce the elements of uric acid, carbonic acid, and water, thus—

	C N H O		C N H O	
1 atom protein	=48+6+36+14	=	15+6+6+ 9=1½	at. uric acid.
91 — oxygen	= 91		33 66=33	— car. acid.
			30+30=30	— water.
	48+6+36+105		48+6+36+105	

If, then, sufficient oxygen and water be conveyed in the arterial blood, the greatest part of the uric acid is converted into urea and carbonic acid, so that the effete nitrogenised elements of the tissue reach the emunctories in a soluble form, a condition necessary for their ready excretion. The new body discovered by Pettenkofer being, as I have elsewhere hinted, a possible transition formation between the uric acid and urea (71).

	C N H O		C N H O	
1 atom uric acid	=10+4+4+6	=	4+4+8+ 4=2	at. urea.
4 —— water	= 4+4		6 12=6	— car. acid.
6 —— oxygen	= 6			
	10+4+8+16		10+4+8+16	

65. It is, therefore, obvious, on this hypothesis, that the larger the proportion of oxygen which circulates through a tissue in the act of destructive assimilation, the more complete will be the conversion of uric acid into urea, and in proportion as this oxygenation is perfected the former will disappear from the urine. Hence in the urine of carnivorous animals the quantity of uric acid in relation to the urea, will be in the inverse ratio of the rapidity of the circulation. Thus the boa-constrictor eats an enormous meal of nitrogenised food, but being a cold-blooded, slowly-respiring animal, it takes in too little oxygen to convert the uric acid formed by the metamorphoses of its tissues into urea; and hence the semi-solid urine of this animal consists almost entirely of bi-urate of ammonia. On the other hand, the lion and tiger, equally carnivorous with the serpent, are rapidly respiring, warm-blooded animals, and although from their violent muscular exertions, rapid and great destruction of tissue must occur, scarcely a trace of uric acid is found in their urine, as it is all converted into urea at the moment of its formation, in consequence of the abundant supply of oxygen. As combination with oxygen is the necessary condition for the metamorphosis of tissue, it follows that we should be in constant danger of *oxydising to death*, unless either the vital force is generated in sufficient intensity to oppose the action of oxygen, or some substance be present which opposing a less resistance to its influence than organized tissues, protects them from corrosion. The mucus covering the air-passages and the bile in the intestines, are thus supposed to be the conservative agents which protect the structures imbued with them from destruction by oxidation. In a like manner the non-nitrogenised elements of

our food, as all fatty and amylaceous substances, interfere with the conversion of the uric acid into urea, as they monopolize great part of the oxygen; hence man, being an omnivorous animal, partakes of a sufficient amount of food, rich in carbon, to prevent the complete conversion of insoluble uric acid into soluble urea, consequently the former substance appears in the urine. The average proportion borne by the uric acid to urea in healthy urine being about 1 to 32.

66. If these views be correct, it will follow that other things being equal, the proportion of uric acid in the urine will increase in the urine of a man who takes food rich in carbon, and decrease if he confines himself to a nitrogenised diet, and becomes for a time, a carnivorous animal. Further, the proportion of uric acid will decrease and urea increase, with the perfection of respiration and abundance of blood-discs, the reputed carriers of oxygen (29—32).

It appears to me, however, that these views, ingenious and full of interest as they are, are not supported by any experience hitherto recorded,—in fact, are, in many cases, totally opposed by it. The experiments of Lehmann, already alluded to (58), performed upon himself, demonstrate that vegetable diet and one quite free from nitrogen decreases, and an animal diet increases, the quantity of uric acid; the urea also increases in the same manner. The following table presents the results of Lehmann on himself.

DIET.	Quantity excreted in 24 hours of		PROPORTION OF URIC ACID TO UREA.
	URIC ACID.	UREA.	
Exclusively animal	22.64 grs.	819.2 grs.	1 : 36.1
Mixed animal and vegetable . .	18.17 ..	500.5 ..	1 : 27.5
Exclusively vegetable	15.7 ..	346.5 ..	1 : 22.
Food free from nitrogen . . .	11.24 ..	237.1 ..	1 : 21.

From this table we learn that when living on a diet as free from nitrogen as possible 11.24 uric acid and 237.1 grains of urea were excreted by Lehmann's kidneys in twenty-four hours. These quantities may be assumed as solely produced by metamorphosis of tissue, inasmuch as there existed no other source for them. On confining himself to a strictly animal diet, Lehmann found in his urine 22.64 uric acid, and 819.2 urea, being 11.4 more of the former and 582.1 more of the latter than can be accounted for by the disorganisation of the tissues of his body, and consequently, must have been derived from the ingesta. On mixing vegetable food with his meat, instead of finding an increased proportion of uric acid, as the theory of Liebig would indicate, a much smaller proportion of this substance was discovered in the urine.

The statement, that in carnivorous animals, the use of vegetable food increases the amount of uric acid, is quite opposed to the fact recorded by Magendie,[29] that uric acid disappears from the urine of carnivora which have been fed for about three weeks on non-nitrogenised food.

67. The theory of the perfection of oxidation in increasing urea and diminishing the uric acid, scarcely ap-

pears to be in accordance with the well-known fact, that in carnivorous birds, as sea-fowl, the mortar-like urine is constituted of urate of ammonia, like the urine of serpents, and yet the former class of animals are rapidly-respiring, warm-blooded animals, provided with an abundance of oxygen, totally opposed to the serpents in their physiological characters, and appearing to present all the conditions required by the theory alluded to, for the total conversion of uric acid into urea. This change nevertheless does not occur, and so large a quantity of urate of ammonia is excreted by sea-birds, that many islets and rocks in the tropics inhabited by them, are covered to a considerable depth with this substance, which is now an important article of commerce as a manure under the name of *guano*. Zimmermann[30] attempted to defend Liebig's view against the objection, on the ground that the feathered skins of birds prevented contact of air to capillaries of the surface, and thus cut off one supply of oxygen. This remark, however, applies, with equal force, to the thick hides of the lion, tiger, and leopard, as well as to the scaly armour of serpents, and hence gives no support to either opinion. From a late observation by Heller,[120] it will appear, that of all animals in proportion to their size, butterflies excrete the largest quantity of uric acid combined with ammonia. This substance appears to be a product of metamorphic changes of tissue during the pupa state, as it does not exist in the caterpillars, and the yellow fluid which excretes when the developed insect escapes from the pupa is rich in urate of ammonia. If a butterfly be caught, and gentle pressure be applied to its abdomen, the drop or two of yellow fluid which escapes contains urate of ammonia in globules, and coloured by purpurine. Dr. John Davy has very recently shown that all true insects he had an opportunity of examining in Barbadoes, excreted uric acid free or combined. Spiders, on the contrary, excrete uric oxide. This question will, however, again come before us.

68. What, then, is to be regarded as the physiological source of the uric acid of the urine? There can be no question that all the phenomena of health and disease point out the probability of there being a double origin of this substance, one from the nitrogenised elements of tissues, and the other from the elements of food rich in nitrogen which escape the completion of the process of primary assimilation. No experience yet collected justifies our assuming that uric acid bears any definite relation in quantity to urea; in all probability Dr. Prout's opinion that the latter is derived from the metamorphoses of a different set of tissues (57) from those yielding the former, is correct, although it obviously does not admit of positive proof.

69. *Lactic acid and lactate (?) of ammonia.*—The existence of these compounds in healthy urine first announced by Berzelius, and admitted generally by chemists, has been called in question by Prof. Liebig, who, in a careful repetition of the processes of Berzelius, failed in detecting the slightest evidence of the presence of lactic acid. It appears evident that what was mistaken for lactic acid, is really a peculiar substance rich in nitrogen, lately discovered by Dr. Max Pettenkofer (70). Lehmann[31] has stated that 1.52 grains of free lactic acid, and 1.20 grains of lactate of ammonia, are contained on an average in 1000 grains of healthy urine. Since the discovery of the new nitrogenised body just alluded to, these

numbers must be regarded as indicating the proportion of this substance, and not of lactic acid or a lactate, as was previously supposed.

The composition of lactic acid (C_6, H_5, O_5=81) bears so simple a relation to that of some of the most ordinary elements of our food, that its presence in the secretions, at least under many circumstances, might really be anticipated. Thus the elements of

1 atom of starch are equal to 2 atoms of lactic acid
1 ——— cane-sugar .... do. .... + 1 atom of water.
1 ——— gum .... do. .... do. .. ..
1 ——— milk-sugar.......... do. .... + 2 atoms of water.
1 ——— grape-sugar......... do. .... + 4 ....

Lactic acid can be readily formed out of the body by digesting a solution of sugar with an animal substance in a state of change, as the mucous membrane of a calf's stomach (rennet), or a piece of washed cheese (casein).

69* From the late researches of M. Boussingault, it appears quite certain that lactic acid is an ingredient in the urine of herbivorous animals. He detected distinct traces of it in the urine of a pig fed on potatoes, whilst in the urine of a cow and horse he found respectively 16.51 and 20.09 parts of an alcaline lactate in 1000 of urine. When the quantity of lactic acid is exceedingly small, the test proposed by M. Pelouze for its detection may be employed. This is founded on the property possessed by lactic acid of preventing the complete decomposition of salts of copper by alcalies. For this purpose boil the urine to be examined with milk of lime until the urea is completely decomposed, and ammonia ceases to be given off. The filtered fluid should be mixed with a solution of the sulphate of copper, by which, if any lactic acid be present, a lactate of copper is formed, and on adding some milk of lime, oxide of copper will be precipitated. On throwing the whole on a filter, the fluid which passes through will be found free from copper unless lactic acid is present. In which case, distinct traces of the metal can be detected, by acidulating the fluid with a drop of sulphuric acid, and immersing a polished piece of iron wire, which will become in a short time coated with copper.

70. *Nitrogenised body discovered by Pettenkofer.* $(C_8, N_3, H_8, O_3)=122$. When an alcoholic solution of the extract of urine, previously neutralised by a little carbonate of soda, is mixed with a spirituous solution of chloride of zinc, an amorphous precipitate falls, followed by the slow deposition of minute crystals of a combination of chloride with this new body. Drain the whole on a filter, and pour on some boiling water, in which the crystals dissolve, and may be obtained, by evaporation, in yellowish quadrangular crystals, not very unlike lactate of zinc, for which they have been hitherto mistaken. On adding barytic water to a solution of these crystals, oxide of zinc and colouring matters are precipitated, whilst chloride of burium, with the new body, remain in solution. The solution being evaporated to dryness, is dejected in alcohol acidulated with sulphuric acid, by which baryta is separated as a sulphate; and any excess of acid being got rid of by agitation with oxide of lead, the filtered fluid, by evaporation, leaves crystals of the new substance in a pure form.

This body is neutral, has a bitter, pungent, saltish taste, and readily soluble in water and alcohol. Heated on platinum foil, it melts and burns slowly, evolving an odour of urine and ammonia. Chloride of zinc precipitates it from its watery solution. It contains 54.02 per cent. of nitrogen, and is said to exist in the proportion of 5 grains in 1000 of urine, exceeding one-third the weight of urea!

71. This body must be regarded as playing a very important part in the physiology of the kidneys, both from its quantity and remarkable composition, at least if the recorded analysis of it be correct. Its formula 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. Is it possible that this new body is a transition formation between uric acid and urea? We have seen that the addition of oxygen is competent to the conversion of the former into the latter (64), and there is a sufficient approach in Pettenkofer's formula to that of Alloxan (an artificial result of the oxidation of uric acid) to warrant this supposition; for

$$\left.\begin{array}{lcccc} & C & N & H & O \\ \text{1 at. of the new body} = & 8+ & 3+ & 8+ & 3 \\ \text{8 — oxygen} = & & & & 8 \\ \hline & 8+ & 3+ & 8+ & 11 \end{array}\right\} = \left\{\begin{array}{cccc|l} C & N & H & O & \\ 8+ & 2+ & 4+ & 10 & =1 \text{ at. alloxan} \\ & 1+ & 3 & & =1 \text{ — ammonia} \\ & & 1+ & 1 & =1 \text{ — water} \\ \hline 8+ & 3+ & 8+ & 11 & \end{array}\right.$$

72. *Hippuric acid.* Chem. Comp., C_{18}, H_8, N, O_5+HO=179. (Syn. Urobenzoic acid.) This substance, long known to exist in the urine of herbivorous animals, and according to some, occasionally in that of man, has been shown by Liebig to be a normal constituent of the latter

fluid. The best mode of obtaining this substance from healthy urine, is to evaporate a few ounces of urine to a very small bulk, and then add an excess of hydrochloric acid. A mixture of hippuric and uric acids with altered colouring matter will then be separated and fall to the bottom of the vessel. After a few hours' repose the supernatant fluid should be decanted, and the deposit washed with a small quantity of very cold water. On boiling the residue with alcohol, in which uric acid is insoluble, the hippuric acid will be dissolved, and by spontaneous evaporation, be left in thin delicate needles strongly coloured from adhering impurities. Hippuric acid, when pure, crystallises in long, slender, four-sided, acuminated crystals, and requires nearly 400 times its weight of cold water for solution, and hence can be separated from even a dilute solution of any of its alcaline salts by the addition of a stronger acid.

When an abnormally large proportion of this acid is present, as after the administration of benzoic acid (123), or in hippuric (154), it is easily detected by pouring about half an ounce of the urine into a capsule, and evaporating to a syrupy consistence. On adding an equal bulk of hydrochloric acid, and allowing the whole to cool, a crystallisation of hippuric acid in pinkish tufts of acicular crystals will occur. This is beautifully shown with the urine of the horse, or of a person who has taken half a scruple of benzoic acid a few hours before. If the quantity of hippuric acid is small, it frequently crystallises on the addition of hydrochloric acid, in a very curious manner, in delicate linear branched figures, ramifying in the fluid like a sea-weed, or a leafless bunch of twigs.

A quantity of purpurine usually falls with the hippuric acid, so that when drained on a filter, the paper is stained of a delicate carmine colour—a remarkable fact, when we bear in mind the clear approximation existing between the quantities of carbon and hydrogen existing in hippuric acid and purpurine (77, 142).

Hippuric acid must also exist in the semi-solid urine of birds, as E. Marchand detected it combined with ammonia in guano.[121]

73. *Physiological origin.*—It is believed by its discoverer to be a derivative of some of the non-nitrogenised elements of food, and to exist nearly in the same proportion as uric acid. From my own researches, whilst they fully agree with the results of Liebig as to the existence of hippuric acid, I am inclined to believe that its quantity, in health, is not constant, and always, unless after the ingestion of benzoic or cinnamic acids (127), very much less than has been stated. It is possible that hippuric acid may constitute a means by which carbon may be evolved from the system by the kidneys, and it is probable that in cases in which the emunctories of this substance, the lungs and the liver, are deficient in their function, the kidneys may partially compensate for this, by secreting a larger portion of hippuric acid. It is remarkable that this substance, next to the bile and purpurine, is the richest in carbon of any of the products of vital chemistry, and hence it very probably performs an office of great importance in the body. A comparison of the per centage composition of the organic material of human bile, from the analysis of Dr. Kemp, with that of anhydrous hippuric acid, and the colouring matter of urine from Scherer's analysis (75), will show the relation between them, *quoad* the amount of carbon.[32]

	Bile.	*Hippuric Acid.*	*Urinary Colouring Matter.*
Carbon	68.40	63.93	58.43
Hydrogen	10.13	4.64	5.16
Nitrogen	3.44	8.21	8.83
Oxygen	18.03	23.22	27.58
	100.	100.	100.

74. *Butyric acid.*—Occasionally present in urine, and in all probability owes its origin to an imperfect assimilation of saccharine matter. It may, however, be possibly generated occasionally from the butter, which forms so large a portion of our food. As a product of disease, it is met with in the white creamy deposit occasionally observed in diabetic urine. The opinion of the origin of this acid being traceable to a change in the elements of sugar, is supported by the fact, that out of the body it may be generated by digesting a solution of sugar with a piece of curd of milk, which plays the part of a ferment, the sugar being converted into butyric acid with the evolution of hydrogen and carbonic acid.

$$\left.\begin{array}{lr} & C\quad H\quad O \\ \text{1 at. of sugar} = & 12+10+10 \\ \text{2 — water} = & 2+\ 2 \\ \hline & 12+12+12 \end{array}\right\} = \left\{\begin{array}{ll} C\quad H\quad O & \\ 8+\ 7+\ 4 & = \text{1 at. butyric acid} \\ 4+\qquad 8 & = \text{4 carbonic acid} \\ \quad\ 5 & = \text{5 hydrogen} \\ \hline 12+12+12 & \end{array}\right.$$

This acid may also be derived from protein compounds, for it has been observed (122), that when moist fibrin is exposed to the air for some days, it undergoes metamorphosis, becoming partly liquid, and evolves a strong odour of cheese. Carbonic, acetic, and butyric acids with ammonia are generated; and on distilling the residual mass with sulphuric acid, the two latter acids pass over into the receiver.

75. *Colouring matter of urine.*—The nature of the pigment which communicates the characteristic tint to urine is quite unknown. By the late Dr. Simon it was regarded as identical with hæmaphaein,[33] the matter which gives to serum of blood its yellow colour, and to whose presence in excess the jaundiced hue of the surface, so common in chlorosis and anæmia is supposed to be owing. Dr. Prout has suggested that two distinct pig ments probably exist, one of them remarkable for its power of uniting with urate of ammonia, and communicating to it the fawn colour, so characteristic of this salt in urinary deposits. Berzelius has indeed described such a yellow colouring matter under the name of *halophyle*, a term applied to it from the remarkable obstinacy with which it adheres to the urinary salts. Ether readily extracts from inspissated urine a golden-yellow acrid matter, but it is questionable whether it can be regarded as the pure urinary colouring matter. Heller has lately given the name of *uroxanthin* to the reputed pigment, but which he has not succeeded in separating. According to him, the body is characterised by its undergoing oxidation by the action of acids, and under the influence of disease, giving rise to *uro-glaucin*, a blue, and *ur-rhodin*, a red pigment. These, however, are merely new names applied to what I have long ago described as purpurine. Heller has indeed correctly stated that these metamorphosed varieties of the urinary pigment may fall as insoluble deposits, but he has described as crystals of uro-glaucin, uric acid merely tinted by the changed colouring matter.

This error is an important one, and throws much doubt on many of his conclusions.

On referring to the analysis of urine passed in twenty-four hours (53), we find no less than 160 grains of matter set down as compound of volatile saline, and organic combinations. This mass contains ammonia, with organic acids, as well as, perhaps, phosphoric and hydrochloric acids; but when these compounds, as well as Pettenkofer's new body (70), are deducted, a considerable quantity of matter, varying probably from 40 to 60 grains, in the urine of twenty-four hours, will be left. To this residual matter the conventional terms of yellow extractive, colouring matter, or uroxanthin may be conventionally given. And it is to this matter that, in the following pages, the term of colouring matter is always supposed to refer.

A very characteristic reaction of this matter was pointed out by myself some years ago, founded on the action of hydrochloric acid upon previously warmed urine. When a test-tube is about one-third filled with healthy urine and raised to a boiling heat, the subsequent addition of a few drops of hydrochloric acid produces a tint varying, according to the proportion of colouring matter present, from a delicate lilac to the deepest crimson. The substance thus generated I have always regarded as identical with that excreted by the kidneys in certain diseases (140), (especially those connected with the imperfect elimination of carbon), and which communicates the peculiar hue to the so-called pink deposits.

76. The pink pigment thus generated under the influence of disease, or by the action of hydrochloric acid,

is readily soluble in weak hot alcohol, communicating to it a yellowish-pink colour, and is remarkable for the facility with which it unites with urate of ammonia. If this salt, quite colourless, be dissolved in a warm solution of the pink pigment, or in urine containing it, it is deposited on cooling of a pink colour, having absorbed the colouring matter like a mordaunt, just as alumina carries down with it the colouring matter of cochineal. To this pigment I proposed to give the name of purpurine. It is, I presume, identical with what Simon afterwards called uro-erythrine, and Heller, more lately, ur-rhodin.

77. The recent researches of Prof. Scherer[140] of Wurtzburg, on the yellow extractive of urine, are highly important. He has supposed that this substance is the direct result of the destructive assimilation of old blood corpuscles. The following is the mode he recommends for its preparation. Precipitate urine by basic acetate of lead, the deposit consisting of a combination of the colouring matter, and the acids of the urine with lead is digested in alcohol acidulated by hydrochloric acid. The lead is thus separated from the animal matter in question as an insoluble chloride. The alcoholic solution yields, by careful evaporation, the colouring extractive, of course more or less modified by the action of the acid, in the form of a blackish mass. By washing with water, the acid may be removed, and a blackish-brown powder is left by careful desiccation. If neutral acetate of lead be substituted for the basic salt, a much smaller quantity of animal matter is precipitated, but it appears to be richer in carbon. This, among other circumstances, leads to the conclusion, that the substance termed by Scherer colouring matter of urine, is really a mixture of two or

more bodies, and justifies our adopting this as a mere conventional term.

Scherer found this substance, obtained from the urine of a healthy person, to consist of—

Carbon	58.43
Hydrogen	5.16
Nitrogen	8.83
Oxygen	27.58

These researches invest the hitherto neglected colouring matter, or extractive of urine, with high physiological importance. It must for the future be regarded as a vehicle for the excretion of carbon from the blood by the kidneys, and these glands thus appear, in all probability, to play no mean part in compensating for a deficient function of those organs whose especial duty it is to secern carbon, as the liver and lungs. To this matter we shall again return when speaking of purpurine (141).

By loading the system with carbon, or by preventing its due elimination, an excess of this element has been proved to escape by the kidneys. Of the former, a good illustration is met with in the urine of a healthy man who for three weeks daily swallowed a large quantity of cod's liver oil, and of the latter, the urine of a person suffering from considerable pleuritic effusion, will serve as an example.

	Colouring matter of urine before the use of cod's-liver oil.	Colouring matter of urine after the use of cod's-liver oil	Colouring matter of urine of the case of pleuritic effusion.
Carbon . . .	56.65	57.22	61.65
Hydrogen . .	4.10	5.46	5.60
Nitrogen . . .	6.25	} 37.32	7.29
Oxygen . . .	33.00		25.46

78. *Ammonia.*—The presence of this alcali in the urine has been doubted by many late observers except as a product of decomposition of urea or other elements. The recent researches of Heintz[123] have, however, set this question at rest. This chemist availed himself of the property of chloride of platinum of forming an insoluble compound with ammonia. He added to fresh healthy urine, a solution of the chloride, and poured in a mixture of alcohol and ether; the double salt of platinum and ammonia soon fell, and the quantity of spongy platinum left after ignition of the deposit was an index of the quantity of ammonia present—a correction being made for the quantity of precipitate produced by the potass present in the urine. By this process the quantity of ammonia was found to vary from 2.16 to 2.19 in 1000 parts of urine.

Ammonia exists combined with uric acid, and probably with phosphoric acid and soda, forming the triple compound, known as microcosmic salt (80).

79. *The fixed salts of the urine* are so called from their being left after the other ingredients are destroyed by a red heat; they amount on an average to upwards of 138 grains in twenty-four hours. These consist, as has been shown (54), of combinations of chlorine, sulphuric and phosphoric acid, with soda, lime, magnesia, and potass. Of these, the combinations of chlorine and phosphoric acid are probably nearly entirely derived from the food.

To show how readily the supply of earthy phosphates may be thus obtained, I have calculated from the best authorities the quantities of these salts which exist in an ounce of eleven different articles of food. The numbers must not be assumed as rigidly correct, as in some of the analyses the sulphates and carbonates were included with the phosphates.

Articles of Food.	Phosphates in 1 ounce.	Authority.
Pease (Pisum sativum) .	9.26 grs.	Braconnot
Maise (Zea mays) . .	7.2	Gorham
French Bean (Phaseolus vulgaris)	4.7	Braconnot
Wheat (Triticum hybernum)	4.7	Liebig
Beans (Vicia faba) . .	4.7	Einhoff
Potatoes (Solanum tuberosum)	2.35	Liebig
Rice (Oryza sativa) . .	1.92	Braconnot
Milk	1.2	Liebig
Artichoke (Helianthus tuberosus)	0.96	Payen and Braconnot
Vetchling (Lathyrus tuberosus)	0.756	Do.
Beef	0.38	Liebig

The salts found in the urine after the use of any particular kind of food, may at once be known by referring to the composition of the ashes obtained by burning the substances entering into the food—the saline elements of the ashes and of the urine being always identical.

80. It is impossible to state with certainty in what manner, and with what bases, the phosphoric acid exists in the urine. Phosphate of soda and lime are certainly present, and in all probability the former possess the chemical constitution of the common rhombic salt, or perhaps is combined with phosphate of ammonia forming the double, or microcosmic salt. The phosphate of magnesia is also an element of healthy urine, as on the addition of ammonia a mixture of ammonio-phosphate of magnesia and phosphate of lime is precipitated. The

following formulæ represent the atomic composition of these different salts. They are all tri-basic.

Phosphate of soda	$(HO, 2\ Na\ O, P_2\ O_5) + 24\ HO$
Ammonia-phosphate of soda	$(HO, NH_4\ O, Na\ O, P_2\ O_5) + 8\ HO$
Phosphate of lime	$(HO, 2\ Ca\ O, P_2\ O_5)$
Ammonio phosphate of magnesia.........	$(NH_4\ O, 2\ Mg\ O, P_2\ O_5) + 12\ HO$

81. The form in which the combination of phosphoric acid with soda exists in the urine of other animal fluids, has been lately made the subject of discussion. The fact of the saline residue, obtained by igniting an extract of urine, being alcaline, whilst it often does not effervesce with acids, proves at once that the presence of an alcaline carbonate cannot account for its power of restoring the colour of reddened litmus. Enderlin has endeavoured to meet this difficulty, by assuming that phosphate of soda exists in the urine in the form of the alcaline tribasic phosphate, or $3\ Na\ O, P_2\ O_5$. Among other serious objections that may be urged against this view, I might adduce the fact, that no evidence exists of this particular phosphate occurring, excepting as the artificial product of manipulations in the laboratory. There is not a particle of evidence adduced of its really existing in the urine. Its existence, however, appears very necessary for the support of Liebig's view of the non-existence in the urine of any salt of an organic acid. From a careful series of experiments, I have elsewhere shown,[124] that a combination of an organic acid with an alcali may exist in a fluid containing the common or rhombic phosphate of soda $(HO, 2\ Na\ O, P_2\ O_5)$, and yet the residue of incineration may be free from an alcaline carbonate.

This is easily explained, for during ignition, the organic acid is destroyed, and its base replaces the water in the phosphate, converting $HO, 2\,NaO, P_2O_5$ into $3\,NaO, P_2O_5$. I found that 9 grains of dry phosphate of soda, and 4 of dry acetate of soda, dissolved in water, evaporated to dryness and incinerated, yielded a mass of the alcaline tribasic phosphate, which did not effervesce with acids, and was free from any carbonate. Hence I consider, that until better evidence is adduced, we must be content to regard the phosphoric acid and soda as existing in the state of the common rhombic phosphate unless it is combined with the phosphate of ammonia.

82. The soluble phosphates must be regarded as derived directly from the food, and from the albumen (84) and other elements of the blood when in the act of being organised into muscle. The insoluble phosphates forming part of the structure of the body, derived originally from the blood, are conveyed to the urine in the process of metamorphoses of tissue. Some portion of the phosphoric acid of the urine is in all probability generated from the action of oxygen on many of the structures of the body, into the composition of which, phosphorus largely enters, as the brain and nervous system generally. But the greatest part of the phosphoric acid is, as we have seen, derived, ready formed, from without, the phosphates of lime and magnesia abounding in milk and most varieties of vegetable food; whilst the basic alcaline phosphates exist in flesh, in wheaten flour, leguminous seeds, as beans and pease, &c. From the researches of Dr. B. Jones,[139] it appears that the earthy phosphates are most abundant in the urine passed a few hours after a meal, whether of animal or vegetable food, the smallest

quantity being met with after a meal of meat and distilled water. The earthy salts diminish with the time elapsing since the previous meal, and they appear to be remarkably increased by the administration of calcareous and magnesian preparations. The alcaline phosphates are most abundant shortly after a meal composed chiefly of bread, and do not appear to be materially affected by the circumstances which influence the excretion of the earthy salts. Dr. Jones found that in urine voided shortly after a meal, of a density varying from 1.022 to 1.028, the alcaline phosphates varied from 6.5 to 8.1 grains. The ashes of blood contain the basic alcaline phosphates; and muscle, when incinerated, yields much phosphate of lime and some phosphate of magnesia. The alcaline and earthy phosphates, in the opinion of Liebig, are chemically combined, the former with albumen, the latter with fibrine. During the formation of muscular tissue, whilst blood is becoming converted into muscle, the earthy phosphates remain in the new-formed tissue in a state of chemical combination; the greater amount of the phosphates of soda and potass re-enter the circulation, are separated by the kidneys, and thus find their way into the urine.

83. A part only of the earthy phosphates contained in the food is absorbed into the circulation, the greatest proportion escaping by the intestines. Berzelius found in 3 ounces of human excrements, 6 grains of earthy phosphates.

The insolubility of the salts in water fully accounts for their abounding in the fæces, as the kidneys alone remove those substances not required for the reparation of tissues, which are readily soluble, according to Wohler's well-known law.[125] This is well shown by contrasting the results of Enderlin's analysis of the ashes of human blood and fæces.

	Ashes of blood.		*Ashes of fæces.*
Phosphate of soda (tribasic)	22.1	(bibasic)	2.633
Chloride of sodium	54.769		
——— potassium	4.416		1.367
Sulphate of soda	2.461		
Earthy phosphates & oxide of iron	5.509		82.462
Sulphate of lime			4.530
Silicious matter			7.940
	98.921		98.932

A small quantity of phosphorus also exists in the urine in a non-oxydised form. This fact, lately discovered by Dr. Ronalds, may be easily demonstrated by comparing the quantity of phosphoric acid existing in the ashes of urine obtained by simple incineration with that found in the ashes of the same urine, after deflagrating its extract with nitre in a red-hot crucible. The excess of phosphoric acid thus found arises from the oxydation of the phosphorus of the urine.

If a tolerably fluid fæcal evacuation of a person who partakes freely of farinaceous food is allowed to repose for a short time, after being mixed with a pint or two of water, and the greater part of the mixture decanted; a quantity of large crystals of triple phosphate of magnesia can be easily detected at the bottom of the vessel. These crystals are sometimes coloured grass-green from the presence of bili-verdin, or of modified colouring matters of blood.

84. The proportion of sulphuric acid present in the

urine, nearly double that of the phosphoric acid, is too large to be entirely explained by its presence in the food in a state of saline combination. Indeed, an abundance of sulphuric acid may be detected in the urine, whilst food absolutely from sulphates is taken into the stomach. The presence of this acid is rather to be traced to the oxidation of the sulphur which exists with phosphorus in the elements of those tissues which contain albumen and fibrin. These two substances consisting, according to Prof. Mulder, of

	Albumen.	Fibrin.
Carbon	54.84	54.56
Hydrogen	7.09	6.90
Nitrogen	15.83	15.72
Oxygen	21.33	22.13
Phosphorus	0.33	0.33
Sulphur	0.68	0.36
	100.	100.

Thus, during the destructive assimilation or metamorphosis of tissue (33), oxydation of the sulphur occurs and explains the presence of at least a portion of the sulphuric acid met with in the urine.

85. Since the discovery lately announced by Professor Redtenbacher of the existence of nearly twenty-five per cent. of sulphur in taurine, (one of the products of the metamorphosis of bile,) a portion of the sulphuric acid of the urine may be regarded as resulting from the oxidation of the biliary sulphur. For it must be borne in mind that the bile is not separated from the portal blood by the liver as an entirely effete and useless product, for it certainly in some form or other re-enters the circula-

tion, and plays an important part in the animal economy connected in all probability with the evolution of heat prior to the final excretion of its elements. That sulphur exists in the urine in a non-oxydised form has been long suspected, and the fact of its blackening silver when boiled in a basin of that metal has been often adduced in proof of this statement. The only element of urine rich in sulphur, hitherto isolated, is a strictly morbid product of rare occurrence, viz., cystine (151). Some late very interesting researches of Dr. Edmund Ronalds, which he kindly undertook at my request, have, however, shown that all urine contains a compound of sulphur, and that in this form from three to five grains are excreted in the course of twenty-four hours. Dr. Ronalds found that when urine was precipitated by an excess of basic acetate of lead, a dense deposit of compounds of uric, sulphuric, and phosphoric acids, chlorine, coloring extractive matters, with lead, was obtained, and the filtered liquid, after being freed from the excess of the lead, contained the urea and the sulphur compounds. The lead precipitate containing hardly a trace of sulphur in a non-oxydised form. In five specimens of urine of healthy persons, Dr. Ronalds found the proportion of sulphuric acid existing in one thousand grains to bear to the non-oxydized sulphur the following proportions:

1.06 : 0.17—1.46 : 0.18—1.42 : 0.18—2.44 : 0.153—1.32 : 0.165.

86. The chloride of sodium of the urine is probably derived immediately from the common salt which forms so important a constituent of our food.

Some of the saline combinations existing in the urine can be readily recognized by the crystalline forms they present when obtained by simple evaporation on a glass plate (11).

Formation of deposits or sediments.

87. Whenever the different constituents of the urine maintain their proper relation to each other, the fluid, as it leaves the urethra, is clear and of a pale amber colour, its transparency being but slightly affected on cooling by the gradual subsidence of a slight mucous cloud, occasionally entangling in its meshes a very few microscopic crystals of uric acid. Whenever, however, one or other of the ingredients exist in real or comparative excess, or a new substance is superadded, the urine does not generally remain clear, but either immediately on being voided, or at least on cooling, becomes more or less turbid. Different names have been applied to the different degrees and states of turbidity, viz., pellicle, cloud, eneorema, and sediment, the hypostasis of the ancients.

When the urine, on cooling, becomes covered with a thin membrane-like scum, a *pellicle* is said to exist; when the substance producing the opacity floats in detached portions near the surface, it is said to form a *cloud*, and when this falls towards the base of the vessel, it is termed an *eneorema;* the term *sediment* or hypostasis being applied to a positive deposit collected at the bottom of the vessel. Of these, the terms pellicle, cloud, and sediment, or deposit, are still retained as general terms, but are not now used for the purpose of distinguishing any real or imaginary pathological condition. It very frequently happens that deposits do not become visible in the urine until after it has cooled down to the temperature of the air; this is particularly the case with those which are soluble in warm water, as the urates, more especially the urate of ammonia, which constitutes the great bulk of the red and fawn-coloured amorphous sediments. A crystalline deposit may escape detection by fixing itself in translucent crystals on the sides of the vessel, as sometimes happens with pale uric acid and triple phosphate. It is quite possible also for a crystalline substance to be present in large quantity, and yet, on account of the minuteness of the crystals and their refractive power not greatly differing from urine, to remain unnoticed. This is remarkably the case with oxalate of lime, and such deposits are best detected by gently warming the urine, and, after a few moments repose, to pour off the greater part of the fluid; on replacing this with distilled water, the previously overlooked deposit will become visible.

88. Urinary deposits, including under this term all substances which disturb the transparency of urine by their presence, whether they subside to the bottom of the vessel or not, may be conveniently 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 oxide.
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.

CHAPTER IV.

CHEMICAL PATHOLOGY OF URIC ACID AND ITS COMBINATIONS.

(*Lithi-uria.*)

89. WHEN uric acid exists in an urinary deposit, uncombined with a base, it is invariably in a crystalline form, never occurring in the state of an impalpable amorphous powder. The crystals are often sufficiently large to allow their figure to be defined without the aid

of the microscope; sometimes, however, they are so minute, that the deposit has been mistaken for urate of ammonia, or even for mucus, until microscopic examination has discovered the error. Uric acid never occurs quite colourless; indeed, excepting when mixed with urate of ammonia, which is frequently the case, it presents a characteristic yellow or amber colour. Every shade of intensity of tint, from the palest fawn-colour to the deepest amber or orange-red, may be often observed in these deposits; and hence the terms yellow or red sand are applied to them. In general, the deeper the colour of the urine, the darker the sediments.

90. *Diagnosis of uric acid deposits.*—When heated in the urine, the uric acid deposit does not dissolve; the crystals merely become opaque. They generally become more distinct from the solution of the urate of ammonia, which is frequently mixed with them, and sometimes completely conceals them from view. Hence the best mode of discovering this deposit, is to warm urine, turbid from excess of urate of ammonia, in a watch-glass; the acid becomes visible at the bottom of the glass, as soon as the urate dissolves. Heated with liquor potassæ, the uric acid deposit dissolves, from the formation of an urate of potass of sparing solubility. Hydrochloric and acetic acids are without any action, but the nitric readily dissolves it, and by careful evaporation a residue of a beautiful pink colour becoming of a rich purple, on being held over the vapour of ammonia, is left. This coloured residue is the murexid of Liebig, the purpurate of ammonia of Dr. Prout. Exposed to heat in a platinum spoon, the uric acid deposits burn, evolving an odour of bitter almonds; and finally leave a small quantity of a

white ash, which generally contains phosphate of soda or lime.

91. *Characters of urine depositing uric acid.*—When urine contains an excess of this acid, it generally lets fall crystals on cooling, uric acid being very seldom deposited before emission. It usually possesses a deeper amber tint than natural, sometimes being of a reddish-brown colour. Very high-coloured urine, however, seldom deposits uric acid until after the addition of a stronger acid. Urine never lets fall spontaneously all its uric acid as a deposit, until decomposition has commenced, for after being filtered from a sediment of this substance, the addition of a drop of nitric acid generally causes the deposition of an abundance of crystals of uric acid in a few hours.

Urine depositing uric acid always reddens litmus paper, and often contains an excess of urea, so as to crystallize slowly when mixed with nitric acid in a watch-glass (5, 56). Its specific gravity is generally above 1.020. An exception to the above character is presented by the pale urine of infants at the breast, among whom deposits of uric acid are common. These often appear as a yellow crystalline sand, whilst the supernatant urine is frequently of low specific gravity, often 1.006, as pale as water, and nearly destitute of urea. This circumstance admits of explanation from the small proportion in which the alcaline phosphates, the presumed solvent for uric acid (63), exists in the urine of infants.

92. *Microscopic characters.*—The varieties presented by uric acid in its crystalline form, are very remarkable; all of them, however, may be traced to some modification of the rhombic prism, which may be assumed as the

normal crystalline form of this substance. But two varieties can be artificially obtained, by filtering a warm solution of urate of potass or ammonia, into dilute and warm hydrochloric acid; either perfect rhomboids, or square tables, generally excavated at the sides into an imperfect hour-glass figure, being obtained. These varieties cannot be produced at will, and appear to depend upon the strength of the solution of the urate employed, and temperature of the dilute acid.

The crystalline forms of urinary deposits can be examined by merely placing a drop of the turbid urine on a plate of glass, and examining it with a microscope under a good half-inch achromatic object-glass. By far the most satisfactory mode is, however, the following, which, by rendering the crystals distinct, amply repays the trouble it requires. Allow the urine to repose for a short time in a tall vessel, decant the greater proportion, and pour a tea-spoonful of the lowest turbid layer into a watch-glass, gently warming it to dissolve any urate of ammonia, and to aid the deposition of the deposit. Remove the supernatant urine with a pipette, and replace it with a few drops of water; then place the watch-glass under the microscope, and the crystals covered by the water will become most beautifully distinct. They may be examined by transmitted or reflected light, the latter having some advantages when the crystals are large or in masses. All that is then required is to place on the stage of the microscope, and under the watch-glass, a piece of black velvet; by means of a condensing lens, let a strong light be thrown upon the crystals; then bring the object-glass into proper adjustment, and the colour, as well as the figure of the crystals, will become beautifully defined on a black ground. In the following microscopic views, all the larger crystals are thus represented.

93. In Fig. 9 are represented the common rhomboidal crystals of uric acid; these are sometimes found so thin, as to be merely pale, lozenge-shaped laminæ; more generally, however, they are thicker, and then by adjusting the light carefully, their sides and true figure become well marked. Many of them appear nucleated, from the

FIG. 9.

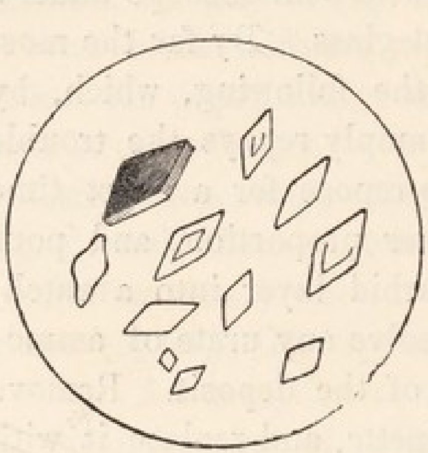
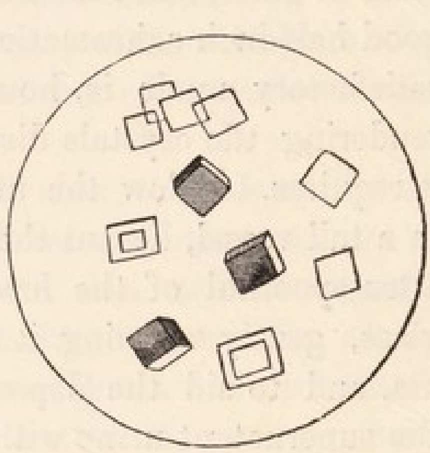


FIG. 10.



presence of certain internal markings, as if one crystal included another. It seldom happens that the angles of these are sharply defined, the two obtuse corners being most generally rounded off; and sometimes the acute angles are blunted, so that the whole crystal appears elliptical. The most perfect specimens of these are found in deposits of yellow sand in the urine of young infants; I have never seen them in red sand, or in deposits produced artificially by the addition of a mineral acid to urine. When the deposit has been of long continuance, especially in cases of calculous disease, the rhomboid outline of the crystal is replaced by a square one (Fig. 10). The deposit is then generally high-coloured, and the crystals much thicker than in the former variety. In these an internal marking, like a framework, is visible. Several accidental varieties of these rhomboid and square crystals exist; of these the most curious present a spindle-like figure, the obtuse edges being rounded, and the margin on either side excavated (Fig. 11), so as sometimes to approach a fleur-de-lys outline. Many uric deposits appear at first sight to be made up of flattened cylinders, presenting a very remarkable appearance (Fig. 12). Upon making them roll over, by

FIG. 11.

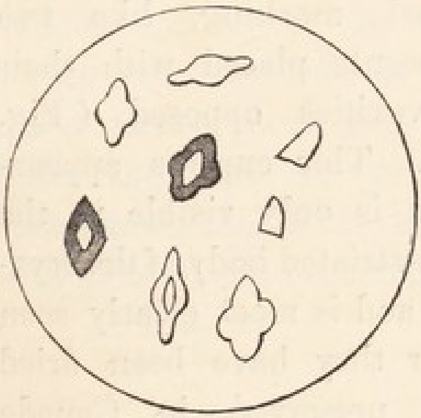
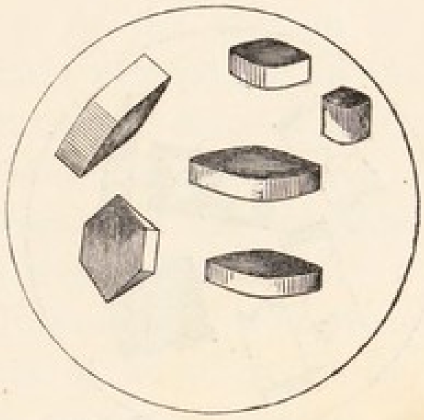


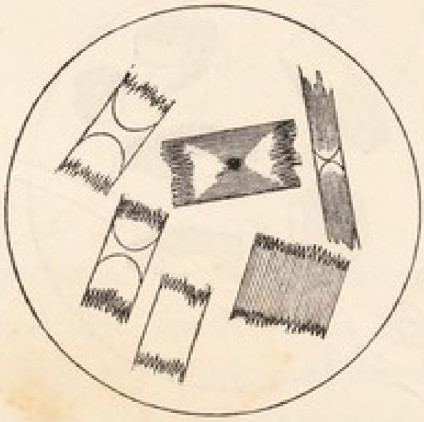
FIG. 12.



adding a few drops of alcohol, or by agitation, the fallacy will be detected, they being really very thick lozenges lying on their sides; and hence, without this precaution, and carefully adjusting the object, they might be regarded as cylinders, for which indeed they were formerly erroneously described both by M. Vigla and myself. This variety is frequently found mixed with urate ammonia and oxalate of lime; and is frequently observed in the deposit produced by the addition of hydrochloric acid to urine.

94. The crystals are sometimes found very thin, and longer than broad, so as to represent square tables. These in general have their surfaces quite smooth, especially when they occur in pale urine. When, however, they are met with in very acid urine, or are precipitated by the addition of nitric acid, the sides of the tables are strongly defined, but the extremities are closely serrated, as if made up of a number of closely-packed, irregular needles, crystallized on the body of the crystal. The whole surface is sometimes marked with myriads of close dark lines. When carefully examined, the bodies present a very remarkable internal marking, like two crescents placed with their convexities opposed (Fig. 13). This curious appearance is only visible in the non-striated body of the crystal, and is most clearly seen after they have been dried and preserved in Canada balsam.

FIG 13.



Course, and deep orange or red, sand is generally composed of cohering crystals, forming, indeed, minute calculi. Two varieties of these are met with, one formed (Fig. 14) of cohering, thick rhomboidal prisms, and the other of aggregated lozenges in spinous masses. The latter are most frequently found where a marked ten-

FIG. 14.

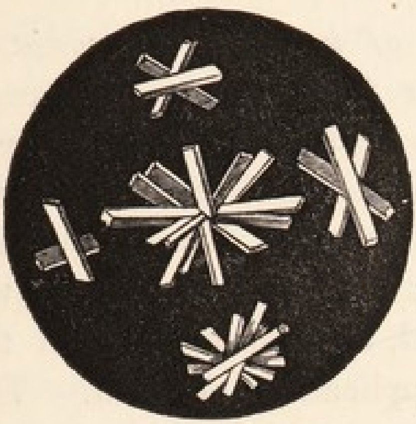
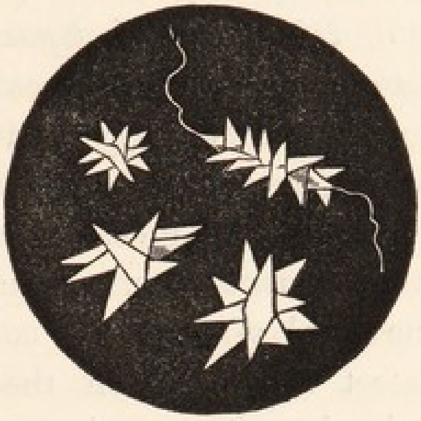
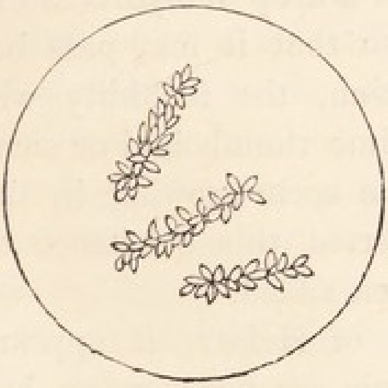


FIG. 15.



dency to the formation of calculi exists (Fig. 15). It is not unfrequent to find these masses crystallized on a hair, just as sugar-candy is crystallized on a string or thread. When very hastily deposited by the sudden cooling of the urine, or by the addition of a strong acid, uric acid is sometimes precipitated in irregular masses, resembliug on microscopic inspection irregular fragments of yellow quartz; this, however, is unfrequent, and is the only exception I am acquainted with to uric acid occurri ng in well-defined crystals.

FIG. 16.



In examining some specimens of urine, in which I had reason to suspect the presence of uric acid, I have occasionally met with a remarkable variety resembling to the naked eye slender fibres or hairs about the eighth of an inch in length.

These, on microscopic examination, were found to consist of numerous very minute lozenges cohering in linear masses (Fig. 16).

