W. Sturgis Bigelow
52 Beacon St.

KIDNEY DISEASES, URINARY DEPOSITS,

AND

CALCULOUS DISORDERS.

KIDNEY DISEASES,

URINARY DEPOSITS,

AND

CALCULOUS DISORDERS;

THEIR NATURE AND TREATMENT.

CONTAINING
SEVENTY PLATES, AND TABLES FOR THE CLINICAL
EXAMINATION OF URINE.

BY

LIONEL S. BEALE, M.B., F.R.S.,

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS; PHYSICIAN TO KING'S COLLEGE HOSPITAL,
PROFESSOR OF PHYSIOLOGY AND OF GENERAL AND MORBID ANATOMY IN, AND
HONORARY FELLOW OF, KING'S COLLEGE, LONDON.

THIRD EDITION,
MUCH ENLARGED.

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DEDICATED TO THOSE WHO

WORKED WITH THE AUTHOR IN HIS LABORATORY,

AND AT AN EARLY PERIOD OF HIS CAREER

GAVE HIM

ENCOURAGEMENT AND SUPPORT.

PREFACE.

THE present edition has been very much enlarged and several of the articles have been re-written. My friend Prof. Bloxam has kindly revised the chemical part of the work, Mr. Sutton has re-written the article on volumetric analysis which is now of great practical value, and in that part of the work which treats of lithotomy and lithotrity I have had the advantage of important aid from my friend John Wood who has written the article on catheterism.

Part I on the kidney and its diseases, has been very much extended, and the clinical remarks and observations on the treatment of urinary diseases are of greater length than in the previous editions of this work.

The usefulness of the book has been increased by the addition of nearly one hundred new drawings, and as many more have been re-engraved in order to render them more truthful representations of nature; as in my other works scales have been appended to the illustrations by the aid of which every object represented can be accurately measured without difficulty.

L. S. B.

61, GROSVENOR STREET,
October, 1868.

PREFACE

TO

THE FIRST EDITION.

THE Lectures which are now published were first given in November, 1852, at a laboratory adjoining King's College Hospital (27, Carey Street, Lincoln's Inn Fields), which I had arranged for the study of those branches of chemistry and microscopical enquiry which have a special bearing on medicine. Several courses of lectures and demonstrations were given during the seven succeeding years; but of late, increased work in other departments has prevented me from devoting so much of my time to this branch of teaching.

The course on urine included oral lectures and practical demonstrations, in which every pupil performed the experiments with his own hands, according to the directions given in the Tables, which will be found at page 440 of the present work.

The lectures were first published in the "British Medical Journal," and are now printed in a collected form, with several additions. I have endeavoured to restrict myself, as far as possible, to those parts of the subject which are of practical importance in investigating the nature of a case. It must be borne in mind that the Lectures were given to practitioners, most of whom had far larger experience in practice than myself. Little advantage, therefore, could have resulted under these circumstances from discussing special questions connected with the treatment of disease, and almost the whole time was devoted to the practical examination of the urine and urinary deposits by the microscope, and by applying the appropriate tests. I have thought it right to retain this character in the present work, and only a few very general remarks will be found with reference to the treatment of urinary diseases.

I have had frequent occasion to refer to numerous works, and have inserted many references in the text between brackets. The names of almost all the authors consulted will also be found in the index.

Nearly all the analyses have been made by myself, and the drawings have in most cases been copied by me on the blocks, which were afterwards engraved. Those illustrating the chapter on the kidney have been very recently copied from specimens carefully prepared. I have endeavoured, as far as possible, to give accurate copies of the objects ; and almost all the drawings have been traced directly on the wood-blocks or lithographic stones. Each object has been represented of the exact size it appeared. The magnifying power is given, and a scale appended, by which anyone can measure each object.

References to different parts of the work are inserted where required, especially in the Tables at the end of the volume. Pains have been taken to arrange the subjects to be discussed in the most convenient manner. A glance at the arrangement which immediately follows will at once give the reader an idea of the contents of the book, and the order in which the subjects are treated of.

LIONEL S. BEALE.

61, GROSVENOR STREET, W.,
March, 1861.

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LIST OF ORIGINAL ANALYSES.

ON

KIDNEY DISEASES, URINARY DEPOSITS, AND CALCULI.

PART I.

THE KIDNEY AND ITS DISEASES.

GENERAL ANATOMY OF THE KIDNEY—MINUTE STRUCTURE—THE GROWTH OF THE RENAL APPARATUS—THE ACTION OF THE KIDNEY IN HEALTH —OF DERANGED ACTION—OF THE VARIOUS STRUCTURAL CHANGES IN DISEASE—OF THE TREATMENT OF KIDNEY DISEASES.

THE kidney is not a mere filter by which certain soluble substances existing in the blood, are strained off. It is a remarkable apparatus in which the oxidation of certain matters about to be got rid of is effected, and imperfectly soluble substances are converted into readily soluble and highly diffusible compounds. The urine which is the *secretion* of the gland consists of a solution of the salts which are filtered away from the blood and the highly oxidised soluble matters, some of which are actually formed in the kidney. Without an intimate knowledge of the minute structure and action of the kidneys in health, it is not possible to form an accurate notion of the manner in which temporary or permanent derangements of function may arise. It is, therefore, desirable that every physician should be well acquainted with the anatomy and physiology of these most important excreting organs.

Kidney diseases unfortunately are in these days, but too common, and many of them are grave. But if we detect them at an early stage, before any general constitutional changes have been induced, as the labours of Richard Bright, William Bowman, and George Johnson have enabled us to do, we may in very many instances be of real service to the patient. Derangements of the renal organs often seriously affect the general changes taking place in every part of the body, and give rise to many and considerable alterations in the structure and action of other tissues and organs, especially the liver, heart and vascular system, lungs, brain, and nervous system. The proper treatment of many renal diseases is now satisfactorily established, and there is no department of medicine in which much of the knowledge we possess is more definite and precise, or the practical utility of scientific investigation more apparent.

GENERAL ANATOMY OF THE KIDNEY.

Anatomy of the Kidney. — The rough anatomy of the kidney is shown in section in the diagram, fig. 1, pl. I. Each kidney is enclosed in a capsule composed of fibrous tissue, but supplied with blood-vessels, and with nerves and lymphatics. At the hilus or notch of the kidney, the capsule is continuous with the areolar tissue which surrounds the large vessels, and extends in intimate relation with them for some distance into the interior of the organ. The figure shows the general arrangement of the kidney as seen upon section. The *ureter* traced upwards is continuous with the *pelvis*, a large cavity in the interior of the kidney, into which the urine is poured. Extending outwards from the *pelvis*, narrow funnel-shaped prolongations of the mucous membrane, *infundibula*, are observed. Sections, and portions of the trunks of, arteries and veins are observed between the infundibula, and smaller vessels are seen in the section between the cortex and medulla. From these, branches proceed in two directions, *outwards* to the cortex, and *inwards* to the pyramids. The drawing is about two-thirds of the natural size. The scale at the side is divided into eight spaces, representing half-inches.

Cortex.—The *cortex* or *cortical portion* of the kidney consists of a layer about half an inch in thickness, which forms the surface of the entire organ, and dips down often to the depth of an inch in the intervals between the pyramids. It is easily distinguished from the medullary portion by the irregular granular appearance the section presents to the unaided eye, as well as by the numerous minute points, often red from being injected with blood (Malpighian bodies), seen in it.

Medullary Portion.—This lies immediately within the cortex, and is directly continuous with its inner portion. It is composed of from ten to fifteen pyramids, their bases being continuous with the cortex; their apices, *h*, fig. 2, free, and projecting into the cavity in the interior of the organ (*pelvis of the kidney*). Each pyramid is composed of tubes continuous with those in the cortex, and disposed in lines which converge to the apex of the pyramid (papilla or mamilla), where they open by from fifteen to twenty orifices.

Pelvis: Mamillæ: Infundibula: Calyces.—The mucous membrane, with the fibrous and muscular tissue externally, forms a dilated cavity in the interior of the kidney, called the *pelvis*, *c*, fig. 2. From the *pelvis*, passing beyond the apices of the pyramids, are several tubular prolongations, forming funnel-shaped channels (infundibula), *e*, *d*, usually not more than twelve in number. In many cases, two pyramids open into one infundibulum. Each of these funnel-shaped prolongations forms a cup-shaped cavity round the tip of the pyramid (*mamilla* or *papilla*), called a *calyx*, *f*. Lastly, the mucous membrane, after forming this reduplication, becomes firmly adherent to the mamillæ, and is immediately continuous with that of the tubes, which open by orifices varying from ten to twenty or more in number, upon the summit, *h*, fig. 2, pl. I, fig. 28, pl. VI. Some of the free extremities of the pyramids are thin and flattened, and extend in a longitudinal direction, perhaps for the distance of a quarter of an inch or more. The term *mamilla* or *papilla* can hardly be properly applied to these.

In the *cortex* of the kidney we find *Malpighian tufts*, invested by the flask-like dilations of the secreting tubes, fig. 3, the *highly-convoluted portions* of the urine-forming tubes, with *capillaries*, *branches of arteries*, and *veins*, with some transparent and fibrous tissue, and bundles of *nerve fibres*. The *medullary portion*, pl. I, figs. 1 and 2, is made up of the pyramids which are formed by the straight or non-secerning portion of the urine-bearing tubes, with *capillaries*, bundles of *straight arterial branches* (*vasa recta*), and numerous straight venous branches. These are all connected, so as to form a very firm, hard texture, in which an intervening material, having a firm consistence, but not a distinctly *fibrous* network or stroma, can be discerned. *See* pl. VI, figs. 25 to 28.

MINUTE ANATOMY OF THE KIDNEY.

Of the Preparation of Specimens of the Kidney for Microscopical Investigation.—In order to demonstrate the arrangement of the vessels of the kidney, opaque injections have been recommended. Mr. Bowman used the chromate of lead injection. He first forced in a solution of bichromate of potash into the arteries, and afterwards injected one of acetate of lead. Double decomposition took place within the vessels, and the insoluble chromate of lead was precipitated. By this plan he was able, in many instances, either to rupture the vessels of the Malpighian body, or to force the solutions through them, so that the *capsule* and the uriniferous tube continuous with it were well injected. Thus was this most important anatomical point demonstrated. Certain observers, misled by the appearances resulting from faulty methods of preparation, have recently called in question the accuracy of his conclusions, but their objections have been shown to be founded on error, and

Bowman's statements in all important particulars fully confirmed. Most extraordinary methods of preparing specimens of the kidney for microscopical examination have been recently recommended, and no wonder some very curious and striking results have been arrived at by those who have adopted them. Some who have recently written upon the anatomy of the kidney have been really going back instead of advancing. Imagining they were correcting the errors of those who preceded them, they have actually propounded views much further from the truth, and by careless and ill-conceived and but too often elaborately worked-up representations of poor specimens have succeeded in throwing doubt upon observations, the accuracy of which every thorough worker has been able to confirm. Let it not be supposed, however, that little still remains to be made out. We may feel sure that many important facts in connection with the anatomy and action of the kidney are yet to be discovered, but not, probably, by those who fancy they have disproved the observations of Bowman upon the structure and connections of the Malpighian body.

Many of the methods of preparation recently recommended are wrong in principle, and must lead to most erroneous conclusions. In order to examine the tubes of the kidney, one of the latest writers on the subject, following the recommendations of some German writers, makes use of a kidney which has been hardened by some *days' stay in strong alcohol* after it had been injected. Portions of this hardened kidney are to be cooked for from *five to eight hours* in a mixture of equal parts of alcohol and hydrochloric acid. After being then parboiled the author remarks that the pieces of kidney are exceedingly friable. But they are nevertheless to be gently shaken in distilled water, and the acid neutralised with carbonate of soda, &c. No wonder this observer regards the nature of the connection between the uriniferous tube and the glomerulus as most difficult to determine. Others have published inferences arrived at from the examination of specimens hardened in strong alcohol, digested in alcohol and hydrochloric acid, parboiled, shaken up with chloroform, and lastly dried and mounted in Canada balsam. Observations made upon specimens prepared according to such methods can only add to the existing confusion, and the drawings taken from the preparations will mislead the student, encumber scientific literature, and retard the advance of knowledge.

Many of the conflicting statements concerning the minute structure of tissues have their origin in faulty methods of preparing and examining specimens. The system of mounting healthy and morbid structures in Canada balsam still resorted to by many observers must be condemned. It has been proved by experiment that no reliance can be placed upon inferences arrived at with regard to the structure, development, and growth of tissues in health, or the nature of structural

STRUCTURE OF THE KIDNEY.

Fig. 1.

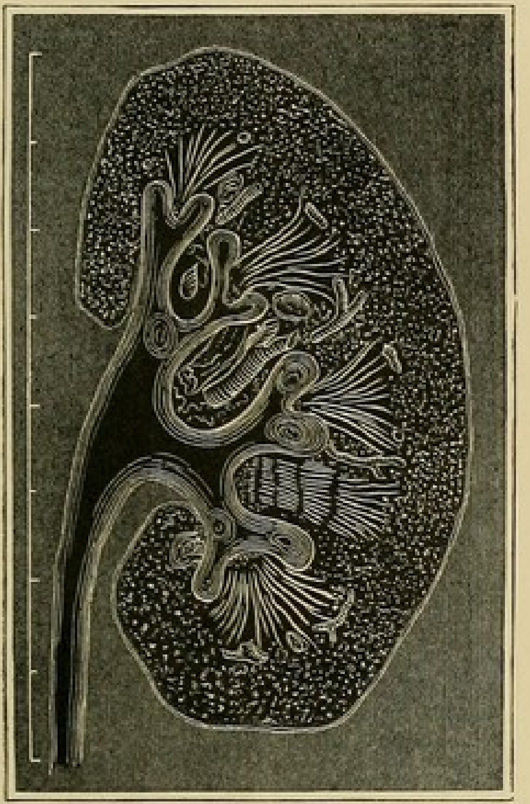
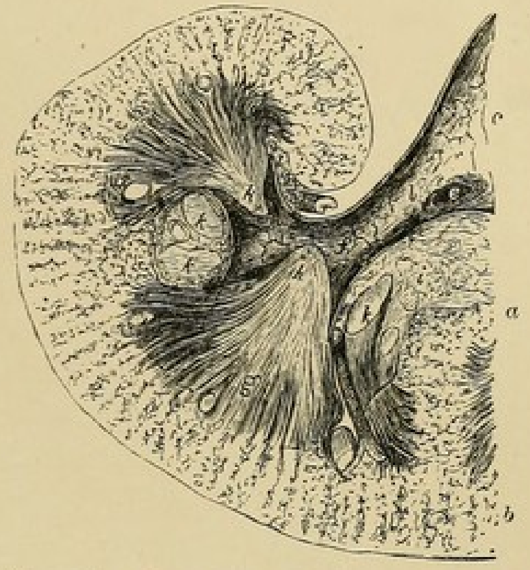


Diagram showing the general anatomy of the human kidney as seen upon section. About two-thirds the natural size. The scale at the side is divided into eight spaces representing half-inches. p. 2.

Fig. 2.



Thin section of a portion of the human kidney. *a*, cortical; *b*, medullary portion; *c*, pelvis; *d*, infundibulum; *e* opening of an infundibulum into pelvis; *f*, calyx; *g*, pyramid; *h*, mamilla or papilla; *i* adipose tissue; *k*, large veins divided in making the section. Small arteries are also seen cut across in different parts of the section, some large branches being situated between the cortex and the medullary portion of the organ. p. 3.

Fig. 3.

The secreting portion of the human kidney, showing the uriniferous tube, *k*, commencing in a flask like dilatation, *a*, *i*, which embraces the capillary vessels of the Malpighian tuft; *b*, a branch of the artery, afferent vessel, which enters the Malpighian tuft. *c*, the vein or efferent vessel. × about 50. p. 6.

[To face page 4.

alterations in disease, if derived from the examination of preparations mounted in balsam. By this process many delicate structures are very much altered or obliterated altogether, and peculiarities to be clearly demonstrated by other methods of proceeding rendered invisible.. *See* "How to Work with the Microscope," 3rd edition, p. 105, figs. 165, 166, pl. XXV.

A method of examination which has succeeded admirably in my hands, and is now recommended strongly by Frey and many other practical observers in Germany, is that which I have fully described in my works on the microscope. The artery is first injected with *Prussian blue fluid*. Then small pieces are removed and soaked in *Carmine fluid*. Or, the kidney is first injected with carmine fluid, and afterwards with the Prussian blue fluid. The pieces are to be transferred to glycerine and acetic acid (5 or 10 drops to the ounce), and when hard, exceedingly thin sections are cut with a sharp knife and mounted in glycerine, or in glycerine jelly. *See* "The Microscope in Medicine," 3rd edition, §§ 99, 101. "How to work with the Miscroscope," 4th edition, "On Injection," p. 90, and part V, p. 304. By these plans, any student, after a few trials will have no difficulty in demonstrating for himself the points of greatest importance in connection with the minute structure of the kidney. He will find the kidney of a young rabbit, dog, or kitten answer exceedingly well, but from the newt's kidney he will, with a little practice, be able to obtain specimens, showing all the important points represented in pl. I, fig. 3, but far more beautifully and clearly than can be delineated in an ordinary drawing. *See* also pl. VIII.

OF THE VESSELS OF THE KIDNEY, AND OF THE CIRCULATION OF THE BLOOD.

Artery.—The artery, entering at the hilus behind the vein, divides outside the mucous membrane of the pelvis into branches, which are distributed to the structure of organ. The arterial branches do not anastomose, but divide freely as they radiate outwards in their course towards the surface of the cortex. Arrived at a point between the cortical and medullary portions of the kidney, pl. I, fig. 2, pl. II, fig. 4, many branches pursue for some distance a more or less horizontal, or rather curved course, corresponding to the bases of the pyramids. From these, radiating outwards, pass a number of nearly straight branches, which give off on all sides little vessels, each of which seems to bear at its extremity a Malpighian body. The greater proportion of the very large quantity of blood carried by the artery to the kidney is undoubtedly distributed to the Malpighian bodies; but a few small arterial branches pass straight through the cortex, and supply the capsule of the kidney and the connective tissue around; others are distributed upon the external surface of the pelvis, and ramify amongst the adipose tissue there; while some (*vasa recta*), pl. IV, fig. 13, are given off from the vessels that lie between the cortex and medulla, many branches of which, as I have shown, anastomose with one another, and pass in the substance of the pyramids towards their apices.

In the small branches of the renal arteries, the muscular fibre cells may be demonstrated very easily. They may be followed to the point where the arterial branch enters the Malpighian tuft. All the arterial ramifications are very freely supplied with pale nerve fibres, exhibiting numerous oval nuclei, the arrangement of which may be most distinctly demonstrated in the kidney of the frog and newt, if the method of preparation I have recommended be followed out. The action exerted by the nerve fibres is considered in p. 17, and the changes taking place in the walls of the small arteries in disease are referred to near the end of this part of the work.

Vasa Recta.—Of the comparatively small quantity of the blood which passes *inwards* towards the apex of the pyramids, a very small proportion passes into vessels which supply the walls of the pelvis and the adipose tissue. The remainder is conducted towards the apex of each pyramid by the *vasa recta*, or branches resulting from the division of small trunks of the *artery*, one of which is represented at *a a*, pl. II, fig. 4, and pl. IV, fig. 13. These *vasa recta* which have been injected by Arnold, Hyrtl, Leydig, Virchow, and myself, terminate in a capillary network in the longitudinal meshes of which the straight portions of the tubes lie. It must not be concluded, however, that all the straight vessels in the pyramids are vessels which exhibit the structure of arteries; for the efferent vessels of those tufts near the bases of the pyramids divide at once into long and nearly straight branches, which pour their blood into this system of capillaries, from which it is collected by radicles which also pursue a straight course, and unite together to form small trunks, which open into branches of the vein lying between the cortical and medullary portions of the kidney. This arrangement was fully described by Bowman in his memoir; but he thought that *all* the straight vessels in the pyramids came from the Malpighian bodies. Virchow,* on the other hand, seems to have arrived at the conclusion that *all*, or *very nearly all*, the straight vessels in this situation consist of *vasa recta*, while Berres and Kölliker have failed to find them altogether. I have shown conclusively by transparent injections that many of these vessels are the efferent vessels from Malpighian bodies, as Bowman long ago stated, while a certain and not inconsiderable number undoubtedly come directly from arteries, pl. II, fig. 4 *aa*. The latter have the structure of arteries and are freely supplied with nerve fibres. In diseases

* Einige Bemerkungen über die Circulation Verhältnisse in den Nieren.—"Virchow's Archiv," vol. XII.

[*To face Page* 6.

STRUCTURE OF THE KIDNEY.

Plate II.

Fig. 4. Part of the cortex, with the commencement of the medullary portion of the kidney, magnified 15 diameters. *a.* Branches of artery. *b.* Afferent vessels of tuft. *c.* Malpighian tufts. *d.* Efferent vessel of tufts. *e.* Network of capillaries, into which the blood, after having traversed the capillary loops of the tuft, is carried. *f.* Small radicles of renal vein, by which the blood is returned to the large trunks. *g.* Long and almost straight vessels (*vasa recta*), into which the efferent vessel of those tufts situated at the bases of the pyramids, divides. These straight vessels may be traced for some distance towards the apex of the cone. *h.* Veins in the same situation, which return the blood to the large venous trunk, *i.* *k.* Capillary network in the pyramids. *l.* Portion of the capillary network of the cortex, where the meshes are elongated, corresponding to the direct course which many of the uriniferous tubes take, at regular intervals, in the cortex. *m.* Network of other parts of the cortex, in which this arrangement is not observed, *n.* Malpighian bodies not injected. *o.* Convoluted portion of uriniferous tube. *p.* Tubes having a direct course towards the cones, situated at regular intervals through the cortex. At *l* would be situated another parcel, and at *q* a third. The arteries pass in the intervals between these, as represented. *q.* One of the tubes isolated. I have never been able to demonstrate the branches represented, in the human subject, but from their existence in some of the lower animals, it is probable that a similar arrangement may be found in the higher. The branches *r* must therefore be considered merely diagrammatic. *r.* Branches continuous with the convoluted portion. *s.* Wavy portion of uriniferous tube, at the commencement of the cones. *t.* Capsule of kidney. *u.* Uriniferous tube, with Malpighian tuft and capillary vessels complete. *v.* Capillary network, with fragments of uriniferous tubes, from which the epithelium has been washed out (the so-called *matrix* of the kidney).

Fig. 5. Uriniferous tube, with dilated extremity, which embraces the vessels of the Malpighian tuft. The epithelium is seen in the convoluted portion of the tube, but cannot be traced within the capsule in the human subject.

Fig. 6. Small artery, with tuft and capillary network, accurately copied from a specimen. The artery is seen to divide into three or four branches, and each of these gives off capillary loops, which divide and subdivide for some distance before they communicate with those of another division. The letters refer to the same parts as indicated in fig. 1. Every part of fig. 1, with the exception of *q*, *r*, has been copied from actual specimens, prepared from a number of kidneys. The separate drawings thus obtained have been grouped in their proper position, in order to complete the drawing. Fig. 5 is partly copied from nature. Fig. 6 is entirely traced from a preparation. The injection employed for making the specimens was the Prussian blue fluid.*

* "How to work with the Microscope."


Fig: 5.
Fig: 4.
Fig. 6.
100 ths ×42
100 ths ×15
L. S. B. 1858.

[*To follow Plate II.*

Plate III.

EPITHELIUM OF URINIFEROUS TUBE, PELVIS OF THE KIDNEY, URETER, AND URETHRA.

Fig. 7. Convoluted portion of uriniferous tube with epithelium, from the cortical portion of the kidney. *a.* Basement membrane. *b.* Epithelium. *c.* Part of tube from which the epithelium has been squeezed out, leaving only the basement membrane. *d.* Capillary vessels containing transparent injection, showing their relation to the wall of the tube. *e.* Separate cells of epithelium magnified 403 diameters.

Fig. 8. Straight portion of uriniferous tube from the base of a pyramid. *a.* Basement membrane. *b.* Epithelium. *c.* A tube from which the epithelium has been removed. *d.* One of the large straight vessels found among the tubes in the pyramids. *e.* Capillaries also present in this part of the kidney. *f.* Separate epithelial cells magnified 403 diameters.

Fig. 9. Epithelium from the pelvis of the kidney, in part tessellated (*a*) and in part columnar.

Fig. 10. Epithelium scraped from the surface of a pyramid.

Fig. 11. Epithelium from the ureter, entirely columnar.

Fig. 12. Columnar epithelium from the urethra.

The specimens from which all these drawings were copied, were taken from the organs removed from the body of a man, aged 40, who died of pneumonia, otherwise healthy.

The vessels of part of the kidney were injected with Prussian blue fluid,* in order that the relation of the capillaries to the uriniferous tubes might be distinctly made out. The character of the epithelium lining the convoluted portion of the uriniferous tube is represented at *e* (fig. 7). Generally, the cell does not exhibit a distinct outline as is usually represented, although, on the contrary, the outline of the nucleus is often sharp and well defined. The material around the nucleus usually appears granular, and I am not satisfied as to the existence of a distinct cell-membrane. The nuclei are very large, and may easily be mistaken for the entire cell. The epithelium in the straight part of the uriniferous tube in the medullary portion of the kidney is flatter, and its outline is more distinct. In the cortex, the epithelium takes part in *secretion*, but in the medullary portion of the organ it probably corresponds to the epithelium of the *ducts* of glands generally. Many vessels in this part of the kidney pursue a very straight course, and are of large size, their diameter being equal to, or even greater than, that of the tubes, *d* (fig. 8).

* For the composition of this fluid, *see* "How to work with the Microscope."

Plate III

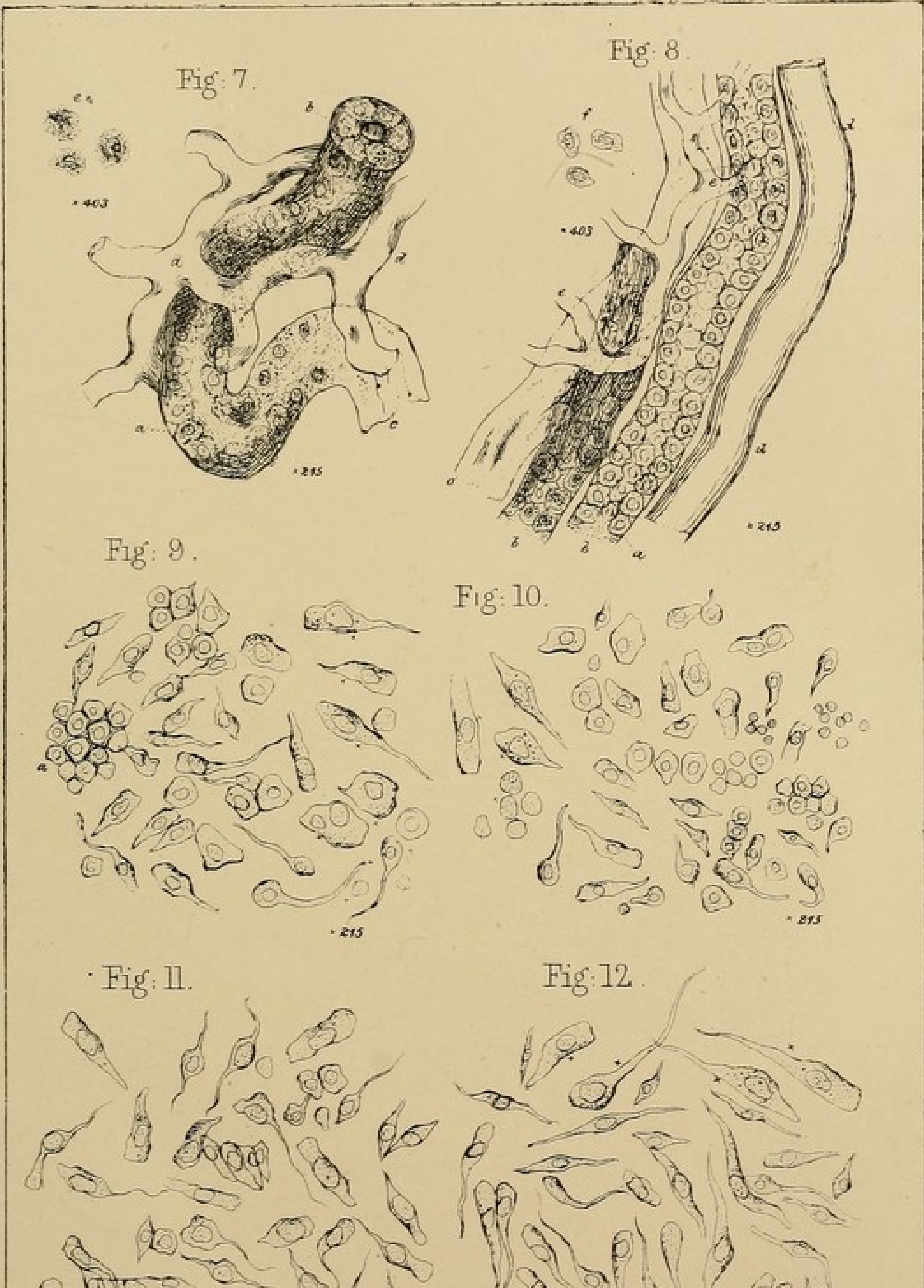


Fig: 7.
Fig: 8.
Fig: 9.
Fig: 10.
Fig: 11.
Fig: 12.
× 403
× 215
magnified 403
1000 ths × 403
1000 ths × 215
Path. Lab. 1858

in which much more blood is made to pass into the pyramids than normally, these arterial branches or vasa recta, become much thickened, and the circular muscular fibres are more readily demonstrated than in health. A few branches of these arteries pass right through the kidney and reach the capsule. ("On the Vasa Recta in the Pyramids of the Kidney," Archives of Medicine, vol. I, 1856.)

Many observers have *criticised* Virchow's statements concerning the arteriolæ rectæ, and have stated that these vessels *do not originate directly in arteries*, unless it be as a very small and most irregular source. Yet it seems to me that my specimens copied in pl. XXIX, Archives, vol. I, published in 1856, pl. IV, fig. 13, prove conclusively that numerous arterial branches do come off from arteries in the healthy kidney, turn downwards in the pyramids and break up into bundles of small elongated vessels, the blood circulating through which, has never passed through any Malpighian bodies whatever. I have re-examined this point, and can arrive at no other conclusion. Moreover, in the *newt's kidney*, I have succeeded in demonstrating vessels which come off directly from the large artery and divide and subdivide amongst the tubes without giving off any vessel whatever, to a Malpighian body.

Vein.—The *Emulgent* or *Renal Vein* is formed by the union of a number of smaller trunks which receive the blood from the capillaries. Numerous large branches may be seen in the intervals between the cortex and medullary portion. They converge from all points, receiving the blood distributed by the arteries as above described and at length form one large trunk, which emerges at the anterior part of the hilus and opens into the inferior cava. The relation of the efferent vessels of the Malpighian bodies to the capillaries of the kidney and the radicles of the renal vein will be described presently, but it will be understood at once if pl. I, fig. 3 at *c* and *e*, or pl. II, fig. 6 at *d*, is referred to. The coats of the small veins of the kidney exhibit the muscular fibre-cells very beautifully, and amongst these fine nerve fibres ramify in great numbers. In many cases the number of nerve fibres distributed to the coats of the veins is greater than to the coats of the arteries.

Vessels of the Malpighian Body, and Course of the Circulation.—The course of the blood, as it circulates in the vessels of the kidney. may now be described. Starting from the arterial branches between the cortex and medullary portion of the organ, the blood pursues two directions—*outwards* towards the external surface, and *inwards* towards the apices of the pyramids.

Of the blood which passes *outwards*, a little is distributed to the capsule and membrane of the pelvis, but by far the larger proportion is carried to the Malpighian bodies. Arrived at the Malpighian body, the trunk of the little artery divides into three or four dilated branches, each being as wide as the artery itself, pl. II, fig. 6. These subdivide into capillary loops which have their convexities towards the uriniferous tube, and which lie uncovered by epithelium within its dilated commencement; so that fluids passing through the membranous walls of these capillaries, and everything escaping from them when they are ruptured, must at once pass into the uriniferous tube.

The appearance of some of the capillary vessels of the Malpighian tuft of the human kidney, separated and, to some extent, flattened out, is represented in pl. IV, fig. 14. The vessels were injected with dilute Prussian blue injection. The nuclei connected with their walls are well seen: *a*, a few coils separated from the rest of the tuft; *b*, part of a loop somewhat compressed, showing the nuclei a little flattened; *c*, tissue connecting the coils with each other, in consequence of which the globular form of the tuft is preserved, even when it is removed; *d*, a small portion of a capillary compressed as much as possible, showing the thickness of the capillary wall at the point of reduplication.

The blood is collected from the capillaries of the Malpighian body by small venous radicles which lie in the central part of the tuft, and there unite to form usually a single efferent vessel that emerges at a point very close to that by which the artery entered, pl. II, fig. 6, *d*. In some specimens, however, I have seen two and even three efferent vessels leaving the tuft at different points some distance from the artery, but this is not common.

The arrangement of the secreting structure and vessels of the kidney of man, magnified about 50 diameters, is represented in the drawing, pl. I, fig. 3, *a*, Malpighian body; *b*, Malpighian artery or afferent vessel; *c*, efferent vessel; *d*, capillary network, into which the blood passes from the efferent vessel; *e*, small venous radicle, which carries off the blood after it has traversed the capillaries just alluded to; *f*, commencement of the uriniferous tube by a dilated extremity, which embraces the vessels of the tuft; *g*, the tube; near the point where it opens, it joins others, *h*, to pursue a straight course towards the pyramids of the kidney; *i*, another tuft, the vessels of which are empty and shrunken; *k*, portion of a tube cut across, showing the basement membrane. The attention of the reader is particularly directed to this figure.

The *efferent* vessel of the tuft pursues a short course, and then divides into an extensive network of capillaries, in the meshes of which the tubes ramify, pl. II, fig. 6, *e*. It is from the blood, which, after passing through one system of capillaries in the tuft, thereby losing much of its water, slowly wanders in a more concentrated state, through this extensive intertubular capillary system, that the most important of the solid constituents of the urine are probably separated, some being much modified or actually formed or elaborated by the agency of the epithelial cells lining the tubes. The water, *fully charged with oxygen*, transuding from the capillaries of the Malpighian body, is made to traverse in succession the epithelial cells lining the tube. At the same time that it dissolves the different substances which have been separated from the blood, it no doubt *oxidises* the matter forming the outer part of the cells, and thus some of the soluble substances, characteristic of the urinary secretion, are formed. The urine becomes richer and richer in solid constituents as it approaches the straight portion of the tube by which it is rapidly conducted to the pelvis. From the intertubular network of capillaries above alluded to, the blood is collected by small venous radicles, pl. I, fig. 3 *c*, which at last pour their contents into the renal or emulgent vein.

Lymphatics of the Kidney.—There are numerous lymphatic vessels distributed to the kidney. They leave the organ at the hilus, where the large vessels enter. I have succeeded in injecting the lymphatics of the liver, in which organ they exist in great number, and ramify in the substance of the capsule and in the portal canals, but although I have made many attempts to investigate the arrangement of the lymphatic vessels in the kidney, so far I have failed. Ludwig and Zawarykin describe an abundant network of lymphatic spaces in the kidney. The capsule of the kidney is, probably, also supplied with lymphatics, although it is not easy to demonstrate them by injection.

OF THE SECRETING APPARATUS AND EPITHELIUM.

Of the Uriniferous Tubes. — The renal secreting apparatus consists essentially of a tube lined with epithelium. The tube in the vertebrate kidney commences in a small flask-like dilatation, which embraces the capillary vessels of the Malpighian tuft, fig. 3, pl. I, and fig. 5, pl. II. In continuation with this is the tube which, in the greater part of its extent, is very much convoluted, being frequently bent upon itself; so that a great length of secreting tube is packed in a very small space. The convoluted tubes are so close together, that it is impossible to trace, in man and mammalian animals generally, the course of one individual tube for any great distance; and, in thin sections of the cortex, segments of the windings of different tubes are seen divided in all directions. A tube may however be followed in its whole length in the newt's kidney. The tube differs in diameter in different parts of its course. It is somewhat constricted near the Malpighian body forming a sort of *neck*, it then becomes wide and gradually contracts again as it passes towards the pyramids.

The tubes, as they are about to leave the cortex, pursue an almost straight course, and here commences the *ductal portion of the urinary apparatus*. A certain number of these straight tubes extend nearly to the surface of the kidney, and carry off the secretion from the tubes which lie most superficially. They may be seen lying in the cortex, at certain intervals. In the pyramids, the tubes are straight; and as they converge, they unite together, and become fewer in number; while their calibre greatly increases as they approach the apex of the pyramid, where they open as before described. Some of these orifices are figured in pl. VI, fig. 28.

Attention has been drawn to the fact, familiar to all who have worked much at the minute anatomy of the kidney, that many of the convoluted tubes dip down for some distance amongst the straight tubes of the pyramids, forming loops the convexities of which are directed towards the apex of the pyramid. These tubes were supposed by Henle to be connected with Malpighian bodies, and he has been led to conclude that they form a system of tubes distinct from those which open into the pelvis of the kidney. He adopted that strange inference which has astonished most anatomists familiar with the structure of the kidney, that there were tubes without any opening whatever, forming as it were closed tubes connected with Malpighian bodies, while the urine-secreting open tubes were said to be independent of Malpighian bodies. Numerous memoirs have been written to disprove Henle's views, which will probably soon be abandoned. His observations have excited many comments, and although there still remains something to be cleared up with reference to these tubes, it may be considered as proved that they are but coils of the convoluted portions of the uriniferous tubes. Perhaps the most curious suggestion yet advanced concerning these loops is the following:—"What mean these closed down loopers of Henle, and wherefore do they dip down among the water drains? (!) Ask, why do the roots of trees tend towards the water wells if not for water? These are the thirsty spongioles which pick up the water to flush down the drains which had otherwise been choked up with solid urinary excreta*."

It seems to me that Henle has enormously exaggerated the number of the loops in the pyramids, while he has not given drawings of what certainly is exceedingly common, namely, a tube running straight for a certain distance, and then after being bent upon itself, continuing its straight course towards the apex of the pyramid. But his statements concerning the two sets of tubes are completely disproved by a careful investigation of a well-prepared kidney of a young animal. Frey has given some excellent schematic drawings showing this point, pl. IV, fig. 15, *a*.

These looped tubes in the pyramids exhibit the same general structure as other parts of the convoluted portion of the uriniferous

* Dr. Reginald Southey, Bartholomew's Hospital reports, 1865, pp. 187, 188.

tubes, and there seems, therefore, no reason from the anatomical side for inferring that they are otherwise than convolutions drawn down some distance during the growth of the pyramids. The different characters observed in different tubes as seen in a section of the cortex of a healthy kidney, upon which Henle lays so much stress, are due to the varying ages and degrees of development attained by contiguous tubes. That this is the correct explanation may be demonstrated very conclusively in the kidney of a young mammalian animal.

If Professor Henle will examine the thin part of the kidney of the common black newt in spring, he will see tubes in different stages of growth, but he will have no difficulty in demonstrating that each is one continuous tube which may be followed coil by coil in every part of its course. By studying the kidney of this animal at different periods of the year, the changes taking place during the development and decay of the urinary apparatus may be observed, and an excellent life history of the renal apparatus of this animal might be written. I have succeeded in ascertaining many points of the greatest interest in connection with the development of that highly elaborate organ, the Malpighian body, which will be referred to shortly.

It seems strange that the idea of there being *two distinct systems of tubes* in the kidney, the one open and the other closed should have been received at all by anatomists who had studied renal structure in man and animals. That mere critics should have accepted the notion is, perhaps, scarcely to be wondered at, although one would have supposed that a view involving the doctrine of the Malpighian bodies being appended to tubes forming a closed system would have excited the surprise even of reviewers. Instead of examining specimens, or even thinking about the wonderful mechanism of the Malpighian bodies, writers both here and in Germany have vied with each other in propagating Henle's view, and complimenting the author. The amount of useless discussion upon this matter has been great, although there can be no doubt that at the very time Henle wrote, there were many preparations in Germany that would have satisfied him he was in error before he gave his memoir to the world. In this country I know there were such specimens. It seems strange that a few persons connected with the periodical press, having little or no practical experience, should have it in their power to force into notoriety views which practical anatomists know to be erroneous, and which they could convince others were erroneous. But reviewers seldom have time to examine specimens. A few years have now passed, and the fever is over. After a great deal of unnecessary writing, and no little injustice to English observers, we are allowed to return to the view advanced by Bowman in the year 1841 of the truth of which most practical anatomists, and not a few students have convinced themselves by preparing specimens.* As has been already mentioned a single uriniferous tube may be so injected that its convolutions may be traced by the extravasation from the vessels of the Malpighian body, in which case the artificial injection takes the same course as the urine. Sometimes hæmorrhage takes place shortly before death, and thus a natural injection of a single uriniferous tube results.† Occasionally insoluble materials are deposited in the uriniferous tubes, and thus the observer is able to demonstrate the wall of the tube very distinctly, and may even measure its thickness. The insoluble matter sometimes forms an amorphous deposit, sometimes exists in the form of spherules or dumb bell-like crystals, and sometimes takes a crystalline form. The tubes represented in pl. VII, fig. 29, are choked up with an amorphous granular deposit which consists of albuminous matter and altered blood. It has collected in tubes situated here and there in different parts of the kidney, and in some instances the tube is distended to twice its ordinary diameter at the seat of obstruction. The obstructions are most numerous in the straight portion of the tubes.

Dumb-bell crystals of oxalate of lime not unfrequently collect in the narrow part of the tube between the cortex and medullary portion of the kidney, but this form of concretion will be again referred to when the subject of urinary calculi comes under consideration. Spherical and oval masses of ammoniaco-magnesian phosphate and phosphate of lime have also been found in the tubes. Amorphous granules of earthy phosphate are seen amongst the cells of the tubes represented in pl. VII, fig. 34.

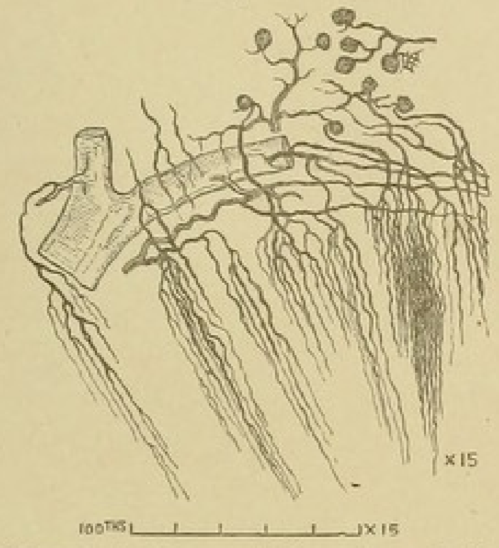
Well-formed crystals of uric acid are rarely seen in the uriniferous tubes of the human subject. I have, however, some sections of the kidney of a common snake which had been long kept in confinement, in which beautiful crystals of uric acid or a urate exist in great number in the tubes. A drawing of this specimen is represented in fig. 30, pl. VII. Urates, principally of soda and ammonia, are sometimes found in the tubes. I have met with them in the fœtal kidney. Leucine sometimes crystallises in the renal tissue after the kidney has been removed from the body, minute crystals being deposited in the tubes. These may afterwards undergo solution and larger crystalline masses be deposited in the intertubular tissue external to the tubes, as represented in figs. 31, 32, pl. VII.

* A few references may be of interest. Henle, zur Anatomie der Niere, Göttingen, 1862. Luschka, Anatomie des Menschen, Tubingen, 1863. Chrzonszczewsky, Archiv f. path. Anat., 1864, p. 153; Schweigger-Seidel, Die Nieren des Menschen, Halle, 1865; Frey, Das Mikroskop, 1866.

† Bowman. Phil. Trans. 1842, p. 67.

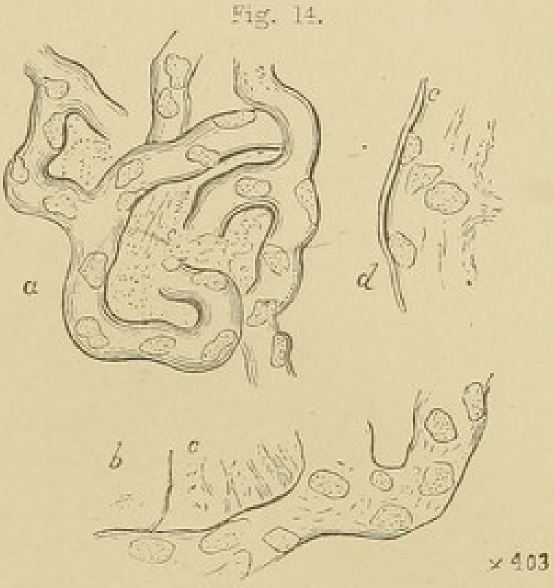
STRUCTURE OF THE KIDNEY.

Fig. 13.



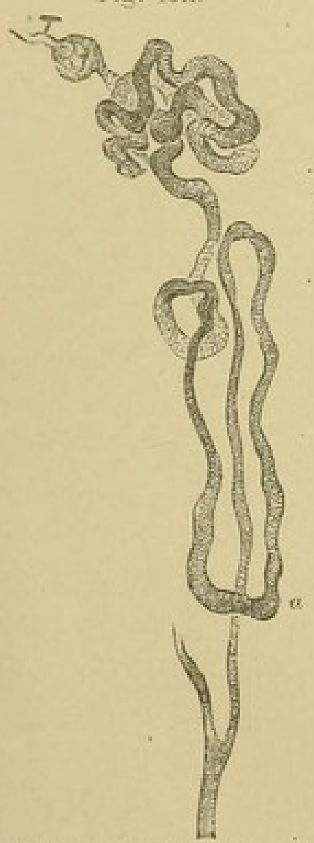
Vasa recta in the pyramidal portion, and Malpighian bodies in the cortical portion. At about the point of union between cortical and straight portions of kidney. p. 7

Fig. 14.



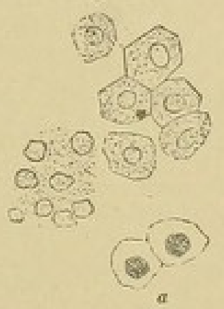
Capillary vessels from Malpighian tuft of human kidney, showing the nuclei connected with their walls. *a*, a few coils separated from the rest of the tuft. *b*, part of a loop somewhat compressed, showing the nuclei a little flattened. *c*, tissue which connects the coils with each other, by which the globular form of the tuft is preserved even when it is removed. *d*, a small portion of a capillary compressed as much as possible, showing thickness of capillary wall at the point of reduplication. p. 8.

Fig. 15A.



Uriniferous tube bent upon itself at *a* in the pyramid of the kidney. The looped tube of Henle. p. 10.

Fig. 16.

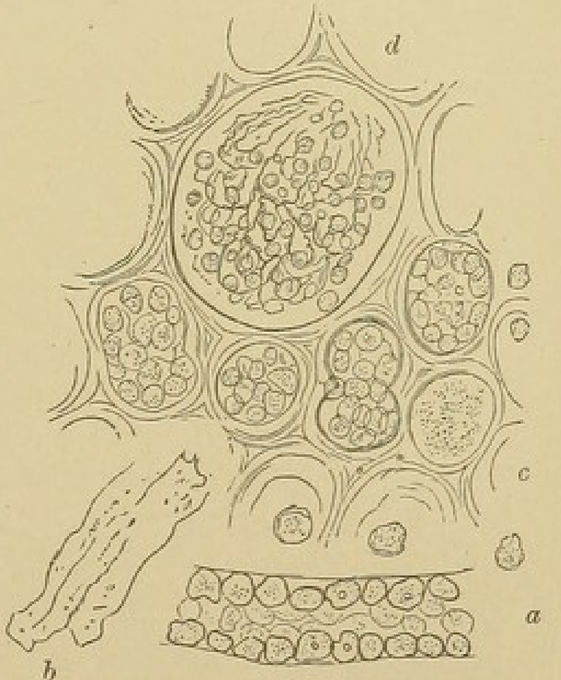


Epithelium from a uriniferous tube. Human kidney. *a*, treated with acetic acid. p. 13. × 215.

Fig. 17.

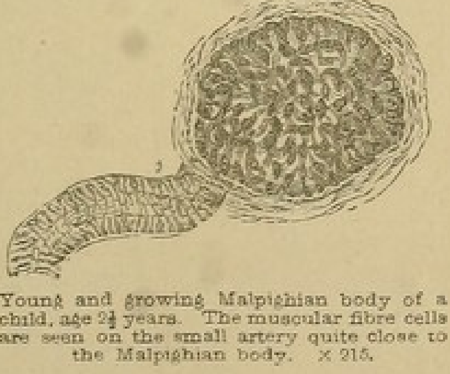
Epithelium from the pelvis of the healthy human kidney. p. 14. × 215.

Fig. 15.



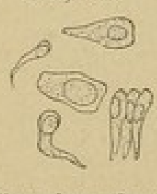
Thin section of healthy human kidney, slightly washed in water. *a*, convoluted portion of uriniferous tube. *b*, portion of a tube stripped of its epithelium. *c*, outline of tube and crumpled capillaries, having a fibrous appearance—the so-called matrix. *d*, very small Malpighian body; loops of vessels shrunk, showing cells in their walls. × 215. pp. 18, 20.

Fig. 17A.



Young and growing Malpighian body of a child, age $2\frac{1}{2}$ years. The muscular fibre cells are seen on the small artery quite close to the Malpighian body. × 215.

Fig. 18.



Epithelium from the ureter. p. 14. × 215.

[To face page 12.

The deposition of insoluble substances in the uriniferous tubes is a subject of the greatest importance. There is reason to think that it is in this way many serious structural diseases commence, and it is quite certain that calculous formations almost always originate in this manner.

Epithelium.—The epithelium of the kidney differs somewhat in its characters in different parts of the tube, and also at different ages. That in the convoluted or secreting portion of the tube is described as being polygonal; it projects into the tube to the extent of one-third of its calibre. The epithelium in the straight portion of the tube is flatter, and approaches to the tessellated variety. Although the convoluted portion of the tube is much wider than the straight portion, *the diameter of the channel is much wider in the latter position than in the former*, in consequence of the much greater thickness of the epithelium in the secreting portion of the tube. Epithelium from the convoluted portion of the uriniferous tube is represented in pl. III, fig. 7, and in pl. IV, fig. 16; *a*, treated with acetic acid.

In healthy human kidneys, I have never seen the outline of the secreting cells so distinctly as it is usually figured in anatomical works, or indeed in my own figure. The round body, usually termed the nucleus, is very clear and well defined, and this seems to be surrounded by a quantity of soft granular matter. Although sometimes there appears to be a cell wall, no such structure really exists. In many cases of disease, the round central bodies or nuclei are all that can be made out; and sometimes these are found in great number in the urine. The round "cells" (masses of germinal matter) present in the urine, in cases of acute nephritis, are generally the so-called "nuclei" of the "cells" lining the uriniferous tube, the soft granular material around having been completely disintegrated. By the action of acetic acid, "nucleoli" may be observed. It would seem as if the granular matter external to the rounded granular body (nucleus) became altered in character under certain circumstances. From numerous observations, I feel compelled to dissent from the descriptions generally given both of the kidney and liver epithelium, inasmuch as the appearance of a cell wall can only be seen under certain circumstances; and in the normal cell there is undoubtedly no such structure. I would rather say that the spherical masses of germinal matter, the so-called "nuclei" are embedded in a granular material, which they have produced, and by which they are separated from each other by nearly equal distances, as represented in the upper part of fig. 16, pl. IV. If, instead of using the terms *nucleus*, *cell-wall* and *cell-contents*, we call the central mass *germinal or living matter*, and the outer granular matter *formed material*, the changes actually observed can be described without any difficulty or confusion. The formed material is rendered transparent by acetic acid, as represented at *a*, fig. 16, and during life it is slowly converted into soluble substances by the action of the oxygen dissolved in the water discharged from the Malpighian capillaries. The secreting epithelium probably acts in this way:—the germinal matter takes up certain constituents from the blood, and thus new germinal matter is formed; but the mass does not increase in size because, at the same time that matters are taken up from the blood, a portion of the germinal matter already formed undergoes conversion into formed material; nor in a normal state does the formed material accumulate, because that which is already formed becomes disintegrated by the action of water and oxygen, and is resolved into urinary constituents which escape in solution in the water.

The renal epithelium, as above remarked, readily undergoes great change. In health the outermost part of the soft granular material is perhaps a little firmer in consistence than that which is more central. In some chronic diseases all this may become hard and firm, so that the germinal matter in the centre of the cell (nucleus) cannot be easily dislodged from its position. More commonly, however, this outer part breaks down, and the masses of germinal matter being set free, grow and multiply, and pass into the urine in great number. *See* plates of casts, &c.

The epithelium in the straight portion of the tube is much flatter than that in the convoluted part, and probably serves the office of a protective covering. It is doubtful if it takes part in secretion, but there is some reason for thinking with Virchow that at least in certain cases albumen escapes from the blood into this portion of the uriniferous tube. The epithelium from the pelvis of the kidney and from the ureter is represented in pls. III and IV.

At an early period of development epithelium may be detected in the Malpighian body of the mammalian kidney, but in the adult it is doubtful if any exists. In batrachia, epithelium exists all over the inner surface of the capsule.

OF THE NERVES OF THE KIDNEY, THEIR ULTIMATE DISTRIBUTION, AND OF THEIR ACTION.

Of the Distribution of Nerves to the Vessels and Secreting Structure of the Kidney.—The nerves of the kidney are for the most part branches of the sympathetic, and are distributed to the secreting tubes and capillaries as well as to the arteries. Bundles may be traced for a considerable distance into the interior of the gland. In these bundles dark-bordered, as well as pale, fibres may be seen and the smaller bundles ramifying in the substance of the gland also contain dark-bordered nerve fibres. Connected with the bundles of nerve fibres distributed to the kidney are numerous ganglia and ganglion cells arranged in a manner similar to those met with in connection with the ramifications of the sympathetic generally in mammalia. All the branches of the artery as well as the vasa recta of the human subject are freely supplied with nerve fibres, and numerous very fine nerve fibres with nuclei connected with them lie amongst the tubes. These "nuclei" or masses of germinal matter so numerous in all the peripheral nerve fibres of various textures of mammalia have been hitherto included amongst the connective tissue corpuscles of the matrix.

It is somewhat difficult to obtain specimens of the ganglia above referred to, which exist in great number embedded in the areolar tissue, not only of the notch and hilus, but also and in considerable number in the areolar tissue beneath the mucous membrane of the pelvis. I have, however, obtained good specimens from the kidneys of children. The ganglia seem to be much more numerous in the kidney of the pig than in that of the human subject, and in the young animal a great number of ganglia may be found in very small pieces of the areolar tissue removed from the pelvis. The general arrangement and form of the ganglia are well seen in fig. 20, pl. V, which has been carefully copied from one of my specimens; and in fig. 21 a single ganglion with its bundles of nerve fibres from the human subject is represented magnified two hundred diameters. The ganglion cells represented in pl. VII, fig. 33, are seen to give off processes which gradually become attenuated, and form the fibres which exhibit at short intervals elongated nuclei, fig. 22. In the natural state the nerve fibres are broader, and their texture more delicate and transparent than is represented in the drawing. Amongst them connective tissue fibres resulting from the degeneration of nerves, are to be demonstrated, but at the early age of three years the amount of connective tissue is small. The nuclei and fibres around the ganglion cells which are usually regarded as capsules of nucleated connective tissue really consist principally of true nerve fibres with their nuclei.

Although it has long been known that the kidney is freely supplied with nerves, their arrangement and distribution in the vascular and secreting portion of the gland have not been accurately determined. The opinion seems to have been generally entertained that the nerves were distributed mainly, if not solely, to the vessels of the kidney, but from some recent observations, more especially upon the kidney of the newt, I have been able to demonstrate nerve fibres in every part of the organ, and in large number.

In man and the higher animals the nerves are so extremely delicate, and their distribution so obscured by other firmer, more granular, and more distinct textures, that they cannot be readily followed and traced to their ultimate distribution. In the frog and newt, however, this can be effected with the greatest certainty and exactness. In the latter animals nerves may even be traced from their ganglia and followed to their ultimate distribution around the tubes and capillary vessels of the kidney.

In my specimens extremely fine nerve fibres may be readily followed to the external surface of every uriniferous tube in every part of its course. Having reached the wall of the tube, the fine nerve fibres divide and subdivide freely, giving off still finer branches which ramify in the connective tissue entering into the formation of, and continuous with, the so-called *basement membrane*, pl. V, figs. 19, 19*a*. The nerves are extremely delicate, and consist for the most part of pale nucleated fibres. In the case of the thin portion of the kidney of the newt, but few dark-bordered fibres can be discerned, but in the frog's kidney and in the thick part of that of the newt, I have seen many dark-bordered nerve fibres. The fine pale nucleated nerve fibres above mentioned form lax networks around the uriniferous tubes, many of the meshes being as much as the $\frac{1}{200}$ of an inch in diameter.

The capillaries of the kidney are also freely supplied with nerves. The general arrangement and mode of distribution of these fibres are as I have described in my Croonian Lecture (1865) and other memoirs. I have been able to follow fine nerve fibres on the branches of the artery quite to the point where it penetrates the capsule, and I have no doubt that these fibres form networks around the capillaries of the tuft of the Malpighian body, but owing to the thickness of the wall of the capsule, and to the layer of epithelium which lines it in the newt, I have not been able to demonstrate the nerve fibres in this situation, *in situ*. In cases where the tuft has been withdrawn from the Malpighian body, fine nerve fibres with their elongated nuclei may, however, be seen in close proximity to the vessels.

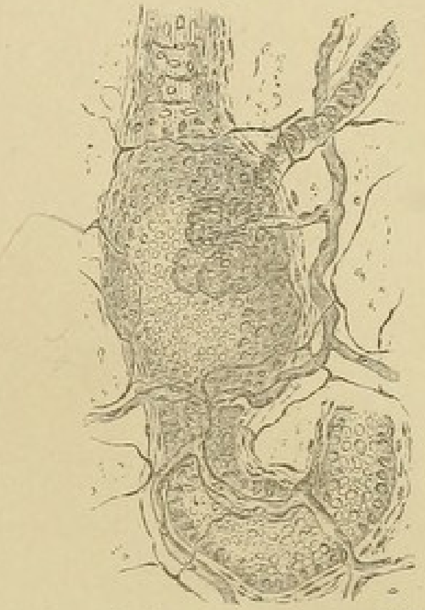
My specimens then positively demonstrate that to the convoluted portion of the uriniferous tube, to the intertubular capillaries, and to the capillaries of the Malpighian body, nerve fibres are distributed. They of course also exist in considerable number in the coats of all the small arteries and veins. These nerve fibres are all connected with ganglion cells, from each of which two or more fine fibres proceed in different directions, establishing connections between the cells of these and other ganglia and peripheral parts, figs. 20, 21. These anatomical researches must necessarily lead to important conclusions with reference to the physiological changes taking place in the kidney in health, and the pathological phenomena occurring in disease.

The investigation of the distribution of the nerve fibres in the mammalian kidney is far more difficult, but by comparing the appearances observed in this organ with those in tissues in which the arrangement of the nerves can be positively demonstrated, we may learn many important things, and be led to an interpretation which I think may be

Fig. 19.

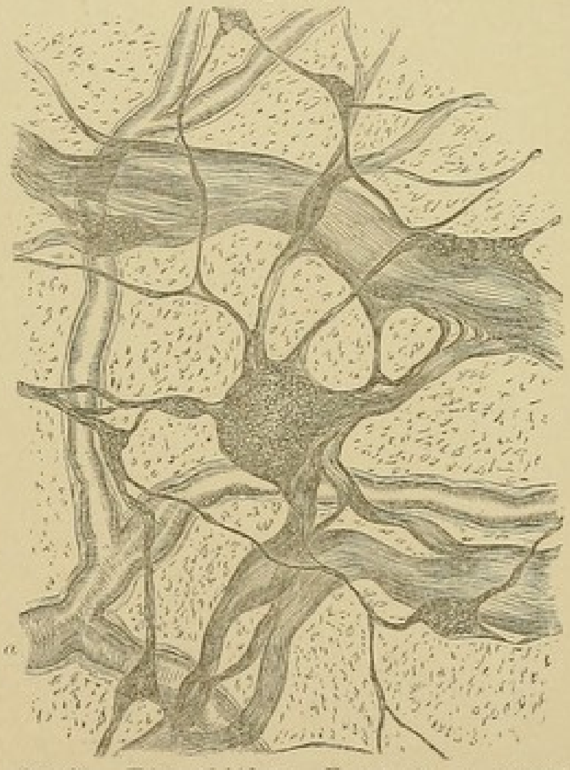
A part of the convoluted portion of a uriniferous tube from the newt's kidney, showing capillary vessels and nerve fibres, and the thickened basement membrane continuous in structure with the connective tissue.
× 215. pp. 16 19.

Fig. 19A.



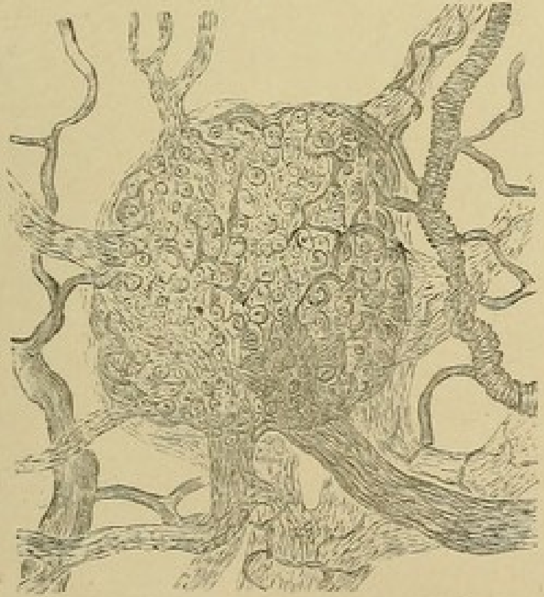
alpighian body and tube of the newt's kidney
× 130. pp. 16, 19.

Fig. 20.



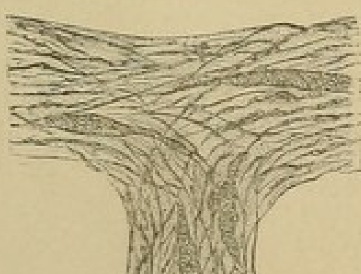
Ganglia. Hilus of kidney. Young pig. *a*, a small artery. × 20. p. 15.

Fig. 21.



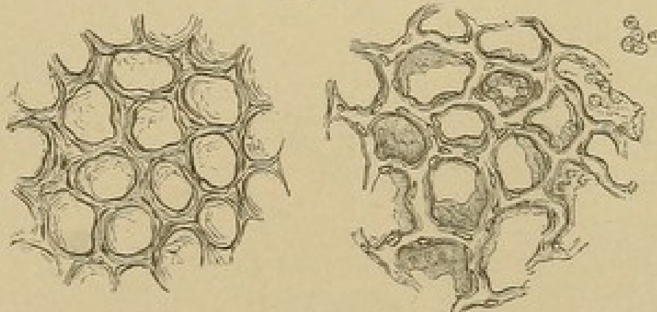
Ganglion from the pelvis of the kidney of a boy 3 years of age, showing small arteries and capillaries, nerve cells and bundles of nerve fibres. × 215. p. 15.

Fig. 22.



Delicate nerve fibres entering into the formation of the bundles connected with the ganglia of the kidney, showing their arrangement and their nuclei.
× 700. p. 15.

a Fig. 23. *b*



a, section of cortical portion of healthy kidney (human). Washed in water and examined in the same medium. The capillaries were not injected, and having collapsed and shrunk exhibit the fibrous appearance which is considered to depend upon the matrix. *b*, section of another part, in which the vessels were injected. The nuclei on their coats are seen, but no "fibrous matrix." × 100. p. 20

[*To follow Plate V.*

STRUCTURE OF THE KIDNEY.

Plate VI.

Fig. 24. Section of the cortical portion of a human kidney, the vessels of which have been injected with the Prussian blue solution. *a.* Membrane of the tubes. The *a* to the right of the figure shows the position of a Malpighian body: *b* a portion of a capillary loop of a Malpighian body: *c* venous capillaries lying between the uriniferous tubes. In many places the double shaded line indicates the basement membrane of the tubes: *d* position of the uriniferous tubes.

Fig. 25. Transverse section at the base of a pyramid.

Fig. 26. A similar section a short distance lower down, showing sections of the uriniferous tubes. The small tubes join the larger ones at a point lower than that at which the section is made.

Fig. 27. Section nearer the apex of the pyramid.

Fig. 28. Apex of a pyramid showing the manner in which the uriniferous tubes open into the pelvis of the kidney.

Fig. 24.

Fig. 25.

Fig. 26.

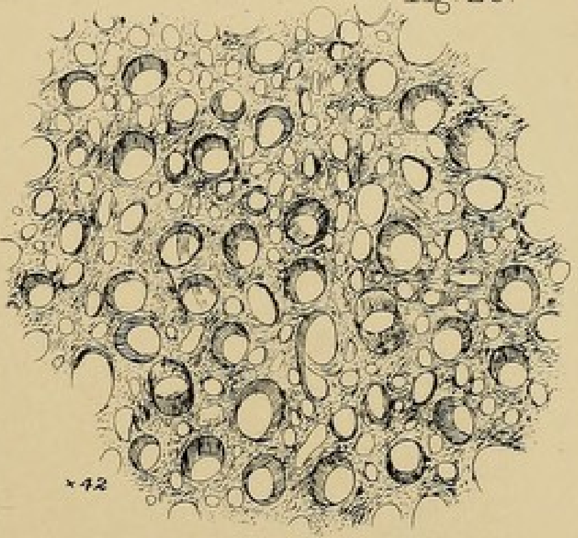


Fig. 27.

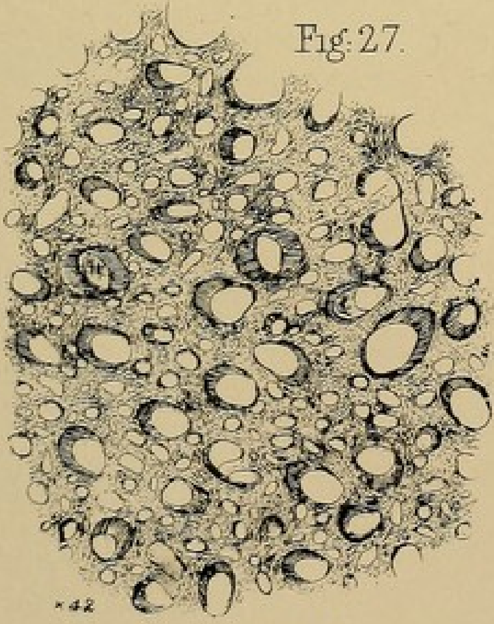
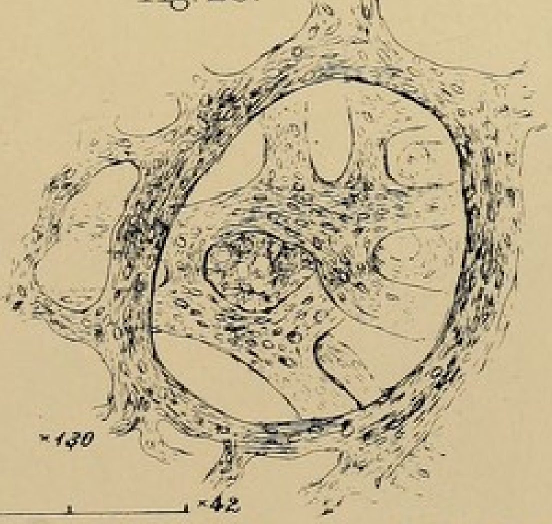


Fig. 28.



100 ths ×42

1000 ths ×130

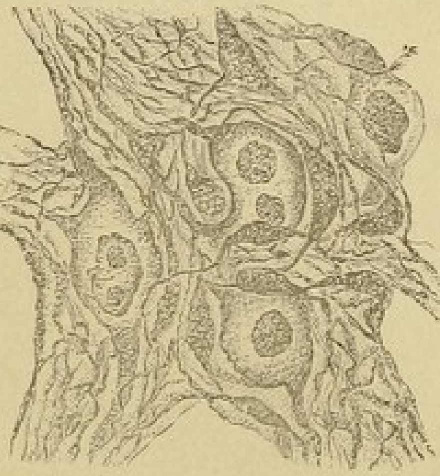
L.S.B. Path. Lab. 1858

STRUCTURE OF THE KIDNEY.

Fig. 29.

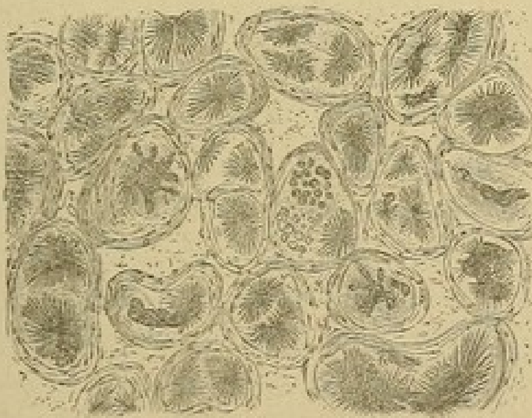
Uriniferous tubes, some of which are choked with a deposit consisting of albuminous matter and blood. × 29. p. 12.

Fig. 33.



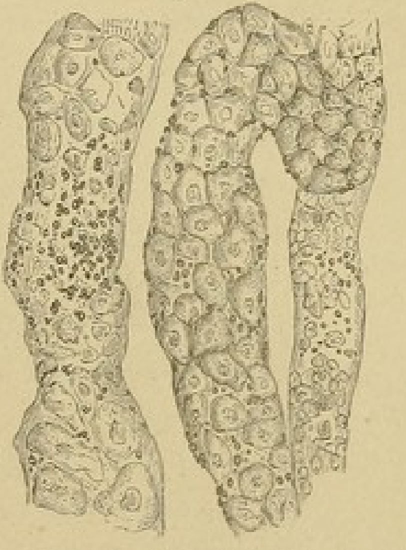
A small portion of the small ganglion represented in Fig 21, Plate V., but magnified 700 diameters, showing ganglion cells and their connexion with the nerve fibres. p. 15.

Fig. 30.



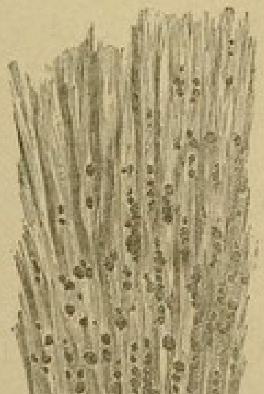
Transverse section of the tubes of the kidney of a snake, occupied by large crystals of uric acid × 29. p. 12.

Fig. 34.



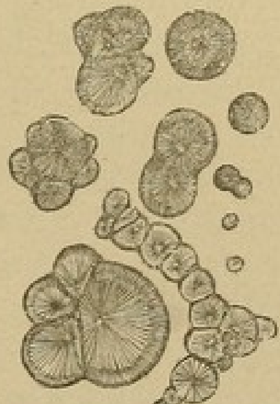
Tubes of human kidney. With earthy phosphates precipitated amongst the cells. × 215. p. 12.

Fig. 31.



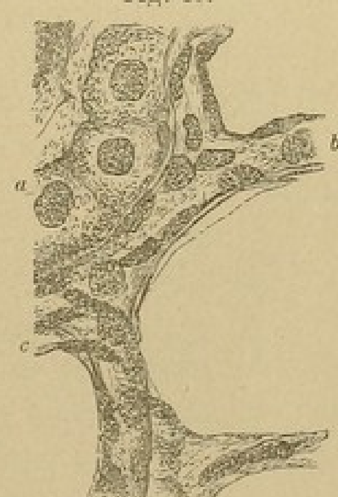
Crystals of leucine in the substance of kidney. Human subject. × 29. p. 12.

Fig. 32.



Crystals of leucine more highly magnified. From the same specimen. × 215. p. 12.

Fig. 35.



a, portion of uriniferous tube; *b*, capillary vessel; and *c*, nerve fibres. Kidney, child, age 3 × 700. p. 21.

relied upon. Many of the oval masses of germinal matter seen in the intervals between the tubes, and upon the surface of the vessels of the mammalian kidney belong, I have every reason to believe, to nerve fibres, the structure of which is so delicate, that it is extremely difficult to trace their course. I have, however, great hopes that by modifying my plan of preparation in some slight particulars, I may succeed in demonstrating in man the arrangement of these fibres quite distinctly.

Of the Action of the Nerve Fibres and Ganglia.—With reference to the action of the nerve fibres of the kidney, it may be well to offer a few remarks. The very rapid secretion of a quantity of urine consisting almost entirely of pure water under the influence of emotion is well known, and is no doubt to be explained by the action of the nerve fibres upon the small arteries from which the capillaries of the Malpighian bodies spring. The relaxation of the arterial muscular walls in consequence of a change occurring in the ganglia in which the nerve fibres originate, will permit a distension and consequent thinning of the elastic capillaries, the walls of which becoming in proportion more permeable to fluids, will permit the escape of a much larger quantity of water in a given time. In this way the formation of much watery urine is explained.

The nerve fibres I have shown to be distributed to the walls of the uriniferous tubes, pl. V, fig. 19, constitute I think an afferent system precisely corresponding to that which I have described in other tissues, and capable of influencing through the nerve centre the efferent fibres distributed to the arteries. Thus they govern the calibre of the arteries, and necessarily regulate the proportion of blood flowing through the capillary vessels. The influence of nerve fibres upon the mechanism of the Malpighian body, and in determining the flow of oxygenated water along the uriniferous tube, as well as the slow or quick passage of blood charged with solid urinary constituents through the intertubular capillaries, is a matter of the greatest interest.

The ganglia above referred to are without doubt special nerve ganglia of the kidney, and bear the same relation to this organ that the little ganglia in connection with the cardiac nerves bear to the heart. Here as elsewhere we find an arrangement of commissural fibres between the ganglia themselves and between the different parts of the renal apparatus, by which the actions of different ganglia and different parts of the organ are harmonised. The ganglia within the kidney are also connected with ganglia external to the organ, as well as with spinal nerve fibres, which probably connect the renal nerves and ganglia with the great nervous centres. We may perhaps explain in this way the influence exerted by the emotional centres upon the secretion of urine. Perhaps through these fibres, currents which usually cause a certain amount of contraction of the muscular fibre cells of the artery, are neutralised or diverted. Dilatation of the vessel occurs. A rush of blood is suddenly determined to the capillaries of the Malpighian body and an abundant flow of watery urine immediately follows.

The disturbance of the relation between the different operations which occurs in disease, and in which nervous action performs a highly important part, forms a theme upon which very much might be said, but as the discussion of the subject would require more space than I can devote to it here, I shall not enter upon it.

BASEMENT MEMBRANE OF THE TUBES AND OF THE SO-CALLED MATRIX.

Basement Membrane.—The *basement membrane* of the uriniferous tubes, first described and thus named by Mr. Bowman (Phil. Trans., 1842, p. 58), is easily demonstrated by washing a thin section of the kidney, so as to remove the epithelium. It is much stronger and thicker in the pyramids than in the cortex. Compare figs. 26, 27, pl. VI, with fig. 24. It is, however, more easily demonstrated as a separate structure in the latter situation. In the kidney of the embryo, considerable lengths of tubes may be torn from the pyramids. The tissue in the pyramids of the adult kidney is so very firm that excessively thin sections may be made in any direction without difficulty, and most instructive specimens may be prepared. The texture to which the greater firmness of the pyramidal tissue is due is a modified form of connective tissue which seems to be incorporated with, and indeed to form a part of, the so-called "wall" of the uriniferous tube.

The "basement membrane" of the cortical portion of the tubes is usually described as consisting of perfectly clear transparent structureless membrane readily permeable to fluids in both directions, not even exhibiting an appearance of striation, pl. IV, fig. 15 *b*. Recent investigations have, however, satisfied me that this view must be somewhat modified, for upon its outer surface the basement membrane is rough, and it sometimes exhibits a fibrous appearance. It is structurally continuous with undoubted fibrous connective tissue. Nerves and vessels are intimately associated with it, and sometimes appear to be so embedded in its structure that they may be said to enter into the formation of the "basement membrane" itself. In my paper "On the Structure and Formation of the Sarcolemma of Striped Muscle," &c. (Microscopical Society, June, 1864), I showed that that transparent texture was not perfectly smooth upon its external surface, but was continuous with, and passed into, the intermuscular connective tissue, and that in certain cases nerve fibres and vessels, and in insects tracheæ, intimately adhered to it and helped to form the membrane itself. The membrane of which the uriniferous tube is composed closely resembles the sarcolemma in these particulars. It appears to me that so far from constituting a distinct and definite tube it consists not of a peculiar and special kind of tissue, but of condensed connective tissue, the texture of which is so very fine that it appears as a general rule perfectly homogeneous if examined in the ordinary way. Its thickness, however, increases as the tissue advances in age, and in certain morbid conditions it is found to be much thicker than in healthy organs of corresponding age. In these cases its continuity with the so-called intertubular connective tissue or matrix is still more distinct.

The true structure of this apparently homogeneous membrane, so difficult to ascertain in the case of mammalia, may be most conclusively demonstrated in the tubes of the newt's kidney, pl. V, figs. 19 and 19 *a*. The expansion which is ordinarily described as homogeneous is here seen to be composed of distinctly fibrous connective tissue. The "wall" of the uriniferous tube in this specimen is so thick that its inner smooth portion can be seen to pass gradually into the outer part which is most distinctly fibrous. Numerous elongated oval connective tissue corpuscles with the fibres continuous with them may be detected and even partially isolated. The tubes indeed seem to be composed of many different layers of connective tissue the germinal matter (corpuscles) of which have in great part, and especially in the inner portion of the tube, disappeared.

Nerve fibres can be readily traced upon the external surface of the tube of the newt's kidney, and may be seen to ramify amongst the connective tissue just as they ramify in that of the external coat of an artery. The capillaries also which cross the tubes or run parallel with them are also embedded in and held together with connective tissue. Close to these capillaries again nerve fibres may be very distinctly seen. The nerve fibres distributed to the uriniferous tubes and those ramifying close to the capillary vessels of the kidney are, I believe, for the first time figured in pl. V, figs. 19, 19 *a*. I have several specimens which demonstrate these points most distinctly. The characters of the membranous tube above described, are seen only in the case of the *adult* newt, and the thickness of the wall of the tube increases as the animal advances in age. If it be kept in confinement for some time without food, the secreting cells waste, the diameter of the tube is much reduced, while its walls increase considerably in thickness, so that these points may be demonstrated with greater distinctness than can be effected in a perfectly healthy animal. In the same way the liver tubes may be seen very readily in the shrunken wasted liver of *cirrhosis*, although it is not easy to demonstrate them in the healthy organ without special preparation. This thickening of the walls of the uriniferous tubes and wasting of the secreting cells is common enough in disease. I have before remarked that from disease some organs rapidly acquire the characters which are very slowly induced in the ordinary course of nature, but which probably would not have been established under normal conditions until an age much greater than that ever attained by any one in these days had been reached.

The basement membrane has been considered by some to be the seat of origin of the renal cells, and it has been termed a germinal membrane. Basement membrane is, however, in all cases, perfectly passive, and takes no part in the development of cells. These result from the growth and multiplication of masses of germinal matter lying upon the surface of the so-called basement membrane or connective tissue. They have, however, in all probability descended from the same masses of germinal matter as those which have been concerned in the formation of the connective tissue. The increased growth and multiplication of the cells depends upon their increased nutrition. Their detachment is a passive process and depends in some measure upon the rate at which they increase.

Matrix.—The matrix described and delineated by Goodsir, Kölliker, Dr. G. Johnson, and others, as a distinctly fibrous supporting framework, in the meshes of which tubes and vessels ramify, I have not succeeded in demonstrating. If the capillaries of a young healthy kidney be distended with transparent injection, no fibrous structure at all resembiing the drawings given of it can be seen between the wall of the tube and that of the vessels. All that can be proved to exist is a very small amount of perfectly transparent tissue, which connects together the tubes and vessels. The appearance considered to be due to the fibrous matrix may be seen in any thin section of an *uninjected* kidney which has been washed and examined in water; but in such a section how are we to distinguish the walls of the tubes, those of the capillaries, and the so-called fibrous matrix, from each other? It has been often figured as a very distinct structure; and fig. 23*b*, pl. V, representing a section which has been washed in water, gives the appearance. The capillaries not being injected, have collapsed and shrunk, and exhibit the fibrous appearance which has been considered to be due to the matrix. Fig. 23*a* represents an injected specimen from the very same kidney, and this does not exhibit any indication of fibrous tissue existing between the capillaries and the tubes. The nuclei in the coats of the vessels, and some nuclei external to them which are probably connected with nerve fibres, are distinctly seen, but no fibrous matrix is observable. In the kidney and elsewhere, stretched and crumpled capillaries produce an appearance resembling fibrous tissue or matrix ("Archives of Medicine," No. III, 1858). A thin section of the cortical portion of a kidney, which had been slightly washed in water, is also represented in fig. 15, pl. IV. The vessels are not injected. *a*, convoluted portion of uriniferous tube; *b*, a portion of a tube stripped of its epithelium; *c*, outline of tube and crumpled capillaries, having a fibrous appearance—the so-called matrix; *d*, very small Malpighian body with its loops of vessels shrunken, showing germinal matter in their walls, and with blood corpuscles within the capillary loops. × 215.

This so-called matrix has been compared to the ultimate ramifications of Glisson's capsule of the liver; and it has been considered necessary as a support to the structures of which the gland is composed. I have never seen fibrous tissue in the situation described in the healthy adult liver or kidney. It is obvious that the structures do not require any supporting tissue, as they mutually support each other; and any matrix would tend to increase the distance between the secreting cells and the blood, and so render the gland less perfect and less fitted for the performance of its function. On the other hand, we find in these organs every arrangement to reduce as far as is possible consistently with strength, the distance between the blood and the gland cells. This matrix ought of course to be *developed* as a structure distinct from the tubes and vessels, and statements have been made implying that this was so; but at an early stage of development of the kidney or liver no one has yet succeeded in demonstrating the "fibrous matrix." In a careful examination of embryonic structures generally, one cannot fail to be struck by the absence of such fibrous or connective tissue, which by some schools appears to be regarded not only as an essential part of every organ, but almost as its necessary foundation upon which the other textures are raised as a superstructure. It is at this early period of development that the tissues are softest, and most in need of support; and yet the embryonic structures are peculiarly destitute of any supporting fibrous framework whatever.

In the kidney of the child only a mere trace of material besides vessels and secreting tubes can be detected. In properly prepared specimens most of the numerous nuclei lying between the tubes and vessels can be proved to belong to the capillary walls, or to the white blood corpuscles within them. It is probable that most of the remainder are connected with delicate nerve fibres, and that very few, if any, can be properly looked upon as belonging to the connective tissue. In pl. VII, fig. 35, a small fragment of the cortical portion of the kidney of a child three years of age is represented. Its numerous nuclei are very distinct, and in the interior are some white blood corpuscles. If this capillary had been but very slightly compressed by the thin glass, its tubular appearance would have been lost and striæ would have appeared which any one might have concluded were occasioned by the presence of fibres of connective tissue, and the nuclei would have been mistaken for connective tissue corpuscles.

The conclusions at which I have arrived, from numerous investigations on this subject, may be summed up as follows:—

1. In the cortical portion of the kidney there is no evidence of the existence of a "*fibro-cellular matrix,*" distinct from the walls of the tubes and capillaries.

2. The fibrous appearance observed in thin sections of the kidney which have been immersed in water is fallacious, and is due to a crumpled, creased, and collapsed state of the membranous walls of the secreting tubes and capillary vessels.

3. A small quantity of a transparent material, is to be demonstrated between the walls of the tubes and the capillary vessels in health, and not even this can be detected at an early period of development.

It seems to me, therefore, that in the perfectly healthy kidney as well as in many other organs, there exists between the structural elements only a mere trace of passive indefinite connective tissue. It is this indefinite connective tissue, of all textures in the body the least important, which has been regarded by many modern observers as the seat of the most important operations. Virchow and his school hold that through its corpuscles and supposed tube system, it is concerned in the distribution of nutrient matter to other and higher textures ; while some members of the Dorpat school have given it, if possible, a still higher significance, and have regarded it as a most important constituent of some of the highest textures. To such a length has the notion been carried, that the most delicate nerve structures have been considered to consist principally of connective tissue. The highly important nerve elements of the brain and cord are supposed to be embedded in a supporting framework of connective tissue, which in some situations occupies more space than the nerve elements themselves.*

It is not to be wondered at, therefore, that this indefinite and unimportant connective material should be made to play so important a part in modern pathology. But if I am not mistaken, future observers will be much astonished at the rapid spread and general acceptance of these doctrines. Connective tissue is now regarded as the actual seat of the active changes of inflammation and various forms of degeneration. It is supposed to become hypertrophied and then to contract, and by compressing glandular tissues to cause them to waste and to lead to their destruction. I cannot, however, subscribe to these views, for careful observation compels me to conclude, that in many forms of inflammation the connective tissue is passive, while the phenomena wrongly

* The views expressed by Bowman as long ago as 1845 are undoubtedly correct. Concerning the areolar or connective tissue of glands, he says :—"There appears to be a very prevalent misconception with regard to the quantity of this tissue found in the interior of the large glands, as the liver and kidney. It is imagined that it *penetrates* into every interstice, mingles with the capillary rete, and envelopes the ultimate secreting tubules. It is, however, impossible in the most recent specimen of these organs to discover anything answering to this description." Art. "Mucous Membrane." Todd's Cyclop. of Anat. and Phys., vol. III, p. 495.

attributed to it are really due to the presence of particles of germinal matter which have been detached from the white blood corpuscles, and have passed through the vascular walls into the meshes of the connective tissue where they grow and multiply very quickly. These, and not the connective tissue corpuscles, are the bodies which give rise to those collections of granular cells or corpuscles, pus corpuscles, and allied bodies, familiar to all who have studied the alterations occurring in tissues during the early stages of inflammation. After the lapse of some little time, the germinal matter of the connective tissue corpuscles, that of the tissues, nerves, vessels, &c., all participate in the changes, and in consequence of being freely supplied with nutrient matter, increase, divide and subdivide, and also give origin to pus-corpuscles.*

In the contraction and wasting which affect glandular organs, the connective tissue is equally passive, and the real nature of the morbid processes seems to have been completely misunderstood in consequence of observers having drawn conclusions from imperfect observations. It is strange that such an observer as Frerichs should have failed to find the remains of much of the secreting texture of the lobule of the liver in the so-called *interlobular connective tissue*, and very remarkable that he should not have represented the liver ducts in any one of the numerous sections of hepatic tissue delineated in his atlas. Nevertheless, by adopting a mode of enquiry, different to that employed by him, we may demonstrate the ducts in great number. The above facts being taken into account, it was only to be anticipated that corresponding views would be adopted concerning the morbid changes occurring in the course of renal disease, and we shall not feel surprised that almost all observers attribute many important changes in the kidney to the connective tissue of this organ. But how weak is the evidence upon which the generally received views rest! A little careful observation will, I think, convince any observer that what has been termed connective tissue in sections of contracted and other kidneys, is really composed principally of altered vessels and wasted secreting structure, while a study of the changes taking place in the course of such disease will teach him that from first to last the connective tissue has been perfectly passive, while both the glandular and vascular elements have been concerned in changes which would assuredly end in the complete destruction of the glandular apparatus, were it not that their progress was interfered with by the patient's death.

For an account of the observations which have been advanced in favour of the importance of connective tissue in pathological changes in the kidney, the reader may refer to Dr. Dickinson's new book on

* "On the Germinal Matter of the Blood." Microscopical Journal, 1863.

"Albuminuria," and to a work by Arnold Beer "Die Binde-Substanz der Menschlichen Niere." Unfortunately the drawings in the last work are so roughly executed, that little dependence can be placed on them.

Capsule.—All writers lay some stress upon the fact of the capsule adhering firmly or only slightly to the renal structure. It is interesting to consider what the circumstance really means, and what determines it. In the healthy kidney, the thin semi-transparent capsule peels off without any of the renal tissue adhering to it. In the small rough contracted kidney and in other forms of disease, the firm thickened capsule cannot be torn off without employing considerable force, and portions of kidney structure are invariably detached and torn away with it. This capsule, the outermost limit of the kidney, consists principally of connective tissue and vessels. It increases as age advances. It is in immediate contact with the oldest part of the cortical structure, and it must be remarked, that from its earliest formation its tissue is continuous with the proper renal texture. Not only do the vessels and nerves pass from the gland tissue to the capsule, but secreting tubes adhere to it. In the healthy capsule both of the liver and kidney, the remains of glandular tissue may be often demonstrated distinctly. As the cortex grows, the débris of the old tubes and vascular and nervous elements which are gradually removed to make way for new ones, become slowly added to the capsule, and thus, like the capsule of the liver, it becomes increased in thickness. In health, however, the process proceeds so regularly and so slowly, that the amount of débris is really very small, and its addition occurs very evenly. In some forms of disease, where the wasting is considerable while the partly degenerated textures are not removed and absorbed as fast as they are produced, the wasted tubes adhere more intimately to the capsule than to the rest of the renal structure, and portions are torn away when the capsule is peeled off. In other cases exudation is poured out into the tissue of the capsule as well as into the intertubular and intervascular spaces of the renal tissue. The particles of germinal matter which have passed through the capillary walls grow and multiply, and gradually give rise to the formation of a firm connective tissue, by which all the elements of the capsule and gland structure become firmly glued together forming a compact mass, which is not torn and broken without using some degree of force.

OF THE ESSENTIAL STRUCTURES OF THE KIDNEY AND OF THEIR FORMATION.

Apart from the anatomical question, what tissues are to be demonstrated and named in the healthy kidney, and, far more interesting to the physician than this, is the physiological question, what elements are of functional importance,—what elements are necessary and essential to the active secreting apparatus? It is impossible to arrive at a correct notion concerning the changes which take place in disease until we have been furnished with accurate information on this point.

Of the Growth of the Renal Apparatus and of the Changes occurring in it.—The *essential* structures in the fully formed kidney seem to be these—vessels for conveying the blood,—nerve fibres which govern the calibre, and thus determine the rate of flow of the blood from the arteries into the capillaries,—and epithelial cells which are arranged round the tubes so as to leave a channel by which the materials separated or formed by them may be readily carried away in solution in water. It is probable that these are the only anatomical elements which exist when the renal apparatus first begins to perform its active functions, and the only ones which constitute the simplest form of kidney. But as the growth of the body proceeds, the demand for a more extensive renal apparatus arises, and, as in the case of other organs in vertebrata, the increase must be gradual, and must take place while the organ is actively discharging its functions. The *growth* of the kidney necessitates a change in the relative position of the individual nerve fibres, vessels, and secreting structure in different parts of the gland, and the progressive development of new elements as extensions from those already existing. The successive changes are not easily traced with accuracy, and it is very difficult to convey in words a clear idea of the phenomena which succeed and as it were overlap one another. A separate memoir well illustrated, might with advantage be devoted to the consideration of this interesting and highly important subject; but its bearing upon the nature of disease is so obvious, that no apology is needed for its introduction in this place.

At an early period of development the secreting cells multiply and become arranged so as to form a hollow tube. By their division and subdivision the tube increases in length and circumference, at least during a certain period, in every part of its extent. At the deep or external portion of these cells, adjacent to the vessels, matter is slowly deposited in an insoluble form, and thus a thin membranous boundary corresponding to the outer limit of the tube results, and this becomes extended as the cells grow, while at the same time it is increased in strength by the addition of new matter. Between the lines of masses of germinal matter from which the tubes are developed, and those which take part in the formation of vessels and nerves are a few masses which are not concerned in the formation of any definite structure, but which perhaps take part in the production of a small quantity of intervening substance. The membrane becomes further modified by its relation to the nerves and blood-vessels. These were very close to the cells at the earliest periods of development, and a very close relationship between them must be maintained throughout life or the free action of the gland would be impaired. Moreover, as the gland which already actively performs its functions grows, new nerve fibres and new capillaries must be developed around the uriniferous tubes. The position which a capillary or an ultimate nerve fibre occupies at an early period will at a later time be the situation where a bundle of nerve fibres, or small arteries and veins must be placed. The structural changes involved in all these alterations are considerable. Old capillaries and nerve fibres must be removed as new ones are developed to take their place, and all the original gland cells will have disappeared probably long before the uriniferous tubes have acquired their fully formed characters. But these structural elements are not completely removed. There will remain a small quantity of matter which cannot be taken up by the ordinary processes at work. This is no doubt capable of being removed like every texture in the body, but complete removal would probably involve the destruction of the gland, while its almost complete removal permits of the continuous development of the latter and does not interfere with its continuous action. The conditions of existence in the case of man and the higher vertebrata, with a few unimportant exceptions only, permit the very gradual but not absolutely complete removal and renovation of tissues.

In insects, the state of things is very different, for in their textures there is an almost complete absence of connective tissue. The organs and tissues of the larva are entirely removed while new organs and textures of the imago or perfect insect are laid down afresh and developed *ab initio*, instead of being built up upon those first formed. Such complete change, however, necessitates a state of existence during which action or function remains in complete abeyance. In the pupa or chrysalis period of life, functional activity is reduced to a minimum, and nothing is allowed to interfere with the developmental and formative processes. The new and more perfect being which is evolved does not probably retain a trace of the structure of its earlier and less perfect state. Although the elements of matter in the imago are, of course, those of which the larva and pupa were composed, they have been as completely re-arranged as they would have been had they been introduced into the organism of another individual altogether. Not only have the old tissues been utterly destroyed and new ones produced, but in many instances these new ones belong to a totally different type; and were it not that observation has taught us that they have been really evolved at different periods during the life of one and the self-same individual being, we should have concluded not only that they belonged to different species, but in many cases to species far removed from one another.