95. *Diagnosis of deposits of urate of ammonia.*—These deposits vary in colour from absolute whiteness, through almost every variety of tint, to a pale fawn-colour, (the most frequently met with,) brick-red, pink, or purple. All these various-coloured deposits present certain characters in common; they never appear in the urine until after it has cooled, and disappear with the greatest readiness on the application of heat. The purple deposits require rather a higher temperature for solution than the paler varieties, and sometimes, on account of the concentration of the urine, require the addition of a little water before they quite disappear. The addition of liquor ammoniæ, or liquor potassæ, immediately dissolves deposits of urate of ammonia, at the same time rendering the urine a little turbid from the precipitate of the earthy phosphate. Their chemical constitution is shown in a very interesting manner by examining a drop of the turbid urine, or a portion of the deposit, with the microscope between two plates of glass; an amorphous powder will be alone visible, unless free uric acid be present. Then place a drop of hydrochloric acid on the edge of the glasses, so that it may pass between them by capillary attraction, the turbidity will partly disappear, and in a short time rhomboidal or compound crystals of uric acid will be seen growing in the fluid, the ammonia having deserted this substance to unite with the acid which had been added.

From some recent researches of Heintz, it appears that deposits of urate of ammonia are never pure, but always contain appreciable quantities of the urates of lime and soda, and often of magnesia and potass.

96. *Characters of urine depositing urate of ammonia.*—The following modifications are most important.

1st. A pale urine of low specific gravity (1.012), becoming opaque on cooling from the deposition of nearly white urate of ammonia, which, instead of readily falling, forms rope like masses in the fluid, and presents on a superficial view so much the appearance of muco-pus, as to have been mistaken for it. Its disappearance on the application of heat will at once discover its real nature.

2nd. A pale amber coloured urine of moderate density (1.018), which on cooling lets fall a copious fawn-coloured deposit, resembling bath-brick grated into the urine, disappearing with the utmost readiness on applying a gentle heat. This deposit is of frequent occurrence, often very transient, and is so constantly an attendant on the slightest interference with the cutaneous transpiration, that a "cold" is popularly diagnosticated whenever this state of things exists.

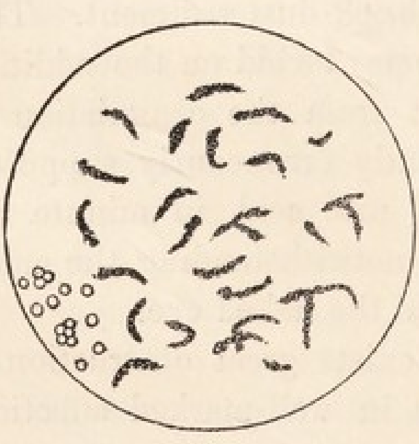
3rd. Whenever febrile excitement prevails, the urine becomes concentrated, rises in density (1.025), and deposits on cooling a reddish-brown sediment, constituting the well-known lateritious, or brick-dust sediment. This variety of urine generally becomes turbid on the addition of a drop of nitric acid, not from the coagulation of albumen, as has been frequently erroneously supposed, but from the precipitation of uric acid in minute microscopic rhomboidal crystals, notwithstanding the amorphous appearance it presents to the naked eye.

4. In all cases where there exists great obstruction to the elimination of carbon, as in well-marked affections

of the portal circulation, especially when connected with organic disease of the liver or spleen, or less frequently when suppuration, particularly of a strumous character, is going on in the body, the urine is generally found to possess in many instances a deep purple or copper colour, often verging on crimson, so as to have led to the idea of blood being present. These deep tints appear to me to depend upon the presence of an excess of purpurine (136). Whenever a deposit of urate of ammonia occurs in such urine, either spontaneously or by immersing it in a freezing mixture, it combines with the pink pigment, forming a kind of lake, and which is often so abundant as not to entirely disappear by heat, until the urine is diluted by the addition of water. These deposits do not exhibit their delicate tints until after being collected in a filter; they readily give up their colouring matter to alcohol, which scarcely acts on the urate of ammonia they contain.

97. *Microscopic characters of urate of ammonia.*— When a drop of urine, turbid from the presence of this substance, is placed between two pieces of glass, and examined with the microscope, a mere amorphous precipitate is first seen. On minute examination this will be found to be composed of myriads of excessively minute globules adhering together, forming little linear masses (Fig. 17), often mixed with crystals of uric acid. Sometimes, especially if the

Fig. 17.



urine has been long kept, the minute particles cohere and form small opaque spherical bodies, appearing black by transmitted light, on account of their opacity; when examined by reflected light, on a black ground, they present a buff or fawn-colour. On the application of a slight heat to the drop of urine, the particles of urate of ammonia disappear, again becoming visible on cooling. An elegant mode of showing the composition of the deposit, is to place a drop of the turbid urine in a watch-glass, and gently warm it; as soon as it has become clear, add a drop of almost any acid, (the hydrochloric is perhaps the best,) and as soon as it has become cold, examine it with the microscope. The muddiness previously produced by the urate, will have become replaced by lozenges of uric acid (Fig. 9). The urate of ammonia occurs very rarely in spherules with crystals of uric acid adhering to their surface; this is frequently observed in albuminous urine, occurring in dropsy after scarlatina (Fig. 18), and from its opacity, is best observed by reflected light.

FIG. 18.

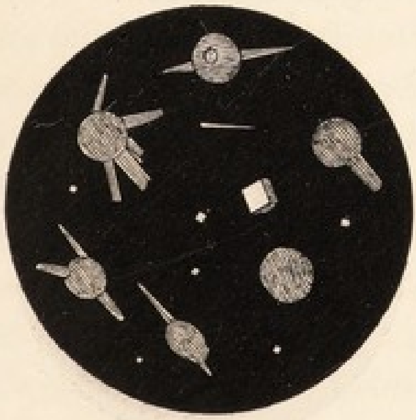
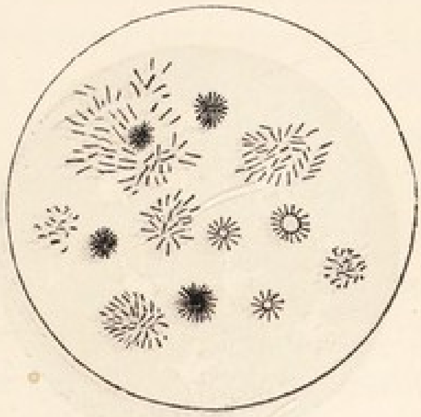


FIG. 19.



98. It has been stated, especially by continental observers, that urate of ammonia occurs in deposits in delicate needles, sometimes united so as to form stellæ. I have never seen this variety in urine. Fig. 19 shows the minute needles and stellæ of urate of ammonia, artificially prepared by dissolving uric acid in a warm solution of ammonio-phosphate of soda, and allowing the crystals to separate by repose (61). It is difficult to imagine this form ever occurring in urine, as Dr. B. Jones has shown that the presence of saline matter, or of the colouring matter of urine, interferes with the needle-like crystallisation of urate of ammonia, and converts it into minute globular particles.

99. Of the other salts of uric acid, the urate of soda is the only one I have distinctly recognised, forming a distinct deposit. It occurs occasionally in gout, but I have more generally met with it in the urine of persons labouring under fever, who were treated with carbonate of soda. It then occurs in round yellowish or white opaque masses, provided with projecting, generally curved processes, (Fig. 20,) forming a very remarkable

FIG. 20.

FIG. 21.

FIG. 22.

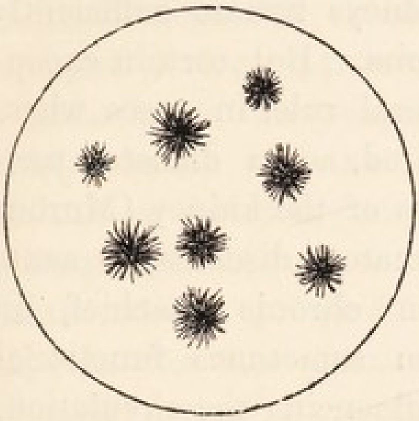


figure. This regular form has never occurred to me more than twice; a variety more confusedly crystalline (Fig. 21) is less unfrequent. When artificially prepared, by dissolving uric acid in a hot solution of carbonate or phosphate of soda, it appears in two forms depending upon the mode of preparation. If allowed to separate on cooling from the solution, the urate of soda crystallises in needles and tufts (Fig. 22); but if a solution of it be allowed to evaporate spontataneously on a glass plate, it assumes the form of spherical masses like minute pearls. In chemical characters, the urate of soda resembles the salt of ammonia, but does not disappear quite so readily on heating the urine.

100. *Pathological changes in the quantity of uric acid and urate of ammonia.*—Independently of an alteration in the proportion of uric acid by an excess or deficiency of nitrogen in the food (66), certain pathological states of the system exert a most important influence on the quantity excreted. We have seen that uric acid may be traced to two great sources, viz., the disintegration of tissues, and to nitrogenised food (68). It is obvious, therefore, that whatever increases the rapidity of the former process, or interferes with the due digestion or assimilation of the latter, will materially affect the amount of uric acid contained in the urine. Experience has shown that in all diseases attended with great emaciation, when the wear and tear of the frame is not compensated

by the supply of food, an increased quantity of uric acid appears in the urine, if the kidneys remain sufficiently healthy to perform their functions. But certain exceptions are presented to this general rule, in cases where the renal function is itself impaired, as in diabetes mellitus, and in the granular diseases of the kidney (Morbus Brightii). In all acute inflammatory diseases, in acute inflammation supervening upon chronic mischief, in rheumatitis, in organic, or even sometimes functional affections of organs materially influencing the circulation, as the heart, liver, and perhaps the spleen; a considerable increase in the quantity of uric acid will occur, and deposits of this substance, either free or combined, will appear in the urine. Taking the average of eleven cases of acute inflammatory diseases, reported by M. Becquerel, and twelve of continued fever (on the fifteenth day), by M. L'Heritier, we find that the quantity of uric acid was more than double the healthy average.

	Acute inflammation.	Fever.	Health.
Specific gravity of the urine .	1.0216	1.0229	1.017
Water	653.454	591.775	974.935
Uric acid	1.041	1.312	0.398

In the two allied affections, gout and rheumatism, exclusive of the many neuralgic diseases popularly referred to the latter, a remarkable tendency to the formation of an excess of uric acid, both pure and combined, occurs. The elements of the acid, or its combinations are in these diseases supplied both by the nitrogenised elements of the food, as well as by the changing tissues of the body. In such quantities is urate of soda often generated, that the watery portions of the blood are not sufficient for its solution; and part of it is deposited in the joints, and sheaths of the tendons, producing painful swellings.

101. In all diseases attended with excessive debility, independently of acute disease, especially where an anæmic or chlorotic state exists, and when the circulation is languid, or if excited, is owing to irritation rather than inflammation, a deficiency of uric acid occurs, and no deposits ever take place in the urine, unless the quantity of water present is remarkably diminished. The diminution of uric acid is well observed after losses of blood, in chlorosis, and in many neuralgic and hysteric affections. The average drawn from four cases of chlorosis, observed by Becquerel, and one of melæna, another of irritable uterus, and a third of spermatorrhæa, examined by myself, is as follows:—

Average density	1.015
Water	976.0
Uric acid	.184

The quantity of uric acid being less than one-half the normal proportion.

102. As a general rule, whenever the functions of the skin are impaired, where a due amount of secretion is not exhaled from the surface, an excess of nitrogen is retained in the blood, and ultimately separated by the kidney in the form of urate of ammonia, or perhaps urea, or the nitrogenised substance of Pottenkofer (70), which substances contain respectively 38, 46, and 54 per cent. of this element. A person in apparently good health, experiences from exposure to a current of cold air a slight check to perspiration, and the next time

he empties his bladder, he voids urine of a deeper colour than is usual with him, and on cooling it becomes turbid from the precipitation of urate of ammonia. The explanation of this phenomenon, with which every one is familiar, is found in the kidneys assuming temporarily a kind of compensating function (9) for the skin. It is true that uric acid, or urate of ammonia, is not naturally expelled from the surface of the body, but certain organic matters, rich in nitrogen, certainly are; and if their proper emunctory, the skin, has for a time its function arrested, they are probably filtered from the circulating mass by the kidneys, in the form of urate of ammonia. That nitrogenised products are exhaled from the skin is indubitable. Dr. Faraday calcined pure river sand, and on heating it with hydrate of potass, it yielded no trace of ammonia. On merely passing this sand over his hand, and then treating it in a similar manner, ammonia was evolved. A piece of ignited asbestos, by mere pressure for a short time between the fingers, absorbed enough of some nitrogenised organic matter to evolve ammonia when heated with hydrated potass.

A short time ago I was consulted by a medical friend on the case of a patient lying bed-ridden from rheumatic gout. His legs were covered with an eczematous eruption, and the parts on which the exudation had dried, were actually frosted with microscopic crystals of urate of soda.

Although my observations have not been sufficiently extended to warrant its announcement as a general law, I may state that in cases of lepra, psoriasis, and icthyosis, the urine has been much richer in urea than was consistent with health.

103. It is quite certain that the value and importance of the functions of the perspiratory system, in relation to the rest of the organs, has not been sufficiently estimated. The following observations of Mr. Erasmus Wilson[126] on this subject are exceedingly striking and interesting. "I counted the perspiratory pores in the palm of the hand, and found 3528 in a square inch; now each of these pores being the aperture of a little tube of about a quarter of an inch long, it follows that in a square inch of skin on the palm of the hand, there exists a length of tube equal to 882 inches or 73.5 feet. Surely such an amount of *drainage* as 73 feet in every square inch of skin, assuming this to be the average of the whole body, is something wonderful, and the thought naturally intrudes itself,—What if this *drainage* were obstructed?" ——— "The number of square inches of surface in a man of ordinary height and bulk is 2500; the number of pores, therefore, is 700,000, and the number of inches of perspiratory tube 1,750,000, that is 145,833 feet, or 48,600 yards, or nearly 28 miles."

104. From a series of careful observation, Seguin[38] ascertained that, on an average, eleven grains of matter were exhaled from the skin in a minute, equal to 15,840 grains, or 33 ounces, in 24 hours. Consequently the amount of perspired matter very nearly equals that of the urine. The exhaled fluid was afterwards examined by Anselmino,[39] who found that it contained on an average 0·88 per cent. of solids; and 100 grains of this solid extract contained 22.9 grains of saline matter. Hence in the course of 24 hours the skin exhales

Organic matter	107.47 grains.
Saline matter	81.92
Water and volatile matter . .	15750.61
	15840.

This organic matter contains much nitrogen, and I have more than once detected in it a body resembling, if not identical with, urea. Berzelius[40] states that osmazome, another nitrogenised substance, is an ingredient in the perspired fluid. It may be safely assumed, that when the skin is unable to perform its functions, the 107.47 grains of organic matter, which then lose their proper outlet, appear wholly or partly in the urine in the state of urate of ammonia.

105. As already stated, this occurs when the kidneys are healthy; but if organically diseased, or even merely in a state of congestion, or at most sub-acute inflammation, as in the dropsy after scarlet fever, they simply pour out albumen, the vital chemistry of these organs being too far depressed to allow of the conversion of this substance into a body normal to the kidneys. Hence, in the disease in question, the disappearance of albumen, and presence of uric acid in the urine, become valuable indications of convalescence. Dr. Marcet[41] was the first who suggested that interference with the functions of the skin might in some way account for calculous deposits.

106. Professor Liebig recognises one great cause of the appearance of an excess of uric acid in the urine, founded on his theoretical views of the conversion of this substance into urea (65). It may be thus briefly enunciated; that as normally, the insoluble uric acid first produced by the metamorphosis of tissues is, under the

influence of oxygen conveyed in the red blood-discs, converted into the soluble urea, whatever increases the number of blood-discs, (carriers of oxygen,) or quickens the circulation, must cause the more complete conversion of uric acid into urea; and less of the former and more of the latter will appear in the urine. Conversely, whatever interferes with the perfection of oxygenation in the body, must necessarily produce an excess of uric acid. From this view,[42] it follows that the quantity of uric acid ought to be positively or relatively to urea, decreased in

1. Fever.
2. Acute Phlegmasiæ.
3. Phthisis.

And conversely it should be increased in

1. Chlorosis.
2. Anæmia.
3. Pulmonary emphysema.

The only mode of testing hypotheses of this kind, emanating from a great and respected authority, is by clinical observation; and so far as recorded facts are concerned, they fail altogether to give the slightest support to the ingenious theory of Professor Liebig.

107. The labours of Edmund Becquerel[43] in urinary pathology, furnish us with a mass of carefully recorded observations, which, made with no view of supporting or disputing any preconceived notions, are peculiarly entitled to respect. The numbers in the following table are calculated from some of the analyses alluded to, and point out the actual quantity of uric acid and urea excreted in the twenty-four hours, and the relative proportion they bear to each other, in several diseases.

	Quantity in 24 hours of		Ratio of uric acid to urea.
	Uric acid.	Urea.	
	Grains.	Grains.	
Healthy urine (Becquerel's average)	8.1	255.	1 : 31.48
Chlorosis, minimum of five cases .	1.8	77.5	1 : 43.
Chlorosis, maximum of five cases .	6.	172.	1 : 29.
Pulmonary emphysema, extreme dyspnœa . . .	4.9	172.	1 : 35.1
Phthisis, tubercles softened . .	9.1	66.7	1 : 7.33
Phthisis, three days before death .	9.8	29.4	1 : 3.
Morbus cordis, with icterus . .	9.82	73.3	1 : 7.6
Acute hepatitis, with icterus .	11.18	61.6	1 : 5.6
Icterus	17.75	285.6	1 : 16.1
Milk fever	19.	133.	1 : 7.47

From this table, we find that in chlorosis, a disease of anæmia, in which oxygenation of the blood, on the theory of Liebig, must be most imperfect; the uric acid, instead of being in excess, is positively and relatively below rather than above the healthy average (101). In pulmonary emphysema, again, the same thing is observed, although, from the want of integrity in the function of respiration, uric acid ought to abound; while in acute hepatitis, and in phthisis, diseases in which, on Liebig's own showing, oxygenisation is actively going on, the uric acid, both abstractedly and in relation to the urea, is at a minimum instead of a maximum. The curious disease, diabetes mellitus or glucosuria, seems, moreover, to offer a serious objection to the validity of the opinion, that in phthisis, excessive oxydation is going on, and therefore the uric acid must be oxydised into urea and disappear from the urine; (even if it were true that uric acid deposits did not occur in this disease). Diabetes and phthisical disease of the lungs so frequently occur together, that some pathologists have even gone so far as to suppose this complication to be a necessary one. Yet here, while phthisical disorganisation is pursuing its destructive course, and excessive oxydation is supposed to be entirely destroying the tissues of the body, an abundance of a highly-carbonised, indeed a readily oxydisable substance, is generated in the body, circulates in the blood, and escapes by the kidneys. I confess it seems difficult to conceive how excessive oxydation can be supposed to be going on contemporaneously with the copious formation of an inflammable body, sugar.

108. Is it possible in any manner to reconcile these facts, the actual results of clinical observation, with the hypothesis of Liebig? If we admit that an amount of oxygen, requisite for the destruction of tissue alone, enters the system, uric acid ought to occur in the urine; in proportion as this amount is exceeded, the acid becomes converted into urea. Therefore, by supposing that in inflammatory affections, the change of tissue (or emaciation) is so rapid in its progress under the influence of disease, that all the oxygen entering the lungs in a given time is sufficient alone for the production of uric acid, deposits of this body will occur in the urine. On the other hand, if the disease does not so rapidly emaciate the patient, the metamorphosis of tissue will proceed sufficiently slowly to allow oxygen to react on the uric acid, and but a minimum reaches the urine. By allowing this latitude to the theory, the general absence of uric acid deposits in chlorosis and anæmia, and their presence in inflammation, is accounted for. Still the great objection

regarding phthisis remains, as this disease is especially mentioned by Professor Liebig in his work as one in which the excess of uric acid does not occur. Even this may be reconciled to his views by a remark he made to me, that he did not mean by phthisis the disease in any stage in which disorganisation of lung was going on, for here he admitted with all, that uric acid occurred in excess, but intended his remarks to apply when only the early stage of tuberculisation existed, corresponding, so far as I understood him, to what is known in this country of the term tubercular cachexia.

109. Excluding all abstract theories, 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-fours), it may safely be inferred that one or other of the following states exist.

A. Waste of tissue more rapid than the supply of nitrogenised 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 nitrogenised food not being in excess, but the digestive functions unable to assimilate it.	All the grades of dyspepsia.

Cause	Occurs in
D. The cutaneous outlet for nitrogenised 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.	Blows and strains of the loins, diseases of genital apparatus.

110. It is quite possible for an excess of uric acid to exist in the urine without forming a deposit, and *vice-versâ*, the presence of a deposit does not necessarily indicate the existence of an abnormal proportion. It is, however, easy to discriminate between these cases, for if a deposit of urate of ammonia be present whilst the bulk of the urine in twenty-four hours is not much below the average, it is certain that an excess of uric acid exists. But if the bulk of the urine be much below the natural quantity, a deposit may occur simply from there not being sufficient water to hold it in solution. To determine whether an excess exists, let all the urine passed in twenty-four hours be collected, well shaken, and a given quantity, as about two ounces, be mixed in a conical glass vessel with about half a drachm of hydrochloric acid. In six or eight hours crystals of uric acid will be copiously deposited on the sides of the glass, and may be washed, dried, and weighed in the manner already described (16). This little operation is so easily performed, that it can scarcely be deemed troublesome; and by a simple multiplication sum, the whole amount of uric acid secreted in

twenty-four hours can thus be readily ascertained without the fear of any considerable error.

111. The copious deposit of urate of ammonia occurring after eating more freely of animal food than is required for the supply of the wants of the body is a well-known phenomenon, and will occur in persons whose digestive organs are in perfect vigour, simply from a greater amount of matter being given them to assimilate than they are adequate to. In like manner, if a person's digestive powers are impaired, either partially or temporarily, as after a debauch, he will be unable to convert into healthy chyle even a small proportion of food, and hence its albuminous elements imperfectly assimilated enter the circulation, to be evolved by the kidneys and perhaps other emunctories. Particular idiosyncrasies with regard to the action of the stomach on certain articles of diet also exist; thus a single cup of coffee or green tea will, in many persons, determine the formation of a deposit in the urine, as if the caffein present in these two beverages had escaped the digestive powers of the stomach, and become converted into urate of ammonia.

112. The conditions above referred to, apply alike to the presence of free or combined uric acid, but certain other circumstances require consideration in connexion with its occurrence in a free or crystalline state. The appearance of a deposit of urate of ammonia, may be caused by a mere exaggeration of a natural condition; being a simple increase in quantity of a salt normal to the urine. When, however, the acid occurs in a free state, it shows that not only it may be in excess, but some change has occurred in the urine, which has separated it from the

base with which it had been previously combined. A deposit of free uric acid may depend on one or other of the following conditions:

A. An excess of this acid may exist, and be separated by the kidney in too large a quantity to be all converted into urate of ammonia.

B. The quantity of acid being normal or nearly so, certain changes have occurred in the urine which have induced a separation from its solvent.

So long as in the pathological states above enumerated, the quantity of uric acid is not too great to combine with the ammonia simultaneously excreted, whether derived from the phosphate or not (63), the urine will be transparent upon being passed, but on cooling a more or less copious deposit of urate of ammonia takes place. But if the acid exceed this quantity, it is held in solution by phosphate of soda so long as the urine is warm; on cooling, being partly deposited (61) in the form of a crystalline sand or gravel (62.) If, without the amount of this substance being increased, mere traces of a stronger acid reach the urine, the uric acid is deprived of its base, and is precipitated in crystals.

113. Of the first of these conditions the urine frequently presents a good illustration in heart-disease, especially in great hypertrophy of that organ, in rheumatism, and many phlegmasiæ. In these, it is common to find one day a deposit of urate of ammonia, and perhaps on the next a sediment of crystallised uric acid will occupy the bottom of the glass vessel, and a dense stratum of urate of ammonia will rest upon it.

Of the second condition, examples are furnished by cases of irritative dyspepsia with pyrosis; here a large proportion of free acid is generated in the stomach, and being absorbed, finds its way to the kidneys, setting uric acid free from any soluble urate that may be present. The acid thus generated by the stomach by disease is often considerable, far exceeding the proportion poured out during healthy digestion. In one case of scirrhus pylorus, in which the patient often vomited several pints of fluid in twenty-four hours, I found a quantity of free hydrochloric acid, equal in each pint to 22 grains of the pharmaceutical acid,[44] in addition to a sufficient quantity of some organic acid (lactic ?) to neutralise near 7 grains of pure potass. At another time the hydrochloric acid nearly disappeared, and the quantity of organic acid in each pint required for saturation nearly 17 grains of the alcali. The probability of these acids being absorbed and finding their way to the kidneys, is shown by the well-known fact, that the medicinal employment of the mineral acids will be followed, in the majority of cases, by the appearance of crystalline grains of uric acid in the urine.

114. If, as has been supposed, an organic acid (lactic or butyric) be an element of the perspired fluid, it is quite possible that by being retained when perspiration is obstructed, it may find its way to the urine, and precipitate uric acid. In this way, imperfect action of the skin may cause an uric deposit without increasing the amount of nitrogenised matter conveyed to the kidney (102). Seguin, in addition to the facts already stated (104), observed that perspiration was lessened during digestion,

and considerably diminished when this function was imperfect. In this way, a bulky meal may be an indirect cause of an uric acid deposit, besides affording pabulum for the formation of urate of ammonia (110).

115. Uric acid and urates may occur in great abundance in the urine, so as to become serious sources of irritation, and then especially become primary objects of attention as definite diseases. These bodies may be deposited in an insoluble form in the kidney or bladder, and aggregating, form a mass, on which, by a kind of imperfect crystallisation, great portions of the acid or its salts may be deposited, giving rise to the formation of a calculus. Uric acid is of more serious importance than most other elements of calculous formations, not only from its constituting a large proportion of all urinary calculi, but even when they are chiefly composed of other ingredients, the nuclei on which they are deposited are, in the great majority of cases, composed of uric acid. Of 374 calculi contained in the museum of Guy's Hospital, the nuclei are in 269 composed of uric acid or urate of ammonia alone.[45]

On account of its solubility (61), urate of ammonia is not a frequent component of entire calculi, although it often enters with other ingredients into their composition. Indeed, calculi wholly composed of this compound are almost peculiar to childhood; in Guy's museum there are but eight concretions entirely consisting of this substance, although it constitutes the nucleus in eighteen. It is hence very probable that if ever by medical treatment we can succeed in overcoming a calculous diathesis, or dissolving a stone in the act of growth, it will be by means directed to the solution of the uric acid or its combinations.

116. Regarding the medical treatment of the different forms of uric acid gravel (limiting this term to deposits occurring so persistently or abundantly as to have become primary sources of irritation or annoyance) much might be said. Discarding altogether the existence of any specific agent for a disease which is rather symptomatic of another affection than really idiopathic, the therapeutical agents may be briefly referred to the following heads.

1. *Attention to the function of the skin.*—The remarks already made on the effect of an arrest of perspiration furnishing a pabulum for the formation of a deposit (102-3), or by retaining in the circulation a substance capable of rendering uric acid insoluble (114), show the necessity of attending to this indication. I have repeatedly seen diaphoretics, warm clothing, the use of a flannel, and in winter, even a chamois leather waistcoat, with friction by means of a flesh-glove or hair-glove, repeatedly remove a deposit of uric acid gravel, and in more than one instance, where even an hereditary taint existed from gouty or calculous progenitors. The observations of Dr. Wilson Philip[46] have shown that the proportion of uric acid in the urine is notably diminished by the use of active diaphoretics. It is also probable that the extreme rarity of calculous affections in the navy might be partly explained by the kind of vapour-bath in which sailors sleep, " the lower decks being the parts allotted to repose, the ports are for the safety of the ship necessarily closed at night, and the temperature of the surrounding air is thereby so exalted that the place becomes a kind of steam-bath from animal exhalations; the

men being literally immersed in their own perspiration." These are the remarks of Mr. Copland Hutchinson,[47] who, in allusion to the rarity of calculus among sailors, adds that from 1800 to 1815, upwards of 126,000 men were employed in the navy. Of these, nine-tenths had been employed at sea from a very early period of life. But eight were affected with stone. It appears probable that three of these were affected with calculus before entering the service. So that taking all the cases in the navy in the period above mentioned, it cannot be said that more than 1 in 34,000 were the subject of calculus.

117. My own experience induces me to regard the warm, or still better, the vapour-bath, as the most valuable diaphoretic. The latter is readily employed in private practice by means of the very convenient and portable apparatus of M. Duval, which has for a long time superseded other forms of vapour-bath at Guy's Hospital. Actual diaphoresis is by no means necessary in the treatment of all cases of uric gravel; friction to the skin, and when persons are sufficiently robust, immersion in the cold-bath, or cold sponging on rising from bed, followed by rubbing the surface of the body with a dry and rough towel, until reaction is produced, is often of great service.

118. *Restoring the tone of the organs of digestion.*—By effecting this, a double object is attained; the perfection of the primary assimilation of the food by which the entrance into the blood of a crude nitrogenised matter, capable of being converted into uric acid, is checked (111); and the prevention of the generation of any acid, the product of unhealthy digestion (113), which might be absorbed into the circulation, reach the kidneys, and

act as a precipitant of uric acid. This part of the treatment of calculous affections must be modified by the peculiarities of the case, and indeed is identical with that of the different forms of dyspepsia. Careful attention to the bowels, avoiding excessive purging, the use of minute doses of mercury, as of a grain of pil. hydrargyri or hydrarg. c. creta, with thrice that quantity of ext. conii, administered two or three times a day, with moderate doses of the carbonates of potassa or soda in the mist. gentianæ comp., if constipation exist; or if not, in inf. calumbæ, or what is preferable, from its action on the skin, inf. serpentariæ, will often effect immense relief. Where gastrodynia, with or without pyrosis, exists, the use of half a grain of argenti nitras, or one of argenti oxydum, immediately before a meal, will often check alike the gastric and renal symptoms. But the most important element in the treatment is a rigid attention to the quality and quantity of the ingesta, taking the utmost care to select those articles of diet which the patient can best digest, it being of far greater importance, in the majority of cases, to regard this, than to choose articles of food according to their chemical composition. A too bulky meal of animal or vegetable food is injurious to persons labouring under calculous dyspepsia, for whilst the former supplies too much nitrogen, both will become sources of mischief by overloading the digestive functions, and preventing the chylopoietic viscera doing their duty (111). In protracted cases, however, much good is derived by actually cutting off part of the supply of nitrogen. In this way I have seen a copious deposit of uric acid gravel disappear, after other measures had failed to give relief.

119. The following case is a good illustration of the latter mode of treatment:—

CASE 1.—*Exposure to cold.—Uric acid deposits, resisting ordinary treatment, relieved by diaphoretics, and cured by excluding nitrogenised food.*—John Lynch, æt. 37, admitted into Luke ward, Guy's Hospital, under Dr. Addison, on October 2nd, 1839. By trade a porter in a warehouse at Spitalfields, and constantly exposed to alternations of temperature. When young he had lived freely, and partaken to excess of spirits and malt liquors, and had eaten meat daily. His health, up to the present illness, had been excellent. No hereditary taint of calculus or gout. On admission, he stated that nineteen months previously he got very wet, and allowed his clothes to dry on him; this was followed by fever and profuse perspirations. The next day he became the subject of rheumatic pains, from which he had never since been free. He complains of constant pain in the region of the kidneys, increased by pressure and flexing the trunk, and some pain at the extremity of the penis. He passes water thrice in the day and once at night, each time discharging uric acid gravel most copiously. The latter symptom has been present a twelvemonth. The urine is not coagulable, contains some mucous flocculi, and the deposit of gravel does not disappear by boiling. The tongue is clean and moist, he complains of habitual heart-burn, has occasional bilious vomitings, the bowels are generally relaxed, and he is griped or purged on slight causes, especially by exposure to cold. Pulse 78, natural. From October 2 to November 27, his treatment consisted of purgatives, soda and uva-ursi, occasional mild mercurials, under which the deposit decidedly increased. He then took dec. alchemillæ with potass without relief.

Nov. 27 to Dec. 18.—A trial of diaphoretic treatment was made. The warm-bath twice a week, with pulv. ipecacuanhæ comp. gr. viij. ex julepo ammon. acet. ℥j. twice a day. Under this treatment he improved, the skin acted profusely, and the deposit gradually disappeared.

January 10, 1840.—The urine up to the present time remained healthy; he went out of the hospital, took cold, checked the perspiration, and the uric acid deposit appeared as abundantly as before. He was again relieved by the diaphoretic treatment, but soon afterwards relapsed. It was therefore determined to confine his diet to arrowroot, sago, potatoes, and bread, and butter, excluding the four ounces of cooked meat he had previously daily taken. The effect was very remarkable, the deposit almost immediately disappeared, and he remained free from it up to Feb. 25th, when he was discharged. On one occasion the urine of this man deposited in twenty-four hours upwards of 30 grains of uric acid.

120. Moderate muscular exertion and a due amount of exercise is quite essential in the treatment of this disease; for not only do they call into play some very important functions, but often improve the general health. Besides this, when the stomach is imperfectly able to digest nitrogenised food, exercise will often aid its assimilation by making a call upon the chylopoietic organs for supply for the waste of tissue it produces.

121. Among the remedies which appear most successful when the food is not converted into healthy chyle, and an unhealthy state of the blood from the presence of imperfectly assimilated matters results, the preparations of iron deserve notice. I have repeatedly seen copious deposits of uric acid in persons of low power completely disappear *pari passu* with the cure of the pseudo-chlorotic symptoms present, by the use of this important drug. The best mode of administering it, is in combination with a vegetable acid, as the stomach bears it well in this form, and it is probably more likely to enter the circulation. From 6 to 12 grains of the ammonio-citrate or ammonio-tartrate of iron taken thrice a day *immediately after a meal* in a glass of water, has been most successful. The solution of the sesqui-acetate of iron is also a very valuable preparation, but is often inconvenient to prescribe, in consequence of its not being of constant strength.

122. There is one other remedy which does appear to exercise a marked and decided control over the formation of uric acid, although its effects are by no means so constant as might be wished. I refer to the colchicum. Wherever the general health appears to be tolerably good, and any marked irregularities of the digestive functions been corrected, I would recommend the careful

and guarded administration of this drug in small doses, especially when there is an hereditary arthritic taint. In several cases I have succeeded completely in checking a long-continued secretion of uric acid by the use of the ext. colch. acet., in doses of a grain twice a day, with or without the addition of a grain of pil. hydrarg., and keeping up at the same time a moderate action in the bowels, by some tonic-aperient, as the inf. rhei or mist. gentianæ co.

123. *Remedies which act as solvents of uric acid.*— These chiefly consist of the alcalies and their carbonates, biborate and phosphate of soda, benzoic and cinnamic acids. As the alcaline urates are far more soluble than the free acid, soda and potass with their carbonates have been long popular remedies in the treatment of uric gravel. They moreover exert a beneficial effect in neutralising any free acid in the primæ viæ, and thus prevent a precipitant of uric acid reaching the kidneys. The liquor potassæ may be employed in doses of half a drachm thrice a day; it is best taken about an hour after a meal, and may be conveniently administered in any bland vehicle, or in a little bitter ale, which conceals much of its disagreeable flavour. The carbonates of potass and soda are, however, far more agreeable, and perhaps more efficient remedies,—of these the bicarbonate of potass deserves the preference. It should be given thrice a day in doses of ℈j. or ʒss. I think it appears to act best when taken in a glass of warm water. To make it more agreeable, I generally order, what I am accustomed to term to my patients, the artificial Vichy water, made by stirring ʒss. of bicarbonate of potass and gr. v. citric acid into a tumbler of lukewarm water. This

mixture evolves enough carbonic acid to be "sparkling," and is generally taken with readiness.

To render this treatment efficacious, it is quite essential that the patient should partake very freely of diluents. Two or three pints of water drank during the day will double the bulk of the urine and remarkably aid the solution of uric acid. Indeed, it has been well remarked that pure water is one of the best lithontriptics.

124. A very convenient mode of impregnating the urine with an alcali is to administer the potass or soda in combination with a vegetable acid, especially with the acetic, citric, or tartaric. The mode in which these act is easily explained; when acetate, citrate, or tartrate of potass are ignited, the acid absorbs oxygen, and is converted into carbonic acid and water, part of the former uniting with the alcali. In a similar manner are these salts decomposed during the process of healthy digestion; a carbonate finds its way into the circulation, and reaching the kidneys, renders the urine alcaline. If, however, the digestive powers are impaired, the vegetable acid is only partly decomposed, and in some few persons it escapes the influence of digestion altogether. 114 grains of tartrate of potass, 106 of citrate, 99 of the acetate, absorb respectively 40, 48, and 64 grains of oxygen, to be converted into carbonate of potass and water. These salts may be administered by directing the use of the common saline powders made with carbonates of potass or soda and the citric or tartaric acid, in effervescence. It is a remarkable fact, that in the Rhenish provinces where the common beverage of the inhabitants consists of poor wines, containing a considerable allowance of bitartrate of potass, calculous affections are unknown.

A circumstance admitting of explanation by the decomposition of the bitartrate into carbonate of potass, which thus prevents the urine becoming sufficiently acid to allow the deposit of uric acid. When not contra-indicated, the use of roasted apples, strawberries, currants, and some other fruits containing alcaline citrates and malates, are capable of making the urine alcaline, and may be occasionally employed with advantage.

Some persons cannot bear the use of free or carbonated alcalies without suffering severely in their general health, nor is their protracted use altogether without some ill effect. A flabby state of the muscles, and an anæmiated condition of the system, is frequently produced by the persistent use of alcaline remedies. Their injudicious employment may, indeed, possibly induce the formation of oxalic acid.

Moreover, it is impossible to render the urine alcaline for any length of time without risk of precipitating the phosphates of lime and magnesia, thus giving the patient a change of evils instead of removing them. In reading the accounts recorded of the treatment of real or imaginary calculous affections a century ago, by the celebrated alcaline remedy of Miss Stevens, it is impossible to avoid noticing how very much of the sabulous and fœtid state of the urine of her patients was obviously engendered not by the disease, but by the remedy.

125. Uric acid is soluble in a solution of borax, the biborate of soda,—more so, indeed, than in alcaline carbonates; and this salt may be taken for some time, at least by male patients, without producing any very injurious constitutional effects, and readily finds its way into the urine. On this account its administration has been

suggested in cases of uric acid gravel, but it has not been much employed in this country. In women, this drug cannot be employed with impunity, as it certainly exerts a stimulant action on the uterus, and I have seen it in two instances produce abortion.

The borate of potass has been strongly recommended as a substitute for ordinary borax, on account of its greater efficacy as a solvent for uric acid. M. Bouchardat recommends the following remedy as very efficacious in uric gravel; it should be mixed with as large a quantity of water as can be conveniently drank, and taken several times in the day whilst effervescing. If it purges, it of course must be taken less frequently, or in smaller quantities.

℞. Potassæ Bitartrate, ʒj. gr. xv.
——— Boratis,
——— Bicarbon, *aa*. gr. xv M.
Fiat Pulvis.

126. The remarkable solvent action of phosphate of soda on uric acid, to which Liebig has lately directed attention, (61), inspires a hope that its administration may be of use in cases of calculous disease, by impregnating the urine with an active solvent. All that is required to ensure this drug reaching the urine is to administer it in solution sufficiently diluted; ℈j. to ʒss. might be administered in any vehicle, as in broth or gruel, for when diluted, the phosphate tastes like common salt, and few persons object to its flavour. I have administered this drug in two very chronic cases of uric acid gravel, and in one with the effect of rapidly causing a disappearance of the deposit. This occurred in the

person of a lady about forty years of age, who had, at my wish, for some weeks used the artificial Vichy water of the German Spa at Brighton without relief. The triple salt, ammonio-phosphate of soda, would perhaps be a more active remedy than the simple phosphate, but its disagreeable flavour constitutes an objection to its employment.

127. Much attention has been lately drawn to the effects of benzoic acid in preventing the formation of uric acid, by the observations of Mr. Alexander Ure.[49] When this acid or its salts are administered, they are acted upon by the stomach in a very different manner from the other vegetable acids. Instead of becoming oxidized, and converted into carbonic acid, benzoic acid combines with those nitrogenised elements which would otherwise have formed urea or uric acid, and is converted into hippuric acid (72). It has been stated that the quantity of uric acid falls, when the benzoic acid is administered, below the average quantity, or even disappears from the urine. This has been, however, shown by Dr. Garrod,[50] to be an error, who has observed that the urea alone diminishes in quantity. Be this as it may, it is certain that the acid does appropriate to itself some body rich in nitrogen to form hippuric acid; and experience has shown that, in in cases where an excess of uric acid is secreted, the administration of this drug appears to limit it to about the normal quantity.

If ten or fifteen grains of benzoic acid be swallowed on retiring to rest, and the urine passed on rising from bed the following morning be examined, it will be found to contain abundance of hippurate of ammonia. A couple of drachms of it evaporated in a watch-glass to a few drops, and, mixed with hydrochloric acid, generally becomes nearly solid in a short time from the deposition of delicate interlacing needles of hippuric acid.

The recent researches of Dr. Booth and Mr. Boyce,[127] of Philadelphia, have confirmed Dr. Garrod's statement that uric acid is unaffected by the conversion of benzoic into hippuric acid. They have shown that when benzoic acid is swallowed, it appears in the urine metamorphosed into hippuric acid in from twenty to forty minutes, and continues coming away for eight hours: its weight exceeding that of the benzoic acid employed, by about one-third.

Benzoic acid may be administered in doses of eight or ten grains in syrup, or dissolved in a weak solution of carbonate or phosphate of soda thrice a day. Cinnamon water forms a good vehicle, as cinnamic acid exerts a similar action to the benzoic, becoming converted into hippuric acid. I have found the following formula of great service in several cases of chronic uric acid gravel :—

℞. Sodæ Carbonatis, ʒjss.
Acidi Benzoici, ℈ij.
Sodæ Phosphatis, ʒiij.
Aquæ Ferventis, f℥iv. solve et adde
Aquæ Cinnamomi, f℥vjiss.
Tincturæ Hyosciami, fʒiv.
Fiat mistura, cujus sumat æger, coch. ij. amp. ter in die.

In addition to its chemical action, benzoic acid acts beneficially by exciting diaphoresis, and thus fulfils an important general indication in the treatment of calculous affections (117).

128. The conversion of benzoic into hippuric acid, with a corresponding diminution in the quantity of urea in the urine, can be readily understood, by admitting that these two bodies unite with oxygen, and are converted into hippuric and carbonic acids with water; thus,

	C N H O		C N H O	
4 at. benzoic ac.	56+0+20+12	=	36+2+16+10=	2 at. hip. ac.
1 at. urea .	2+2+ 4+ 2		22 44=	44 at. car. acid.
48 at. oxygen .	48		8+8=	8 at. water.
	58+2+24+62		58+2+24+62	

Cinnamic acid, when taken into the stomach, appears to appropriate to itself nitrogen and oxygen, in undergoing conversion into hippuric acid, for

	C N H O
1 atom of cinnamic acid - -	18+ 8+4
1 atom oxygen and 1 nitrogen=	1 1
Equal 1 atom hippuric acid=	18+1+8+5

129. It is important to bear in mind that by the employment of remedies capable of dissolving a deposit in the urine, we are merely palliating, not curing, the disease. And we must never lose sight of the great importance of endeavouring to remove that pathological state of the whole system, or of any particular organ, which may be the exciting cause of the calculous formation. Nothing but a careful investigation of symptoms can put us in possession of the knowledge necessary for this purpose. Still, solvent remedies are not to be de-

spised; for when the disease is chronic, and does not readily yield to treatment, it is of the utmost importance to prevent the formation of a calculus, or lessen the irritation produced by the presence of gravel, whilst endeavouring to remove the primary affection which led to the formation of the deposit; and hence both these indications should be carefully attended to.

CHAPTER V.

CHEMICAL PATHOLOGY OF URIC OXIDE.

Xanthi-uria.

Uric Oxide.

Syn. Xanthic oxide—Xanthine—Urous acid.

130. THIS substance has not been discovered among the constituents of healthy urine, although it is probable that it bears some relation to the yellow colouring matter (75); and hence it may possibly exist in minute quantities, and have escaped the investigations of chemists. But little is known either of the chemical or pathological history of this very rare ingredient of calculous concretions. It was first met with by Dr. Marcet,[51] constituting the whole of a small calculus weighing but eight grains; the history of the case being unknown. Some years afterwards, some minute pisiform concretions passed

by a gentleman with diseased bladder were found by M. Laugier[52] to consist of uric oxide. More recently, this substance was discovered in a stone removed by Professor Langenbeck of Hanover,[53] from a boy eight years of age. It weighed 338 grains, and after an examination by Professor Stromeyer, was submitted to minute chemical investigation by Professors Wohler and Liebig. A fragment of this calculus has been, by the kindness of my friend, Dr. Willis, placed in the museum of Guy's Hospital. A fourth specimen, weighing but seven grains, was lately removed from the urethra of a boy by Professor Dulk of Konigsberg.[54] Uric oxide has been met with in deposits by Berzelius,[55] M. Morin, of Geneva,[56] and one or two other observers. It has been announced by Dr. Unger,[112] that this substance exists in the guano of commerce in small proportions ($\frac{5}{8}$ per cent.) To obtain it, he directs guano to be digested in milk of lime until the solution assumes a yellowish-green tint, filter the mixture, and add hydrochloric acid, a mixed precipitate of uric acid and oxide falls. On boiling this with hydrochloric acid, the oxide dissolves, and on cooling it a compound of it with the acid crystallizes. This, on being digested with ammonia, leaves uric oxide pure in the form of a white powder.[122] There is, however, room to doubt this substance being really identical with human uric oxide, as the latter is insoluble in hydrochloric acid, and appears to differ in its elementary composition (135).

131. *Diagnosis of uric oxide.*—Concretions composed of this substance closely resemble, and are generally mistaken for, uric acid. They present externally a similar appearance, but their sections are of a well-marked

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salmon, or rather cinnamon tint, which to a practised eye will distinguish such concretions from uric acid. According to Berzelius, when uric oxide forms an urinary deposit it appears as a grey powder. In the only one in which I ever met with a deposit composed of a substance approaching uric oxide in chemical characters, it presented a honey-yellow colour. A wax-like lustre is readily assumed by submitting fragments of uric oxide to friction. If a deposit be suspected to consist of or to contain this substance, it should be digested in a weak solution of carbonate of potass, which removes uric acid, and leaves the oxide undissolved. So closely do these two bodies resemble each other, that their diagnostic distinctions will be best observed by contrasting their action towards reagents.

Uric oxide.	*Uric acid.*
1. Dissolves slowly in nitric acid almost without the evolution of bubbles of gas.	1. Dissolves readily in nitric acid, with copious effervescence.
2. The nitric solution leaves by evaporation a yellow residue.	2. The nitric solution leaves by evaporation a pink residue.
3. Soluble in strong sulphuric acid, not precipitated by the addition of water.	3. Is precipitated by water from its solution in concentrated sulphuric acid.
4. Its solution in liquor potassæ is not disturbed by hydrochlorate of ammonia.	4. Hydrochlorate of ammonia precipitates it combined with ammonia from its solution in liquor potassæ.
5. Precipitated uncombined, when a current of carbonic acid traverses its solution in potass.	5. A current of carbonic acid gas throws down from the alcaline solution an acid urate of potass.
6. Insoluble in solution of carbonate of potass.	6. Readily soluble in dilute solution of carbonate of potass.
7. Ignited in a tube, does not yield urea.	7. When ignited, yields urea as one of its products.

132. Uric oxide has constituted the whole mass of the calculus in all, except in that examined by Professor Dulk, in which the nucleus consisted of uric acid. According to him, uric oxide furnishes, with nitric acid, some of the same products which uric acid yields, especially alloxantin.

133. *Characters of urine depositing uric acids.*—Unknown, no observations of the urine of the persons from whom calculi of this substance were removed, having been recorded.

134. *Microscopic characters of uric oxide.* — This substance does not appear to assume a crystalline form. A careful microscopic examination of the fragment of the calculus removed by Langenbeck, and now in the museum of Guy's Hospital, failed in detecting any appearance of crystalline arrangement. I dissolved a portion of this concretion in liquor potassæ, and precipitated the oxide very slowly by the cautious addition of acetic acid. Uric oxide fell in a perfectly amorphous state, presenting none of the well-defined crystalline form which uric acid assumes when similarly treated.

The only instance in which I had reason to believe a deposit was made up of this substance was in the urine of a child, which let fall by cooling a honey-yellow sediment. This, on microscopic examination, by reflected light, was found to be composed of rather large yellow masses, having much the appearance of yellow wax, and presented no trace of crystalline structure. This substance was replaced in the next specimen I examined, by uric acid.

135. *Pathological and therapeutical indications.*—Unknown, although from the remarkable similarity of

their composition it is highly probable that the majority of the remarks already made on the pathology of uric acid apply to that of the oxide. Uric oxide consists of C_5, N_2, H_2, O_2; if, therefore, we suppose two atoms to be oxidised by combining with two of oxygen, one atom of uric acid will be found.