In vertebrata, however, there is not an organ in the adult but retains, not only the form which it assumed at a comparatively early period, but some of the very same structure that was active in early life remains in an altered and deteriorated state. Every adult organ may be said to contain as it were the imperfect skeletons of organs which were active at earlier periods of life. This material which slowly accumulates, clogs and perhaps even in the most perfect state of things, slightly interferes with the free activity of the organ. If from any interference with the changes this unabsorbed débris accumulates in undue proportion the action of the organ may be very seriously impaired. It indeed soon grows old, while all the rest of the body may remain young. Its imperfect action deranges other processes of the body, and these react upon it until further action becomes impossible, and death results. The gradual but continuous and regular decay and renovation of an organ is normal in the vertebrate animal. The changes exhibit wonderful elasticity within certain limits, according to the demand for functional activity of the organ, but these limits, narrow in some, wide in others, cannot be exceeded without derangement and slow deterioration resulting.

This continuous renovation of an organ and accumulation of the skeleton of its earlier periods of existence may, however, be almost suddenly interrupted. In those changes which lead to the formation of pus the removal of every texture is as perfect as during the pupa state of the insect, but the germinal matter constituting the pus corpuscles has no power to give rise to that which will take part in the development of new tissues, while that taking part in the removal of the larval tissues during the pupa state does possess this power, so that when in vertebrata this complete change occurs the organ is destroyed, and a new one is never developed in its stead. A part of a complex organ may be destroyed and removed, but it cannot be formed anew, so that in man the gradual or sudden destruction of a great part of an organ necessary to life cannot be repaired, although in many cases the patient may adapt himself to the altered state of things and live under the changed conditions. The above considerations afford, I think, an explanation of the formation of the so-called interstitial indefinite connective tissue found not only in the kidney but in all organs of all vertebrate animals, and of its increase as age advances. The more regularly, gradually, and perfectly the changes are effected, the smaller will be the proportion formed, and the more slowly will it accumulate. When this is the state of things in all the organs of the body, health and longevity result. The opposite entails disease and too early death.

Formation and Action.—Next I would offer a few remarks upon the nature of the processes of formation and development as contrasted with those of action and disintegration. For *formation* and *function* are opposed. While formation is most active, function is in abeyance, and during the period of the greatest activity of an organ the formative process is reduced to a minimum. In short, when a secreting organ is most actively discharging its functions its texture is undergoing disintegration or destruction, and a period of rest is required for new formation and renovation. In certain diseases where the organ increases enormously in size and much tissue is formed, little secretion occurs; so little, that death may result from the accumulation in the blood of those substances which it is the special office of the cells of this organ to eliminate. So far from disease being universally a *destructive* process, —a *disintegration*, it consists essentially, and in the majority of cases, of a too rapid increase of the living or germinal matter—of an addition to a part rather than a subtraction from it—and if in many morbid changes, increased destruction could be brought about, the diseased state would cease. When renal epithelium goes on increasing in bulk and choking up the tubes, what is wanted is the disintegration and oxidation of much of the matter of which these cells consist. They have grown too large. The conditions have been too favourable to their increase. Too much matter has been added to them, and the disintegration and removal of this excess is much required. There is superabundant growth, diminished disintegration, cessation of action and function.

On the Development of the Malpighian Bodies of the Kidney.—It would be out of place in a practical work like the present to attempt to discuss in detail the changes which occur during the earliest periods of development of the kidney, but it may be well to allude briefly to the results of some investigations upon the development of the Malpighian bodies in which I have been engaged for some time past.

I have studied this subject in several vertebrate animals, but as the appearances are far more distinct and easy of investigation in the thin part of the kidney of the newt, pl. VIII, fig. 36, I have devoted myself principally to the Malpighian body of this animal. It is well known not only that the young Malpighian bodies are much smaller than those which are fully formed, but that the vascular loops are smaller and fewer in number. The entire organ in its imperfectly developed state accords very closely in its characters with the permanent form assumed by the Malpighian body of the simplest type, which has been well described by Bowman, in birds and certain of the reptilia.

The main question for consideration relates to the manner in which the first formed capillary comes into relation with the tube, and how it comes to pass eventually that the capillary loops which have been developed become completely invested by the extremity of the tube, so as to be at length completely enclosed in its interior. It is not so difficult to understand how the loops once formed, increase in length and number, seeing the great number of masses of germinal matter in their walls. The formation of membrane occurs at each of these points, and thus is explained the fact that the interval between them increases in length as development advances. If the upper thin part of the newt's kidney be examined with due care in spring time, several extremely young Malpighian bodies will be found, and in injected specimens some will be met with which contain several vascular loops in their interior, while others have only one or two, and in the youngest no trace of injection will be perceived. In some very young ones I have, however, been fortunate enough to have forced a little injection into the capillary at the base of the tuft, although it had not passed into the convexity of the loop.

From many observations I feel sure that a fully formed vessel does not approach the blind extremity of a developing tube and penetrate into its interior, pushing before it the wall of the tube; nor on the other hand does the terminal extremity of the uriniferous tube approach and ultimately enclose the vascular tuft; but the blind end of the tube and the capillary vessels which are ultimately found in its interior are developed and grow *pari passu.*

At first, one observes masses of embryonic germinal matter which may be traced from a point where undoubted capillary vessels exist. These lose themselves among groups of spherical masses of germinal matter which are evidently to take part in the formation of the uriniferous tubes. It is in fact, at this time, as difficult to determine which particular masses of germinal matter are to become instrumental in the formation of capillaries and which are to give rise to the secreting cells, as it is to decide, in developing muscle, which masses of germinal matter are to take part in the formation of contractile tissue, and which are concerned in the production of nerves and capillary vessels.

Diverging from the tubes in the thin part of the kidney of the female newt at about $\frac{1}{250}$ of an inch below the Malpighian body, but nearer to it in the young than in the more advanced or fully formed tubes, I have discovered a short blind tube, as represented in pl. VIII, fig. 36 *c*, and fig. 37. It seems to me probable that a new Malpighian body may be formed at the end of this appendage when the original one has wasted. Sometimes a second diverticulum diverges from the first as represented in fig. 37, at *a*. I have not, however, been able to trace the development of vessels in connection with these curious tubular appendages. They communicate freely with the uriniferous tube, and I have injected them in cases in which the loops of the Malpighian body were ruptured and the injection had extravasated into the tube. At *b* in fig. 36, is a tube or off-set which evidently passed into a collection of fatty matter in which were the remains of capillaries. In many of these collections I have seen indications of the wasted uriniferous tube and its Malpighian body. There is no indication of true adipose vesicles, but numerous apparently free oil globules are found lying in the meshes of a capillary network. A little nearer the median line than this collection of oil globules was situated were the large oval collections of fatty matter which have a very intimate relation with the ganglia of the kidney. Large veins and lymphatic vessels enter and emerge from these. Some of them might also be mistaken for altered Malpighian bodies, but they are not of this nature. They are present both in the male and female newt, and in the spring of the year, a great number of small ganglion cells are always seen at the margin of these collections. They are undergoing development and are about to take the place of old nerve cells which have passed the period of their functional activity and are undergoing disintegration and removal.

In the male newt Malpighian bodies are developed from tubes which diverge outwards at intervals from each of the two tubes in the median line, which during the spring are filled with spermatozoa and extend through the entire length of the kidney. At the upper extremity of the kidney, the narrow prolonged portion of these tubes exhibits dilatations here and there, some of which are undergoing development into Malpighian bodies, while in other situations diverticula may be observed, pl. VIII, fig. 40, which probably become gradually developed into new tubes. In many instances the Malpighian body is seen to be a mere dilatation of the tube, as is represented in fig. 19*a*, pl. V, and which was first pointed out by Victor Carus, of Leipzig, many years ago. The vessels form a very few coils within the tube, and their development probably commenced at a time when the tube itself was represented by a collection of masses of germinal matter. As the Malpighian body becomes fully developed, the upper part of the tube wastes and the body acquires its usual characters, but in the male newt some of the tubes remain open and spermatozoa pass into the convoluted uriniferous tube.

The investigation of the development of the Malpighian bodies in mammalia is much more difficult, but many very young ones may be isolated in the kidney of the fœtal kitten, prepared as I have recommended. The general mode of development of the capsule and tuft of vessels seems to resemble that already described in the newt. Wherever Malpighian bodies and tubes are being formed one finds an immense number of masses of germinal matter arranged as a wavy band which can be seen here and there amongst Malpighian bodies and tubes whose formation is much more advanced.

The general results of my observations lead me to conclude that the vascular loops of the Malpighian tuft are developed amongst the masses of germinal matter which take part in the formation of the dilated extremity of the tube, so that although some of the cells will lie upon the convexity of the loops which look towards the tube, I do not think that we are justified in inferring that the loops of vessels are, as it were, pushed into the end of a closed tube so as to be covered with a layer like that of a serous membrane, which is reflected over a viscus in a serous cavity, for at the time when the formation of the vessels commences there is certainly no membrane to invest them.

Of the Wasting of the Uriniferous Tubes and Malpighian Bodies.—I have already briefly referred to the wasting of the oldest tubes, but the process is of such interest with reference to pathological changes that it is desirable to allude to it more particularly. In the frog and newt the wasting process may be studied with advantage. Previous to removal the epithelium seems invariably to become fatty, and I have seen loops of tubes which I believe were about to be removed, stuffed quite full of large oil globules. Soon after the apparatus has ceased to perform its function, the quantity of blood in the vessels becomes much reduced, and the vessels themselves soon cease to be distinct, so that the loops of the tube come into close proximity, the Malpighian body shrinks, and is with difficulty recognizable. In the irregular mass thus formed in which oil globules seem to predominate, portions of tube may here and there be traced. At intervals the epithelium has entirely disappeared, and everywhere contraction and waste are going on. These points are well seen in fig. 42, pl. IX, which is taken from a part where the oil globules were very few in number. The germinal matter of some of the cells, however, remains in the constricted part of the tubes, and as the tubes become more and more wasted, these assume the appearance of connective tissue corpuscles, the boundary of the apparent corpuscle representing the wall of the tube while its processes correspond with portions of the tube itself.

WEIGHT, SPECIFIC GRAVITY, COMPOSITION, AND UNUSUAL POSITION OF THE KIDNEY.

Weight and Specific Gravity of the Kidney.—The kidneys vary much in weight in different individuals, for the amount of renal tissue required varies according to the weight of the body and the activity of certain functions. Reid estimates the kidney of the male at from 4½ to 6 ounces, and that of the female at from 4 to 5½ ounces. Five ounces is probably about the average weight of a healthy kidney. The left generally weighs a little more than the right. The specific gravity of the kidney in health is about that of blood, 1050, but in disease it is often much less.

Of the Chemical Composition of the Kidney.—The presence of urea and other urinary constituents is not as a general rule to be detected in the renal structure after death. It is probable that these substances are removed as fast as they are formed, and that the conditions under which the changes in the kidney are carried on for some time before death, are unfavourable to the production of these highly oxidised compounds. It is not unlikely, however, that they might be formed out of the body by the artificial oxidation of the constituents which enter into the composition of perfectly healthy renal cells.

It is interesting to compare the proportion of solid matter, extractives, fatty matter and salts, in the healthy and diseased kidney. Subjoined is an analysis of the kidney of a perfectly healthy man, thirty-one years of age, who was killed by falling from a second floor window. Death occurred five hours after the accident. The body was in an excellent state of nutrition.

ANALYSIS I.

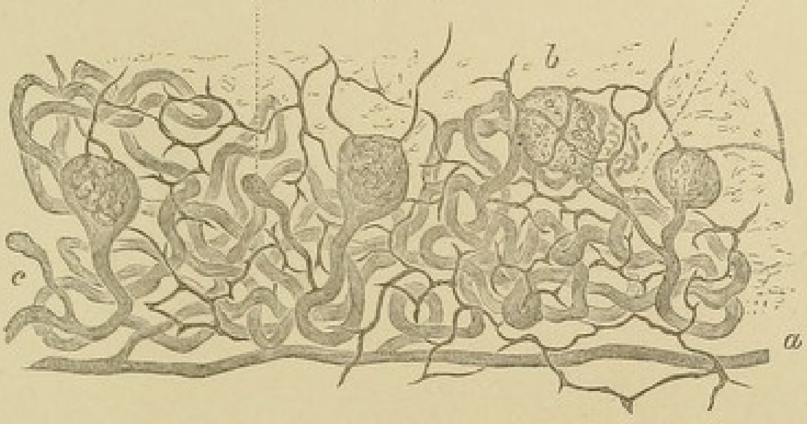
Water	76·45
Solid matter	23·55
Fatty matter with much cholesterine	·939
Extractive matter soluble in water	5·840
Soluble salts	1·010
Earthy salts	·396
Albuminous matters in blood, fibrin, blood corpuscles, vessels, connective tissue, &c.	15·365

This analysis may be contrasted with the analyses of diseased kidneys, further on.

Unusual Form or Position of Kidneys.—Malformations of the kidney as well as of the ureters and bladder, are to be met with in all our museums, and need not be referred to here. Sometimes only one kidney is developed, in which case it is large in proportion. Occasionally more than two have been found.

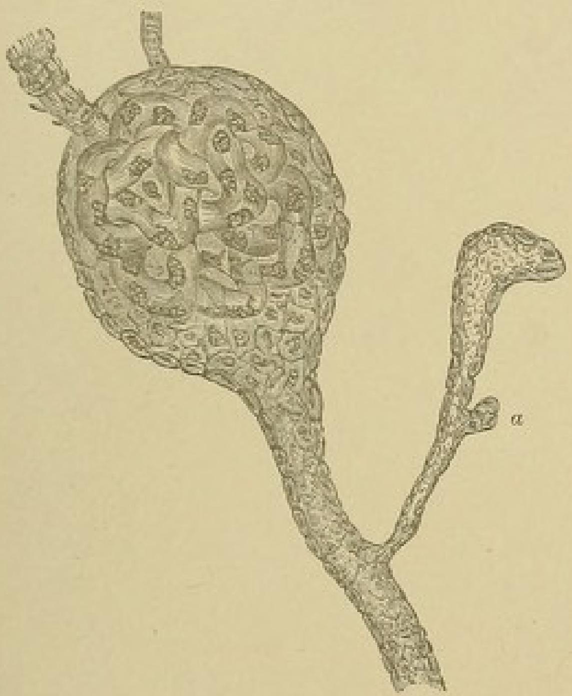
Alterations in position are not uncommon, and sometimes give rise to great difficulty in the diagnosis of pelvic and abdominal tumours. But the most interesting kind of displacement occurs in cases of what is termed movable kidney which are now and then met with. In consequence of unusual looseness in its attachment, one of the kidneys is capable of being moved forwards for some distance in the abdominal cavity, as well as upwards and downwards to a varying extent. Several cases have been reported both in this country and on the continent. Dr. Hare has seen as many as seven. Two very remarkable instances have lately fallen under my own notice, one occurring in a man, the other in a woman. In both when the bowels are emptied, the organ comes so near the surface, that it can be grasped, and its form distinctly felt beneath the abdominal walls. Pressure gives rise to some uneasiness, and the organ always slips back into its natural place when the patient lies down. A good case of this peculiarity is reported by Dr. Hare, in the Med. Times and Gazette, 1858, vol. I, pp. 7, 30, 86. *See* also Durham's papers in the Guy's Hospital Reports for 1860, p. 404.

Fig. 36.



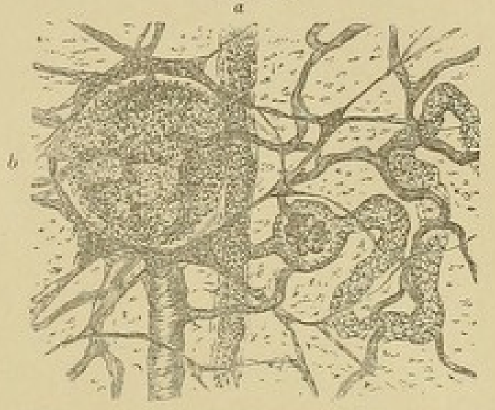
Part of the thin portion of the kidney. Female newt. *a*, portion of straight tube continuous with ureter. *b*, collection of fatty matter, perhaps a wasted Malpighian body. *c c*, remarkable diverticula connected with tubes just below the Malpighian body. The capillaries are also represented. × 40. p. 28.

Fig. 37.



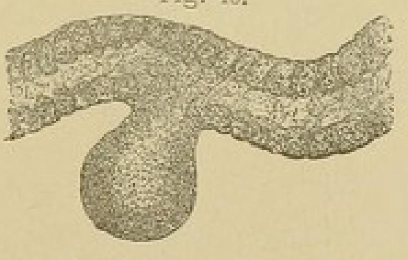
Malpighian body and portion of uriniferous tube, with remarkable diverticulum. Female newt. At *a*, a bud projects from the diverticular tube as if a branch were growing from it. × 130. pp. 28, 29.

Fig. 38.



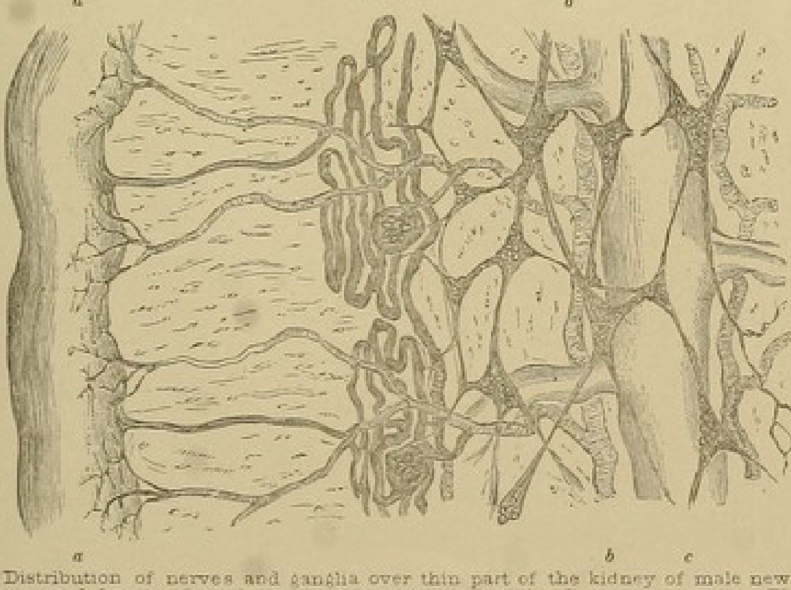
Tube, *a*, containing spermatozoa, from which some Malpighian bodies and uriniferous tubes of the male newt are developed. An old ganglion which has undergone degeneration, and new ganglion cells, are also seen at *b*. × 40. p. 29.

Fig. 40.



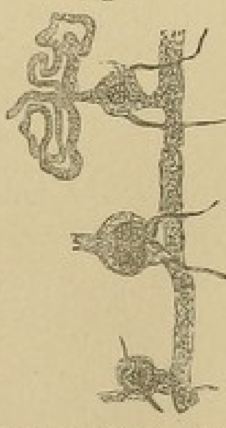
Diverticulum from tube. Kidney, male newt. p. 56.

Fig. 39.



Distribution of nerves and ganglia over thin part of the kidney of male newt. *a*, vas deferens; the uriniferous tubes opening into it. *b*, artery. *c*, vein. The numerous ganglia and nerve fibres are seen ramifying over the vessels and tubes. × 10.

Fig. 41.



Tube containing spermatozoa, showing connection with uriniferous tubes and Malpighian bodies. One of the latter is double. Male newt. × 30.

[To face page 32.

ON SOME POINTS CONNECTED WITH THE PHYSIOLOGY AND PATHOLOGY OF THE KIDNEY.

In a state of health, the diminished rapidity of the circulation in the capillaries of the Malpighian body, consequent upon the greatly increased area of the tubes which the blood must traverse as it flows from the small artery which alone supplies them, favours the transudation of water through the capillary walls. This fluid must at once pass into the uriniferous tube; and as it gradually traverses in succession the cells which line it, the soluble substances are dissolved out—the quantity of solid constituents gradually increasing as the solution passes down the tube, while the substances are being more fully oxidized at the same time. Now the blood just brought from the Malpighian body has parted with water, and, being more concentrated, is richer in materials which are to yield the *urinary constituents* than the blood in any other part of the kidney. This is conducted by the vessels into which the efferent vessel of the Malpighian body divides, to the upper part of the uriniferous tubes. We should expect that the cells in this region would be more fully charged with soluble urinary constituents than those lower down the tube; and, in accordance with this view, we find that these cells are acted upon by the almost *pure water*, *in which oxygen is dissolved*, which has just escaped from the capillaries of the Malpighian body; while, by the time the fluid has reached the cells at a lower point of the tube, it is already charged to a great extent with soluble constituents, and its solvent power and oxidising properties are of course proportionately reduced.

Not the least important office of the cells lining the convoluted portion of the uriniferous tube is undoubtedly that of separating from the blood a considerable quantity of the *débris* of blood-corpuscles, in the form of *extractive matters*. It is now certain that the cells have the power of altering some of the substances they separate from the blood, and converting them into urea, uric acid and the peculiar urine extractives, of which so large an amount is excreted, and the physiological importance of which must be very great.

Some observers have considered that special vessels are concerned in carrying blood to *nourish* the tissues of the gland, and Dr. Goodfellow thinks that the intertubular capillaries are concerned in this office. The quantity of blood passing into these vessels is, however, far greater than is required for the nutrition of the tissues of the kidney, and reasons have been already advanced for accepting the view propounded by Bowman with reference to these capillary vessels. The tissues of organs generally, are *nourished* by the plasma present, and do not require special vessels. Many arguments may be adduced against the view, that the hepatic artery merely serves the purpose of distributing blood to *nourish* the tissues of the liver as is generally supposed, while there is no doubt that venous blood contains the elements of nutrition received by the various tissues.

The views of Bowman, with regard to the office of the Malpighian body and the epithelium of the uriniferous tube, have been opposed by Ludwig, and more recently by Dr. Isaacs, in America, who tried to prove that the solid constituents were separated by an epithelium, covering the capillaries of the Malpighian body. If this exists at all, it is certainly very unlike glandular epithelium generally, and the cells must be very much smaller than represented by Dr. Isaacs. This observer does not attempt to show what office is performed by that enormous extent of epithelial surface in the convoluted portion of the tube, or explain why the very peculiar relation between the extensive system of capillaries around the tubes and that of the Malpighian body exists. Dr. Goodfellow thinks that the urinary constituents are separated with water from the Malpighian capillaries, and that any constituents of the serum, or blood, that may have transuded through their walls, "are absorbed by the epithelial cells of the tubules or by some other agents."* There does not, however, seem to be any reason for assuming that any constituents of the serum do really transude through the Malpighian capillaries merely to be absorbed again into the blood.

If the urine was secreted in its fully formed state by the agency of the vessels of the Malpighian body and the epithelium supposed to cover them, it is difficult to find an explanation of the fact that in every mammalian animal such fully formed urine is made to pass down a very long and tortuous tube instead of a short straight one. And it might be argued that, admitting a thin layer of small cells to exist upon the capillaries of the Malpighian body, it seems very improbable that these should alone be concerned in the secretion of the urine, while the large cells in such great number lining the uriniferous tube are destined to perform no important office, and the difficulty is much increased when we consider that the convolutions of the tube permit so large a number of these cells to be packed in very small space.

It seems extraordinary that any one after carefully comparing the Malpighian bodies of man and animals which secrete much fluid urine, with those of birds and reptiles which have urine of a pasty and nearly solid consistence, should come to the conclusion that these organs are not destined for the transudation of water from the blood.

The idea of the capillaries of the *straight* portion of the uriniferous tubes being principally concerned in this process is still more astonish-

* "Lectures on Diseases of the Kidney," p. 152.

ing, because one cannot understand how those who maintain such a doctrine fail to see that the arguments they advance in favour of their own view apply with tenfold force to the capillaries of the Malpighian bodies. If water passes from the capillaries around the straight portion of the tube it must traverse the capillary wall, connective material, and lastly the thick wall of this portion of the uriniferous tube. How much more readily then must it escape from the capillaries of the Malpighian body since it has to pass through the very thin capillary walls only! Moreover the urine which is so quickly secreted in states of mental emotion, contains but mere traces of solid constituents, and it seems more probable that this depends upon the rapid percolation of water from the blood as it traverses the thin-walled capillaries of the Malpighian body, and its quick passage over the cells of the tubes than that some peculiar and quite undescribed mechanism in connection with the intertubular capillaries permits the rapid escape of water and causes the salts dissolved in it to be retained.

The alterations in calibre of the small arteries of the kidney, as in the case of other minute arterial tubes, are determined entirely by the muscular coat. By the degree of contraction maintained in the muscular fibre cells by the influence of the nerves, the quantity of blood flowing through the vessels is regulated. It is not probable that the muscular coat of the artery is concerned in propelling the blood onwards towards the capillaries, for a reduction in the calibre of the vessel could only have such propelling effect if it were obstructed behind; so far from propelling the blood, it is probable that the muscular walls constitute a mechanism for impeding the free flow of blood onwards towards the capillaries, and for preventing undue pressure upon the delicate walls and tissues external to them. By the contraction of the small arteries, any increase in the force of the heart's action is prevented from being felt in the capillary vessels, and the rate of flow through the capillaries most effectually governed.

The *afferent nerve fibres of the capillaries*, p. 16, will be affected by alterations in the tension of the vessels as well as by the action of the fluids which transude from the blood. The influence transmitted to the ganglia or nerve centres, will of course affect the *motor vascular nerves* connected with the centres and determine an alteration in the calibre of the minute arteries which distribute blood to the capillary networks. Slight irritation of capillary nerves, or of those ramifying in the tissue will be followed by sudden contraction of the arteries as may be well seen in the frog's foot. By prolonged stretching or pressure as well as by certain chemical substances, the capillary nerve fibres may be temporarily or permanently paralysed, and the efferent nerves distributed to the arterial coats being no longer subjected to their wonted stimulus will fail to cause the contraction of the muscular fibres of the arteries, which vessels will then suffer dilatation, and the capillaries will be gorged with blood. The phenomena referred to in pp. 44 and 45 soon succeed. The *afferent capillary nerve fibres*, the ganglia or nerve *centres*, and the *efferent or vaso-motor nerves* constitute the self-regulating mechanism by which in health the equable flow of nutrient fluid from the blood to the tissues is determined, and by which those temporary disturbances continually occurring are immediately corrected, and serious derangement effectually provided against.

Bernard showed in 1845, "Comptes Rendus," t. XLVI, pp. 159–165, that the blood which was being carried away from the salivary glands was red while saliva was being secreted, and black when the glands were in a quiescent state. In the dog and in the rabbit the blood which escaped from the renal vein was as bright as that which was being carried to the kidney by the artery while urine was being freely secreted, but black when secretion was not going on. Bernard attributed these and other phenomena to some direct influence exerted by the nerves, but it seems more probable that they are due to the escape of fluid from or its retention in the blood. If arterial blood retained its water, and more especially if, as is very probable, in traversing the capillaries of a gland in which the cells were quiescent it absorbed fluid, it would very readily become of a dark colour; while, on the other hand, if water were separated from it, the corpuscles would continue in their flattened state or even become flatter and therefore still better reflectors of light, as they were carried away by the vein, than when they passed along the artery towards the capillaries.

In a former edition of this work, I endeavoured to show that an organ having the structure of the kidney could not possibly be a mere filter to strain off from the blood certain substances already in a fully formed state and dissolved in water, and stated that urea, uric acid, and extractives were probably formed in the kidney just as bile is formed in the liver. The experiments of Oppler,* Perls,† and Zalesky,‡ have demonstrated the correctness of this view. If the renal vein be tied, more urea is found in the blood than if the kidneys be removed. Perls proved that no urea was to be detected in the tissues of animals if the kidneys were extirpated; but, on the other hand, when the ureters were tied, the accumulation was very considerable. The observations of Zalesky on serpents are still more to the point. When the kidneys were removed no uric acid or urates could be detected in any part of the body, although the animals lived three weeks, while on the other hand if the ureters were tied, every tissue in the body contained urates in large quantity. It may, therefore, be concluded that although traces of

* Beitr. z. Lehre d. Urämie. Virchow's Archiv, v. XXI., p. 260.

† Beitr. z. Lehre d. Urämie. Königsberg. Med. Jahrb, v. IV, p. 56.

‡ Untersuch. über d. Urämischen Process. Tübingen, 1865.

urea, uric acid, and other special urinary constituents may be found in the blood and in some of the tissues, by far the largest proportion is produced in the kidneys, which, like the liver, are truly *formative organs*, and not mere separators of things already existing in the blood.

Collateral Circulation.—Virchow lays great stress upon the existence of a *collateral circulation* in the kidney, which is maintained by the vasa recta. The arrangement is such that the blood flowing to the kidney by the renal arteries may pass into the vasa recta and reach the veins by the capillaries of the pyramids without passing into the Malpighian bodies at all. There can, I think, be little doubt concerning the correctness of these views, and many of Virchow's statements have been positively confirmed by observations of my own.

Many years ago (about 1853) I was surprised at the thickness of the walls of some of the vasa recta in the pyramids of many diseased kidneys. Upon further examination I had no difficulty in demonstrating numerous circular muscular fibre-cells, so characteristic of the walls of arteries. More recent researches upon the healthy kidney have convinced me that many of the straight vessels which run parallel with the tubes in the pyramids are in fact small arteries. I suspect that some of these arterial branches communicate very freely with the veins in the same situation; and it is not impossible that in health by the contraction and relaxation of muscular fibres induced by nerves distributed to the vessels, the blood may be caused to pass through the Malpighian bodies, or be diverted into these vasa recta, and so returned to the veins very quickly, without having any excrementitious substances separated from it at all.

If the arteries going to the Malpighian bodies contracted, and the vasa recta became relaxed and distended with blood, the straight portion of the uriniferous tubes would be compressed, and thus the escape of fluid from the uriniferous tubes would be retarded, and a longer time would be allowed for it to dissolve the solid constituents. The urine would be highly concentrated and would exhibit a tendency to the formation of deposits in the narrow and straight portion of the tubes. These alterations in the renal circulation are of the greatest importance in connection with kidney diseases. According to Virchow albumen may be separated from the vessels of the pyramids independently of those of the cortex.

Circumstances under which the Urine may be altered in quantity or quality.—In the remarks I am about to make, I shall consider it as proved that the solid organic constituents peculiar to the urine, are formed through the agency of the cells lining the uriniferous tubes while pure water, or water holding in solution traces of salts, but fully saturated with oxygen, filters through the walls of the capillaries of the Malpighian body.

Diuretics may act in two ways. 1. Directly, as when an increased quantity of fluid is introduced into the organism, or substances are taken which facilitate the passage of fluids through membrane, or which give rise to the formation of substances in the blood acting in this way, or increasing the solubility and diffusibility of matters which have accumulated in the tissues and in the blood, and which it is the office of the kidneys to remove. 2. Indirectly through the influence of nerves upon the circulation in the kidney. I do not think that we are yet in possession of sufficiently reliable facts to justify the inference, that here or in any other glandular organ, nerves are capable of exerting any *direct* influence in exciting *secreting cells to increased action* or in diminishing the activity of the changes taking place in them. I believe that the nerves act only upon the muscular coats of the small arteries and veins, thus producing an alteration in the calibre which determines the quantity of blood transmitted to the capillaries within a given time, and that the cells are in all cases perfectly passive, and entirely removed from the control of the nervous system. *See* p. 35. Cells will grow quickly or slowly according as the pabulum distributed to them is abundant or deficient. If the blood is surcharged with excrementitious substances, or if there be any impediment to the quick removal of these from the fluid, the cells of the uriniferous tubes may be incapable of removing it sufficiently quickly. In this case congestion of the vessels perhaps running on to inflammation will occur, and there is danger of serious damage to the secreting apparatus. Many cases in which temporary hæmorrhage occurs, are to be explained in this way. It is not uncommon to meet with instances in which an attack of congestion of the kidney, perhaps gouty in its nature, ceases after the excretion of a large quantity of brown matter embedded in mucus casts. This brown material probably results from disintegration of the blood corpuscles which have remained for some time in the obstructed capillaries.

The albuminuria following scarlatina, and that coming on from exposure to cold, result from congestion of the vessels, particularly those of the Malpighian body, as is fully explained further on. The action of many irritating diuretics is due to the same circumstance. A quantity of cantharides, which would do no harm to a strong healthy man with sound kidneys, would produce dangerous congestion and inflammation, with rupture of the capillaries of the Malpighian body, in a person who was recovering from an illness, or in one whose kidneys were affected by disease. In the one case, the secreting power of the cells appears to be sufficiently active to perform the increased work suddenly thrown upon them; while in the other they are incapable of this, and the results above described must occur. Kramer and Golding Bird state that squill, copaiba, broom and guiacum, cause the removal of an increased proportion of water from the blood, but do not influence the quantity of solid matter removed from the body in twenty-four hours. It seems probable that these remedies affect the capillaries of the Malpighian tuft, probably through their action upon the nerves distributed to the renal vessels.

In cases where the blood is very watery, the excess of fluid is carried off by the kidneys; but at the same time, a greater amount of solid matter is removed in a given time. This arises partly from the tissues being washed out by the large quantity of fluid, and partly because the formation of urea, &c., is favoured by a dilute state of the fluids.

Many neutral salts (nitrates, sulphates, &c.) seem to increase the secretion of urine by being attracted from the blood in a state of solution, in all probability by the renal epithelium, the kidney being the channel by which they naturally leave the system. Urea has a similar diuretic action. Within certain limits, the greater the quantity of these substances in the blood, the more will be removed by the renal epithelium, supposing this to be healthy. The more strongly the epithelial cells be charged with urinary constituents, the greater the quantity of water required to dissolve them out. This seems to be effected as follows:—When the urinary constituents are not removed from the cells by the water coming down from the tuft as fast as they are separated from the blood, they must accumulate until the surcharged cells cease to exert that attractive force upon the blood in the capillaries around the tube which they do ordinarily. The tendency to stasis in the circulation thus caused, necessarily interferes with the free passage of the blood through the Malpighian capillaries, and the increased pressure which results causes the escape of fluid into the tube, and the solid matter accumulated in the cells is soon washed out. The cells resume their action, the circulation becomes free again, and the normal relation between the action of the cells of the tube and the Malpighian body is re-established.

Now alkalies, and especially the citrates, tartrates, and acetates, which become converted into carbonates in the system, increase not only the quantity of water removed from the system, but also materially augment the total amount of solid matter removed from the body in a given time. These salts increase the quantity of urea and other matters formed. They seem to favour the conversion of the products resulting from the disintegration of tissue into these constituents. The alkali perhaps facilitates the process of oxidation going on in the uriniferous tubes. The action of such remedies is very desirable in a vast number of cases; and even where the kidneys are diseased, these salts act favourably. Atropine (Parkes), digitalis, and colchicum like alkalis increase the proportion of urinary solids; the favourable action of the two last in gout is probably to be explained by their influence in encouraging the formation of urinary constituents. Narcotics such as opium, henbane, Indian hemp, have a contrary effect. Quinine, iron, and alcohol also tend to reduce the amount of solid matter excreted in the urine.

A certain degree of dilution is necessary to ensure the diuretic action of many neutral salts. If the density of the solution be very great, exosmose of fluid from the blood will take place in the intestines, and a purgative action will be produced. Certain salts may be made to act as purgatives or diuretics, according as they are diluted with a small or with a large quantity of water. The observations of Dr. Headland, however, show that this physical explanation cannot be applied in all cases. That sulphate of magnesia is absorbed into the blood, at least in the majority of instances, there can be no doubt. It is often excreted in large quantity in the urine; and it is probable, as Dr. Headland suggests, that its *purgative action* is due to its removal, in the form of a weak solution, from the blood by the action of the intestinal mucous membrane.

The excretion of urine will also be materially affected by all those circumstances which influence the circulation in the kidney. There exists a compensating action between the cutaneous secretory surface and the kidneys. If a large quantity of water escapes in the form of sweat, the urine will be small in amount and highly concentrated; but if, from the effects of cold, there be scarcely any perspiration, the excess of fluid is entirely removed by the kidneys, and the solids of the urine are therefore held in solution in a much larger quantity of water. Pressure on the renal arteries, or on the aorta above their origin, will diminish the secretion of urine. Pressure on the veins, on the other hand, will first of all cause an increased flow of urine, and afterwards albumen will escape. In congestion of the liver and portal system, the amount of solids is greatly increased. It would appear that, in many cases, where the action of the liver is imperfect, and especially in some forms of organic disease, the kidneys, to some extent, perform the functions of the liver. In jaundice, both colouring matter and biliary acids are carried off in the urine. In this case, however, it must be borne in mind that these biliary constituents are formed by the liver, reabsorbed into the blood, and separated from it, as are many other substances abnormally present, by the kidney. In many affections of the liver, the urine-pigment is much increased; and it is probable that a certain proportion of material which, in a state of health, would have been converted into bile, is transformed into certain extractive matters and other substances, and eliminated in the urine. The *crisis* of many acute diseases is characterised by the presence of a large quantity of solid matter in the urine, and increased action of the kidneys. Free sweating, and the secretion of a urine containing a large amount of urea and urates, in the course of many diseases, are often the earliest and most important indications of approaching convalescence. Dr. Golding Bird showed that abatement in the severity of the symptoms of ague was always associated with an increase in the amount of solid matter in the urine. Now, in all these cases, it is obvious that the activity of the renal epithelium is increased. The separation of urinary constituents from the blood cannot be regarded as a mere percolation, but is dependent upon a vital property of the cells. These cells take part in the actual formation of some of the urinary constituents, just as sebaceous matter is formed by the cells of the sebaceous glands, saliva by those of the salivary glands, &c. An alteration in the proportion of the water is rather to be attributed to temporary alteration in the calibre of the arteries which supply the Malpighian bodies, and to the variable pressure exerted by the blood as it traverses the Malpighian capillaries, depending, to some extent, upon the freedom with which it passes onwards into the capillary system, among the meshes of which the tubes lie.

Of the Absorption of Substances by the Stomach, and their Excretion in the Urine.—The rapidity with which weak solutions are absorbed from the digestive organs, and secreted by the kidney, is marvellous. In Mr. Erichsen's well-known experiments, it was shown that ferrocyanide of potassium could be detected in the urine within a minute after it had entered the empty stomach. These interesting conclusions were derived from experiments made on a case in which, from the deficiency of the anterior wall of the bladder and abdomen, the orifices of the ureters could be seen, and the urine collected as it trickled from them. A German suffering from this terrible malformation was in London in 1858, and many had an opportunity of seeing him, and observing how very soon, after a large quantity of water had been swallowed, the rate of the flow of urine from the ureters increased. Salts of iron in solution, may be taken up by the stomach, carried through the system in the blood, and excreted in the urine in the course of a few minutes.

Anything interfering with the absorption of fluid from the stomach or intestinal canal will necessarily affect the secretion of urine. In various cases where the contents of the alimentary canal are in a condition unfavourable for absorption, but a very small quantity of urine is formed. Dr. Barlow has gone so far as to say that the seat of an obstruction in the intestine can be ascertained by noticing the quantity of water excreted in the form of urine. When close to the pylorus, it is stated that scarcely any urine is separated. In ordinary cases of what is known as sick headache, where, from temporary stomach derangement, little absorption occurs for some hours, no urine is secreted perhaps for twelve hours or longer. The termination of the attack is marked by the very free and rapid action of the kidneys.

Of Deranged Action.—Having considered the action of the kidney in health, we may now briefly discuss how the normal changes may be modified in certain cases. And in the first place it is necessary to consider the nature of those temporary derangements in action, which, however serious they may be at the time, may pass off without leaving any permanent structural changes, the organ again performing its functions as perfectly as if nothing had happened.

From what has been already stated, it is obvious that the characters of the urine must vary according to the state of the vessels and the quality of the blood transmitted through them. It has been shown that if the muscular walls of the small arteries be relaxed so that the calibre of the vessels is increased more blood will pass into the Malpighian capillaries in a given time, and a more free transudation of water through the membranous walls of the capillaries will occur. If, on the other hand, the arteries become contracted, the secretion of urine will be diminished accordingly.

Many sudden and temporary alterations in the circulation of the blood through the Malpighian bodies of the kidney depend upon an influence exerted through the nerves alone; but certain changes, of which some are, unfortunately, of a more permanent character, are due to an altered action of the secreting cells. The *rapidity* of the circulation in the Malpighian body will be greatly influenced by the rate at which the blood traverses the capillaries around the uriniferous tubes. If, from any cause, the action of the secreting cells becomes impaired, and they cease for a time to exert their attraction for the constituents which they ought to separate from the venous blood, a retardation of the circulation in these capillaries must result. This would affect backwards, as it were, the capillaries of the Malpighian body, in which the blood, urged on through the arteries, would tend to accumulate. Their thin walls, being much stretched, would not resist the passage of certain constituents of the blood; albumen and extractive matters would pass into the tube, and escape in the urine. Supposing this state of things to go on, the pressure upon the Malpighian capillaries must necessarily increase; and these capillaries, distended to the utmost, and their walls thinned to the last degree, at length burst, and all the constituents of the blood, including the blood-corpuscles, pass into the tube, and escape with the urine. The tenuity of the walls of the Malpighian capillaries, which permits the escape of water in health, necessarily favours the escape of other constituents of the blood, and increases the chance of the formation of longitudinal rents or fissures in disease, if they be exposed to increased pressure. The *collateral* circulation already referred to in some measure counteracts this tendency, but if the pressure be considerable rupture occurs and blood escapes.

That lateral pressure upon the vessels may be exerted to an extent sufficient to cause blood and albumen to escape has been proved experimentally by Mr. G. Robinson, who in 1843 showed that if the renal vein were tied completely, or partially so as to permit the blood to pass through it slowly, congestion sufficient to cause the escape first of serum and then of blood occurred (Med. Chir. Trans.). Congestion of the kidneys and an albuminous condition of the urine, arising from obstructed venous circulation, are commonly met with. In certain forms of heart and lung disease, in rheumatic fever, cholera, and other conditions in which there is considerable accumulation of blood in the veins and impeded circulation, albumen and blood are not unfrequently found in the urine.

Venous congestion resulting from exposure to cold, and occurring in the course of many fevers and inflammations, as pneumonia, erysipelas, gout, croup, diptheria, pyæmia, often results in hæmorrhage. Various chemical irritants, cantharides, turpentine, and some violent diuretics also induce congestion and hæmorrhage. In all these conditions the albuminous and bloody urine is not associated with dropsy, and in many cases the blood continues to escape in the urine only during a few days.

As is well known an increase of the cellular elements, or rather of the masses of germinal matter of a tissue, is invariable in all cases of "inflammation." In pneumonia the air cells, which in health are occupied by air only, are choked with masses of germinal matter, actively growing and multiplying. These have been derived from the white blood corpuscles, or particles of germinal matter resembling these, so small as to be able to make their way through the slight fissures produced when a thin-walled capillary is considerably stretched. And in inflammation of the kidney, liver, and other organs, not only is there an increase of the epithelium, or rather of its germinal matter, which in health exists in considerable quantity, but materials from the blood, including much living germinal matter pass through the vascular walls and become mixed with the glandular elements, and accumulate between the tubes and capillaries. The masses of germinal matter being freely supplied with nutrient pabulum increase and multiply rapidly, and seriously interfere with the action of all neighbouring textures. Before we can give an intelligible account of the phenomena of congestion and inflammation as they occur in the kidney and liver, it is clear we must endeavour to answer the question, Why does the epithelium or its germinal matter increase so as to choke up the uriniferous tube? Instead of enquiring what led to the accumulation of the epithelium in the uriniferous tubes, pathologists for the most part seem to have contented themselves with making this given fact of the accumulation the starting-point of their enquiry. I have endeavoured to show that the increase of the germinal matter is due simply to the supply of an increased amount of pabulum. The pabulum consists of readily permeable matters which accumulate in the blood. And this accumulation is probably due to the formation of these materials more quickly than they can be eliminated from the blood by the usual channels. They are taken up and appropriated by various kinds of germinal matter in the organism. It seems to me therefore that the enquiry ought to commence with the consideration of the circumstances under which the formation of the very permeable substances which accumulate in the blood, and which form the ordinary pabulum of the cells concerned in excretion, occurs, and this renders necessary a digression from the special subject under consideration. In order to elucidate the matter, I shall endeavour to discuss briefly the phenomena which occur in that most simple departure from the normal state of health—an ordinary cold.

The shivering, the chilliness, the feeling of malaise which afford the first intimation of our not being in the ordinary healthy state, and invariably precede the occurrence of any acute affection, which are often most severe in certain specific fevers, are due, I think, to an altered state of blood. Some are disposed to attribute these phenomena to changes affecting the nervous system, and there can be no doubt that the peripheral and central parts of the nervous system are affected. But are not the nerve-phenomena themselves due to an altered state of the blood affecting the nutrition and action of the nerve structures? Perhaps insufficient oxidation lies at the root of the matter, and materials resulting from disintegration in an imperfectly oxidised state may be the substances which perhaps under the form of "extractive matters" permeate the capillary walls and supply nourishment to the germinal matter of the blood and tissues, instead of being fully oxidised and very soon removed in the form of carbonic acid, urea, &c. If such materials accumulate unduly in the blood the capillary circulation will everywhere be retarded, although to the greatest extent in those organs which are concerned in elimination. In certain specific fevers the accumulation of such imperfectly oxidised excrementitious substances in the blood seems due to the presence and growth and multiplication of peculiar kinds of germinal matter (the contagium or fever poison). The changes induced in the capillary circulation and in the conditions of nutrition may through the peripheral nerves react so violently upon the nerve centres as to cause the most serious rigors and sometimes even fatal collapse. The collapse stage of cholera, which is so terribly fatal, probably bears the same relation to what is usually termed "the secondary fever," as the period of shivering, &c., which precedes a specific febrile attack (scarlatina, typhus, small-pox, &c.) bears to the eruptive fever itself.

It seems then to me probable that when we "catch cold," certain matters are not freely oxidised, and being in a condition not favourable for elimination, accumulate in the blood in undue quantity. The presence of these soon affects the delicate peripheral nerves, and causes the feeling of chilliness which we experience, and which excites a desire for artificial warmth. By yielding to this desire and applying external warmth, an increased flow of blood to the cutaneous surface is encouraged, and this determines increased action of the cells of the sudoriparous glands, if these be in a healthy state, and increased excretion. Thus the "cure" of the cold may be sometimes effected. In many cases, however, the relief is only partial, various imperfectly oxidised matters still remain in the blood, and these have to be eliminated by the agency of masses of germinal matter. Upon the surface of the nasal and respiratory mucous membrane are many such particles, which soon increase in number, and give rise to the abundant "mucous secretion" so well known. In some persons, perhaps in consequence of some peculiar state of the respiratory and cutaneous surfaces, instead of this operation being effected by the mucous membrane of the nose or air tubes, the renal epithelium has to bear the brunt of it, and renal congestion, perhaps running on to actual inflammation, is the consequence. It is obvious that if the blood flowing through the capillaries of a secreting organ contains more than the ordinary amount of excrementitious matters, a longer time must be occupied in its transit if it is to be entirely freed from them, and until it is entirely freed (the vessels and cells of the gland being in a healthy state) it cannot pass. The cells continue to absorb from it the substances which they are destined to separate, and become enormously enlarged. If therefore the blood charged with a considerable excess of such substances be pumped on at the ordinary rate, and still more if at an increased rate, it is impossible it can be depurated. It is, in fact, prevented from flowing onwards. The capillaries become distended to twice or thrice their normal diameter, the blood flows more and more slowly, until at length complete stagnation occurs, or rupture takes place.