	C N H O
2 atoms uric oxide	10+4+4+4
+2 —— oxygen	2
=1 atom uric acid	10+4+4+6

The supposed uric oxide obtained from guano (130) differs in elementary composition from that obtained from the human subject. How far this discrepancy depends upon errors of analysis or not, future observations can alone determine.

	C N H O
2 atoms uric oxide, human	10+4+4+4 (Liebig)
———— from guano	10+5+5+2 (Unger)

Dr. John Davy has very recently announced his belief that the urinary excretion of spiders consists chiefly of uric oxide. He obtained a body presenting all the properties of this substance from the excrements of all the different spiders he examined; whilst in those of true insects he found uric acid exclusively.

It is remarkable that in most of the recorded cases, the uric oxide has occurred only in children. One observer stated that he had met with it as a deposit in diabetic urine.[57]

CHAPTER VI.

CHEMICAL PATHOLOGY OF PURPURINE.

(*Porphy-uria.*)

136. THE chemical characters of this remarkable colouring matter have been already pointed out (76), but it merits some notice as a pathological product, from the serious lesions its presence frequently indicates. On account of its solubility in water, purpurine never occurs as a deposit, unless urate of ammonia is present, this salt having the property of removing the great mass of purpurine from urine, and assuming thereby a more or less deep carmine tint.

137. *Diagnosis.*—When a deposit of urate of ammonia is coloured by this substance, it presents a tint varying from the palest flesh-colour to the deepest carmine (96). To appreciate the beauty of these tints, the deposit should be collected on a filter, and allowed to dry. The

presence of purpurine interferes with the ready solubility of the deposit with which it is combined, on the application of heat; and free dilution with water is often required to aid its solution (95). I have never seen purpurine colouring any other deposits except those of urate of ammonia, and hippuric acid when precipitated from concentrated urine by hydrochloric acid (72.) Uric acid scarcely appears to have any affinity for it. It is by no means uncommon for a very highly coloured deposit of pink urate of ammonia to be by a careless observer mistaken for blood, and I have seen this error committed when it occurred in albuminous urine. The appearance of the deposit when collected on a filter, and its giving up the purpurine to alcohol, will at once remove any doubt on the subject, and the absence of blood-discs on microscopic examination will aid in demonstrating the real nature of the deposit.

The chemical composition of purpurine, occurring as a product of disease, is unknown. This body bears no analogy whatever to murexid or purpurate of ammonia, substances with which it was long confounded, owing to the countenance afforded to this opinion by the high authority of Dr. Prout. This want of identity is so clearly made out that I have deemed it unnecessary to adduce the evidence brought forward in the last edition of this work on the subject. According to Scherer, the purpurine generated by the action of hydrochloric acid on urine (77) consist of

Carbon	62.51
Hydrogen	5.79
Nitrogen . . . . } Oxygen . . . . }	31.70

There are several calculi in Guy's museum, with layers of urate of ammonia deeply stained with purpurine. Similar calculi have been described by Mr. Taylor,[58] as occurring in the museum of St. Bartholomew's Hospital, and Brugnatelli[59] has recorded many instances of the same kind.

138. *Microscopic characters.*—Always those of the deposit with which the purpurine is combined. All the sediments I have met with were amorphous. I possess one specimen, however, of a rich pink colour, given me by Dr. Percy of Birmingham, in which the deep crimson urate is composed of minute ovoid particles acuminated at both extremities, and possessing a crystalline lustre.

139. *Characters of the urine containing purpurine.*—It invariably happens that when an excess of urate of ammonia is present, it, on the urine cooling, falls to the bottom of the vessel, carrying down with it a great part of the purpurine. If this excess be not present, the urine simply presents a pink or purple colour, and on dissolving white and pure urate of ammonia in it by heat, it is precipitated on cooling deeply coloured by the purpurine. The presence of the yellow extractive which yields purpurine, can be readily discovered by the action of hydrochloric acid as already described (77).

On evaporating urine containing purpurine to the consistence of an extract, and digesting it in alcohol, a fine purple tincture is obtained, the intensity of the tint being rather heightened by acids and diminished by alcalies.

The specific gravity of this highly-coloured urine is subject to great variation; when the colour is as deep as brandy, its density varies from about 1.022 to 1.030. The addition of nitric acid generally produces an immediate muddy deposit of uric acid, made up of microscopic rhomboids, which has been more than once mistaken for albumen.

140. *Pathological indications.*—The presence of an excess of purpurine appears to be intimately and invariably dependent upon some imperfection in the excretion of carbon by those organs whose special function it is to eliminate this element from the blood, as the liver and lungs, but especially the former. It hence is almost always connected with some functional or organic mischief of the liver, spleen, or some other organ connected with the portal circulation. The appearance of a flesh-coloured deposit in the urine is the commonest accompaniment of even slight derangement of the hepatic function, as every case of dyspepsia occurring in gin-drinkers points out. The intensity of colour of the deposit appears to be nearly in relation with the magnitude of the existing disease. In the malignantly diseased, in the contracted, hobnail, or cirrhosed liver, the pink deposits are almost constantly present in the urine. They are also of frequent occurrence in the hypertrophy of the spleen following ague. The most beautifully coloured deposits I have seen have occurred in ascites connected with organic disease of the liver; and I think I have received some assistance in the diagnosis between dropsy depending upon hepatic and peritonæal disease, in the presence of the pink deposits in the former, and their general absence in the latter. I have occasionally seen the deposits in question occur in phthisis, when large quantities of pus were poured out from vomicæ, as well as in deep-seated suppuration, as in psoas abscess. But even in these cases, the excretion of carbon, and the integrity of the portal

circulation is always more or less influenced. My experience, indeed, leads me to express a firm belief that an excess of purpurine is almost pathognomonic of disease in the organs in which portal blood circulates, and consequently must be essentially connected with the non-elimination of the carbonised elements existing in the fluid.

141. This opinion of the pathological indications of purpurine, which I have now for some years supported and taught in my lectures at Guy's Hospital, has received important confirmation from the late researches of Professor Scherer,[140] of which mention has already been made (77). This excellent chemist* observed that when a person in good health is confined to a diet nearly free from nitrogen, active exercise being avoided, the quantity of carbon and hydrogen excreted in the urine is always at a maximum. In fever, or where metamorphosis of tissue (26) is actively going on, in addition to the abundance of nitrogenised products eliminated in the urine by the kidneys, a pink pigment, very rich in carbon, communicating the well-known tint to the secretion, also exists. This state of things always occurs, and affords a

* I trust I may not be considered too egotistic in remarking that the opinions above expressed of the function of the pink pigment, as well as the use of the hydrochloric acid test for its detection, are original with myself. They were the result of careful clinical observation, and were announced in my lectures, delivered at Guy's Hospital in 1841-2, afterwards reported in the Medical Gazette. A long review of these lectures was given by Professor Scherer himself in Canstatt's Jahres-bericht, for 1843, in which he translated the account I had given of the hydrochloric acid test, and of the supposed function of purpurine. So that he must have been well acquainted with my own observations made four years before the announcement of his own much more elaborate researches.

ready explanation of the characteristic high colour of febrile urine, unless a great diminution of water or some other cause exist to explain it. Scherer found the following proportions of carbon and hydrogen in the pigment of urine of a case of hectic, and two cases of typhus fever.

	Hectic Fever.	*Typhus Fever.*	*Typhus Fever.*
Carbon	65.25	64.43	62.80
Hydrogen	6.59	6.30	6.39
Oxygen and nitrogen	28.16	29.27	30.81

Indeed, in every case the presence of an excess of an highly carbonised pigment, independently of any deposit, as shown by the test of hydrochloric acid and heat, may be regarded as a satisfactory indication of a lesion of functions of one of the great normal emunctories of carbon, especially the lungs and liver. The presence of this matter in the urine is therefore to be regarded as an evidence of the kidneys performing a compensating function for the lungs or liver.

142. It is a curious fact, and one which strongly substantiates the accuracy of this opinion, that the colouring matter of bile often co-exists with this carbonised colouring matter or purpurine. This may, often where scarcely suspected, be detected by collecting the precipitate produced, by adding di-acetate of lead to the urine, on a filter, and boiling it in alcohol acidulated by hydrochloric acid. The bile-pigment will dissolve, forming a green solution. Another remarkable corroboration of this opinion is afforded by the analogy in composition existing between the carbonised colouring matter of urine (purpurine) and the bile-pigment (billiphœin) so fre-

quently met with in urine in cases of jaundice, and easily recognised by proper tests (47). This pigment may be obtained by precipitating it from urine by chloride of barium, and digesting the precipitate in alcohol, acidulated by sulphuric acid. The following is a view of the chemical composition of the colouring matters under consideration.

	Normal colouring matter of urine.	Urinary colouring matter in jaundice.	Urinary colouring matter in organic disease of the liver.	Bile-pigment from urine.
Carbon . .	58.43	60.19	65.76	68.182
Hydrogen .	5.16	6.66	6.01	7.437
Nitrogen . .	8.83	34.25 (Nitrogen and Oxygen together)	28.23 (Nitrogen and Oxygen together)	7.074
Oxygen . .	27.58			17.261

CHAPTER VII.

CHEMICAL PATHOLOGY OF CYSTINE.

(*Cystin-uria.*)

143. THIS substance was first discovered by Dr. Wollaston in a calculus given him by Dr. Reeve of Norwich. It does not exist as an ingredient of healthy urine, and rarely occurs as an element in the diseased secretion. Its chemical composition is extremely remarkable, as it contains no less than 26 per cent. of sulphur. Cystine has been found in urinary sediments by very few observers, and it was not recognised in this form until a long period after its discovery in calculi.

144. *Diagnosis of cystine.*—This substance, when present in the urine, forms a nearly white or pale fawn-coloured pulverulent deposit, much resembling the pale

variety of urate of ammonia (95). The greatest proportion of it appears to be merely diffused through the urine whilst in the bladder, as at the moment of emission the secretion is always turbid, and very soon deposits a very copious sediment. I have seen a six-ounce bottle full of urine let fall by repose a sediment of cystine of the height of half an inch. On applying heat to the urine, the deposit undergoes no change, and very slowly dissolves on the subsequent addition of hydrochloric or nitric acid. Pure cystine is soluble in the mineral and insoluble in the vegetable acids; with the former it forms imperfect saline combinations, which generally leave by evaporation gummy masses or acicular crystals. It is readily soluble in ammonia and the fixed alcalies and their carbonates, but insoluble in carbonate of ammonia. Heated on platina foil it burns, evolving a peculiar and disagreeable odour.

A deposit of cystine may be distinguished from one of white urate of ammonia, by not disappearing on warming the urine, and from the earthy phosphates, by being insoluble in very dilute hydrochloric or strong acetic acid. The best character of cystine is its ready solubility in ammonia, mere agitation of some of the deposit with liquor ammoniæ being sufficient to dissolve it, and a few drops of the fluid, when allowed to evaporate spontaneously on a slip of glass, leaves six sided tables of cystine (148). The ammoniacal solution, when kept for some time in a white glass bottle, stains it black, from the combination of the sulphur of the cystine with the lead in the glass.

145. Another test has been proposed by Liebig,[60] founded on the presence of sulphur; he directs the de-

posit suspected to contain cystine to be dissolved in an alcaline solution of lead, made by adding liquor potassæ to a weak solution of acetate of lead until the oxide at first thrown down is re-dissolved. On heating the mixture, a black precipitate of sulphuret of lead appears if cystine be present. All sulphuretted animal matters similarly treated yield black precipitates, and hence this test is useless, if any portions of albuminous or mucous substances, or of bile, are mixed with the deposit to be examined. If cystine exist, mixed with urates or phosphates, in a deposit; it is easily discovered by a few minutes' digestion with ammonia, and the evaporation of a few drops of the fluid, as already mentioned, leaves the characteristic crystals. This process is not liable to the fallacy of Liebig's test. Cystine has never been artificially formed; some fruitless attempts have been made to effect this by treating albumen with the sulphuret of potassium. The internal administration of sulphur does not appear to induce its formation, for I have repeatedly examined the urine of patients who were taking sulphur abundantly, without detecting it.

146. *Character of urine depositing cystine.*—Most of the specimens of this variety of urine that I have met with, were pale yellow, presenting more of the honey-yellow than the usual amber tint of urine, not unfrequently possessing a somewhat oily appearance, like diabetic urine. The specific gravity of cystic urine is generally below the average (39), and is sometimes passed in larger quantity than natural. In one case (a child), in which Dr. Willis[61] met with cystine, the urine was of a specific gravity of 1.030; but this is certainly

unusual. It is often neutral, less frequently acid to litmus paper, but soon becomes alcaline by keeping.

The odour of this form of urine is very peculiar, bearing in general a close resemblance to that of sweet-briar, and is sometimes rather powerful; less frequently the odour is fœtid, like putrid cabbage, owing, I suspect, to partial decomposition and evolution of sulphuretted hydrogen. In such specimens the colour has usually changed from pale yellow to green. In one case that occurred to me, the urine was actually of a bright apple-green; it presented this tint for a few days, and the specimens subsequently voided were yellow.

Cystic urine, on being kept for a short time, has its surface covered with a greasy-looking pellicle, consisting of a mixture of crystals of cystine, and ammonio-phosphate of magnesia. I have frequently observed it to undergo a kind of imperfect viscous fermentation in warm weather, bubbles of gas being evolved, and the whole becoming ropy and rather viscid (263).

A certain portion of cystine exists in solution in the urine, as the addition of acetic acid always precipitates a small quantity. When a case of this disease is carefully watched, and the urine repeatedly examined, the deposit will often be found to vanish for days together; but crystals of cystine are even then generally precipitated by acetic acid. The urea and uric acid are present in very small quantities, and in some specimens the latter is nearly absent. I found a specimen of urine passed by a boy from whom a cystine calculus had been removed a short time previously by my colleague, Mr. Aston Key, to consist of

Water	974.444
Solids	25.556
Urea (impure)	5.7
Uric acid	.016
Cystine	.340
Extract containing the fixed salts	19.5

147. Calculi composed of cystine are generally pale yellow or fawn-coloured, but by long keeping they undergo some change, and assume a greenish grey, and sometimes a fine greenish blue tint. The specimens described by Dr. Marcet in 1817, and existing in the museum of Guy's Hospital, were at that time pale brown; they now possess a colour resembling that of green sulphate of iron, which hue they have, to my knowledge, presented for the last thirteen years. This change of colour in the concretions, as well as in the urine, before alluded to, is probably owing to some change in which the evolution of sulphur is an element.

148. *Microscopic characters of cystine.*—These are so well marked and easily recognised, that the microscopic examination of a sediment composed of cystine, renders the application of tests unnecessary.

When an ammoniacal solution of cystine is allowed to evaporate spontaneously on a piece of glass (144), it leaves crystals in the form of six-sided laminæ (Fig. 23). These are probably exceedingly short hexagonal prisms. When the evaporation is slowly and carefully performed, these laminæ are transparent; but in general they are crystallised in a confused and irregular manner in the centre, the margins only being perfectly transparent. When examined by polarised light, these crystals, when sufficiently thin, present a beautiful series of tints, which are not observed when thick, on account of the high refracting power of cystine.

FIG. 23.

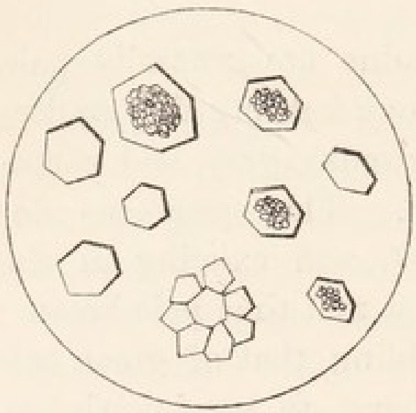
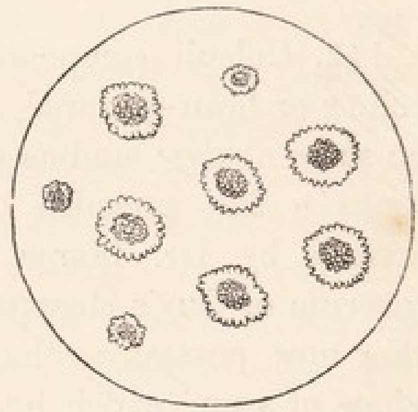


FIG. 24.



149. When cystine occurs as a sediment, it is always crystallised, never under any circumstances being amorphous. Among the crystals, a few regular six-sided laminæ are often seen, but the great mass is composed of a large number of superposed plates, so that the compound crystals thus produced appear multangular, as if sharply crenate at the margin; and the whole surface is traversed by lines, which are really the edges of separate crystals (Fig. 24). They thus resemble little white rosettes, when viewed by reflected light. These compound crystals always appear darker in the centre than at the circumference, which is sometimes quite transparent. Prisms of the triple phosphate (191) are often mixed with the cystine, but on the addition of a few drops of acetic acid, they readily dissolve, leaving the rosettes of cystine unaffected.

150. A fallacy may possibly arise in the detection of cystine under the microscope, by the evaporation of the urine, and crystallisation of the chloride of sodium or common salt. The salt naturally crystallises in cubes, but assumes an octahedral figure if urea be present. If, however, a small quantity be allowed to crystallise spontaneously from its solution in urine, it forms minute transparent crystals, which present generally a three, four, or six-sided outline (Fig. 25), according to the position in which they happen to lie on the glass, and might at first sight be mistaken for plates of cystine. Their solubility in water, and absence of all colour when examined

Fig. 25.

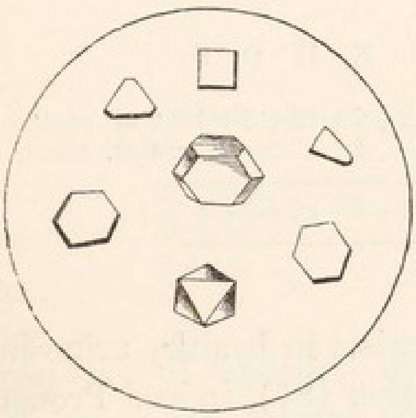
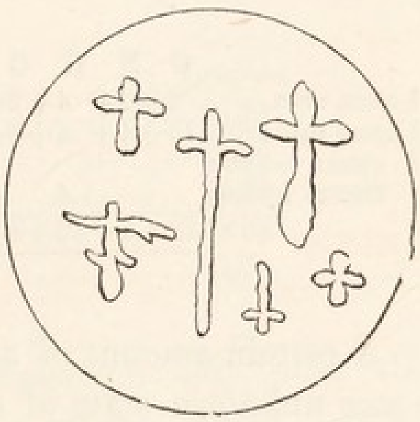


Fig. 26.



by polarised light, will prevent these crystals from being mistaken for cystine. If urine containing common salt be hastily evaporated on a slip of glass, the regular transparent octahedrons are not met with, being replaced by a series of elegant crystals, shaped like crosslets and daggers (Fig. 26). The appearance of these, on the evaporation of a fluid containing a little common salt, is a tolerably safe indication of the presence of urea.

151. *Pathological origin and indications of cystine.* —This curious substance is in all probability a derivative of albumen, or of structures into which it enters, and appears to be the result of derangement of the secondary assimilative processes (28), essentially connected with the excessive elimination of sulphur; every ounce of cystine containing more than two drams of this element. From an examination of its chemical composition, there appears no difficulty in explaining the origin of cystine, by supposing that it is formed by those elements of our tissues which would normally have been converted into urea and uric acid (31), in consequence of the presence of an excess of sulphur; probably connected essentially with a scrophulous diathesis. Cystine consists of C_6, N, H_6, O_4, S_2.

	C N H O S		C N H O S	
1 atom urea . .	2+2+ 4+2+0	=	12+2+12+8+4	=2 at. cystine.
1 atom uric acid	10+4+ 4+6+0		4	=4 at. nitrog.
4 atoms sulphuretted hydrog.	4 +4			
	12+6+12+8+4		12+6+12+8+4	

A certain amount of sulphur exists in healthy urine in some unknown state of combination (85), indeed Proust long ago proved, that when urine is boiled in a silver basin, a brown crust of sulphuret of silver is formed.

152. Although but little is known of the pathological condition of the system which induces the formation of cystine, there is sufficient evidence before us to justify our expressing a strong opinion of its essentially scrophulous and remarkably hereditary character. In one family alone, several members were nearly at the same time affected with cystin-uria; and one instance exists in which

it can be traced with tolerable certainty through three generations. In one well-remarked case, which fell under the care of Mr. Luke, at the London Hospital, extensive disorganisation of the kidneys co-existed with a cystine calculus. There is probably a remarkable deficiency of the process of oxidation in these cases; Dr. Prout has even seen fatty matter mixed with the urine, and suggests the probability of its connexion with fatty liver. And this opinion seems to be by no means improbable, especially when the close approximation that exists between the elementary composition of cystine and taurine, the crystallised substance into which bile is partly converted by digestion with hydrochloric acid. The following is a comparative view of the percentage compositions of cystine and taurine.

	Cystine.	*Taurine.*
Carbon	30.31	19.28
Hydrogen	4.94	11.25
Nitrogen	11.70	5.73
Oxygen	26.47	38.04
Sulphur	26.58	25.70

So that it appears by no means unlikely, that the excretion of cystine may be a means, under certain circumstances, of compensating for deficient action of the liver *quoad* the excretion of sulphur. It appears that the sulphur discovered by Redtenbacher in taurine, was by former chemists confounded with oxygen, as was the case in the earlier analyses of cystine. Dr. Shearman, of Rotherham, believes that he has discovered crystals of cystine in the urine of chlorotic females—a very interesting circumstance in connexion with the probable general deficiency of oxidation existing in this affection. In a communication from the zealous and excellent physician alluded to, he mentions the following particulars.

Some urine passed by a chlorotic girl, after being mixed with ammonia, and set aside in a white phial, evolved in a few days sufficient sulphuretted hydrogen to stain the glass black. When fresh, the urine had a very peculiar odour, and deposited a white sediment unaffected by acetic or hydrochloric acid, but soluble in ammonia. The solution left by evaporation six-sided laminæ, which, in all their microscopical and optical properties, resembled cystine.

Two specimens of urine exhibiting these characters were passed by two sisters; a third was obtained from a girl belonging to another family.

153. *Therapeutical indications.*—These are unfortunately in the present state of our knowledge not very well understood. The cases have been observed too seldom to allow of any accumulation of experience, and most of them having occurred in private practice, have precluded that minute and persistent watching which is so necessary for satisfactory information. The most important indications are to correct the unhealthy condition of the assimilative functions, and if possible to render the cystine, so long as it continues to be formed, soluble in the urine. To effect the latter, the persistent use of nitro-hydrochloric acid has been recommended by Dr. Prout, and in some cases with success. In one I had an opportunity of watching, it failed in either dissolving the deposit, or preventing its formation. In this case, however, there was but little doubt of the presence of a

renal calculus. The general health should be most carefully attended to, and everything interfering with it removed as completely as possible. Sea bathing, exercise, nutritious and digestible diet, with attention to the functions of the skin, promise to do much. I feel inclined to place great confidence in the use of iron, especially of the iodide, in tolerably large doses. Unfortunately, as in all ailments demonstrably hereditary, we have an obstinate disease to treat, and the prognosis must be extremely guarded, as in the majority of cases the generation of cystine goes on to the formation of a calculus.

CHAPTER VIII.

CHEMICAL PATHOLOGY OF HIPPURIC ACID.

(HIPPURIA.)

154. HIPPURIC acid is very generally present in the urine of herbivorous animals, and is indebted for its present appellation to its constant occurrence in the urine of the horse. Rouille, as long as seventy years ago, described it as occurring in the urine of graminivorous mammals, but mistook it for benzoic acid. Scheele, and subsequently Fourcroy, Renard, and Proust, demonstrated its existence in the urine of young infants. Lehmann and Ambrosiani announced its presence in diabetic urine, and still more recently it has been proved by Prof. Liebig to be a constant element in the healthy secretion (72).

155. *Diagnosis of urine containing an excess of hip-*

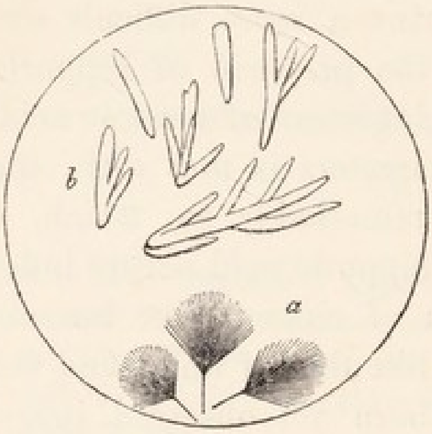
puric acid.—As this substance. never, so far as is yet known, appears in the form of a sediment until after the addition of a stronger acid, our diagnosis must entirely depend upon the characters of the urine containing it.

Urine containing an excess of hippuric acid is generally either slightly acid or neutral, often alcaline. Its characters can be best studied in the urine of a calf, as the copious deposit of carbonate of lime, as well as its viscidity, make the horse's urine a more difficult object for examination. When the presence of hippuric acid is directly traceable to the ingestion of benzoic acid, an exception to the above characters is met with, the urine then being acid, often remarkably so, which, I believe, is never the case when hippuric acid occurs independently of the administration of cinnamic or benzoic acids. The odour is generally like that of whey, and the specific gravity, so far as has been yet observed, below rather than above the healthy average, varying in M. Bouchardat's case (159) from 1.006 to 1.008. Deposits of the triple phosphate of magnesia are by no means unfrequent in such urine. A drop of neutral or alcaline hippuric urine, as that of the calf, when allowed to evaporate spontaneously on a glass plate, leaves delicate feathers of hippurate of ammonia, very distinct in appearance from any crystals I have seen from any other variety of urine.

156. To detect the presence of an abnormal proportion of hippuric acid, fill a large watch-glass with the urine, and evaporate it over a lamp to a few drops, then add about half the bulk of hydrochloric acid, and set the mixture aside. On the addition of the acid, the mixture becomes bright pink, and a pungent odour, not unlike

that of new hay, is evolved. After a few hours examine the contents of the watch-glass, and if an excess of hippuric acid be present, its characteristic linear crystals will be observed. These almost always assume a very remarkable form like a bunch of leafless twigs, cohering with sufficient firmness to allow of their being washed and dried in this position (Fig. 27 *a*). The watch-glass should not be emptied for twenty-four hours after the first addition of the acid, for sometimes the crystals form very slowly, owing to their solubility in the precipitant. The glass should be examined under the microscope, and delicate, slender, often branched crystals, needles of hippuric acid, which may escape the naked eye, may thus be detected (Fig. 27, *b*). Sometimes so much hippuric acid is present, that if sufficient time be allowed, crystals of it appear without any previous evaporation. This is well seen in the urine of the horse, especially when obtained after being well fed, and resting all day in the stable. It is quite certain, however, that a considerable quantity of hippuric acid may be present and yet escape detection by this process, in consequence of the urea interfering with its crystallisation. From very careful experiments, I find that when the acid exists in less quantity than one grain in the fluid ounce of urine, it cannot be thus detected. In this case we must have recourse to the process before described for the preparation of the acid from the healthy urine (72).

FIG. 27.



157. *Microscopic characters of hippuric acid.*—If crystals are obtained by the modes just described, all possible doubt of their real nature may be removed by dissolving a portion in alcohol and some in hot water. On placing a drop of these solutions when cold on plates of glass, beautiful crystals, some of a dendritic and plumose outline, others arranged like zeolites, will be left by the spontaneous evaporation of the alcoholic solution (Fig. 28), and minute needles mixed with four-sided

FIG. 28.

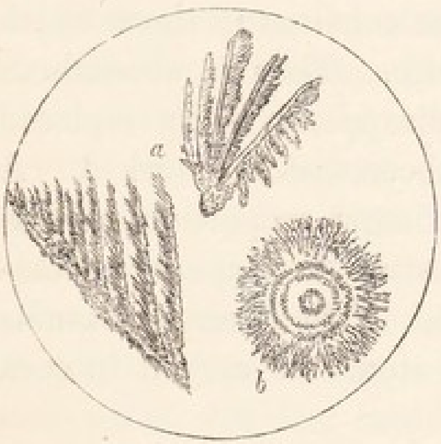
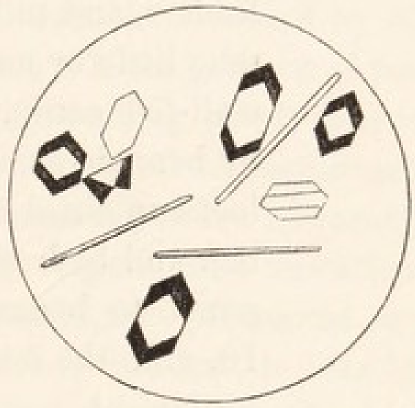


FIG. 29.



prisms acuminated at their ends, will be formed from the watery solution (Fig. 29). On heating some of the crystals in a glass tube until they begin to char, they evolve a very characteristic odour of the Tonquin bean.

All these characters may be observed, and the crystals readily obtained from the urine passed by a person an hour or two after swallowing 10 grains of benzoic acid.

Both the hippuric and benzoic acids will disappear from the urine of over-driven animals. I could not detect a trace of either in the urine of an ox which had been driven up from the country to Smithfield and killed a few hours after. Neither of these acids was found by Boussingault in the urine of pigs, even when their food was varied. The large amount of carbon appropriated by these animals in their enormous accumulations of fat, probably interfere with any considerable excretion of this element by the kidneys.

158. *Pathological origin and indications of hippuric acid.*—This part of our subject is enveloped in much obscurity. All that is known with certainty of the matter, may be thus stated :—

A. Hippuric acid appears to be peculiar to vegetable feeders, and to be most constant in those which take little or no exercise. Thus it abounds in stall-fed cattle, and disappears, being replaced by benzoic acid, in those that are worked. A fact explained by the larger proportion of carbon and hydrogen existing in hippuric as compared to benzoic acid. The former contains 18, and the latter 14 atoms of carbon in each equivalent.

B. When in excess in human urine, it has been generally traceable to peculiarities of food. In one case connected evidently with a long confinement to a milk diet (159); in another, to the almost exclusive use of apples (161). Its occasional (but by no means constant) occurrence in the urine of infants at the breast is in all probability traceable to their mal-assimilating the large quantity of carbon contained in the food.

C. It does not necessarily interfere, at least in man, with the production of uric acid; for although occasionally absent, yet this substance is so generally present, as to lead to belief that hippuric and uric acids owe their origin to two very different causes.

D. In general a deficiency of urea occurs in hippuric urine. It appears nearly proved that the elements (C_4, N, H_3, O_2) by the presence of which hippuric differs from benzoic acid, are derived either from urea or from nitrogenised matter, which would, under ordinary circumstances, have formed this substance.

159. The first case observed, in which an excess of hippuric acid was detected in disease, is recorded by M. Bouchardat. Madame G——, æt. 53, the mother of one child, residing in the country, possessing good general health, and in easy circumstances, ceased to menstruate at the age of 45. After this period she became frequently the subject of a severe obscure hepatic and intestinal affection, which, as her convalescence was protracted, led to her being placed on a milk diet. She kept to this for nine years, and her health became re-established. Her general diet consisted of coffee, with a pint of milk, and five ounces of bread, for breakfast. For dinner, soupe-maigre or graisse, with two ounces of meat, and about five of vegetables, and as much of bread, taking wine and water for drink. In the evening she took merely a pint of milk. This lady's health again gave way; there was great lassitude and much indisposition to exertion, with absence of all perspiration, which, for the preceding nine years, had been profuse. Skin harsh and almost scaly. Vague pains in the region of the liver, with a jaundiced tint of the surface. Fæces black. Mouth

dry, with a disagreeable taste. Headache and tinnitus aurium; vision imperfect. The night passed in broken slumbers. Palpitation of heart, accompanied with an anæmic murmur in the carotids, and a rapid pulse. Slight œdema of the lower extremities towards evening. For months previously she had become the subject of partial paralysis of the right side, which disappeared on depletion. Lungs healthy, although the subject of occasional dyspnœa. The most prominent symptoms of all, were, however thirst, and increased bulk of the urine, often drinking six to ten pints of water in the day.

Character of the urine.—Limpid, with a whey-like odour. Sp. gr. 1006-8, acid, slightly coagulable by heat. On evaporating the urine to a small bulk and adding hydrochloric acid, the hippuric acid crystallised on cooling. Uric acid was absent. The urine consisted of—

Water	985.46
Solids	14.54

Urea	1.56
Hippuric acid	2.23
Albumen	1.47
Fixed salts	5.28
Organic and volatile combinations	4.
	14.54

This patient ultimately sank exhausted.

160. The second case occurred to Dr. Garrod, to whom I am indebted for the following brief account of it. The subject of this affection was a young man, æt. 23, who in September 1842 became a patient of Dr. Garrod's for

general malaise, accompanied by the excretion of an excess of urea in his urine, and the deposition of ammoniaco-magnesian phosphate, from which, under the use of opiates with nitric acid, he recovered. A few months subsequently he suffered from an attack of atonic dyspepsia, with pain in the loins. On adding some hydrochloric acid to the urine for the purpose of precipitating uric acid, long crystals of hippuric acid were formed, and on these the uric acid was slowly deposited. This condition of urine continued for several days, half-a-pint yielding as much as 40 grains of hippuric acid. The uric acid and urea existed in normal proportion. After a few days the hippuric acid decreased in quantity, so that the urine did not afford crystals on the addition of hydrochloric acid until concentrated by evaporation. In a short time the urine became normal. No information as to the source of the hippuric acid could be obtained from the history of the patient. He had lived on a mixed diet, and never used any excess of vegetable food, nor had he ever taken any benzoic acid.

161. The third and most interesting case is the one alluded to in the last edition of this work, and since published by Dr. Max Pettenkofer, who examined the urine.

A girl, æt. 13, admitted in January 1844, with chorea, into the Julius Hospital of Wurzburg, under the care of Dr. de Marcus. She had been long the subject of chorea, complicated with anomalous hysteric symptoms. Prior to her admission she refused to take any other food than apples, with bread and water, upon which she had for some time entirely subsisted. The urine was yellow, limpid, and faintly acid when first passed, soon becoming alcaline, and depositing crystals of triple phosphate of magnesia. The addition of hydrochloric acid to it after moderate concentration, produced a copious formation of crystals of hippuric acid. The addition of nitric acid, by its oxydising influence, caused the deposit of hippuric to be replaced by one of benzoic acid. In 1000 parts of the urine there were—

Water	959.332
Solids	40.668
	1000.

Solids soluble in alcohol	18.451
— insoluble in alcohol	9.417
Anhydrous hippuric acid	12.800
	40.668

Fixed salts containing much carbonate of soda	10.599

The characters of the urine in this case approached those of an herbivorous animal in the presence of hippuric acid and of carbonate of soda in the ash, as well as in the absence of uric acid.

The hippuric acid disappeared, and the urine assumed its normal proportions on inducing the girl to return to a mixed diet.

162. From what little experience we possess regarding hippuria, it appears pretty certain that the existence of this condition of the urine is strictly connected with the use of a diet deficient in nitrogen, or in the mal-assimilation of the carbon of the food. The following temporarily the use of benzoic acid, its occurring after the use of nearly exclusively vegetable food (161), or of

a milk diet, as shown in Bouchardat's case (159), as well as in infants at the breast, all help to prove the former proposition. I do not know enough of Dr. Garrod's case (160) to be able to state how far this might be regarded as an example of the second condition. If the functions of the liver, *quoad* the depurating influence of the gland, were imperfectly performed, we should possess a probable solution of the cause of the presence of hippuric acid in the urine. When we regard the composition of hippuric acid (72, 3), and call to mind the fact of its occurring in stall-fed cattle, and its being replaced by an acid less rich in carbon in animals taking much exercise, we cannot avoid arriving at the conclusion, that hippuric acid may be one of the agents by which the kidneys perform a vicarious function for the liver in removing an excess of carbon from the system.

In this respect, hippuric acid probably performs an analogous function to purpurine and bile-pigment (142), each being respectively competent to the removal from the system of 63.93, 62.0, and 68.182 per cent. of carbon, and 4.6, 6.2, and 7.437 per cent. of hydrogen.

163. My own experience in these cases has been too limited to justify my offering any opinion on the pathological complications attending them. From what little I have observed, I feel inclined to believe that when an excess of hippuric acid exists, it may be always regarded as traceable to, and pathognomonic of, the deficient function of the liver, lungs, or skin, the great emunctories of carbon; or to the use of food deficient in nitrogen. It hence follows, that our treatment will consist in appealing to the function at fault, and carefully regulating the diet.

I would suggest the propriety of seeking for the presence of hippuric acid in the urine, where it is copious, of low specific gravity, but slightly acid or neutral, and occurring in persons who have a dry and inactive state of surface with anæmia. In many pseudo-chlorotic cases in both sexes, I am inclined to believe an abnormal proportion of this acid will often be met with.

CHAPTER IX.

CHEMICAL PATHOLOGY OF OXALATE OF LIME.

(OXALURIA.)

164. THE supposed extreme rarity of crystalline deposits of oxalate of lime in the urine has often attracted the notice of writers on calculous affections, and many have expressed their surprise that, although they have repeatedly examined the urine in cases where calculi of oxalate of lime exist, they have never succeeded in detecting a deposit of this substance. To the generally admitted accuracy of this statement all investigators have borne witness; thus in the third edition of the elegant and elaborate work of Dr. Prout, which must be regarded as giving the most complete account of the state of our

knowledge on these matters at the time it was published (1840), the deposit of oxalate of lime is scarcely described. The remarks there made on the oxalic diathesis apply to the cases in which the oxalate of lime has existed in a truly calculous form, or to those in which the presence of oxalic acid is rather suspected than proved;[62] the whole series of observations inclining to the generally received notion of the almost necessary connexion between the presence of saccharine matter and development of oxalic acid. M. Rayer alludes, on the authority of M. Donnè, only to the artificial production of crystals of oxalate of lime, effected by administering to patients alcaline oxalates;[63] and figures, among his very accurate delineations of urinary deposits, the precipitate produced by the addition of oxalate of ammonia to urine. The only case of the occurrence of oxalate of lime in the urine that he cites is one which occurred to myself several years ago, the details of which appeared in the *Medical Gazette*,[64] in a laborious paper on urinary deposits, by Dr. Brett. And this is also the only instance alluded to by Dr. Willis, in his very interesting work on Urinary Diseases.

I was first led to question the accuracy of the generally received opinion of the extreme rarity of the presence of oxalate of lime in a crystalline form, during my examination of urinary deposits preparatory to the publication of an essay in the seventh volume of the Guy's Hospital Reports. Since then, I have, in the extensive field of experience at my command, pursued these researches on a large scale, and have examined microscopically the urine in an immense number of cases of various diseases.[65] The result of this investigation led to the discovery of the comparative frequency of oxalate of lime in the urine in fine and well-defined octahedral crystals, and of the connexion between the occurrence of this substance and the existence of certain definite ailments, generally characterised by nervous irritability. The accounts of my researches were published in the London Medical Gazette for 1842.

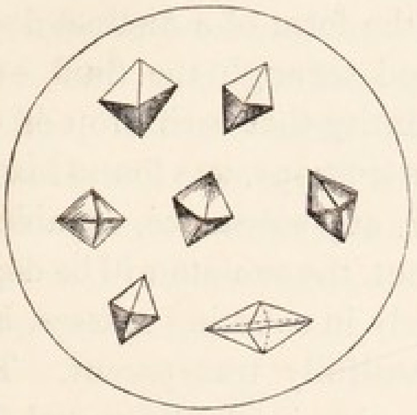
The reason of the oxalate having been overlooked so long is explained with great readiness, for without the aid of the microscope it is utterly impossible to demonstrate its presence, so long as it is diffused through the urine in separate crystals. In the very rare form of concretions or hemp-seed calculi, of course it is readily recognised, but such cases are as rare as the occurrence of the oxalate in separate crystals is common.

It will be a matter of great interest to investigate the comparative frequency of the oxalate of lime in the urine in different localities, for the purpose of ascertaining how far the formation of this salt is connected with the depressing influences always more or less active in large and densely populated cities; for, in the cases of disease occurring in the metropolis, I have no hesitation in declaring, as the result of my own experience, that the *oxalate is of far more frequent occurrence in the urine* than the deposits of earthy phosphates. And since the publication of the last edition of this work I have received repeated communications from provincial practioners confirming this statement. Dr. Shearman of Rotherham indeed states what I believe to be perfectly correct, that next to the urates, small quantities of oxalate of lime are most frequently met with in the urine.

165. *Diagnosis and microscopic characters of oxalate*

of lime.—To examine urine for the purpose of detecting the existence of the salt under consideration, allow a portion passed a few hours after a meal to repose in a glass vessel; if this be done in winter, or during the prevalence of frequent and rapid alternations of temperature, a more or less dense deposit of urate of ammonia will generally make its appearance, arising either from the sudden cooling of the urine, or from interference with the functions of the skin prior to its excretion (102). In warm weather, however, or when the functions of the skin are tolerably perfect, the urine, albeit it may be really loaded with oxalate of lime, may still appear limpid, or, at furthest, its lower layers only be rendered opaque by the deposition of a cloud of vesical mucus. Decant the upper 6-7ths of the urine, pour a portion of the remainder into a watch-glass, and gently warm it over a lamp; in a few seconds the heat will have rendered the fluid specifically lighter, and induced the deposition of the crystals of oxalate, if any were present: this may be hastened by gently moving the glass, so as to give the fluid a rotatory motion, which will collect the oxalate at the bottom of the capsule. The application of warmth serves, also, to remove the obscurity arising from the presence of urate of ammonia, which is readily dissolved on exposing urine containing it, to a gentle heat (95). Having allowed the urine to repose for a minute or two, remove the greater portion of the fluid with a pipette, and replace it by distilled water. A white powder, often of a glistening appearance, like diamond-dust, will now become visible, and this, (under a low magnifying power, as by placing the capsule under a microscope furnished with a half-inch object-glass,) will be

FIG. 30.



found to consist of crystals of oxalate of lime in beautifully - formed transparent octahedra, with sharply-defined edges and angles (Fig. 30). It sometimes happens that the oxalate is present in the form of exceedingly minute crystals: it then resembles a series of minute cubes, often adhering together like blood-discs: these, however, are readily and distinctly resolved into octahedra under a higher magnifying power. If the crystals be collected and ignited on platinum foil, oxalic acid is decomposed, and carbonate of lime left; the subsequent addition of dilute nitric acid dissolves the residue with effervescence.*

This is by far the most satisfactory process for the detection of oxalate of lime, and, although it requires a little tact, still, after some trials, it can readily be performed in a very minutes. But even this little waste of time may be avoided, by placing a drop of the lowermost stratum of the urine on a plate of glass, placing over it a fragment of thin glass or mica, and then submitting it to the microscope: the crystals diffused through the fluid becoming very beautifully distinct. In this way, however, it is obvious that a very much smaller quantity is submitted to examination than by the former process.

166. It is a very remarkable and interesting circum-

* It has been recently suggested by a high chemical authority that these crystals consist not of oxalate, but of oxalurate of lime. I confess that I am not prepared at present to admit the accuracy of this opinion.

stance, that this salt, although I have now examined a very large number of specimens of urine containing it, has scarcely ever occurred to me in the form of a distinct deposit; remaining for days diffused through the fluid, even when present in so large a quantity that each drop of the urine, when placed under the microscope, was found loaded with the crystals. If, however, any substance, capable of constituting a nucleus, be present, the oxalate will be deposited around it, although scarcely in cohering masses, and invariably colourless and beautifully transparent. The only exception to this is met with in the large and fine octahedral crystals of the oxalate which I discovered in the urine of the horse.[130] These are slightly opaque, and possess a fine amber hue, constituting most beautiful microscopic objects. If, as occasionally occurs, a specimen of oxalic urine happened to contain an excess of triple phosphate, the crystals of this salt are found mixed with those of the oxalate. I have also found the octahedra beautifully crystallised on a hair accidentally present in the urine, like sugar-candy on a string. The fact of a large quantity of the oxalate, when present, escaping the eye, is explained, I suspect, from its refractive power approaching that of urine (87); for whenever we meet with a specimen in which the salt has partially subsided, and replace the decanted urine by distilled water, the crystals often become readily perceptible to the unaided eye, resembling so many glistening points in the fluid.

167. The crystals of the oxalate, when collected in the manner above directed in a watch-glass, are unaltered by boiling either in acetic acid or solution of potass. In nitric acid they readily dissolve without effervescence. The solution may be very readily watched under the mi-

croscope. When the oxalate is allowed to dry on a plate of glass, and then examined, each crystal presents a very curious appearance, resembling two concentric cubes, with their angles and sides opposed, the inner one transparent, and the outer black, so that each resembles a translucent cube set in a black frame (Fig. 31). This is best observed, unless the crystals are very large, under a half-inch object-glass; as with a higher power this appearance is lost.

FIG. 31.

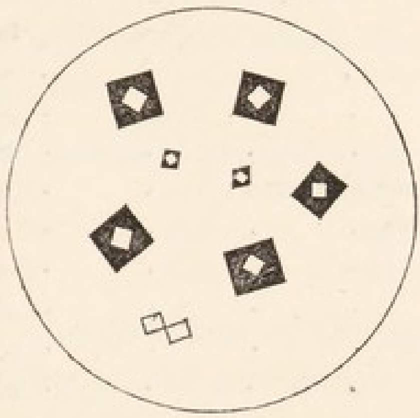
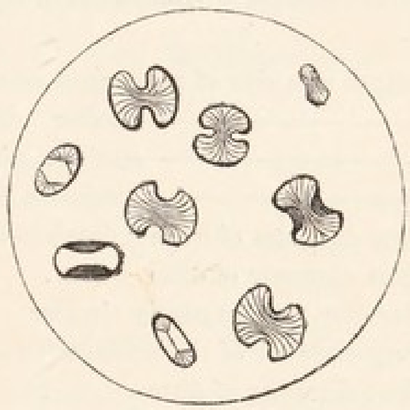


FIG. 32.



168. In very few cases the oxalate is met with in very remarkable crystals, shaped like dumb-bells, or rather like two kidneys with their concavities opposed, and sometimes so closely approximating as to appear circular, the surfaces being finely striated. These crystals are produced, in all probability, by a zeolite arrangement of minute acicular crystals, (Fig. 32,) presenting a physical structure resembling that of spherical crystals of carbonate of lime (221). I have not met with many cases in which this variety was present. Some of these were under my care for months; and I had repeated opportunities of examining the urine. The remarkable crys-

tals now referred to, became in all mixed with, and ultimately replaced by, the ordinary octahedral variety.

The greatest possible variation in the size of these crystals is often observed, not only in different specimens of urine, but often in the very same portion. I have often met with small octahedra of oxalate mixed with others four or six times larger in a single drop of urine. The following measurements were made from some specimens preserved between plates of glass; by means of the beautiful micrometer of Powell, belonging to the large microscope constructed by him for Guy's Hospital:—

	Inch.
Length of a side of the largest octahedra	$\frac{1}{750}$
———————— smaller ditto	$\frac{1}{3750}$
———————— smallest ditto	$\frac{1}{3600}$
———————— octahedra in the urine of a horse	$\frac{1}{150}$
Long diameter of large "dumb-bell" crystals	$\frac{1}{363}$
Short diameter of ditto	$\frac{1}{750}$
Diameter of some nearly circular	$\frac{1}{500}$
Long diameter of the smallest "dumb-bells"	$\frac{1}{1420}$
Short diameter of ditto	$\frac{1}{2500}$

169. *Characters of urine containing the oxalate of lime.*—In the great majority of cases, the urine is of a fine amber hue, often darker than in health, but never presenting to my view any approach to the greenish tint described by Dr. Prout as characteristic of the secretion during the presence of what he has described as the oxalic diathesis, unless the colouring matter of blood was present. In a few cases the urine was paler than natural; and then was always of lower specific gravity. This, however, was in most instances but a transient alteration, depending upon accidental causes; the odour was generally natural, rarely aromatic like mignionette. In many

instances a deposit of urate of ammonia, occasionally tinted pink by purpurine, fell during cooling. I have observed this to be infinitely more frequent during the spring than summer: hence it in all probability depended upon the influence of cold upon the cutaneous functions, causing a large amount of nitrogen and carbon, under the form of the urate of ammonia and purpurine, to be excreted by the kidney (102, 141). The specific gravity of oxalic urine varies extremely; in rather more than half the specimens being, however, between 1.015 and 1.025. In eighty-five different specimens of which I have preserved notes, the ratio of the densities was as follows:—

In 9 specimens	the specific gravity	ranged from	1.009 : 1.015
In 27	ditto	ditto	1.016 : 1.020
In 23	ditto	ditto	1.021 : 1.025
In 26	ditto	ditto	1.025 : 1.030

The densities of the specimens of urine passed before going to bed at night, and immediately on rising in the morning, were frequently very different; thus, in twenty-six cases in which the night and morning urine were separately examined:—

The night specimen was heaviest in	12
The morning specimen heaviest in	5
Both alike in	9

And, as a general rule, the heaviest specimens contained most of the oxalate. It seldom happened that the total quantity of urine passed in these cases very much exceeded the average proportion; in a very few only, positive diuresis could be said to exist. Frequently the patients have, from occasional irritability of bladder, mistaken the frequent desire to pass urine for an increased quantity; but the absence of any very considerable increase was proved by positive measurement of the quantity of urine passed in twenty-four hours.