In an attack of acute congestion of the kidney, the secreting cells of the convoluted portion of the uriniferous tubes fail to remove from the blood as it flows through the intertubular capillaries the soluble excrementitious matters which have accumulated in it, at a sufficiently rapid rate. Consequently, as has been fully explained by Dr. Johnson, this blood accumulates behind, and the capillaries of the Malpighian body become distended, and not unfrequently rupture occurs, and the pressure is relieved by the escape of blood, or the congestion mass may be reduced by the transudation of the serum of the blood only, in which case the patient's urine, of which very little is formed, is found to be highly albuminous.

But it is doubtful if the escape of albumen and its presence in the urine is in all cases to be attributed merely to increased pressure upon the capillary walls and the transudation of serum. The albumen present in the urine often differs chemically from that present in the blood, and from time to time cases have been met with in which the albumen in the urine exhibits very peculiar chemical properties. This leads us to suppose that albumen of a particular kind may be actually *formed* in the kidney, just as mucus is *formed* upon the surfaces of mucous membranes by the agency of masses of germinal matter which are situated there. Dr. Basham concludes that the formation of the albumen which is present in the urine is due entirely to the cells, which either " secrete it or produce it by their disintegration or breaking up." But I think the presence of albumen in cases in which the tubes are almost bared of their epithelium, and the very large quantity passed in the urine in cases in which the tubes undoubtedly contain much epithelium adherent to the basement membrane, prevent us from applying this view in every case. The presence of albumen in large quantity in fluid in serous cavities the walls of which are uncovered by epithelium, in that which collects in the areolar tissue in œdema and anasarca, and its existence in the cerebro-spinal fluid, render it certain that at least in these cases it escapes from the blood by transudation. Moreover, a weak solution of albumen may be made to permeate the capillary walls by injecting it under increased pressure. Upon the whole, it seems probable that in those cases in which there is temporarily increased pressure upon the vascular walls as in the internal congestion which exists in pneumonia, cholera, diptheria, fever, and other conditions, albumen transudes through the vascular walls, while in other cases there is reason to think that the albumen like that peculiar modification of which " casts " consist, is formed by the epithelial cells, or rather by their germinal matter. Dr. Parkes thinks the liver is concerned in the development of albuminuria. The albumen in consequence of being absorbed in a crude state and imperfectly elaborated, filters away from the blood as the circulating fluid passes through the renal capillaries.

The fact that the secretion of a large quantity of urine containing much albumen occurs in cases in which the capillary vessels of the Malpighian body are much thickened and less permeable than in the normal state must not be passed over, for it is certainly reasonable to suppose that in some of these cases the albumen may filter away from the *straight portion* of the uriniferous tubes, p. 37. If, however, the escape of albumen almost invariably occurred in this way we ought to find an œdematous condition of the kidney, and blood effused between the tubes more frequently than is the case. It seems to me that, before such a lesion as that referred to became possible, the Malpighian capillaries must have become enormously thickened. In many chronic cases, as has been shown by Dr. Johnson, the Malpighian arteries become very much thickened, and the capillaries of the Malpighian body are often in a like condition; so that the permeability of their walls must be considerably diminished. It is in such instances that albumen probably escapes from the intertubular capillaries and the vasa recta.

But there can be no question that in the majority of cases the blood corpuscles and fluid matters escape from the Malpighian capillaries although these may have undergone thickening to a considerable extent, for they may be seen in the convoluted portion of the tubes after death, and I have seen corpuscles extravasated from the vessels in the capsule of the Malpighian body.

If in a case of acute congestion of the kidney, passing into inflammation, the urine be examined, it will be found to exhibit a smoky appearance due to the presence of blood corpuscles, the colour of which is changed to a brown colour by the acid of the urine. Besides the altered colour and the presence of albumen, an abundant brownish deposit is diffused through it, and this after a time collects at the bottom of the vessel. Besides blood and epithelial cells, casts or moulds of the tubes will be found in considerable numbers. These casts are probably formed by the cells in somewhat the same way as mucus is formed by the mucus corpuscles upon the surface of a mucous membrane. In inflammation the masses of germinal matter increase and multiply, and it is probable that the material of the cast results from changes taking place in these. It is also probable that in many cases the germinal matter derived from the white blood corpuscles gives rise to albumen and some of the solid albumen-like matter of which casts are formed. It has been already shown that in inflammation of the kidney the cells or rather the masses of germinal matter multiply, as in inflammations generally, in consequence of an increased proportion of soluble nutrient matters filtering through the walls of the vessels as described in p. 43. Henle was probably the first who showed that all inflammations of mucous surfaces were characterised by this increased cell-growth accompanied with an increased formation of the mucous secretion. Some consider that the increased secretion results from the decay and disintegration of the cells themselves, an idea which involves a far greater activity in the processes of cell-formation and cell-multiplication than really exists. Dr. Basham has expressed himself in favour of this view. He says he has no hesitation in expressing his conviction "that these casts are derived from the metamorphosis or breaking up of the epithelial cells of the renal tubes, excepting in the case of the fibrinous blood-casts" which result directly from hæmorrhage.

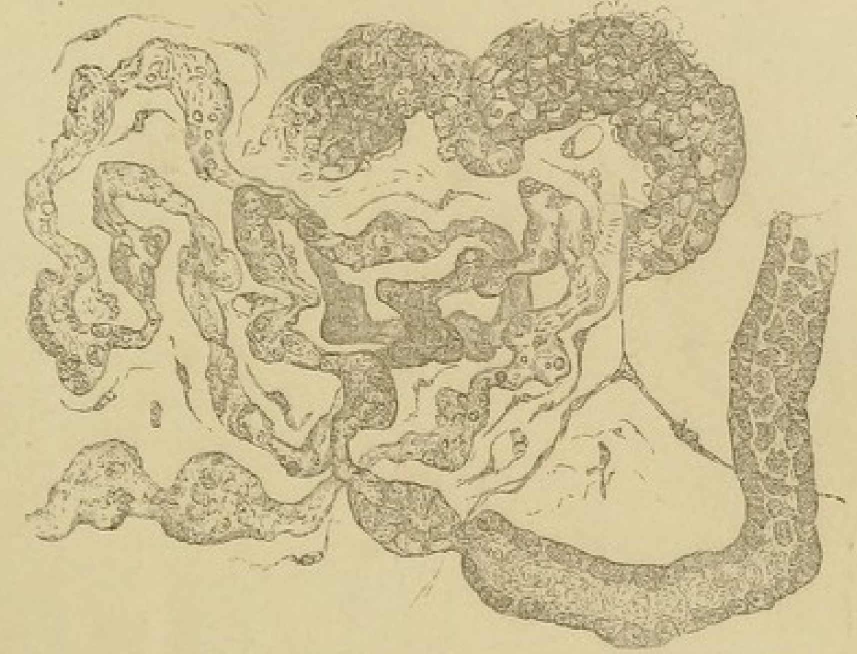
We may now proceed to consider further the phenomena which occur in the kidney in a state of congestion and inflammation while the condition is progressing towards recovery and the organ returning to its normal state. If a patient in this condition rests completely the rate at which the blood is pumped through the vessels is soon reduced —time is allowed for the cells to remove the materials from the portion of stagnating blood which then flows slowly onwards, while its place is occupied by a new portion driven through at a slower rate—the pressure becomes less and less, the blood flows through the organ as freely as before, and it becomes thoroughly depurated as fast as it circulates.

More commonly, however, instead of the recovery being so rapid as this, the congested state remains for some time, serum or actual blood continues to pass through the stretched vessels and free action of the skin and bowels occurs before the kidneys are relieved. But if relief is not thus afforded, it sometimes happens that complete stagnation occurs and then the phenomena comprised under 'inflammation' are manifested. The ordinary excretory action of the cells entirely ceases; but the germinal matter of the cells, of the blood, as well as that of the nerves, vessels, and connective tissue, being entirely surrounded with soluble pabulum, appropriates it and the masses increase in size, divide and subdivide. Some portions detaching themselves make their way into the tubes and into the intercellular spaces. Those in the tubes with the masses resulting from the sub-division of the germinal matter of the secreting cells, under favourable circumstances make their way into the urine, and by slow degrees things may return to their normal state. On the other hand, the phenomena above described may persist, and advance towards irreparable changes which may gradually progress or end at once in suppuration. The entire cessation of the excreting action of an organ so important as the kidney, necessarily however, causes death before *general* suppuration of the kidney can occur. In cases, however, where the inflammation is partial, not only may suppuration take place, but a portion of the kidney may be detached by the suppurating process and be found in the urine. The following is an interesting example of a bad case of *acute nephritis*, or inflammation of the kidney passing into suppuration.

The case occurred in the practice of Mr. Image, of Bury St. Edmunds. The patient was 33 years of age, and was operated on for strangulated hernia. Four days after the operation, erysipelas appeared, which subsided in the course of three days. The day after the erysipelas disappeared, the urine which had hitherto been healthy, was found to contain albumen, blood-casts, and blood corpuscles. The man died nineteen days afterwards, the *urine having been nearly suppressed for the last three days of his life.* There was anasarca but no disturbance of sensory or motor power, and no vomiting. The casts in the urine, three days before death, are represented in pl. IX, figs. 45, 46, and in fig. 44 a portion of a cast is shown, magnified 700 diameters. It contains in its *central part*, blood corpuscles and bodies like white blood corpuscles, which appear to be *undergoing multiplication* in the cast. The kidneys were much enlarged; one weighed 13 and the other 15 ounces. This considerable increase in weight was mainly due to the accumulation of matters in the capillary vessels and in the secreting

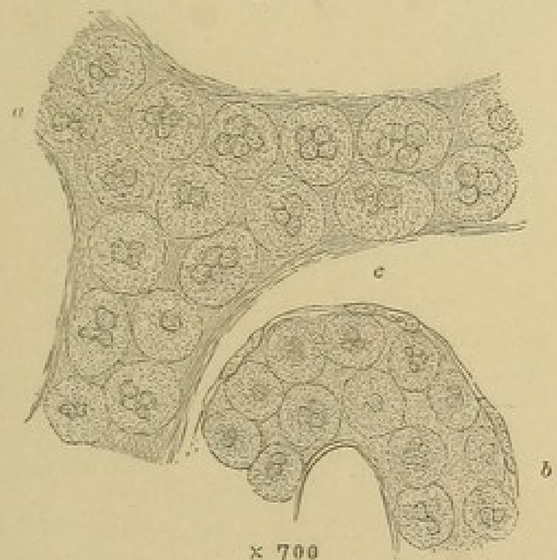
STRUCTURE OF THE KIDNEY.

Fig. 42.



Tube of kidney of female newt, part of which has undergone degeneration and wasting. The healthy portion of the tube is seen to the right of the figure. Nerve fibres are also seen in some places. × 215. p. 31.

Fig. 43.



a, portion of a capillary vessel of the kidney, distended with altered white blood corpuscles. *b*, round flattened cells, from inner surface of capsule of the Malpighian body. *c*, nucleus of capillary wall. Acute suppurative nephritis. p. 45.

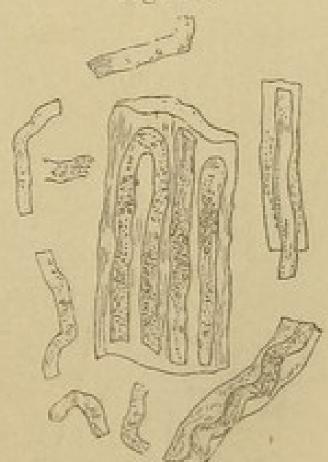
Fig. 44.

Portion of a cast magnified 700 diameters, with cells in the central part resembling white blood corpuscles or pus corpuscles, which have probably multiplied while they were entangled in the coagulable material of the cast. p. 49.

Fig. 45.

Casts containing cells like pus and blood corpuscles. Acute suppurative nephritis. Three days before death. p. 49.

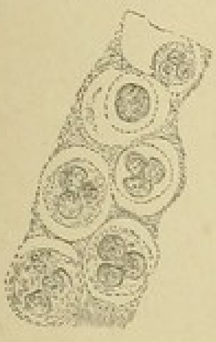
Fig. 46.



Small casts formed in the convoluted portion of the uriniferous tubes, which have become embedded in transparent material during their passage down the straight portion. × 50. p. 49.

DISEASES OF THE KIDNEY.

Fig. 47.

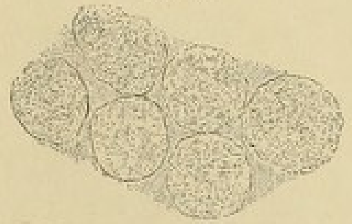


Portion of a cast, with distinct cells, showing nuclei and granular contents. Acute nephritis. × 700.

Fig. 48.

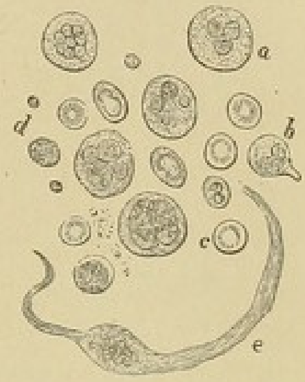
Bodies found between the capillaries of the Malpighian body and the walls of the capsule. Case of acute suppurative nephritis. × 700.

Fig. 49.



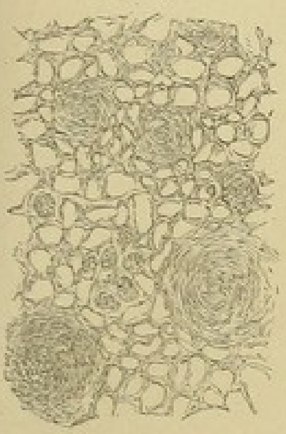
A portion of one of the capillary loops of a Malpighian body, distended with modified white blood corpuscles. × 700.

Fig. 50.



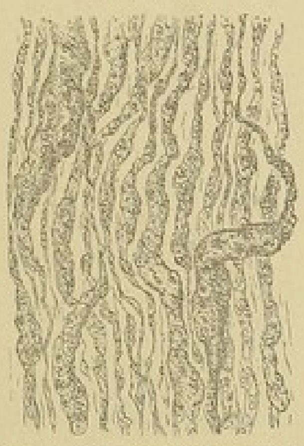
Separate cells found in the urine. Case of acute suppurative nephritis. × 700.

Fig. 51.



Malpighian bodies, showing different degrees of wasting. × 40. p. 50.

Fig. 52.

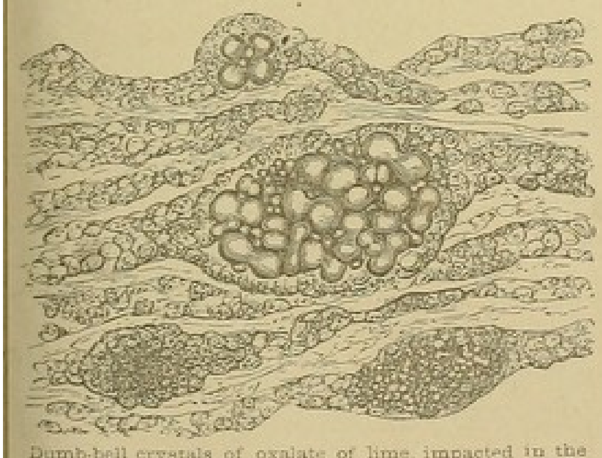


Tubes of the kidney degenerated and wasted. × 215. p. 54.

Fig. 53.

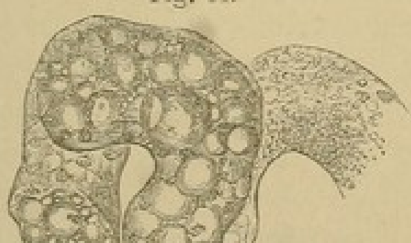
Multiplication of masses of germinal matter about tubes prior to wasting. × 215. p. 53.

Fig. 53*.



Dumb-bell crystals of oxalate of lime, impacted in the tubes of a kidney, forming minute calculi. × 215. p. 12.

Fig. 54.



Portion of a tube from the cortex of the kidney of a healthy (?) cat, containing much oil. × 215. p. 58.

Fig. 55.

Malpighian body and portions of uriniferous tubes, with capillary vessels containing much oil. From a kidney of a diabetic. × 215. p. 60.

tubes. The vessels were distended with large cells like white blood corpuscles, pl. IX, fig. 43, and the tubes were filled with casts and cells like pus corpuscles. Now, there can be little doubt that the cells represented in figs. 43, 49, in the capillaries, have been formed from the white blood corpuscles, and it is almost certain that the pus-like corpuscles in the *centre* of the casts, figs. 44, 47, have the same origin. The whole organ was passing into a state of suppuration, and the pus-like corpuscles in the urine of this case probably resulted from the multiplication of corpuscles in the tubes which were produced by the white blood corpuscles. (*See* "Archives of Medicine," vol. II, p. 286.)

OF STRUCTURAL CHANGES IN THE KIDNEY.

Having considered the changes which may be induced in the secretion of urine through nervous influence or by a temporary alteration in the composition of the blood transmitted to the kidney, we may refer briefly to those permanent progressive alterations in structure which may be slowly effected by the persistence for some time of the altered conditions already referred to, or which may result from abnormal changes occurring at an early period of development.

If unhealthy blood be continually transmitted through the kidney, the action of the renal cells becomes gradually impaired. In cases of long continued wine and spirit drinking it is probable that the changes which ensue, result from an altered state of the blood engendered by the spirit and not from the direct action of the alcohol itself upon the tissues. Large quantities of spirit may exist in the blood for short periods of time without producing any serious change in the kidney. When, however, the renal cells have long been subjected to the influence of blood modified by the constant presence of alcohol, they lose their healthy appearance, sometimes merely becoming smaller and more condensed, sometimes appearing granular and in a state of disintegration. And perhaps in consequence of the growth of the germs having been interfered with at an early period, the place of the disintegrated cells cannot be occupied by a new generation. Moreover a complicated series of morbid changes in other structures of the kidney besides the epithelial cells gradually ensues, the blood becomes still more depraved by the accumulation in it of matters which ought to be removed by the kidney, and other tissues and organs of the body. These phenomena react upon the epithelium and thus the changes continue to progress as it were in a circle. The coats of the smaller arteries become much thickened, the capillaries shrink, while their walls become condensed and granular. The quantity of blood distributed to every organ in the body is reduced; and many of the capillaries being no longer required, shrink and cease to transmit blood. Basement membrane becomes thickened and more impervious to fluids. The kidney and liver become hard, small, and wasted. This decrease in size takes place principally at the expense of the cortical or secreting portion of the kidney and of the outer active part of the lobules of the liver. The Malpighian bodies of the kidney waste. The remains of many may be seen without a capillary in them being pervious ; and not a few of those which still exist are found to be so altered that they can hardly be recognised as Malpighian bodies at all, pl. X, fig. 51. The greater part of the blood sent to the kidney passes into the pyramids by the *vasa recta* and is returned to the veins without being properly depurated by passing through the vessels of the cortex.

Noxious materials in the blood by paralysing the afferent nerves distributed to the capillaries and uriniferous tubes, may induce local disease in renal as in other textures. This paralysis of excitor nerves would assuredly be followed by dilatation of the small arteries and accumulation of blood in the capillaries, for the nerve centre would no longer receive the stimulus required to excite the vaso-motor nerves to maintain the arterial muscular fibre cells in a state of contraction. And it is better that noxious matter should be obstructed in the capillaries though local inflammation and complete destruction of the neighbouring tissue ensue, than that it should traverse the capillaries, pass into the veins and contaminate every drop of blood, which must result in certain death.

Although an acute attack not unfrequently seems to be the origin of chronic renal disease, we meet with so many cases in which an acute affection passes off without any further change taking place, and so many instances of serious and fatal chronic disease which come on so insidiously that it is often impossible to ascertain when they commenced —that it is doubtful if there is any more intimate connection between acute and chronic renal disease, than there is between acute and chronic diseases of the lungs, stomach, liver, brain, and other organs.

Great attention has been paid to the results of chronic disease of the kidney, nevertheless much yet remains to be worked out in connection with the subject. Some pathologists argue that there are at most only two or three essentially different forms of Bright's disease, others describe several distinct affections which they consider in no way related to one another, except that all are characterised by one common symptom—*albumen in the urine.*

In this short sketch I shall not attempt any systematic arrangement, but shall endeavour to give a brief account of those forms of disease which seem to me well marked and are capable of being clearly distinguished. As precise observation advances no doubt a great number of distinct forms of renal disease will be accurately defined. Just as we now know that numerous very different pathological changes have been included under the vague term "tubercular disease" or "phthisis," so Bright's disease includes several diseases essentially distinct, different in their origin, in their progress, and often in the results to which they lead. Dr. Johnson has accurately described several of these morbid changes, and his observations have been confirmed by other pathologists. Nevertheless some physicians still insist that the different conditions above alluded to are merely different stages of one and the same morbid process. But let any one examine carefully the small contracted kidney so commonly found in the bodies of old drunkards, with its rough puckered surface and diminished cortical portion, and contrast it with the large, smooth, and pale kidney, in a state of fatty degeneration, which is not unfrequently met with in young people not more than twenty years of age, and he will be quite convinced of the different nature of these affections. The causes of these diseases are different ; the conditions under which they occur are different ; and although the result is fatal in both, death occurs in a very different way. Their chemical characters are different : their microscopical characters indicate the occurrence of changes which are totally distinct. Again, the treatment required in the early stages of these diseases, when alone any benefit is likely to be derived from treatment, is different.

Before alluding to the forms of chronic Bright's disease, I must again direct attention to the several structures which are combined to form the renal apparatus. In the healthy kidney at an early period of life are the following essential structures,—the *cells* lying in the tube of very thin membrane,—*blood* circulating through the intertubular vessels and through the capillaries of the Malpighian body,— and *nerve fibres* ramifying around the vessels and secreting tubes. These are alone necessary for the further growth of the gland and for the secretion of urine. The " connective tissue corpuscles " exist in very small proportion when the gland is first formed, but they increase in number as age advances. These are non-essential structures, and so far from taking part in the functional activity of the gland, they impede its action to some extent. Connective tissue is not required as a supporting framework, for the arrangement of the textures is such that they must mutually support each other.

Pabulum to nourish the cell,—the cell itself consisting of germinal matter and of soft formed material,—and oxygen to disintegrate the latter and combine with some of its constituents, are all that is essential for the formation of the constituents of urine.

Morbid changes may originate in the cells themselves primarily, or the cells may be affected secondarily through altered blood, or by an irregular, insufficient, or too abundant supply of blood. Morbid changes may first appear in the vessels, and there is reason to think that some renal diseases are of nervous origin. It is quite certain that some forms of kidney disease originate at a very early period of development of the gland,—even during intrauterine life. Some of these may perhaps be due to defective nutrition, while others are "developmental" in their origin, being due to some defect in the changes which succeed one another during the evolution of the elements of gland structure.

Many observers have arrived at the conclusion that certain forms of kidney disease result from morbid changes primarily affecting the connective tissue, but in this I cannot agree; for although I admit the occurrence of the actual changes which have been described, these changes are, I believe, but the consequence of phenomena which have previously taken place in the glandular and vascular or nerve structures. In contraction and wasting of glandular texture there invariably appears to be much connective tissue, but this contraction and wasting may occur at an early period of development, when scarcely a trace of connective tissue can be discerned; and we cannot therefore attribute the wasting of the glandular structure to the hypertrophy of a tissue which at the time when the change commenced was not developed. *See* p. 21. The division of renal diseases into *tubal*, *intertubal*, and *vascular* seems to me unsatisfactory, because it is quite certain that the intertubular connective tissue is not the seat of origin of any form of renal disease while it is at least most doubtful if the vessels can in any case be regarded as the starting point of morbid actions.

Of Contraction and Wasting of the Kidney.—The small contracted kidney, with uneven surface, adherent capsule, and wasted cortex, so frequently met with in those who for many years have indulged in spirit drinking, results from morbid changes closely resembling those occurring in the liver, and producing that contracted, wasted state of the organ generally termed *cirrhosis*. Contracted kidney, like cirrhose liver, is, however, not peculiar to drunkards and those who have suffered from a gouty or rheumatic habit of body. The disease is occasionally met with in young persons as well as in those whose habits of life have been perfectly temperate—nay, the contracted state has been known to affect the fœtal kidney and liver. The change may have been progressing for years. The derangement may have resulted in consequence of an altered state of blood affecting the cells; or it may have originated primarily in the cells themselves, the consequence perhaps of some change having occurred at a very early period of development.

This is, however, one of those structural diseases which I think may be induced, so to say, artificially, at least in a vast number of cases. I think it probable that if a hundred persons in good health were placed for a certain number of years under conditions favourable to the production of contracted kidney, the condition would be actually produced in at least 80 per cent. In some cases it is almost certain that the wasting is a consequence of undue action at an earlier period of life. Shrivelling and wasting of the kidney are often preceded by an enlarged and engorged state. An early stage of the wasting process when masses of abnormal germinal matter are multiplying and the normal structures are being removed, is represented in pl. X, fig. 53. It is probable that overwork is not unfrequently a cause of chronic degeneration of renal structure, and there is reason to think that the kidneys may be subjected to undue action or excited to perform increased work, by over-eating, by violent, irregular, excessive, and prolonged nervous exertion, particularly in close hot rooms with a very imperfect supply of air.

In "contracted kidney" the whole organ wastes, but the wasting process is more marked in the cortex than in the medullary portion. The cortex is often reduced to a very thin layer, in which few Malpighian bodies can be seen with the unaided eye. Upon microscopical examination all these will be found much smaller than in a healthy organ, and pale, not a few having been converted into knots of fibroid tissue, pl. X, fig. 51.

The surface of the kidney is irregular, often appearing puckered from the irregular contraction which has been taking place. The secreting structure is torn away when the capsule is removed, the probable explanation of which fact has been given in page 24. Thin sections of the cortex show the tubes to be much altered. In a good specimen the wasting process can be studied in every stage. Often portions of wasted tubes may be discerned which have been slowly separated and altered until at last distinct and detached angular bodies represent all that remains of what was once a continuous tube filled with epithelium, pl. XI, fig. 57, at *a*. These are the bodies which have been termed by most pathologists "connective tissue corpuscles." Similar bodies formed in precisely the same manner, also exist in the cirrhose liver, and instead of belonging to connective tissue formed in the course of the disease, are the last remnants of the wasted cell containing network. It has been too hastily assumed that cirrhosis of the liver is due to inflammation and contraction of the fibrous matrix, which is supposed to penetrate into every part of the organ, and which has been spoken of as "Glisson's Capsule." I have shown in the first place that the supposed fibrous matrix does not exist in the situations where the contraction has occurred; secondly, that the so-called fibrous tissue supposed to be between the lobules forms a part of the substance of the lobule itself, and really consists of wasted glandular elements; and, thirdly, that the phenomena occurring in cirrhosis may be fully explained in a totally different manner, while they cannot be satisfactorily accounted for by the theory commonly entertained. In the same way many have been led to conclude that contraction of the kidney was caused by the pressure exerted upon the tubes at short intervals by the contraction of the matrix. But the conclusion has been forced upon me that those forms of kidney disease which are supposed to result from hypertrophy or inflammation of the matrix, or intertubular connective tissue, are due neither to hypertrophy nor to inflammation of any kind whatever. The secreting tubes shrivel and waste, and leave a residue of "connective tissue," which accumulates between tubes and vessels which have not yet suffered, and which still perform active functions. The cause of this change is to be sought for in connection with the cells themselves, not in inflammation or any active changes occurring in the perfectly passive intervening material.

An organ which is made to take upon itself an undue amount of work, at first undergoes considerable and rapid increase in size. The relation of the structures to each other becomes altered, and action seriously deranged. Then wasting of the whole commences and continues as long as life lasts. Further observations upon the minute changes occurring during wasting will be found on p. 65.

Before the wasting process has reached the stage above referred to, it not unfrequently happens that portions of tubes which have been separated by the shrinking and wasting going on faster in some places than in others, exhibit a tendency to modified growth. The epithelium, or masses of germinal matter descended from its nuclei, may grow and multiply and secrete an albuminous fluid which accumulates in the cavity. In this way the small cysts are formed which are so commonly met with in wasted kidneys. Other explanations of the process have been advanced, but in the majority of cases the view here given, which was put forward by Dr. Johnson, is, I have little doubt, correct. *See* also "On the formation of cysts in the kidney."

The small contracted kidney usually contains about 20 per cent. of solid matter—actually less than is frequently found in the healthy kidney, but more than is met with in the enlarged soft kidneys, p. 57. A kidney may cut almost like cartilage, and yet contain but a small proportion of solid matter. Indeed, the percentage of solid matter present in the hardest and most solid kidney rarely exceeds that present in healthy blood, and is often considerably less than this.

The symptoms of the small contracted kidney, the condition of the urine, and the course of the disease, will be again referred to under the heads "Albuminous Urine" and "Casts of the Tubes." The changes occurring in the vessels are described further on.

Of Enlargement of the Kidney.—Enlargement of the kidney, like enlargement of the liver, may be temporary, due merely to accumulation of blood in the smaller vessels. The pressure exerted upon the walls of the vessels increasing, these may give way here and there, the rupture usually occurring in the capillaries of the Malpighian bodies, and blood may escape into the secreting tubes. Or, from the cells of the uriniferous tubes acting very freely, the materials capable of being taken up may be quickly removed from the blood, when the circulation will again become free, and the congested state pass off; and a quantity of urine highly charged with organic constituents will be secreted. The kidney then returns to its former volume.

In other cases considerable pouring out of serum occurs and accumulates between the tubes and capillaries, and the kidney becomes much enlarged. Suspended in the fluid which escapes from the vessels (exudation) are minute masses of germinal matter which being at rest, and freely supplied with pabulum, grow and multiply in their new situation and take part in the formation of a very soft fibrous texture. This material may increase in quantity, and a long time must elapse before it can be reabsorbed. In such a case the increased size of the kidney is due; 1, to the vascular distension; 2, to multiplication of cells in the uriniferous tubes; and 3, to the formation and growth of a new material which is formed external to the capillaries in the seat of the supposed matrix or supporting tissue of the healthy kidney. No wonder, therefore, that the kidneys of those who die from acute inflammation should often be found to be twice the normal weight, p. 57.

In cases in which enlargement of the kidney depends upon congestion of the vessels and the effusion of lymph external to them, as in acute inflammation from cold or after scarlatina, the enlarged state is not unfrequently followed by contraction, and it has been supposed that by the contraction of the effused lymph, or of the fibrous tissue resulting from it, the blood vessels are compressed and the gland structure caused to waste. The morbid appearances observed, seem to me to justify us in concluding that in the first stage the secreting cells from being supplied with an increased quantity of pabulum have enormously increased in size, while their secreting function has been seriously impaired. This is necessarily followed by thickening of the vascular walls, shrinking and wasting of the capillaries, and wasting of the previously enlarged secreting cells. If the change has occurred in every part of the kidney the shrinking is tolerably uniform. If, on the other hand, only a portion of the renal structure has been involved, the wasting is partial and there may be sufficient healthy structure remaining for the requirements of the system under favourable conditions.

In those forms of renal enlargement which are chronic, and in which there is every reason to think that the alteration in volume has been proceeding during many months or years, the cells themselves are increased greatly in number, though often reduced in size, and the tubes in places appear completely choked up with them. In some of the cases of chronic enlargement of the liver and kidney which I have examined, the cells were of about the normal size, in others much less than in health, but of firm consistence.

It is doubtful if any change more constantly impairs the action of a secreting organ than the numerical increase of the secreting cells. This increase is indeed incompatible with the discharge of its function. The activity of a secreting cell occurs at a time when the processes of increase and multiplication are in abeyance. In embryonic life when the various organs are being formed, the process of cell multiplication is most active, but at this time little secretion is produced. If then, in the adult, the cells of an organ or part of an organ exhibit phenomena characteristic of embryonic life, their functional activity is impaired or destroyed. Cancer, it need scarcely be mentioned, is an example of this, but there are many other instances of cell-multiplication in glands whose functional activity is thereby destroyed, which cannot be regarded as cancer. In enlargement of the kidney I have seen numerous diverticula growing from the tubes at short intervals, amongst the tubes already existing, not only discharging no office themselves, but interfering with the action of adjacent secreting structure which yet remains capable of activity. The sweat glands, the tubular glands of the uterus and testicle exhibit the same change in certain cases of disease, leading to enormous increase in bulk, and the cessation of functional activity. Such diverticula may become detached from the tube from which they were offsets, and still continuing to increase in consequence of the growth and multiplication of the masses of germinal matter within them, at length become small cysts. This is probably one way in which cysts in the kidney originate. The manner in which a diverticulum grows from a tube is well represented in pl. VIII, fig. 40.

It is interesting to ascertain the nature of the material upon which the enlargement of the kidney depends. In the majority of cases the enlarged kidney is found to contain a smaller percentage of solids than the healthy organ. This shows that the increase in size is due principally to water or to the formation of delicate texture which contains much water. No doubt much of the material is capable of being re-absorbed, and thus the enlarged organ may at a subsequent period become much reduced in bulk. In analyses 2, 3, and 4, the composition of a kidney weighing 10 ounces is given. The opposite one weighed 9 ounces. They were obtained from a person 31 years of age. The greater part of the cortex exhibited an uniformly yellow appearance, it was firm but much fluid was easily pressed out, the tubes were much wider than usual, the epithelium well defined. The surface was uneven and mottled with whitish patches. On section the renal tissue was seen to be interspersed with much yellowish fat-like matter. The cortex was not separated from the medullary portion by any distinct line. In some places the tissue seemed replaced by a perfectly fibrous-looking structure. The Malpighian tufts were large, and the vessels apparently covered with well-formed epithelium, but the vascular structure appeared less distinct than usual. The small arteries were enormously thickened, and many of the tubes in the straight portion were completely blocked up by crystals of phosphate of lime. On the surface of the kidney were two or three collections about the size of a hempseed of what appeared to be pus. This matter consisted of round granular non-nucleated cells, which did not show nuclei when heated with acetic acid, and much granular matter. (Mic. B. 501.) 2. Cortex of the kidney. 3. Medullary portion. 4. Soft pus-like matter on surface.

ANALYSES	2	3	4
Water	80·10	80·18	82·25
Solid matter ...	19·90	19·82	17·75
Fatty matter	2·69	2·10	
Fixed salts	1·06	1·02	·99

It will be observed that the gland tissue contained little more solid matter than the semifluid pus-like substance forming collections on the surface of the kidney.

In the kidney, the analysis of which is given in No. 5, a still larger proportion of water was found. Each kidney weighed half a pound. They were obtained from a woman aged 35, who died suddenly. The renal tissue was uniformly pale, soft, and flabby (examined the same day as that on which the p. m. was made). The distinction between the cortical and medullary portions was not well marked. The capsule was easily peeled off. The tubes gorged with epithelium. Here and there small collections of oil globules were found, but these were not within the cells or tubes. The epithelium generally was not well defined; it appeared to be broken down and much free granular matter and epithelial débris were found. (Mic. B. 497, Lab. B. Vol. III, p. 84.)

ANALYSIS 5.

Water	85·61	
Solid matter	14·39	100·00
Fatty matter consisting chiefly of cholesterin	1·006	6·99
Fixed salts	·900	6·25
Vessels, albumen, &c. ...	12·484	

Analysis 6 shows the composition of a very large kidney from a man aged 34, who died of acute dropsy a month after taking cold. There were general anasarca and ascites. The lungs were healthy, the liver large, and the heart small. Each kidney weighed 13 ounces. The surface was mottled pale and red. The capsule was very easily stripped off. The texture cut almost gristly. The section of the cortical substance was pale, of the natural thickness, but of a fatty appearance. The tufts appeared large to the naked eye and very pale. The matrix very distinct and much more abundant than natural, in consequence of the presence of a quantity of glistening material. The vessels were large, and their coats thickened. (C. B. p. 87. Mic. B. 428. Lab. B. Vol. III, p. 160.)

ANALYSIS 6.

Water	84·75
Solid matter	15·25
Fatty matter	·80
Extractive matters	5·69
Renal tissue, &c.	7·63
Alkaline salts	·91
Earthy salts	·24
	100·00

Of the Fatty Enlarged Kidney.—Fatty matter is found in connection with the vascular and secreting structures of the kidney in various morbid conditions, and sometimes in very large proportions. This morbid deposit may affect a portion of a uriniferous tube here and there only, a few of the uriniferous tubes in one part only of the kidney, or almost every one of them throughout the entire organ. And instances are not uncommon in which oil globules are present in large numbers in every structure of the kidney. It is a remarkable fact in connection with this important pathological change that at least in some animals a highly fatty state of the secreting tubes of the kidney is not incompatible with what at any rate seems not to be an unhealthy state. If the student desires at any time to examine a kidney in a state of fatty degeneration he has only to make a thin section of the kidney of a full-grown cat. A very large proportion of the London cats have kidneys in an extreme state of fatty degeneration. I have examined the kidneys of from twenty to thirty apparently healthy animals, and have found in every one much fatty matter. In the following analysis of the cortical portion of the kidney of a London cat, nearly one-third of the solid matter of the kidney was found to consist of fat. It is very remarkable that the cat should remain in a state of apparent health and vigour although its kidney contains a very high percentage of fat.

ANALYSIS 7.

Water	73·80
Solid matter	26·2
Crystalline fat	3·46
Oily do.	4·40
Animal matter	15·67
Fixed salts	·68

A thin section of a part of a tube from the cortex of a cat's kidney is represented in pl. X, fig. 54. In many cases the tubes appear to be so fully occupied with oil globules that the nuclei or masses of germinal matter are quite invisible if the specimen is examined in the ordinary manner. If, however, the kidney be stained with carmine, "How to Work with the Microscope," 4th ed., p. 107, "The Microscope in Medicine," 3rd ed., p. 53, the germinal matter is readily discerned amongst the oil globules. In the same way the cells and their germinal matter may be demonstrated in the liver of the fish, which on ordinary examination seems to consist of fatty matter only. The tubes containing the largest amount of oil are those upon the surface of the organs, and these are the oldest. Can this state of kidney so general among domestic cats be explained by the over-feeding and want of exercise contingent upon their mode of life?

The Large White Fatty Kidney of the human subject exhibiting stellate veins on the surface is in no way related to other forms of renal disease. It seems to be connected with that habit of body which is associated with the development of tubercle. It may be traced, at least in some instances, to changes occurring in the kidney at a very early period of life. This is a form of chronic renal disease which is not uncommon in young people, and it is frequently met with in children. Of several children in whom there is an hereditary taint, some may die of hydrocephalus or tuberculous disease of the membranes of the brain, others of lung disease, others of mesenteric disease or tubercular peritonitis, while some become rickety, and one or two die of enlarged white fatty kidney. This disease may come on after scarlatina or measles during childhood, and may be attributed to an acute attack, or it may develop itself more insidiously between the fifteenth and twenty-fifth years without any warning. There is not the slightest doubt, as Johnson long ago stated, that this form of renal disease is not an early stage of the contracted kidney. That a white kidney may reach a *large* size and become *smaller* is true enough, just as a fatty liver may become smaller, but it is not an early stage of disease which *necessarily* precedes chronic wasting. Neither has the large fatty liver anything to do with cirrhosis. The two conditions are quite distinct.

In a well-marked specimen of this form of fatty kidney the fatty matter is found accumulated in the cells of the uriniferous tubes and many of the oil globules lie free in the cavity of the tubes which are sometimes so choked up that the central canal is obliterated. The intertubular capillaries and those of the Malpighian bodies are also affected, and little collections of minute oil globules may often be seen at intervals in their walls. The change often commences in a few of the tubes, and gradually extends until the whole organ is affected. The kidney is in many instances much enlarged from the increase in number and size of the fat containing epithelial cells, while its colour is very pale.

The quantity of fatty matter in the cortical portion of a fatty kidney is sometimes very great. In one case of enlarged fatty kidney, occurring in a girl 22 years of age, I found in 100 parts of cortical substance 20·35 of solid matter, of which 5·49 (more than one-fourth) consisted of solid fat. *See* "Diseases of the Kidney," by Dr. G. Johnson, p. 44.

The following is an example of a fatty kidney which was somewhat enlarged, but the colour was dark and the structure was tinged with bile. The patient from whom it was obtained was very corpulent and died suddenly. (Lab. B., v. I, p. 59.)

ANALYSIS 8.

Water	76·55
Solid matter	23·45
Fatty matter	6·03
Renal tissue / Albumen, salts, &c. }	17·42

I have found many excellent examples of fatty kidney in the bodies of young persons who have died at an early age of diabetes. Analysis 9 gives the composition of such a kidney from a girl who died of diabetes at the age of 27 (M. B., 495. L. B., vol. III, p. 76). The kidneys were of about the natural size and of the usual colour. Their consistence was softer than usual, and the tubes were quite filled with epithelium and appeared choked up with granular matter and oil particles. Many of the tubes were wider than in the healthy state. The cells were pale, containing much oil, and were very large. Much free granular matter and oil particles existed in every part of the sections, pl. X, fig. 55.

ANALYSIS 9.

Water	77·11
Solid matter	22·89
Fatty matter	4·617
Fixed salts	1·136
Chloride of sodium	No traces.

In the following analysis of a kidney taken from a girl who died of diabetes, age 19, the fatty matter was not in the cells of the kidney but between the tubes.

Each kidney weighed 6½ ounces. The cortical substance was pale. The pyramids were much congested. The cortical portion presented the whitish appearance often observed in fatty kidney. Upon microscopical examination the tubes were found to be large, and contained well-formed epithelial cells of a circular form, but the tubes did not contain fat, nor did they vary much in size. On the surfaces of the tubes and between them much free oil was found. Acetic acid rendered the sections more transparent, so that the condition was then readily made out. No cells containing fat could anywhere be detected, but in all parts of the kidney the epithelium could be distinctly seen.

ANALYSIS 10.

Water	75·53
Solid matter	24·47
Extractives	7·13
Albumen, cells, vessels, &c.	12·91
Fatty matter	3·51
Alkaline salts	·92
Earthy salts	A trace.

Analyses 11 and 12 give the proportion of fatty matter in two other specimens of ordinary fatty kidney.

ANALYSES	11	12
Water	77·20	76·8
Solid matter	22·8	23·2
Fatty matter	2·50	3·016
Animal matter	19·61	18·792
Fixed salts	·68	1·392

Of the Fatty Contracting Kidney.—One of the most serious forms of renal disease is that in which the formation of new texture, the deposition of fatty matter, and shrinking and wasting of the gland tissue are proceeding at the same time. The occurrence of these different changes renders this form of kidney disease most difficult to investigate, and has given rise to much misapprehension respecting it. Tubes of twice or thrice the normal width are often seen close to tubes considerably less than the natural diameter. Of the first, many are choked with fat, some loaded with epithelium, and others filled with glistening material. In some of the wasted tubes all traces of original structure have entirely disappeared. Not far off from these, perhaps, tubes may be seen in which little departure from the normal characters can be discerned.

I have known cases of this condition occurring in young healthy-looking men, who, although they would not be called intemperate, had, nevertheless, lived far too freely during several years. The attack may come on as one of slight acute dropsy. The urine containing a large quantity of albumen and being of fair specific gravity, about 1020 or higher. There is usually little œdema, and for some time the case appears likely to progress favourably. But the albumen does not diminish. In some instances, vomiting and head symptoms come on after two or three months, and the patient soon dies. The symptoms may not have been at all urgent, and up to within a week or two of the patient's death, there may have been nothing in his appearance to lead us to suspect the extremely fatal form of disease from which he was suffering.

Even a careful examination of the urine does not always enable us to discover the nature of the disease. In one of these cases I failed to detect any casts whatever, although the urine was frequently examined; in another only a few were found, with a very few fat cells interspersed.

In some rapidly fatal cases of this form of renal disease I have noticed that the heart's action was feeble, and at the post mortem examination the heart was found to be much smaller than natural. No doubt a small heart, a weak circulation, very liberal diet, and hard work would conduce to disease of the kind under consideration. Persons suffering from it may not be aware that anything is the matter even up to a very few weeks before death. They are often full coloured, well nourished, and are perhaps considered by themselves and their friends to be in thoroughly good health. The patient perhaps first consults the practitioner on account of obstinate vomiting, giddiness, and feeling of heaviness about the head, and dimness of sight. At this time there may be little to direct the attention to the kidney; but if the practitioner examines the urine, he may find a very large quantity of albumen present. I have seen cases in which nausea and headache were the only symptoms complained of, and have been surprised to find after examination evidence of advanced kidney disease. In such cases death sometimes occurs almost suddenly, and at a comparatively early period of the disease. Occasionally it is suspected that death has resulted from the administration of poison. It is very important to bear in mind that very small doses of opium may induce profound coma from which the patient never rallies. If the patient becomes thin, and the quantity of blood in his body very gradually and naturally reduced, his chances of living for some months or even a few years are very much increased. In this case the kidneys become small, and are perhaps extremely wasted by the time death occurs. *See* p. 52.

Persons suffering from fatty contracting kidney occasionally present themselves for life assurance, and unless the life is refused on the ground of doubtful habits, which is probably not unfrequently the decision, the case may be taken and the life drop within a month, the proposer himself not having been aware he was ill at the time he assured. Nothing but an examination of the urine in every case can protect life assurance offices from occasional serious losses of this kind. Well-nourished men who appeared to have been in robust health, have been suddenly seized with epileptic fits which have resisted all treatment, and proved fatal within twenty-four hours.

A very good example of this form of disease is recorded below, but in this instance the nature of the malady was apparent from the first. (T. C., vol. XI, p. 4. Notes taken by Mr. Oliver Penfold.) The patient was a boiler rivetter, and therefore accustomed to hard work, and exposed to great heat, cold, and wet. He was only twenty-five years of age, but had drunk ten or twelve ounces of spirit per diem for three or four years. He had, nevertheless, enjoyed good health. Five months before he came under my care he appears to have "caught cold." The legs soon began to swell. At this time the urine probably contained albumen. When he came into the hospital he was rather stout for his age, and although he was becoming a little pallid, he would have been mistaken at times for a man in sound health. The urine was of sp. gr. 1034, and contained more than half its volume of albumen. Numerous granular casts, some of which contained oil and free oil globules, and a few "waxy" casts of considerable diameter, were found in the deposit of the urine. The quantity of urine passed varied from 20 to 80 ounces in the twenty-four hours, and the specific gravity was usually about 1030. The secretion of so large a quantity of urine of good specific gravity could hardly have occurred unless a considerable amount of healthy secreting structure remained at this time. My friend Dr. Berrell found that an ounce of the urine contained nearly five grains of dry albumen. On some days the patient passed more than two hundred and fifty grains of this substance.

The patient was treated with hot air baths and moderate purgation, but relief was only temporary. Headache and vomiting came on after he had been in the hospital about two months, and troubled him from time to time till he died, three months after admission and eight after the first appearance of symptoms of renal disease. He continued conscious almost to the time he died.

P. M.—There was general but slight anasarca. The adipose tissue had not been absorbed, and a layer an inch in thickness was found beneath the skin of the abdomen.

The *lungs* were congested; the right weighed eighteen and the left fourteen and a-half ounces. At the bases were nodules of lung tissue very highly congested, but even these floated in water. There was no fluid in the pleura or pericardium, nor were any adhesions detected.

The *heart* was firmly contracted, but very small for a man of the patient's size and strength. In each ventricular cavity was a firm clot which extended into the large arteries.