170. Many of the specimens of oxalic urine gave a precipitate with salts of lime, insoluble in acetic acid, and consisting of oxalate of lime. This, in some instances at least, depended on the presence of oxalate of ammonia, and very delicate acicular crystals of this salt occasionally formed upon the edge of the capsule by spontaneous evaporation.

The acidity of these specimens was always well marked, often far more so than in health, and never being absent. I have not yet met with a single case in which an alcaline, or even positively neutral, state existed, unless complicated with calculus or diseased bladder.

A greater increase in the quantity of urea, than the density of the urine would have led us to suspect, was frequently found; indeed, I have scarcely met with a specimen in which, when the density was above 1.015, distinct indications of an excess of urea were not met with. In twenty-four of the eighty-five specimens above referred to, so large a quantity was present, that very rapid, and in some almost immediate, crystallisation ensued on the addition of nitric acid. In general, in cases where the greatest excess of urea was present, the largest and most abundant crystals of the oxalate were detected.

Mr. J. H. Stallard, of Leicester, who has lately contributed some important information on this subject, has discovered that in oxalic urine the indeterminate organic matters (53) are greatly increased, often reaching nearly double the average proportion excreted in 24 hours.

171. *Complication of the oxalate of lime with other*

deposits.—In more than half the cases, the oxalate of lime was found unmixed with any other saline deposit; in a very few, crystals of uric acid were found from the first, mixed with the octahedra of oxalate of lime; and in nearly all the successful cases, this acid appeared in the course of the treatment, and ultimately replaced the oxalate altogether, at a period generally cotemporary with the convalescence of the patient. Much more rarely, prisms and stellæ of the ammoniaco-magnesian phosphate were found mixed with the oxalate, and occasionally replacing it in the course of the treatment; and still less frequently, the phosphate was observed in the urine some time before the appearance of the oxalate.

In several specimens a copious troubling was produced on the application of heat; this generally depended upon the precipitation of the earthy phosphates, as a drop of dilute acid immediately restored the limpidity of the fluid. This troubling, in very few cases, has been found to depend upon the presence of albumen, and then it was usually transient, and generally traceable to the presence of some secretions from an irritable vesical mucous membrane. I have met with scarcely a well-marked instance of a complication of this oxalic affection with granular degeneration of the kidneys.

Out of the eighty-five cases before referred to

Oxalate was present unmixed in - - -	43 cases
Mixed with urate of ammonia in - - -	15 ,,
Mixed with uric acid - - - -	15 ,,
Mixed with triple phosphate - - -	4 ,,
Phosphate deposited by heat - - -	8 ,,
	85

In one of the specimens containing the triple phosphate, the application of heat produced a deposit of the earthy salts.

One very constant phenomenon is observed in the microscopic examination of oxalic urine, viz. the presence of a very large quantity of epithelial scales (256); it is, indeed, the exception to the general rule to meet with this form of urine free from such an admixture. So constantly has it been found, that repeatedly a white deposit of epithelium has often attracted my attention, and led to the suspicion of the probable presence of oxalate of lime. In general the scales of epithelium are unaltered in form, being more or less oval and marked with a circular spot in the centre; constituting the varieties described by Bowman under the name of *scaly and prismatic epithelium.* Sometimes irregular lacerated fragments of epithelial structure are met with; and frequently, if not too intense a light were used, a portion of the urine can, under the microscope, be seen to be full of them.

172. Although the oxalate of lime is generally found diffused through the urine, yet, if much mucus is present, so as to form a tolerably dense cloud, the salt may often be seen entangled in its meshes like glistening points; and whenever any other matter is present, which becomes deposited by repose, a greater portion of the oxalate will almost invariably fall with it. This is particularly the case when triple phosphate of magnesia and ammonia, or uric acid, exists under the form of a crystalline deposit; for on submitting a portion of this to the microscope, the octahedra of oxalate may be readily detected mixed with the prisms or stellæ of the former, or with the tables or lozenges of the latter.

173. *Pathological origin of oxalate of lime.*—This

question is one of great interest, and becomes the more important since the discovery of the very frequent existence of this salt in the urine; so that, instead of being very rare, it really is considerably more frequent than many other deposits (164). It is scarcely possible 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 ailments; we know that the great majority of farinaceous matters are partially converted into this element during the act of digestion.[66] 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 may, whilst in the stomach, be 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,[141] of Dublin, has even lately suggested the probability of a substance analogous to sugar, 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.

My own experience, has led me, however, to the following conclusions regarding the circumstances under which oxalate of lime occurs in the urine.

1. That in the urine under examination oxalate of lime is present, diffused through the fluid, and in a crystalline form.

2. 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.

3. 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 crystallised into a nearly solid mass on the addition of nitric acid.

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

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

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

174. Every one is now tolerably familiar with the composition of the urine in diabetes, and it has been determined, from extended observation, that, as a general rule, diabetic urine very seldom contains an excess of urea, uric acid, or urates, especially the pink variety; and that this secretion is remarkably free from saline deposits; the increased specific gravity depending upon

the presence of large proportions of sugar. In the oxalic urine under consideration, the density *increases with the quantity of urea*, which is often present in large excess: deposits of uric and urates are frequent; and, further, no analogy whatever with saccharine urine exists, save in density, which we have already learned depends upon a totally different cause. Thus, so far as the abstract examination of the urine is concerned, not the slightest countenance is given to the idea of there being any relation between oxalic and saccharine urine, however much our preconceived and hypothetical views may have led us to expect the existence of such relation. In but few instances have I yet found sugar present in oxalic urine; and although these investigations were commenced with a strong bias in favour of the almost necessary connexion between the presence of saccharine matter and oxalic acid, yet, in proportion as I have extended my researches, this idea became less and less supported by experience. In fact, I have never as yet met with oxalate of lime in diabetic urine. I have been twice shown specimens in which a white creamy sediment was considered to be oxalate of lime; but this, by chemical examination, turned out to be a chylous deposit, containing much fatty matter, and yielding butyric acid, or something analogous to it, by distillation. What, then, is the source of the oxalate of lime? and how can its production be explained consistently with the phenomena presented by the urine? From the symptoms presented in cases of this disease, there is no difficulty in proving to a demonstration the positive and constant existence of serious functional derangement of the digestive organs, especially the stomach, duodenum, and liver; and, further, that the quantity of oxalic acid generated is, to a very considerable extent, under the control of diet; some articles of food quite free from oxalic acid at once causing the excretion of this substance in very large quantities, whilst others appear to have the effect of nearly totally checking it. These circumstances alone, together with the emaciation so generally present in the disease under consideration, at once prove, that whatever be the immediate agent which causes the kidneys to secrete the oxalic acid from the blood, the primary cause must, as Dr. Prout has well and satisfactorily shown, be referred to an unhealthy condition of the digestive and assimilative functions. An excess of urea, and often of uric acid, in most instances co-exists with deposits of oxalate of lime, it is, therefore, highly probable that both these unnatural states of the secretion are produced by the same morbid influence. Further, when the very remarkable chemical relation existing between urea, uric acid, and oxalic acid, is borne in mind, as well as the readiness with which the former bodies are convertible into the latter, is it not a legitimate conclusion to suppose that the disease under consideration ought to be regarded as a form of what has been aptly termed by Dr. Willis azoturia, (of which an excess of urea is the prevalent indication,) in which the vital chemistry of the kidney has converted part of the urea, or of the elements which would in health have formed this substance, into oxalic acid? This view appears to me to be supported by what I have observed of the history, symptoms, and progress of the cases, as contrasted with the changes presented by the urine during treatment. It may, however, be asked, from whence are the nitrogenised matters derived, whose metamorphic changes (26) give rise to the formation of oxalic acid? are they derived from the tissues of the body, like healthy urea and uric acid (31)? Of course it is quite possible that such may be their origin, but as the quantity of oxalate of lime deposited from the urine is always the greatest after a full meal, and often absent in the *urina sanguinis*, or that passed on rising in the morning, frequently disappearing under the influence of a carefully regulated diet, and reappearing on returning to the use of unwholesome food, it is highly probable that this salt is, in the majority of cases, primarily derived from the mal-assimilated elements of food, and not, like uric acid generally, a product of metamorphosed structures.

175. The ready conversion of uric into oxalic acid, under the influence of oxidizing agents, has been satisfactorily demonstrated by Professors Liebig and Wohler; for when uric acid is heated with water and peroxide of lead, the latter gives up part of its oxygen, and oxalic acid, carbonic acid, with allantoin, the peculiar ingredient of the allantoic fluid of the fœtal calf, are generated.

	C N H O		C N H O	
1 at. uric acid =	10+4+4+6	=	2+2+4+2 =	1 atom urea.
+2 — oxygen =	2		4 6 =	2 at. oxalic acid.
+3 — water =	3+3		4+2+3+3 =	1 at. allantoin.
	10+4+7+11		10+4+7+11	

The allantoin itself requires merely the addition of three atoms of water to be converted into oxalate of ammonia, a change readily effected by boiling with an alcali.

The readiness with which, under certain circumstances, uric acid is converted into the oxalic, may be well illustrated by a fact which has been observed in connexion with the *guano* of South America (67) a substance now acquiring great celebrity as a manure. This contains, when recent, a considerable proportion of urate of ammonia, which salt, after a certain length of time, often during the voyage to this country, nearly wholly disappears, and is replaced by oxalate of ammonia. The relation between urea and oxalic acid is readily shown; for if we conceive urea to exist in the blood, and it be the duty of the kidney to separate it, we have only to suppose the organ to exert a slight deoxidating or decomposing influence to insure the conversion of urea into oxalate of ammonia. We know that under a depressing influence exerted on the nervous system at large, or upon a portion of it connected with the functions of the kidney, as during typhus adynamic fever on the one hand (198), and blows over, or a fracture of the spine, on the other (201), such decomposing influence is unquestionable, and the urine becomes loaded with carbonate of ammonia from a re-arrangement of the component elements of the urea; one atom of urea and two of water being resolved into two atoms of carbonate of ammonia. If, then, a less energetic amount of this morbidly depressing influence be supposed to be exerted, we shall have one atom of urea and two of water, lose an atom of oxygen to become converted into oxalic acid and ammonia.

	C N H O		C N H O	
1 at. urea =	2+2+4+2	=	2 . . 3	= 1 at. oxalic acid.
			. 2+6 .	= 2 at. ammonia.
2 at. water =	. . 2+2		. . . 1	= 1 at. oxygen.
	2+2+6+4		2+2+6+4	

176. Having traced the origin of oxalate of lime deposits to changes in nitrogenised food, or to an abnormal destructive assimilation of effete tissues, it becomes next of importance to direct attention to the fact that this salt may often be a direct derivative from vegetable food, for it is quite certain, from the researches of Schleiden and others, that oxalic acid is of all acids that which is most extensively diffused through the vegetable kingdom. In the polygonaceæ, it particularly abounds, and after the ingestion of preparations of rhubarb and sorrel, crystals of oxalate of lime can always be detected in the urine. Oxalate of lime constitutes a large proportion of the acicular crystals or raphides so common in the intercellular lacunæ of many plants, and in the liber of trees it is of very frequent occurrence. The physiological origin of oxalic in vegetables admits of ready explanation, for it is well known that under the influence of light they possess the power of decomposing the carbonic acid of the air, and evolving its oxygen, the carbon becomes fixed in their tissue. The generation of oxalic acid becomes a nearly necessary result of the first stage of this de-oxygenizing action, and most of the other vegetable acids may be regarded as the results of ulterior changes. Thus,

$$
\begin{array}{lcccl}
 & C & H & O & \\
 & 12+ & & 24 & = 12 \text{ atoms of carbonic acid.} \\
- & & & 6 & \\
\hline
 & 12+ & & 18 & = 6 \text{ atoms of anhydrous oxalic acid.} \\
+ & & 6+ & 6 & \\
\hline
 & 12+ & 6+ & 24 & = 6 \text{ atoms of hydrated oxalic acid} \\
- & & & 9 & \\
\hline
\end{array}
$$

$$
\begin{array}{rl}
 & 12+6+15 = 1\tfrac{1}{2} \text{ atoms of tartaric acid.} \\
- & \quad\quad\; 3 \\
\hline
 & 12+6+12 = 1\tfrac{1}{2} \text{ atoms of malic acid.} \\
- & \quad\; 1+\;1 \\
\hline
 & 12+5+11 = 1 \text{ atom of citric acid.} \\
- & \quad\; 2+\;2 \\
\hline
 & 12+3+\;9 = \text{lichenic acid, \&c.}
\end{array}
$$

Thus we are authorised in assuming that animals and vegetables generate oxalic acid by two very distinct processes, the former by oxydation, the latter by de-oxydation.

These facts show the vast importance of carefully ascertaining the peculiarities of the patient's diet before giving too confident an opinion as to the morbid state of the urine.

177. It hence becomes a very important matter to diagnose between deposits of oxalate of lime which acquire their acid directly from the food in which it existed ready formed, and those in which its origin is strictly pathological. The nature of the patient's food will soon enable us to resolve this question satisfactorily. It may, however, often assist in our diagnosis to recollect that the great acidity, the high specific gravity and excess of urea generally present in true oxaluria, will often at once distinguish between a deposit, the result of diseased action and one of accidental origin.

Since the first publication of the formula (175), Professor Liebig has suggested that oxalic acid is a derivative of uric acid and not of urea, thus,

$$
\begin{array}{lcl}
 & \text{C N H O} & \quad \text{C N H O} \\
\text{1 atom of uric acid} & =10+4+4+6 & \left.\right\} \quad 4+4+8+4=2 \text{ atoms urea.} \\
\text{4 atoms water} & =\quad\quad\; 4+4 & = \\
\text{3 atoms oxygen} & =\quad\quad\quad\;\; 3 & \quad 6 \quad\quad 9=3 \text{ at. oxalic ac.} \\
\hline
 & 10+4+8+13 & \quad 10+4+8+13
\end{array}
$$

It is, however, a matter of very secondary importance whether the oxalic acid be a derivative of uric acid or urea, considering the close relation which exists between these two bodies (64). From whatever source it may arise, the presence of oxalic acid in the urine must necessarily lead to the formation of oxalate of lime, as this acid readily precipitates lime from all its combinations with acids.

178. *Symptoms accompanying the secretion of oxalic acid.*—It is difficult, notwithstanding the experience we have had of this ailment, to offer a very satisfactory account of the symptoms attending it. As a general rule, however, persons affected with the disease under consideration are generally remarkably depressed in spirits, and their melancholy aspect has often enabled me to suspect the presence of oxalic acid in the urine. I have seldom witnessed the lurid greenish hue of the surface to which Dr. Prout has referred. They are generally much emaciated, excepting in slight cases, extremely nervous, and painfully susceptible to external impressions, often hypochondriacal to an extreme degree, and in the majority of cases labour under the impression that they are about to fall victims to consumption. They complain bitterly of incapability of exerting themselves, the slightest exertion bringing on fatigue. In temper they are irritable and excitable; and in men the sexual power is generally deficient, and often absent, an effect probably owing to the exhaustion produced by the excessive secretion of urea so common in this affection (173). A severe and constant pain, or sense of weight, across the loins, is generally a prominent symptom, with often some amount of irritability of bladder. The mental

faculties are generally but slightly affected, loss of memory being sometimes more or less present. Well-marked dyspeptic feelings are always complained of. Indeed, in most of the cases in which I have been consulted, I have been generally told that the patient was ailing, losing flesh, health, and spirits, daily; or remaining persistently ill and weak, without any definite or demonstrable cause. In a few the patients have been suspected to be phthisical. It is, however, remarkable that I have yet met with very few cases in which phthisis was present. In six instances only I have seen the cases terminate in the formation of a calculus. In three of them, the concretion passed spontaneously from the urethra; in another, it became impacted, and was cut out by Mr. Harding; and in the other two cases, the calculi were removed by the operation of lithotomy performed by my colleague, Mr. Hilton.

179. Regarding the exciting causes of the secretion of oxalic acid, they were, in the majority of cases at least, generally well marked; and in nearly all, the predisposing cause was nearly the same, viz. a chronic and persistent derangement of the general health, or the result of previous acute disease, dyspepsia, injury to the constitution by syphilis and mercury (Case 2), by child-bearing and over-lactation, by venereal excesses or intemperance. (Cases 4, 8.) The accession of the disease has generally been traced to some circumstance which has determined the irritation to the urinary organs. Of these, exposure of the lower part of the spine to cold (Case 3), mechanical violence inflicted over the kidneys (Case 7), unnatural excitement of the genital organs, as shown by the frequent occurrence of involuntary seminal emissions (Case 6)

(259), or irritation from passing a bougie; have most generally constituted at least the most evident exciting causes. Dr. Rigby has lately shown that deposits of oxalate of lime often occur during the existence of functional and organic disease of the uterus; in many cases, however, no other obvious cause existed than great mental anxiety (Case 5), produced by excessive devotion to business or study.

Among acute diseases, none appears to be so frequently accompanied by the generation of oxalate of lime as rheumatism. The deposits of urate of ammonia so frequent in this painful disease being rarely free from the crystals of the oxalate.

180. *Therapeutical indications.*—The treatment, in the majority of cases, is very successful; a few only resisting all the plans which were adopted. As a general rule, the functions of the body, where obviously imperfect, should be corrected, the general health attended to by the removal of all unnaturally exciting or depressing influences, the skin should be protected from the sudden alternations of temperature by a flannel or woollen covering, and the diet carefully regulated. This has generally consisted of well-cooked digestible food, obtained in about equal proportions from the animal and vegetable kingdom; all things which tend to produce flatulence being carefully avoided. The drink should consist of water, or some bland fluid, beer and wine being excluded, especially the former, unless the patient's depression render such positively necessary. A very small quantity of brandy in a glass of water has generally appeared to be the most congenial beverage at the meals. The administration of nitric acid, as suggested by Dr. Prout; or

what appeared to be preferable, the nitro-hydrochloric acid, in small doses, in some bitter infusion; or, laxative mixture, as the mistura gentianæ comp., is, with minute doses of mercury, generally successful, if continued a sufficient length of time. Where great nervous irritability exists, the sulphate of zinc is often of great service. It should be given in graduated doses, beginning with one grain, thrice a day, increasing the dose every third or fourth day until 18 or 20 grains are taken daily. The addition of a grain or two of ext. hyosciami or camphor often enables it to be better borne. The shower-bath, by acting in a similar manner, has been also of great service. Where the patient is anæmiated or chlorotic, the salts of iron in large doses, appear to be of great use, not only by subduing the irritable state of the nervous system, but by increasing a healthier condition of the blood. No preparation of this important drug succeeds better than the ammonio-citrate or ammonio-tartrate in doses of 7 or 8 grains thrice a day, dissolved in a glass of water. The headache occasionally following the use of iron is readily prevented, and the success of the remedy insured by taking it directly *after* a meal so that it may be assimilated with the food.

181. In a few obstinate cases resisting all other treatment, I have prescribed colchicum with advantage. The influence of this remedy in often checking a long-continued formation of uric acid has been already alluded to (122). And in some cases, where copious deposits of oxalate of lime existed, they have, under the influence of this drug, become replaced by uric acid or urate of ammonia, thus inducing a condition of urine much more amenable to treatment. The rationale of the action of

colchicum is probably traceable, not to any specific power it exercises over any form of urinary deposit in particular, but rather in the influence it exerts over the secreting functions, controlling the action of the heart, (on which it appears to act as a direct sedative,) and consequently the capillary circulation, the very seat of secretion.

The circumstance of the replacement of oxalate of lime by uric acid or urate of ammonia, under the influence of the colchicum, may be regarded as evidence of its influence on the capillary system in inducing the formation of normal products from the disintegration of effete and exhausted tissues during the process of secondary assimilation.

182. I have selected the following cases from those of which I have preserved notes, on account of their illustrating the chief varieties of ailments in which I have met with the oxalate, more than for the sake of pointing out the treatment. I only trust that they will appear of sufficient importance to draw attention to the subject generally, and to impress the profession with the fact of the very frequent, and very generally overlooked, production of oxalic acid in the animal economy.

ILLUSTRATIVE CASES.

CASE II.—*Intense hypochondriasis; emaciation; copious discharge of crystals of oxalate of lime, with excess of urea.*

On Feb. 15th, 1842, I was consulted by Mr. W. Stone, in the case of a gentleman residing in a densely populated district in this metropolis. He was a remarkably fine man, about thirty years of age, of dark complexion, and whole expression strongly characteristic of deep melancholy; he was highly educated, and appeared to have painfully susceptible feelings. It appeared from his history that, until within the last four years, his health had been excellent; at that time he contracted a sore, which was regarded as syphilitic, and so treated with, *inter alia*, abundance of mercury and iodine, which appeared to have aided in bringing on on extremely cachectic condition. Partially recovering from this, he left England on an eastern tour. He visited Malaga, Egypt, and returned to England *viâ* Constantinople. At each of these places he underwent treatment for what he regarded as a return of venereal symptoms, apparently only manifested by relaxation of the throat producing hacking cough. At the latter place he fell under the care of Dr. Mac Guffog, who evidently took a very correct view of the case, and he received decided benefit from his treatment. At last, wearied and dispirited, with an irritable throat, bearing about with him what he regarded as a venereal taint, and tired with wandering, he returned to England, a prey to the most abject hypochondriasis. When I saw him, his naturally expressive countenance indicated despair: he complained bitterly of the inefficacy of medicine, and seemed only in doubt whether he were doomed to die of syphilis or phthisis. The pulse was quick and irritable; tongue morbidly red at the tip and edges, and covered in the centre with a creamy fur. He had lately lost much flesh; he was troubled with a constant hacking cough, which evidently depended on an enlarged uvula; for on examining the chest I could not succeed in detecting any evidence of disease. There was extreme palpitation, increased by eating and by exercise, much flatulent distention of the colon, with pain between the shoulders, across the loins, and over the region of the stomach; extreme restlessness, and nervous excitement, accompanied every action. The bowels were inclined to be constipated; urine copious; appetite rather voracious, but unsatisfying; skin acted imperfectly.

Feb. 15th.—The urine passed last night was acid, pale, of specific gravity 1.0295, contained much mucus, with abundance of flesh-coloured urate of ammonia in suspension. On warming a portion, so as to dissolve the latter, a very copious crystalline deposit of oxalate of lime, in *cuboid* crystals, was rendered beautifully visible by the microscope. A large excess of urea was present, the addition of an equal bulk of nitric acid rendering some of the urine placed on a watch-glass nearly solid in ten minutes. The urine passed this morning was precisely similar.

℞ Acid. Nitrici Acid. Hydrochlor. aa. ʒss.; Inf. Serpentariæ, ℥xj.; Syr. Zinzib. ℥j. M. capt. ℥j. ter die.

℞ Ext. Aloes Pur. ij.; Conf. Opii, gr. iij. M. ft. pil. o. n. s.

Allowed a bland nutritious diet, with three glasses of old sherry daily: no vegetables, butter, or sugar.

27th.—Has continued the treatment up to this date with very marked improvement; his expression is now cheerful; bowels act freely and healthily; pain much less; skin active; throat not so troublesome.—Pergat.

The night urine was now of lower specific gravity, being 1.020, scarcely containing an excess of urea; a slight deposit of urate of ammonia was present, mixed with but a small quantity of oxalate of lime in crystals. The morning urine contained less of the oxalate.

He continued this treatment patiently and persistently until March 20, when he was so much better that he desired to take a country trip. I discontinued his medicines, and ordered him a mild tonic aperient occasionally.

May 1st.—I again saw this gentleman. He has gained strength, flesh, and spirits; he only complained of occasional headache, and a dread of a return of his ailment, and is anxious to break through his restrictions of diet. The urine now contained no excess of urea, and was nearly free from oxalate of lime. An occasional aperient was ordered him.

June 4th.—He again called upon me; he is free from disease, and his most pressing evil seems rather to arise from a lurking dread of phthisis than aught else. The urine is natural.

CASE III.—*Intense lumbar pain following exposure to cold; diuresis; great hypochondriasis; copious discharge of oxalate of lime following, and succeeded by uric acid gravel; excess of urea.*

Mr. F——, æt. 53, a gentleman residing in the neighbourhood, came under my care May 1st, 1842, complaining of intense pain across the loins, so severe as to interfere materially with his comfort. From his history it appears that the general health had been good; always had an excellent, indeed often a voracious appetite, and been "a heavy feeder," eating and drinking abundantly, but scarcely ever had been intoxicated. His life has been one of great activity, being daily for several hours out on horseback or in his gig. Ten years ago he became the subject of severe irritative dyspepsia, lasting about six months: from this he recovered, and remained tolerably well for four years, when he suffered a relapse, attended with severe pain in the left hypochondrium, referred to flatulent distension of the colon, consequent on constipation, by the late Mr. Vance, under whose care he then was. This pain has since been always more or less constantly present, and is generally relieved by an escape of flatus. About five years ago he went to Cheltenham on the outside of a coach, and got chilled. He soon became the subject of severe lumbar pain, which, although frequently varying much in severity, has now left him. It is greatly increased by all indiscretions in diet, and when absent a hearty meal will at any time bring it on; when it is present it completely cripples him. By making a powerful effort he can sometimes manage to walk: and this generally gives some amount of relief, although too much exercise will always bring it on. He feels no increase of pain when riding on horseback, but a short drive on a coach will bring on a paroxysm of lumbar pain. Neither headache nor sickness have been present during the whole illness. The urine is generally turbid, and occasionally passed in larger quantities than natural. This gentleman has of late become subject to the most distressing hypochondriasis, looking at all occurrences as tinted with a colouring of melancholy or misfortune. So far as I could learn, the sexual powers had not become materially impaired. He has never had pains along the ureters, and inherits no tendency to calculus or gout. The tongue is tolerably clean; having in its centre a mere creamy layer. The bowels act well.

May 1st.—The urine passed last night was pale amber-coloured; it contained much mucus, was acid, did not coagulate by heat; it contained in diffusion a large quantity of urate of ammonia, which, on the application of heat, dissolved, and left a copious deposit of lozenges of uric acid, mixed with cohering crystals of that substance in the form of crystalline gravel; in specific gravity was 1.026: it did not coagulate by heat, but contained an excess of urea: on the addition of nitric acid, it in a few seconds became filled with fine crystals of nitrate of urea.

The urine passed this morning was of specific gravity 1.024, and in other respects resembled the night urine.

℞ Hyd. c. Cretâ, gr. iss.; Ipecac. Pulv. gr. j. ft. pilula o. n. s.
Omit all beer and spirits, as well as fatty and indigestible articles of food. Plain diet with animal food once daily.

8th.—Much the same; the bowels had acted with copious bilious discharges; pain still intense; depression very great. The urine passed last night was of specific gravity 1.030; it was acid, pale, contained abundance of urate of ammonia, which, by heat, disappeared, leaving, distinctly visible under the microscope, a copious deposit of oxalate of lime in minute octahedra, mixed with an abundance of nucleated epithelium: no uric acid. On the addition of nitric acid, the urine almost immediately solidified from the copious crystallisation of nitrate of urea.

The morning urine was of a specific gravity 1.027. It contained a great excess of urea, and resembled the night urine in every particular, except that the urate of ammonia was tinted with pink, and the crystals of oxalate of lime were much larger, being fine octahedra.

℞ Acidi Nitrici, ♏iij.; Acidi Hydrochloric. ♏vj. ter in die ex cyatho Inf. lupuli, sumend:

9th.—The urine was sent to me; that passed last night was healthy in colour; quite limpid; sp. gr. 1.027. Under the microscope it appeared full of fine octahedra of oxalate of lime. That passed this morning resembled it in everything, save in its lower specific gravity, being 1.021. Both contained excess of urea.

16th.—Very much improved. He has been quite free from pain for several days; is in excellent spirits. He has taken more exercise, having been out rook-shooting the whole week, and been "living well."

Last night's urine was of sp. gr. 1.022. No visible deposit. Under the microscope a few small octahedra of oxalate of lime, mixed with "cylinders" of uric acid, were visible. The specimen passed this morning was of sp. gr. 1.017, and contained still few crystals of the oxalate.

23rd.—Appears completely well in health and spirits; he is now cheerful, and free from pain. The urine passed this morning contained no oxalate;

had a slight deposit of uric acid in lozenges, but was still rather too high in specific gravity, being 1.024.

Oct. 2, 1845.—This gentleman again came under my care, having enjoyed excellent health since I last saw him. He has become the subject of "a fit of gravel," ending in the passages of several very minute uric acid calculi.

CASE IV.—*Irritative dyspepsia, gastrorrhœa, great emaciation and depression, voracious appetite, copious deposit of oxalate of lime in large and well-defined crystals.*

Mary Wardell, ætat. 35, admitted under my care at the Islington Dispensary, April 26, 1842: a pallid nervous woman; had one child nineteen months ago; suckled it during nine months; previous to this had suffered from four miscarriages, losing at each a large quantity of blood; has no leucorrhœa. Previous to her first pregnancy her health had been excellent. During the last year she has been rapidly losing flesh, and her energies are almost prostrate, the spirits being intensely depressed. She has, for a long period, suffered from pain at the scrobiculus cordis, and gastrorrhœa. For several months her most serious evil has been a fixed persistent pain across the loins, which becomes much more intense by exertion. No evidence of uterine disease; bowels constipated; appetite craving, and distressing, never being satisfied; thirst great; flatus considerable.

26th.—Shortly after each meal a gush of limpid fluid rises from the stomach, which, in about an hour after, is followed by the vomiting of the meal in a semi-digested state, mixed with a considerable quantity of black grumous matter; bowels confined.

Pil. Col. c. Hyd. ℈ss. o. n. s.

30th.—Bowels freely open; vomiting considerable and distressing, accompanied with great pain at the epigastrium.

Pil. Cal. c. Opii, j.; ante prandium quotidie; M.M. c. M.S. ℥ss. c. Acid. Hydrocyan. dil. ♏viij. t. d.

May 5th.—Bowels freely open; vomiting not so frequent; complains of severe pain, referred to the right side of the chest.

Rep. Mist.
℞ Bismuth. Trisnitratris, Conii fol. Sodæ Carbon. sic. aa. g. iv. t. d.

10th.—Was suddenly seized last night with fainting, and severe pain in epigastrium. This was relieved by a little brandy and water. After a short time sleep came on, and she awoke somewhat relieved. The emaciation has rapidly increased during the fortnight. I now requested her to send me a specimen of the urine passed in the evening. It was pale, of sp gr. 1.030, acid and turbid from the presence of flesh-coloured urate of ammonia. On exposing a portion to heat, the latter dissolved, and a white opaque deposit was left; this, under the microscope, was found to consist of oval epithelial scales, mixed with very fine and large octahedra of oxalate of lime.

Perstet. in usu pulverum; Ammoniæ Sesqui-carbonatis, gr. iv.; ex Inf. Serpent. ℥j. et Sp. Eth. Sulph. co. ʒss. ter in die.

11th.—Passed a good night; no pain either in back or epigastrium; much headache; bowels thrice open from a dose of rhubarb she took this morning; motions offensive; no sickness since yesterday, which followed the eating of a couple of figs; feels comfortable, but weak; urine clear; oxalate of lime not so abundant.

Mist. Effervescens c. Syr. Papav. ʒj. 4tis horis.

12th.—Vomited yesterday after dinner; passed a good night; complained this morning of pain all over the abdomen, and between the scapulæ; bowels acting freely.

Pergat. Fotus Papaveris abdomini.

16th.—Decidedly improving; now can bear on the stomach a light meal of animal food: complains bitterly of pain across the abdomen, compared to a cord tightly drawn round it.

℞ Sp. Ammon. Co. ♏xx.; Inf. Serpent. ℥j.; Syr. Papav. ʒj. M. ter in die.

21st.—Improving; is gaining flesh and spirits; complains of gastrodynia daily after dinner.

Pergat. Pil. Cal. c. Opii j. bis die.

27th.—Has gained strength enough to walk from Hoxton, where she resides, to my house; is very much better, but still has great lumbar pain.

The urine is still of rather too high a density, contains an excess of urea, and a tolerably copious deposit of crystals of oxalate of lime.

℞ Inf. Serpent. ℥j.; Acid. Nitrici dil.; Acid. Hydrochlor. aa. ♏v. M. ter die. Allowed to take some porter.

29th.—Much improved; urine copious, pale, sp. gr. 1.009.

June 7th.—Convalescing; urine 1.019, free from oxalate.

13th.—Has suffered a slight relapse, attended with returns of lumbar pain, following her taking a glass of hard porter. This lasted but a few hours; and she intends leaving town to recruit her strength in the country.

CASE V.—*Emaciation; extreme melancholy, following great mental distress; severe lumbar pain; great excess of urea, and discharge of oxalate of lime; remarkable gelatinisation of the urine by heat.*

Catherine Cutler, æt. 39, a tall thin woman, of fair complexion, presenting the appearance of great emaciation and melancholy, admitted under my care at the Islington Dispensary on May 3, 1842. She has been a widow four years; has had two husbands, and lost both by phthisis; this, with her depressed circumstances, has caused her to experience great mental and bodily distress. She has had eight children, of which she has lost six. Menstruation still regular, but, to use her own expression, almost drowned in leucorrhœa; bowels habitually constipated. She states that she has for two years been gradually losing flesh; but lately this has so increased as to amount to rapid emaciation. Her depression and melancholy are intense, probably, however, partly depending on her being dependent on dress-making as the only means of support. For some months past she has been the subject of almost constant "wearing" pain across the loins, increased by exercise, and so severe at night as to prevent her lying in the recumbent position. The pain is always increased by exercise. Her nights are usually sleepless; and if she does get a little rest, she starts from it with the most frightful dreams. She has frequent palpitations, and pain about the epigastrium after taking food; no great amount of flatulence; tongue red at the tip and edges, white fur in the centre.

Pil. Col. c. Hyd. ij. o. n. s.; Emp. Belladonnæ regioni cordis.

May 6th.—The urine passed last night was of sp. gr. 1.027, acid, and turbid from its holding much urate of ammonia in diffusion. On decanting the clear portion, and gently heating the opaque part, the urate dissolved, and left a copious deposit of microscopic octahedra of oxalate of lime, and numerous scales of nucleate epithelium. No change was produced in this urine by heat. The specimen passed this morning was of sp. gr. 1.011, very pale, and limpid. It became opaque on the application of heat; the troubling not being removed by nitric acid. It scarcely contained a trace of oxalate of lime. I ordered all medicines to be omitted, for the purpose of watching the state of the urine for a few days.

8th.—Bowels for three days have been confined. She complains of a sense of distension in the abdomen, and has for two days been confined to bed with intense headache, giddiness, and feverish excitement.

Morning urine clear, 1.028, acid; no oxalate.

Night urine contained a mucous cloud, 1.022, abundance of oxalate of lime in octahedral crystals.

Pil. Col. c. Hyd. ij. 6tis horis ad catharsin.

9th.—Last night's urine turbid from the presence of urate of ammonia; feels very weak.

Mist. Gent. Co. ℥j.; c. Sp. Ammon. Co. ♏xx. ter in die.

12th.—Much the same; constipation continues.

Pulv. Jalapæ Co. ʒj. o. m. s.

15th.—No change for the better; bowels have acted well; she still feels wretchedly ill, and depressed.

The urine passed last night was of a density of 1.028, acid, pale, and contained in suspension the fawn-coloured urates. On warming a portion, the urates dissolved, and the clear fluid soon let fall a white deposit, which, on decanting the still warm liquor, and examination under the microscope, was found to consist of various-sized octahedra of oxalate of lime, mixed with myriads of oval nucleated epithelial scales. During the application of heat, the urine underwent a remarkable change. It did not become opaque, or coagulate, but assumed a gelatinous consistence, retaining its transparency. It then required violent agitation to diffuse it through water.

The morning urine was of sp. gr. 1.030, contained an abundance of epithelium, but no oxalates. Both specimens were loaded with urea, and were converted into nearly semi-solid crystalline masses on the addition of nitric acid.

K 2

I was by no means satisfied upon what this very remarkable gelatinisation depended. Certainly not upon the presence of albumen, as nitric acid produced no opacity further than what arose from the rapid production of crystals of nitrate of urea. Nor could I attribute it to the great excess of the latter element, as this change is by no means characteristic of urine containing a large quantity of urea.

Rep. medicamenta.

17th.—Improving; bowels act well, and leucorrhœa decreasing; pulse 24; general health better; the symptoms of uterine irritation have decreased with the leucorrhœa, but the want of strength, emaciation, depression, and severe lumbar pain, continue; the oxalate of lime still abundant in the night urine.

Capiat Acid. Nitric. Dil. ♏xv.; ex Dec. Cinch. ℥j. bis die. Ordered nutritious diet, avoiding vegetables and beer, weak gin and water at dinner.

June 1st.—Has been, during the last week, completely free from lumbar pain; this morning, apparently owing to an indiscretion in diet last evening, she had a slight return. The urine passed last night just before going to bed was pale, of specific gravity 1.015, contained abundance of epithelial scales, and no visible oxalate.

Rep. omnia.

5th.—The return of lumbar pain has been quite evanescent; she is now quite free; complains of debility and occasional headache; still suffers from constipation; skin acts well; occasional feverish flushes, especially in the evening. The urine passed last night had increased in specific gravity to 1.029; it was loaded with pale urates; it contained no oxalate of lime, and, by heat, underwent the remarkable gelatinization before referred to.

Rep. Mistura. Sumet. Pil. Col. c. Hyd. ℈ss. p. r. n.

12th.—By taking the pills on alternate nights, a tolerably healthy action of the bowels has been kept up; she is much improved; the flushes are less frequent; no return of lumbar pain; merely complains now of not feeling quite strong.

Inf. Serpentariæ ℥j. t. d. Allowed a little porter.

13th.—The urine passed last night was of a density of 1.028, healthy in colour, contained no visible deposit, save a mucous cloud. The microscope, however, detected a considerable deposit of octahedral crystals of oxalate of lime, with an immense quantity of oval nucleate epithelial scales.

Ordered to omit the porter.

20th.—Feels quite well. The oxalate has again disappeared.

Case VI.—*Rapid emaciation and depression; nervous palpitations; lumbar pain; excess of urea, and discharge of oxalate of lime.*

John Berry, æt. 31, admitted under my care at the Finsbury Dispensary, June 3, 1842.

A tall and remarkably fine man, extremely emaciated, his cheeks hollow, and his whole appearance resembling that of a diabetic patient. He is a currier, and is exposed to extreme alternations of temperature, working in a half-bent position, without coat or waistcoat, in a shop through which are constant currents of air. He is unmarried, and has been very irregular with regard to women; for two years he has been gradually losing flesh, strength, and spirits; his sexual powers have also rapidly declined, and now scarcely exist; he has frequent seminal emissions in his sleep, which leave him weak, exhausted, and melancholy, during the ensuing day. Regarding his previous habits, he considers he has been temperate, rarely getting intoxicated more than twice a week, and then on porter or ale. During two months his decline has been rapid,—a *facilus descensus.* He has now an almost constant headache, a constant aching pain across the loins, a sense of sinking at the stomach, as if, to use his own expression, he had no inside, frequent chills, with cold and clammy sweats, succeeded by feverish flushes; tongue red at the tip and edges, with a white central fur; frequent giddiness; his memory has been for some time failing His nights are wretchedly restless, generally tossing all night from side to side, in vain endeavouring to sleep, and if he does slumber, he awakes as fatigued as when he retired to rest; appetite bad; no thirst; frequent palpitation, and flatulence; pulse small and irritable; no chest disease.

Sumat. Pulv. Rhæi Salin. ʒj., cras mane.

5th.—Bowels acted once yesterday from the powder; hands tremulous. The urine passed last night was deep amber-coloured, acid, of a density of

1.030, no visible deposit: by microscopic examination, however, myriads of splendid octahedral crystals of oxalate of lime became visible. On the addition of nitric acid to the urine, a copious formation of crystals of nitrate of urea occurred.

The urine passed this morning was paler, acid, of a density of 1.025, and contained less oxalate and urea.

Pil. Col. c. Hyd. ij. o. n. s.; Acid Nitric. dilut. ♏xv. ter die, ex Dec. Cinchonæ, ℥j. Nutritious diet, light pudding daily, no beer, weak brandy and water at dinner.

15. Bowels act thrice daily; motions offensive and dark coloured; complains greatly of palpitation of the heart.

Rep. Mist. c. Inf. Serpentariæ, vice Dec. Cinchonæ.

The urine passed last night was deep amber-coloured, of specific gravity 1.028: the microscope detected myriads of smaller octahedra than before. The morning urine was of a density of 1.018.

28th.—Very much improved; rests better at night; no lumbar pain; great sense of sinking at the scrobiculis cordis. Night urine, 1.026, deposited phosphates by heat, and contained numerous minute crystals of oxalate of lime. Morning urine 1.026 like the night specimen, but did not become opaque by heat.

M. Ferri Co. ℥j.; c. Tr. Lyttæ, ♏x. b. d.

July 2nd.—Improving; seminal emissions ceased. Still copious octahedra in the night urine, which is of the density 1.025.

Sumat. Vin. Colch. ♏x. ex Mist. Gent. Co. ℥j. b. d.

10th. So much better that he is anxious to leave London on a long journey; the urine is now free from oxalate.

CASE VII.—*Discharge of dumb-bell oxalates, apparently succeeding to mechanical injury.*

David Maneford, æt. 58, admitted under my care at the Finsbury Dispensary, May 25, 1842: a pallid-looking man, with a face, although not remarkably attenuated, presenting a gaunt hollow aspect, with a slight hectic flush over each cheek-bone; engaged up to the age of 32 as a ship's carpenter, in vessels chiefly in the Mediterranean, and once in a privateer on the American coast; during this time his life was one of great intemperance, drinking rum abundantly. Since he left the navy he has worked as a cabinet-maker. In 1831, whilst lifting a heavy weight, he experienced a "wrench" across the loins, the effects of which injury, although apparently not severe at the time, have ever since, more or less, annoyed him; although his general health, up to the last year, has been tolerably perfect.

His chief ailment now consists in a gradual, but persistent, loss of strength and health during the last twelve months, during which period he has lived more regularly than previously. He is very low-spirited; his memory has of late become defective; perspires freely on the slightest exertion; has frequent nausea at the sight of food; appetite bad; no pain in the stomach after the meals; no acid or bitter eructations; great and frequent flatulent distension. His nights are wretched and restless. During the last year, a fixed and constant pain across the loins has distressed him; this he can succeed in *walking off* for a time, but fatigue will eventually increase it; the bowels have of late been relaxed, acting three or four times a day, the motions being dark and fluid; his sexual appetite and powers have of late rapidly declined; frequent involuntary seminal emissions appear at night; the tongue is clean, vividly red, and polished at the tip and edges; pulse full and hard, but jerking. The urine passed on the night of May 25th was clear, amber-coloured, acid, of specific gravity 1.017, and contained no visible deposit; a drop of the lower stratum of the urine, after repose, was full of oxalate of lime in dumb-bell crystals, which were hard and somewhat gritty, unaltered by boiling acetic acid, but readily soluble in nitric and hydrochloric acids. The specimen passed in the morning resembled the last; was of the density of 1.012; it let fall a slightly cloudy deposit by repose, which, under the microscope, was found to be made up of myriads of minute cuboid crystals of oxalate, mixed with a very few dumb-bells.

℞. Acidi Hydrochlorici, ʒiij.; Acidi Nitrici, ʒj.; Mist. Camphoræ, ℥iiiss.; M. capt. cochl. j. min.; ex Inf. Anthemidis, ℥iss. ter die; Sumat. Pil. Hydr. Chlor. Co. gr. v. o. n. He was ordered to wear a flannel bandage round the loins, to keep to a bland nutritious diet, omitting all fermented liquors.

27.—Night urine clear, amber-coloured, no visible deposit, 1.016, very acid, no opacity by heat: some white pearly granules became visible by repose, which consisted of cohering dumb-bell crystals of oxalate. Morning specimen pale, contained mucous clouds, with some flakes of uric acid mixed with cohering dumb-bells.

June 2nd.—Notwithstanding the warm weather, he has not perspired so much as usual; bowels act once daily; motions dark, and tolerably healthy; urine in less quantity; that passed at night, 1.019, pale, and had a copious deposit of "cylinders" of uric acid, mixed with lozenges and rosettes, nearly free from oxalate of lime. The morning specimen was 1.018 in density, and perfectly resembled that passed at night. He gets better nights' rest; lumbar pain still severe, but altogether feels stronger.

9th.—Tongue not so vividly red; gums slightly affected. Has been drinking cider, which not appearing to disagree, I have permitted him to continue. The night urine is of density 1.024, and contained a copious deposit of uric acid.

Rep. mist.: omitte pil.

23rd.—Improving manifestly in general health; no sickness; bowels act well. Night urine 1.018; morning 1.015; no visible deposit; feels only weak and nervous.

Zinci Sulph. gr. iij. c. Conf. Opii gr. ss. formâ pilul. ter die.

30th.—Convalescing: has now only a pain in the back, chiefly confined to the spine, from the first lumbar vertebra to the sacrum; this is not constant, but now comes on after fatigue in the evening; still complains of frequent involuntary seminal emissions at night. He was ordered to continue his zinc, and to have cold water copiously applied in a stream from a kettle over the genitals and loins twice a week.

Case VIII.—*Copious excretion of oxalate of lime; over-lactation; probable existence of calculus in the right kidney.*

Mary Rootham, æt. 37, came under my care at Guy's Hospital, December 14, 1843; a pallid thin woman, the mother of two children; has been for years ailing from vague pains connected with irritable uterus. Eighteen years ago, whilst in service, received a violent blow in the right hypochondrium, and has never since been free from more or less persistent pains in that region, extending to the right kidney. From the period when she received the blow, she has, at each return of the catamenia, been jaundiced, and is generally relieved by spontaneous bilious vomiting. Every two or three months she suffers severe paroxysms of pain in the region of the right kidney, lasting three or four days, and relieved by a copious discharge of very turbid urine, attended with great irritability of the stomach, no hæmaturia. After one of these attacks she brought me the urine.

Night urine—pale, acid, specific gravity 1.025, with a copious deposit of urate of ammonia, which vanished on the application of heat, and left undissolved an immense number of the largest dumb-bell crystals of oxalate of lime I ever saw.

Morning urine—clear; by heat a scanty deposit of phosphates fell; much epithelial debris; no oxalates. Ordered her a generous diet, and to wean her infant, who is thirteen months old; no medicine

December 18th.—Has suffered much from sickness; pains over the right kidney less defined; bowels act well; feels extremely weak and depressed; probably owing to over lactation.

℞ Acidi Nitrici, ʒj.
—— Hydrochloric., ʒiss.
Tinct. Gentianæ co. ℥iss. M. Ft. guttæ.
Capt. coch. j. parv. ter die ex aquæ cyatho.

She continued this treatment persistently until February 20th; the oxalate of lime gradually disappeared, and she appeared tolerably well.

I again saw this patient in June; she has still frequent returns of renal suffering, with occasional discharge of oxalate of lime; her general health remained good. There is but little doubt of the existence of a calculus of oxalate of lime in the right kidney.

CHAPTER X.

CHEMICAL PATHOLOGY OF THE EARTHY SALTS.

(PHOSPHURIA.)

(Phosphate of Lime, Ammonio-phosphate of Magnesia, and Carbonate of Lime.)

183. We have seen that on an average, about six grains and a half of phosphoric acid are excreted from the blood by the kidneys in the course of twenty-four

hours. This quantity appears to be divided between four bases, soda, ammonia, lime, and magnesia; forming, in all probability, the three following salts, whose composition have been already pointed out (80):

Ammonio-phosphate of soda.
Phosphate of magnesia.
Phosphate of lime.