The peritoneum contained about a pint of brownish fluid and a good deal of loose yellowish lymph. The *liver* weighed seventy-eight ounces; its surface was smooth and its texture firm. The *spleen* weighed fourteen ounces.

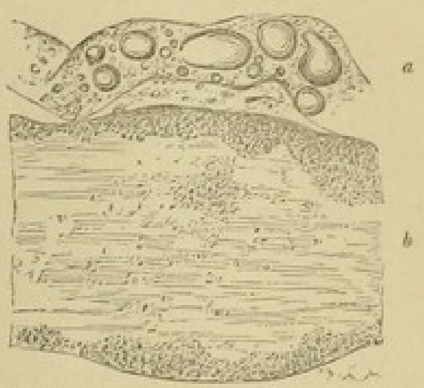
The *right kidney weighed nine and a-half, and the left ten, ounces.* The capsules peeled off easily. The surface of the kidney was mottled, and the vessels of the pyramids contained much dark blood. The cortical substance was plentiful, and here and there small white spots could be discerned lying embedded in a tissue which exhibited generally a reddish hue.

I propose now to consider the minute changes which occur in this common form of renal disease, for these seem to have been very little studied in their details. The kidneys, it will be observed, weighed nearly twenty ounces. The cortex was not wasted. The surface of the section was mottled, and the pyramids much congested. It is worthy of remark that at the time of the patient's death there was an inch of fat over the abdominal parieties. His muscles were still large and well developed, so that the man was in a good state of nutrition when he died. Two months before his death his appearance was that of a healthy man, but at that time advanced structural alterations must have existed in the kidney. A thin perpendicular section of the cortex is represented in pl. XI, figs. 57, 58, and in pl. XII, fig. 64. Even in the small area figured, the results of complex morbid changes may be discerned. Here and there large collections of oil globules form very distinct objects, and by reflected light appear as white spots. In some of these crystalline fatty matter has separated from the oily fat, as seen in the lower part of the specimen, fig. 64, to the left. Many of the oil globules are seen distinctly in the cavity of the tubes, but numerous collections are free, and probably occupy the position formerly filled by tubes and Malpighian bodies which have wasted, some having completely disappeared.

In all the drawings familiar to me the very narrow tubes seen in my specimens have been in great part or entirely omitted, and, as well as the intertubular capillaries, have been included in the term "indefinite granular matter," or "hypertrophied connective tissue or matrix." Some of the tubes are so large and prominent that they alone seem to have attracted attention and the very small ones have escaped notice. The identification of the remains of the secreting tubes is, however, important, for it leads us to adopt a conclusion concerning the changes through which the tube has passed in its degeneration, which is quite at variance with the views generally held. The changes seem to result simply from wasting or shrinking of the secreting structure, while there is no evidence whatever of the contraction of the matrix and the consequent constriction of the tubes at intervals, which has been generally accepted as the explanation of the change. The largest tubes are usually filled with wide transparent casts.

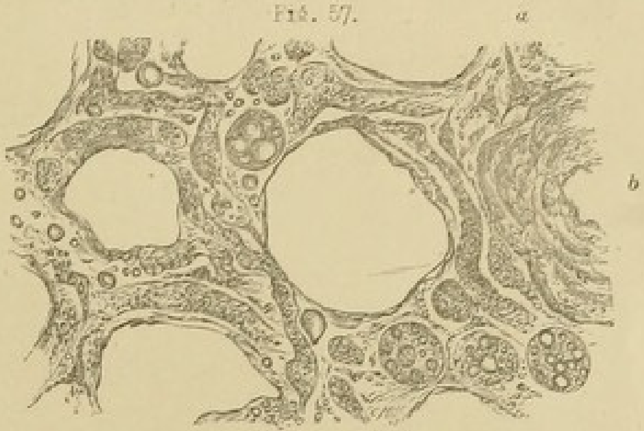
The epithelium is usually very narrow, the cells small and irregularly scattered. Sometimes all traces of epithelium disappear from some parts of the tubes, and in place of this is found a large quantity of actively growing germinal matter, which increases so as to form large collections from which buds or offsets proceed as in fig. 63. Thus new growth occurs. After a time, perhaps from the supply of nutrient matter being cut off, this germinal matter dies, and large oil globules result. These collect in patches. In some of the partially wasted tubes

Fig. 56



a, wasting tube, with oil globules in the interior. *b*, a tube containing transparent waxy cast, with germinal matter resulting from altered epithelium. Fatty and contracting kidney. × 215.

Fig. 57.

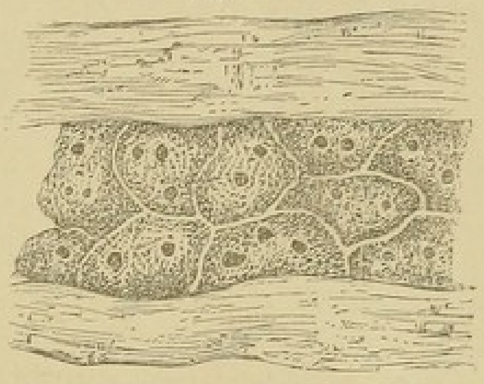


A thin section of the cortex of a fatty and contracting kidney, showing the remains of tubes and vessels in what is generally considered as the 'matrix.' *a*, the remains of a tube appearing as a connective tissue corpuscle. *b*, small artery with thickened walls × 215. pp. 53, 64.

Fig. 58.

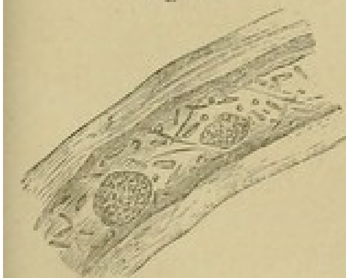
Section of cortex of fatty and contracting kidney. × 130. p. 64.

Fig. 59.



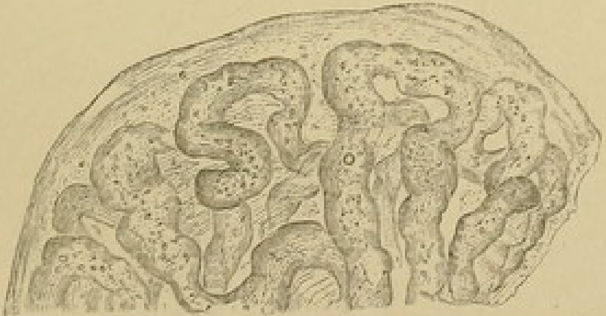
Epithelium of tube much altered. Walls of tube much thickened. × 700. Fatty and contracting kidney. p 65.

Fig. 61.



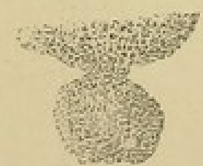
Capillaries, Malpighian body. Fatty and contracting kidney. Bacteria are seen in the interior of the vessel, the walls of which are very much thickened × 700.

Fig. 60.



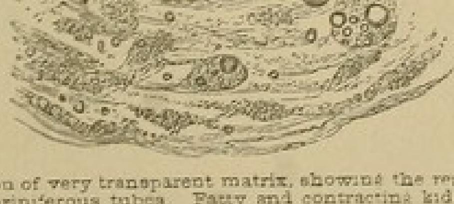
Loops of vessels of the Malpighian tuft, distended with granular matter, and containing oil globules. × 215. p. 65.

Fig. 63.



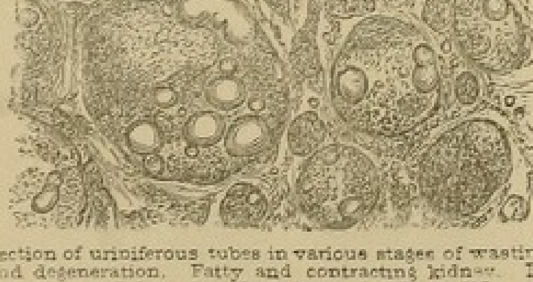
Portion of altered tube, with a bud growing from it. Fatty and contracting kidney. × 700. p 56.

Fig. 62.



Portion of very transparent matrix, showing the remains of uriniferous tubes. Fatty and contracting kidney × 700. p. 56.

Fig. 63*.



Section of uriniferous tubes in various stages of wasting and degeneration. Fatty and contracting kidney. In some of the tubes there is much oil. × 215.

the epithelium is completely altered in character. Each mass representing perhaps an original cell is composed entirely of germinal matter and the shape of these appears to be determined by mutual pressure, as they slowly grow closely packed within the narrow tube. In each mass several nuclei are often present. *See* fig. 59.

The *vessels* are very much altered in character. The walls of the intertubular capillaries as well as those of the Malpighian bodies are much thickened but perfectly transparent, pl. XI, fig. 60. Many of the capillaries contain a quantity of granular material, in which masses of germinal matter are embedded, but nowhere can an unaltered red blood corpuscle be found. Numerous bacteria, fig. 61, have been developed in the vascular contents. It is therefore certain that the circulation in these tubes ceased a considerable time before death occurred. It is difficult to fix the period, but it must have been long enough to permit of the complete disintegration of the red blood corpuscles. I found capillaries with the contents just referred to in every part of the kidney. The walls of the small arteries were much thickened, but as this change occurs in many different forms of kidney disease, it will be more convenient to consider it further on.

Matrix.—The appearances I have represented in fig. 57, show that much of the texture which has been often described as 'matrix hypertrophied,' really consists of altered tubes and vessels with thickened walls. Transparent coagulable lymph appears to have transuded through the vascular walls or to have been formed by some of the germinal matter present, and to have led to the thickening of the capillaries and walls of the tubes.

It seems to me that the morbid appearances above described result from different processes which have been going on simultaneously—the process of wasting and shrinking,—the addition of new material from the blood,—and the process of fat deposition and accumulation in the substance of the cortical part of the kidney. The changes exactly correspond with those which occur in the liver and oftentimes in the very same subjects. At first there is increased vascularity and considerable increase in size of the tubes which become distended with cells. In some places much fatty matter is formed in these. After a time the secreting structure wastes and shrinks in places,—or in one spot there is increase in bulk from the accumulation of fat, while immediately contiguous to this there is shrinking. It is probable that some of the fatty matter which has been deposited is afterwards absorbed. And it is possible, if the patient live long enough that the liver and kidney may lose the greater proportion of the fatty matter which has been deposited, and become much reduced in volume. After death we say that the liver is cirrhosed, and the kidney may be adduced as an example of the small, hard, contracted kidney, with wasted cortical structure, though differing in many particulars from the form described in p. 52. The form of renal disease under consideration, is doubtless the one which has led Frerichs and others to conclude that the large white kidney is but an early stage of the small contracted kidney, and the view is perhaps correct as regards some cases of this particular form of enlarged kidney, but it has no wider or more general application. This disease is quite distinct from the large, pale, fatty kidney of scrofulous persons referred to in p. 58. Like the corresponding condition of the liver the form of renal disease under consideration occurs in highly fed, well nourished persons, and often destroys life while the body is yet very fat. I believe, in many cases the affection of both glands is the direct consequence of over eating and drinking, especially beer and porter, and in not a few instances is brought on by that most unnatural modern fashion of passing twelve hours of the day almost without food, and then taking at one meal a quantity far too large for solution and absorption without all the organs concerned in those processes being strained.

In analysis 13, the composition of the kidney of a man who died suddenly from this form of kidney disease is given. Of one kidney nothing remained but a mere cyst, the size and shape of the original organ. This change had resulted from the ureter having been blocked up by an almond-shaped calculus, which was impacted close to its opening into the bladder. The other kidney was larger than natural. Its surface was smooth, and evenly mottled with white and pink spots. The white patches consisted entirely of tubes filled with fatty matter. There were a few cells containing oil, but for the most part the fat was deposited in very minute globules and granules. Upon section the cones were seen to be well defined and of a red colour, lying in a mass of pale mottled, cortical substance. Some of the tubes were transparent and contained delicate circular epithelial cells without the slightest trace of fat. The muscular substance of the heart of this patient appeared healthy and had not undergone fatty degeneration (L. B. VIII, p. 75, M. B. 491.)

ANALYSIS 13.

Water	80·84
Solid matter	19·16
Cholesterine and other fatty matter ...	4·79
Fixed salts...	1·03

The following is an analysis of a kidney which contained less than the usual proportion of solid matter :—

ANALYSIS 14.

Water	83·1
Solid matter	16·9
Fatty matter	2·366
Animal matter	13·738
Fixed salts	·796

In another case (E. M., vol. XII, p. 83), 100 grains of the cortex of the kidney contained 17 grains of solid matter.

Below is an analysis of a kidney which was one-third larger than natural, but which was probably undergoing the process of contraction. The cortical substance was of a light fawn colour and was thickly interspersed with little nodules of fatty matter. The external surface of the kidney was smooth; its substance was brittle, but not soft (Lab. B., vol. I, p. 136).

ANALYSIS 15.

Water	79·9
Solid matter	21·1
Fatty matter	2·954
Animal matter, including vessels and renal tissue	17·091
Fixed salts	1·055

Of the so-called Amyloid Waxy or Albuminous Degeneration.—The amyloid or wax-like kidney is pale in every part, more or less translucent, often larger than natural and from the cut surface serous fluid may be squeezed, but very little blood escapes from the vessels. The tissue of the kidney somewhat resembles that of the amyloid liver in appearance. Indeed the liver, kidney, and spleen may be affected in the same way. The kidney is seldom enlarged in the same degree as the liver which often weighs as much as eight or nine pounds even in children. Mere traces of fatty matter are present in organs thus affected. The disease is most common between the ages of twenty-five and forty-five. It usually comes on very insidiously, and may not prove fatal for several years. Amyloid kidney seems to be connected with that kind of constitution in which tubercular affections are prone to manifest themselves under circumstances different to those which favour the production of amyloid disease. Amyloid kidney and liver are sometimes associated with phthisis, and commonly with scrofulous and syphilitic caries.

The urine is usually pale, is often passed in considerable quantity, and is sometimes of high density. It often contains a small quantity of albumen, but the amount varies much at different periods of the disease. Occasionally so large a quantity is present that the case may be mistaken for one of enlarged fatty kidney. The deposit usually contains numerous casts. *See* "casts" in part IV of this work.

There is emaciation with pallor and often a brownish tinge of the skin. In these cases the blood is poor and not unusually contains excess of white corpuscles. The quantity of blood in the body is small, and the superficial vessels alter very little in calibre at different times. Patients who have long been the subjects of it cannot blush. The heart's action is usually very feeble. There is marked debility and gradual emaciation. Dropsy, slight in extent, usually comes on early. The debility, pallor of the skin, and pale colour of the urine, probably depend upon the small number of red blood corpuscles and the diminished activity of oxidation. Patients suffering from this form of disease seldom die from uræmia.

It is remarkable that in the liver the transparent material, upon which the increase in bulk and weight depends, forms a part of the cells themselves, while in the kidney it seems to be deposited chiefly in connection with the arterial and capillary walls. The secreting cells are usually much reduced in size, but the uriniferous tube is often enlarged, the greater part of its cavity being occupied with a transparent material, allied to but not identical in composition with the translucent amyloid substance, for as Dr. G. Stewart has stated, the material in question does not often exhibit the characteristic iodine reaction, although Dr. Dickinson, on the other hand, asserts that it does so. In short, the *liver cell* is enlarged by the presence of the amyloid matter itself, but the cells in the uriniferous tubes are for the most part wasted, and much smaller than natural. Fatty matter in minute globules is not unfrequently found in some of the cells, but its presence is not invariable. Fatty matter is also sometimes present in the intertubular tissue.

The quantity of albuminous material which may be squeezed out ot organs affected by this disease is very great, and from this circumstance the condition was termed by the older observers "albuminous" or "serous" liver and kidney. Dr. Budd has remarked that the scrofulous liver was most frequently found in young persons who had long suffered from scrofulous caries, and that there was some circumstance connected with caries "most probably the *protracted suppuration resulting from it*," that disposed to this peculiar form of disease. Dr. Dickinson not only adopts this view, but considers that all cases are to be attributed to the removal of certain substances from the system (albumen and alkalies) in discharge of pus or more rarely of albuminous matter in the urine, and he terms this affection "depurative" disease of the kidney.

The transparent glistening material to which the increased thickness of the coats of the arteries and capillaries of the so-called amyloid kidney is due, exhibits a peculiar reaction with iodine. An aqueous solution of this substance tinges it of a red brown colour, while healthy tissue is coloured yellow under the same circumstances. Virchow considered that the glistening matter was closely allied to starch, and therefore called it *amyloid matter*, but further investigation has proved that it is quite exceptional to obtain a blue or even greenish colour by the action of iodine and sulphuric acid. The material in question cannot be converted into sugar like the amyloid matter to be obtained from the healthy liver, and Kekulé has proved that it contains much nitrogen, and is more closely allied in composition to albumen and fibrine than to a starch or cellulose. Moreover, it has been shown by Friederich, that the amyloid reaction is obtained by testing old decolourised fibrin with iodine and sulphuric acid, and Dr. Dickinson has obtained, by dissolving fibrin in dilute hydrochloric acid, and subsequent evaporation, a gelatinous substance, which he terms "dealkalised fibrin," which exhibits the reactions of the so-called amyloid matter in the kidney (Albuminuria, p. 171). This observer, in fact, regards the so-called waxy or amyloid matter which, as has long been well known, exhibits an acid reaction, as fibrin deposited in an insoluble form, in consequence of being deprived of the alkali, by which it is ordinarily held in solution. By a purely chemical theory of this kind, however, neither the formation of such a morbid deposit as this, nor the production of a healthy tissue can be explained. Kühne and Roudneff state that amyloid is not soluble in dilute hydrochloric acid, while Dr. Dickinson says that it is dissolved by the acid. This, however, is by no means the only fact in connection with this subject upon which authorities differ. Dr. Wilks, in 1855, states that the whole series of cases adduced by him, containing ninety-six examples, "proves indisputably that the disease is one implying a long standing and deep-seated cachexia," while Dr. Dickinson, writing only one year afterwards, says, that it is necessary to abandon the view "that the disease is necessarily connected with any especial cachexia or specific diathesis."

Kühne and Roudneff (Virchow's Archiv, vol. XXXIII) obtained amyloid from the tissues as follows. The texture was first extracted with cold water and very dilute acids, and then digested in artificial gastric juice for some time at a temperature of 100°. Cholesterin and fats were afterwards removed by alcohol and ether. Like the tissues from which it has been extracted the reaction of this substance with iodine differs much. Sometimes only a brown colour results, in other cases a violet, and in some instances with iodine and sulphuric acid a brilliant blue is brought out. According to these observers the pure amyloid matter is not soluble in dilute acetic, hydrochloric, nitric, or sulphuric acids.

Amyloid matter is deposited in small proportion in many forms of hepatic and renal disease, but I conceive few pathologists would place these in the same category as undoubted instances of amyloid liver or kidney. To the difference of opinion as to what is entitled to be regarded as amyloid must be attributed some of the discrepancies in articles upon the disease. In many cases where there is only slight deposition of matter exhibiting an amyloid reaction, this is not the essential or most important characteristic change. Fatty degeneration or wasting of the secreting structure may kill the patient, and, although faint traces of amyloid matter may be detected in the organ, the condition is not amyloid kidney. Some of the cases advanced by Dr. Dickinson as examples of 'depurative disease' would not I think be regarded by many as instances of the affection known hitherto as waxy, amyloid, or lardaceous disease. Dr. Dickinson seems to rely implicitly upon the iodine test, and any kidney which exhibits in places the brown colour would be regarded by him as an example of 'depurative disease.'

If the 'depurative' theory is true there ought, one would think, to be some quantitative relation between the purulent discharge and the development of the amyloid, but in some cases of waxy liver where the organ weighed eight or ten pounds, no history of purulent discharge was obtained, and I cannot think that to attribute the disease in these cases to albuminuria in any way strengthens the depurative theory. On the other hand cases of long continued purulent discharge frequently occur without any amyloid degeneration being discovered. To me it seems more reasonable to consider the waxy disease, the purulent discharge, the disease of bone, or tubercle, where it exists, as the result of some cause or condition common to them all, than to look upon the first as the consequence of one or other of the latter morbid states. Much stronger evidence than has yet been advanced is I think required to justify the conclusion that any disease results from a withdrawal of so much potash and soda from the system, and that the amyloid deposit is of the nature of a 'residuum.' Is it probable that the loss of one-fifth of the alkalies in an amyloid as compared with a healthy liver expresses more than one of the less important points in which the two differ? These purely chemical theories of great pathological changes are generally very disappointing. Alkalies and foods rich in albumen may be given to compensate for the loss of alkali and albumen, but such treatment will exert little influence upon true amyloid disease of liver or kidney. Dr. Dickinson seems to think that the deposit affects the small arteries first. He says "a morbid deposit first appears in the walls of small arteries, then penetrates their coats, and subsequently infiltrates the neighbouring tissues" (Medico-Chir. Trans. for 1867). Dr. Grainger Stewart states that the change commences in the capillaries of the Malpighian body, and my observations entirely confirm his conclusions, for I have never seen a specimen in which the arteries were affected in which also thickened capillaries could not be found, and several circumstances lead me to think that the capillaries are invariably first affected.

After amyloid disease is established there must be insufficient oxidation in all parts of the organism, while at the same time there is increased growth of the germinal matter of the blood which is intimately concerned in the production of fibrinous material. The state of the liver, kidney, and spleen, is of great interest in connection with the fact of the reduced quantity of blood and the deficiency of the red blood corpuscles in the subjects of this disease. The white blood corpuscles, the corpuscles in the lymphatic glands, those in the solitary glands of the alimentary canal, and in the Malpighian corpuscles in the spleen

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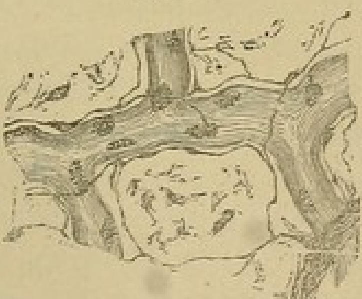
Fig. 64.

Section of cortex of a kidney undergoing contraction and fatty degeneration. At *a* the process of wasting is complete At *b* a portion of the matrix, showing varying size of the tubes. Under the low magnifying power of 40 the wasted tubes and vessels cannot be seen in the specimen. See Figs. 57 63, Plate XI. At *c* much fatty matter, with crystals, probably of chloresterine. p 64.

Fig. 65.

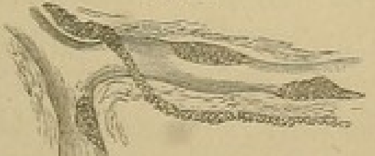
Section of an amyloid kidney, showing altered tubes with increased number of altered epithelial cells. A Malpighian body, with amyloid matter deposited in capillary walls, is seen in the centre, and portions of thickened arteries in different parts of the specimen. p. 71. × 130

Fig 66.



Capillary vessels, with nerves of capillaries. Skin of Frog. × 215.

Fig. 67.

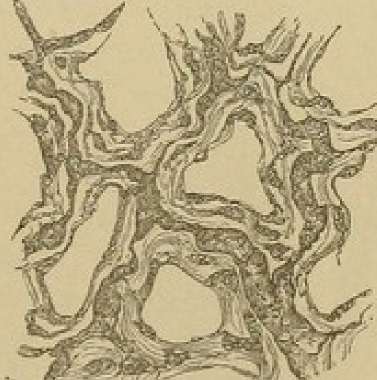


Small capillary, with nerve fibres, *a*. Healthy human kidney. × 700.

Fig. 69.

Altered Malpighian body. Fatty and contracted kidney Capillaries obstructed. Tube of artery, containing altered blood and angular particles of blood colouring matter. × 40.

Fig. 68.



Wasting capillaries from a fatty and contracting kidney. Circulation through these vessels must have ceased some time before the patient's death. × 215.

[To face page 70.

are considerably increased in number, and as would be supposed the fibrin-like material formed by these closely allied forms of germinal matter is much increased in proportion and is deposited in the capillaries, and external to them, as well as in the walls of the small arteries, to their great detriment. The contractility of their coats is destroyed and their channels reduced often to less than half the diameter in the healthy state. In the vessels of the brain and spinal cord, the mode of deposition of the new material may be very successfully studied. The masses of germinal matter external to the vessels here exist in great number in perivascular spaces which are supposed by some to communicate directly with the lymphatics. The corpuscles gradually produce a quantity of a form of connective tissue which adds very much to the thickness of the arterial wall, while the calibre of the vessel becomes almost obliterated. These changes may proceed to such an extent that at last the small artery may become a mere cord of transparent tissue without any central canal. Capillaries undergo a similar change. Pl. XII, fig. 65.

Of the Thickening of the Walls of the Small Arteries of the Kidney.— One of the most frequent alterations met with in many forms of chronic kidney disease, and constantly present in that particular affection considered in the last section, is a thickened state of the arterial walls, wrongly termed *hypertrophy*. In many cases this has proceeded to such an extent that the external diameter of very small arteries equals, or is greater than that of the uriniferous tubes. There is much difference of opinion concerning the manner in which the change in question is brought about. Attention was, I think, first drawn to the thickened state of the arteries in diseased kidneys by Dr. G. Johnson, in his work on kidney diseases. Very recently the same observer * has expressed the opinion that this so-called "hypertrophy" of the arterial walls is due to the "continued *over-action* of the small arteries in antagonism to the heart."

This theory is not, I think, very satisfactory, for, to say the least, it is more probable that in the morbid change in question the action of the arterial coats is diminished than that it is increased, while it is most difficult to understand how anything like *over-action* can possibly occur. It has, I think, been too hastily assumed that the thickening is really hypertrophy of the muscular coats of the arteries. If this thickening is to be regarded as *hypertrophy*, it is unquestionably associated with *great change and degeneration of the normal tissue*. The new tissue added is completely destitute of the properties characteristic of the healthy structure. It is true that we speak of *hypertrophy* of the muscular coat of the intestine and of the bladder, although the tissue may have lost all contractile power; but it is obvious that

* Med. Chir. Soc. December, 1867.

the word "hypertrophy" is inapplicable, and ought to be restricted to those cases in which there is not only increased bulk but an increased development of a tissue without impairment of function. In "hypertrophy" of the heart and of the muscles of the limbs, there is increased formation of healthy muscular tissue, and a corresponding increase of muscular power; but in the case of these thickened arteries, thickened bladder, intestine, &c., there is an increase of substance depending upon the formation of an abnormal tissue with impaired action or *loss of healthy function* altogether. In the case of the thickened arterial coats there is an increased bulk with altered structure, not simply increased bulk without change in structure (hypertrophy). Careful observation leads me to remark in the first place that the muscular fibre cells are much less distinct than in the normal state. The oval nuclei are to be readily distinguished, and are often increased in size and number, but the contractile tissue has degenerated into mere fibrous tissue, which possesses no contractile property whatever. Secondly. The connective tissue external to the muscular fibre cells is often enormously thickened, and all indications of the delicate nerve fibres which ramify in this situation in health are lost. Thirdly. The calibre of the small arteries is considerably reduced, partly perhaps from deposit taking place internal to and amongst the muscular fibre cells,—partly to the reduced quantity of blood traversing them, but mainly to the increased deposition of new material externally in what was the areolar coat of the vessel. *See* pl. XIII, figs. 70 to 74.

In the first instance, probably the arterial coats are unduly stretched, the muscular fibre cells lose their contractile property, and thickening soon follows. In many cases where the morbid changes have advanced, the calibre of the artery is irregular, as if matter had been deposited from the blood upon the lining membrane, figs. 73, 74. The considerable dilatation, which occurs in the first place, permits liquor sanguinis with numerous particles of germinal matter to pass through the vascular walls. These grow and multiply, and give rise to the formation of fibroid tissue, which gradually accumulates until the artery is converted into a small tube with almost rigid walls. In this state it is incapable of undergoing alterations in diameter, and can no longer regulate the supply of blood to the capillaries.

The gradual changes which at length lead to the extreme thickening of the arterial walls may be studied in many organs and tissues of the body besides the kidney; but in investigations of this kind great care must be taken that a small artery in a state of extreme contraction is not mistaken for one with morbidly thickened walls. The vessels of the brain and spinal cord, those of the Pia Mater or its extension, as the choroid plexuses, are the most favourable. Different arteries may be found exhibiting various degrees of change. The so-called *perivascular* *canals* are often seen completely occupied with bodies like white blood corpuscles. These spaces become gradually filled up with fibrous tissue, formed by the cells which occupy them, and thus the external coat of the vessel is enormously thickened. The so-called perivascular spaces considered by His and others to be connected with lymphatic vessels, are probably but the irregular meshes of the delicate areolar tissue of the artery, which in health contain serum with a few corpuscles only. The arrangement permits the vessels of the brain and cord to undergo those great alterations in volume which take place in the perfectly healthy state, under different circumstances, without any alteration in the relative position of the easily deranged cells and fibres of the surrounding nerve tissue occurring. In disease, however, minute masses of germinal matter make their way through the vascular walls into these spaces, grow and multiply there in considerable number, and then undergo change, becoming converted into the so-called compound granular fatty corpuscles, or giving rise to fibrous tissue. In either case the arterial tube undergoes the greatest alterations, and the nutrition of nerve tissue is interfered with.

I have observed precisely similar changes in the arteries of the intestinal canal in many cases of chronic disease of the liver; and in almost all the cases of cholera which I have examined, the small arteries distributed to the small intestines, even of children under three years of age, exhibited remarkable thickening, accompanied by wasting of the muscular fibre cells.

In the thickened arteries of amyloid disease, the new material is deposited amongst the muscular fibre cells as well as internal and external to them, pl. XII, fig. 65. In some specimens it appears as if the new glistening matter had been produced by the nuclei of the contractile cells in place of the contractile matter. In the case of the liver cell this amyloid matter is undoubtedly formed instead of the normal formed material of the liver cell.

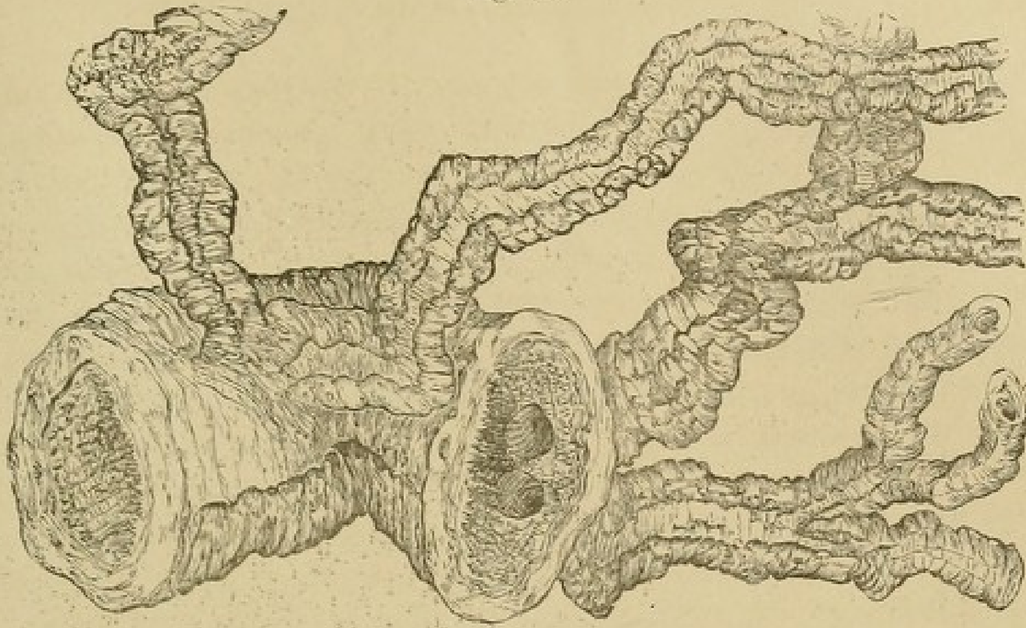
In some forms of thickened arteries the change seems to be due to thickening, perhaps from infiltration, of the areolar coat external to the muscular fibre cells, only. In frogs and newts, which have been some time in confinement, this change and the wasting of the vascular nerves may be accurately investigated, and it is not uncommon to meet with vessels the walls of which are six or seven times as thick as the channel is wide, fig. 72. As the action of the arteries has been already considered in p. 35, it is not necessary to refer to it here. The change under consideration is in all probability a consequence of altered conditions of the capillary circulation and altered composition of the blood. The capillaries are themselves much altered in structure, and sometimes their walls are much thickened, pl. XI, fig. 61. The nerve fibres of the capillaries, fig. 66, must be destroyed long before the disease has reached the stage represented in many of my drawings. The destruction of the peripheral portion of the afferent nerve fibres soon affects the efferent or vaso-motor fibres distributed to the arteries, and probably leads to their degeneration. Dilatation of the small arteries and infiltration and thickening of their coats follow. The altered structure of the small *arteries* may therefore be a consequence of the destruction of the afferent nerve fibres distributed to the *capillaries* and the secreting tubes.

Changes resulting from Obstruction of the Small Arteries.—Embolism.—Little fibrinous masses detached from deposits formed upon some part of the lining membrane of the heart or arteries may plug up a small branch of the renal artery, and the supply of blood to a certain portion of renal tissue being thus cut off, wasting results. Little clots are also sometimes formed in the interior of small arteries. I have met with them in small arteries in all parts of the body in cholera, and have found them in many cases of fever and other conditions. Sometimes from roughness consequent upon disease of the delicate lining membrane, fibrin coagulates, and thus the vessel is obstructed. Whenever such change occurs a circumscribed portion of renal tissue becomes pale, and soon assumes a yellowish hue. The tissue is usually firm, and I believe may remain in this state for a considerable time, not receiving blood enough to permit it to take part in secretion, but, nevertheless, not softening or undergoing absorption. Cases have been described by Kirkes, Traube, Virchow, and others. It is said these spots break down into débris, and that occasionally pus is formed. It is quite certain that in the cortex of the kidney patches of softened tissue are not unfrequently found, but the evidence which connects these with embolism appears to me to be far from conclusive. It might, however, be urged that it is only *before* these changes had occurred that the only positive evidence—the actual demonstration of the plug in the vessel, could be obtained.

Changes in other Tissues in Renal Diseases.—I have already adverted to certain modifications in the nutritive process, in the tissues of the body generally, consequent upon changes in the composition of the blood, induced by kidney disease. In very chronic cases there is probably scarcely an organ in the body which retains its healthy state, and of persons whose deaths are registered as resulting from *pneumonia*, *bronchitis*, *dropsy*, *convulsions*, various forms of disease of the *nervous system* and other conditions, not a few are really caused by renal disease, and the special disease is but a consequence of the primary changes in the kidney. Many structural morbid alterations consequent upon diseased kidney progress very slowly, and as nearly the whole tissue of the organ is affected, its action as a whole is impaired, although it is not completely destroyed in any one part. The great nerve centres in

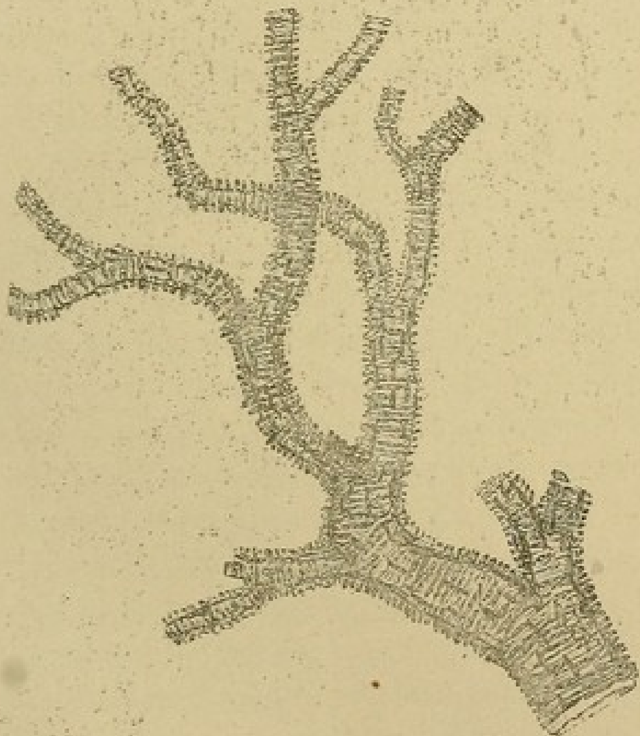
DISEASES OF THE KIDNEY.

Fig. 70.



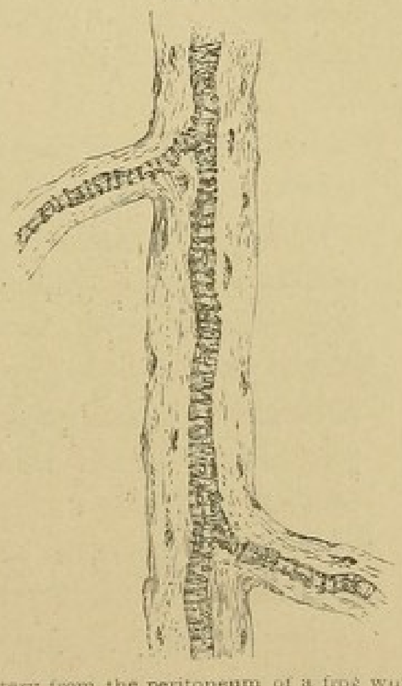
Arteries from a fatty and contracting kidney, showing complete degeneration of muscular fibre cells and the deposition of glistening albuminous material. The walls of the artery have probably long lost all contractile power, and are converted into rigid inelastic tubes, the inner surface of which is uneven, with great irregularity in calibre. × 215. p. 72.

Fig. 71.



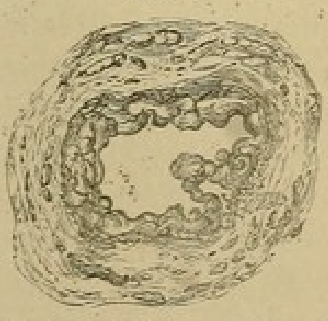
A healthy artery from the kidney of a child, 3 years old, showing muscular fibre cells and longitudinal nuclei of muscular and elastic fibres within. × 215.

Fig. 72.



Artery from the peritoneum of a frog which had been kept for some time without food, showing wasting of muscular fibre cells and great diminution in calibre. In its present wasted and contracted state the external areolar coat is many times the diameter of the vessel. × 215. p. 73.

Fig. 73.



A transverse section of a small artery from the same kidney as Fig. 70. × 215. p. 72.

Fig. 74.

Artery from the same kidney as Figs. 70 and 73, showing great irregularity of calibre and degenerated muscular coat. Oil globules and debris are seen in the interior. × 215. p. 72.

$\frac{1}{1000}$ of an inch |___| × 215.

[To face page 71.

particular suffer more or less in every part, so that all nerve phenomena are affected to some extent, although usually there is no one complete local lesion.

By minute and careful investigation important changes may be demonstrated in every case, but general superficial examination will not enable the observer even to distinguish the altered textures from perfectly healthy structure. Recent minute investigation renders it certain that most striking and long standing disease existed in many cases in which it has been confidently asserted that such and such organs had been found 'perfectly healthy.'

During the course of chronic renal disease there is usually abundant evidence of impaired nervous action, both of the cerebro-spinal and ganglionic system, but it is the exception to meet with symptoms indicative of serious special nervous lesion till towards the close of the case. In the nerve textures of those who die without any serious derangement of any one part of the nervous system, important changes are revealed by minute microscopic research, and by further investigation the immense importance of many structural alterations which are now almost entirely passed over will most certainly be demonstrated.

Changes in the Retina.—In the course of many forms of chronic disease of the kidney, impairment of the sight is not unfrequently met with, though in many cases it is so slight as scarcely to attract the patient's attention. In some, however, the affection continues to progress until there is almost total blindness. The gradual loss of sight depends upon important structural changes in the vascular and nerve tissues of the retina, which are of the utmost interest to the practitioner, because in many instances he may ascertain their exact nature, and watch their progress during life. The instrument by which we are now able to study these changes is the Ophthalmoscope. By its use the physician may gain positive information of the highest importance in diagnosing the nature of many general disorders of the nervous system, as well as purely local changes, in place of those vague guesses which he would otherwise have to substitute for facts, in arriving at an opinion on the nature of the case.

It has not yet been made out in which particular forms of chronic renal disease retinal affection is most common; but it is certainly very frequently met with in fatty kidney. The condition is usually considered to be a form of inflammation, and is known to ophthalmologists as *nephritic retinitis* or the *retinitis of albuminuria*. Liebreich has accurately described the changes taking place, and several cases of the disease will be found recorded in Mr. Power's new work on the Diseases of the Eye. At first the vessels of the retina are seen to be distended with blood. Ecchymoses soon follow, and the hæmorrhage takes place, according to Liebreich, in the inner retinal layer. As the blood is effused between the nerve-fibrillæ a striated appearance results which is characteristic. The nerve tissues, according to some, become more or less infiltrated with serum, which is a consequence of the congestion. At length the retinal tissues pass into a state of fatty degeneration. Usually the disease progresses very slowly, but in some instances sight is almost completely lost in a few weeks. By the ophthalmoscope a number of important changes may be demonstrated, and these vary according to the stage of the disease. The arteries seem small in consequence of thickening and alteration of their coats, but the veins are more tortuous than in the healthy eye and are much enlarged. The capillaries are congested, and nearly always patches of ecchymosis may be found. Serum is infiltrated into the substance of the retinal tissue, which may be seen to be swollen from œdema around the papilla. In more advanced cases, white, yellow, or greyish spots, which gradually increase in size and at length coalesce, are found in the neighbourhood of the optic disk, the outline of which becomes indistinct. Liebreich states that small white points appear at some distance from the nerve, and coalesce to form broad white patches. At length a milk white band of granular cells is formed around the optic nerve, and this extends outwards in the course of the vessels. Von Græfe has drawn attention to little star-like figures, not unfrequently observed around the yellow spot in this form of retinal disease. Corpora amylacea have been met with amongst the degenerated nerve cells and fibres. In one case examined by H. Müller, the choroidal vessels were much thickened by transparent homogeneous material, which refracted the light very strongly, perhaps of the nature of the matter now termed amyloid. Numerous spots of ecchymosis and collections of cell-like bodies, with numerous oil globules and granules and colloid bodies were also found. Ecchymosis and spots of fatty degeneration in the retina are met with in many other diseases, and have been observed by M. Galezowski in a peculiar form of inflammation of the retina, which is occasionally met with in cases of diabetes (Compte rendu du Congrès Ophth. de Paris, 1862, p. 110, quoted by Mr. Power "On Diseases of the Eye," 1867).

Cancer of the Kidney.—Cancer may affect one kidney in every part, and the organ may attain an enormous size and occupy almost the entire abdominal cavity. Such an altered kidney may weigh twelve pounds or more. This form of disease occurs more frequently among children than adults. In some cases every cell in the kidney appears to be cancer, and all traces of the healthy structure are lost. The disease is probably developmental in its nature, and originates at a very early period of intrauterine life. It would be difficult, I think, to distinguish the cells found in certain forms of renal cancer from those which compose the developing kidney of health before any structural peculiarities had appeared.

In some cases, however, distinct nodules of cancer are developed amongst healthy gland tissue, as is commonly seen in the liver, and separate tumours of considerable size may result. These usually consist of soft cancer allied to *encephaloid*, but hard tumours resembling scirrhus have been observed. I have seen a tumour weighing more than ten pounds growing from one end of the kidney, while the greater part of the renal texture remained perfectly healthy or suffered only from stretching and compression. It is comparatively seldom that cancer of the kidney is recognised by the presence of cancer cells in the urine for the disease does not often grow towards the pelvis of the kidney or the ureter.

Tubercle of the Kidney occurs in several forms. Sometimes, and this is commonly the case when the disease is secondary, minute rounded tubercles are deposited in every part of the substance of the organ, being usually most abundant in the cortex, and easily seen on section. In other cases the deposition of tubercular matter seems to affect the mucous membrane of the pelvis and ureter in the first instance. The tubercles usually increase in size and run together, forming larger masses, which after a time begin to soften, and lead to breaking down of the renal tissue. Inflammation and pus-formation go on in the neighbourhood, and soon ragged irregular cavities are scooped out from the renal tissue, upon the rough free surface of which numerous crystals of triple phosphate, and phosphate of lime are deposited. I have seen one kidney thus converted into a great cyst, in which several pints of dirty, offensive purulent matter accumulated. The ureter remained pervious, but only allowed the contents of the tumour to escape very much more slowly than they were formed, so that the mass increased rapidly in size. Life was prolonged by the tumour pointing in the lumbar region where an opening was at length made, through which much of the pus was discharged. Certain morbid changes in the kidneys of children, would be considered by some pathologists to be cancer, while others would consider them of a tubercular nature.

Of Cysts in the Kidney.—We have yet much to learn in connection with the formation of cysts in the kidney, and it is probable that in this organ, as elsewhere, cysts may be produced in many different ways,—as for example, by the bulging of tubes above the situation of an obstruction,—by the growing out of diverticula from the tubes,—by changes in the Malpighian bodies,—and by wasting of a circumscribed portion of renal structure, and the formation of a cavity. Some have maintained that cysts may be formed by the growth of a single cell.

The walls of cysts in the kidney differ much. They may be very thin and transparent, or composed of firm and thick fibrous tissue, and in some cases they are hard and bony. The lining membrane may be very slightly or very highly vascular, smooth upon the internal surface or covered with a soft spongy tissue like that of an ordinary mucous membrane. The cysts may be very numerous, and in close contact, or there may be more or less ordinary healthy renal tissue between them.

The production of cysts has by many been attributed to the constriction of the tubes at intervals, produced by the contraction of lymph effused in the matrix, or to hypertrophy and subsequent contraction of this tissue; but, as I have endeavoured to show in p. 54, it is very improbable that any form of kidney disease is due to any active change whatever in the intertubular tissue, while the fact of the production of cysts, during intrauterine life when scarcely any intertubular matrix exists, proves that at any rate cysts may be developed, and to an enormous extent, under circumstances which render such an explanation of their formation untenable.

A good example of *congenital* cystic disease is represented in pl. XIV. For the engraving of this specimen I am indebted to Dr. Jardine Murray, of Brighton, who gives the following extract from his notes of the case.

"J. J., aged twenty, has never previously had a child or miscarriage. Labour tedious; after the head and arms had been expelled, the greatly enlarged abdomen of the child remained firmly impacted within the maternal passages, and considerable extractive force had to be employed in order to remove the mass. Patient recovered without a bad symptom. Child still-born, full-grown, female. It is the subject of several malformations. There is what may properly be regarded as spina bifida of the occiput, arising from deficiency of the occipital bone. On each hand there is an additional finger, but without any additional metacarpal bone. There is fissure of the soft palate. A fleshy tumour is attached to the margin of the tongue. But the most remarkable feature of this case is the enormous size of the abdomen, caused by cystic disease of the kidneys. Both kidneys are affected in a manner precisely similar, and they are of equal size. The right kidney, being carefully dissected from its position, is found to have its vessels and ureter quite normal in size and appearance. The peritoneal covering and the fibrous coat are readily separated from the uniformly smooth external surface of the organ. This kidney weighed 13 oz. 6 dra. 2 scru. On making a clear section, the whole substance seems to consist of pearly cysts containing serous fluid. The cysts vary somewhat in size, the average being that of a pea. Other viscera healthy: bladder empty."