The first of these is readily soluble in water, and on the hypothesis I have ventured to suggest (63), is of importance as the solvent of uric acid, and is indirectly the source of the acidity of urine. The other two salts are nearly totally insoluble, although the presence of a very minute portion of almost any acid, even the carbonic, enables water to dissolve a considerable quantity. They are besides soluble, to a certain extent, in hydrochlorate of ammonia, and possibly may sometimes exist in the urine thus dissolved. In healthy urine, the earthy phosphates are held in solution by the acid of the super-phosphates, produced by the action of uric (or hippuric) acid on the tribasic alcaline salts (61); and these salts are also, according to Enderlin,[69] capable of dissolving a certain quantity of phosphate of lime. The physiological source of the phosphate has been already pointed out (79).

The earthy phosphates, according to Dr. B. Jones,[139] are most abundant in the urine passed a few hours after a meal, and range from 0.97 to 0.91 in 1000 parts of urine, varying in the specific gravity from 1.027 to 1.033.

184. *Diagnosis of the earthy phosphates.*—Deposits of these salts are always white, unless coloured with blood; soluble in dilute hydrochloric acid, and insoluble in ammonia or liquor potassæ. On heating the urine,

the deposit undergoes no further change, except agglomerating into little masses. Mucus, pus, and blood, are often present in the urine, and mask the chemical characters of the deposit.

185. *Chemical constitution of the phosphates, and character of the urine depositing them.*—If a very small quantity of ammonia be added to a large quantity of healthy urine, the mixture becomes turbid from a deposit of the triple phosphate, mixed with some phosphate of lime. On placing a drop of this turbid urine under the microscope, myriads of minute prisms of the triple salt (192), mixed with amorphous granules of the phosphate of lime, will be seen floating in the fluid. These readily disappear on the addition of a drop of almost any acid. As these earthy salts are insoluble in water, it is evident that they must be held in solution in the urine by the free acid which generally exists. If from any cause the quantity of solvent acid falls below the necessary proportion, the earthy phosphates appear diffused through the urine, disturbing its transparency, and subside, forming a deposit. Hence, whenever the urine is alcaline, phosphatic deposits are necessary consequences. If urine be secreted with so small a proportion of acid as barely to redden litmus paper, a deposit of triple phosphate often occurs a few hours after emission; a phenomenon depending partly on the influence of the mucous matter present, which, readily undergoing change, acts like a ferment, induces the decomposition of urea, and the formation of carbonate of ammonia (201), which, by neutralising the solvent acid, throws down the phosphates. The precipitation of the phosphates thus takes place in a manner analogous to that in which carbonate of lime is thrown down (220),

the action being, however, here limited to a neutralisation of the free acid; indeed, where phosphate of lime forms the great bulk of a deposit, a certain portion of carbonate is generally present.

The triple phosphate which is precipitated artificially from urine by means of a very small quantity of ammonia, and which occurs spontaneously in prismatic crystals (192 A), is a neutral salt, and may co-exist as a deposit with a very sensible acidity of the supernatant urine.

186. There is, however, another triple phosphate produced by the addition of an excess of ammonia to urine, and which is of frequent occurrence in the fluid when in an alcaline or putrescent condition. This differs from the former salt in containing an excess of base, and cannot possibly be present in urine which exerts the slightest acid reaction on litmus paper. The crystals are quite characteristic, being invariably stellar or foliaceous (192 D). This salt is termed the basic phosphate, but the chemical distinctions between this and the prismatic salt are very unsatisfactory. I am aware of but one chemist who has given formulæ for the two salts, but in a manner so opposed to the known habitudes of phosphoric acid as to authorise their rejection. The composition of the ammonio-phosphate of magnesia previously given (80) applies to the stellar salt. The probable constitution of the two salts is,

In the neutral or prismatic salt (dry $= (H\,O,\ N\,H_4\,O,\ Mg\,O,) + P_2\,O_5$

In the basic or stellar salt (dry) $= (N\,H_4\,O,\ 2\,Mg\,O,) + P_2\,O_5$.

187. The phosphate of lime, which is often precipi-

tated with the neutral, and always with the basic triple salt, is not quite so readily soluble in very dilute acids as the two latter; and hence, when a mixed deposit of the calcareous and magnesian phosphates exist, the phosphate of lime is but slowly acted upon when digested in very dilute acetic acid, which readily dissolves the magnesian salt. When the triple or calcareous phosphates are separately exposed to the heat of a blow-pipe flame, they fuse with great difficulty, and not until the heat has been urged to the utmost. If, however, the phosphate of lime is mixed with a triple phosphate in about equal proportions, they readily melt into a white enamel. These mixed salts constitute what is hence termed the fusible calculus, and they can be readily detected by this property in concretions; a character very available in the examination of gravel and calculi, as the two phosphates generally occur together.

188. The physical appearance presented by deposits of the earthy phosphates vary extremely; sometimes, especially when the triple salt forms the chief portion of the deposit, it falls to the bottom of the vessel as a white crystalline gravel. If but a small quantity of this substance be present, it may readily escape detection by remaining for a long time diffused through the urine; after a few hours' repose, some of the crystals collect on the surface, forming an iridescent pellicle, reflecting coloured bands like a soap-bubble or a thin layer of oil. If, then, the lower layers of the urine be placed in a watch-glass, and held obliquely over the flame of a candle or any strong light, a series of glittering points will become visible from the reflection of light from the facets of the minute prisms of the salt.

The phosphates will often subside towards the bottom of the containing vessel like a dense cloud of mucus, for which they are frequently mistaken. Not unfrequently they will form dense masses in the urine, hanging in ropes like the thickest puriform mucus, from which it is utterly impossible to distinguish them by the naked eye. Their disappearance on the addition of hydrochloric acid will at once detect their true nature. Where, as frequently occurs, a large quantity of ropy mucus, pus, or blood co-exist with the phosphates, no mode of investigation can be so satisfactory as the examination of a few drops of the urine between two plates of glass, by the microscope, when the characteristic crystals of the phosphates are readily recognised (192).

189. It is by no means necessary for urine to be alcaline for a deposit of phosphates to exist (185); indeed, in the great majority of cases, urine which deposits the triple phosphate is acid at the time of emission, and often for long after. This may appear rather paradoxical, when we recollect the ready solubility of triple phosphate in a very weak acid; but admits of a ready explanation when the fact that a fluid may redden litmus, and still contain no uncombined acid, is borne in mind. Thus, a solution of hydrochlorate of ammonia will redden litmus paper, and yet it contains no free acid; and as this salt exists in the urine, it is quite possible that it may be one of the causes on which its acid reaction depends where deposits of phosphates exist. It has been rendered very probable by the interesting experiments of my colleague, Dr. Rees,[48] that this very salt may in some instances be really the solvent of the earthy phosphates when in excess, as they are to a certain extent soluble in

solutions of sal-ammoniac. These solutions possess the very remarkable property of becoming opaque by ebullition, from a deposition of a portion of the earthy salt. The very same phenomenon often occurs in urine which contains an excess of phosphates. Indeed, it is not unfrequent to meet with urine which does not contain any visible deposit, and yet on the application of heat appears to coagulate, not from the presence of albumen, but from the deposition of earthy phosphates. The addition of a drop of nitric acid immediately dissolves this deposit, and distinguishes it from albumen (237). A different explanation to this phenomenon has been offered by Dr. Hargrave Brett,[117] and undoubtedly is perfectly true in some cases. Dr. Brett's explanation is founded on the solubility of phosphates in water impregnated with carbonic acid. It has been long known that carbonic acid frequently exists in a free state in the urine, and in a large number of specimens examined by Dr. Brett and myself we succeeded in readily isolating it. These experiments were made several years ago, in consequence of our having noticed some curious phenomena presented by the urine of a student of Guy's Hospital (since dead), a pupil of the late Mr. Bryant, of Kennington. This gentleman, in endeavouring to raise a heavy sack of Epsom salts, strained his back, and soon after fell into a state of marasmus, with occasional hectic, which ultimately exhausted him. During the last six months of his life he passed a very large quantity of pale acid urine, which by keeping soon became alcaline. This urine was limpid when first passed, but became opaque as soon as it had cooled, still, however, retaining its acidity, so that the deposition of the phosphates did not necessarily depend upon the development of an alcali. On warming the fresh urine an evolution of carbonic acid gas took place, accompanied by a deposition of phosphates. When two portions of the fresh urine were placed as soon as passed in separate bottles, one being left open, the other closely corked, the urine contained in the latter remained transparent, and that in the former became opaque.

Another explanation of the precipitation of the earthy salts by heat has been proposed by Dr. B. Jones.[139] He has shown, that if to any urine rich in phosphates, as that passed shortly after a full meal, a minute portion of an alcali, or of common phosphate of soda (tribasic) be added so as to neutralise any great excess of acid, the subsequent application of heat produces a precipitation o the earthy salts. If, therefore, a more than average proportion of the latter exists in a barely acid urine, their precipitation by heat would appear to be a necessary consequence.

190. The urine, in cases where an excess of phosphates of either kind exists, varies very materially in its physical character. Certainly no general rule can be assigned for the colour, density, or quantity of the urine secreted in these cases, taking them in a mass; although I think there are certain facts connected with the presence of the phosphatic deposits which serve to connect the colour and quantity of the urine with the pathological conditions producing, or at least co-existing with them.

As a general rule, where phosphatic deposits, whether magnesian, calcareous, or both, exist for a considerable time, the urine is pale, often whey-like, generally secreted in very large quantities, and of low specific gravity (1.005—1.014). This is especially the case where organic lesion of the kidneys exists. On the other hand, when the deposits are of occasional occurrence, often disappearing and recurring in the course of a few days, the urine generally presents a deep amber colour, and is not only of high specific gravity (1.020—1.030), but often contains an excess of urea, and presents an iridescent pellicle on its surface by repose. This is especially the character of the phosphatic urine secreted under the influence of some forms of irritative dyspepsia, and where the phosphates themselves may be traced to mal-assimilation. A considerable quantity of prisms of triple phosphate are often found in the urine entangled in the meshes of a mucous cloud. This frequently occurs in the urine passed after an indigestible meal, and will often be observed for a day or two and then disappear. Again, phosphatic urine may be met with, varying from a pale whey-like hue to deep brown or greenish brown, exceedingly fœtid, generally but not constantly alcaline, and loaded with dense ropy mucus, often tinged with blood, and in which large crystals of the triple phosphate and amphorous masses of phosphate of lime are entangled. This variety is almost always met with, either under the irritation of a calculus, or even of a catheter worn in the bladder (204), or where actual disease of its mucous lining exists.

191. The phosphates are occasionally found mixed in a deposit with urate of ammonia ; in this case the latter is always of the pale variety, and nearly white. It has indeed been stated that when urine deposits pale urate of ammonia, it indicates a tendency to the deposition of the phosphates. This remark is so far true, that as phosphatic urine is usually very pale, it would follow as

a necessary consequence that any urate of ammonia deposited from it, would be nearly white from the absence of colouring matter to tint it of any other hue. Beyond the fact, then, that white urates are deposited by pale urine, and that phosphatic urine is often scarcely coloured, I am not aware of any circumstance authorising the belief of any necessary connexion between them.

192. *Microscopic characters of earthy phosphates.*—A. *Prisms of neutral triple phosphate.*—These are always exceedingly well defined, the angles and edges of the crystals being remarkably sharp and perfect (Fig. 33). The triangular prism is the form most frequently met with, but it presents every variety in its terminations. These are sometimes merely truncated, often bevelled off, and not unfrequently the terminal edges are replaced by facets.

FIG. 33.

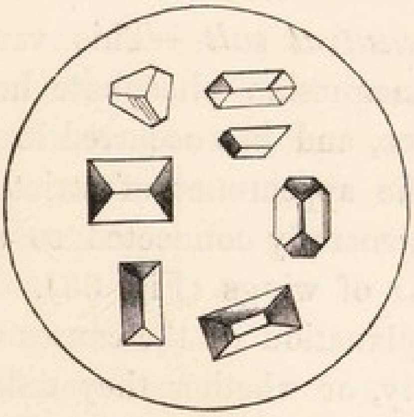
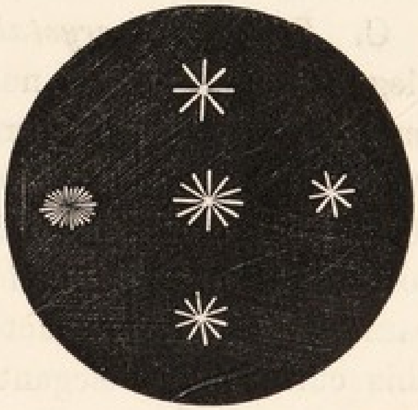


FIG. 34.



I scarcely know a more beautiful microscopic object than is afforded by a well-marked deposit of this salt. The different degrees of transparency presented by these crystals is very remarkable; generally they are so transparent as to resemble prisms of glass or crystal; sometimes presenting an enamel-like opacity, so that they can only be viewed as opaque objects. This change may be artificially effected by exposing the transparent prisms to a boiling heat. When preserved in balsam, they depolarise light, exhibiting a beautiful series of tints, when the axes of the tourmalines or calc-spars are crossed in the polarising microscope.

B. *Simple stellæ of the neutral salt.*—These are in fact minute calculous concretions, and are generally composed of acicular prisms cohering at one end, so as to represent simple stellæ (Fig. 34). Not unfrequently they adhere so closely and are so crowded as to resemble rosettes. I have repeatedly seen small prisms crystallized like uric acid on one of the fine transparent hair-like bodies which are of frequent occurrence in urine. The crystals of the phosphatic magnesian salt are invariably colourless, never presenting the yellow or orange hue of uric acid.

C. *Penniform crystals of neutral salt.*—This very elegant variety of the neutral magnesian phosphate has only lately fallen under my notice, and has occurred in a very few cases. It presents the appearance of striated feather-like crystals, two being generally connected so as to cause them to resemble a pair of wings (Fig. 35). I cannot give any satisfactory explanation of the causes of this curious and elegant variety, or whether they differ in any way chemically from the prismatic form. The few specimens I have met with occurred in acid urine.

D. *Stellar and foliaceous crystals of basic salt.*—This variety, as I have already stated, cannot generally be regarded in any other light than as a secondary for-

FIG. 35.

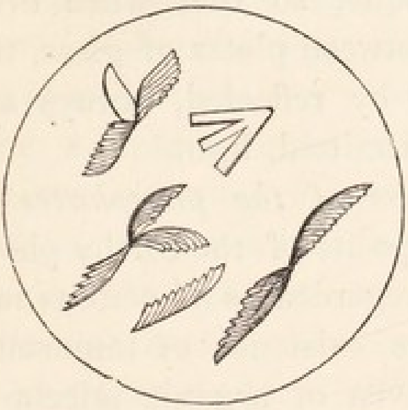
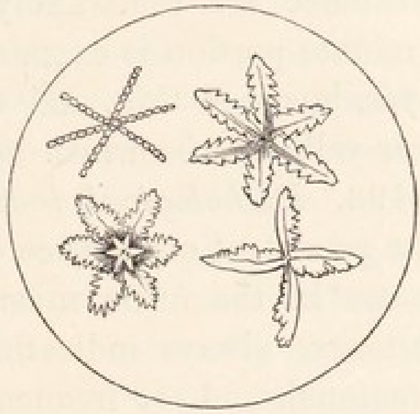


FIG. 36.



mation taking place out of the body. When rapidly formed, this salt generally appears in the form of six-rayed stars, each ray being serrated, or iregularly crenate, often renuncinated, like the leaf of the taraxacum (Fig. 36). This, however, presents several subordinate varieties, depending, in all probability, upon accidental circumstances. When this salt is more slowly formed, as on the surface of the urine in pregnancy, it presents large and broad foliaceous laminæ, often so thin and transparent as to escape notice altogether, especially if viewed in too strong a light. I have, indeed, often overlooked them until I illuminated the specimen under the microscope with polarised light, when they started into view elegantly tinted with colours, in which pink and green are the most prominent.

E. *Phosphate of lime.*—I have never seen this salt in a crystalline form, but it has been said to occur in irregularly crystallised masses.[67] In all the specimens I have examined, no appearance of structure could be detected; the phosphate either resembling an amorphous powder, or collected in roundish particles often adhering to prisms of triple phosphate. The sediments of this substance are remarkably opaque, so that when even a minute portion is examined between plates of glass, the layer, however thin, and white by reflected, always appear yellow or brownish by transmitted, light.

193. *Pathological indications of the phosphates.*—The persistent occurrence of deposits of the earthy phosphates in the urine, must be regarded as of serious importance, always indicating the existence of important functional, and too frequently, even of organic mischief. One general law appears to govern the pathological development of these deposits, viz., that they always exist simultaneously with a depressed state of nervous energy, often general, rarely more local, in its seat. Of the former, the result of wear and tear of body and mind in old people, and of the latter the effects of local injury to the spine, will serve as examples. It is true, that in the majority of these cases there is much irritability present, there is often an excited pulse, a tongue white on the surface and red at the margin and tip, with a dry, often imperspirable, occasionally hot skin. Still it is irritability with depression, a kind of erythism of the nervous system, if the expression be permitted, like that observed after considerable losses of blood. The pathological state of the system accompanying the appearance of deposits of phosphate of lime are analogous to those occurring with the triple salt; indeed, as has been already observed (138), they often, and in alcaline urine always, occur simultaneously. So far as my own experience has extended, when the deposit has consisted chiefly of the calcareous salt, the patients have appeared to present

more marked evidence of exhaustion, and of the previous existence of some drain on the nervous system, than when the triple salt alone existed.

194. *When the triple salt occurs in small quantities, nearly or entirely free from phosphate of lime,* the urine being acidulous or neutral at the moment of emission, and not restoring the colour of reddened litmus paper until some time after; we have the simplest cases, or those in which the amount of organic or functional lesion is at a minimum. These patients are generally regarded as labouring under severe dyspepsia. The most prominent symptoms they present, are great irritability of temper, extreme restlessness, mal-performance of the digestive functions, with such imperfect assimilation of the ingesta, that a certain and often extreme amount of emaciation is a constant attendant. The appetite is uncertain, occasionally being voracious; vomiting, or at least irritability of stomach, frequent; fatigue is induced by the slightest exercise; there is a remarkable inaptitude to any mental or bodily exertion, and the patient is often, from the exhaustion thus produced, unfitted for his ordinary duties. In severe cases these symptoms become aggravated by an excessive elimination of urea, which aids considerably in depressing the patient's strength. Where the presence of triple phosphate is only occasional, its connexion may be traced to some cause which has rendered the system morbidly irritable, at the same time that its tone or vigour has become depressed. The simplest examples of this kind that have occurred to me, have been in the cases of individuals of nervous temperament, who have periodical duties to perform requiring extreme mental tension and bodily exertion. I

have witnessed this state of things several times in clergymen, especially in those who, from the nature of some secular engagements, have been compelled to lead sedentary lives during the week, and to perform full duties on Sundays. The best illustration of this I ever met with, was in the person of a well-known and deservedly popular clergyman, who, from his connexion with a public school, scarcely used any exercise during the week, whilst on Sunday he performed duty thrice in his church. This gentleman was a tall, thin person, of dark complexion, lustrous eyes, and almost phthisical aspect. He was the subject of constant dyspepsia. The urine passed on Saturday evening, as well as on Sunday morning, although repeatedly examined, was healthy, except in depositing urate of ammonia, and being of high specific gravity. Before his Sunday duties were completed, he almost invariably became the subject of extreme fatigue, with a painful aching sensation across the loins, in addition to the flatulence and epigastric uneasiness under which he always laboured. The urine voided before retiring to rest after the severe exertions of the day was almost constantly of a deep amber hue, high specific gravity, and deposited the triple phosphate in abundance. The urine of Monday would contain less of this salt, which generally disappeared on the following day, and once more reappeared on the following Sunday evening. I had an opportunity of observing this state of things for several weeks, and it ultimately disappeared by the patient relaxing from his duties and enjoying the amusement of travelling for a few weeks.

195. In mild cases of indigestion, especially in gouty dyspepsia, it is not uncommon to find the iridescent pel-

licle (180) of triple salt, the urine being rich in urea. This condition must be regarded as an attempt made to get rid of an excess of a salt derived either directly from the food, or by a freer disorganisation of tissue by secondary assimilation, than exists in health, and is most frequent in the urine passed after breakfast. I have repeatedly observed its occurrence in the dyspepsia attended with a sense of weight and tightness after food, with flatulent distention of the stomach so frequent in women at the period of their great climacteric. This state does not generally terminate in decided gravel or the formation of a stone; it is rather to be regarded as an index of the state of the assimilative functions than as leading to the ulterior deposit of calculous matter. The most valuable diagnostic mark of these cases, in contradistinction to those where organic mischief is to be apprehended, is founded on the fact that the phosphates are chiefly confined to the urine passed at night. (See Table, opposite.)

196. Deposits of the triple salt frequently occur in very old people, in whom the state of decrepitude depending on senility has either become extreme, or been aggravated by low living and a want of the ordinary comforts of life. In several cases of this kind occurring in octogenarian dependants on parochial relief, the urine has been very pale, of low specific gravity (1.008—1.0012), subacid or neutral, and extremely fœtid. This fœtor, not unlike that of stale fish, did not appear to depend so much upon the presence of free ammonia as from the occurrence of a slow decomposition of the organic constituents of the urine.

197. Crystals of triple phosphate have been observed by

URINE DEPOSITING PHOSPHATES INDEPENDENTLY OF ORGANIC DISEASE.

Evening urine.				Morning urine.				
Colour.	Density.	Action on litmus.	Deposit.	Colour.	Density.	Action on litmus.	Deposit.	Case.
Pale amber.	1.029	Neutral.	Prisms of triple phosphates.	Dark amber.	1.031	Neutral.	Red urates.	Gouty dyspepsia.
Normal.	1.028	Alcaline.	Ditto.	Normal.	1.025	Acid.	Ditto.	Ditto.
Pale.	1.020	Neutral.	Ditto with phosphate of lime.	Pale.	1.025	Ditto.	Uric acid.	Ditto.
Pale.	1.022	Neutral.	Nearly all phosphate of lime.	Normal	1.025	Ditto.	Ditto.	Ditto.
Normal.	1.028	Barely alcaline.	Prisms and stellæ of phosphate.	Ditto.	1.031	Neutral.	Ditto and scanty prisms of phosphate.	Dyspepsia of intemperance.
Amber.	1.025	Acid.	Prisms of phosphate.	Ditto.	1.020	Acid.	None.	Dyspepsia following fatigue
Amber.	1.025	Acid.	Fine stellæ of triple salt.	Ditto.	1.020	Ditto.	Ditto.	Dysmenorrhœa.

Simon in the urine of persons convalescing from pleurisy and pneumonia. I have met with them very generally in the slightly acid urine of patients who were just emerging from an attack of acute disease, especially of rheumatic fever. During the past summer the urine of all the patients under my care at Guy's Hospital was almost daily examined by two of my most indefatigable and intelligent pupils, Mr. R. Finch and Mr. H. F. Johnson, acting at that time as clinical reporters. The results of their investigation was the discovery of the fact above stated. In these cases, also, the presence of the salt must be regarded as indicative of irritability with exhaustion, and it disappears spontaneously on the recovery of health and vigour.

198. It has been frequently stated, that in the course of continued fever, the urine at a certain period becomes alcaline, and deposits phosphates. It is well known that early in fever the urine is high-coloured, acid, and loaded with uric acid or urates (109); and it is distinctly stated by Dr. Simon,[72] from observations made under the sanction of Professor Schönlein of Berlin, that the acidity vanishes, and is replaced by an alcaline state, at a period of the disease varying with the powers of the patient, but generally about the end of the second week. Simon states that in cases of severe typhoid fever, in which the urine is acid and deep-coloured, it, just at the period when comatose symptoms set in, becomes alcaline and pale. On examination he found carbonate of ammonia in solution, resulting of course from the re-arrangement of the elements of urea. That this alteration of acid to alcaline urine may and does occasionally occur in the course of a case of fever, is certain, but that it is the

general rule, as assumed by Schönlein and Simon, is certainly opposed to all the experience I have had in the disease in question. M. Becquerel[73] has made a similar remark, and adds, that out of thirty-eight cases of typhus, where urine was constantly examined, he found it alcaline in one case only, and in this pus was present. Dr. Graves,[74] of Dublin, some time ago drew attention to the fact that the urine in fever was occasionally ammoniacal, and deposited the earthy phosphates; in the two cases related by him, extreme exhaustion existed, in one anasarca, and in the other petechiæ, accompanied the fever. In the epidemic of maculated fever, which occurred in London some years ago, I often found the urine alcaline in the second week; but this appeared to me almost peculiar to that epidemic. On submitting the urine to analysis, a marked deficiency, and after a time, a total absence, of urea was detected. Hence it appeared, that owing to the state of enervation which existed, the kidneys in separating C_2, N_2 H_6, O_4, from the blood, instead of resolving these elements into C_2, N_2, H_4, O_2,=urea and $2\ H\ O$=water, allowed them to become obedient to ordinary chemical laws, and they then arranged themselves into $2\ C\ O_2 + 2\ N\ H_3$=two atoms of carbonate of ammonia (59). In all cases in which alcaline urine occurs, care must be taken to ascertain the possibility of its having been produced by the ingestion of salts of the vegetable acids, or by subacid fruits, as Prof. Wöhler[131] has shown that a meal of apples or baked plums soon renders the secretion alcaline (124).

199. The late researches of Drs. Sutherland and Rigby[135] on the urine of insane patients, appear to authorise the assumption, that cerebral lesion, independent of any obvious implications of spinal mischief, may induce the

conversion of urea into carbonate of ammonia. They found the urine capable of effervescing on the addition of *acetic acid* in 34 per cent. of cases of dementia, 30 per cent. of melancholy, and 16 per cent. of mania.

200. When the deposit is copious, either readily falling to the bottom of the vessel, or remaining suspended in the urine like mucus, the two phosphates are generally found mixed. In these cases an alcaline condition of the urine almost invariably occurs, a piece of turmeric paper being readily stained brown on being immersed in it. The odour also is very disagreeable, and is generally said to be ammoniacal, although in very many instances the term fœtid would be more appropriate, as ammonia is by no means necessarily evolved. This kind of urine, if not depending upon organic disease of the urinary apparatus, is always connected with some serious affection of the spinal marrow. In a mild form this is observed after slight violence inflicted on the spine or over the region of the kidneys, and generally disappears in a few days. I have seen a copious deposit of phosphates with alcaline urine occur for a few days in the case of a young gentleman who had exerted himself too much in a riding-school. The fact of alcaline urine resulting from strains or blows on the back was first noticed by Dr. Prout,[68] and injuries to the loins have been long enumerated among the existing causes of renal calculi. This alcaline state of the urine and deposition of phosphate, is a pretty constant result of anything which depresses the nervous energy of the spinal marrow, whether the result of insidious disease of the spine, or the effect of sudden mechanical violence. Further, as observed by Sir B. Brodie, this condition of the urine, whenever it follows

spinal injuries, appears not to be connected with the particular locality of the injury, but to occur equally in accidents to the lumbar, dorsal, or cervical regions.

201. It is well known that all the hollow organs of the body are endued with a sufficient amount of nervous energy, or vital power, to preserve the fluids they contain from change for a long time. Thus the blood in a vessel, even when its motion is prevented by ligature, does not change in a space of time sufficient to convert it, if removed from the vessel into a putrescent mass. The bile in the gall bladder, the urine in the kidneys and bladder, the fæces in the intestines, are examples of the same fact. This law even obtains in disease; for a serous or purulent effusion, the result of morbid action, will be preserved in the living cavities of the body unchanged, while a few hours would be sufficient to render it fœtid and putrid, if exposed out of the body to the influence of a similar heat. It is, therefore, evident that in so complex a fluid as the urine, the vital endowments of the living cavities containing it, alone preserves it from undergoing the change which so readily occurs out of the body. The power thus possessed by the bladder of preserving its contents unchanged is indisputably dependent upon the integrity of the spinal nerves and branches from the organic system, supplying it. If, therefore, any injury, even of an indirect character, be inflicted upon them, the result must of necessity be the diminution to a certain extent of the vital power of the organ, and the fluid it contains will become susceptible of changes analogous to those which occur in it when removed from the body. One of these changes is the union of the urea with the elements of water, and the for-

mation of carbonate of ammonia (59). This salt, by uniting with the normal acid of the urine, will precipitate the earthy phosphates with some carbonate of lime; the latter being the result of the decomposing influence of the carbonate of ammonia on the phosphate of lime. Whether the decomposition of urea be the primary chemical change, or is the result of some antecedent one, is unknown. Professor Dumas[118] has ingeniously suggested that the vesical mucus may undergo a putrescent change; and this, acting as a ferment, may induce the metamorphosis of urea into carbonate of ammonia, just as yeast aids the conversion of sugar into alcohol.

202. The urine thus rendered ammoniacal, acts as an irritant on the mucous membrane of the bladder, exciting a form of inflammatory action; and the result of this is the secretion of a large quantity of mucus of a more viscid character than usual. By persistence of the irritation, puriform mucus is at length poured out, and this, from the chemical influence of the carbonate of ammonia, becomes changed into a viscid, almost gelatinous mass, which greatly adds to the patient's sufferings by preventing the ready escape of the urine even when the contractile power of the bladder is not quite paralysed. On this view the production of alcaline urine is looked upon as the exciting cause of the excessive secretion of unhealthy mucus, and the result of changes in the bladder, the urine being supposed to be acid at the time of secretion by the kidneys. In the case of a woman in Guy's Hospital, labouring under complete paraplegia, and passing, with the aid of a catheter, fœtid, alcaline, and phosphatic urine, I washed out the bladder with warm water, and allowing the secretion of urine to go on for half an

hour, the catheter was again introduced, and an ounce of pale acid urine escaped; proving that the alcaline condition of the urine previously removed was owing to changes it underwent subsequent to secretion.

203. A somewhat different view of the cause of alcaline urine has been published by Mr. Blizard Curling;[71] this gentleman believes that the immediate result of spinal lesion, is the loss of the natural sensibility of the bladder; the result is the secretion of unhealthy alcalescent mucus, and this acting chemically upon the urine, renders it alcaline, and leads to the deposition of the earthy phosphates. Subsequently the urine may be actually secreted in an alcaline state by the extension of irritation from the bladder to the kidneys, or by the latter sympathising with the debilitated yet irritable state of the system.

The opinion that alcaline urine may eventually be secreted by an extension of irritation to the kidney, receives considerable support from an interesting case which occurred at Guy's Hospital in the early part of last year. A man was admitted under the care of my colleague, Mr. Bransby Cooper, for injury to the spine, resulting from accident. He was paraplegic; the urine soon became alcaline, and he died. On a post-mortem examination, the contents of the bladder restored the colour of reddened litmus paper, and on making a section of the kidneys, the papillæ were found encrusted with prismatic crystals of the triple phosphate.

204. Mr. Curling considers that the mere continuance of urine in the bladder is not sufficient to allow it to become alcaline, but that a diseased condition of the mucous lining is a necessary condition in effecting this change.

Hence in enlarged prostate, when the bladder is often distended for a long time, the urine is generally acid, even when only emptied by the catheter twice in the day. But when, on the other hand, a catheter is worn in the bladder, so that no accumulation can take place, the urine is often alcaline; a circumstance admitting only of explanation by the secretion of unhealthy mucus, excited by the irritation of the instrument.

205. The urine may be alcaline, and loaded with phosphates, simply from diseases limited to the bladder. In all cases in which disease of the mucous membrane, especially of a chronic character, exists, more particularly where retention of urine occurs, the urine is almost always phosphatic, and abounds in viscid mucus. This is seen in cases of old stricture of the urethra, chronic cystitis, and many of the affections included under the generic term of irritable bladder. I have witnessed more than one instance in which the state of the urine alluded to has resulted, in women, from secretion of unhealthy mucus, by the propagation of irritation from an irritable uterus, or even inflamed vagina. In all these cases the patient's suffering is much increased by the formation of soft pseudo-calculous masses of mucous phosphates, blocking up the urethra. These cases ought to be regarded as quite distinct from those already alluded to, in which the presence of the phosphatic deposit is indicative of, and produced by, great irritability and depression, or spinal lesion. It is hence very important to be able to diagnose correctly between cases of alcaline urine depending upon causes strictly local (i. e. bladder affection), and those of a more general character. Dr. B. Jones[139] has suggested for this purpose the action on litmus paper, as,

according to him, it would appear that urine is alcaline from ammonia when the cause is local, and from a fixed alcali when the ailment is more general. Accordingly, if a piece of blue litmus paper after immersion in the urine retains its tint on drying, he assumes that the alcalescence of the urine is owing to a fixed alcali; but when it becomes red by desiccation, he believes that ammonia is alone present, and the cause of the alcalescence strictly local. I have not yet had an opportunity of testing the accuracy of this statement with sufficient care to venture to offer an opinion upon it.

206. Cases occasionally present themselves in which the urine is very copious, pale, and freely deposits the phosphates, independent of any local disease in the genito-urinary organs, and in which the general symptoms are those of marasmus; the appearance of the patient, and his most prominent ailments, much resembling a case of diabetes. It is in these that the formation of a calculus is more especially to be dreaded; and even if these evils be arrested, the patient too generally goes on from bad to worse, and dies worn out with irritation. An instance of this kind has been alluded to (189), and I shall have occasion to refer to another when speaking of the treatment (219) of the disease. Even in these, a careful investigation of the case will generally lead to a detection of some antecedent causes of spinal mischief; and in many, abuse of the sexual organs have constituted the most prominent exciting cause. I have seen some in which no other antecedent morbid influence could be discovered, than the cachexia produced by the abuse of mercury.

207. The deposits of phosphates, where no organic

disease exists, are often absent, not only for hours (195), but for days together; and this fact will often enable us to predict with tolerable confidence the happy or unsuccessful termination of the case. From all the experience which I have had of phosphatic deposits, I feel confidence in offering the following as a safe indication from clinical observation, and one of great service in practice.

That, where the presence of a deposit of phosphates is independent of the irritation of a calculus, or of organic disease, it is most abundant in the urine passed in the evening (*urine of digestion*), *and absent or replaced by uric acid, or urates, in the morning* (*urine of the blood*), *the urine being always of tolerably natural colour, never below, and often above the mean density. Where the presence of phosphatic salts depends on the irritation of a calculus, or of organic mischief in the urinary passages, the urine is pale and whey-like, of a density below the average, often considerably so, and the earthy deposit is nearly equally abundant in the night and morning urine.*

208. Some curious cases are occasionally met with, in which enormous quantities of phosphate of lime have come away for a long time in the urine without apparently doing much mischief. A very remarkable instance of this kind occurred some years ago among the out-patients of Guy's Hospital, in the person of John Jenkins, an old man under the care of my colleague, Dr. Hughes. This patient was an habitual dyspeptic, and had laboured under pyrosis from boyhood. He had during many years been in the habit of passing almost milky urine, which by repose deposited such an extraordinary quantity of phosphate of lime, that he brought to me at one time

more than an ounce of the salt. He had been for this disease under the treatment of half the hospital physicians and surgeons in London. He stated, that fifty-five years previously he had been a patient at Guy's Hospital under Dr. Saunders, and subsequently under Dr. Fordyce at St. Thomas's; but his urine had never at any time exhibited any signs of improvement. Indeed, all the remedies tried appeared quite useless; at the same time this man's general health was so good, that there was scarcely an excuse for submitting him to any course of treatment, beyond the apprehension of the possible formation of a calculus. In cases of this kind, it is very possible that the phosphate of lime is secreted from the mucous membrane of the bladder, and not derived from the urine. All mucous secretions contain phosphoric acid, combined with earthy bases; and hence, if an excess of the latter is secreted with the vesical mucus, it may be washed away by the urine, and form a deposit. This is by no means unfrequent in the irritable bladder, depending on the existence of prostatic diseases, &c.; we have a perfect analogy to this in the calculous concretions found in the ducts of glands furnishing mucous secretions. These are all prone to secrete phosphates in too great an excess to be washed away with the secretion; they are, therefore, retained, and form a calculus. These, from whatever part of the body they are obtained, present nearly the same composition.

Composition of phosphatic concretions.

Species.	Prostatic.	Bronchial.	Seminal.	Salivary.	Pancreatic.
Phosphate of lime	84.5	8.0	90.	75.	80.
Carbonate of lime	.5	2.3	2.	2.	3.
Animal matter	15.0	7.7	10.	23.	7.
Authority . .	Lassaigne	Brandes	Peschier	G. B.	G. B.

209. *Therapeutical indications.*—In considering the indications for treatment in cases where the phosphates appear in the urine in the form of deposits, whether their quantity be in excess or not, it will be necessary to regard practically at least four pathological conditions, the existence of one or other of which must be deduced from the symptoms presented by the patient.

A. Cases in which dyspepsia, often to an aggravated extent, with some febrile and nervous irritation, exists independently of any evidence of antecedent injury to the spine (194).

B. Cases characterised by high nervous irritability, with a varying amount of marasmus, following a blow or other violence inflicted on the spine, but without paralysis (200).

C. Cases in which the phosphatic urine co-exists with paraplegia, the results of spinal lesion (202).

D. Cases of diseased mucous membrane of the bladder (205).

Of these it will be only necessary to direct attention to the first, second, and fourth series of cases, as the third includes cases in which the deposition of phosphates constitutes a mere symptom of a grave and serious lesion, which whether the result of accidental violence or insidious disease, must be treated according to the particular disease existing.

210. The first class of cases, or those in which a particular form of irritative dyspepsia is the characteristic feature, is by no means uncommon. Every now and then cases occur in practice, in which the most prominent symptoms are a capricious appetite, sense of weight and fulness at the præcordia, especially after meals, irregular bowels, severe lancinating pains darting between the scapulæ from the pit of the stomach; much flatulence, tongue white, often with injected marginal papillæ; pulse quick and irritable, dull heavy aching pain across the loins, excessive depression of spirits, despondency so intense as often to excite the most painful ideas. In a merchant surrounded by affluence, visions of impending beggary often embitter the moments that are free from the excitement of business; in the mechanic, unfounded ideas of immediate loss of property, and the interior of a workhouse, are generally present. On examining the urine, its specific gravity is often above the average; the deposition of crystalline or amorphous phosphates, and often excess of urea, will refer the case to its proper class, as one of irritative dyspepsia, in which the excess of phosphates indicates the " drain" on the nervous energies.

211. The treatment of these cases must be rather directed by general principles, than limited to the solution of phosphatic deposits. It is true that by the persistent administration of acids the deposit may disappear for a time, but the ailment goes on; all that is effected

by such treatment is to mask a symptom, and an important one, of the progress of the malady. After having attended to the morale of the case, as far as possible rousing the patient from any morbid influence excited in his mind, whether real or imaginary, the next thing is to attend to the general health. The bowels should be freed from an unhealthy accumulation by a mild mercurial laxative, as a few grains of pil. hydrarg., followed by a dose of rhubarb or castor-oil; but all active purging should be avoided, as it generally aggravates the distress of the patient, and decidedly interferes with the success of the treatment. A combination of a tonic-laxative with a sedative may then be administered, as tinct. hyoscyami et sp. ammon. aromatici āā ℳxx—ʒss. ex mist. gentianæ co. ℥j. ter in die. If the bowels be irritable, the inf. cascarillæ, or inf. serpentaria, may be substituted for the mist. gentianæ comp. Should gastrodynia exist, great relief will be obtained by the administration of half a grain of oxyde of silver, made into a pill with confection of opium, before a meal. The diet should be very carefully regulated, all bland nutritious articles of food being preferred; vegetables should be avoided, and in general a small quantity of good sherry may be allowed. By a plan of treatment of this kind, the patients generally do well, and the phosphates and excess of urea vanish from the urine. As the patient approaches convalescence, much good is often effected by the use of sulphate of zinc in gradually increasing doses, beginning with a grain thrice a day, made into a pill with a little ext. hyoscyami, or ext. gentianæ, and increasing the quantity every three or four days, until five grains or more are taken at a dose. Under the use of the zinc, I have seen many cases do well, in which the symptoms approached in severity and character those of mild delirium tremens. I need hardly say that change of scene and occupation are important adjuvants to our medical treatment.

212. Much less frequently these cases will become chronic, the secretion of phosphates being continued for years, and the irritability of stomach being so severe and persistent as to emaciate the patient and present all the symptoms of schirrhus pylorus. These cases are sometimes relieved by the administration of strychnia. This drug has a remarkable influence over a simply irritable stomach, and is indeed superior to any other anti-emetic remedy, providing there be no acute or inflammatory action in the affected organ; and under its use I have seen the urine assume a remarkably healthy character. It may, indeed, be hazarded as a probable opinion, that strychnia may prevent the decomposition of urine in the bladder and consequent deposition of earthy salts from its influence on the spinal nerves. The following case is a remarkable illustration of the foregoing remarks. It is abridged from the account of Mr. Robert Finch, who reported it.

CASE IX.—*Irritative dyspepsia simulating scirrhus pylorus, with copious secretion of triple phosphates.*

G—— L——, æt. 18, admitted into Luke's Ward, under Dr. Golding Bird, April 9, 1845, a native of Bristol, and employed at an iron-factory; has always lived temperately, and his health previous to the present illness has been good, being merely the subject of occasional attacks of indigestion, with flatulent eructations. Four years ago vomiting came on suddenly, after an ordinary meal, accompanied by severe pains at the pit of the stomach, to which, in a less severe form, he had been subject during the previous year. With occasional, but rare intermission, this vomiting recurred daily after every meal for six months, being preceded by intense pain, relieved on emptying the stomach. It became less frequent for the following eight months, occurring but once or twice a day, but never losing it for twenty-four hours at a time. He then became a patient at the Bristol Infirmary, and underwent a great variety of treatment, with the general result of obtaining partial relief, but never losing his daily paroxysms of pain and vomiting.

On admission into Guy's Hospital, the lad's complexion was pale and bloodless, with a slight icteric tint; emaciation most extreme, his bones were barely covered, and his face was so extraordinarily emaciated, that it rather resembled a skull, over which parchment had been drawn, than anything else. His general appearance was that of a person in the last stage of scirrhus pylorus. He complained of burning heat at the scrobiculus cordis, and heavy pain across the loins; tongue clear and red; pulse quick and sharp; skin dry and imperspirable. He vomits a short time after every meal, and declares that he has not passed a single day during four years without vomiting three or four times. There is great thirst; bowels act daily, with frequent eructations possessing an odour of stale fish. Urine loaded with the triple phosphate and alcaline, with a disgusting fishy odour, even when first passed, sp. gr. 1.020, not albuminous. No tumor can be felt at the scrobiculus cordis, where there is some tenderness on pressure; the abdomen distended with flatus.

April 9th.—Vomited nearly four pints of thin acid yeast-like matter.

Misturæ Magnesiæ, ℥j. ter in die.
Milk diet.

11th.—Vomited daily after dinner. The vomited matter presented the same yeast-like appearance. Urine has an ammoniacal odour, and deposited phosphates copiously.

℞ Strychniæ, gr. j.
Acidi Nitric dil., ʒj.
Aquæ, ℥xij.—Solve et capiat æger, ℥j. ter in die.

He was strictly confined to milk diet; the medicine to be taken fifteen minutes before each meal.

14th.—Vomited yesterday before dinner, and again after tea, and after breakfast this morning.—P.

15th —Vomited last night, but not since; has passed 30 ounces of urine in the preceding twenty-four hours, copiously depositing phosphates; appetite good; begs for a continuance of the medicine, stating that it keeps his food down; abdomen not so flatulent.

16th.—In no pain; vomited last night at 7 o'clock, with rather more than usual pain; urine alcaline; 40 ounces in twenty-four hours, and full of prismatic triple phosphates.

℞ Olei Tiglii, ʒj.
Lin. Saponis, ʒvij.—M. ft. Linimentum scrobiculo cordis bis die illinendum et Pergat.
Fish diet.

19th.—Not vomited since the morning of the 17th; the liniment has brought out a crop of pustules; has felt no pain since the vomiting has ceased; urine neutral, containing but little deposit; complains of great thirst.—P.

22nd.—For the last two nights his skin has acted freely; urine free from deposit, sp. gr. 1.014; troublesome flatulent eructations.—P.

From this report, the same treatment being continued, the patient improved, the vomiting ceased, and the urine became acid. He had recovered his good looks, and became decidedly fat in his face. On May 19th, he suffered a slight relapse after paroxysms of pain in the region of the left kidney, followed by vomiting and the discharge of urine loaded with phosphates, and becoming alcaline soon after emission. This was but a transient attack; he soon recovered, and left the hospital apparently quite well.

May 31st.—This patient appeared among the out-patients apparently pretty well; he had suffered one relapse since leaving the hospital, after a copious meal of tripe. The urine was, however, not quite healthy, and contained some phosphates.

213. Sometimes, although rarely, the phosphates will disappear from the urine, and be replaced by the oxalate of lime; a change that should excite serious apprehensions for the patient's ultimate welfare. This generally occurs in persons who by imprudence have drawn some time previously a heavy bill upon their health. The following is one of the few cases of this kind I have witnessed.

CASE X.—*Irritable bladder following repeated gonorrhœa; dyspepsia; severe lumbar pain; triple phosphates followed by crystals of oxalate of lime.*

I was requested by my friend, Mr. Complin, of Charter-House Square, to see a patient in whom he suspected the presence of renal disease. He was a fine florid person, ætat. 25, who, from his own confession, had been most irregular in his habits; he owns to having laboured under twenty-five different attacks of gonorrhœa. Eight years ago he had cystitis, following the injection of some fluid into the urethra for the cure of gonorrhœa; he at the same time drinking a bottle of port daily. During this attack he passed a large quantity of bloody mucus, which continued pretty constantly for five months; nor did it entirely cease for fifteen months. He was then treated by Dr. Budd, of Plymouth.

He spent the year 1837, and part of the succeeding one, in yachting to the West Indies, and Southern Africa. He then returned to England, and got married. Since then his habits have been more regular, occasionally only indulging in wine. His appetite, however, continued to be, as it ever was, most voracious, often eating, as he, at least, declares, three pounds of meat and bread for dinner.

In January, 1842, he fancied he had some obstruction in the urethra, and passed a bougie: this produced much irritation, and was followed by intense pain over the left kidney, darting to the sacro-sciatic notch; this has continued up to the time I saw him (April the 23rd), occasionally only being absent for a day or two, always being reproduced after partaking of a hearty or indigestible meal. Walking does not appear to increase the pain; on the contrary, although its severity often cripples him, yet if he can succeed in walking for a few yards, he generally becomes relieved.

When the severe pain is absent, there is always a considerable amount of tenderness on pressure over the left kidney. To add to his annoyances, he suffers considerably from irritability of the sexual organs, attributed to his rarely being able to indulge in intercourse, in consequence of his wife suffering from profuse menorrhagia.

April 23rd.—The urine passed last evening was faintly alcaline, of specific gravity 1.028, of natural colour, and appeared to contain a dense mucous deposit, which, under the microscope, was found to consist of large prisms of triple phosphate, mixed with stellæ, formed by a number of finer prisms cohering together; the whole presenting a magnificent appearance, when viewed as an opaque object. By repose an iridescent film of crystals of the triple salt formed on the surface of the urine: and on the application of heat, an amorphous deposit of the phosphate of lime. On the addition of acetic acid to the turbid urine under the microscope, the whole deposit dissolved, the prisms vanishing much more rapidly than the stellæ.

24th.—The urine passed this morning was neutral, of a deep amber colour; its specific gravity was 1.031; it contained a mucous cloud, entangling a few prisms; on the application of heat, a thick deposit of phosphate fell. A large excess of urea was present: the addition of nitric acid producing a rapid growth of crystals of the nitrate of urea in a few seconds.

25th.—His symptoms continued the same. The urine was again examined; that passed last night was acid, of a deep amber colour, and of a density of 1.030; it contained merely a delicate mucous cloud in suspension, there being no distinct deposit; on the application of heat, a deposit of phosphates, soluble in acetic acid, occurred. A large excess of urea was present. On placing a drop of the urine under the microscope, it was found abundantly loaded with very large octahedral crystals of oxalate of lime, unmixed with phosphates or urates.

26th.—The urine passed this morning much resembled the night specimens, save that it was quite free from oxalate; its specific gravity was 1.030, and was loaded with urea; it did not become turbid by heat.

May 2nd.—I again saw my patient: up to this time he had taken no medicine, except a brisk purgative, as I was anxious to watch the urine. He now stated that since its action the lumbar pain had become much diminished. He boasted to me that two evenings previous he had drank a bottle and a half of port at dinner, and felt better for it. He begged to be allowed to avoid physic, unless he became worse; and it was with some difficulty that I procured a specimen of urine.