"Whatever the special pathology of these renal cysts may be—and to discuss the subject here would be out of place—there can be no question that they are consequent on intrauterine disease of the fœtus; and the tumour on the tongue has doubtless a like origin. The spina bifida of the occiput and the cleft palate are admitted defects of formation. The redundant fingers and the enormously increased growth of the kidneys are also interesting, as they show that defective development of one portion of the body in the fœtus is sometimes accompanied by excess of development or by increased growth of other parts."

Dr. Murray expresses the opinion that these cysts are the result of intrauterine disease of the fœtus. Curious sacculi in the lower lip are attributed by him to the same cause, and it is remarkable that in the same subjects, the results of arrested development, such as hare-lip, cleft palate, and spina bifida, were also observed. *See* Contributions to Teratology, by J. Jardine Murray, F.R.C.S.E. Brighton, British and Foreign Med. Chir. Review, No. LII, October, 1860, p. 502.

Johnson considers that cysts in the kidney arise from obstruction of the tubes. Virchow is of the same opinion, and considers that inflammation of the straight portion of the tubes may occur during intrauterine life, and end in obliteration of the cavity of the tube at this situation, and the formation of a cyst above. If the obstruction occur near the Malpighian body, the vessels may waste, and the capsule become dilated and converted into a cyst.

Cysts are common enough in adult kidneys. A few small ones are not unfrequently met with in organs which in other respects are perfectly healthy, but if the cysts are numerous or of large size, they may seriously injure the kidney by pressing upon or stretching the secreting structure and thus give rise to its wasting and destruction.

The cysts are perfectly closed and are seldom found to communicate with one another. The contents consist of serous fluid which varies much in composition in different cases and in different cysts in the same kidney. Sometimes a mere trace of albumen is present, but I have seen specimens in which the contents of the cysts were very viscid and almost gelatinous, becoming perfectly solid upon the application of heat. Granular cells are usually suspended in the fluid, and sometimes are so numerous as to give it a brown grumous character. I have found casts of the tubes in many of these cysts, proving that although no openings could be discerned, they must at one time have communicated with the interior of the tubes. Crystals of cholesterine are not unfrequently met with. Simon thought that cysts commonly originated from the enlargement of a single epithelial cell, but it is doubtful if this theory can be applied to cyst-formation generally. That cysts may result from obstruction of a uriniferous tube and dilatation has been proved in some instances in which crystals have been discovered impacted in the tube a little below the point at which the commencing dilatation was observed Quekett was of opinion that cysts generally resulted from changes in the Malpighian body, and it is very likely that in some instances this explanation is correct, but I do not think it is the most common mode of cyst-formation. In some instances single cysts may result from the wasting and softening of a portion of renal tissue, in which case the cysts may be regarded as *intertubular*. Cysts in the liver and some other organs unquestionably originate in this manner. It is probable that in many of the cases in which the cysts are found in the adult kidney, they have existed for a long time before death occurred, and were perhaps congenital. Ordinarily, cysts give rise to no symptoms, and there is no means of diagnosing their existence during life.

Rupture of the Kidney.—Among rare accidents is injury to the kidney causing laceration or rupture of its tissue. It need scarcely be remarked that if the injury is extensive the result will almost certainly be fatal, but there are cases on record in which there is every reason to think the texture had been lacerated, and the injury afterwards completely repaired. One of these will be referred to when the subject of *Hæmaturia* is discussed.

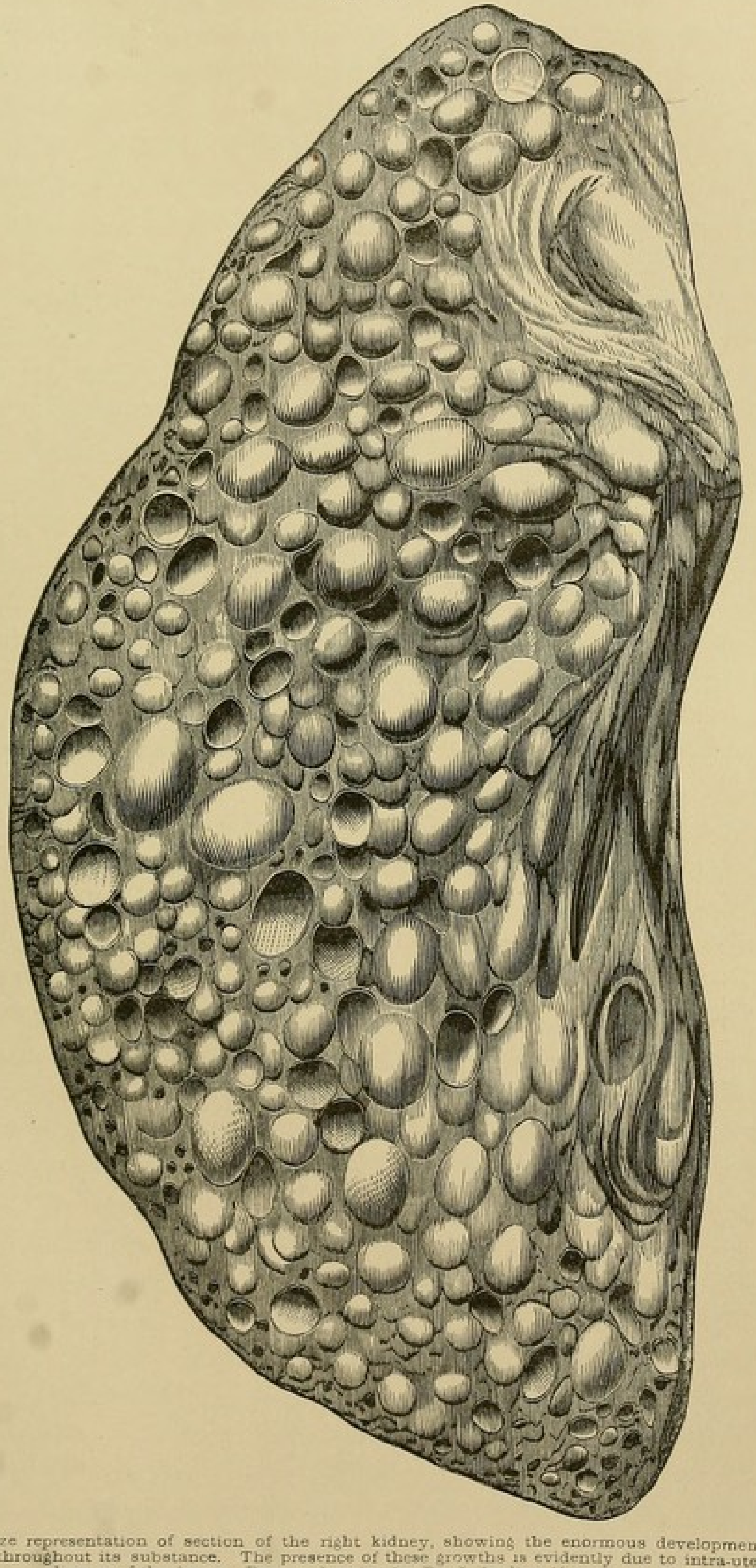
ON THE TREATMENT OF DISEASES OF THE KIDNEY.

To distinguish those cases of renal disease which it is possible to relieve or cure, or which may be restored to health by remedial measures, from those which are absolutely incurable,—and among the latter to distinguish those which will be rapidly fatal, from those which are likely to become very chronic and last for many years,—are very important objects which the practitioner has in view in undertaking the careful and minute study of renal physiology and pathology.

Those who are familiar with this class of diseases know that cases have been needlessly condemned which have made complete and rapid recoveries; while on the other hand persons suffering from certain serious and fatal forms of the disease in which there were no observable general symptoms, who have scarcely believed themselves to be out of health and have even been recently accepted by Insurance Offices as perfectly healthy lives, have nevertheless succumbed within a few weeks. The diagnosis between slight and serious maladies of many kinds, although still very uncertain, is, thanks to modern investigation, becoming more and more clear, and even in the case of renal diseases which in their course and progress are among the most uncertain with which the practitioner has to deal, something approaching precision, as regards prognosis as well as diagnosis is attainable in an increasing number of instances. So slight are the general symptoms in some of the most grave cases that it is not unfrequently difficult to persuade the patient there is anything really wrong, and his life becomes very much shortened from want of ordinary care on his own part, although the practitioner may be acquainted with the exact state of things and have ascertained the particular form of the disease with almost as much certainty as if it had been possible for him to see the diseased organs themselves. Observation and experience have shown that by judicious management, cases which some years ago would have been considered among the least hopeful,

DISEASES OF THE KIDNEY.

Fig. 75.



Full-size representation of section of the right kidney, showing the enormous development of cysts throughout its substance. The presence of these growths is evidently due to intra-uterine disease of the fœtus. From a drawing by Dr. J. Jardine Murray. p. 79

[To face page 80.

may be kept alive for a considerable time, or may be restored to comparative health, even for many years.

It is obvious that the changes taking place in the kidney can only be influenced by remedial measures in two ways. Through alterations effected in the composition of the blood, by air, food or medicine; or by reflex nervous action through the instrumentality of peripheral nerve fibres distributed upon the external cutaneous surface, or upon the mucous membrane of the intestine.

Acute disease.—The broad principle to be acted upon in the treatment of acute affections of the kidney is to relieve the renal organs as much as possible of their work for a certain time—in short to allow them to rest, while we endeavour to excite the skin, the bowels, and perhaps the lungs to perform for a time the work which it is the duty of the kidney ordinarily to discharge. And of course when in the case of acute disease there is reason to believe that the bowels are overloaded or that the quantity of excrementitious substances has accumulated in the blood in undue proportion, or that the proportion of blood in the system is greater than is advantageous to the economy, it will be still more necessary to act upon the principle above referred to. Blood letting, free purgation, the administration of sudorifics, and the application of heat to the cutaneous surface may be adopted. Cupping over the loins is also an excellent remedy.

Bleeding has been recommended in acute inflammation of the kidney, but it is only necessary in very exceptional cases. If blood is to be taken, cupping over the loins should as a general rule be resorted to, but in most cases dry cupping will be sufficient to relieve the congestion of the kidneys. In children, especially if there is lumbar pain, dry cupping, or the application of a mustard poultice sometimes gives much relief, but no blood should be taken.*

Free purgation should be excited by castor oil, colocynth, jalap (pulv. jalap co.), scammony, gamboge, elaterium, or other vegetable purgative, but mercurial preparations should be avoided in all forms of kidney disease, as mercury is very liable to excite salivation, and sometimes sloughing results from its exhibition, even in very small doses, in renal diseases.

Sweating is to be encouraged by the application of external warmth which is the best and most effectual method of exciting rapid diaphoresis. The patient may be well covered with blankets or eider down coverlets, and placed near the fire. The ordinary warm bath or the vapour bath may be used with the same object, but hot dry air is preferable.

Hot-air Baths.—The hot-air bath is a valuable remedy in many forms of renal disease accompanied with dropsy, and even patients who appear

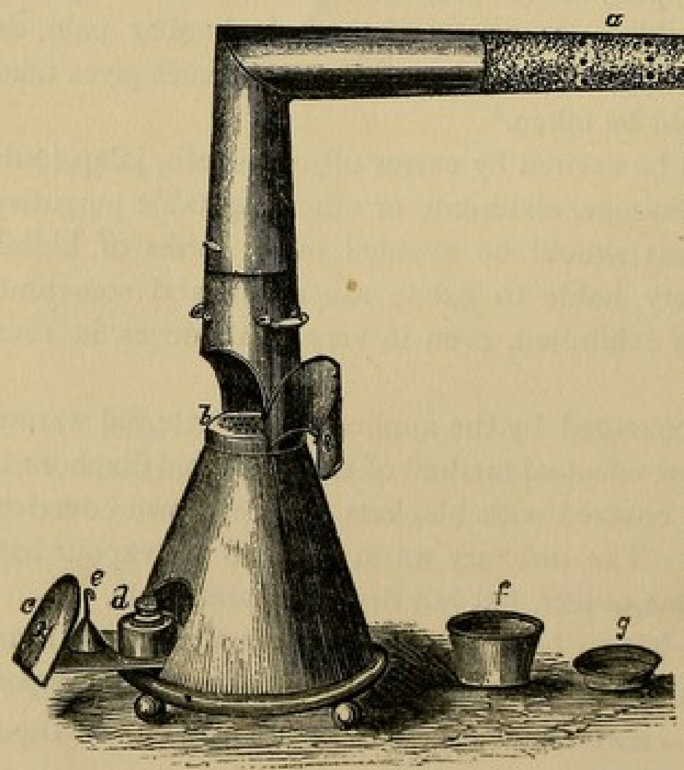
* Rigollot's mustard leaves are excellent and can be applied most easily. Depot, 23, Henrietta-street, Covent Garden.

to be very weak, often bear free sweating well. The patient should, however, always be carefully watched, and if faintness comes on, a little ammonia or brandy should be given, and the bath suspended.

There is often some difficulty in administering the hot-air bath satisfactorily. The simplest apparatus consists of a wicker frame, like a half cylinder, which is placed over the patient and then covered with blankets, the head being left out. The lower end is closed with a piece of wood having an opening into which a tin or iron pipe made without soldering, and about two inches in diameter, is made to fit. The lower end of this pipe is placed over a large spirit lamp or ring gas burner. The heated air passes up, and in this way profuse sweating may be induced very soon. An excellent form of hot-air bath has been lately introduced by Dr. Joseph Rogers, medical officer of the Strand Union, and described by him in the British Medical Journal for November 16, 1867. It is made by Messrs. Addis, ironmongers, of 6, Leicester-street, Leicester-square. My friend Surgeon-Major Wyatt, has also for some time been engaged in devising a convenient form of hot-air bath. The description of his arrangement is not yet published in a complete form.

The structure of the hood for the lamp will be understood by reference to the figure below. The apparatus may be used for simple hot air or vapour, or for air or vapour impregnated with various volatile substances. For the latter a diaphragm plate has been placed above the lamp. The following description is in Mr. Wyatt's own words.

"The upper end of the pipe is covered with thick felt and perforated, so as to allow of the lateral escape of the hot air or vapour, when it is



a. End of tube perforated and covered with felt.
b. Loose perforated diaphragm upon which either a small dish for fumigating materials or a vessel to contain water can be placed.
c. Sliding door to which is attached the spirit lamp and extinguisher.
d. Spirit lamp.
e. Extinguisher.
f. Vessel to contain water which may be placed upon the diaphragm, *b*.
g. Dish to hold calomel or other substance for fumigation.

required for the use of the extremities only. The spirit lamp is so contrived, that the flame can be extinguished without any effort of the attendant to blow it out, and the perforated diaphragm above the lamp is moveable, so that drugs can be placed upon it (through which the hot air easily permeates), or a small dish for sublimating powders, or generation of moist vapour in a vessel which is adapted to hold half a pint of water, this commences to boil in ten minutes after the lamp is lighted, and becomes dissipated in forty minutes. With regard to the employment of mercurial fumigations I believe that the most successful method, is first to produce a gentle diaphoresis over the entire cutaneous surface by the hot air alone, and then to place the material for sublimation in the dish on the diaphragm: the vapour soon begins to ascend, and is deposited on the body previously rendered in the most favourable condition for absorption. And when for special reasons inunction by mercury is deemed necessary, the absorption of the mineral is much assisted by the employment twice in the week of the simple hot air.

The cradle is made of wood and iron in sections, being contrived for packing and portability, and of little weight. I may remark in conclusion, that independently of any consideration of a medical character, all the requirements and comforts of a Turkish bath can be well procured by this simple domestic contrivance, with the use subsequently of the hot and tepid water arranged by the bedside in a common slipper bath."

This apparatus was made under Mr. Wyatt's supervision by Mr. Nettleton, ironmonger, Sloane-square, Chelsea, who will supply the whole complete in box, weighing in all 14 lbs., for the sum of three pounds.

Sweating may also be promoted by the solution of acetate or citrate of ammonia, or the granulated effervescing citrate of magnesia may be given, and is a most pleasant remedy. Small quantities of ipecacuanha may be prescribed with the same object, but no preparation of opium must be employed in acute cases, for a very small dose of this drug may do serious mischief, especially if there is any tendency to coma.

Diet.—A patient suffering from acute inflammation of the kidney should be restricted to slop diet. Beef tea and milk may be given but not in too large quantities at first as it is not desirable to encourage a very free secretion of urine immediately. A day or two after the commencement of the attack, diluents act very favourably. The patient may then take plenty of weak beef tea or broth or even plain water. A drink composed of two drachms of bitartrate of potash to the pint of water, flavoured with lemon and a little sugar, will be grateful to the patient, and will increase the quantity of urine without irritating the kidneys.

Chronic Disease.—In the treatment of chronic diseases of the kidney it is very necessary to act upon principles arrived at from a careful study of the physiology of the gland and a knowledge of the morbid changes which occur in it, and which re-act upon almost all the phenomena going on in the body. It is obvious that the morbid action of the kidney can only be influenced through the blood, and as there is no hope of producing immediate improvement it is desirable that in adopting a plan of treatment the right one should be selected in the first instance, more especially as it has been proved that judicious interference during the early stages of many chronic renal diseases is productive of the greatest benefit to the patient, and, by careful management, the progress of some structural changes, which cannot be altogether prevented or cured may be retarded, and the patient's life considerably prolonged. Nay, I feel almost sure that, in certain instances, with judicious management a patient may live for twenty or five and twenty years, although afflicted with incurable renal disease. It is of the utmost importance that the practitioner should make the patient distinctly understand the conditions which favour or tend to retard the progress of his malady. He who is the subject of a chronic renal affection is in constant jeopardy, and even a violent cold may cut short his life in a comparatively short period of time. If such a person gets an attack of pneumonia, or bronchitis, or pleurisy, it will probably be fatal. He would probably succumb to an attack of fever; and an injury from which a healthy person would recover without an untoward symptom might prove fatal to him. It need scarcely be said that such a life is not insurable on any terms; but, nevertheless, some patients attain a good old age in spite of disease of the kidney.

I have seen several cases of young persons who habitually passed traces of albumen in the urine. Slight albuminuria has continued for several years and has then passed off, while at the same time the general health and nutrition much improved. Some of these cases certainly recover entirely, and I know of one instance in which the patient reached the age of fifty without any recurrence of the malady. Kidney diseases have not yet been carefully studied for a sufficient length of time to enable us to form an opinion as to the probability of the occurrence of such a favourable result in each particular case, but there are instances in which this may be done.

Warm Clothing.—The observations already made will have led the reader to conclude that in my opinion not much benefit is likely to result in these cases from mere physic giving; while the greatest improvement is frequently observed after the patient has been placed for a few weeks or months under judicious management. Good air, and plenty of it, is most important. During the winter, patients who are compelled to remain in England should reside on the south coast. It is important that the clothing should be warm, and in all cases woollen or wash leather should be worn next the skin. Shetland wool garments, socks, &c., of every kind, for summer and winter wear, may be obtained at Standen and Co.'s Shetland warehouse, Jermyn-street, St. James's. Some consider a suit of wash leather more efficient than flannel for persons who suffer much from cold and sudden changes of temperature, but it is not so pleasant to wear and is far more expensive.

Sea Air.—In chronic renal disease the greatest benefit often results from sea air, and I believe life is often prolonged by wintering in Pisa, Rome, Naples, Cannes, Madeira, Egypt, Torquay, the south of the Isle of Wight, or St. Leonards, or Bournemouth. Patients suffering from this class of diseases require plenty of air, and during the winter it is very important that they should live in a climate where they can be out of doors for several hours on most days and get as much sun as possible. A sea voyage is often of the greatest advantage, and, although the disease may not be entirely cured, the general health is much improved and the morbid changes may cease to progress. The journey to Australia or New Zealand and back seems to have conferred lasting benefit in many cases.

The diet should be generous and good, but simple. There is I think little doubt, that many persons comfortably off, healthy as well as sick, take far more food, especially in the shape of meat, than is required for the perfect performance of the work of their organism or than is conducive to a thoroughly healthy and vigorous state of body. Indeed it is probable that excessive eating is as frequently the cause of hepatic and renal disease, as excessive drinking. A large proportion of excess of meat taken passes off from the body in the form of urea and other urinary constituents, which it is the special work of the kidney to remove from the blood. It is obviously of the utmost importance to relieve the kidneys of at least this unnecessary and useless work in cases in which they are diseased, when their working power is seriously impaired. The diet should therefore be carefully regulated, so that while the organism is well supplied with the full amount of nutrient materials which it requires, a useless excess which would still further damage the diseased organs is carefully avoided. I have often noticed that patients suffering from chronic renal affections bear cod liver oil, and a diet containing a larger amount of fatty and starchy matters in proportion to the meat, than is usually taken by persons in health. Fat bacon may be recommended, and glycerine or the pancreatic emulsion where cod liver oil cannot be taken. Provided the lungs and the liver be sound, it is easy to understand how the patient might progress favourably upon such a diet, in spite of serious damage to the kidneys.

In this class of diseases the blood is often poor, and the digestion weak, and the condition of the patient is often wonderfully benefited by remedies which improve the state of the blood, and act upon digestion.

Indeed, in most cases of chronic disease of the liver or kidney, we must endeavour to improve the action of the stomach, rather than to influence the organs implicated, for as I have already remarked, we have no means of acting upon them, except indirectly through the blood. The character of the blood and the state of nutrition generally must be altered before we can hope to benefit the local malady. Experience proves that by careful attention to the digestive process in these cases of chronic renal disease the greatest advantage will result. Bitter tonics, small doses of hydrochloric acid before meals, and pepsin often do much good.

Pepsin.—Many practitioners doubt the efficacy of pepsin in any case, and some consider it perfectly useless. I believe that such conclusions have been arrived at from bad pepsin having been used. Some years ago (1856), I made some experiments in connection with the action of artificial digestive fluids, and found that, by the following simple method, a very powerful digestive powder, almost tasteless and inodorous, could be readily obtained from the pig's stomach. The pepsin prepared in this way is more active than any of the preparations now in use. I have used it very frequently during the last six years, and it is well known to many other practitioners. The method of making this form of pepsin is as follows.

Preparation of Pepsin.—The mucous membrane of a *perfectly fresh* pig's stomach is carefully dissected from the muscular coat, and placed on a flat board. It is then cleansed with a sponge and a little water, and much of the mucus, remains of food, &c., carefully removed. With the back of a knife, or with an ivory paper-knife, the surface is scraped very hard, in order to press the glands and squeeze out their contents. The viscid mucus thus obtained contains the pure gastric juice, with much epithelium from the glands and surface of the mucous membrane. It is spread out upon a piece of glass, so as to form a very thin layer, which is dried at a temperature of 100° over hot water, or in vacuo over sulphuric acid. When dry it is scraped from the glass, powdered, and kept in a stoppered bottle. A good digestive fluid may be made as follows :—

Of the powder	5 grains.
Strong hydrochloric acid	18 drops.
Water	6 ounces.

The fluid may be filtered easily, and forms a perfectly clear solution, very convenient for experiments on artificial digestion, or as a medicine.

The pepsin may be taken in doses of from three to five grains, made into a pill with a little glycerine, and taken about twenty minutes before a meal, with ten drops of dilute hydrochloric acid in a wine-glassful of water, or infusion of quassia; or the powder may be mixed with the salt taken with the meals, or sprinkled upon the meat or on bread and butter as it is tasteless and inodorous. Eight tenths of a grain dissolve 100 grains of white of egg.

Pepsin is made from the pig's stomach by Messrs. Bullock and Reynolds, of 3, Hanover Street, Hanover Square.

Stimulants.—With reference to stimulants, some have advised that these should be altogether withheld, on the ground that stimulants, especially spirits, provoke chronic renal diseases. But it need scarcely be said that this argument cannot be employed against the use of stimulants altogether. There are some persons who actually require a little stimulant for the due performance of the digestive process, and, as is well known, there are many forms of dyspepsia which may be completely cured by the administration of a stimulant, or by changing the kind of stimulant which the patient has been in the habit of taking. Light wines of the Claret and Burgundy class often do good, but I have frequently given, with the greatest advantage, from two to five or six ounces of brandy or whisky in certain forms of chronic renal disease. Although many forms of renal disease are due to drink it must not be supposed that stimulants are in all cases inadmissible. Life may be much prolonged in some cases by the judicious administration of stimulants. Some time since I had a man under my care suffering from fatty and contracting kidney with excessive dropsy, who appeared almost to be kept alive by brandy. For six months this man's urine contained half its bulk of albumen. He was frequently delirious, but was so exhausted that we thought it right to give stimulants. Immediate benefit followed, and the stimulants were continued. He lived to our great surprise more than four months, and I feel confident that his life was prolonged for several months by brandy. Sometimes we gave as much as eight ounces of brandy in four and twenty hours, but usually from four to six ounces.

Counter-Irritation.—There is, I think, little doubt that the action of the kidney is affected by counter irritants, and, as is well known, the afferent nerve fibres distributed to the skin influence the state of the vessels distributed to an organ beneath by reflex action. Blisters, mustard, turpentine, dry cupping over the region of the kidney, probably act in this manner.

Bleeding is seldom desirable in chronic renal disease. The quantity of blood in the body gradually becomes much reduced and in many chronic diseases of the kidney is below that required by the organism. If there is hæmorrhage from the kidney we should endeavour to check it by the administration of tincture of perchloride of iron, gallic acid in ten or twenty grain doses two or three times a day, by tannin, or by turpentine.

A well nourished burly man is more likely to die quickly from renal disease than a thin person. If the patient be very stout, appearing to be in rude health, florid, full blooded when the attack first appears, and especially when dropsy comes on early and is considerable, with nausea, some dyspnœa, quick pulse and irritable weak heart, but without any evidence of the attack being acute, the prognosis is bad, and the case is likely to terminate fatally in a short time. Such cases often end in epileptic renal coma, or uræmia. If, however, the dropsy is only slight, and the patient begins to emaciate and grow pale in consequence of the quantity of blood being reduced, he may get into a state in which the disease progresses very slowly, and he may, with care, be kept alive for many years. The reader would perhaps conclude that if a full blooded patient were bled it would be to his advantage, but such patients do not bear large bleedings, as is proved by the circumstance that rapid prostration and death soon follow a violent attack of hæmorrhage from the bowels or lungs when it occurs in such a case. Sometimes, however, moderate hæmorrhage from the nose seems to do good, or at any rate improvement which was observed has been attributed to this circumstance. So that I am by no means certain that advantage would not result from oft repeated moderate bleedings in well selected cases, although I am unable to speak from actual experience. Such a plan of treatment, if carried out, should be tried cautiously, and the patient most carefully watched.

Medicine.—The appropriate remedies will, in many cases, at once suggest themselves to the mind of the practitioner. Iron, various bitter tinctures and infusions, the mineral acids, and many remedies included in the class of tonics may be employed. I will not venture strongly to recommend one particular remedy of the class in preference to others, but in my own practice I am in the habit of prescribing principally the tincture of perchloride of iron and infusion of quassia. I find the remedy very useful. Mercury, even if given in very small doses, in chronic renal disease often causes profuse salivation, and sometimes extensive sloughing dangerous to life results.

Digitalis is a remedy which acts favourably as a diuretic in some cases of renal disease, and has been very largely prescribed by some physicians. The infusion or the powder may be given. The former is by far the most efficacious, and in some cases increases the quantity of water secreted without irritating the kidney. Many diuretics do not act disadvantageously in some forms of renal disease, and I think life is sometimes prolonged by their use. As a general rule, irritating substances, such as cantharides, should be avoided, but citrates, acetates, tartrates, and nitrates of potash may be given.

Pericarditis in Renal Disease.—Pericarditis is a very common complication of chronic renal disease. It is probably due to the altered state of the blood and its increased tendency to form fibrinous deposits. The affection does not usually occur until the patient has become very weak. This form of pericarditis may be treated by the application of external warmth, fomentation or a linseed meal poultice, or moderate counter irritation; but leeches are scarcely ever necessary, and bleeding or lowering remedies would only hasten death. The affection is seldom accompanied by much effusion of serum, and in most cases the pericarditis may be allowed to run its course. It usually progresses very slowly, and it is better not to adopt any very active measures.

Uræmia.—In blood poisoning, occurring in the course of renal disease or when there appears any tendency to this condition, we must never give sedatives. A very little opium may destroy life in chronic renal affections. The treatment that must be adopted is free purgation and the administration of sudorifics, and where there is reason to think the kidneys will respond, diuretics, such as certain tartrates, citrates, acetates, carbonates, or nitrates; but irritating diuretics, such as cantharides, juniper, and the infusion of broom should not be given. Renal coma may often be kept off for a long time by the frequent use of the hot-air bath, p. 82. Many patients bear very free sweating every day and experience the greatest relief. Headache and nausea often precede more serious symptoms of blood poisoning, and should always be looked for. Sudorifics and purgatives should be given freely and continued until the symptoms have passed off. In cases in which the strength is not much reduced elaterium may be given in doses of the fourth of a grain, repeated if necessary. This drug sometimes acts very satisfactorily, but it should be used with great care. Patients exhibiting any tendency to uræmia require most careful watching, and ought to be seen at least twice during each twenty-four hours. When vomiting occurs, it may sometimes be relieved by small doses of creosote, hydrocyanic acid, and carbonate of soda, or small quantities of ice.

Anasarca.—In cases in which the anasarca becomes considerable, and the skin is stretched and brawny, the tension must be relieved; but a moderate degree of anasarca often passes off without requiring any special treatment. Acupuncture may be performed by any sharp-pointed instrument, but experience has fully proved that the punctures made by a common sewing needle seldom become inflamed and are rarely followed by erysipelas; and although such slight orifices often heal up very quickly, fresh ones may be made as often as may be necessary. In many cases the areolar tissue of the scrotum and penis becomes enormously distended with fluid. Punctures with an ordinary needle give great relief and seldom occasion trouble. But at a later period of the case I have so often seen erysipelas or very troublesome sloughing sores follow *incisions* in the skin that I never now resort to them in renal dropsy. In certain cases of cardiac dropsy, however, incisions about an inch in length near the inner ancle sometimes answer most satisfactorily, and give very great relief within a few hours.

Further observations on treatment will be found under "Treatment of Albuminuria."

PART II.

OF HEALTHY URINE AND ITS EXAMINATION.

CHEMICAL AND MICROSCOPICAL APPARATUS—OF VOLUMETRIC ANALYSIS—THE GENERAL CHARACTERS, QUANTITY, AND COMPOSITION OF HEALTHY URINE—CONSTITUENTS OF HEALTHY URINE.

For the clinical investigation of urine the practitioner requires certain reagents and apparatus for performing chemical analysis, as well as instruments and apparatus for the microscopical examination of the salts obtained from the urine and urinary deposits. It is desirable he should familiarise himself with the use of these as soon as possible, and in order to do so he should in the first place study the characters of healthy urine. Systematic tables which will be very useful for self teaching will be found at the end of the present volume. The process of volumetric analysis is given on page 99.

Note-Book.—The result of every observation should be carefully entered in a *note-book* at the time it is made; and it is often of the greatest importance to make a sketch of the microscopical characters of a deposit, and to append a careful but short description of the specimen at the time the drawing is made, as well as notes of the case from which the urine was obtained. (On drawing and measuring objects, see "The Microscope in its Application to Practical Medicine," or "How to Work with the Microscope;" refer also to p. 97, and to pl. III, fig. 26, of the present Work.)

Now suppose a specimen of urine brought for examination; how is the investigation to be commenced? What are the first points which should attract notice? In what order should they be observed? And how is the nature of the constituents which are dissolved in the fluid, or which form a visible deposit, to be ascertained? *See* p. 115.

The perfectly fresh urine should be poured into a conical glass vessel, pls. of Apparatus, I, II, figs. 1, 15. If any deposit is formed, it must be subjected to examination in the microscope, and certain chemical reagents must be applied. The characters of some urinary deposits vary much according to the time they have been allowed to stand in the urine, and some do not make their appearance till six or more hours after the urine has been passed.

I shall now refer briefly to those instruments and pieces of apparatus I have found most necessary, inexpensive, and useful. These can be readily obtained of most instrument makers.

TESTS AND CHEMICAL APPARATUS.

Tests.—The principal reagents required for qualitative and quantitative analysis of the urine are enumerated below. They should be kept in stoppered bottles, of from two to four ounces' capacity. The strength of the solution required varies somewhat in different test solutions; but from ten to fifty grains of the salts may be dissolved in each ounce of distilled water. Distilled water should be kept in a quart bottle; and it will be convenient to keep one of the wash-bottles represented in fig. 10, pl. II, also filled with distilled water.

		Strength.
Alcohol	HO,C^4H^5O	**Sp. gr. 0·83**
Sulphuric Acid	HO,SO^3	**Sp. gr. 1·84**
Hydrochloric Acid	HCl	**Sp. gr. 1·20**
Nitric Acid	HO,NO^5	**Sp. gr. 1·20**
Oxalic Acid	$C^2O^3,HO+2Aq.$	**50 grs. to 1 oz.**
Acetic Acid	$HO,C^4H^3O^3$	**Pharmacopœia.**
Ammonia	NH^3	**Sp. gr. 0·88**
Oxalate of Ammonia	$NH^4O,C^2O^3+Aq.$	**80 grs. to 1 oz.**
Potash	KO,HO	**Sp. gr. 1·060**
Ferrocyanide of Potassium	$K^2,FeCy^3+3Aq.$	**25 grs. to 1 oz.**
Chloride of Ammonium	NH^4Cl	**50 grs. to 1 oz.**
Lime Water	CaO,HO	**Sat. sol.**
Carbonate of Soda	$NaO,CO,^2+10Aq$	**160 grs. to 1 oz.**
Phosphate of Soda	$2NaO,HO,PO_5+24Aq.$	**50 grs. to 1 oz.**
Chloride of Calcium	$CaCl.$	**50 grs. to 1 oz.**
Chloride of Barium	$BaCl$	**50 grs. to 1 oz.**
Perchloride of Iron	Fe^2Cl^3	**100 grs. to 1 oz.**
Sulphate of Copper	CuO,SO^3+5Aq	**50 grs. to 1 oz.**
Nitrate of Silver	AgO,NO^5	**25 grs. to 1 oz.**
Bichloride of Mercury	$HgCl^2$	**25 grs. to 1 oz.**
Bichloride of Platinum	$PtCl^2$	**Sold in solution.**

Fehling's Solution.—For mode of preparation, *see* the section on the Examination of Diabetic Urine.

Balance and Weights.—A very efficient balance, which weighs to the 1-50th of a grain, and bears 1,000 grains in each scale, and is adapted for the quantitative examination of urine and other animal fluids and solids, may be obtained of Mr. Becker, of the firm of Elliott Brothers, Strand, for the sum of £3. It is desirable to be provided with *gramme*, and also with *grain* weights. These are furnished with the scales.

Test-tubes, of various sizes, will be required. The observer should also be furnished with a rack and drainer.

Test-tube Holder.—A very simple form is represented in pl. I, fig. 2.

Small Retort Stand, as seen in pl. I, fig. 8; or attached to the spirit-lamp, as in fig. 11.

Tripods and Wire Triangles, for supporting platinum capsules or foil, while the organic matter is being burned off.

Spirit-lamp.—The ordinary glass spirit lamp is the most convenient form.

Small Platinum Capsule and Platinum Foil.—A capsule about two inches in diameter will be large enough. This can be purchased for 12*s.* or 14*s.* It should be exposed to the clear smokeless flame of a spirit lamp, or to that obtained by burning coal gas mixed with air, as it issues through fine wire gauze, or from a small conical tube placed over the gas burner. Care must be taken that no lead or pewter comes into contact with the platinum when heated, or it will be instantly destroyed.

Water-bath.—A very simple form of water-bath is represented in pl. I, fig. 9; or a small saucepan may be used. But when the observer desires to make many careful analyses of urine, he should be provided with a large water-bath, so that four or five basins may be placed over it at one time. Several rings, of various sizes, cut out of thin sheet copper, will be required to support basins of different sizes over the water-bath. A little hot-water drying-oven is necessary for careful quantitative determinations. The injecting-can ("The Microscope in Medicine," or "How to Work with the Microscope,") also forms a most convenient water-bath.

The porcelain basins with residues, which have been dried over the water-bath, should be allowed to cool before being weighed. The observer will find it useful to have two or three glass shades, about 9 inches in diameter, with shallow glass dishes, for containing strong sulphuric acid, about four or five inches in diameter. Upon the glass dish about half filled with the sulphuric acid, is placed a piece of wire gauze, or perforated zinc, to support the basins. In this manner the residues may be allowed to cool, without absorbing water, and they may be kept dry for some time, if requisite.

Two or Three Nests of Beakers.*

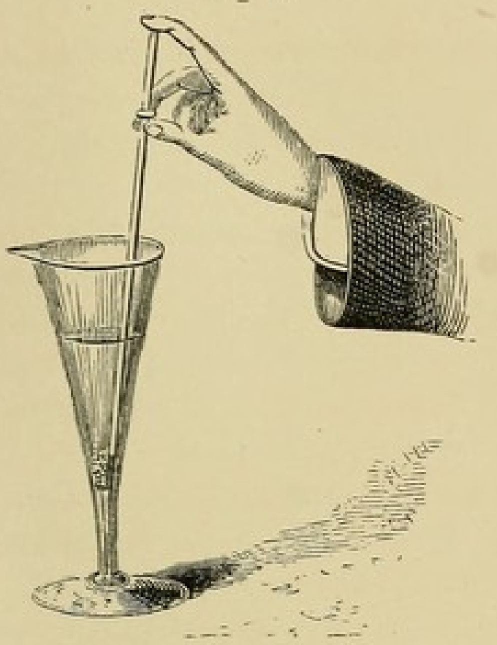
Conical Glasses, of the form represented in pl. II, fig. 13, or in pl. I, fig. 1. The former combines the glass for the urinometer with a conical glass for collecting urinary deposits. This is a most useful form of conical glass. It was devised by Dr. Budd.

* Glass and porcelain apparatus may be obtained of Messrs. Powell, of the Whitefriars Glass Works, or they will be furnished by the instrument makers.

PLATE I.

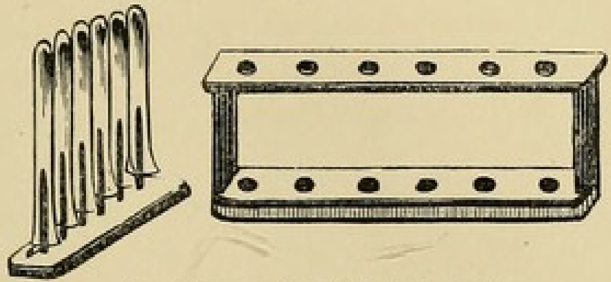
CHEMICAL AND MICROSCOPICAL APPARATUS.

Fig 1.



Conical glass for allowing deposits from fluids to subside. p. 92.

Fig. 2.



Test tubes, rack, and drainer. p. 92.

Fig. 3.

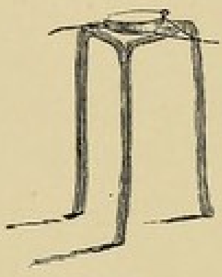
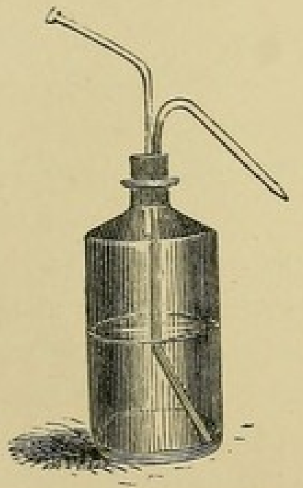


Fig. 4.

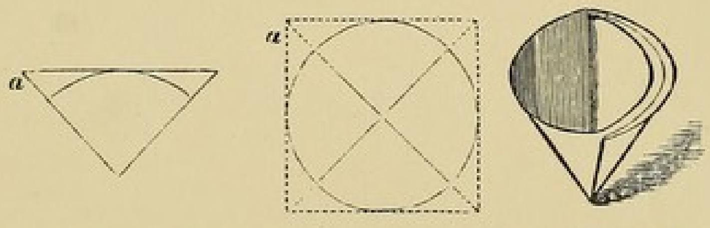
Wire triangles for supporting platinum capsules or foil while the organic matter is being burned off. p. 92

Fig. 5.



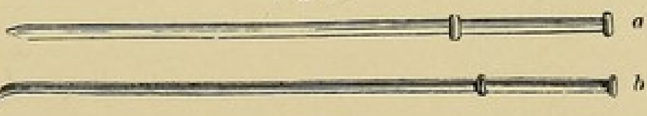
Wash bottle for washing precipitates, &c. p. 93.

Fig 6



Represents the mode of folding the paper used for filtering purposes. p. 93.

Fig. 7.

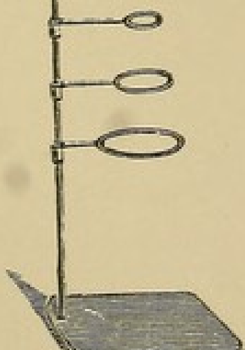


Pipettes. p. 93.

Fig. 7*.

Pipette forming stopper. p. 99.

Fig. 8.

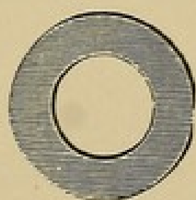


Small retort stand. p. 92.

Fig. 9.

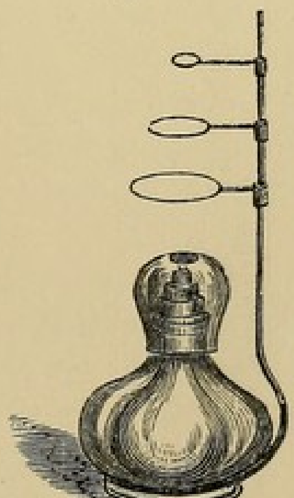
Simple form of water bath.

Fig. 10.



Ring used as an adapter for fitting various sized basins to the simple water bath. p. 92.

Fig. 11.



Spirit lamp p. 92.

[To face page 92

Porcelain Evaporating-basins, of various sizes, from eight ounces to half an ounce capacity.

Wash-bottle, for washing precipitates on filters, pl. I, fig. 5.

Glass Funnels, of various sizes.

Filtering-paper, which can be purchased of the instrument makers, or of most stationers, under the name of white blotting paper. The mode of folding filtering-papers is represented in pl. I, fig. 6, or they may be purchased, ready cut in circles, of the operative chemists.

Glass Measures.—One pint measure, one 4-ounce, one 1-ounce, 1,000-grain measure, cubic inch measure. The cubic centimeter measures are described in page 99, under "The Volumetric Analysis of Urine."

Stirring-rods.—These are made of ordinary glass rod, rounded at each end in the blow-pipe flame; or of pieces of glass tube, the ends of which are drawn off and closed in the flame of the spirit-lamp or blowpipe.

Test-papers.—Blue litmus and reddened litmus.

Thermometer.

Blowpipe.—An ordinary gas-fitter's blowpipe, which costs *6d.*, answers every purpose.

Pipettes, of two or three sizes.

Urinometers—Specific Gravity Bottles, for taking the specific gravity of urine. The specific gravity of a fluid is obtained most correctly by ascertaining the weight of equal bulks of the fluid to be examined, and distilled water. For this purpose, a small bottle, with a tubular stopper, holding exactly 1,000 or 500 grains of distilled water, at a temperature of 60°, is the most exact form of apparatus, pl. II, fig. 15. All that is necessary is to fill the bottle carefully with the urine at 60° F., wipe it dry, and then weigh it, after having counterpoised the bottle. The number of grains which the fluid weighs is the specific gravity in the case of the 1,000-grain bottle, double the weight for the 500-grain bottle, four times the weight for a bottle holding 250 grains, and so on, in like proportion. This method, although perfectly exact, and readily performed where a good balance is at hand, is nevertheless too tedious and troublesome for the practitioner in a general way, and, in the sick wards, a much simpler, though less correct method, is usually resorted to.

The specific gravity is obtained by a small hydrometer, usually termed a *urinometer*. The form of this instrument, and the mode of using it, are well known; but there are one or two points in its construction and management which it may be well for me to refer to. As sold, these instruments are often nearly useless, in consequence of the carelessness displayed in their manufacture. Out of twenty of the common instruments, I have found several differing as much as ten degrees from one another. If the stem of many urinometers be examined, it will be found that all the degrees marked upon it are equal, which clearly ought not to be the case, pl. II, fig. 14 A; for, when fluids of low specific gravity are operated on, a very small portion of the stem remains above the surface of the liquid, pl. II, fig. 13 *b*, while the reverse holds with respect to liquids of great density. In the latter case, there is, of course, a much greater weight of stem above the liquid, tending to force the instrument lower in the fluid than in the former, pl. II, fig. 13 *a*. Allowance must also be made for the fact that the fluid becomes denser as we pass from the upper to the lower strata.* The tendency of the instrument to indicate a higher density than the real one, renders it necessary that the degrees should *decrease* in length from the upper towards the lower part of the stem. The practitioner should carefully examine his urinometer, to see that there is this difference in the degrees, and if not, it should be changed. I strongly recommend everyone to test the urinometer by immersing it in fluids, the specific gravity of which has been ascertained by the bottle, or by a well made and previously corrected urinometer. If the degrees are incorrect, the observer can always bear in mind the amount of error, and allow for it in taking the specific gravity of different specimens of urine. The vessel which is employed for receiving the urinometer should not be too narrow, in case the bulb should rub against the sides, when it becomes difficult to ascertain the real density. Its diameter should be rather more than a quarter of an inch over that of the widest part of the bulb of the urinometer. The glass delineated in pl. II, fig. 13, is a very convenient form.†

Another method of taking the specific gravity, which is sometimes followed, consists in having a number of small glass bulbs, with the density of the fluids in which they neither sink nor swim marked upon them. By placing one after another in the urine, one is found which remains just beneath the surface, and the number upon it indicates the specific gravity of the fluid.

⁂ The chemical apparatus required for the analysis of urine will be provided by Messrs. Bullock and Reynolds, 3, Hanover Street, W.; Messrs. Griffin, Long Acre, W.C.; Messrs. Horne, Thornthwaite, and Co., Newgate Street; and other Operative Chemists; or they will be procured for the practitioner by most of the Instrument Makers.

* This error has been corrected by Mr. Ackland. See note below.

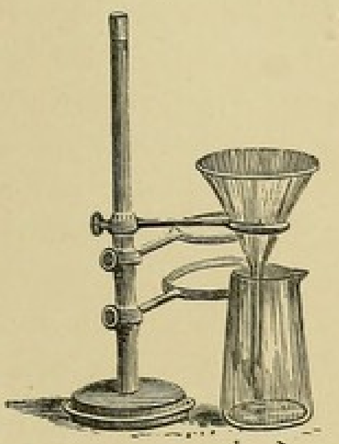
† The following remarks on the construction of urinometers have been published by Mr. W. Ackland, of the firm of Horne and Thornthwaite:—

In the construction of hydrometers it is very important to obtain certain fixed points on the scale with considerable accuracy, and great difficulties arise when the instrument is of small size, from the sluggish manner in which it floats in dense liquids.