3rd.—The urine passed last evening was acid, of deep amber, specific gravity 1.030, contained no visible deposit, but the microscope detected an abundant deposit of octahedral crystals of oxalate of lime diffused through it; it deposited phosphates by heat, and contained a large excess of urea.

4th.—The urine passed this morning resembled the last described specimen: both were remarkable for the oily appearance they presented when poured from one vessel to another—a circumstance probably depending upon the great excess of urea they contained.

214. The second class of cases, characterised by a much higher amount of nervous irritability, and of a rapidly progressing emaciation traceable to some shock

to the spine, are less frequent than those just alluded to, and are far less amenable to treatment.

In these, the phosphatic deposit is often copious and sometimes consists nearly exclusively of phosphate of lime; the lumbar pain and weight are considerable, the skin often dry and scarcely perspirable; in some cases, indeed, I have seen it look as if varnished; the tongue sometimes white, is often red; and thirst often great; indeed, the general appearance of the case closely resembles one of diabetes. The urine is generally more copious than natural, frequently pale, and of a specific gravity below the average. On investigating the patient's history, some evidence of a previous strain or wrench of the back, or a blow over the spine, is always elicited. These patients are seldom hypochondriacal; but intense irritability of temper, and a painfully anxious expression of countenance and manner, are almost invariably present.

In the treatment of these cases, the great end and aim must be to subdue the morbidly irritable state of the brain and nervous system; and subsequently, by a generous diet and persistent use of those tonics which appear especially to exert their influence on the organic nerves, as silver, bismuth, zinc, &c., to endeavour to restore the assimilative functions to their due vigour. Besides the general indications to be fulfilled by regulated diet, amusements, exercise, &c., the use of narcotics, especially of opium, or the preparations of morphia, should be regarded as of the highest value; and we are indebted to Dr. Prout for first directing the attention of the profession to their use.

215. The case of this affection recorded by Dr, Prout[75]

was one of peculiar severity, and I have had but few cases before me in practice which at all equalled it. I can, however, add my testimony to the efficacy of narcotics in the cases I have seen. Morphia appears to me to be somewhat preferable to crude opium, and under the persistent use for several weeks of one-third or one-half a grain of the acetate, three or four times in the twenty-four hours, the depôsit has vanished from the urine, and the patient done well. In these, as in the preceding class of cases, the shower-bath, and cold douche over the loins, followed by friction with horse-hair gloves, have been of essential service. To succeed in these cases, the treatment must be persistent, for they are essentially chronic in their character; and if remedies be intermitted too soon, may end in fatal marasmus, and in some the formation of a calculus.

216. Cases occasionally occur in which the symptoms are of a much milder character, but which insidiously go on to the formation of a calculus. It is in these in particular that the use of acids is called for, to hold the phosphatic salts in solution, and prevent their being moulded into a concretion in the pelvis of a kidney. Unfortunately there is a great uncertainty attending their use; indeed, I felt almost inclined to question whether any of the mineral acids, except the phosphoric, really do reach the urine and thus destroy its alcaline character; certainly, in the majority of cases, even their continued employment appears to be utterly ineffectual in rendering the urine acid. So far as I have watched cases of this kind, the nitric acid seems to produce the smallest amount of gastric derangement, and appears sometimes to render the urine acid, or at least diminish its alcaline reaction. Al-

though I do not feel inclined to believe that the acid itself really reaches the urine, and acts as a solvent for the deposit, I am disposed to explain its influence by a reference to its tonic and alterative action, so that when it acts at all, it does so by improving the general health. From some late observations, it appears probable that bodies which coagulate albumen are by no means readily if ever absorbed, and cannot consequently be discovered in the urine; thus gallic acid, which scarcely acts on albumen, is absorbed, and soon reaches the urine;[132] while its close ally, tannine or tannic acid, (242,) readily coagulates albumen, and I believe has never been discovered in the urine after its administration. Is it possible by this view to explain the fact recorded in the first edition of this work, that phosphoric acid had appeared in many cases to lessen the alcalescence of the urine when other acids were useless? Mr. Ure[76] has recommended the employment of benzoic acid, under the idea of its destroying the alcaline state of the urine in consequence of its metamorphosis into hippuric acid; and he has recorded the history of a case thus treated. I confess that in my hands this drug has not been very successful, and when it is recollected that hippuric acid requires about four hundred parts of water for solution, and that it reaches the urine combined with ammonia (128), and not in a free state, we can, I think, hardly place much confidence in it as a solvent for the earthy phosphates.

217. The following case will illustrate the general progress of an excess of phosphates, ending in the formation of a calculus.

CASE XI.—*Phosphatic urine and formation of calculi, following injury to the kidney; gradually increasing diuresis; persistence of the deposit of phosphates.*

George W——, æt. 39, came under my care, February 24th, 1843; he had been engaged at the distillery of Messrs. Booth during the preceding five years, during which period he had partaken pretty freely of gin. Four years before he fell down a trap-door, and fractured two ribs on the left side. Since then he has had almost constant pains in the region of the *right* kidney, with occasional, although slight hæmaturia, to which, as he states, he has been more or less subject from childhood. About six months after his accident he suffered from intense pain in the course of the right ureter, followed by retention of urine, which was relieved by the passage of an oval calculus. He remained tolerably well until a year ago, when, after another similar attack, a second calculus escaped. From this time he remained free from complaint, except the occasional discharge of white sand in his urine, until Sunday, February 19th. On the evening of that day he was attacked with what he regarded as colic, attended with excessive vomiting; this continued until February 21st, when he was relieved by the bowels acting.

For six months before the man came under my care he had been subject to profuse nocturnal perspiration, and his skin acted copiously on slight exertion during the day. The desire to pass urine, which has been very frequent since the passage of the first calculus, has of late much increased, so that he is called upon to empty the bladder a dozen times a day. He is much emaciated, his countenance pale and haggard, his manner anxious; pulse 100 soft; tongue clean; complains of heavy aching pains across the loins. The calculi were brought to me, and on analysis I found them to consist of the triple phosphate, with a small quantity of phosphate of lime. Urine 35 ounces in twenty-four hours.

February 25th. *Urine passed at night.*—Specific gravity 1.020, neutral to litmus paper, deep brandy-coloured, with a copious white crystalline sediment of the triple phosphate mixed with mucus. A deposit of phosphate of lime occurred on the application of heat.

Morning urine.—Same as the night specimen, but the sediment more copious.

February 26th. *Urine of twenty-four hours* only 22½ ounces, faintly alcaline and brandy-coloured. Specific gravity 1.022, no deposition by heat. Sediment copious, and as before consisted of triple salt. The small bulk and high colour of the urine of the last two days is attributable to rather copious purging from an aloetic aperient he had been taking.

A nutritious diet was ordered, and a flannel bandage to the loins.

℞. Acidi Nitrici diluti, ♏xx. ter die ex dec. sarsæ. co. cyatho.

February	2.	Urine 35 oz.	Faintly alcaline to litmus, and loaded with phosphatic deposits.
March	1.	— 42 oz.	
	2.	— 40 oz.	
	3.	— 57 oz. sp. gr. 1.015	

March 3rd. The dose of acid has been gradually increased to half a drachm. The urine, in increasing in quantity, has become paler and whey-like; the morning and evening specimens exactly correspond, and both contain a copious sediment, which to the naked eye resembled pus. It, however, consisted of large prisms of phosphate mixed with very little mucus. The night specimen only deposited phosphate of lime on applying heat. All the urine contained a small quantity of albumen.

The patient says he feels better, and is nearly free from a severe lumbar pain, which had been distressing a week before.

Rep. omnia.

March 5th. Perspiration at night less intense.

March 4th.	Urine, 47 ounces	Sp. gr. 1.019 neutral, deposit copious.
—— 5th.	— 45 ounces	
—— 6th.	— 60 ounces	Sp. gr. 1.016 neutral, deposit still copious.
—— 7th.	— 70 ounces	

——10th. Sufficiently relieved to enter business; he thinks the urine continues increasing, but he has not measured it. Sp. gr. 1.015 neutral.

April 7th. Improving slowly in health, urine still profuse and pale, still copiously depositing phosphates. Complains of return of lumbar pain.

Applic. emp. opii regioni renum.
Acidi benzoici, gr. vj. bis die.

14. Urine certainly improved; a mere mucous cloud in the morning specimen, sp. gr. 1.014; night specimen, 1.014: both slightly acid for the first time, and containing hippurate of ammonia. He passes 80 ounces in twenty-four hours. P.

21st. Much the same in health; urine the same in quantity and density, but a rather copious deposition of phosphates has occurred. He looks as emaciated as ever, but declares he feels fit for all his duties. He wishes to leave off his medical treatment.

October 29th. I again saw him; his general health is improved, and he is stouter; has had but one attack of pain in the kidney since I saw him. He still passes a very large quantity of urine containing a small quantity of phosphates in diffusion, quite neutral to test-paper. Specific gravity 1.015. His only complaint now is a want of power on contracting the bladder, being often obliged to use powerful efforts to expel the urine. There is no stricture, but he has found great relief to this symptom by emptying the bladder with an elastic catheter every night. He effects this himself, and is then enabled to get a good night's rest.

November 5th. Much the same; urine 50 ounces in twenty-four hours.

August 2nd, 1844. Tolerably comfortable in health; urine still pale, copious, and neutral, without sediment, but soon by heat lets fall a deposit of phosphate of lime.

218. The third class of cases, or those in which the phosphates are probably entirely secreted with unhealthy mucus by a diseased lining membrane of the bladder, are familiar to every practitioner. Chronic cystitis or cystorrhœa, and retention of urine from stricture of the urethra or enlarged prostate, may, and often do, lead to this state of things. Here, of course, the primary affection, and not its effect, the deposit of phosphates, must be the great object of treatment. The urine is often very fœtid and pale, sometimes green, and almost viscid from the abundance of mucus. On placing some of the latter between plates of glass under the microscope abundant crystals of the triple phosphate are seen entangled in it. One point of great practical consequence must be borne in mind in forming a prognosis from the state of the urine, viz., not to regard it as ammoniacal, because the odour is offensive; and not to consider the deposit as purulent, because it looks so. A piece of litmus paper will often show the urine to be really acid, and microscopic inspection often proves that the puriform appear-

ance of the urine is owing to abundance of phosphates with mucus. For want of these precautions, I have seen one or two cases regarded as almost hopeless, which afterwards yielded to judicious treatment. It is quite certain that the mucous membrane of the bladder may, under the influence of chronic inflammation, secrete so much of the earthy phosphates and unhealthy mucus as to render the urine puriform and offensive without having necessarily undergone any structural change.

219. A few cases have occurred to me in practice, in which the kind of urine just referred to was secreted for a long time, and yet yielded readily to treatment. In these, the greatest good has arisen from freeing the bladder from the phosphates which appear almost to incrust it, by acid injections. In this way cases have occasionally yielded which have quite defied all other treatment. The following case is a good illustration of this, and I record it in the hope of drawing particular attention to this form of phosphatic cystitis, if a name be required for the disease.

Case XII.—*Phosphatic cystitis co-existing with pregnancy and vaginitis?—Discharge of phosphatic calculi—Cure by injection.*

Mrs. K——, a fair and delicate looking lady, 34 years of age, residing in Essex, was married in 1832, and had nine children in the succeeding ten years, being pregnant of a tenth when she came under my notice in May, 1842. She appears to have enjoyed good health up to December 1841, when without any assignable cause she had severe scalding in micturition, with considerable irritability of bladder. These symptoms rapidly increased in severity, and soon afterwards the urine became loaded with mucus, occasionally streaked with blood. She continued getting worse until March, 1842, when her sufferings became intense; she had frequent desire to pass water every few minutes, with most distressing straining, especially after each attempt at emptying the bladder; this almost entirely deprived her of sleep. The urine was thick, fœtid, and let fall a copious deposit, which was considered as purulent; although acid when first passed, it soon became ammoniacal. About this time, as a calculus was suspected, a sound was passed; this gave rise to the most excruciating pain, but no stone was detected. She suffered severely from hæmorrhoids, and sexual intercourse was attended with positive torture, so that from her own account her life became a miserable burden of woes. From the report of the very experienced surgeon under whose care this lady was, (Mr. May, of Maldon,) it appears that the bladder was decidedly thickened. In May, 1842, I was consulted by letter, the patient being then three months pregnant, and two specimens of urine, which were described as being purulent and bloody, were sent up.

On examination I found the specific gravity of the urine to be only 1.009; it was opaque and rather green; odour extremely fœtid, although faintly acid to litmus paper. A thick creamy deposit, equal in volume to one-fourth of the whole, occupied the bottom of the bottle. The deposit, which bore the closest resemblance to pus I ever saw, was examined by placing a portion between two slips of glass under the microscope. It consisted of mucous particles, with a few blood-discs and myriads of large prismatic crystals of the triple phosphate, mixed with amorphous phosphate of lime. On pouring the lower layers of the urine containing the deposit from one vessel to another, it formed a nearly continuous rope and entangled some small coagula of blood. But mere traces of albumen were found in the urine. I suggested a nutritious diet, and

Pil. Saponis comp. gr. v. pro suppositorio omni nocte.
Acidi Hydrochlorici diluti ♏x. gradatim augens dosin ad ♏xxx. ter die ex Dec. Sarsæ. co.

In a fortnight (May 20th) I received a report from Mr. May, with another specimen of the urine, and some irregular calculous masses the size of peas, consisting of crystals of triple phosphate with mucus. "The poor lady tells me that manual aid was required to remove them from the orifice of the meatus, some hæmorrhage followed, and continued for a few days. The deposit bears a less proportion to the urine than it did, and the intervals between the attempts made to empty the bladder are longer. The recumbent position increases her uneasiness, and renders micturition more frequent (about twice in an hour). An aggravated condition of habitual hæmorrhoids has rendered it necessary to substitute an anodyne draught for the suppositories. She has continued the use of the acid, and she has certainly not lost ground: on the contrary, she appears stronger. Within the last few days the legs have become œdematous; this has been the case in previous pregnancies, but not at so early a period." I then suggested the daily careful injection into the bladder of acidi hydrochlorici ♏x. vini opii ♏xx. in barley-water, in the hope of dissolving and bringing away some of the phosphatic masses which I suspected to be in the bladder, and thus remove one source of irritation. A poultice of conium leaves was directed to be placed over the pubes, and the recumbent position enjoined.

In a few weeks, I received a letter from my friend, Dr. Baker, of Maldon, who had seen the patient in consultation with Mr. May; he states, "I am happy to say that Mrs. K—— has derived infinite benefit from the use of the injection into the bladder. She could not, previously to her injection, retain her urine for twenty minutes, and then the pain and straining was most distressing; she can now retain it four hours without pain, and there is no appearance of deposit." I had an opportunity of seeing this patient with Dr. Baker on June 19th, on being called to Maldon to see another case; she was well, and progressing comfortably with her pregnancy.

It is rather a curious circumstance that I was consulted in the spring of the following year, by the son of this lady, for a calculous affection, the urine being loaded with triple phosphate.

Deposits of Carbonate of Lime.

220. It has been already stated that carbonate of lime often occurs in small proportions in deposits of earthy phosphates (201), when the urine is decidedly alcaline. Its origin may then be explained by a decomposition of phosphate of lime by the carbonate of ammonia which replaces the urea. In this state, the carbonate of lime simply appears as an amorphous powder, and its presence may easily be recognised by the addition of any dilute acid, which dissolves it with effervescence. Care must, however, be taken to wash the deposit with water before adding the acid, for unless all traces of adherent carbo-

nate of ammonia are removed, an effervescence will be excited by the acid, whether the calcareous salt be present or not.

FIG. 37.

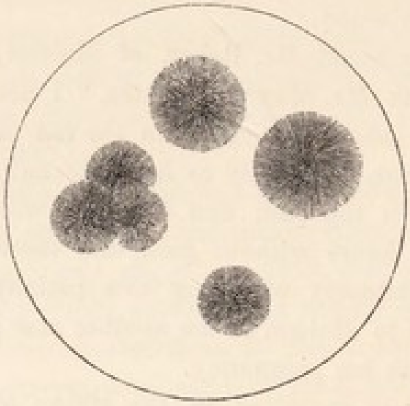
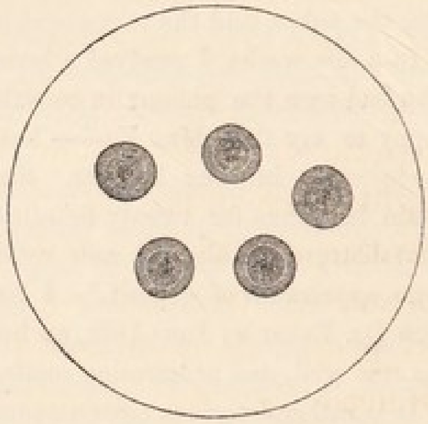


FIG. 38.



Very rarely, the carbonate is found crystallised in dense stellæ affecting the circular form, and apparently composed of excessively slender prisms (rhomboids ?) cohering at the centre (Fig. 37). The few instances of this kind I have met with occurred in neutral or faintly acid urine, a condition probably necessary to insure the regular structure of the little crystalline masses. Polarised light shows that the structure of the mass is regular, its density decreasing with the distance from the centre, for a black cross becomes visible in each on properly arranging the calc-spar prisms of the polarising microscope.

221. Deposits of carbonate of lime are of constant occurrence in the urine of herbivora. These may be readily collected for examination from the urine of the horse, in which they occur spontaneously. When exa-

mined by the microscope, after being washed with water, the particles of the carbonate are observed to be small transparent spheres, like globules of glass, and strongly refracting light. Allowed to dry, and examined after immersion in Canada balsam, their structure is beautifully distinct. Each sphere being made up of myriads of minute needles radiating from a common centre (Fig. 38), the whole having a circular and well defined outline, in which respect they differ greatly from the carbonate deposited from human urine. With polarised light, these interesting objects present a series of concentric coloured rings traversed by a black cross. These beautiful little bodies present a remarkable resemblance to pearls, the well-known concretions of the pearl oyster. Indeed, they may almost be regarded as urinary pearls.

Some few cases are recorded, in which little concretions and gravel of carbonate of lime have been passed in the urine, as if an excess of lime had been eliminated without its usual adjunct, phosphoric acid. I have, however, never met with any examples of this kind, although I have detected carbonate of lime in phosphatic calculi, both mixed with the mass of the concretion, or more rarely forming a distinct stratum.

Carbonate of magnesia is said to occur occasionally in phosphatic deposits, its presence being in all probability due to the decomposition of phosphate of magnesia by carbonate of ammonia (metamorphosed urea).

Deposits of Silicic Acid.

222. Silicic acid exists in infinitessimally small quan-

tities in some of the animal fluids, and therefore may possibly be met with as an urinary deposit. It was found in crystals forming part of a calculous concretion by Dr. Yellowley,[77] and some other instances of its occurrence have been recorded. Lassaigne[78] found a calculus consisting of pure silicic acid in the urethra of a lamb, and Wurzer[79] has given the analysis of one removed from an ox, in which silicic acid existed to the amount of thirty-eight per cent.

It is, however, very necessary to be on one's guard respecting siliceous concretions; for as there is a popular notion that calculous matter is *bonâ fide* gravel, whenever an imposition is intended, a silicious pebble is usually chosen to deceive the medical attendant. I have met with repeated instances of this, in which common rolled pebbles of quartz have been placed in my hands, with the assertion that they were actually passed from the bladder. This has usually occurred in hysterical girls, who laboured under that most unintelligibly morbid desire of deceiving the doctor, by representing themselves as afflicted with some disease of the genito-urinary organs. I have heard of instances in which such pebbles have actually been thrust by a girl into her own urethra, and thus have reached the bladder. In a case mentioned to me by Dr. Christison a piece of chlorite slate was found forming part of the supposed calculus, thus attesting its true origin. A case occurred many years ago in St. Thomas's Hospital, in which the late Mr. Cline operated, and removed a quantity of common coals from the bladder of a patient.

As silicic acid has been found in calculi by such excellent observers as the late Dr. Yellowley and Dr. Venables, and as the ox and lamb mentioned by Wurser and Lassaigne could hardly have been supposed to have put the silicious matter into their own bladders, the occasional possible occurrence of silicic acid in urinary deposits and concretions must be conceded. Still, that it is extremely rare all experience has proved, as indeed might be anticipated from the chemical relations of this very refractory substance.

CHAPTER XI.

DEPOSITS OF ABNORMAL BLUE OR BLACK COLOURING MATTERS.

223. In addition to the various tints communicated to urine by bile and blood (47, 235), certain peculiar colouring matters, strictly the products of diseased action, are occasionally, although very rarely, met with. These generally communicate to the urine a blue or black colour. Three different blue pigments, at least, have been met with, viz., cyanourine, indigo, and percyanide of iron, and probably two black ones, melanourine and melanic acid. Blue, green, and black urine has been described by the ancients, but it is probable that the varieties of tint so often mentioned by all physicians since Hippocrates, were produced by blood or bile modified by the state of the urine.

224. *Cyanourine* was first discovered by Braconnot,[80] and has since been observed by Spangenberg, Garnier, Delens, and others. Urine containing it, possesses a deep blue colour, and by repose lets it fall as a blue deposit capable of being readily separated by the filter. It may be freed from adhering mucus, uric acid, phosphates, &c., by washing with water, and digesting it in hot diluted sulphuric acid. The cyanourine may be precipitated from the acid solution by the careful addition of magnesia. It may also be obtained by boiling the blue deposit from the urine in alcohol, and evaporating the solution to dryness.

225. *Diagnostic characters.*—Cyanourine is a tasteless and inodorous dark blue powder, scarcely soluble in water, merely at a boiling heat communicating to it a brown colour, which on the addition of an acid becomes red. Moderately soluble in boiling alcohol, being partly deposited on cooling. Diluted acids dissolve it, the solution being brown or red, according to the proportion of acid present. The solution in sulphuric acid leaves by evaporation a carmine-red extract, which dissolves in water, forming a brown fluid. Ammonia, lime-water, and magnesia, precipitate it unchanged from its acid solution. Hot solutions of alcaline carbonates dissolve cyanourine, forming a red, whilst the pure alcalies yield a brown solution. Nitric acid converts this substance, like indigo, into nitro-picric acid. Heated in a glass tube, it forms an oily fluid which burns to a bulky ash.

Cyanourine is distinguished from indigo by not subliming when heated in a tube, and from percyanide of iron by not yielding sesqui-oxide of iron when digested with carbonate of potass.

226. Another modification of blue colouring matter has been described by Dr. Schmidt as occasionally occurring in the urine of patients under hydropathic treatment at Gräfenberg.[133] The deposit consisted of ovoid globules about one-third the size of a blood-corpuscle, and of a fine blue colour. It was partially soluble in hot ether and alcohol, forming blue solutions. Neither dilute sulphuric acid nor ammonia acted on it. Oxalic acid dissolved it, forming a blue solution. Potass, aided by heat, destroyed its colour. No uric acid could be detected.

The origin of this pigment is quite obscure; it is probably traceable to some metamorphic change in a protein compound; for we know that albumen, when boiled with hydrochloric acid, forms a bluish solution. Also, when vegetable gluten, a body closely allied to albumen, spontaneously decomposes in the air, it becomes partly converted into a blue substance. Dr. Heller has lately stated that these curious deposits are merely metamorphosed uroxanthin or yellow colouring matter of urine, and has applied the name of uro-glaucine to the blue pigment. He assumes, therefore, that it is identical with what I have described as purpurine, produced by the action of hydrochloric acid on previously-warmed urine. The statements of Heller, however, are mixed up with certain inaccuracies, and can hardly be admitted without more minute investigation.

The pathological indications of these substances are quite unknown.

227. *Indigo.*—This pigment, when taken into the stomach, as is occasionally done in the empirical treatment of epilepsy, finds its way into the urine, forming a

blue deposit. It, however, appears probable that indigo has occasionally been generated in the animal economy, and instances of this kind have occurred to Drs. Prout[81] and Simon.[82] When this substance is present, the urine acquires a dark blue colour, and by repose a deposit of the same hue falls. This, when collected on a filter, presents all the well-known chemical characters of indigo.

The composition of this substance (C_{16}, N, H_5, O_2), approaches sufficiently close to that of some animal products to render its occasional development in the organism a matter of high probability.

228. *Diagnostic characters of indigo.*—This substance dissolves in strong sulphuric acid, forming a purple solution. Nitric acid converts it into nitro picric acid. Carefully heated in a tube, it sublimes in purplish red crystals. By de-oxidising agents it is bleached, and white indigo produced; this, by exposure to the air, loses an atom of hydrogen by oxidation, and becomes blue.

Simon[83] gives the following as the best mode of detecting indigo in a blue deposit.

Heat the deposit with a little grape-sugar in a mixture of alcohol and liquor potassæ, the blue colour disappears and a yellow solution is obtained. By agitation and exposure to the air the fluid assumes a red, and eventually a green colour, from the re-production of blue indigo.

The pathological indications of deposits of indigo are unknown. Whenever they are met with, care should be taken to investigate the patient's history so as to discover whether this substance had been previously medicinally administered.

229. *Sesqui-ferro-cyanide of iron, or Prussian blue.*—This substance was first found by M. Julia Fontanelle[84] in

the urine of a boy residing at Mont-Louis in the Pyrenees. He was labouring under severe colic, attributed to his having swallowed a quantity of ink. The blue deposit continued for a day or two after the attack, leaving the urine of its natural colour, but containing some soluble cyanide, as a blue precipitate was produced on the addition of a salt of iron. Several other instances of Prussian blue deposits have occurred, and it is remarkable that in most of them iron has been accidentally or intentionally taken. These deposits can be artificially produced by giving to a patient who has been taking some preparations of iron, a few doses of ferro-cyanide of potassium.

The origin of the cyanogen of the blue deposit can be readily explained from the known composition of urea. We have seen that this substance may be regarded as a carbonate of ammonia (30), but it may also be considered as a cyanate of that base; thus—

		C	N	H	O
1 atom cyanic acid =	1 atom cyanogen =	2	+1		
	1 — oxygen =				1
1 — ammonia	=		1	+3	
1 — water	=			1	+1
Composition of an atom of urea	=	2	+2	+4	+2

Prussian blue consists of seven atoms of iron, united with nine of cyanogen. If, then, any cause determines the resolution of urea into the above proximate elements, and iron be present, a precipitate of the percyanide must be the necessary result.

230. It has been lately asserted by Prof. Pietro Piretti of Rome,[134] that when persons labour under the influence

of malarious poison, the urea normally present in the urine is really replaced by cyanate of ammonia, and which can be obtained by careful evaporation. He adds, that during the successful treatment of ague by valerianate of quina, the cyanate gradually disappears, and is replaced by true urea.

231. *Diagnostic characters of Prussian blue.*—A blue powder insoluble in water and alcohol. By digestion with liquor potassæ its colour is destroyed, sesqui-oxide of iron being set free, and a yellow solution of ferrocyanide of potassium formed. This solution is precipitated blue by sesqui-salts of iron, and hair-brown by sulphate of copper.

The pathological indications of these deposits are unknown.

232. *Melanourine and melanic acid.*—Under these names have been described some black pigments which have been met with in urine. Their chemical properties are very ill-defined, and their origin and pathology alike obscure. It is more than probable that in some instances at least, these pigments ought to be regarded rather as altered colouring matter of blood than anything else.

a. Braconnot[85] describes a black matter which he regarded as a weak salifiable base; it occurred in the blue urine (224), and remained in solution after the cyanourine fell. It was obtained after the latter had fallen, by merely boiling the clear urine, when the black matter coagulated and became insoluble. It in all probability was merely modified hæmatosine.

b. The late Dr. Marcet[86] met with a black matter in the urine of a child, unaccompanied by the ordinary constituents of the secretion. To this substance the name of melanic acid was applied by Dr. Prout. The urine in which it occurred was like ink; it slowly deposited black flocculi after the addition of an acid. The black matter was insoluble in water and alcohol; nitric and sulphuric acids dissolve it, forming a black solution, which by dilution deposited the pigment unchanged. Alcalies and their carbonates dissolved it, and acids precipitated it from its solution. Its alcaline solution produced brown precipitates on the addition of metallic salts.

c. Prof. Dulk, of Königsberg, has described a curious kind of urine of a blackish grey colour passed by a patient affected with hepatic disease. On filtering it, a yellow fluid, which was merely diluted urine, passed through, and a black matter was collected on the paper. This was slightly soluble in nitric and hydrochloric acids: the solution being precipitated by tincture of galls.

Prof. Dulk suggests that this pigment was merely a highly carbonised hæmatosine, arising from the imperfect performance of the hepatic functions.

CHAPTER XII.

NON-CRYSTALLINE ORGANIC DEPOSITS.

233. The elements of the urinary deposits already examined, are capable of being easily recognised by their crystalline form, or chemical properties. Those which we have now to investigate are secreted organic sub-

stances, often possessing organisation, and sometimes enjoying an independent vitality. In the detection of these in deposits, microscopical examination is in almost every instance quite indispensable, and in many, furnishes the only means for discovering their true nature.

The best mode of examining these deposits microscopically, is to allow the urine to repose in a glass cylindrical vessel for a short time, decant the upper nine-tenths of the fluid, and then place a drop of the residue on a plate of glass. Gently drop it on a piece of very thin glass, and submit it to the microscope. A good achromatic objective of a quarter of an inch focus is generally sufficient for all these investigations, but it is sometimes necessary to use one of one-seventh or one-eighth of an inch, when the object is very minute; but to a person familiar with these observations a good half-inch glass is sufficient for almost all cases.

ELEMENTS OF BLOOD.

234. All, or any, of the elements of the blood may find their way into the urine, either as the result of mechanical violence to the kidney or any part of the genito-urinary tract, of the irritation of a calculus, of organic disease, or any breach of surface of the mucous membrane of the kidneys or bladder; or of sufficient pressure on the renal veins to prevent the return of blood from the kidneys to the cavæ (240). We may find in the urine, serum of blood alone or accompanied by red particles; sometimes the liquor sanguinis is alone effused, and containing but a small proportion of colouring matter; or more fre-

quently, all the elements of blood may be poured out together. Of the first of these, the urine of morbus Brightii, and of cases of anasarca resulting from scarlatina, are good examples; in these the urine is characterised by the presence of albumen, and in acute cases presents the dingy hue characteristic of the presence of colouring matter of blood, or of entire blood-corpuscles. Of the second condition, the urine in fungus hæmatodes of the kidney often furnishes a good example; this is often observed to be of the colour of infusion of roses whilst warm, and on cooling solidifies into a pink transparent mass, like red-currant jelly, retaining the figure of the vessel. Every case of idiopathic or symptomatic hæmaturia affords examples of the presence of all the elements of blood in the secretion.

235. *Diagnosis of urine containing blood.*—When blood is effused in any considerable quantity in the urine, it coagulates into blackish masses like pieces of black-currant jelly; and when it partly coagulates in the bladder, linear masses of clot of nearly the shape of leeches are passed from the urethra, often to the great distress of the patient, by producing temporary suppression of urine. Even after this coagulation, the urine retains a port-wine colour, and the microscope detects an abundance of entire blood-corpuscles; although in a great proportion of them, the investing membranes have given way, and the coloured contents been diffused through the urine. If too small a quantity of blood has been effused to give a decided red colour to the urine, it will be frequently found possessing merely a dirty dingy hue; less frequently being pinkish, like the washings of flesh. In either case a sufficient number of blood-corpuscles will

subside by repose to allow of their being readily identified by the microscope (239).

The coagulation of urine by repose will readily indicate the presence of the liquor sanguinis, as the fibrin it contains is the only spontaneously coagulating substance in the body. This element is very rarely effused by itself, being generally mixed with blood-corpuscles, giving the coagulum a red colour; or with a fatty matter, which causes the coagulum to assume the appearance of *blanc-mange* (277). It is, however, sometimes found depositing in the form of minute linear tubular masses, each being probably the cast of one of the uriniferous tubules (237*). The red corpuscles, or the hæmatosine contained in them, and the albumen of serum, do not present characters always sufficiently satisfactory to be able to identify them without the application of reagents.

236. *Albumen* may readily be detected in urine containing it, by the production of an opacity by the application of heat. This experiment, where any amount of accuracy is required, should always be performed in a clean test-tube, heated over a spirit-lamp. The clumsy mode of heating it in a metallic spoon over a candle, although answering the purpose very tolerably when a glass tube cannot be procured, is infinitely inferior in the delicacy of its indications. If a large quantity of albumen be present, the urine will become quite solid on the application of heat, and will vary from this state to the production of a mere opalescence, according to the quantity existing in the urine. It is a curious fact, that the greatest amount of coagulation by heat, is often found in urine either free from, or containing but a small quantity of the colouring matter of blood. The dingy-red urine

in granular disease of the kidneys, generally deposits less albumen by heat than when it is straw-coloured, and nearly free from hæmatosine.

Albumen does not require actual ebullition for its coagulation by heat; if any be present in urine, the latter becomes opaque before a bubble of vapour is evolved.

The addition of a drop of nitric acid to albuminous urine immediately produces a copious coagulation of the albumen; but if only mere traces of the latter be present, the opacity first produced will disappear by agitation, and will re-appear by the addition of a second drop of the acid. A drop of a mixture of one part of nitric acid and three of hydrochloric acid, is much more decided in its effects, and more delicate in its indications than pure nitric acid. This admits of ready explanation in the presence of chlorine evolved by the abstraction of hydrogen from the hydrochloric acid, and chlorine is one of the most delicate precipitants of the protein compounds.

Another delicate test consists in the addition of a solution of ferrocyanide of potassium previously acidulated with acetic acid. This, like the last test, has the inconvenient property of precipitating other protein compounds besides albumen, as mucus, &c.

237. *As a general rule*, if urine becomes opaque by heat, and on the addition of nitric acid, albumen is present. It is important to bear in mind that certain sources of fallacy exist when only one of these tests are used.

1. Heat will produce a white precipitate in urine containing an excess of earthy phosphates (190).

Distinguished from albumen by disappearing on the addition of a drop of any acid.

2. Heat being applied to urine containing deposits of urate of ammonia, will sometimes, if actual ebullition be prolonged, produce a deposit of an animal matter (tritoxide of protein ?) insoluble in nitric acid. This is rare, *but is distinguished from albumen by being deposited only after protracted ebullition.*

3. Nitric acid will often produce white deposits in the urine of patients under the influence of copaiba, cubebs,[83] and perhaps some other resinous diuretics. *Distinguished from albumen by not being produced by heat.*

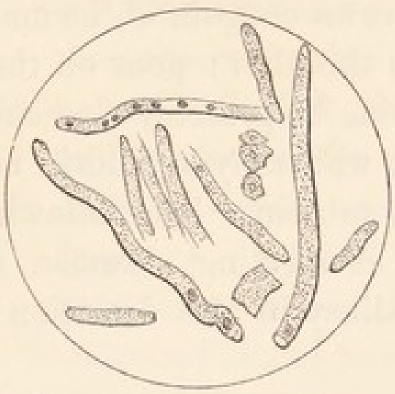
4. Albumen may be present in urine and not be precipitated by heat, providing the secretion be alcaline. If, therefore, urine suspected to be albuminous, is capable of restoring the blue colour of reddened litmus paper, *nitric acid must be used as the test,* as albumen, when combined with alcalies, does not coagulate by heat.

5. It may occasionally happen that albumen may be present in the same incipient or hydrated state in which, according to Dr. Prout, it occurs in chyle.[84] Heat scarcely affects this variety of albumen, except by ebullition ; but nitric acid immediately coagulates it. Where but small quantities of albumen are present in urine containing rather more than an average proportion of phosphate of soda, the application of heat scarcely produces any visible opacity until after the addition of an acid, and hence it is possible for the albumen to be erroneously regarded as existing

in the hydrated state. A condition which has never occurred to me. In the latter stages of diabetes mellitus, I have occasionally found the urine previously warmed rendered opaque on the addition of nitric acid; the precipitated matter appeared to me to resemble some of the oxygenised compounds of protein described by Mülder.

237*. Albumen is occasionally found in the urine in a coagulated state, and presenting a tubular vermicular appearance. In this form it has been mistaken for minute hairs (Fig. 39).

FIG. 39.



It is of common occurrence in Bright's disease, even in the earlier stages, and the deposit appears to be made up of fibrinous (albuminous) casts of the uriniferous tubules of the kidney. Portions of epithelium are often found adhering to them, generally, according to Dr. G. Johnson, loaded with fat (278). Urine containing these bodies, lets them fall by repose in the form of a dirty-white sediment, easily diffused by agitation, and not unlike mucus. A solution of potass dissolves and gelatinises the deposit, which will at once distinguish it from mucus. The tubular masses of albumen are seldom larger than $\frac{1}{50}$ or $\frac{1}{100}$ inch, generally much shorter, and in diameter correspond closely with that of the tubuli uriniferi, never exceeding $\frac{1}{1000}$ inch. This deposit may be regarded as pathognomonic of Bright's disease.

238. *Hæmatosine* is the colouring matter of the blood,

normally contained within the delicate sac of the corpuscles, particles, discs, or globules of blood; all these terms being synonymous. When hæmatosine is present, the urine is always more or less coloured by it, and a few entire corpuscles are almost always found floating in the fluid. It never occurs unaccompanied by albumen, and being acted upon by tests in a similar manner, the remarks already made on the latter substance (237) apply equally to hæmatosine, excepting that the deposits produced by heat or nitric acid, are always brown instead of white. M. Pariset[105] has proposed the following process for the detection of blood in urine, as least liable to fallacy. Boil the urine and filter it. Brown coagula of hæmatosine and albumen will be left on the filter; pour on these liquor potassæ, and if hæmatosine be present, a greenish solution will pass through, from which hydrochloric acid will precipitate white coagula of protein. The following, in addition to those mentioned as affecting albumen, are the most serious sources of fallacy in the detection of hæmatosine.

1. *Purpurine*, when present in the urine (136), will often communicate to it so intense a colour, as to cause the patient to report his urine to be bloody. *Distinguished by not being affected in colour or transparency by a boiling heat.*

2. *Uric acid*, when present in concentrated urine, as in the first week of fever, is often immediately precipitated by nitric acid, brown coagula, much resembling those of hæmatosine, falling; but really composed of extremely minute crystals of uric acid. *Distinguished by not being affected by heat, and by the microscopic character of the deposit* (96).

3. *Bile,* or at least its colouring ingredient, often tints the urine of a deep brown colour, and may lead to an unfounded suspicion of the presence of blood. One or other of the following tests will at once detect bile or its colouring matter in a fluid.

a. Pour on a white plate a small quantity of the urine or other fluid, so as to form an exceedingly thin layer, and carefully allow a drop or two of nitric acid to fall upon it. An immediate play of colours, in which green and pink predominate, will, if the colouring matter of bile be present, appear around the spot where the acid falls.

b. (Pettenkofer's test.)—To a small quantity of the suspected urine in a test-tube, two-thirds of its volume of sulphuric acid are to be carefully added, taking care that the mixture, which soon becomes hot, never exceeds a temperature of 144°. Three or four drops of a solution of one part of sugar to four of water are then added, and the mixture shaken. A violet-red colour becomes developed if bile be present. My own experience of this test has not led me to regard it as either a generally useful or trustworthy one, and in applying it, there are numerous sources of fallacy to be guarded against, arising chiefly from the action of sulphuric acid on sugar, which develops a red colour in the absence of bile. A mixture of albumen or oil with sugar will even, in very minute quantities, produce a purple or scarlet colour, with sulphuric acid, as Raspail long ago stated.

c. (Heller's test.)—Add to the urine any albuminous fluid, as serum of blood or white of egg, then pour in sufficient nitric acid to produce a considerable albuminous coagulum. On examining this after a short repose, it will be found to possess a bluish or green colour if bile-pigment existed in the urine, whilst, if none were present, the deposited mass will be white or merely slightly yellow.

d. It may occasionally happen that bile may exist in the urine so modified (oxydised?) as not to exhibit the characteristic reaction with acids. This has been observed in cases of cholera; the urine, although containing modified bile, became merely imperfectly reddened by it. Ammonia then becomes a valuable test, as it produces an immediate deep red colour.[136] The fallacies of this test are the accidental presence of vegetable colouring matters, especially rhubarb, and the newly-observed fatty body, stearolith (282).

4. *Hæmatoxylon,* administered as a medicine, will often, by the red colour it communicates to the urine, lead to an unfounded suspicion of the existence of hæmatosine. *Distinguished by the dark precipitate produced by sulphate of iron, and by absence of coagulation by heat.*

5. *Pareira* and *Chimaphila* will both sometimes communicate a dark brown tint to the urine; but the absence of all the characteristics of albumen and hæmatosine will distinguish it from the colour produced by blood.

239. *Microscopic characters of blood-corpuscles.*—These furnish the readiest and most infallible mode of detecting blood in the urine. To discover them, if the urine possess a red or brown colour, a drop taken from it after agitation will be sufficient to allow their ready

detection. But if the urine be barely coloured, it is better to allow it to repose for some hours, and examine a drop from the bottom of the vessel, to which the corpuscles generally sink with readiness.

If blood be recently effused into the bladder from some mechanical injury, the components are observed not only unaltered in figure, but even adhering in rouleaus (Fig. 39), as when a drop of fresh blood unmixed with urine is examined.

If the blood is present in smaller quantity, or even if copious, but its effusion has been slower, all traces of the linear arrangement of the corpuscles is lost, and they are found separate and floating in the fluid (Fig. 40). On first examining the object, the corpuscles resemble little rings; an optical illusion arising from their being nearly emptied of their contents by exosmosis. The

FIG. 40.

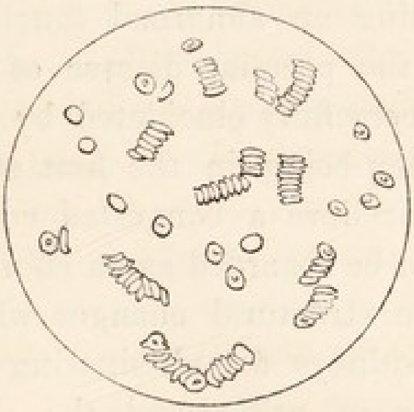
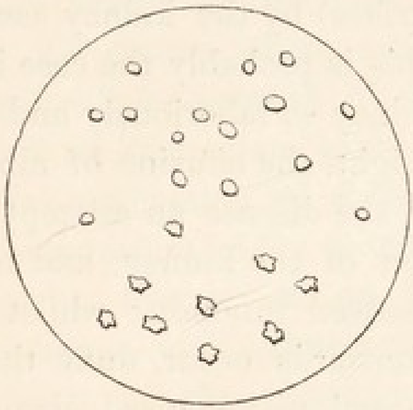


FIG. 41.



corpuscle thus becoming a doubly concave disc, a change which receives a ready explanation by the very interesting demonstration of the real structure of the corpuscles by Dr. Rees.[90] Sometimes an appearance of a spiral fibre, like that described by Dr. Martin Barry,[91] is observed. This appearance of the supposed fibre has always appeared to me to be an optical delusion arising from the delicate investing membrane of the nearly empty corpuscle collapsing in circular folds round the nucleus, as a centre. By longer repose in urine, the corpuscles alter still further in figure, becoming irregular at their margins, as is shown in part of Fig. 41.

Whatever are the modifications presented by the blood-corpuscles in urine, their non-granular surface, uniform size, and yellow colour under the microscope, will always be sufficient to identify them.

240. *Pathological indications.*—Whenever the elements of blood appear in the urine, there is ample proof of the existence of active or passive hæmorrhage. If, however, the quantity of hæmatosine be so minute as barely to tint the urine, it is probable that the albumen present may be really secreted (i. e. without breach of surface) by the kidney assuming an abnormal function. This is probably the case in the peculiar disease of the kidney so laboriously and successfully elucidated by Dr. Bright, the effusion of albumen being in the first stage of the disease an attempt to relieve a congested condition of the kidney, and must be regarded as an effort of diseased function; whilst the structural changes which afterwards occur, unfit the kidneys for eliminating the normal nitrogenised elements of urine, and the chief relict of its secreting power is found in the separation of water and albumen from the blood. On the recession of some affections, in which the cutaneous function is tem-

porarily impaired or suspended, especially in scarlatina, a congested kidney occurs as an almost necessary result, and albuminous urine occurs as in the first stage of morbus Brightii. During the existence of pregnancy, and perhaps of some pelvic tumours, the urine is occasionally and temporarily albuminous; a fact first noticed by my friend Dr. Lever,[92] and meeting with a ready explanation from the probable existence of pressure on the emulgent veins, a condition which the late researches of Dr. Robinson[92] have shown to be capable of producing congestion of the kidney, and serous urine.

Where blood is present in large quantity, or coagula are mixed with the urine, hæmorrhage from some breach of surface is indicated; and the immediate cause of this, whether a ruptured vessel from excessive congestion only in any part of the urinary organs, the irritation of a calculus, mechanical violence, or malignant disease, as fungoid degeneration, can alone be made out by a careful examination of the existing symptoms.

241. *Therapeutical indications.*—These will vary according to the immediate cause producing the sanguineous or albuminous effusion. Of course, where active hæmorrhage exists, the treatment will be directed by the view taken by the practitioner of its immediate exciting causes. Absolute rest, the local application of cold to the hips and loins, the relief of congestion of the kidneys by local or general blood-letting, free action on the bowels by saline (sedative) purgatives, with dilute acids, will constitute the essential part of the therapeutic agents. The administration of the acetate of lead is frequently of great service, but it should be administered boldly, and in tolerably large doses, for a *short* time; a

plan far more effectual than that generally followed, of giving small doses for a longer period. In doses of three or four grains, with one-fourth of a grain of opium in a pill, repeated every two hours until six or eight doses are taken, this remedy is very successful. I, however, prefer administering the lead in solution; in this form it is readily taken by the patient, and seems to act most efficiently, as in the following formula.

℞. Plumbi acetatis, gr. xxiv.
Aceti destillati, f℥j.
Syrupi papaveris, f℥j.
Aquæ rosæ, f℥iij.
—— destillatæ, f℥iv. M. fiat mistura
Cujus sumat æger coch. ij. magna omni secundâ horâ.

If care be taken to keep the bowels acting by a saline purgative, no fear of any unpleasant consequences from the lead need be apprehended, during the period required to give it a fair trial. The gums should, however, be watched, and if the blue edge described by Dr. Burton[94] be seen, the medicine must be at once given up.

242. No remedy has, however, appeared to me to be of such extraordinary value in the treatment of hæmaturia as gallic acid. I have seen this drug arrest for many weeks bleeding from an enlarged (and fungoid ?) kidney, after all other remedies had failed. It should be given in doses of five grains in a draught, with mucilage, and a little tinct. hyoscyami, and repeated at short intervals. This drug really acts as a direct astringent, reaching the capillaries of the kidney, and finding its way into the urine, which soon becomes so impregnated

with it, as to be changed into ink on the addition of a few drops of tinctura ferri sesqui-chloridi.

I believe it to be very important to take every precaution that tannic acid or tannin is not substituted for gallic acid. Closely allied as these bodies are, and readily as the former is converted into the latter, merely by a few hours' exposure of its solution to the air, still there is great reason to believe that tannin is never absorbed into the circulation. Professor Mulder[182] has explained this on the power it possesses of coagulating albumen, and hence, unless it undergoes some previous change, it cannot possibly circulate in the blood, as it would immediately coagulate it. Mulder has declared his belief that if the astringent matter present in two ounces of cinchona bark could, by any possibility, be absorbed into the blood, it would, in this manner, produce instant death.

243. When the only constituent of blood present in the urine is albumen, the treatment will vary according to whether the kidney is merely congested or structurally affected. The treatment of the latter class of cases has been fully detailed elsewhere, [95] so that it is unnecessary for me to give any account of it. The treatment of the acute stage of congested kidney, occurring in children in the dropsy after scarlet-fever, when the urine is albuminous, and dingy from the presence of red particles, is in the great majority of cases so successful and uncomplicated, that it is important to allude to it.

I may remark, as a prophylactic remedy, that the warm-bath is invaluable; I scarcely recollect, even in a large experience, a case of dropsy after scarlet-fever occurring, when the warm-bath was daily used as soon as the skin began to exfoliate, and continued until a perspiring healthy surface was obtained. When anasarca has occurred, strict confinement to bed, or at least to a warm room, must be enjoined, the warm-bath used twice a week, and a free action on the skin encouraged. The bowels should be kept acting by the pulvis jalapæ compositus, and the antimonii potassio-tartras administered in doses varying from one-twelfth to one-eighth of a grain, four or five times in the twenty-four hours, according to the age and strength of the patient. A bland and nearly fluid, but moderately nutritious, diet should be enjoined. This plan must be continued until all anasarca has vanished, a supple and perspiring surface obtained, and urine free from albumen. The remedies may then be gradually left off, a more nutritious diet allowed, and the ammonio-citrate of iron administered thrice daily, in doses of three to five grains, to remove the anæmiated state of the patient. On leaving the bedroom, a flannel-waistcoat, extending to the loins, should be worn for some time. This treatment has been almost invariably successful in every case I have employed it, and I may remark that I have never in these cases witnessed the excessive prostration said by some to be the almost necessary result of the employment of antimony in the diseases of children.

PURULENT DEPOSITS.

244. Pus is not unfrequently met with in the urine, as the result of suppuration of the kidney, or of some portion of the genito-urinary mucous membrane, or of ab-

scesses from adjoining viscera or abnormal growths, bursting into the urinary cavities. There is said also to be occasionally another source of purulent matter in the urine, viz., when a vicarious discharge of pus occurs from the kidneys. Many pathologists, especially in Germany, have declared their belief in the frequent occurrence of this phenomenon, and cases have been recorded of empyema disappearing contemporaneously with the discharge of purulent urine. The subject is, however, still obscure, and any opinion must in the present state of our knowledge be given with caution (247).

At present, however, there does not exist a single satisfactory proof that bodies, the size of pus-particles, can ever enter or escape through the walls of capillary vessels without breach of structure. In all cases where a purulent deposit is really absorbed into the circulation, independently of breach of surface, it is, in all probability, first metamorphosed into soluble products (270).

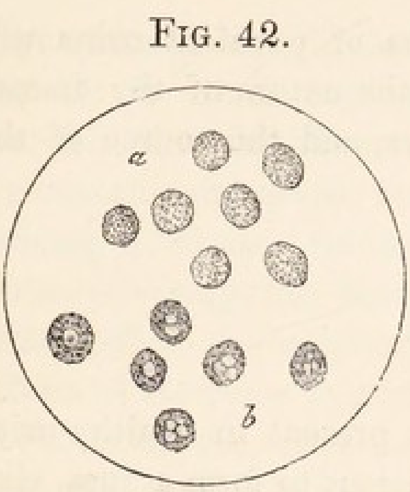
245. *Characters of urine containing pus.*—Generally acid or neutral, unless long kept, and slow to assume putrefactive change. By repose, pus falls to the bottom, forming a dense homogeneous layer of a pale greenish cream colour, seldom hanging in ropes in the fluid like mucus, and becoming by agitation uniformly diffused through it. The addition of acetic acid neither prevents this diffusion, nor dissolves the deposit. If a portion of the deposited pus be agitated with an equal quantity of liquor potassæ, it forms a dense translucent gelatinous or mucous mass, often so solid that the tube can be inverted without any escaping;[96] a character which constitutes the best test for the presence of pus. On decanting some urine from the deposited pus, the presence

of albumen can be detected by heat and nitric acid (237). When pus is agitated with ether, a quantity of fat is dissolved, which is left in the form of yellow butter-like globules, when the ether is allowed to evaporate in a watch-glass.

If the urine containing pus happens to be alcaline and to contain free ammonia, the character of the deposit is completely altered, becoming viscid, not readily diffused by agitation through the fluid, and resembles in appearance some varieties of mucous deposits. The detection of albumen in the supernatant fluid by the addition of nitric acid, and the conversion of the deposit into a white granular mass, destitute of its previous viscidity by the addition of acetic acid, will generally enable a safe opinion as to the nature of the deposit to be arrived at. A source of fallacy may occur in the urine of women, which may be supposed to contain pus, merely from an admixture of leucorrhœal or other vaginal discharges. In such specimens, traces of albumen can generally be detected in the urine, whilst the deposit, instead of presenting the dense homogeneous layer so characteristic of pus, is flocculent and granular; although often extremely copious, and readily gelatinising with liquor potassæ.

246. *Microscopic characters of pus.*—This substance consists essentially of round granules, or particles rather larger than blood-corpuscles, floating in an albuminous fluid, or *liquor puris*, differing essentially from *liquor sanguinis*, in the absence of a spontaneously coagulating power. When a drop of a purulent fluid is placed under the microscope, the particles become visible; they are white, roughly granular exteriorly, and are much more

FIG. 42.



opaque than blood-corpuscles (Fig. 42, *a.*) On the addition of a drop of acetic acid, the interior of the particle becomes visible, and is found to be filled with several transparent bodies or nuclei, as shown in the figure at *b.* Hence pus is usually considered as a regularly organised body, consisting of a granular membrane enveloping transparent nuclei; being in fact a nucleated cell. The microscopic examination of a suspected purulent deposit is essential, for, as we have seen, phosphatic sediments will sometimes so closely resemble pus, as to deceive a practised eye (188).

247. *Pathological indications.*—Whenever pus occurs in urine, it generally indicates the existence of suppurative inflammation in some part of the urinary apparatus. It must, however, never be forgotten that an abscess from any adjoining viscus, may discharge its contents by an ulcerated opening into the pelvis of a kidney or into the bladder. Suppuration in a more distant organ will often, by burrowing under the peritoneum or through muscles, be discharged by the urinary apparatus. An empyema has thus been known to find its way to the kidney, emptying itself through an ulcerated opening, and be discharged with the urine. This is in all probability the mode in which the purulent contents of a diseased pleura have escaped, in the supposed cases of metastatic discharges of pus from the kidney, which have lately been published on the continent (244).

The therapeutical indications of purulent urine will of course strictly depend upon the nature of the disease under which the patient labours, and the source of the suppuration.

MUCUS.

248. The quantity of mucus present in healthy urine is very small, being merely sufficient to form a just visible cloud. When collected on a filter it dries, forming a thin varnish-like layer.

Characters of urine containing an abnormal proportion of mucus.—The quantity of mucus in urine may vary under the influence of different degrees of irritation or inflammation, from a mere flocculent cloud to the production of a fluid so viscid and tenacious, as to be capable of being poured from one vessel to another in a continuous rope.

Urine containing a deposit of mucus is generally alcaline, and soon undergoes a putrefactive change, becoming ammoniacal even in the bladder, if long retained. If the urine itself be acid when first voided, the mucus it deposits will always restore the blue colour of reddened litmus. Thus a specimen of urine will frequently redden litmus-paper, and the blue colour will be restored by allowing it to sink into the mucous deposit at the bottom of the vessel.

Indeed, as a general rule, all mucous secretions exert an alcaline action on faintly reddened litmus-paper, a condition which becomes better marked under the influence of inflammatory action however slight. In common cynanche tonsillaris, in which the infusum rosæ compositum is often used as a gargle, nothing is more common than to observe the red mixture ejected from the mouth quite green, the white fur on the tongue presenting a similar colour, the quantity of alcali in the mucus covering the fauces and tongue, being sufficient to neutralize the sulphuric acid, and to change the red colour of the roses to green.

Providing the urine is even slightly acid, a deposit of pus and mucus may be readily distinguished, as the former will appear as a homogeneous opaque layer, readily miscible by agitation with the urine; whilst the latter will appear gelatinous and hang in irregular masses, often entangling large air-bubbles, and no agitation, however violent, can completely mix it with the urine. There can never be any difficulty in distinguishing between purulent and mucous deposits by simple inspection, unless the urine be alcaline (201); or a large quantity of earthy phosphates (190) be mixed with the mucus, which thus acquires great opacity, and may be readily mistaken for pus without microscopic examination.

249. The action of acetic acid on mucus is very characteristic, and is of great value in discriminating between that fluid and pus. When a fluid containing the former is mixed with acetic acid, the fluid part of the mucus in which the particles float, coagulates into a thin semi-opaque corrugated membrane, presenting an appearance so peculiar, that once seen it can never be mistaken.

Mucus contains no albumen in a state allowing of coagulation by heat or nitric acid (237); hence simply mucous urine can never be albuminous like pus (245) unless the albumen be derived from some other source.

Agitated with ether, mucus gives up but mere traces of fat, and in this respect also differs from pus.

250. *Microscopic characters of mucus.*—Mucus, like pus, is composed of granular round particles, floating in a fluid, which is viscid and glairy, and does not contain uncombined albumen. Under the microscope, it is nearly, if not quite, impossible to distinguish between the pus and mucous particles—in fact, it may be questioned whether they are not identical. Where mucus and pus essentially differ is not in the nature of the particles, but in the fluid secreted with them, and in which they float; the *liquor puris* being albuminous and coagulable by heat (245), the *liquor muci* not being affected by it. Treated with acetic acid, the mucous particle exhibits the internal nuclei just as pus does (246). The particles are by no means so numerous as in the latter, and are perhaps not quite so distinctly granular; a rather higher magnifying power being required to show satisfactorily the granular surface of the mucus, than of the pus particle. Even this slight distinction may depend rather upon the greater refractive power of the fluid part of the mucus, concealing the irregularities on the surface of the mucous particle from ready observation, than upon any real difference between them.

251. *Pathological indications of mucous deposits.*—Their general indication, that of an irritated or inflamed state of the genito-urinary mucous membrane, which may be excited by a variety of causes. Independently of *idiopathic* acute or chronic cystitis, certainly rare affections, the mucus may be the result of the disease termed

cystorrhœa, probably really a low form of chronic inflammatory action, in which a large quantity is poured out from the mucous membrane of the bladder, and gives great distress by producing much irritability of the viscus, and interfering with the free flow of urine. Mucous deposits are more generally symptomatic of some mechanical cause irritating the vesical mucous membrane, as the presence of a calculus, or the existence of a stricture in the urethra, or of some other mechanical obstruction to the free escape of urine. Cystorrhœa, accompanied by a copious secretion of phosphates by the vesical mucous membrane, has been already alluded to (218).

252. The treatment of mucous urine must strictly depend upon the nature of the exciting cause. It can never be treated as a special affection, except perhaps in cases of cystorrhœa or chronic cystitis, when much advantage is gained by the employment of certain remedies which are supposed to exert a specific action over the secreting function of the mucous membrane of the bladder. This specific action, after all, generally depends upon the astringent element of the drug reaching the urine, and thus acting nearly as directly as an injection of alum into the vagina does in leucorrhœa. Most of the vegetable astringents containing gallic acid are here available, but some have obtained a more especial reputation, from their containing some elements which enable them to fulfil more than one indication, and hence become applicable in particular cases. Among these, the leaves of the arctostaphylos uva ursi, barosma* crenata, chimaphila umbellata, and root of the pareira brava, are the most celebrated. Although these are often prescribed,

* Diosma of the Pharmacopœia.

as if they all acted in the same manner, in checking the excessive mucous secretion, yet each fulfils a second indication which never should be lost sight of. Thus we find in the—

Uva ursi, a simple astringent, but slightly diuretic.

Chimaphila, a less active astringent, but freely stimulating the kidneys.

Barosma, a stimulating tonic, diuretic, and diaphoretic; whose active principle (volatile oil) is excreted by the kidneys.

Pareira, a narcotic? tonic diuretic.

253. When microscopic examination of the mucus has shown that an excessive elimination of phosphates does not exist, the irritability of bladder and cystorrhœa are remarkably relieved by the administration of alcalies, especially of the bicarbonate of potass (℈j.) or liquor potassæ (♏xx—ʒj.) with a sedative, as tinct. hyosciami (ʒss.), in an infusion or decoction of one or other of the above drugs. When the earthy salts are copiously excreted, the dilute phosphoric acid (ʒss.) may be advantageously substituted for the alcalies. Although it must not be supposed that the presence of a moderate quantity of phosphatic deposit with the mucus necessarily contraindicates the administration of alcalies. We have already seen that the alcaline state of urine and deposition of earthy salts is a result of the action of an unhealthy mucus secreted by the bladder upon the urine (202). When the administration of alcalies is capable of controlling the secretion of mucus, these remedies

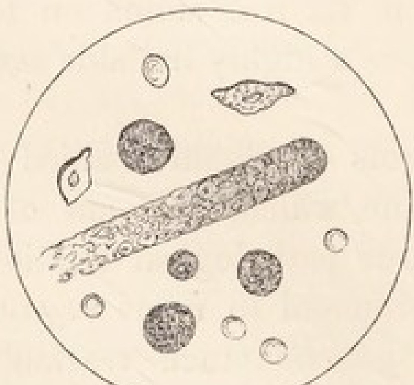
will lessen and even remove the earthy deposits instead of increasing them, by checking the formation of the substance which induced their precipitation. In several cases I have seen marked relief follow the use of benzoic acid (gr. ix.) given in dec. pareiræ (℥iss.) with a minute dose of acetate of morphia (gr. $\frac{1}{8}$—$\frac{1}{4}$). In one very severe case, which was for some time under the joint care of my colleague Mr. Cock and myself, in which such an enormous quantity of alcaline purulent mucus was secreted from a chronically inflamed bladder that micturition was often quite prevented from the urethra becoming temporarily blocked up with the secretion, so much temporary relief was afforded by this medicine that the patient declared he could not make water without it.

The pareira indeed, as remarked by a high authority, Sir Benjamin Brodie,[97] is of the greatest use, where the mucus is copious and opaque, and the distress of the patient, from a constant desire to empty the bladder, considerable. In mild cases, where the normal character of the mucus is scarcely changed, we may employ the uva ursi; the chimaphila being preferred if the kidneys are inactive. The barosma, from its free action on the skin, being of most service where a highly irritable state of kidney or bladder exists.

254. There are two other forms of globules allied to mucus occasionally found in urine, which, for want of a better name, and until their true pathological relations are better understood, I have proposed to name *organic globules*. *The large organic globule* much resembles the mucous particle or globule, being composed of a granular membrane investing a series of transparent

nuclei which become visible on the addition of acetic acid. In some, two nuclei of a crescentic shape, with their concavities opposed, are alone seen. I know of no character by which these bodies can be distinguished from pus or mucus, excepting that they are unaccompanied by the characteristic albuminous (245) or glairy fluids (250) in which the pus and mucous particles respectively float. The large organic globules seldom form a visible deposit, being free and floating in the urine, and are generally so scattered that not more than a dozen or two are visible at one time in the field of the microscope. They are abundant in the urine of pregnant women, especially in the latter months, and when there is a frequent desire to empty the bladder. They have existed in every case of ardor urinæ I have examined, although irritability of bladder was not *necessarily present*. In the latter disease, however, they abound. The globule under consideration occurs in the greatest abundance in the albuminous urine of confirmed morbus Brightii. I have seen them so abundant as to cause a drop of the urine to resemble, when microscopically examined, diluted pus, a resemblance rendered more close by the albuminous character of the urine. Is it possible that these globules may here be indicative of subacute inflammatory action going on in the structure of the kidney? I am not aware whether they are quite identical

Fig. 43.



with what have been termed the exudation or inflammatory globules of Gluge. The marginal figure, copied from one by Simon in his Beytrage, accurately shows the common microscopic appearance of deposits in the urine of morbus Brightii. The large dark bodies are organic globules; mixed with them are seen altered blood-discs and epithelial cells, the latter, as shown from some late researches of Dr. G. Johnson, frequently containing globules of fat (278), whilst a tubular mass of coagulated albumen, probably the cast of a uriniferous tubule, entangling granules (237*) and blood-discs occupies the centre of the figure.

255. *The small organic globules* are very beautiful microscopic objects. These little bodies are very much smaller than the pus or mucous particles, and are essentially distinguished from them by the absolute smoothness of their exterior, no trace of granulation being visible even with a high magnifying power. I have never been able to detect a nucleus, or any other sign of definite structure, except their well-defined figure. In hot acetic acid they are quite unchanged. On the slightest agitation they roll over each other with the utmost facility, which their perfectly spherical figure readily permits.

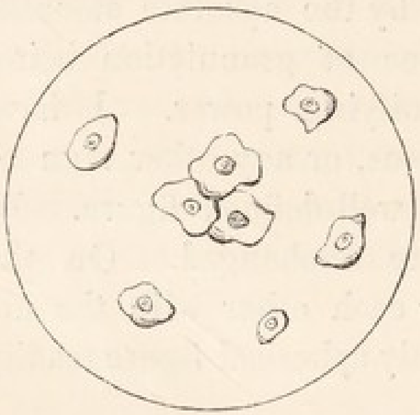
These globules form a visible white deposit, resembling to the naked eye a sediment of oxalate of lime.

So rare are these curious little bodies, that but three examples of them have occurred to me; in two, the urine was passed by women during menstruation. It is just possible that they may really be nuclei of some larger nucleated cell, as pus or mucus, and have escaped by the bursting of the investing membrane, or sac of the cell.

EPITHELIUM.

256. The epithelial covering of the genito-urinary mucous membrane is, like the internal skin, constantly experiencing the effects of wear and tear, causing a more or less rapid exfoliation of epithelial cells. These are sometimes partly broken up so as to appear like patches of membrane-like mucus, and often are irregularly lacerated. Most generally, however, a certain number are entire, and can be readily recognised by their microscopic characters, being either regularly oval, or irregularly angular flattened cells; containing a well-marked central nucleus, often appearing, if the focus be not properly adjusted, to project like the central boss of a shield (Fig. 44). These cells sometimes contain fat globules, and when existing in any quantity, have been stated to be pathognomonic of morbus Brightii (278). The exfoliation of epithelium sometimes is very considerable, so as to give rise to a copious deposit in the urine which to the naked eye resembles mucus; but may be readily distinguished by the absence of all viscid qualities. When oxalate of lime exists in the urine, an abundance of epithelium is generally found, and indeed has often, from its presence,

FIG. 44.



induced me to examine specially for that substance (170).

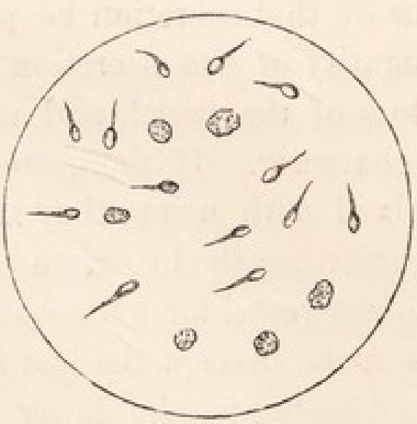
SPERMATOZOA.

257. Spermatic animalcules are by no means very unfrequent in urinary deposits; a few being occasionally found on examining microscopically the inferior portions of the urine of the male adult, after allowing it to repose for some time in a glass vessel. In some cases, however, a sufficient quantity of spermatic fluid is found mixed with the urine to form a visible cloud, and becomes an important guide to the practitioner in the investigation of a case perhaps previously obscure.

Diagnosis of spermatic urine.—If a small quantity of spermatic fluid is present in urine, it may easily be passed over and mistaken for mucus, from which there is no character, independent of microscopic examination, capable of distinguishing it. If, however, we have a specimen of urine passed by a man which is cloudy and opalescent, reddens litmus-paper, and does not become clear on the application of heat or nitric acid, the presence of spermatic fluid may be at least suspected, especially if the characteristic odour of that secretion be perceptible. Should a larger quantity of the secretion be present, it subsides to the bottom of the vessel, and may be recognised by its physical character. If mere traces of spermatic liquor only are mixed with urine, they may easily be detected by violently agitating the urine, and allowing it to repose in a conical glass vessel for a few hours. On carefully decanting all the urine except the last few drops, the spermatozoa may be detected in the latter by the microscope. The addition of nitric acid will often produce a slight troubling in this urine. M. Lallemand[106] describes spermatic urine as opaque and thick, as if mixed with gruel, with a fœtid and nauseous odour, characters sufficiently common in ammoniacal urine (202), but certainly by no means, at least in this country, necessarily or generally characteristic of urine containing spermatozoa. In fact, an abundance of these little organisms may be present, without modifying materially the physical characters of the urine.

258. *Microscopic characters of spermatic urine.*— No character can be assumed as distinctly diagnostic of the presence of semen in urine, except the discovery of the spermatozoa. These minute beings never occur living in urine, unless protected by the presence of a deposit of pus, in which they retain their power of moving for a long period after emission. Urine appears to be immediately fatal to their vitality, but exerts no further action upon them, as they may be detected scarcely changed even after it has become ammoniacal. An object-glass, of one-eighth of an inch focus, should be used for the detection of these minute bodies. The drop of urine chosen for examination should be taken from the bottom of the containing vessel, placed on a slip of glass, and covered with a piece of mica or thin glass. The spermatozoa will be observed as minute ovate bodies, provided with a deli-

FIG. 45.



cate bristle-like tail, which becomes more distinct on allowing the drop of urine to dry on the glass (Fig. 45). Mixed with these are generally found round granular bodies, rather larger than the body of a spermatozoon, and nearly opaque from the numerous asperities on the surface of the investing membranes? These appear to be identical with the seminal granules described by Wagner[107] and others.

259. Well-defined and often large octahedra of oxalate of lime (165) are of common occurrence in spermatic urine. The connexion of this saline body with the presence of spermatozoa was first pointed out to me in a private communication with which I was favoured by Professor Wolff, of Bonn. Very lately M. Donne has stated, as the result of his observations, that they frequently occur together, and that the presence of oxalate of lime is a constant indication of the existence of spermatorrhœa. This statement is quite opposed to my own experience, for although in the latter disease oxalate of lime often exists, yet this salt constantly occurs where no suspicion of an escape of semen can be entertained (179).

260. *Pathological indications.*—Whenever spermatozoa, or spermatic granules, are detected in the urine, it is quite certain that the seminal secretion must have been mixed with it. The causes of this admixture are numerous, for it must be recollected that if the bladder be emptied even some time after a seminal emission, a sufficient number of spermatozoa will remain in the urethra to be washed away with the urine, and cause it to assume the ordinary microscopic character. A certainly not unfrequent cause of the escape of semen is extreme consti-

pation, for after the passage of hard and scybalous fæces, an oozing of fluid from the urethra, full of spermatozoa, is not uncommon. In some cases of stricture of the urethra, anterior to the orifices of the seminal ducts, an accumulation of semen may, upon sexual excitement, collect, and flowing into the bladder be voided subsequently with the urine. An admixture of semen with the urine may occur occasionally in paraplegia, in persons reduced in health by excessive indulgence in intercourse, or by even less creditable modes of producing excitement of the sexual organs.

261. *Therapeutical indications.*—The irritable state of the nervous system, the depressed general health, and in some cases the appearance of epilepsy, or of symptoms not unlike mild forms of delirium tremens, and characterised by the most abject melancholy and despondency; are familiar to all, as the effects of the too copious and frequent excretion of seminal fluid, whether excreted or involuntary. To this ailment, spermatorrhœa, as it has been named, great attention has been lately drawn by M. Lallemand, and by several writers in the English weekly medical journals. That the detection of spermatozoa in the urine will often enable the physician to detect a source of exhaustion previously concealed from him, and baffling his treatment, is unquestionable; but that this matter really merits all the verbose attention lately lavished upon it, is not so evident. It certainly is not very consistent with our national character, to dilate so freely upon a subject which, in the great majority of cases, can be treated of only as the effects of a most degrading vice.

In the treatment of spermatorrhœa, it appears necessary to examine the therapeutic means to be employed in two points of view; as curative of the involuntary discharge, and of the habits keeping it up. The first indication is best fulfilled by attending to the general health, by cold hip-baths, or by dashing cold water over the genitals: by the use of astringent injections into the urethra, or the application of solid nitrate of silver to that part of the canal where the seminal ducts open, as recommended by Lallemand and Mr. B. Phillips. The use of iron, persisted in for some time, with a little quinine, and a careful use of purgatives, will greatly expedite the recovery of the patient. The second indication is fulfilled by an influence on the moral feelings of the person, and if these have no effect, the application of a blister, or croton oil, to the prepuce, or in some cases circumcision, will be found available in breaking through an iniquitous and injurious habit.

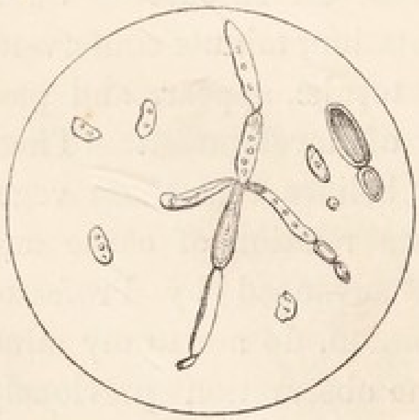
TORULÆ.

262. It is well known that in all saccharine fluids undergoing the alcoholic fermentation, minute confervoid, or fungoid vegetations, called torulæ, appear, and pass through certain definite stages of development. There is indeed considerable reason to believe that these vegetations bear to fermentation the relation of cause and effect. The arguments lately advanced by Professor Liebig in opposition to this opinion, do not to my mind afford a satisfactory answer to the observations previously made on this subject.

When urine contains but very small portions of sugar, too little even to affect its specific gravity materially, or to cause it to assume a diabetic character, certain phenomena are developed connected with the production of the vegetation of the genus torula or saccharomyces, which will at once point out the presence of sugar. These indications are of very great value, as a saccharine condition of the urine is not uncommon in dyspepsia, and some other affections, and is of course of the highest importance in directing our treatment.

263. When saccharine urine is left in a warm place, a scum soon forms on its surface, as if a little flour had been dusted upon it. This consists of minute oval bodies which soon enlarge from the development of minute granules visible in their interior. These continue expanding, and dilate the oval vesicle containing them into a tubular form; soon afterwards the internal granules become larger and transparent, and project from the exterior of the parent vesicle like buds. The whole then resembles a jointed fungoid or confervoid growth, which ultimately breaks up; and a copious deposit of oval vesicles or spores, fall to the bottom. All these stages of development (Fig. 46) require but a few hours for their completion. If the deposited spores be placed in weak syrup, they rapidly germinate, and exciting fermentation, produce a new crop of torulæ. During the

FIG. 46.



growth of the torulæ, bubbles of carbonic acid gas are evolved, and the urine at length acquires a vinous odour, sometimes accompanied by an odour of butyric acid. There are two kinds of urine which may be mistaken for saccharine, by the occurrence of a kind of fermentation, not unlike that of fluids really containing sugar. I refer to the from of viscous[108] fermentation which occurs in urine and ending in the appearance of much ropy mucus. This has occurred to me repeatedly in specimens of urine containing cystine, the odour evolved being, however, disagreeable and sulphureous, quite distinct from the vinous odour of the alcoholic fermentation. Somewhat similar phenomena are occasionally presented by the urine of persons exhausted in health from scrofulous, or syphilitic cachexia.

264. The presence of sugar once suspected, may be easily proved by analysis or the application of tests.[109] If a moderate quantity of sugar exists, the urine may be evaporated to an extract and digested in hot alcohol; when cold, the tincture should be decanted and allowed to evaporate spontaneously in a cylindrical vessel (a cupping-glass answers very well). In this way white granular masses of sugar will crystallise on the sides of the glass, whilst if the evaporation be expedited by heat, crystals are obtained with great difficulty, and often not at all, until the urea and other organic ingredients have been got rid of by a tedious process.

265. The most trustworthy tests for the detection of sugar in urine depend for their action upon the reducing action of sugar on salts of copper, or upon the decomposition of the sugar by alcalies.

1. *Trommer's test.*—Add to the suspected urine in a

large test-tube just enough of a solution of sulphate of copper, to communicate a faint blue tint. A slight deposit of phosphate of copper generally falls. Liquor potassæ must then be added in great excess; a precipitate of hydrated oxide of copper first falls, which *redissolves in the excess of alcali,* if sugar be present; forming a blue solution like ammoniuret of copper. On gently heating the mixture to ebullition, a deposit of red suboxide of copper falls if sugar be present.

Several objections have been made to this test, on the ground that mere uric acid is sufficient to reduce the copper, and thus introduce a serious source of fallacy. I confess that I have never met with any variety of urine which completely produced the above described phenomena with the test unless sugar existed. I believe the solubility of the precipitate first produced by liquor potassæ in an excess of the precipitant, and its depositing a dense red cupreous precipitate by heat, to be quite characteristic of sugar. This dense red deposit is very different from the light orange-coloured flocculent clouds which slowly subside when non-saccharine urine is employed.

2. *Capezzuoli's test.*[110]—Add a few grains of blue hydrated oxide of copper to urine contained in a conical glass vessel, and render the whole alcaline by the addition of liquor potassæ. If sugar be present, the fluid assumes a reddish colour, and in a few hours the edge of the deposit of oxide acquires a yellow colour which gradually extends through the mass, from the reduction of the oxide to a metallic state (suboxide ?).

3. *Moore's test.*[113]—This very easily applied and excellent test was lately proposed by Mr. Moore, of the

Queen's Hospital, Birmingham, and depends for its action on the conversion of colourless diabetic (grape) sugar into brown melassic (or perhaps sacchulmic) acid under the influence of a caustic alcali. Place in a test-tube about two drachms of the suspected urine, and add nearly half its bulk of liquor potassæ. Heat the whole over a spirit-lamp, and allow actual ebullition to continue for a minute or two; the previously pale urine will become of an orange-brown, or even bistre-tint, according to the proportion of sugar present. The subsequent addition of an acid generally causes the evolution of an odour of boiling molasses. This test appears to be remarkably free from sources of fallacy, as boiling with liquor potassæ rather tends to bleach non-saccharine urine than to deepen its colour.

4. *Pettenkofer's test.*—This is founded on the production of a violet colour when sulphuric acid and bile are mixed with a saccharine fluid. I believe it to be so far inferior both in facility of application and accuracy of its indication to the last-mentioned test that it is unnecessary to give any further account of it than has already been done when pointing out the diagnostic indications of bile (238).

5. *Polarised light.*—The apparatus for applying this test has been already described (49).

VIBRIONES.

266. Minute animalcules, belonging to the genus Vibrio (V. Lineola ?[111]), are occasionally developed in urine, so soon after passing as to lead to the idea that

their germs must have existed in the urine whilst in the bladder. All the urine in which I have found these minutes creatures has been pale, neutral, of low specific gravity, and rapidly underwent the putrefactive fermentation.

When a drop of such urine is examined under the microscope between plates of glass with an object-glass of one-eighth inch focus, it will be found full of minute linear bodies hardly so long as the diameter of a blood-corpuscle (about $\frac{1}{3000}$ inch) moving with great animation. The motion is of an oscillating character, and strong enough to excite tolerably rapid currents in the fluid. Even under a very high magnifying power, no satisfactory evidence of organisation can be detected in these minute beings.

267. I have only met with these animalcules in the urine of persons in an excessively low and depressed state. In cases of syphilitic cachexia, where the prostration of the strength is extreme, and in mesenteric diseases, I have repeatedly found them abundantly developed, with remarkable rapidity. They appeared in great abundance in the urine of a patient under my care at Guy's Hospital during the past summer. The subject of this case was a most miserable looking young man, who entered the hospital half-starved, and labouring under polydypsia, passing a very large quantity of urine of low specific gravity. He died of rapid phthisis in a few weeks, the urine became full of vibriones in active motion a few hours after being passed.

MILK.

268. No satisfactory case is recorded by any observer of credit, in which milk has been discovered in the urine; although there are few who have devoted themselves to investigations connected with the pathology of the urine, but have met with urine rendered opaque by the fradulent admixture of milk,—a piece of deception occasionally practised by persons who labour under the unintelligible delusion of wishing to appear the subjects of some marvellous disease. All the cases of milk-like urine where no fraud has existed, are instances of phosphatic (183), purulent (245), or fatty (277) urine. Although milk itself does not occur in urine, yet there can be little doubt that some of its elements may be met with in it, by a kind of vicarious action of the kidneys, in the same manner that bile is. It must be remembered that milk consists of globules of fatty or oily matter floating in a fluid or serum in which a peculiar protein-compound, *casein*, is dissolved. This substance is distinguished from other protein-principles by the action of acetic acid, which immediately coagulates it, producing the well-known curd, the basis of cheese. The most interesting subject connected with the supposed presence of this substance in the urine, is its apparent connexion with utero-gestation; and its temporary occurrence when an obstruction occurs to the ready escape of milk from the breast.

269. An account of the supposed discovery of a peculiar mucilaginous principle in the urine of pregnant

women appeared a few years ago in several of the British and Foreign Medical Journals,[99] and attracted much notice as a diagnostic sign of pregnancy. This new constituent of the renal secretion, to which the name of *Kiestein* was applied, was stated to exist in the urine of the human female during utero-gestation, and to become visible when the secretion is allowed to repose in a cylindrical vessel, in the form of a cotton-like cloud, which in a lapse of time, varying from the second to the sixth day of exposure, becomes resolved into a number of minute opaque bodies, which rise to the surface, forming a fat-like scum, remaining permanent for three or four days. The urine then becomes turbid, and minute flocculi detach themselves from the crust, and sink to the bottom of the vessel: this action continues until the whole pellicle disappears. This crust of Kiestein was stated to be distinguishable from analogous pellicles which occasionally form on the surface of urine, from its never becoming mouldy, or remaining on the surface beyond three or four days from the time of its complete formation.

270. This subject appeared of sufficient importance to justify a minute investigation, the results of which were published in the Guy's Hospital Reports for 1840. As nothing has appeared since, to induce me to modify the opinions I then made public, I now republish the most important part of these remarks.

The first specimen of urine submitted to examination was some voided by Catherine Shaw, aged 28, a married woman in the sixth month of pregnancy, admitted under my care at the Finsbury Dispensary, on October 17th, 1839, for a slight attack of bronchitis. The urine was passed immediately on rising from her bed: it was tolerably copious, pale, acid, and rather opaque, of sp. gr. 1.020. About half a pint of it was placed in a glass cylinder, covered with paper. After two days' repose, it became very much troubled: numerous globules, presenting a fatty or greasy aspect, appeared on its surface: in two days more the urine became completely covered with a pellicle, very closely resembling that which forms on the surface of mutton-broth in the act of cooling: on the sixth day of exposure, this crust broke up, and fell to the bottom of the vessel. On the 26th of October, this patient, then convalescing from her bronchial affection, again sent me a specimen of the urine, voided as before, immediately after awaking from sleep; and the very same results were obtained; the pellicle of fat-like matter being, however, much thicker. On November 30th, the urine was again exposed, with precisely identical results.—Although in this woman the phenomena presented by the urine were tolerably constant, yet it became an important matter to determine whether such appearances were not to be met with in the urine of women who were not pregnant, and whether they were constant in every case of utero-gestation. To determine the latter question was, within certain limits, somewhat easier than the former: for this purpose, every pregnant woman who came under my care at the Finsbury Dispensary, or among my out-patients at Guy's Hospital, was desired to furnish specimens of urine, passed after awaking from sleep: this request was not in every instance complied with; but during the months of November and December, specimens from about thirty women, in the third to the last month of pregnancy, were obtained; and in every case, with but three exceptions (to which I shall hereafter allude,) copious fat-like pellicles were observed, after two or three days' exposure. The three women, whose cases thus appeared to be exceptions to the general rule, were all affected with inflammatory fever accompanying severe catarrh. Their urine was turbid with urate of ammonia. On the disappearance of the latter by the convalescence of the patients, the phenomena characteristic of pregnancy appeared.

271. Whilst collecting these specimens of the urine of pregnant women, I directed several young women, who presented themselves to be treated for amenorrhœa, to bring specimens of their urine; which were exposed simultaneously with those furnished by the pregnant women;—and in two instances only, was any evidence of the presence of the peculiar matter manifested. In one, a servant-girl of 18 years of age, I strongly suspected pregnancy, from the appearance of the areola around the nipple; but she was so much annoyed at my questioning her on this point, that she ceased to attend. The second case was more satisfactory: it was that of a stout, tall, unmarried woman, a servant, aged 33, who came under my care, November 7th, 1839, suffering from cough, apparently depending upon deranged digestive functions, and relaxed uvula: she had not menstruated since the preceding May, and attributed the disappearance of the catamenia to exposure to cold. She had morning sickness, and the veins of her lower extremities were varicose. On examining the abdomen, no evident enlargement of the uterus could be observed, in consequence of the parietes being loaded with fat;

and on looking at the breasts, the nipples were found surrounded by a large purplish-brown areola. On being charged with pregnancy, she obstinately denied it: but admitted having been the mother of an illegitimate child eleven years previously. She declared that she had preserved absolute chastity since that period, and wept bitterly at my (as she termed them) unjust suspicions. I procured a specimen of her urine, and exposed it in a lightly-covered glass cylinder: in two days, a dense pellicle of fat-like matter formed on its surface: this increased in thickness during three days, and then evolved so powerful an odour of putrefying cheese, that I was obliged to throw it away. Five months later this woman was delivered of a male child.

The odour of putrescent cheese remarked in this case, is by no means unfrequent in those specimens of urine in which the pellicle is very thick.

272. None of the specimens of urine voided by pregnant women, that I examined, were coagulable by heat, nitric acid, or, with but two or three exceptions, by acetic acid, and therefore could not contain any considerable portion of albuminous or caseous matter. The addition of ammonia almost invariably produced a dense deposit of earthy phosphates; and, with the exception of this proof of the existence of an excess of earthy phosphates in the secretion, no appreciable portion of any abnormal ingredients could be detected.

Some of the fat-like pellicle was removed from the surface of urine on which it had formed, by plunging a plate of glass perpendicularly into the fluid, and withdrawing it adroitly, in a nearly horizontal position: an equable layer of the substance was thus procured;

and, when carefully covered with another plate of glass, it could be very conveniently submitted to examination.

The pellicle thus procured, appeared glistening with a lustre like that of spermaceti; when placed under a microscope, and examined with an object-glass of a quarter-inch focal length, myriads of triangular prisms of triple phosphate (191) were seen imbedded in a mass of granular matter, mixed with which, might here and there be seen patches of tolerably regular globular bodies. The prisms of triple phosphate were so beautifully distinct, and their angles so sharply defined, that the whole became a most interesting microscopic object: some of the crystals were placed on end, and thus appeared like triangular plates.

When the urine is kept so long that the pellicle begins to break up, it falls, in the form of a deposit, to the bottom of the vessel. If the supernatant fluid be decanted, and the deposit collected on a slip of glass, it is found to present the same appearance as the pellicle; excepting that the crystals are much more numerous, and all the animal matter present is entirely composed of amorphous granules; all trace of anything like a regular structure being lost.

273. A slip of glass, on which a portion of the pellicle had been collected, was placed under the microscope, and covered with a few drops of acetic acid: the whole became opaque, the crystals were rapidly dissolved, and a white pultaceous mass resulted. On washing the whole with a few drops of water, and carefully drying the residue, the animal matter was left upon the glass in a white opaque layer, in which no trace of crystalline matter was perceptible, upon very minute microscopic investigation.

Another portion of the pellicle, also collected on a glass plate, was placed under the microscope, and a few drops of strong liquid ammonia were added : the crystals underwent no change, but became much more distinct from the opaque matter, in which they were imbedded, undergoing solution. In the course of half-an-hour, the glass was carefully washed with a little water, and again examined; when every trace of animal matter was found to have disappeared, and the crystals of the triple phosphate were alone left.

From these investigations, it is evident that the greasy aspect of the pellicle of the so called *Kiestein* arises not so much from the presence of fat, but from the numerous crystals of triple phosphate, which, from their brilliancy, produce this glistening appearance. Some fatty matter is, however, present, and Lehmann,[100] in repeating these observations, discovered that on digesting the pellicle in ether and allowing the ethereal solution to evaporate, a fat was obtained which closely resembled butter, and when saponified with potass, yielded butyric acid (74) on the addition of sulphuric acid. Dr. Rees[137] has even detected genuine fat globules, precisely like those found in milk. With regard to the nature of the animal matter soluble in ammonia, mixed with these crystals, it is difficult, in the present state of physiological chemistry, to give a positive opinion. It is not mere albumen or casein, although much closer allied to the latter than to any other product of organization I am acquainted with, especially when we connect with its chemical characters the powerful cheese-like odour so frequently evolved, during its development in the urine, in the form of a pellicle. To this view may be objected the circumstance, that the urine yielding it, does not coagulate on the addition of acetic acid: this, however, is by no means an important objection, as milk, when very much diluted with a saline solution, or even water, is not perceptibly troubled by acids. The pellicle may be regarded as possibly constituted of an imperfect caseous matter, mixed with traces of butter and crystals of the ammoniacal phosphate of magnesia. It has been proposed by Dr. Stark to dignify the animal matter present in this mixture with the name of *gravidine,* but we are not justified in considering it as constituting a new organic principle.

There are few products formed during repose in urine which can be readily confounded with this caseous pellicle, if it be borne in mind, that the secretion remains faintly acid up to the moment of the crust breaking up. Which phenomenon seems to depend upon the development of ammonia in the urine, as at that time it acquires distinct alcaline properties. The crust of earthy phosphate, which forms on the surface of all urine by long repose, cannot be mistaken for the pellicle under consideration; as that which destroys the latter, viz. putrefaction, causes the production of the former.

274. If it be granted that we possess sufficient evidence of the presence of certain ingredients of the milk, as an imperfect caseous matter, and abundance of earthy phosphates, in the urine of pregnant women; it might be suggested as a probable explanation opposed to no physiological views that I am acquainted with, that during utero-gestation, certain ingredients of the milk are eliminated from the blood by the mammary glands, and, as is very well known, often accumulate in the breasts, in sufficient abundance, to escape from the nipple on press-

ing it between the fingers. This imperfectly-formed secretion, not having a ready exit by the mammæ, is taken up into the circulating mass, is separated by the kidneys, and eventually escapes from the body by the urine. This view is certainly sanctioned by the statements of a high authority, Prof. Burdach,[101] of Konigsberg, and although not quite consonant with the opinion of M. Rayer,[102] yet it is quite in accordance with what we find occurring, under certain circumstances, in the bile, in the cases of obstruction of the biliary ducts; and more rarely in the urine, when, from the presence of calculi or other causes, the ureters are completely obstructed.

275. Although it is extremely probable that similar pellicles, which I have assumed to be characteristic of the presence of certain elements of milk in the urine, may be met with in the renal secretion of nurses whilst suckling, yet I have never met with an instance of this kind: indeed, the following interesting case appears rather opposed to this view:—

Oct. 26, 1839. I was consulted by Mrs. T——, then in the third month of utero-gestation, on the case of her child, a boy sixteen months old, whom, notwithstanding her pregnancy, she was then suckling. This little patient had a severe attack of pneumonia following measles, from which he was recovering, when, a few days before I was called in, from imprudent exposure to cold, he contracted bronchitis; and when I saw him he was evidently dying: his face was pale, lips livid, and extremities cold: he had, however, sufficient strength to take the breast. As it was evident that the child would in all probability expire in a few hours, I was anxious to ascertain whether the urine of the mother contained any of the supposed caseous matter; and if not, how long after the death of the boy it would appear. Some of her urine was accordingly collected; and after six days' repose, it underwent no particular change: putrefactive decomposition then commenced, and it was thrown away. She continued to suckle her child until within a few hours of its death, which took place forty-eight hours after my first visit; and on the following day I procured another specimen of the mother's urine: this, after two days' repose, had a thin caseous pellicle on its surface. In the course of a week, a third specimen was procured; and this in three days became covered with a complete creamy layer, evolving a strong cheese-like odour.

This case certainly appears to justify the idea, that, whilst suckling, the milk being got rid of almost as quickly as it is secreted, none of its elements find their way into the urine; but as soon as the milk ceases to be removed in this way, indications of it are to be met with in the urine, providing pregnancy exists. The following case appears to support the position I have assumed:—

Emma Cox, aged 24, suckling her first child, five months old, admitted under my care at the Finsbury Dispensary, in December 1839, complaining of symptoms generally referrible to asthenia lactantium. She was a tall, thin, delicate looking woman, and had lost a mother and some collateral relations from consumption: she had little or no cough: on examining her chest, I detected tubercular deposit at the apices of both lungs, with evidence of commencing softening on the left side: her urine was pale, and free from any appearance of caseous pellicle. I desired her to wean her infant; but this she did not do until January 27th, 1840. When she sent her child away, her breasts became painful and hard. She was compelled to have them drawn; and in a week they became flaccid, and the secretion of milk stopped. On January 30th, the breasts being still turgid, and three days after the cessation of suckling, some of her urine was collected, and exposed in a glass cylinder: in the course of four days, a cream-like pellicle, evolving a cheese-like odour, was observed: on collecting some of it on a slip of glass, and examining it under the microscope, it was found to resemble the usual pellicle which forms, by repose, on the urine of pregnant women, in every respect, except in the extreme paucity of the crystals of triple phosphate; the entire portion of the pellicle examined, being nearly entirely composed of the animal matter, insoluble in acetic acid. A few days afterwards the urine was again examined, but with negative results: no evidence of caseous matter, as indicated by the formation of a pellicle, could be detected.

276. It is not known how soon after conception the urine assumes the properties characteristic of pregnancy. In one case, that of a woman who considered herself to be at the end of the second month of her pregnancy, the urine yielded a well-marked pellicle; but I do not place much confidence in this observation, as the woman might very likely err in calculating how far she was advanced in utero-gestation. Kleybolte,[138] who, in common with many others, considers the presence of kiestein as quite indicative of pregnancy, has asserted that he detected it in the urine on the fifth day after conception.

As a test for the existence of pregnancy, the formation of the caseous pellicle, especially if accompanied by a cheese-like odour, will be an extremely valuable *corrobo-*

rative indication: but it would be unsafe to found on it alone any positive opinion, because, as a sufficient number of observations have not yet been made on this subject, we have no right to assume, however probable it may be, that a caseous pellicle can appear *only* when pregnancy exists. This opinion I feel still inclined to maintain, notwithstanding the very opposite opinion advanced by different observers, some of whom have declared the kiestein to be pathognomic of pregnancy, and others have expressed a conviction of its utter worthlessness.

FATTY MATTER.

277. A very minute trace of fatty matter is not unfrequently present in urine, and in some rare instances it increases in quantity, so as to become an important element of the secretion. The majority of cases of this kind hitherto recorded have not been very satisfactory, in consequence of the general dearth of detail respecting both the chemical and microscopical characters of the supposed fatty fluid. In some cases oil has been said to have been seen floating on the surface of the urine in large drops, even to the extent of ounces;[103] but no instance of this kind has ever occurred to me, and I suspect that certainly, in most of such cases, a fraud has been practised by the patient. An oil-like pellicle, often observed on the surface of urine, from the formation of a pellicle of earthy phosphates (135), may have been mistaken for true fat. It has been lately shown, that during pregnancy a portion of butter-like fat may form part of

the pellicle which forms on the urine by repose (201). All genuine specimens of fatty urine that have occurred to me have been opaque, like diluted milk, and in the majority of instances have spontaneously gelatinised, like so much blanc-mange, on cooling. To these the term of *chylous urine* has been applied by Dr. Prout.[104]

278. Great interest has lately become attached to the existence of fat in the urine, from the researches of Dr. Eichholz, and of Dr. G. Johnson, of King's College, who have stated that fatty matter not only exists in abundance in the urine in granular disease of the kidneys, but is even pathognomonic of that affection. According to Dr. Johnson, fat or oil-globules naturally exist in the epithelial cells of the tubular structure of the kidneys; and in the disease in question, the fat increases so rapidly, as to press upon the venous capillary plexuses in the exterior of the tubuli, so as to interfere with the return of blood from the organs. On the cells giving way or escaping from the tubuli, their fatty contents become mixed with the urine.

279. *Chemical characters of fatty urine.*—On agitating the fresh urine with an equal bulk of ether in a tube, the fat is dissolved, and by repose a yellow ethereal solution of it will float on the top of the urine, which, by thus losing the fat, becomes nearly transparent. On decanting the solution, and allowing it to evaporate in a watch-glass, the fat is left in little yellow globules, like butter, and having a rancid odour. This fat readily melts by a gentle heat into a yellow oil, and slowly solidifies on cooling.

Albumen generally exists in the urine in its spontaneously coagulable form (fibrin), so that on cooling it readily assumes the figure of the vessel. In this respect the urine often remarkably varies, sometimes losing its power of spontaneous coagulation for days together. Albumen is, however, even then present, and readily coagulates on the application of heat and nitric acid (237). In some cases which occurred to Dr. Prout, the albumen did not coagulate by heat, although it did by nitric acid; he hence considered it to be in an imperfect or hydrated state, like the albumen of the chyle. If a large proportion of fat exists, the fibrin, if present, is often prevented by its presence from coagulating; in this case, after agitation with ether, so as to dissolve out the fat, a delicate tremulous transparent coagulum of fibrin will form on the surface of the urine, and beneath the ethereal solution of fat.

280. *Microscopic characters.*—Cases have been reported in which globules of fat, like those existing in milk, were detected by the microscope. In all the specimens I have examined, the fat appeared to form a most intimate mixture or emulsion with the albumen, so that under the microscope nothing could be detected except myriads of infinitely minute particles floating in the fluid, unmixed with the slightest appearance of a globule of oil.