This is especially the case in making the small urinometers indicating from 1·000 to 1·060 used by the medical profession for determining the specific gravity of urine; and

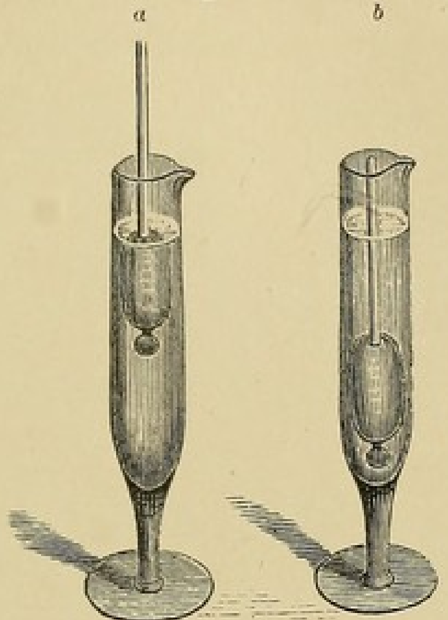
CHEMICAL AND MICROSCOPICAL APPARATUS.

Fig. 12.



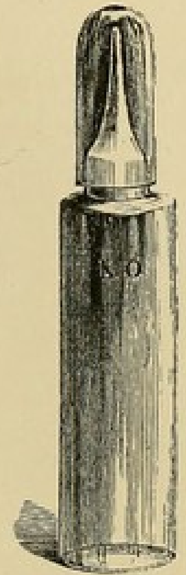
Retort stand, funnel, and beaker, arranged for filtering. p. 92.

Fig. 13.



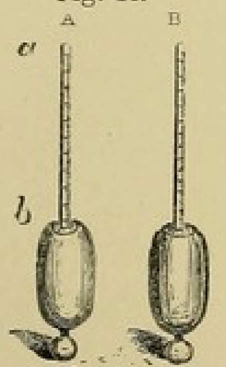
Glasses of convenient form, both for obtaining the specific gravity of fluids and also for collecting the deposits from fluids p. 92.

Fig. 16.



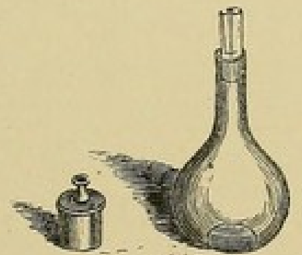
Bottle, with capillary orifice. p. 97.

Fig. 14.



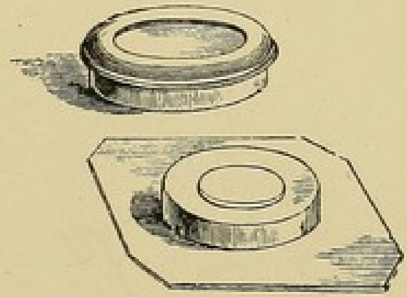
Urinometers for ascertaining the specific gravity of fluids p. 93.

Fig. 15.



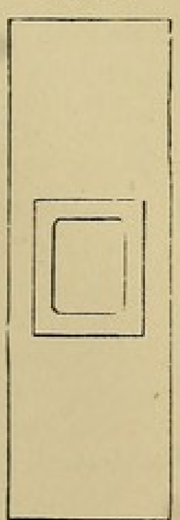
Bottle for finding the specific gravity of fluids by weight. p. 93.

Fig. 17.



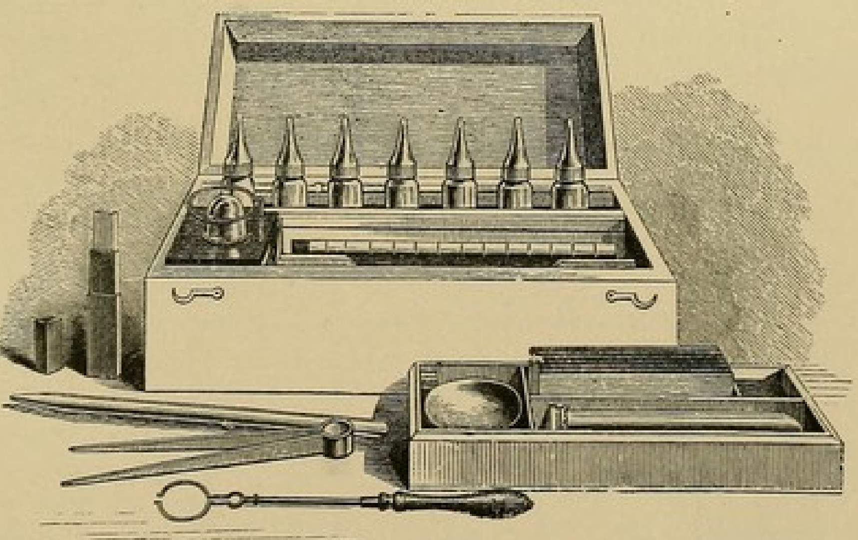
Animalcule cage, also used for examining urinary deposits, &c, under the microscope. p. 97.

Fig. 18.



Simple glass cell for examining of urinary deposits. p. 97.

Fig. 19.



Box containing bottles with capillary orifices, spirit lamp, urinometer and glass, and other appliances and apparatus necessary for minute testing. p. 97.

[To face page 94.

APPARATUS REQUIRED FOR THE MICROSCOPICAL EXAMINATION OF URINARY DEPOSITS.

Clinical Pocket Microscope.—This is a very simple and inexpensive instrument, which I have lately arranged for the microscopic examination of urinary deposits and other substances. It may be used as a field microscope, and will be found a most useful form of instrument for the practitioner. When closed, it is only six inches in length, but when arranged for examination, the tube is drawn out as long as that in the ordinary microscope. Any powers can be adapted to it; and direct light, or light reflected from a mirror, may be employed. I have now used this instrument for many years for teaching in the wards, and find that it answers its purpose well. It may be fitted up with mirror, pipettes, slides and cells, in a leathern case. The instrument is made by Messrs. Powell and Lealand, 170, Euston Road; Mr. Salmon, 100, Fenchurch Street; Mr. Highley, Green Street, Leicester Square; and by Mr. Matthews, Portugal Street, Lincoln's Inn. The clinical microscope is represented in pl. III, fig. 20. It costs, with the eye-piece, but without object glasses, 25*s.* The arrangement of the spring, by which the preparation is kept in contact with the stage, while every part of the field is examined, is represented in fig. 22. I have had this instrument fitted to a small stand, with a lamp for use by night, and a mirror for day, so that it can be very easily handed round in a lecture-room. I find this arrangement most convenient for demonstrating objects to large classes. The stand, with the clinical microscope, is represented in pl. III, fig. 21. It is convenient also to be provided

the remarks hereafter made, although applying to this instrument, may, by a slight variation, be made applicable to every form of hydrometer in use.

The usual plan followed to obtain the two extreme points of the scale is, so to load the bulb that it shall float in distilled water (at temp. 60°) at some point near the top of the scale, where the 0 division is to be placed, and then to immerse it in a fluid whose specific gravity is 1·060, to obtain the place of the 60th division; and these points being obtained, the intervening space is equally divided into 60 equal divisions to form the scale.

In practice this plan of obtaining the fixed points is found difficult, from the well-known fact that such a small floating body cannot be relied on to settle exactly at the same point in different trials in a dense liquid under circumstances apparently similar, and the usual mode of dividing the scale equally is erroneous, as we shall hereafter show. In order to *accurately* obtain the extreme points of the scale, the plan I follow is to take advantage of the fact that such an hydrometer will settle definitively to the same point of the scale in different trials in a mixture of alcohol and water in certain proportions; the strength used ranging between ·910 and ·930.

To test this mixture, a very accurate standard hydrometer, having a large bulb and small stem, is used in order to show its specific gravity with accuracy, and this being noted, is used to obtain the two extreme points of our scale as follows:—

Place the instrument so as to float in the liquid, and load it inside until it sinks to that part of the stem we wish to indicate 1·060—call this *a*. Mark a line on the stem just level with the surface of the liquid, then wipe dry, and ascertain the total weight with a simple student's microscope, with large stage. (*See* "How to Work with the Microscope.") The tube of an ordinary microscope can easily be made moveable and fitted with the end tube and stage of the clinical microscope — a plan which has been carried out by Mr. Highley.

Object-glasses required.—The *quarter of an inch*, magnifying about 200 diameters, and *the inch*, magnifying from 30 to 50 diameters, are the two most useful object-glasses for the purposes of the medical practitioner. The best English objective costs about £5, but good powers may be obtained for about 30*s*.

Microscope Lamp.—An ordinary French lamp affords a very excellent artificial light, especially if provided with a blue glass chimney; but for every kind of microscope work a small paraffin lamp, with a round wick, is to be preferred. This may be obtained of Mr. Collins, 77, Great Titchfield-street, Oxford-street. The best form of gas lamp has been arranged by Mr. Highley.

Glass Slides—the only slides used—should be three inches long by one inch broad. They may be purchased, at from 3*s*. to 6*s*. per gross, of Messrs. Claudet and Houghton, 89, High Holborn, E.C., and of most instrument makers.

Thin Glass, cut into squares and circles. This may be obtained of the various instrument makers, and of Messrs. Claudet and Houghton.

Watch Glasses, of various sizes. Watch glasses are very convenient for evaporating small quantities of fluids. The common glasses are those which are required. They cost 1*s*. per dozen.

of the instrument—call this weight w; then $w \times \cdot 060$ gives an additional weight to be added internally, thus causing the instrument, when again placed in the alcohol mixture, to indicate the point of the stem, which we may call b, and which is also to be marked on the stem, and is where we must ultimately place our 0 division.

These two marks will be the points to which the instrument is to sink in liquids of the specific gravities of 1·000 and 1·060; and we must now ascertain what the final weight of the instrument = W must be made. To do this, calling the specific gravity of our alcohol mixture σ, we find $W = \frac{w \times 1 \cdot 060}{\sigma}$.

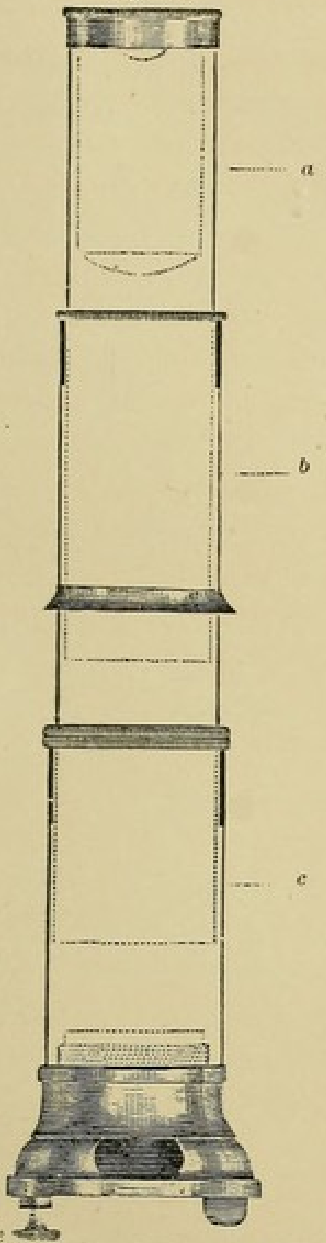
It now remains to subdivide the scale so that the extreme points shall correspond to the two marks we have made on the stem, and that each intermediate division shall indicate each degree of specific gravity, then, after fixing the scale *in situ* and loading it to the weight W, to close it in the usual manner.

As before mentioned, such scales are usually equally divided; but this mode of construction would misplace the 30th division of the scale nearly two degrees, and introduce serious errors in that portion of the scale mostly in use. The scale must of necessity be so divided that the value of each division shall bear a constant ratio to the differences of the reciprocals of the specific gravities indicated. This is easily accomplished by using a dividing engine, specially constructed for this purpose by myself, and which gained the highest commendations and a Prize Medal in the Exhibition of 1851.

We will now proceed to show that this method of finding the two extreme points of our scale is correct in principle.

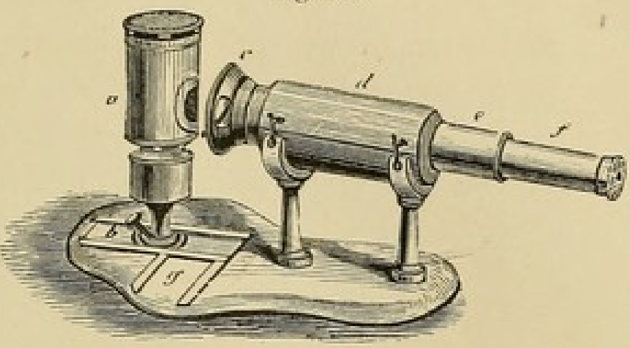
CHEMICAL AND MICROSCOPICAL APPARATUS.

Fig. 20.



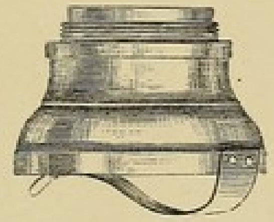
Pocket or clinical microscope, half the real size *a*, tube with eye piece. *b*, tube carrying object glass. *c*, tube in which the last slides with stage. *e*, clamp for fixing preparation p. 95.

Fig. 21.



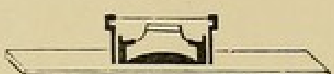
Clinical microscope with stand, and lamp, as arranged for class purposes p. 95.

Fig 22.



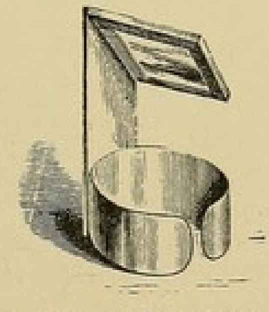
The stage, side view of the clinical microscope, showing position of the spring. p. 95.

Fig. 23.



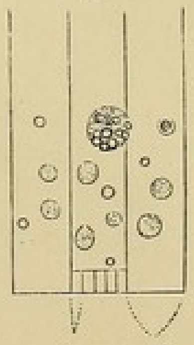
Sectional view of cell for examining urinary deposits. p. 97.

Fig. 24.



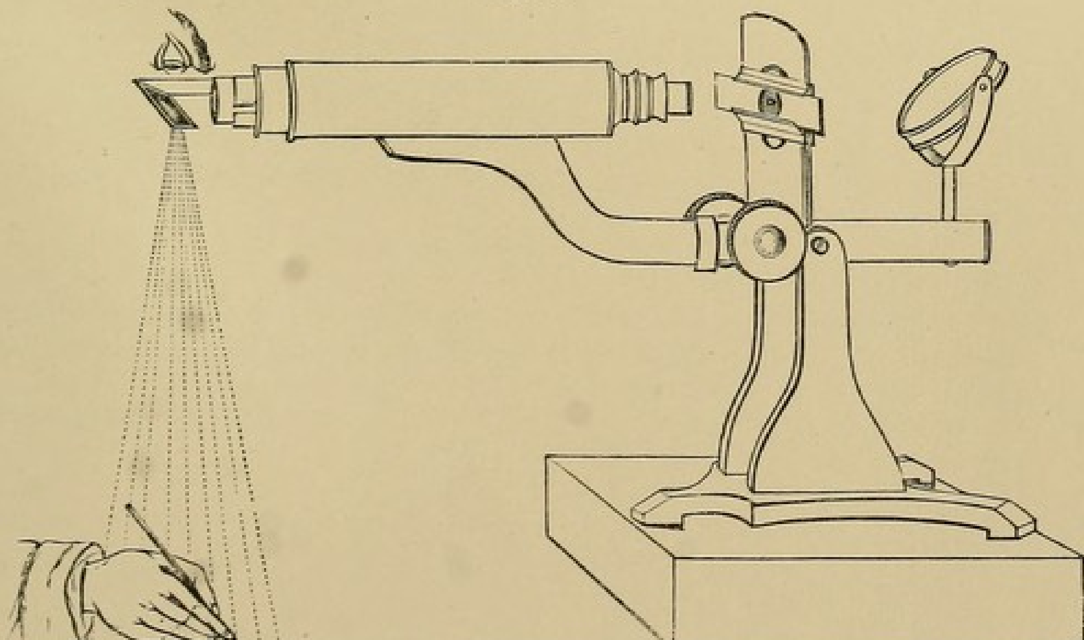
Neutral tint glass reflector. p 97.

Fig. 25.



Scale divided into 1000ths of an inch and magnified 215 diameters. For measuring the size of objects in the microscope. p. 97. × 215.

Fig. 26.



Manner of drawing objects from the microscope with the aid of the neutral-tint glass reflector. p. 97.

[To face page 96.

Glass Cells, for examining urinary deposits. A simple form of cell is represented in 'apparatus,' pl. II, fig. 18, but I have found the so-called "animalcule cages" most convenient instruments for the examination of urinary deposits. The best form is represented in pl. II, fig. 17, which is supplied by Messrs. Powell and Lealand. Fig. 23 is a section of a smaller one, which can be used with the clinical microscope.

Brass Forceps, supplied by the microscope makers.

Stage Micrometer, divided into 100ths and 1,000ths of an inch. This is required for measuring objects, according to the plan described in "How to Work with the Microscope." A scale, divided to 1,000ths of an inch, and magnified 215 diameters, is represented in pl. III, fig. 25.

Neutral-tint Glass Reflector, for tracing the outline of objects, pl. III, fig. 24. It is very important that the observer should be familiar with the methods of drawing and measuring objects accurately. The arrangement of the microscope for tracing the outline of objects, with the aid of the neutral-tint glass reflector, is represented in pl. III, fig. 26.

Bottles with Capillary Orifices.—These bottles are most convenient for testing minute quantities. They may be obtained separately, in boxes containing 6 or 12; or fitted up in a box, with other apparatus required for testing urinary deposits and calculi, pl. II, figs. 16, 19.

These bottles are filled as follows:—A little distilled water is poured into a small porcelain basin, the tube being inverted so that the orifice dips

Let V = the volume of the instrument up to a;
V' = ,, ,, ,, b;
w = the weight of the instrument when floating in the alcohol mixture at a;
w' = the weight of the instrument when floating in the alcohol mixture at b;
W = the total weight when finished;
s = specific gravity of point a = 1·060;
s' = ,, ,, ,, b = 1·000;
σ = ,, ,, of alcohol mixture employed.

Then, by the principle that the weight of a floating body is equal to that of the quantity of the liquid whose place it occupies, we have the following:—

Weight of V of liquid of specific gravity s = W; . . . . (1)
V' ,, ,, s' = W; . . . . (2)
V ,, ,, $\sigma = w$; . . . . (3)
V' ,, ,, $\sigma = w'$. . . . . (4)

From (1) and (3) we deduce

$$W : w :: s : \sigma, \text{ or } W = \frac{ws}{\sigma}; \quad \ldots \quad (5)$$

and from (2) and (4) we deduce

$$W : w' :: s' : \sigma, \text{ or } w' = \frac{Ws'}{\sigma};$$

$$\therefore w' = \frac{ws}{s'}. \quad \ldots \quad (6)$$

beneath the surface of the water. Heat being now applied to the bottle, by means of a spirit-lamp, the air in the interior is expanded, and partially expelled. As the bottle becomes cool, a certain quantity of the fluid rises up into its interior. A few drops having been introduced in this manner, the bottle is held in the test-tube holder over the spirit-lamp; and, when the water boils and the greater part has been converted into steam, the orifice is quickly plunged a short distance beneath the surface of the liquid to be introduced, which has been already placed in another small porcelain capsule. As the steam condenses, the solution will, of course, rise up, and would completely fill the little bottle, if it were maintained in this position, but, when about three parts full, it is to be removed. If completely filled, it would be difficult to expel a drop when required. A certain quantity of air, therefore, is allowed to remain within the bottle; this being expanded by the warmth of the hand, the amount of fluid required is forced out. For microscopical purposes, these little bottles possess many advantages over the ordinary stoppered bottles. In the first place, a most minute quantity of the test can be obtained, and this can be carefully regulated. Secondly, there is no danger of the reagent being spoilt by the introduction of various foreign substances from without. If an ordinary stoppered bottle be used, a drop of fluid is generally removed with a pipette, or stirring-rod; but if these should not be quite clean, foreign substances may be introduced, and the reagent spoilt for further operations. Carelessness upon this head will lead to the greatest inconvenience, and may be productive of the most serious mistakes. Thirdly, testing by means

The results (5) and (6) we employ in the construction of the Urinometer.

Objections may be raised against this method, that no allowance has been made for the temperature at which the alcohol mixture happens to be at the time of the experiment, and that since this has an effect on the volume of the instrument, it will also have an effect on the depth to which the instrument will sink, and I now will show how this consideration is provided for. The method of obtaining the specific gravity of the alcohol mixture is by observing a larger, and we may say standard hydrometer floating in it. Now this instrument is constructed with all possible accuracy, so as to show the true specific gravity of a liquid *when the temperature is* 60° F.

But we say that though the standard hydrometer does not show the specific gravity with accuracy except at 60°, no account need be taken of the difference for our present purpose; the effect of change of temperature on the smaller hydrometer is such as to neutralise the error.

To prove this, suppose the points at which the two hydrometers float to be marked A, a, and let V, v be the volume below these points when floating in a liquid of specific gravity S at temperature t. Now suppose also another liquid prepared of such a specific gravity (S′) that the larger instrument may float at the same mark A when the temperature is 60°, and let V′, v' be the volumes below A, a.

Then VS = V′S′, because each is the weight of the larger hydrometer; but the two hydrometers being formed similarly,

$$: \ ' :: V : V',$$

$$\therefore vS = v'S';$$

but vS is the weight of the small hydrometer, $\therefore$ $v'S'$ is also the weight of the small of these little bottles can be conducted in a very short space of time; and all the tests required, even for a very complete qualitative examination, can be packed in a very small compass.

A useful form of pipette, which can be adapted to ordinary bottles, in the form of a stopper, is represented in plate V, fig. 7*. The tube is very narrow near the end (*c*), so that a very small drop can be obtained. A piece of India-rubber is stretched over the other extremity, and by slightly pressing this a drop is expelled.

All the necessary apparatus required for the ordinary qualitative examination of urine, with tests in bottles of capillary orifices, and apparatus necessary for the microscopical examination of urine, have been arranged in a little case, as represented in pl. II, fig. 19.

⁂ The microscopical apparatus required for the examination of urinary deposits may be obtained of Mr. Baker, Holborn; Mr. Collins, 77, Great Titchfield-street, Portland-road; Mr. Highley, Green-street, Leicester-square; Mr. Matthews, Portugal-street, Lincoln's Inn; or it will be procured for the practitioner by the instrument makers.

OF VOLUMETRIC ANALYSIS.

General Remarks on the Volumetric Process.—Although the general processes adopted for the estimation of the various constituents might be systematically arranged under their respective heads, it has been thought more convenient to treat of the subject of volumetric analysis separately.*

hydrometer, consequently the small hydrometer floating in the liquid of specific gravity S has the volume v' immersed; but v' is the volume up to a at the temperature 60°, and S′ is the specific gravity indicated on the scale of the large hydrometer by the mark A. In other words, a is the point at which the smaller hydrometer would float at 60° in a liquid whose specific gravity is given by the *uncorrected* indication of the standard hydrometer.

It will be seen that this method of finding the extreme or any intermediate points of the scale, and the weight of the finished instrument, offers several advantages. There is only one liquid used, and its density can be shown to any degree of accuracy. The interval of time occupied between the determining the two points a and b is so small as not to admit of any sensible change in the density of the liquid, and as no correction for temperature is required in any part of the process, the whole care of the operator is therefore employed in noting the points at which the instrument floats, and noting these correctly.

In a word, the substitution of the alcohol mixture for water, combined with the process described above and the mode of dividing the scale, enabled us to construct Urinometers with an amount of accuracy not hitherto attained.

Still more recently, Mr. Ackland has perfected a very beautiful apparatus for

* The article on Volumetric Analysis has been most carefully revised by Mr. Sutton, of Norwich, who has made many additions, and has kindly given the results of his great experience to the author for publication in this work.

The science of chemical analysis has been of late years so much simplified in practice by the introduction of the volumetric system that medical men may now with comparative ease and accuracy determine the proportions of the chief constituents in any given specimen of urine in a very short space of time. For the development of this system in its general applications, we are indebted mainly to Professors Liebig, Bunsen, Neubauer, and Mohr, on the continent, while in this country, Mr. J. J. Griffin (the well-known apparatus manufacturer), and Mr. Francis Sutton (author of the Systematic Handbook of Volumetric Analysis), have done much to advance the science either by their writings, by laboratory experiments, or by the manufacture of the delicate graduated instruments used in the various processes.

To Liebig and Neubauer, however, special thanks are due for the application of volumetric analysis to urine, since to the former we are indebted for the discovery of processes for determining urea and chlorides, and to the latter, in conjunction with Dr. Vogel, for a most complete treatise on the Chemical Examination of Urine. This work has lately been translated and published by the Sydenham Society, and is well worthy the attention of all who wish to enter fully into the practice of urinary analyses.

I can also confidently recommend to the notice of practitioners and students the Systematic Handbook of Volumetric Analysis, by Francis Sutton, F.C.S., of Norwich, published by Churchill and Sons.

It has been said that by the aid of this rapid system of analysis, medical men may easily and accurately determine the quantities of important bodies which occur in healthy or diseased urine; but let me qualify this statement by saying that this can only truly apply to those who will take the pains to study and understand clearly the principles involved in each process of analysis. To do this does not occupy a great amount of time, but it is very essential at the outset, in order that the result obtained in any given experiment may be reliable and its meaning clearly comprehended. In the limits of a work like the present, the copious explanation of chemical decompositions, and the nature and composition of the various tests brought into use cannot of course be given, but a few hours consultation of any good elementary work on chemistry or the first principles of analysis, such as Bloxam's Chemistry, or Fownes' Manual will suffice. When this preliminary knowledge is once gained, it is hoped and believed that the short instructions about to follow will be found both easy and certain after a few trials.

I am led to make these remarks, from having known instances in which professional men who, through lapse of time or otherwise, had somewhat forgotten their chemistry, have been disheartened by obtaining a few discordant results in their preliminary experiments, whereas a little acquaintance with the chemical reactions to be expected would have enabled them to see the cause of failure and its remedy.

The principle of volumetric analysis is based upon the fact that chemical substances combine in definite and equivalent proportions. If, therefore, we prepare a solution of any particular test, in such a manner as to know that a given measure of it will exactly combine with a definite quantity of the substance to be determined, a simple calculation, according to the chemical equivalents of the two bodies, will enable us after making the experiment to arrive at the desired result.

Three conditions are essential to the practice of analyses upon this method, viz.:—

1stly. A solution of the reagent or test, the chemical power of which is accurately known.

2ndly. A graduated vessel from which portions of it can be accurately delivered.

3rdly. The decomposition which the test-solution produces with any given substance must be of such a character that its termination is unmistakeable to the eye, and thereby the quantity of the substance with which it has combined, be accurately determined. Let us suppose, for instance, that it is desirable to estimate the quantity of sulphuric acid existing in the form of sulphates in any given specimen of urine. We know that a solution of chloride of barium added to a solution containing sulphuric acid in any form, will produce an insoluble precipitate of sulphate of baryta, and that, while any soluble sulphates remain, the addition of the baryta solution will continue to give a precipitate until at last a point is reached at which no further cloudiness is produced, and here the operation ends. If now we know the strength of the baryta solution, we can readily calculate the quantity of sulphuric acid precipitated, because it is an ascertained fact that every equivalent of sulphuric acid (= 40) requires an equivalent of chloride of barium (= 122) to form the sulphate of baryta. Hence, if we dissolve 30·5 grains of dry chloride of barium in 1,000 grains of distilled water, we obtain a solution of such strength, that every 10 grains will contain 0·305 grain chl. barium, and exactly precipitate one-tenth of a grain of sulphuric acid (0·1 grain), these quantities being in the proportion of 122 to 40. Therefore, suppose that in our experiment we had taken for examination 1,000-grain measures of urine, and 250-grain measures of the baryta solution were required to precipitate all the sulphuric acid, the quantity of the latter would be 2·5 grains or 2½ parts per 1,000. With this preliminary explanation of the principle which regulates volumetric analysis, we will now proceed to describe the weights, measures, and graduated apparatus required to be used in the various processes.

SYSTEM OF WEIGHTS AND MEASURES.

In the following directions I have adopted the grain as the unit of weight, and the fluid decem, equal to 10 grains of distilled water at 62° Fahr. (introduced by Mr. Sutton, of Norwich) as the unit of measures. The gramme and cubic centimetre are now, however, coming into use among English chemists, and those who prefer to use them will find no hindrance in these instructions, inasmuch as the solutions prepared according to either system correspond precisely in strength, for if 30·5 grains of chloride of barium are dissolved in 100 decems of water as mentioned in the preceding example, a solution will be obtained of exactly the same strength as if 3·05 grammes were dissolved in 100 cubic centimetres. It is only necessary to take care that when cubic centimetres of the test-fluid are used, the urine to be tested must be measured in cubic centimetres, and when decems are used, the urine must be measured in decems. The standard solutions here described are mostly so prepared that each decem represents 0·1 grn. of substance tested for, and each C.C. 0·01 gm. of the same.

The following abbreviations will be used to distinguish the two systems of measurement :—

Grain—grn.

Gramme—gm. = 15·433 grains.

Decem—dcm. = 10 grains distilled water at 62° Fahr.

Cubic centimetre—C.C. = 1 gramme distilled water at 62° Fahr.

APPARATUS REQUIRED FOR VOLUMETRIC ANALYSIS.

Burettes or Graduated Tubes 'apparatus,' pl. IV, figs. 27 to 31.—It is convenient to be provided with one or more holding either 100 dcm. or 50 C.C. according to the system used and graduated to half decems or cub. cents. The lower part of the tube is drawn to a small calibre; and to its extremity a small piece of glass tube, about two inches long, is connected by a piece of India-rubber tube, *f*, fig. 27, so arranged that it can be compressed at pleasure by a wire spring just below *f*, as represented in the figure. When the two extremities of this spring are pressed by the finger and thumb, fluid will flow down the tube; and when the pressure is removed, the tube is rendered impervious. This little apparatus serves the part of a stop-cock, and possesses many advantages over the latter. Care must be taken to keep the tube perfectly clean, and the India-rubber should be well washed after every analysis. The apparatus required for the volumetric method of analysis is represented in plate IV, figs. 27 to 31. *a*, is a glass jar, capable of holding 500 dcm. or C.C., graduated into 100 parts. *b*, a pipette, graduated to hold 20 dcm. or C.C. *c*, a piece of India-rubber tube for the convenience of allowing the fluid to escape very slowly when pressure is applied by the finger and thumb. *d*, is the burette, which is capable of holding 100 dcm. or 50 C.C., and graduated to half dcm. or C.C. The numbers are not marked on the tubes in the figure. *e*, *e*, are small pieces of wide India-rubber tube to hold the burette in its place. *f*, a small piece of India rubber tube connecting the extremity of the burette with the spout, and capable of being compressed by the spring, the form of which is represented at *g*. The mode of using the apparatus is also seen in this figure.

The pipette is figured at *b*, fig. 27. It is convenient to be furnished with one of 20 dcm. or C.C., one of 15 dcm. or C.C., and one of 10 dcm. or C.C.; instead of these single pipettes, one to hold 50 dcm. or C.C. and graduated into 50 parts may be used. The *Cylindrical Glass Measure*, graduated to 500 dcm. or C.C., is represented at *a*.

The little apparatus represented in pl. IV, fig. 28, was constructed by me for the purpose of filtering a little of the fluid from the deposit, in order to see if all the substance was precipitated. Filtering-paper is tied round the lower extremity, *a*. By plunging this beneath the fluid, the solution rises quite clear in the interior, and may be poured through the spout, *b*, into a small test-tube kept for the purpose. The drawing represents the tube half the real size. In estimating the quantity of sugar, this little apparatus will be found very convenient.

Beakers, stirring-rods, test-paper, funnels, and porcelain basins, a tripod or small retort-stand, with a spirit-lamp, or gas-lamp and small sand-bath, are also required.

The test-solution is poured into the burette at the top till it is nearly full. A beaker is then placed beneath the orifice, and a certain quantity of fluid allowed to flow from the tube until the upper surface reaches zero on the scale. The line on the burette should always correspond to the lowest part of the thick line at the top of the fluid, caused by the capillary attraction of the walls of the tube. Care must be taken that the part of the tube below the India-rubber joint is also quite full of fluid.

It is desirable that the pipettes should be provided at their upper extremity with a short piece of India-rubber tube, *c*, fig. 27, as, by properly applied pressure upon this with the finger and thumb the fluid may be allowed to escape very gradually.

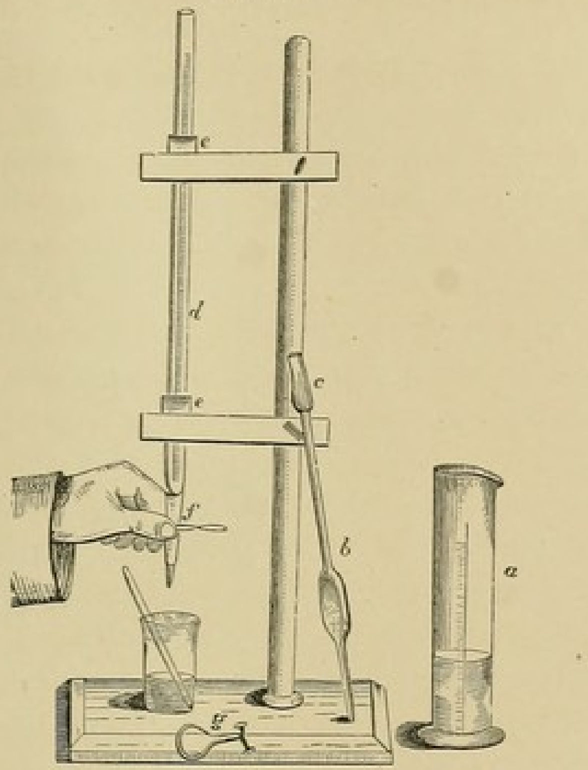
Those operators who desire to prepare their own standard solutions will require to have a tolerably delicate balance with set of weights for weighing the various salts used in making the test solutions, and, though not absolutely necessary, it is advisable to have one or two graduated flasks for mixing and a delicately graduated burette for the purpose of verifying the correctness of the solutions after they are made.

The trouble and expense attendant on these operations may however be obviated by purchasing the solutions ready prepared by some competent authority. Mr. Sutton, of Norwich, guarantees to supply accurately prepared solutions and graduated apparatus, a price list of which may be found at the end of this article.

Estimation of Chlorides and Urea.—The determination of urea and chlorides is effected by solutions of pernitrate of mercury ($HgO.NO^5$). The principle upon which the method depends is this, that *chlorine* gives a soluble, and *urea* an insoluble, compound with peroxide of mercury (HgO), while chlorine has a greater affinity for mercury than urea has; therefore, if pernitrate of mercury ($HgO.NO^5$) be added to a solution containing chlorine and urea, the chlorine will first combine with the mercury, and no precipitate of urea and mercury will take place until all the chlorine has been saturated; and if we observe how much of the solution has been used before a precipitate takes place, we can learn at once the quantity of chloride present. The volume of the solution required for completing the precipitation shows the proportion of urea, as will be explained presently. The same solution, however, is not used for both these determinations, as, for convenience in reckoning, it is better they should be of different strength. In both cases, it is necessary in the first instance to remove the phosphates from the urine. In order to effect this, a mixture of 1 volume of a cold saturated solution of nitrate of baryta ($BaO.NO^5$) and 2 volumes of saturated baryta-water (BaO.HO) must be prepared. This is the *Baryta-solution*.

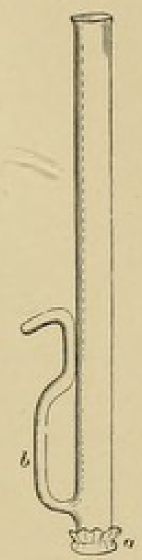
Estimation of Chlorides.—*Standard Solution of Nitrate of Mercury.*—It is of great importance that the solution be pure, for if the mercury from which it is made be contaminated with traces of other metals, such as bismuth, silver, or lead, they will produce a cloudiness in the liquid while under titration, which may possibly hinder the exact ending of the reaction; therefore 184·2 grn. of the purest red oxide of mercury, or 170·6 grn. of pure

Fig. 27.



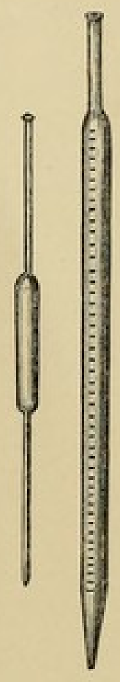
Burette, holding 50 cubic centimetres, and graduated to half c.c., mounted in its stand and arranged as in making analyses. *a*, glass jar capable of holding 500 c.c. *b*, pipette graduated to hold 20 c.c. *c*, india-rubber tube by which the contents of the pipette are caused to flow as required. *d* is the burette. *e*, small pieces of india-rubber for fixing the burette in its place. *f*, india-rubber tube connecting the extremity of the burette with the spout, and capable of being compressed by the spring, the form of which is represented at *g*. p. 102.

Fig. 28.



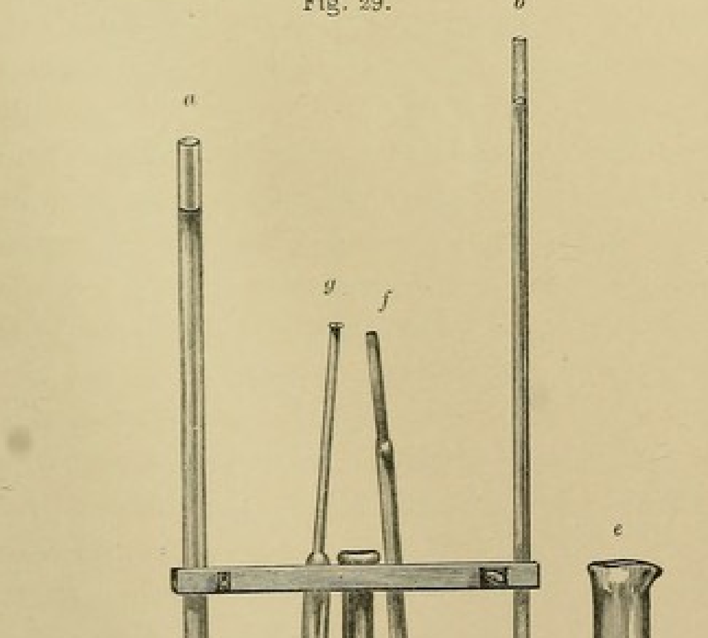
Filter useful in volumetric analyses for obtaining a small quantity of clear solution in order to see if all the substance is precipitated. Filtering paper is tied round the lower extremity, *a*. *b* is the spout through which the clear filtrate is poured. p. 102.

Figs. 30, 31.



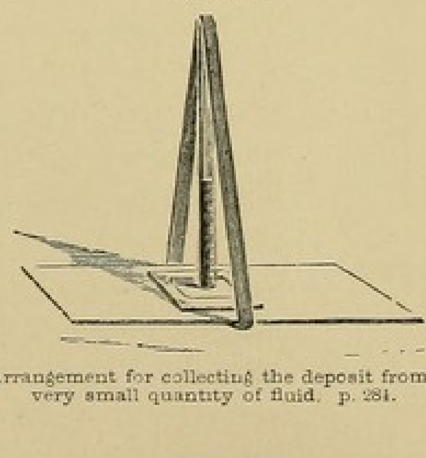
Pipettes of different forms, graduated. p. 103.

Fig. 29.



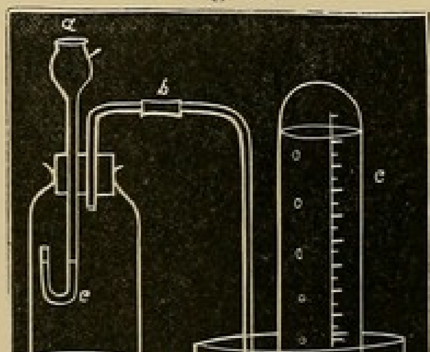
Double burette stand fitted with burettes graduated to dcm *a*, 100-dcm. burette. *b*, 30-dcm. burette. *c*, double burette stand. *d*, a 1000-dcm. flask stoppered. *e*, a 1000-dcm. cylinder *f*, a 50-dcm. whole pipette. *g*, a 50-dcm. graduated pipette. *h*, a 500-dcm. flask *i*, a 200-dcm. flask. According to Mr. Sutton's directions. p. 103.

Fig. 32.



Arrangement for collecting the deposit from a very small quantity of fluid. p. 284.

Fig. 33.



Apparatus as arranged by Dr. Handfield Jones for estimating the proportion of urea in urine. p. 114.

metallic mercury (the former is preferable, as being easier to weigh and less likely to be impure) are put into a beaker, with a sufficiency of pure nitric acid of about 1·20 spec. grav. to dissolve them by the aid of a gentle heat; the clear solution so obtained is evaporated on the water bath to remove any excess of free acid. When the liquid is dense and syrupy in consistence, it may be transferred to the graduated cylinder or flask and diluted to 1,000 dcm. (10,000 grains), 1 dcm. of the solution so prepared is equal to 0·1 grn. chloride of sodium, or 0·06065 grn. chlorine. If, on diluting the concentrated mercurial solution, a yellow precipitate of basic nitrate of mercury should form, it must be allowed to settle, the clear liquid poured off, and a few drops of nitric acid added to the precipitate to redissolve it; the whole is then mixed and preserved for future use in a well-stoppered bottle. It is always preferable to have this precipitate formed on dilution, as it is a proof of there being no excess of acids, which would considerably interfere with the accuracy of results. Dr. Hassall has shown, by a careful series of analyses, that considerable variations from the truth are occasioned by the use of standard solutions containing a large excess of acid, both in the case of chlorides and urea. *See* "Lancet," Feb. 1865.

The Analytical Process.—40 dcm. of the clear urine are mixed with 20 dcm. of baryta solution, and the thick mixture poured upon a small dry filter; when sufficient clear liquid has passed through, 15 dcm. = 10 dcm. urine, are taken with a pipette and just neutralised, if necessary, with a drop or two of nitric acid; if not alkaline, the probability is that sufficient baryta solution has not been added to precipitate all the phosphoric and sulphuric acids; this may be known by adding a drop or so of the baryta solution to the filtrate; if any precipitate is produced, it will be necessary to mix off a fresh quantity of urine with three fourths or an equal quantity of baryta, in which case 17½ or 20 dcm. must be taken to represent 10 dcm. of the urine; the excess in either case of baryta must be cautiously neutralised with nitric acid; attention to this is particularly necessary.

The vessel containing the fluid is then brought under a burette containing the mercurial solution, and small portions delivered in with stirring, until a distinct permanent precipitate is produced; it may happen that a turbidity is produced from the very first drop or two, owing to slight impurities in the mercurial solution, but as this will not increase, the point when the urea precipitate appears is not difficult to determine; the volume of solution used is then read off and calculated for 1,000 parts of urine.

Example: 15 dcm. of the liquid prepared with a sample of urine, as above (=10 dcm. urine) required 6·2 dcm. mercurial solution, the quantity of salt present was therefore 0·62 grn., or 6·2 grns. in 1,000 grains of urine.

Estimation of Urea.—The combination between urea and oxide of mercury in neutral or alkaline solutions has been alluded to previously; it will therefore probably be only necessary to say that the determination of urea in urine is based on that reaction; and as the precipitate so produced is insoluble in water or weak alkaline solutions, it is only necessary to prepare a standard solution of mercury of convenient strength, and to find an indicator by which to detect the point when all the urea has entered into combination with the mercury, and the latter slightly predominates. This indicator is carbonate of soda. If, in the course of adding the mercurial solution from the burette to the urine, a drop of the mixture be taken from time to time and brought in contact with a few drops of solution of carbonate of soda on a glass plate, slab, or watch glass, no change of colour is produced at the point of contact until the free urea is all removed; when this is the case, and the nitrate of mercury is slightly in excess, a yellow colour is produced, owing to the formation of hydrated oxide of mercury.

Preparation of the Standard Solution.—772 grains of red oxide of mercury, or 715 grains of the metal itself, are treated with nitric acid, as described in the article on chlorides, and in either case diluted to 1,000 dcm. (10,000 grains), 1 dcm. of the solution is then equal to 0·1 grn. urea. (The extreme care required to remove traces of foreign metals from the mercury is not so necessary here as in the foregoing instance.)

The Analytical Process.—Two volumes of the urine are mixed with one of baryta solution, as before described, and 15 dcm. = 10 dcm. urine, taken in a small beaker for testing; it is brought under the burette containing the mercurial solution (without neutralising the excess of baryta, as in the case of chlorides), and the solution added in small quantities so long as a distinct precipitate is seen to form, a plate of glass laid over dark paper is previously sprinkled with a few drops of solution of carbonate of soda, and a drop of the mixture must be brought from time to time, by means of a small glass rod, in contact with the soda; so long as the colour remains white, free urea is present in the mixture; when the yellow colour is distinctly apparent, the addition of mercury is discontinued, and the quantity used calculated for the amount of urea. It is always advisable to repeat the analysis, taking the first titration as a guide for a more accurate estimation by the second.

Example: 15 dcm. of urine deprived of phosphates = 10 dcm. of the original urine was tested as described, and required 17·6 dcm. of mercurial solution; consequently there was 1·76 grn. urea present in the 10 dcm., or 17·6 grains in the 1,000 of urine.

Estimation of Phosphoric Acid.—Hitherto the estimation of this substance volumetrically presented peculiar difficulties, but by the discovery of the uranium process, Mr. Sutton has overcome these, as far as urine and many other solutions containing phosphates are concerned.

This method is based on the fact that when a solution of nitrate or acetate of uranium is added to a fluid containing phosphoric acid, acetate of soda, and free acetic acid, the whole of the phosphoric acid is thrown down as phosphate of uranium, having a light lemon colour, and the composition 2 $(Ur_2 O_3)$, PO_5 + Aq. The point at which all the phosphoric acid is precipitated may be readily ascertained by bringing a drop of the yellow liquid in which the precipitate is suspended in contact with a drop of solution of yellow prussiate of potash on a white porcelain plate; an excess of uranium solution immediately produces a brown colour at the point of contact. The yellow precipitate is quite insoluble in acetic acid, but readily so in any of the mineral acids; therefore, if any of them should be used to bring the phosphates into solution they must be neutralised by an alkali previously to adding the acetic acid and testing with the uranium solution.

The following solutions are required for determining phosphoric acid:—

1. Standard nitrate of uranium, containing 406 grains of sesquioxide of uranium, or 709·9 grains of nitrate of uranium in 10,000 grains of liquid. Each dcm. equals 0·1 grn. PO_5. This solution cannot well be prepared by weighing the oxide or nitrate direct and dissolving, owing to the difficulty in obtaining the substances absolutely pure or with definite proportions of water in them. It is therefore necessary to graduate it by testing, as will be hereafter described.

2. Standard phosphate of soda, containing 504 grains per 10,000 grains. Each dcm. equals 0·1 grn. PO_5.

3. Solution of acetate of soda with free acetic acid to be added to urine in the proportion of 5 dcm. to every 50 dcm., prepared by dissolving 1,000 grains of acetate of soda in about 900 dcm. of distilled water, and making up the solution to 1,000 dcm. with concentrated acetic acid.

4. A solution of yellow prussiate of potash, about 1 part to 20 of water.

Preparation of the Standard Solutions.—It would be preferable on some accounts to use acetate of uranium for the determination of phosphoric acid in urine, but as its state of oxidation is easily affected by impurities in the acetic acid, or by light, it is better to use nitrate. In this case, however, nitric acid is set free when the uranium enters into combination with the phosphoric acid, and consequently some acetate of soda or ammonia must be added at the time of testing, so that nitrate of soda or ammonia may be formed, and thus obviate the presence of free nitric acid.