281. *Pathological indications.*—These can scarcely be said to be accurately known. In the few instances, I have witnessed of fatty urine, the patients have (with one exception, occurring in a lady, a native of China, remarkable for her emaciated condition, under the care of my friend, Dr. Protheroe Smith) shown a remarkable disposition to obesity. The continual presence of albumen co-existing with the fat, must, however, excite our alarm, for fear of the probable termination of the ailment in diseased kid-

ney and resulting dropsy, especially if the recent statements of Dr. G. Johnson (278) are corroborated by more extended observations. In these cases there can be no question, notwithstanding the occasionally repeated assertion that albuminous urine is not always connected with renal mischief, that our most serious apprehensions must be entertained for the welfare of our patient. The more extended our experience becomes, the more correct does the law laid down by Dr. Bright, of the almost necessary connexion between persistently albuminous urine and diseased kidney, appear.

I am indebted for the opportunity of investigating a well-marked case of this affection to the kindness of Mr. Montague Gossett, in whose practice it occurred. This case was peculiarly interesting on account of several curious anomalies it presented, as well as from its affording an opportunity of correcting the account generally given of the microscopic characters of urine containing fat.

The first specimens of the urine from the patient to which I have referred, were given to me on April 14th of last year, with an inquiry as to their nature; one specimen was of specific gravity 1.018, somewhat paler than usual, and was perfectly transparent, with the exception of a slight mucous cloud. The other specimen, stated to have been passed some hours before the former, resembled milk in colour and general appearance, and was quite free from any urinous odour: it was faintly acid, of specific gravity 1.020; the addition of either nitric or hydrochloric acid produced a considerable curdling. By repose, a cream formed on the surface of the urine, forming a layer one-tenth the thickness of the whole volume of fluid. When a drop of this milky urine was placed under the microscope, no oily globules could be seen when examined with an excellent object-glass of one-eighth of an inch focus, by Powell: the turbidity appears to depend upon an immense number of particles, so minute, that under a magnifying power of 800 diameters they resembled mere points.

I confess that I could not help suspecting that some addition had been made to the urine by the patient after its being passed; an idea that at first gained some support from the fact, that when the bladder was emptied by means of the catheter, the urine removed was found to be quite transparent and healthy.

On April 22nd, I saw Mrs. T—— in bed: she was an extremely fat, flabby woman, about 35 years of age, the mother of several children. She expressed herself as quite well with regard to her general health, and only complained of the occasional milky state of the urine as possibly indicative of some threatening ailment. She stated to me that for several years she had been accustomed to pass milky urine, especially during part of her pregnancies. On several occasions the urine, although not milky, had gelatinised on cooling so as to assume the form of the vessel like so much ordinary jelly. The appearance of the milky urine was exceedingly capricious, sometimes being constant for weeks together, and then disappearing for some time. She could trace no apparent connexion between its appearance and any obvious exciting cause; it bore no evident relation to the quality, quantity, or hours of her meals, nor to the periods of menstruation. The only general rule she had observed regarding its appearance was that it most frequently appeared when she first voided urine on rising from bed, and hence she fancied it was produced by lying on her back all night. It had become most frequent in its appearance since she had begun to grow fat.

My visit was made about 2 P. M.; Mrs. T—— had not risen except to pass water since the preceding evening. Three specimens of urine were shown me as having been passed since an early hour in the morning.

The first specimen was like ordinary urine; contained an abundance of pinkish urate of ammonia, which disappeared by heat; it was acid, and not coagulable; contained no albumen.

The second specimen was as pale as water, subacid, and, on heating it, clouds formed in it from the coagulation of albumen.

The third specimen was of a healthy amber colour; it appeared natural, and was free from albumen.

The examination of these specimens certainly gave no satisfactory explanation of the nature of the milky urine she had previously passed, and she declared that this was the first occasion on which she had failed to pass that kind of urine for some weeks. I introduced a catheter into the bladder, and a pint of fluid escaped, possessing the odour, colour, and general appearance of hot milk and water; in fact, having none of the physical characters of urine.

The specimen thus obtained was of specific gravity 1.010, slightly acid; by repose a cream-like layer formed on its surface, leaving the lower portion of the fluid nearly transparent. I may remark that Mrs. T—— had not partaken of any food since breakfast.

This milk-like urine presented the following chemical characters.

A. When exposed to heat, a large and tremulous coagulum of albumen formed, becoming firmer and more solid on raising the temperature to ebullition.

B. About four ounces of the urine were agitated with half an ounce of pure ether, and the mixture set aside in a carefully closed bottle. On the following day the mixture had lost all its opacity, and presented three well-defined layers. The lowest, forming the great bulk of the urine, was transparent, and consisted of urine deprived of the ingredients which had produced its previous opacity. On the surface of this, rested a perfectly transparent and tolerably firm coagulum of fibrin, about a quarter of an inch thick, of a pale yellowish colour. The superior layer consisted of an ethereal solution of fatty matter; this fluid was of a fine golden yellow colour.

C. The ethereal solution was decanted and allowed to evaporate spontaneously: a large proportion of yellow fat, closely resembling butter in colour and odour, was left. It differed from some specimens of fatter matter obtained by an analogous process from milky serum of blood, in not presenting any tendency to crystallise. This yellow fat readily fused by heat into a perfectly transparent oil, which slowly solidified by cooling, and it has undergone no change by keeping, up to the present period.

D. A portion of the urine left to itself for some time underwent no further change than the formation of a thin creamy layer on its surface: not the slightest tendency to the formation of a fibrous coagulum appeared.

E. A portion of the milky fluid was evaporated at a boiling temperature to dryness, and digested with hot water. The fluid was filtered, and after concentration, treated with nitric acid, when crystals of nitrate of urea slowly formed.

I carefully examined the urine under the microscope, but not the slightest appearance of oil-globules, blood-discs, or pus-granules, could be detected; the opacity appearing, as in the first specimen given me by Mr. Gossett, to depend upon the presence of particles so minute as to present no defined form; appearing like mere irregular points when examined with a linear power of 800 under an excellent achromatic microscope. The result of this examination is completely opposed to the few statements recorded by continental observers on the optical characters of fatty urine. Thus M. L'Heritier has stated that oily globules can always be detected in fatty urine; and a similar remark was made by the late Dr. Simon of Berlin. The latter has, indeed, stated that he has met with three varieties of fatty urine; one in which the fat is merely diffused through it, and collects on its surface by repose, as in the cases recorded by Dr. Elliotson: the other in which the fat was combined with albumen; and a third in which the fatty matter existed with casein as an emulsion, forming in fact true milky urine. In all these Simon states that fat globules could be seen by the microscope.

UROSTEALITH.

282. A peculiar form of fatty matter has been lately described by Dr. Florian Heller,[136] who has described it

under the name of uro-stealith. The patient was a weaver, 24 years of age, admitted into the Vienna Hospital, in February 1844, under the care of Dr. Bittner, for calculus. He laboured under all the symptoms of stone in the bladder, and passed some small concretions which on examination proved to be composed of a peculiar fatty matter. He was, therefore, treated with carbonate of potass in doses of ʒij. daily, and in fourteen days he lost nearly all the symptoms for which he entered the hospital.

283. *Diagnosis of urostealith.* — When small concretions of this substance are passed, they may be recognised by the following characters. When fresh, they are soft, becoming, when dry, hard, yellow, wax-like, brittle, and amorphous, and by transmitted light, presenting a greenish-yellow colour. By heat, this substance melts, puffs up, inflames, emitting a peculiar pungent odour between that of shell-lac and benzoin, and leaving a voluminous ash. In hot water it softens, but does not dissolve; slightly soluble in alcohol, readily in ether; the latter solution, on evaporation, leaves a residue, which assumes a violet colour by a gentle heat; alcalies readily separating it. Nitric acid dissolves it with slight effervescence, forming a colourless substance.

284. *Characters of the urine.*—The urine, in the only case in which urostealith has been hitherto found, was quite destitute of uric acid, but contained 12.63 grains of urea in 1000 of urine, was quite neutral, contained an abnormally large proportion of chloride of sodium, and deposited crystals of triple phosphate (191) mixed with fat globules. Specific gravity 1.017, inodorous, colour light yellow and whey-like. It was not rendered turbid

by nitric acid. After the administration of the alcaline carbonate to this patient, the fatty matter appeared in the urine completely saponified, and then the addition of ammonia, which previously scarcely affected the urine, produced a reddish-brown colour.

285. *Pathological indications.*—Unknown, from our experience being limited to the single case here related. The successful treatment by carbonate of potass will be a useful hint as to the treatment to be pursued if another case should fall under our notice.

CHAPTER XIII.

REMARKS ON THE THERAPEUTICAL EMPLOYMENT OF REMEDIES INFLUENCING THE FUNCTIONS OF THE KIDNEYS.

Assumed capricious influence of these remedies, 286—First law regulating them, 287—Apparent exception to, 288—Second law, 289—Conditions for the entrance of the remedy into the circulation, 290—Time required for absorption of salts, 291—For decomposition, 292—Illustrated in alcaline salts, 293—In mineral waters, 294—Diuresis opposed by irritable gastro-intestinal mucous membrane, 295—By obstructive diseases of the heart or liver, 296—Dr. Barlow's researches, 297—Applied to the explanation of irregular action of remedies, 298—Practical conclusions, 299.

286. It has been long stated by writers on therapeutics, and as generally admitted by the profession, that few remedies are so capricious in their action as those which directly or indirectly influence the functions of the kidneys. In some patients, a diuretic effect being obtained by the first remedy prescribed in a most satisfactory manner; whilst in other, apparently parallel cases, all medicines have failed in stimulating the secreting functions of the renal capillaries. When we refer to the

writings of authors on this subject, we find, the remedies which are supposed to excite the urinary secretion arranged according to their presumed modes of action; and although there is always included a class of *direct* diuretics, or, in other words, of drugs which are supposed really to reach the capillary circulation of the kidneys, and stimulate the vessels by actual contact: yet daily experience proves that even these, too frequently entirely, fail in exciting the medicinal influence which has been accredited to them.

As much importance has been attributed in the preceding pages to the impregnation of the urine with solvents for deposits so as to prevent the formation of a concretion, it becomes a matter of especial interest to devote a little space to the consideration of the question, whether by any means we can ensure the exertion of a therapeutical effect upon the secreting functions of the kidneys, and whether the apparently uncertain results of our diuretic and other analogous remedies are really as capricious as has been supposed. In a word, whether it is not in almost every case possible to predict, with tolerable certainty, from the knowledge of a few general laws, what will really be the effect of a remedy destined to act upon the kidneys.

287. To save any unnecessary circumlocution, I may be permitted to state that I take it for granted that independently of absorption by the lymphatics, fluids can find their way into the various capillaries by direct imbibition; and further, that living membrane is obedient, *quoad* imbibition and exudation, or endosmosis and exosmosis to the same physical laws as when dead and removed from the body. A consideration of facts re-

corded by observers of credit in all modern works on physiology[114] will afford ample data for admitting these several assumptions. It will then be necessary to consider, seriatim, the laws which appear to be fairly reducible from recorded experience.

> LAW 1st. All therapeutical agents intended to reach the kidneys must either be in solution when administered, or capable of being dissolved in the fluids contained in the stomach or small intestines, after being swallowed.

No one in the present state of physiological science can dissent from this law; not the slightest evidence exists of the kidneys ever allowing a body not in solution to pass their capillaries without positive breach of surface. It has, indeed, been stated that metastatic discharges of pus have occurred from the kidneys; that the purulent effusion of an empyema has been absorbed and finally excreted by those organs. Such statements, however, admit, as we have already seen, of a much more direct explanation. The capillary and lymphatic vessels can be readily submitted to microscopic examination, and no visible pores can be detected in their walls. How then is it possible that organised cells, consisting each of an investing granular membrane with several distinct nuclei (246), can find their way through the walls of a vessel in which no visible pores can be detected, and permeate without breach of surface, other capillary vessels in the kidney similarly organised? In the same way, it has been loosely said, that exudations of blood-corpuscles occur from the renal vessels in some cases of hæmaturia. To this statement a similar objection applies. All experience goes to prove that no escape of blood-corpuscles or pus-particles can possibly occur from a capillary without actual solution of continuity. Where urine really contains hæmatosine without actual lesion of vessels, the corpuscles must have burst in the capillaries, and allowed the oozing out of their contents, as perhaps occurs in purpura and scurvy. The researches of Wöhler[115] have proved to a demonstration that for a body to be excreted by the kidneys it must be actually in solution, and indeed they have shown that the function of these organs is strictly limited to the excretion alone of substances in solution.

288. I am quite aware that an objection may be urged against these conclusions, founded on the presumed metastasis of purulent formations from their original seat and their subsequent deposition in the structure of distant organs, especially of the liver. To the majority of such cases, when really accredited and free from fallacy, the co-existing presence of phlebitis will generally afford a sufficient answer. In some rarer cases, pus may escape from a deep-seated abscess by ulceration into a blood-vessel. In either case, if the pus-particles enter the torrent of the circulation, they would be hurried along with it; to be entangled in the capillary ramifications through which their size, presents an insuperable obstacle to their escaping. Still, although such cases are by no means sufficiently numerous, nor in many instances sufficiently accredited, yet we are not justified in refusing to admit the possibility of a purulent deposit being occasionally absorbed. But this admission by no means implies that the pus-particles really enter the vascular system from the sac of the abscess. The process of absorption here is almost indubitably a process

of metamorphosis, by which the elements of the pus are partly re-arranged to constitute a soluble compound. The presence of oxygen, or saline matters, or of an alcaline salt, conveyed in the arterial blood, will be amply sufficient to explain this reduction of the pus-particle to a soluble form without supposing that ultimate metamorphic change into the elements of bile and urine occurs, as in the case of absorption of muscle (26). The liquor puris (246) of pus contains tritoxide of protein in solution, the pyin of some chemists, the accession of oxygen would soon be able to convert the solid pus-particles into a similar state, whilst the action of salts and alcalies in breaking up the particle has been before explained. Pus thus dissolved and absorbed may readily be deposited in its original form by the removal of its solvent, and thus we are enabled to avoid admitting the necessity of a nearly physical impossibility, viz., the absorption of a pus-particle through the parietes of a vein or absorbent.

> 289. Law 2nd. Bodies intended to reach the kidneys must, to ensure their absorption, have their solutions so diluted as to be of considerably lower density than either the liquor sanguinis, or serum of blood (i. e. below 1.028).

Peculiar attention to this important law has been directed by the published remarks of Professor Liebig already referred to (18). It is founded upon the well-known phenomena described by Dutrochet,[116] under the terms of endosmosis and exosmosis, or imbibition and exudation. They may be thus briefly described. Let a glass tube, open at both extremities, have a piece of animal membrane, as bladder, &c., tied firmly over one end. Partly fill the tube with syrup and immerse it in a glass of distilled water. In a short time the fluid will rise in the tube, the water having permeated the membrane and diluted the syrup; this is an example of imbibition or endosmosis. Empty the tube, partly fill it with water, and immerse it in syrup; the fluid will now fall in the tube, exuding through the membrane, and diluting the syrup in the external vessel, by exosmosis. As a general law, it may, as far as living tissue be concerned, be sufficient to state that when two different fluids capable of mixture, be separated by an animal membrane; the fluid lowest in specific gravity, will permeate the membrane to dilute the denser fluid. In dead animal membrane, whilst imbibition goes on, a certain amount of exudation occurs, but to a much smaller extent, and *vice versâ;* whether this also occurs in living tissue there are no facts before us, to enable us to decide.

290. When, therefore, saline substances, especially, are intended to be absorbed and ultimately to reach the kidneys, it is necessary that the density of their solutions should be much below 1.028; the proportion of solids dissolved in the aqueous vehicles prescribed being always less than five per cent. Daily experience in the employment of remedies will show the importance of this law in a therapeutical sense. Thus, a tolerably strong solution of the tartrate, or acetate of potass, will altogether escape the absorbents; indeed, so far from being imbibed by the capillaries, it will actually excite an exudation of water from these vessels in the stomach and small intestines, thus becoming diluted by exosmosis, and a sensation of thirst is excited, by which the patient is compelled to drink for the purpose of supplying the

water removed from the blood by exudation. In strong solutions, the salts alluded to, stimulate the bowels and purge. They are, moreover, said to act as *hydragogue* purgatives, producing watery motions,—a fact also capable of ready explanation on physical laws; exudation of water from the exhalents (capillaries) occurring, on account of the density of the saline solution traversing the intestines, just as exosmosis was produced in the experiment of the tube of water immersed in syrup. We can hence readily perceive why half an ounce of acetate or tartrate of potass will purge, and a scruple of either, excite diuresis.

291. The rapidity with which even properly adjusted doses of saline bodies reach the urine is liable to great variations from many causes, but from none more than from the influence of the preceding meal. As a general rule, the substance finds its way to the kidneys with the greatest rapidity when the stomach is empty. Some very interesting experiments, lately performed by Mr. Erichsen,[139] throw great light on this subject. This gentleman had under his care a lad who had been the subject of congenital extroversion of the bladder; the abdominal parietes and anterior wall of the bladder being deficient above the pubes to a considerable extent, so that the orifices of the ureters were visible. On ten different occasions a solution of ferrocyanide of potassium was given to this lad, and the urine carefully allowed to drop from the ureters into a solution of sulphate of iron, so that the instant at which the salt appeared in the urine it was readily detected. The following table shows the results of the experiments.

When last meal taken.	Time required for the detection of the salt in the urine.
2 minutes	27 minutes.
2 ——	39 ——
24 ——	16 ——
1 hour	14 ——
1½ —	6½ ——
2 —	12 ——
4 —	2 ——
4½ —	2½ ——
11 —	1 ——
11½ —	2 ——

292. When alcaline citrates and tartrates were administered, the time required for their appearing as carbonates in the urine was found to vary considerably. This admits of a ready explanation, not only in the influence of the previous meal, but in the perfection at the time of the process of assimilation. For, as has been already stated, the salts of vegetable acids undergo decomposition only when the digestive functions are in a state of tolerable integrity, escaping metamorphosis when the assimilating powers are much depressed (124). Mr. Erichsen obtained the following results in his experiments on this patient.

Time since the last meal.	Salt given.	Time elapsing before the occurrence of an alcaline condition of the urine.
3½ hours	Citrate of soda	28 minutes.
5 ——	Citrate of potass	40 ——
12 ——	Tartrate of soda	34 ——
2 ——	Ditto	47 ——

In the first two of these experiments the urine remained alcaline for several days after the administration of the salts.

293. These facts are of the utmost importance to the success of our practice in the treatment of uric acid deposits, or gravel, by saline remedies, especially by phosphate of soda. This salt readily finds its way into the kidneys when administered in a diluted solution; if prescribed in a saturated solution or in large quantities, it, like the tartrate and acetate of potass, excites exosmosis instead of endosmosis, and acts as a mild hydragogue cathartic. A similar remark applies to the majority of salts of alcalies and of magnesia. Most neutral salts are therefore diuretic, if properly administered so as to insure their absorption into the circulation; once being absorbed, it is the duty of the kidneys to filter them off from the blood, and hence they exert a diuretic influence, merely by giving the kidneys an extra amount of work to perform.

294. All the natural waters are diuretic, and if drank in equal quantities are nearly so in the ratio of their levity and consequent purity. Thus the nearly pure water of the Malvern springs, rapidly and readily enters the blood by endosmosis, and escapes by the kidneys, whilst sea-water in equal doses causes the exosmosis of water from the intestinal capillaries; hence exciting thirst and purging with fluid motions, without inducing any diuretic action. On the contrary, sea-water, like all moderately strong saline solutions, diminishes the bulk of the urine, and causes it to escape in a more concentrated form, simply from its inducing an efflux of water from the blood through the walls of the capillaries of the intestines, which would otherwise have escaped by the capillaries of the kidney.

295. In diseases in which an extremely irritable con-

dition of the gastro-intestinal mucous membrane exists, diuresis is often excited with great difficulty, and it is scarcely possible to cause any remedy to reach the urine by direct absorption. Where there is any considerable diarrhœa, and copious watery motions are excreted from the bowels, the urine is always scanty and high-coloured, a condition necessarily arising from its concentration; water freely exuding through the intestines from the blood, and hence but little is left to escape by the kidneys. An extreme instance of this state of things is found in malignant cholera; here, water is so rapidly pumped off, through the intestinal exhalants, that the blood is left absolutely viscid and thick. Hence the nitrogenised elements which it is the duty of the kidneys to excrete, cannot be removed in consequence of the escape of the water by the intestines which would normally have washed them from the circulation; and the patient dies from a retention of a poison in his circulation which the kidneys are unable to remove.

296. The laws just illustrated must be regarded as obtaining only, when the entrance of water into the capillaries of the intestines is unobstructed; and when no serious obstacle presents itself to the transit of the water with the blood from the intestinal capillaries to the vena-porta, through the liver to the ascending cava, thence through the lungs and heart to the aorta, and finally to the emulgent arteries. When any obstacle materially interferes with the route thus taken by the blood, in any part of its career, a small supply of water must reach the kidneys, and the urine will become diminished in bulk and increased in density. To take a familiar illustration, a patient labours under a contracted condition of either

of the auriculo-ventricular openings of the heart, and dropsical effusions occur. In consequence of the impediment opposed to the current of blood, the kidneys excrete but a small quantity of urine. The very dropsical effusions may be regarded as a sort of vicarious effort to relieve the congested state of the veins, by allowing the watery elements of the blood to filter through the walls of the smaller vessels. Again, if a patient has a cirrhose or hobnail condition of the liver, the portal circulation will be materially obstructed, and some effects analogous to those produced by a contracted ventricular orifice are the result, viz. dropsical effusions and diminished secretion of urine. In cases of this kind, no good can accrue by goading the kidneys by diuretics, unless the obstruction can possibly be lessened or removed. They may be irritated by stimulants like cantharides, copaiba, or squills, until congestion or something worse occurs, without increasing the secretion of urine, simply because the fluid elements are prevented reaching the kidneys. In cases of this kind, the physician at once sees that all direct diuretics are comparatively useless, and he wisely endeavours to remove the dropsical effusion by remedies which, like elaterium, exert a hydrogogic action on the intestines.

297. The attention of the profession has been especially drawn to these conditions by the recently published researches of my friend and colleague, Dr. Barlow. He has moreover announced the very interesting fact, that whenever a stricture or other obstruction exists in the course of the small intestines, sufficient to prevent fluids readily passing along them, the urine will be diminished in bulk in the direct ratio of the proximity of the obstruc-

tion to the pylorus; nearly absolute suppression of urine occurring when the stricture is so high up as to allow but a small quantity of the fluid contents of the intestines to be exposed to the absorbing influence of the portal capillaries. So absolutely does this obtain, that the observation of the bulk of urine secreted has been proposed by Dr. Barlow as a means of diagnosticating the seat of obstruction in cases of insuperable constipation.* The proposition laid down by the discoverer of these facts, may properly be assumed for a third law governing the influence of remedies intended to excite the action of the kidneys. I give it in Dr. Barlow's own words.

> LAW 3rd.—" If a sufficient quantity of water cannot be received into the small intestines, or the circuit through the portal system in the vena-cava ascendens, or thence through the lungs and heart into the systemic circulation, be obstructed, or if there be extensive disorganisation of the kidneys, the due secretion of urine cannot be effected."

298. I think, then, that the so-called capricious effects of most diuretics, or the entrance of any remedy into the renal circulation, may all be explained by one or other of the foregoing laws, and that the supposed uncertainty attending their action is in most instances to be traced rather to a want of discrimination on the part of the practitioner, than to any fault in the remedy. An example or two of this kind will be sufficient. Bitartrate of potass is regarded as a diuretic; if a drachm of it be

* For an account of these very important facts, and the arguments deduced from them, I beg to refer the reader to the very philosophical and interesting communications of Dr. Barlow, in the two last numbers of Guy's Hospital Reports (October, 1844, and April, 1845).

administered with a little fluid, or in a confection, it irritates the intestines, produces fluid motions, and the kidneys are scarcely affected. Let the same quantity of the drug be dissolved in water and then given; it is imbibed by the capillaries, and causes an increased excretion of water by the kidneys, in accordance with the first law. Sufficient examples of the second law have been given already. Of the third we have an excellent illustration in the action of mercury and other cholitic drugs, in "directing," as it has been termed, the action of a diuretic. Thus let us suppose we are called to a patient in whom a sluggish state of the portal circulation exists, the liver being congested or even myristicated, and from some dropsical effusion, or other symptoms, we are anxious to stimulate the action of the kidneys. It is notorious that in these cases the acetate of potass, nitric ether, squill, and other active diuretics, may be prescribed in vain; but as soon as moderately frequently repeated small doses of pil. hydrargyri, or hydrarg. c. creta, or even aloetic remedies have been administered, and the liver disgorged of its contents by a free secretion of bile, the kidneys begin to act as the almost necessary result of a readier circulation of portal blood. Experience has shown that there is perhaps no diuretic so valuable in dropsy connected with congested or even contracted liver, as a combination of the squill with a little blue-pill. Many remedies regarded as diuretic, probably really act in this manner; thus colchicum appears to influence the secretion of urine by its stimulating the mucous membrane of the duodenum, and thus by irritating the orifice of the common choledic duct, produces an increased secretion of bile and pancreatic juice, and indirectly removing a loaded state of liver. Taraxacum, a deservedly esteemed cholagogue, owes its diuretic action in all probability to a similar cause. Aloes in small doses, and other remedies, may be referred to this category.

Again, in heart-disease, especially when a contracted mitral orifice, or when, from dilatation of the organ, a loss of relation between its cavities and their orifices exists, and dropsy results, the exhibition of stimulant diuretics is nearly valueless. Here, the guarded employment of the infusion of digitalis, by soothing the irritability of the heart, and calming the irregular circulation, virtually diminishes the congested state of the vascular system, and acts indirectly as an excellent and efficient diuretic.

299. From the above observations, the following practical conclusions may be drawn.

1. Whenever it is desirable to impregnate the urine with a salt, or to excite diuresis by a saline combination, it must be exhibited in solution, so diluted as to contain less than five per cent. of the remedy, or not more than about twenty-five grains in an ordinary draught. The absorption of the drug into the capillaries will be ensured by a copious draught of water, or any diluent, immediately after each dose.

2. When the urine contains purpurine (101), or presents other evidence of portal obstruction, the diuretics or other remedies employed should be preceded or accompanied by the administration of mild mercurials,—taraxacum, hydrochlorate of ammonia, or other cholitic remedies. By these means, or by local depletion, especially by leeches to the anus, the

portal vessels will be unloaded, and a free passage obtained to the general circulation.

3. In cases of valvular or other obstructions existing in the heart and large vessels, it is next to useless to endeavour to excite diuretic action, or appeal to the kidneys by remedies intended to be excreted by them. The best diuretic will in such cases be found in whatever tends to diminish the congested state of the vascular system, and to moderate the action of the heart; as digitalis, colchicum, and other sedatives, with mild mercurials.

APPENDIX.

CATALOGUE OF THE URINARY CALCULI CONTAINED IN THE MUSEUM OF GUY'S HOSPITAL.

In the year 1817, when Dr. Marcet published his Essay, the Museum of Guy's Hospital contained but 228* calculi. During the last twenty-seven years, this number has been augmented to 374; all of which have been divided so as to exhibit their internal structure, with the exception of 21. The great majority of the calculi added since Dr. Marcet's publication have been analysed at different periods, as they were placed in the Museum, by Dr. Babington, Dr. Rees, and myself; and in every instance, the examination has not been limited to the composition of the external crust, but has been particularly directed to the chemical constituents of the ingredients composing each layer. Attention has in each specimen been directed to the composition of the nucleus, in contradistinction to that of the body of the concretion. This is of very great importance; for when once a few solid particles of any substance aggregate and form a mass in the bladder, they very readily induce a crystallisation of oxalate of lime, uric acid, or triple phosphate; or a deposition of urate of ammonia, phosphate of lime, or other amorphous ingredient, according to the lesion of function and state of irritability or enervation present. Hence, if ever, by medical treatment, we shall be enabled to prevent the formation of a calculous concretion, or remove one

* Including 142 removed from one patient.

already formed, it will, in all probability be, by means directed by the character of the matter which there is a tendency to deposit as a nucleus. On this account I have adopted a classification of the calculi in Guy's Hospital Museum, founded not upon the number of alternating layers, but upon the character and composition of the nuclei. In the following Table, it must be borne in mind, that all the distinct constituents present in each concretion have not been mentioned; those only being inserted which were present in such quantity as to constitute a considerable portion of either body, nucleus, or crust of the concretion. Those ingredients, which existed in mere traces, or in very minute quantities, have been omitted; as they are rather to be regarded as accidental contaminations, and as essential elements of the calculus. No urinary concretion, indeed, ever exists perfectly pure and unmixed; for there are very few in which some traces of uric acid, or phosphates, are not observable: and even if these be absent, the colouring matter of urine or blood prevents the calculus being regarded as perfectly pure.

CALCULI IN GUY'S HOSPITAL MUSEUM,

OF WHICH SECTIONS HAVE BEEN MADE,

ARRANGED ACCORDING TO THE CHEMICAL COMPOSITION OF THE NUCLEI.

Genus I.—Nucleus, Uric Acid, 250.

Species 1. *Calculi nearly entirely composed of Uric Acid or Urates.*

A. Nearly all uric acid - - - - - - - - -		32
Uric acid, nearly pure - - - - - -	18	
Stained with purpurine - - - - -	2	
Contained urate of lime - - - - -	2	
. . . . and ammonia - - -	3	
. . . . urate of soda and lime - - -	1	
. . . . oxalate of lime - - - - - -	3	
. . . . phosphate of lime - - - -	1	
. . . . triple phosphate - - - -	2	
	32	

B. Body consisting chiefly of urates - - - - - - -			170
Contained urate of soda - - - - - -		142*	
- - - - - - - - and lime - - - - -		22	
- - - - - urate of lime - - - - - -		4	
- - - - - uric acid in the body - - - - -		2	
		170	

Species 2. *Bodies differing in composition from Nuclei.*

A. Bodies consisting of oxalate of lime - - - - - -			11
Oxalate of lime and uric acid alternating - -		2	
Uric acid in the body, with an outer layer of carbonate of lime - - - - - - -		1	
Oxalate, chiefly confined to external layers - -		1	
Oxalate of lime in the bodies nearly pure - -		7	
		11	

B. Bodies consisting chiefly of earthy phosphates - - -			24
Bodies composed of fusible calculus - - - -		16	
- - - - - - - phosphate of lime - - -		3	
- - - - - - - triple phosphate - - - -		5	
		24	

C. Body consisting of carbonate of lime - - - - -		1	1

D. Body compound - - - - - - - - - - -			12
Body:	Crust:		
Urate of ammonia -	Fusible -	1	
Oxalate of lime - - -	Uric acid - -	3	
- - - - - - -	Fusible - -	3	
- - - - - - -	Triple - -	1	
- - - - - - -	Phosphate of lime	3	
Fusible - - - - -	Uric acid - -	1	
		12	

* From the same patient.

Genus II.—Nucleus, Urates of Ammonia or Lime, 19.

Species 1. *Calculi nearly all composed of Urate of Ammonia* - 8

Urate of ammonia, nearly pure - - - - - -	6
Uric acid, in tubercular patches on crust - - -	1
Traces of urate of soda and phosphate of lime - -	1
	8

Species 2. *Bodies differing from Nuclei* - - - - - 10

Body:	Crust:	
Uric acid and fusible - -	As body - - -	2
Urate of ammonia - -	Uric acid - - -	1
- - - - - - -	Oxalate of lime - -	1
- - - - - - -	Phosphate of lime -	1
- - - - - and oxalate of lime - - -	Uric acid, with oxalate and phosphate of lime -	1
Urate of ammonia and fusible - - - - -	As body - - - -	1
Urate and phosphate of lime	Ditto - - - -	1
Oxalate of lime - - -	Fusible - - -	1
Fusible - - - - -	As body - - -	1
		10

Species 3. *Nucleus, Urate of Lime.*

A. Body fusible - - - - - - - - - - 1 1

Genus III.—Nucleus, Uric Oxide, 1.

Species 1. *All Uric Oxide.** - - - - - - - 1

* A portion of the calculus removed by Langenbeck at Hanover, and analysed by Wöhler and Liebig.

GENUS IV.—NUCLEUS, OXALATE OF LIME, 47.

Species 1. *Calculus nearly all Oxalate* - - - - -		19
Uric acid in nucleus - - - - - - -	1	
Crust, covered with opaque octahedral crystals - -	1	
- - - - transparent - - - - -	3	
- - not covered with crystals - - - -	14	
	19	

Species 2. *Bodies differing from Nuclei.*

A. Bodies consisting of uric acid or urates - - - -		8
Uric acid, nearly pure - - - - - - -	7	
- - covered with urate of ammonia - - -	1	
	8	

B. Bodies consisting of phosphates - - - - - -		14
Phosphate of lime - - - - - - - -	6	
Triple phosphate - - - - - - - -	5	
Fusible mixture - - - - - - - -	3	
	14	

C. Body compound - - - - - - - - - -		
Body:	Crust:	
Uric acid - - - - - -	Fusible - -	2
- - - - - - - -	Oxalate of lime -	1
Urate of ammonia - - -	Phosphate of lime	1
1. Uric acid - - - - 2. Oxalate of lime - - - 3. Uric acid - - - -	Oxalate of lime	1
Cystine - - - - - - - - -		1
		6

Genus V.—Nucleus, Cystine.

Species 1. *All Cystine*		11
Colour, greenish blue	1	
- - - dirty greenish grey	9	
- - - fawn brown	1	
	11	

Genus VI.—Nucleus, Earthy Phosphates, 22.

Species 1. *All Phosphates of Lime*	2	2
Species 2. *All Triple Phosphates*	1	1
Species 3. *All Fusible Mixed Phosphates*	19	19

Genus VII.—Ingredients of Calculus mixed, with no evidence of arrangement in concentric layers - 3

A. Uric acid and triple	1
B. - - - - - phosphate of lime	1
C. - - - - - urates of soda and ammonia, with oxalate and phosphate of lime	1
	3

ABSTRACT VIEW OF NUCLEI.

Nuclei, consisting of uric acid or urates	269
- - - - - - - - oxide	1
- - - - - - - cystic oxide	11
- - - - - - - oxalate of lime	47
- - - - - - - phosphates	22
	350
Mixed calculi	3
	353
Calculi undivided	21
	374

I have not included in the above Tables the fibrinous calculus of Dr. Marcet, in consequence of its differing so totally from other concretions; as it must be regarded as a portion of dried inspissated albuminous matter exuded from an irritated kidney, rather than as a calculus produced under circumstances at all analogous to those of other concretions. Several specimens exist in the Museum, of the pelves of kidneys and ureters being obstructed by clots of fibrin; but none of them present the hard, concrete condition of the calculus described by Dr. Marcet. I am not aware of this variety having been mentioned by any other author except Brugnatelli, who, in his Litologia Umana, describes some calculi as consisting of *crystallized* albumen (di materia albuminosa cristallizata di colore d'ambra): they were passed by one individual, and each was about the size of a nut. These pseudo-calculi were supposed to consist of dried coagulated albumen, which not unfrequently presents considerable lustre and a vitreous fracture, although scarcely sufficient to justify its being regarded as crystallized. I confess I have a strong suspicion that the calculi described by Brugnatelli really consisted of cystine.

Among the other ingredients existing in calculi, in very minute quantities, and not enumerated in the Table, are, hydrochlorate of ammonia, oxide of iron, and carbonate of lime. The former has been described by Dr. Yellowly as a frequent ingredient, generally, however, existing in mere traces of calculi; the second was discovered by Professor Wurtzer, and is often present in uric acid calculi; and the third is frequently present in phosphatic and oxalic concretions. None of these ingredients are so generally present, as to merit their being regarded as presenting much interest, in a pathological sense.

Calculi present the greatest possible variety in appearance; generally, however, having more or less of an ovoid figure. Of those in Guy's Museum, the urate of ammonia and uric acid concretions are the most regular, nearly all being ovoid or circular,[a] a few only reniform;[b] this species never presenting any very prominent processes or projections, unless fresh centres of deposition occur on their surfaces, as when crystals of uric acid are deposited on an ovoid urate of ammonia concretion.[c] The cystic oxide concretions vary considerably in outline; when large, being generally oval and smooth;[d] and when smaller, often presenting projections from their surfaces, as if they were made up of crystals radiating from a common centre;[e] some-

Reference to Calculi in the Museum.

[a] No. 2118. [b] No. 2119. [c] No. 2125.
[d] No. 2143. [e] No. 2145.

times being moulded to the figure of the organ which secreted it, as shown in the curious ear-drop-like concretion.[f] The oxalate of lime is generally most irregular, as far as the surface is concerned ; although its outline is generally tolerably defined, either bearing a close approximation to an elliptic, or even a rectangular figure. The most contorted and irregularly-figured calculus is the triple or fusible, it being often a complete cast of the pelvis and calyces of the kidney ;[g] occasionally, however, it is almost regularly oval, and sometimes circular ;[h] this variation, in all probability, depending upon the position occupied by the calculus, and upon whether, it had been retained in the kidney, or passed down the ureter before it had become of any considerable size. The mixed calculi, or those not presenting any regular concentric arrangement or a distinct nucleus, are often moulded to the kidney.[i] The phosphate of lime calculus is generally smooth externally, and conchoidal in fracture, sometimes appearing as if made up of several cohering portions.[k] The triple phosphate[l] and fusible mixture[m] are not unfrequently found deposited on one side of a previously-formed calculus, as if one surface only had been exposed to the urine containing the earthy salt in solution, which is generally found under the form of elegant white vegetations.

The nucleus is usually found in the geometric centre of the calculus, or nearly so; sometimes, however, being remarkably eccentric, as in some reniform concretions ;[n] and in a few, several distinct nuclei or centres of deposition are met with.[o] In some rare instances, the concretion which forms the nucleus is found loose within the body of the entire calculus ;[p] a circumstance in all probability arising from a layer of blood or mucus having concreted around the nucleus, and on which the matter forming the body of the calculus became deposited In this case, on the whole becoming dry, the mucus or blood would be diminished to a very thin layer, and the calculus would appear to contain loose matter in it. In a few instances, calculi appear to possess no nucleus, the centre being occupied by a cavity, full of stalactitic or mammillated projections, giving the idea of the external layer having been first formed, and the mammillated portions subsequently formed in the interior. This state occurs only, so far as I have seen, in uric acid calculi.[q] In one specimen in the collection, the central cavity is lined with fine crystals of triple phosphate, resembling the crystals of quartz so often found lining cavities in flints.[r] Brugnatelli describes one of a similar kind.

[f] No. 2145[35]. [g] No. 2163. [h] No. 2161. [i] No. 2136.
[k] No. 2148. [l] No. 2198. [m] No. 2154[3]. [n] No. 2119.
[o] No. 2158. [p] No. 2133. [q] No. 2113. [r] No. 2154.

Sometimes calculi present very remarkable appearances, as if they had been divided into segments: this, in some cases, can be explained by the attrition of calculi[s] against each other, where several exist at once. In some, they actually appear as if they had been divided by a fine-cutting instrument; and in one, in the Museum, the apparently divided portions seem as if they had again become cemented and framed in by a subsequent deposit.[t]

[s] No. 2218^{88}.

[t] No. 2136^{50}.

TABLE

OF

THE CHEMICAL COMPOSITION OF THE CONSTITUENTS OF THE ANIMAL ECONOMY, REFERRED TO IN THIS WORK, AND OF SOME OF THEIR MOST IMPORTANT MODIFICATIONS.

The letters affixed show the authorities for the respective formulæ:—L = Liebig, W = Wöhler, P = Playfair, ... M = Mulder, E and W = Ettling and Will, D = Demarçay, T = Thaulow, K = Dr. Kemp, R = Redtenbacher.

A. ELEMENTS OF BLOOD, AND THEIR MODIFICATIONS.

	Composition in 100 parts.					Authority.	Empirical Formula.					Rational Formula.	Authority.
	Carbon.	Nitrog.	Hydrog.	Oxygen.			C.	N.	H.	O.			
Protein*	55.44	16.05	6.95	21.56		Mulder, p. 303.	48	6	36	14			L.
— Ditto							40	5	31	12			M.
— Binoxide	53.69	15.63	6.90	23.71		p. 326.	40	5	31	14		Pr, O_2	M.
— Tritoxide	51.47	15.27	6.60	26.56		p. 326.	40	5	31	15		Pr, O_3	M.
— Superoxide							40	5	33	20		Pr, O_4	M.
Albumen of blood	54.84	15.83	7.09	21.23	P. S. 0.33, 0.68	p. 312.	400	50	310	120	S_2 P.	$Pr_{10} S_2 P.$	M.
— Eggs	54.48	15.70	7.01	22.	P. S. 0.43, 0.38	"	400	50	310	120	S, P.	$Pr_{10} S P.$	M.
— Fibrin	54.56	15.72	6.90	22.13	P. S. 0.33, 0.36	"	400	50	310	120	S, P.	$Pr_{10} S P.$	M.
— Casein	54.96	15.80	7.15	21.73	S. 0.36	"	400	50	310	120	S.	$Pr_{10} S$	M.
— Crystalline	55.39	16.51	6.94	20.91	S. 0.25	p. 315.	600	75	465	180	S.	$Pr_{15} S$	M.
Elastic arterial tissue	53.390	15.36	6.973	24.274		Scherer in Liebig, p. 352	48	6	38	16		Pr, 2 HO.	L.
Mucus	52.54	14.33	7.90	25.18		Dr. Kemp, in Simon, 1.146. Some sulphur is included in the 25.18.	48	6	39	17		Pr, 3 HO.	K.
Horny tissue	51.718	17.469	6.860	23.953		Scherer in Liebig, p. 352	48	7	39	17		Pr, NH_3, O_3	S.
Gelatine	50.05	18.35	6.48	25.12		Mulder, p. 333.	48	7½	41	18		$2 Pr, 3 NH_3, HO, 7 O$	L.
Ditto							52	8	40	20			M.
Chondrine	49.96	14.44	6.63	28.59	S. 0.38	p. 340.	48	6	40	20		Pr, 4 HO, 3 O.	L.
Ditto							320	40	260	140	S.		M.
Leucin	55.64	10.51	9.30	24.55		p. 321.	12	1	12	4			M.
Glycycoll	30.30	22.80	5.62	32.19		In Simon's Med. Chemie, B. 1. s. 197.	8	2	9	7		½ at. sugar. ½ at. urea. $C_{12} H_{12} O_{12} + C_2 N_2 H_4 O_2$	M.
Protid	59.26	10.56	6.62	23.62		p. 322.	13	1	9	4			M.
Erythro-protid	56.63	10.23	5.93	27.21		"	13	1	8	5		Protid + HO.	M.
Hæmatosine	66.49	10.54	5.30	11.01	Fe. 6.66.	p. 346.	44	3	22	6	Fe.		M.
Ox-blood and flesh, excluding inorganic elements	54.12	15.67	7.89	22.32		Playfair in Liebig, p. 314.	48	6	39	15			L.
Glycerine	39.59		8.61	51.80		Pelouze.	6		7	5	+HO	Glyceryle $+ O_5$, HO.	P.
Stearic acid	80.145		12.478	7.377		Chevreul.	68		66	5	+2HO	$2 C_{34} H_{33} + O_5$	
Margaric acid	79.053		12.01	8.937		"	34		33	3	+HO	$C_{34} H_{33} + O_3$	
Oleic acid	80.942		11.359	7.699		"	44		39	4	+HO		
Butyric acid	55.64		8.02	36.33		Pelouze in Liebig u. Wöhler	8		7	3	+HO		
Lactic acid	44.92		6.55	48.53			6		5	5	+HO		

* Very recent researches of Liebig have rendered it probable that protein has really no existence as a separate and distinct substance. If this be true, of course all the oxides and other hypothetical compounds of this body must be discarded. In the present state of our knowledge, it will be best to regard the so-called protein as merely a conventional expression for a recognised proportion of oxygen, hydrogen, carbon, and nitrogen. Liebig's opposition to Mulder's views (which he so completely adopted in his "Animal Chemistry") is chiefly based on the existence of traces of sulphur in carefully prepared protein. The credit of first pointing out this fact is, however, due to my talented friend and colleague, Mr. Alfred S. Taylor, F.R.S.

B. ELEMENTS ELIMINATED BY THE LIVER, AND THEIR MODIFICATIONS.

	Composition in 100 parts.					Authority.	Empirical Formula.					Rational Formula.	Authority.
	Carbon.	Nitrog.	Hydrog.	Oxygen.			C.	N.	H.	O.			
Organic constituent of the bile of leopard	59.8	4.60	9.49	26.11		Dr. Kemp.	64	2	61	22			K.
— man	68.4	3.46	10.13	18.03		Ditto.	50	1	45	10			K.
— ox	64.6	3.40	9.62	22.38		Ditto.	64	2	61	22			K.
Choleic acid	63.707	3.255	8.821	24.217		Demarçay, in Liebig, Handwörterbuch, B. 2, s. 257.	76	2	66	22			L.
Cholic acid	68.5		9.7	21.8		Dumas in do., B. 2, s. 261.	74		60	18			L.
Choloidic acid	73.522		9.577	16.901		Demarçay, in do., B. 2, s. 261.	36		56	12			L.
Bile-pigment	67.409	6.704	7.692	18.185		Scherer, in Chem. Gazette, 1846.							
Taurine	19.28	5.73	11.25	38.64	S. 25.70	Redtenbacher, in Liebig's Annalen, T. 57, p. 170.	4	1	7	6	S. 2		R.
Lithofellic acid	70.80		10.78	18.42		Ettling and Will, in Liebig, p. 322.	40		35	7	+HO.		W.
Cholesterine	85.095		11.880	3.025		Chevreul.	37		32	1			

C. ELEMENTS ELIMINATED BY THE KIDNEYS, AND THEIR MODIFICATIONS.

	Composition in 100 parts.					Authority.	Empirical Formula.					Rational Formula.	Authority.
	Carbon.	Nitrog.	Hydrog.	Oxygen.			C.	N.	H.	O.			
Urea	19.99	46.65	6.65	26.63		Dr. Prout.	2	2	4	2			
Uryle (hypothetical)						Wöhler and Liebig	8	2		4		$4 CO + 2 C_2 N = Ur.$	
Uric acid	36.083	33.361	2.441	28.126		Ditto.	10	4	4	6		Ur + 2 Urea.	
Alloxan	30.38	17.96	2.57	49.09		Wöhler and Liebig.	8	2	4	10		Ur + 2 O + 4 HO.	
Alloxantin	30.556	17.669	3.111	48.362		Ditto.	8	2	5	10		Ur + O + 5 HO.	
Uric oxide	30.28	36.33	2.95	31.94		Ditto.	5	2	2	2		Ur + Urea − 2 O.	
Cyanuric acid	28.19	32.64	2.3	36.87			6	3	3	6		$3 Urea - 3 NH_3$	
Oxalic acid	26.566		2.745	70.689		Gay-Lussac and Berard, (hydrated acid).	2			3			
Oxaluric acid	27.6	21.218	3.122	48.060		Wöhler and Liebig.	6	2	3	7	+HO.	$Urea + 2 C_2 O_3$	
Pettenkofer's body	39.37	33.63	6.79	20.21		Liebig's Annalen, B. 53, s. 97.	8	3	8	3			
Cystine	30.01	11.	5.10	28.38	S. 25.51	Thaulow.	6	1	6	4	S_2		
Uramile	33.23	29.80	3.69	34.17		Wöhler and Liebig.	8	3	5	6		$Ur + NH_3 + 2 HO.$	
Allantoin	30.60	35.45	3.83	30.12		Wöhler.	8	4	6	6			
Parabanic acid	31.95	24.66	2.09	41.30		Wöhler and Liebig.	6	2	2	6			
Murexid	34.425	33.12	3.115	29.34		Ditto.	12	5	6	8			
Ditto	34.78	30.70	2.82	31.60		Fritsche.	16	6	8	11		Purpuric acid. Ammonia. Water. $C_{16} N_5 H_4 O_{10} + NH_3 + HO.$	F.
Hippuric acid	60.742	7.816	4.959	26.483		(Crystallized) Liebig.	18	1	8	5	+HO.		
Benzoic acid	74.7		6.56	20.54		(Anhydrous.)	14		5	3	+HO.		
Urine-pigment	58.43	8.83	5.16	27.58		Scherer, in Chem. Gazette, May, 1846.							

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ALPHABETICAL INDEX.

THE END.

LONDON:
G. J. PALMER, PRINTER, SAVOY STREET, STRAND.