Pure nitrate of the sesquioxide of uranium is dissolved in distilled water in the proportion of about 36 grns. to the ounce, and the clear solution then tested by a standard solution of phosphate of soda, in order to find its exact strength; to this end 504 grains of pure phosphate of soda are weighed, dissolved in water, and the solution made up to 1,000 dcm. Each decem of such solution will contain 0·1 grn. PO_5. The plan of procedure will then be as follows. The uranium liquid of unknown strength is brought into the burette, and 10 dcm. of the phosphate solution placed in a beaker together with 5 dcm. of the solution of super-acetate of soda. The whole is then diluted to about 50 dcm. with distilled water, and heated in a water-bath or by a spirit-lamp until somewhat hotter than can be borne by the hand. The beaker is then brought under the burette, and the uranium solution gradually added, while a distinct precipitate is seen to form. A drop of the mixture is then removed by a glass rod and placed upon a clean white porcelain slab or plate, and a very small drop of solution of ferrocyanide of potassium solution brought by the aid of a thin glass rod into the middle of it. If no brown colour is produced, the uranium must be added drop by drop, until a faint indication occurs. The process is then repeated, and if the two trials agree it may be considered that the strength of the solution is defined. The burette is then read off, which we will suppose to be 8·5 dcm., consequently every $8\frac{1}{2}$ decems of that particular solution will need the addition of $1\frac{1}{2}$ decem of water to constitute it of such a strength that 1 dcm. will represent 0·1 grn. PO_5. By the aid of the graduated glass jar the whole of the solution may be diluted at once, the quantity of water necessary being readily ascertained for any given measure of uranium solution by a simple rule of three sum. Thus supposing there are exactly 560 dcm. of solution, then $8·5 : 10 :: 560 : x = 659$. If, therefore, the 560 dcm. be diluted up to 659 dcm., the solution will be correct.

Performance of the Analysis.—50 dcm. of the clear urine are measured into a small beaker, together with 5 dcm. of the solution of acetate of soda. The mixture is then warmed in the water bath, or otherwise, and the uranium solution delivered in from the burette, with constant stirring, as long as a precipitate is seen to occur; a small portion of the mixture is then removed with a glass rod, and placed on a white plate or slab, into the middle of which a small drop of ferrocyanide of potassium solution is placed by the aid of a very thin glass rod; so long as no brown colour is produced, the addition of uranium may be continued; when the faintest indication of this reaction is seen, the process must be stopped, and the amount of colour observed; if it coincides with the original testing of the uranium solution with a similar quantity of fluid, the result is satisfactory, and the quantity of solution used may be calculated for the total phosphoric acid contained in the 50 dcm. of urine; if the uranium has been used accidentally in too great quantity, 10 or 20 dcm. of the same urine may be added, and the testing concluded more cautiously. Suppose, for example, that the solution has been added in the right proportion, and 9·6 dcm. used, the 50 dcm. will have contained 0·96 grn. phosphoric acid. With care and some little practice the results are very satisfactory.

Earthy Phosphates.—The above determination gives the total amount of phosphoric acid, but it may sometimes be of interest to know how much of it is combined with lime and magnesia. To this end 100 or 200 dcm. of the urine are measured into a beaker, and rendered freely alkaline with ammonia; the vessel is then set aside for ten or twelve hours, for the precipitate of earthy phosphates to settle; the clear fluid is then decanted through a filter, the precipitate brought upon it and washed with ammoniacal water; a hole is then made in the filter and the precipitate washed through, the paper moistened with a little acetic acid, and washed into the vessel containing the precipitate, which latter is dissolved in acetic acid, some acetate of soda added, and the mixture titrated as before described; the quantity of phosphoric acid so found is deducted from the total previously estimated, and the remainder gives the quantity existing in combination with alkalies.

Determination of the Sulphuric Acid.—Preparation of the Solution.— A quantity of crystallised chloride of barium is to be powdered, and dried between folds of blotting-paper. Of this, 305 grns. are to be dissolved in 1,000 dcm. of distilled water. 1 dcm. = 0·1 grn. SO_3.

A dilute solution of *sulphate of soda* is also required.

Performance of the Analysis.—100 dcm. of the urine are poured into a beaker, a little hydrochloric acid added, and the whole placed on a small sand-bath, to which heat is applied. When the solution boils, the chloride of barium test is allowed to flow in very gradually as long as the precipitate is seen distinctly to increase. The heat is removed, and the vessel allowed to stand still, so that the precipitate may subside. Another drop or two is then added, and so on, until the whole of the SO_3 is precipitated. Much time, however, is saved by using the little apparatus represented in fig. 28. A little of the fluid is thus filtered clear, poured into a test-tub, and tested with a drop from the burette; this is afterwards returned to the beaker, and more of the test solution added, if necessary. The operation is repeated until the precipitation is complete. In order to be sure that too much of the baryta-solution has not been added, a drop of the clear fluid is added to the solution of sulphate of soda placed in a test-tube. If no precipitate occurs, more *chloride of barium* must be added; if a slight cloudiness takes place, the analysis is finished; but, if much precipitate is produced, too large a quantity of the test has been used, and the analysis must be repeated.

For instance, suppose that 18·5 dcm. have been added, and there is still a slight cloudiness produced which no longer appears after the addition of another half decem, we know that between 18½ and 19 dcm. of solution have been required to precipitate the whole of the sulphuric acid present, and that accordingly the 100 dcm. of urine contain between 1·85 and 1·9 grn. of SO_3.

Determination of the Sugar.—This method is deduced from the reaction occurring when Trommer's test is employed for testing for grape-sugar. It is well known that grape or diabetic sugar possesses the power of reducing the oxide of copper to the state of yellowish-red sub-oxide.

Preparation of the Copper Solution.—346·4 grains of pure sulphate of copper are dissolved in about 200 dcm. of water. In another vessel 1,730 grains of crystallised tartrate of soda and potash (Rochelle salt) are dissolved in 480 dcm. of solution of pure caustic soda, spec. grav. 1·14. The two solutions are then mixed, well agitated, and diluted to 1,000 dcm. 1 dcm. of the solution so prepared represents 0·05 grn. grape or diabetic sugar. *It must be preserved in the dark, and in well-stoppered full bottles.* It should bear heating when diluted with about four or five times its quantity of distilled water, without any precipitate taking place, and should always be submitted to this test before being used; if any does occur, it probably arises from the alkali having absorbed carbonic acid; in this case the addition of a little fresh caustic soda solution remedies the evil. It has been recommended by some to keep the solution of sulphate of copper and tartrated alkali separate, and mixing the two for every analysis; but I have not found the method to possess any real advantage over the first, as in both cases air must be excluded.

The Analytical Process.—10 dcm. of the clear urine are diluted by means of a measuring flask to 200 dcm. with water, and a large burette filled with the fluid; 10 dcm. of the copper solution ($=\frac{1}{2}$ grn. sugar) are then measured into a white porcelain capsule, 40 dcm. of distilled water added, the vessel arranged over a spirit or gas lamp under the burette, and brought to boiling; the diluted urine is then delivered in cautiously from the burette until the bluish colour has nearly disappeared. The addition of the urine must then be continued more carefully, allowing the red precipitate to subside after each addition by removing the heat, when by gently sloping the capsule, the clear liquid allows the white sides of the capsule to be seen, so that the faintest shade of blue would be at once perceptible. When the colour is all removed the burette is read off, and the quantity of sugar in the urine calculated as follows:—

Suppose that 40 dcm. of the diluted urine have been required to reduce the 10 dcm. of copper solution, that quantity will have contained 0·5, *i.e.*, $\frac{1}{2}$ grn. sugar; but, the urine being diluted 20 times, the 40 dcm. represent only 2 dcm. of the original urine; therefore 20 grains of it contain $\frac{1}{2}$ grn. sugar, or 25 grains per 1,000.

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	per pint		per ½ gall.	
	s.	*d.*	*s.*	*d.*
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,, ,, for Urea	3	6	12	0
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Chloride of Barium for Sulphates	2	0	6	0
Solution of Sulphate of Soda for ditto	1	6		
Nitrate of Uranium for Phosphates	6	0	20	0
Solution of Acetate Soda	2	0	6	0
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Determination of the Free Acid in Urine.—The following details of the operation I have taken from Neubauer and Vogel, translated by the New Sydenham Society, p. 200.

B. Preparation of the Solutions.—a. Standard Oxalic Acid Solution.—This solution serves for the graduation of the caustic soda solution. It is prepared by dissolving 1 gramme of pure oxalic acid, which has not effloresced, and diluting it up to 100 C.C. Each 10 C.C. of this solution contains 100 milligrammes of oxalic acid.

b. Tincture of Litmus.—1 gramme of litmus is digested for some time in 150 grammes of alcohol, and the deep blue solution thus obtained is then filtered.

c. Caustic Soda Solution is prepared in the ordinary way, by means of caustic lime, from carbonate of soda, and its activity determined with the oxalic acid solution (*a*). Each cubic centimetre indicates 10 milligrammes of oxalic acid.

10 C.C. of the oxalic acid solution are accurately measured off by the pipette into a small glass beaker, and rendered of a distinctly red colour, by the addition of from 6 to 10 drops of tincture of litmus (*b*). The glass is then placed upon a white-coloured ground, and the dilute soda solution dropped into it, until the fluid has again become blue. This point may be ascertained with the nicest accuracy, the red colour passing very suddenly into blue. Thus, 6 C.C., for example, of the soda solution, employed in the process, will correspond with the 100 milligrammes of oxalic acid; we therefore add 400 C.C. of water to 600 C.C. of the soda solution, and thus obtain 1 litre of soda solution, each cubic centimetre of which exactly corresponds with 10 milligrammes of oxalic acid. We satisfy ourselves of the accuracy of the dilution by a

second trial; and if, after the last drop of 10 C.C. has been added, the blue colour appears, the soda solution may be safely employed for determining the amount of acids in the urine.

C. Process.—The tincture of litmus cannot be added directly to the urine, as the colour of the urine prevents the passage of the red into blue being accurately observed. Consequently, in determining the point of saturation in the urine, we must employ litmus paper, and carry out the process in the following way:—

The standard soda solution is added, by drops, to 50 or 100 C.C. of urine, which have been measured off into a beaker-glass. After the addition of each half cubic centimetre, a drop of the mixture is taken out on a glass rod, and placed upon a piece of sensitive blue litmus paper; if the spot is reddened, and retains its red colour for a few seconds, we must continue the addition of the soda solution, until, in fact, the reddening of the litmus paper is no longer perceptible. We, then, place a drop of the mixture on reddened litmus paper, and observe whether the paper becomes blue. If this is the case, we must then notice the quantity of soda solution which has been employed, and repeat the experiment with a new quantity of urine; this time, however, not quite so many drops must be employed. In this way, and by frequent testing, the point of saturation may be accurately ascertained.

Davy's Mode of determining Urea in Urine.—A long stout glass tube, 12 or 14 inches in length, capable of holding two and a half cubic inches, is closed at one end, and ground perfectly smooth at the open extremity, and graduated to tenths and hundredths of a cubic inch. It is to be filled more than a third full of mercury, and afterwards a measured quantity (from a quarter of a drachm to a drachm) of the urine poured in. Next, the tube is exactly filled with a solution of chlorinated soda (hypochlorite of soda, sodæ chlorinatæ liquor, of the Dublin "Pharmacopœia"). Care must be taken to avoid adding too much of the solution, which must be poured in quickly. The orifice of the tube is instantly covered with the thumb; inverted once or twice, to mix the urine and hypochlorite; and placed beneath a saturated solution of salt and water contained in a cup. The mercury flows out, and the solution of salt takes its place; but, being more dense than the mixture of urine and hypochlorite, the latter always remains in the upper part of the tube. The urine is soon decomposed, bubbles of nitrogen escape, and collect in the upper part of the tube. When decomposition is complete, which is known by no more bubbles of gas being evolved, the volume collected is read off, and corrected for temperature and pressure.

One fifth of a grain of urea should furnish by calculation ·3098 parts of a cubic inch of nitrogen at 60° F. and 30′ Bar. In one experiment, Dr. Davy obtained from the same quantity ·3001; in another, ·3069.

Amount of Urea in an Ounce of Urine, as estimated by Dr. Davy, according to Liebig's Method and his own.

	Liebig's.	Dr. Davy's.
First experiment	3·610	3·712
Second experiment	5·321	5·472
Third experiment	4·976	4·976

("Dublin Hospital Gazette," 1855, vol. I, p. 134; Braithwaite's "Retrospect," 1854, vol. I, XXX, p. 109.)

Modification of Davy's Method.—Dr. Handfield Jones has found that the results obtained by this plan were not so trustworthy as could be wished, and suggests the following modification. ("Archives of Medicine," vol. I, p. 144.)

"Lately I have used a bottle, of about six ounces capacity, with a curved tube of supply, and another to conduct away the gas into a graduated jar, pl. IV, fig. 33. *a* is the supply tube; *b*, the out-leading tube; *c*, fluid remaining in curve of supply tube; *d*, mixture in bottle; *e*, receiver to hold and measure the gas generated. After the urine is poured in, the supply tube is washed out with a little water. Of course, at any time, more solution of chlorinated soda (measured quantity) can be added through the supply tube. I put into the bottle two drachms of urine, or more, adjust the out-leading tube to the jar, and pour in, with a pipette, a known bulk of solution of chloride of soda.* This drives over, of course, a corresponding amount of air, and the gas generated, a further amount, so that in the jar I have an amount which — the volume of decomposing fluid = the gas generated. I have ascertained by trial that no alteration takes place when air and nitrogen are mixed. The fluid remaining in the curved supply tube bars all escape of gas, and it is perfectly easy to empty the bottle afterwards by simply inverting it, when the contents pour out of the gas escape-tube. By shaking the bottle frequently, I can get an experiment finished in about an hour.

"In six trials (some of them being made with a straight tube of supply, going to the bottom of the jar, instead of a curved one), I obtained the following results:—

		Observed.		Calculated.	
(*a*)	2 grains of urea gave	3·305 C. in.	instead of	3·098 C. in.	or ·207 +
(*b*)	2 ,, ,,	3·0979	,, ,,	3·098	or ·0001 —
(*c*)	1·5 ,, ,,	2·3107	,, ,,	2·323	or ·0123 —
(*d*)	1·3 ,, ,,	2·1313	,, ,,	2·0137	or ·1276 +
(*e*)	2·5 ,, ,,	3·8498	,, ,,	3·8725	or ·0227 —
(*f*)	2 ,, ,,	3·0256	,, ,,	3·098	or ·0724 —

* "The solution of chloride of soda used by Dr. Davy is the sol. sod. chlor. of the Dublin 'Pharmacopœia.' I find that it is not every specimen that serves the purpose well; what I have used lately has been made for me by Mr. Button, Holborn Bars. A fresh solution (filtered) of chloride of lime acts very energetically and quickly, much more so than the sol. sod. chlor., but some carbonic acid is generated and passes over, which complicates the process."

"These are not exact enough to satisfy me, but I do not see any source of fallacy in the mode; and, if in more skilful hands it should prove trustworthy, I think it would have much to recommend it, on the score of facility in previous preparation. The figures have been corrected for temperature and pressure."

GENERAL CHARACTERS OF HEALTHY URINE.

Before resorting to a complete chemical and microscopical examination of urine, it is important to measure the quantity passed in twenty-four hours, to notice its *colour*, *smell*, *consistence*, *clearness* or *turbidity*, and the presence or absence of a *deposit*, and to ascertain its *specific gravity* and *reaction*.

Colour.—Urine from the same person varies much in colour at different times, and specimens taken from a number of perfectly healthy individuals exhibit the greatest variation in tint. Nevertheless, important information is often gained by carefully noticing the colour, for this may at once lead us to suspect the presence of certain substances, or convince us that others are absent. The period of the day, the nature of the diet, the activity of the respiratory process, changes of temperature, and a number of other circumstances influence the colour of the urine. Healthy urine varies from a pale straw colour to a brownish yellow tint. In disease it may be perfectly colourless, of the natural colour, bright yellow, pink, brown, of a smoky appearance, blood red, and even dark blue. What is learnt from noticing these different colours in disease will appear when the characters of morbid urine are considered. The *deposits* in urine in disease also vary much in colour; they may be white, pink, red, pale or dark brown, blue, or black. The nature of the substances which give colour to the urine is discussed in page 147.

Smell.—From the smell of the urine, in some instances, the practitioner may gain useful information. Healthy urine has a peculiar and very characteristic smell, which has been strangely described as aromatic; but it is well known to all. It probably depends upon the presence of certain organic acids (Carbolic $C_{12}H_6O_2$), for example. In disease, the specimen may be highly *pungent*, from the presence of *carbonate of ammonia*, which is produced by the decomposition of the urea excited by some animal ferment, especially by mucus of the bladder in a state of incipient decomposition. In other instances it may smell like healthy urine, but much more strongly. Sulphuretted hydrogen may be evolved from it. The smell of the urine is affected by many articles of food and medicine, such as asparagus, garlic, and cubebs. Turpentine, even if inhaled, causes the urine to evolve an odour something like the smell of violets.

Clearness or Turbidity.—Healthy urine is perfectly clear and transparent; but, after it has been allowed to stand for a short time, a very faint, flocculent, bulky deposit subsides towards the lower part of the vessel. This cloud consists of a little mucus, with imperfectly formed epithelial cells from the mucous membrane of the urinary passages, and epithelial *débris*.

In disease, the urine may be opaque, from the presence of many different substances held in suspension. *Urate of soda* is the most frequent cause of this opacity, in which case the colour of the mass is generally of a dirty yellow, or brown, resembling peas-soup. Very rarely it results from fatty matter in a state of minute division, and the urine has the appearance of milk. This occurs in cases of *chylous urine*. In these instances the turbidity still continues after the urine has been allowed to stand still for some time. Generally, however, the opacity of a specimen of urine depends upon the presence of a deposit temporarily suspended in it from agitation, but which collects at the bottom of the vessel after a time, forming a visible deposit, leaving above it the fluid which is perfectly clear.

Healthy urine is perfectly thin or mobile, like water, and can be readily made to drop from a tube. In disease, however, it may be *slightly viscid*, or so *thick* and *glairy*, or *ropy*, that it may be drawn at the end of a rod, like a thread, and cannot be made to drop at all. It may be *semi-fluid;* and, in rare instances, although passed perfectly fluid, it has afterwards assumed the form of a thick *firm jelly*, so that the vessel containing it might be inverted without its escape. Such specimens have been met with, associated with a milk-like appearance, in cases of *chylous urine*.

Deposit.—The only deposit which healthy urine contains is a faint unimportant mucous cloud, already referred to. All the constituents removed from the organism in this excretion, in health, escape in a perfectly soluble form; but when the healthy physiological changes are in any way interfered with, some of these constituents are produced in abnormal quantity, and are deposited, in an insoluble state, either at the time the urine is secreted, while it remains in the bladder, or at a variable interval of time after it has been passed. The deposit may be soluble in the warm fluid, and precipitated as soon as it becomes cold, or its deposition may be due to the occurrence of certain chemical decompositions.

Specific Gravity: proportion of Solid Matter.—By ascertaining the specific gravity of a specimen of urine, p. 93, we are enabled to form a rough estimate of the quantity of solid matter dissolved in the fluid; and, by measuring the entire quantity of urine passed in the twenty-four hours, we have data for judging approximately of the amount of solid material removed from the organism in this secretion in twenty-four hours.

The specific gravity of healthy urine is about 1,015, and the quantity of solid matter passed in the twenty-four hours, amounts to from 800 to 1,000 grains. It has been considered sufficient to calculate the quantity of solid matter from the specific gravity, by multiplying the number over 1,000 indicating the specifie gravity, by about 2·5. The result will give an approximation to the quantity of solid matter in 1,000 grains of urine. This calculation is by no means exact, and is, indeed, almost useless for accurate investigations. This is shown by the fact that three very different numbers have been proposed, namely, 5·58, 2·33, and 1·65. When it is considered how widely different the composition of the solid matter may be in various specimens of healthy urine, it is obvious that results obtained in this manner must often be very wide of the truth. Take, for example, *albumen and common salt.* A fluid containing 136·4 grains of the former in 1,000 grains, will have a specific gravity of 1,030; while one containing only 80·0 grains of common salt in the same quantity will have a specific gravity of 1,064. The proportion of common salt in urine varies more than the other constituents, as it depends upon the quantity taken in the food. This clearly shows that it is not possible by calculation to ascertain with accuracy the quantity of solid matter in an animal fluid. In investigations, therefore, where any approach to a correct estimate is required, we must evaporate a given quantity of urine (1,000 grains) to dryness, at a low temperature, and weigh the solid matter. As, however, this operation takes some time, some physicians are compelled to content themselves with taking the specific gravity. In many cases, the information gained by this simple operation is very important. Thus, the urine may be not more than 1,002 or 1,003—a sp. gr. common in hysteria, and occasionally indicative of grave disease. A patient may be continually passing urine of specific gravity 1,010 to 1,012, which is commonly the case with albuminous urine, passed by patients suffering from certain chronic kidney diseases. Urine, containing a very large quantity of urea—so much that crystals of nitrate of urea are formed upon the addition of nitric acid, without previous concentration *(excess of urea)*—usually reaches 1,030, or higher; and in cases of confirmed diabetes, where very large quantities of sugar escape from the organism, the urine may have a specific gravity of 1,040 or 1,050.

Reaction.—The reaction of urine may be readily ascertained by the use of litmus-paper, which is prepared by soaking a thin but firm smooth paper in an infusion of litmus. It is desirable not to use blotting-paper, or any spongy form of paper, for this purpose. Urine, having an *acid* reaction, immediately reddens this blue paper.

The *alkaline* reaction of urine is ascertained by the use of *reddened litmus-paper*, prepared by adding a very small quantity of dilute acid to the infusion of litmus. An alkali always restores the *blue* colour of this reddened paper. If no change occurs when the urine is tested with both kinds of paper, the reaction of the specimen is *neutral.*

Acid Urine.—The cause of the acid reaction of urine is obscure, and probably does not always depend upon the presence of the same substance. Sometimes the reaction may depend upon carbonic acid, which is present in greater or less proportion in all the animal fluids. In this case, the blue colour of the paper is restored by gently warming it after it has been changed by the acid. A fixed acid reaction may be due to the presence of an acid phosphate of soda—a salt which exhibits an acid reaction, without the presence of any free acid. This salt may be formed by the action of uric acid upon common rhombic phosphate of soda. If a little uric acid be added to a solution of common rhombic phosphate of soda, the mixture will, while cold, exhibit the characteristic alkaline reaction of the salt; but, when heat is applied, decomposition occurs; the uric acid disappears, and combines with one equivalent of the soda to form urate of soda; and an acid phosphate of soda is produced. The acid reaction of urine, however, cannot always be explained in this manner; and it is certain that traces of free organic acids are present. Lehmann has found both free lactic and free hippuric acids in some specimens of urine. Lately, Hallwachs has shown that a large amount of hippuric acid salts exist in healthy human urine.

Many specimens of urine which are slightly acid when passed from the organism, become more strongly so after standing for some days, and crystals of uric acid are deposited. The acid reaction may remain for weeks or even months, but usually the acidity gradually diminishes, and the specimen at last becomes alkaline from the presence of carbonate of ammonia, formed in consequence of the decomposition of the urea. The researches of Scherer have proved that the gradually increasing intensity of the acid reaction, and the deposition of uric acid, were due to a process resembling fermentation, which was excited by the presence of a small quantity of mucus.

The intensity of the acid reaction of urine in health is continually undergoing change at different periods of the day. Dr. Owen Rees, in 1851, stated that "the degree of the acidity of the urine may, to a certain extent, be regarded as a measure of the acidity of the stomach" (Lettsomian Lectures, "Medical Gazette," vol. XLVIII, 1851). Dr. Bence Jones made some observations, which he thinks have proved that the acidity of urine alternates with that of the gastric juice. When the largest quantity of acid was being set free from the stomach, the acidity of the urine was at its minimum; and when the secretion of gastric juice was diminished, the urine exhibited a strongly acid reaction. The urine passed just before each meal, or at a long time after taking food, was stated to be intensely acid, while that which was secreted during the digestive process, for about three hours after a meal, was very slightly so, and in many instances was said to be decidedly alkaline. It is especially important to bear in mind the existence of these variations in the acidity of the urine in a state of health, and not to refer the intensely acid reaction of urine, secreted while no food is taken, to a morbid process requiring the exhibition of large doses of alkalies. Dr. Beneke, however, has made upwards of one hundred experiments upon healthy and diseased persons without being able to confirm Dr. Bence Jones' conclusion. In only one case did he find the urine *alkaline* after meals. Sometimes the acidity was less, but this was not invariably the case. Nevertheless, he admits that the acidity of the whole amount of urine passed varied considerably, although he could not discover the cause. It seemed to be independent of the quantity passed, and was not affected by exercise or food ("Archiv des Vereins für gemeinschaftliche Arbeiten zur Förderung der wissenschaftlichen Heilkunde," 1 Band, 3 Heft). Vogel, on the other hand, found that urine passed during the night was more acid than that secreted during the digestive process. Although the urine is by no means invariably alkaline after a meal, the acid reaction is always less intense. Dr. Roberts, of Manchester, has more recently performed a very extensive series of experiments upon this question ("Memoirs of the Literary and Philosophical Society of Manchester," vol. XV, 1859; "Treatise on Urinary and Renal Diseases," 1865, p. 22). He comes to the conclusion that, in two or three hours after a meal, the *acidity of the urine is diminished*, but that the secondary or remote effect of a meal is to *increase the acidity* of the urine. These results occur on an animal and also on a vegetable diet. Dr. Roberts considers that the above effects of the meal are due to the mineral constituents of the food, which contain alkali in excess of the phosphoric acid present. Hence arises the alkalinity of the blood; but if this increases beyond a certain point, the kidneys separate the excess, and the urine is alkaline. If, on the other hand, the blood is not sufficiently alkaline, the kidneys separate acid. Thus it would appear that the quantity of alkali in the blood is regulated by the action of the kidneys.

The intensity of the acid reaction is readily determined by ascertaining how much of a graduated solution of carbonate of soda is required to neutralise the acid in a given quantity of urine. Dr. Roberts found that on an average the total daily acidity of the urine of a healthy man was saturated by 14·10 grains of dried carbonate of soda. On one day, however, only 5·9 grains were required, and on another as much as 22·34 grains were necessary.

In stating the results, the degree of acidity is usually expressed as if it depended on oxalic acid—each degree of acidity corresponding to one grain of crystallised oxalic acid ($HO, C_2O_3, 2 Aq.$) In twenty-four hours, a proportion of acid is excreted which corresponds to from 30 to

60 grains of crystallised oxalic acid, according to Vogel. On estimating the quantity of acid, *see* "Volumetric Analysis," p. 112.

Alkaline Urine.—The alkaline reaction of a specimen of urine may be due to the existence of carbonate of ammonia, in which case the blue colour produced by testing it with reddened litmus is destroyed by the application of a gentle heat (*volatile alkali*); or it may depend upon the presence of an alkaline carbonate, as carbonate of soda, or a neutral salt having an alkaline reaction, like common phosphate of soda, in which cases the application of heat does not restore the red colour of the litmus-paper (*fixed alkali*).

Volatile Alkali.—The development of carbonate of ammonia in urine depends upon the decomposition of the urea by the action of the mucus or some animal matter, which acts the part of a ferment. In some diseases of the mucous membrane of the bladder, and in cases of paraplegia, where the muscular coat of the organ is paralysed, and consequently the secretion is retained for a long time, this change is very liable to occur. The pain and distress are much relieved by washing out the bladder thoroughly with tepid water. A mere trace of urine which has undergone this change is capable of exciting a similar decomposition in a very large quantity. It is important to notice that if pus be present in such urine, it becomes converted into a viscid glairy mass, which is removed from the bladder with the greatest difficulty. This action of the volatile alkali on the pus, precisely accords with that which occurs if ordinary liquor potassæ be added to a specimen of pure pus out of the body. Pus thus rendered glairy, forming a viscid adhesive mass at the bottom of the vessel containing the urine, is usually called *mucus*, but as I have said, it really consists of altered pus. If this action on the pus only occurs after the urine has left the bladder, it is unimportant, but when it occurs before its expulsion, it is always necessary to interfere, and if the change cannot be entirely prevented, owing to the existence of certain mechanical impediments to the escape of the urine, we must try to render the urine acid, and thus prevent its occurrence, by giving large and frequently repeated doses of hydrochloric or nitric acid, unless this treatment is contra-indicated, as in certain cases which I shall have occasion to refer to. In some cases the pus comes from the urethra, when it always escapes with the first portion of urine voided.

Whatever causes prolonged retention of the urine in the bladder, in the ureter, or pelvis of the kidney, will excite this change, and, as a consequence, roughening and ulceration of the mucous membrane may ensue, with the precipitation of phosphate of lime and ammoniaco-magnesian phosphate. More pus is formed, which effects the decomposition of the urea and aggravates the mischief already produced, and unless relief be afforded, complete disorganisation of the mucous membrane ensues. Volatile alkali is never detected in healthy urine.

Fixed Alkali.—Urine, however, often exhibits an alkaline reaction due to the presence of an alkali which is not volatile by heat, and this reaction is often to be met with in a state of health. When an alkaline carbonate is detected in the urine, it usually results from the decomposition of salts of certain organic acids in the organism. Salts of tartaric, racemic, citric, and, under some circumstances, those of oxalic and acetic acids, become resolved into carbonates in their passage through the organism, just as by the influence of a red heat they are converted into carbonates out of the body. The urine may always be rendered alkaline, and very quickly so, by giving such salts in sufficient quantity; and their administration is of great advantage in cases where benefit is likely to be derived from alkalies, especially where strong alkalies do not agree with the digestive organs. I believe that in many cases the alkali thus formed in the organism exerts a more beneficial influence than alkalies or their carbonates. The value of the juice of oranges and lemons in various conditions is to be attributed to this change.

If the alkaline reaction of the urine is due to the presence of carbonate of ammonia, crystals of triple phosphate, *see* plates of "Urinary Deposits," Phosphates, Part IV, and a deposit of phosphate of lime in a granular state, or in the form of globules or minute dumb-bells will be present; if, on the other hand, it depends upon fixed alkali, only the latter deposit without the crystals will be detected.

The quantity of alkali can be estimated by the ordinary process of alkalimetry. Dilute sulphuric acid containing a known quantity of pure sulphuric acid is added until the reaction is neutral to test-paper.

THE QUANTITY AND GENERAL COMPOSITION OF HEALTHY URINE.

It is very important in all cases to know the quantity of urine passed in a given period of time. The most minute chemical and microscopical examination often fails to show any fact of importance in the investigation of a case, in consequence of the quantity of urine passed in the twenty-four hours not having been measured. The practitioner desires to know, not only the quantity of urine passed (that is, water and solid matter together), but the absolute amount of solid matter dissolved in water. For this solid matter consists mainly of substances resulting from the disintegration of tissues and blood corpuscles. Such information can only be obtained by carefully measuring the entire quantity of urine passed in twenty-four hours, and evaporating a given amount of the *mixed urines passed at different periods of the day* to dryness. From the result obtained, the entire amount of solids passed can easily be calculated.

The amount of urine and the proportion of solid matter it contains vary very much, from day to day, in healthy persons. The temperature of the air, and the amount of moisture present in it; the state of the skin and mucous surfaces generally; the activity of the functions of respiration and circulation; the amount of exercise; the quantity and nature of the food, and, of course, the amount of fluid taken—are some of the circumstances which affect the *quantity* of the urine passed. The nature of the occupation also may materially influence the amount passed. But the amount of urine secreted in health varies according to the size of the individual, or rather according to his weight, and the activity of the nutritive changes, so that it is useless to attempt to fix definitively the average quantity passed by individuals generally. In round numbers, however, the proportion in health may be estimated at from 20 to 60 oz.; and a greater quantity is passed in the winter than during the summer months, because in cold weather less fluid escapes from the body through the skin. It is stated that rather more than two ounces of urine are secreted per hour, but during some periods of the day the secretion is much more active than at others.

It is clearly very important that we should have some general idea of the quantitative composition of healthy urine, and the amount of the various constituents which are excreted from the healthy organism in twenty-four hours. Those who are making observations on the urine in disease, should be acquainted also with the relative proportion of these different substances to each other in the healthy state. It is true that the healthy variations are very great; but, in certain cases of disease, the difference in the quantity is so considerable that the observer cannot fail to be struck with the importance of the fact. Thus, in health, from 400 to 500 grains of urea are excreted in twenty-four hours. In certain cases of kidney disease, when the cortical portion is impaired in structure, not more than 100 grains are eliminated; while, in some cases of fever, upwards of 1,000 grains have been removed within the same time. Of the significance of such facts there can be no question; and the physician cannot fail to reflect upon the very different chemical conditions under which life is being carried on in these cases. Without considering the many circumstances likely to affect these abnormal processes, how can we hope ever to gain that insight into the nature of disease which alone will enable us to modify or counteract the morbid change going on?

Analysis of Healthy Urine.—The composition of healthy urine is given in analyses 16, 17, 18 by Berzelius, Lehmann, and Dr. Miller.

16 is an analysis of 1,000 parts of healthy urine by Berzelius; 17 is one by C. G. Lehmann.

ANALYSES	16		17	
Water	933·00		932·019	
Solid matter	67·00	100·0	67·981	100·0
Urea	30·10	44·9	32·909	48·4
Uric acid	1·00	1·4	1·098	1·5
Lactic acid*	17·14 (Lactic acid, Uric acid, Water extract, Spirit and alcohol extract together)	25·5	1·513	2·3
Uric acid			1·732	2·6
Water extract			·632	1·0
Spirit and alcohol extract			10·872	16·0
Chloride of sodium	4·45	6·6	3·712 (Chloride of sodium and Chloride of ammonium together)	5·5
Chloride of ammonium	1·50	2·2		
Biphosphate of ammonia	1·65	2·4		
Alkaline sulphates†	6·87	10·2	7·321	10·8
Phosphate of soda	2·94	4·3	3·989	5·9
Phosphates of lime and magnesia	1·00	1·4	1·108	1·7
Mucus	·32	·4	·110	·3
Silica	·03	·04		

The following is an analysis of healthy urine by my friend Dr. W. A. Miller, of King's College :—

ANALYSIS 18.

Specific gravity		1,020	
Water		956·80	
Solid matter...		43·2	100·00
Organic 29·79‡	Urea	14·23	33·00
	Uric acid	·37	·86
	Alcohol extract	12·53	29·03
	Water extract	2·50	5·80
	Mucus	·16	·37
Fixed salts, 13·35	Chloride of sodium	7·22	16·73
	Phosphoric acid...	2·12	4·91
	Sulphuric acid	1·70	3·94
	Lime	·21	·49
	Magnesia	·12	·28
	Potash	1·93	4·47
	Soda	·05	·12

Total Quantity of Substances excreted in twenty-four hours.—But it is very important to be acquainted with the total quantity of the different ingredients excreted in twenty-four hours, and in order to ascertain this, the urine passed during the entire period of twenty-four hours must be collected and measured. From the results obtained, by analysing a portion of the mixed urine, the total quantity of the different ingredients

* It is now generally admitted that lactic acid and lactates are not constituents of healthy urine. ("Millers's Chemistry," Part III.)

† The distribution of acids and bases in these analyses is not warranted by facts. There is little doubt that every acid has a share of every base, and until we know the ratio of distribution, it will be better to state acid and base separately as in Miller's analysis.

‡ The expression of the constituents of the organic matters might be modernised by substituting for "alcohol extract" and "water extract," "hippuric acid, creatinine, ammonia, colouring matter, and unknown organic matter 15·03," or 34·83 per cent. of the total solids.

in the whole amount passed is easily calculated. The quantities of the different substances excreted in twenty-four hours, are stated under their proper heads, and a rough approximation of each is given in the table on p. 127.

Vogel gives the following estimate of the quantity of urine, and its most important constituents excreted in twenty-four hours in a state of health:—

Average quantity in twenty-four hours	52¾ to 56 oz.
Average specific gravity...	1,020
Average quantity of urea	556 grains.
Average quantity of chlorine	154 ,,
Average quantity of free acid, referred to 1 gr. of crystallised oxalic acid (HO, C_2O_3, 2 Aq.) as unity	33 ,,
Average quantity of total phosphoric acid, PO_5	66·7 ,,
Average quantity of total sulphuric acid, SO_3	30·88 ,,

Proportion excreted for each pound weight of the Body.—The relation of the quantity of urinary constituents excreted, to the weight of the body, is also a most important inquiry, and is generally stated at so much for each pound weight.

The following results, taken from Dr. Parkes, give the quantity of urinary constituents excreted for each pound weight of the body in twenty-four hours, adopting 145 lbs. as the average weight of all the men whose urine had been analysed.

Water	158·639 grains.
Urea	3·530 ,,
Uric acid	·059 ,,
Creatine (?)	·032 ,,
Creatinine	·048 ,,
Pigment and extractives	1·062 ,,
Sulphuric acid...	·214 ,,
Phosphoric acid	·336 ,,
Chlorine	·875 ,,

The table below is taken from a valuable paper by the Rev. S. Haughton, in the "Dublin Quarterly Journal," October 1862. The results accord, in some cases, very closely with those just given, but there is considerable difference in the quantities of uric acid, phosphoric acid, and chlorine.

	Excreted in 24 Hours.	Excreted in 24 Hours per pound of the body Weight.
Urine	23021·25 grains.	155·348 grains.
Water	22063·44 ,,	148·881 ,,
Solid matter	957·81 ,,	6·467 ,,
Urea	493·19 ,,	3·331 ,,
Uric acid	3·15 ,,	0·021 ,,
Phosphoric acid	32·36 ,,	0·218 ,,
Sulphuric acid	31·55 ,,	0·214 ,,
Chlorine	106·56 ,,	0·673 ,,
Extractives	175·27 ,,	1·183 ,,
Balance (viz., inorganic bases)	115·73 ,,	0·827 ,,

Variation of Quantity at different periods of life.—The proportion of the different constituents excreted varies, however, as already stated, at different periods of life. The amount of urine excreted is much greater, in proportion to the body weight, in children than in adults. In the fœtus and infant, however, the urine contains a very small quantity of solid matter. In a specimen of fœtal urine, examined by Dr. Moore (Heller's Pathology of the Urine), no urea was present. I found urea in a specimen taken at the seventh month. It contains also numerous casts of the uriniferous tubes with free epithelium but no albumen. The proportion of solid matter is not more than five parts in 1,000.

In young children of from 4 to 8 years, the mean age being 4 years and 2 months, and the mean weight 31 lbs., the quantity and composition as calculated from analyses of Scherer, Bischoff and others, by Dr. Parkes, is as follows:—

	In 24 hours.	Per lb. of the body weight in 24 Hours.
Water	10062·0 grains = f oz. xxiij.	324·58 grains.
Solid matter ...	426·0 ,,	13·70 ,,
Urea	178·8 ,,	5·77 ,,
Extractives	60·7 ,,	1·96 ,,
Fixed salts	186·9 ,,	6·03 ,,

In old age, on the other hand, the solids of the urine are considerably lessened. According to Lecanu, only about 125 grains of urea are excreted in twenty-four hours by old people. The uric acid is in about the ordinary proportion.

Although, in all works on the urine, tables of the average composition of urine are given, it must not be supposed that the numbers given are correct for every individual case examined. It has been clearly shown, not only that the proportion varies according to the weight of the person, the quantity of food taken, the amount of active exercise, and many other circumstances; but that the proportion of solid matter excreted for every pound weight of the body varies considerably in different individuals, in the same person at different times, and enormously at different periods of life. This, however, is no more than would be expected, since the proportion of the most important of the solid urinary constituents depends directly upon the quantity of matter disintegrated in the organism; and this, as is well known, is much greater in the child than in the adult; while in old age these changes are reduced to a minimum.

Average quantity of various Constituents in Healthy Urine.—With a view of giving a rough idea of the amount of the different urinary constituents excreted, and the proportion which these bear to each other, in twenty-four hours, I have arranged the results of numerous observations in a tabular form. The proportion of some of these substances is so variable, that it is impossible to give an average. In most cases, I have purposely given a round number, and avoided fractional parts; but in other instances, in which I have not been able to institute examinations for myself, and when the question has only been examined by one or two observers, I have given the exact figures published by the authority who has made the matter an object of special study. In constructing this table, I have not attempted to follow any single observer, but, with the exceptions alluded to, have put down numbers which appear to me to be tolerably correct. They have been obtained by consulting numerous authorities, and from my own analyses. This table, therefore, is only to be looked upon as a rough approximation to the truth. In the second column will be found the quantity of each constituent eliminated in twenty-four hours corresponding to every pound weight of the body; in the third column the composition of 1,000 grains of urine is given; in the fourth, the quantity of constituents in 100 grains of solid matter; and in the fifth, the percentage of composition of the salts.

It will be seen that, in round numbers, the solid matter composes about $\frac{1}{20}$th of the weight of the urine, and contains $\frac{1}{3}$rd of its weight of inorganic salts; of these last about $\frac{1}{3}$rd consists of sulphates, $\frac{1}{4}$th of chlorides, and the remainder of alkaline and earthy phosphates, in about the proportion of six to one. Of the organic matter, as much as $\frac{2}{3}$rds consists of urea, which therefore forms about one half of the entire solid matter in urine.

The figures in the table may be regarded as the proportion excreted by a strong healthy man in good nutrition, on full diet. Healthy women would excrete from one third less to half the quantities given in the first column.

Some exception may be taken to the numbers expressing the *relative* amount of the different ingredients. For instance, the proportion of urea to extractive matters undergoes the greatest variation. Sometimes the urea is double the weight of the extractives, while in other cases the numbers would be reversed. Many of the saline constituents also exhibit the greatest variations, not only in different individuals, but in the same person, on different days. Thus, the quantity of chlorides is twice as great on some days as on others, depending, as before remarked, partly on the amount taken in the food, partly upon the quantity of fluid and other saline matters. As yet, these extraordinary fluctuations have not fully been accounted for; but, doubtless, in time, the circumstances which determine them will be accurately made out.

Observations on Estimating the Excrementitious Substances.—The above table may, perhaps, assist the practitioner, in some measure, in remembering the general composition of healthy urine, and the proportion of the different constituents eliminated from the body in twenty-four hours. It is, however, quite impossible to use this or any other table as a

TABLE showing the amount of Urinary Constituents in grains excreted in twenty-four hours, and in 1,000 parts of Healthy Urine, with the percentage composition of the Solid Matter and Fixed Salts.

	Excreted in 24 hours.	Excreted for every pound weight of the body, of an adult weighing 145 lbs., in 24 hours.‡	In one thousand grains of urine.	In one hundred grains of solid matter.	In one hundred grains of salt.
Specific Gravity 1,015 to 1,025	40 oz. to 60 oz.				
Quantity	17,500grs. to 16,250 grs.				
Water	16,700 — 25,050	About 158·63	968·0—940·0		
Solid matter...	800 — 1,200	,, 8·0	32·0— 60·0	100·0	
Organic matter	600·0 — 900·0	,, 6·0	24·0 —45·0	75·0	
Saline matter	200·0 — 300·0	,, 2·0	8·0 —15·0	25·0	100·0
Urea	400·0 — 600·0	,, 3·53	12·0 —00·0	45·0	
Creatine	3·45* — 6·32*	,, ·03			
Creatinine	5·50* — 10·0*	,, ·05			
Uric acid	5·0 — 8·0	,, ·06	·3 — 1·0	1·5	
Hippuric Acid	7·50 — 30·0†				
Extractives and colouring matter ...	140·0 — 200·0	,, 1·06	9·0 —20·0	20·0	
Free Acid	20·0 — 30·0	... ...	·32— ·64	1·0	
Ammoniacal Salts	6·0 — 15·0	... ...	1·50— 3·0	5·0	
Mucus...	10·0 — 30·0	... ...	·1 — ·4	1·0	
Sulphates	50·0 — 85·0	... ...	1·5 — 6·0	8·0	30·0
Alkaline Phosphates	60·0 — 100·0 or 160	... ...	2·0 — 9·0	9·0	38·0
Earthy Phosphates	6·0 — 20·0	... ...	·5 — 1·2	1·5	6·0
Chlorides	100·0 — 300·0	... ...	4·0 — 8·0 or more	7·0 or more	25·0 or more
Chlorine	60·0 — 180·0	·88	2·4 — 4·8	about 4·2	15·1
Sulphuric Acid	25·0 — 42·0	·21	·75— 3·0	4·0	15·0
Phosphoric Acid	30·0 — 50·0 or 80	·34	1·0 — 4·5	4·5	19·0

The numbers in the first column are *high*, and must not be considered to represent the smallest proportions excreted consistent with health.

* Thudichum. † Hallwachs. ‡ The numbers in this column are taken from Dr. Parkes.

standard of reference, because the proportion of the urinary constituents secreted in health is very different in different individuals. Before we can judge if a man is passing too much or too little of any substance, we must ascertain his weight, and form some general idea of the activity of his vital actions when he is in a state of health. For example, the statement that a patient is passing daily 150 grains of urea, indicates nothing; for a small woman, in good health, weighing 80 lbs. or less, secretes daily even less than this; but if this amount only were excreted by a tall, strong, active, healthy man, weighing 170 lbs. or more, it would indicate a very serious state, and we should know from this fact alone that he was in the greatest danger. In such a case, the secreting structure of his kidneys must be temporarily or permanently affected, and, unless relief be afforded very soon, death must result from the accumulation of excrementitious substances in the blood.

If it is proposed to conduct a series of researches with the object of ascertaining the proportion of excrementitious substances produced in, and removed from, the organism, the weight of the individual should always be taken, and the amount of ingesta must be estimated daily. The quantity of excrementitious substances generally, including the sweat, must be determined. There is very much to be made out by a careful series of researches of this kind in the cases of patients suffering from various acute affections; and, since the introduction of the volumetric process of analysis, p. 99, we have had great facilities for conducting such inquiries.

Weighing Machines.—In many cases, the most valuable information bearing upon the progress of the case may be gained by the simple process of weighing the patient, which is too seldom adopted. How often in the course of many diseases one desires to know simply if the patient has gained or lost in weight! All our hospitals and public institutions ought to be furnished with weighing machines. The best weighing machines are, unfortunately, very expensive. A good simple apparatus, which can be made for a moderate sum, is much required. Messrs. Weiss construct an improved apparatus, suitable for the practitioner, but the price of this is ten guineas. Mr. Young, of Cranbourne Street, W.C., also makes excellent weighing machines. A very useful machine is supplied by Messrs. Pooley, of Liverpool, and Fleet Street, London, which is well adapted for ordinary observation, and costs less than four pounds.

THE CONSTITUENTS OF HEALTHY URINE.

It is convenient to divide the constituents of healthy urine into three classes, viz. :—I, Volatile Constituents ; II, Organic Constituents ; III, Inorganic Constituents.

The first class includes those substances which are volatilised at the temperature of a steam-bath (212° F. or less). The most important of these are, *water*, *carbonic acid*, and *certain ammoniacal salts*.

The second class contains those organic constituents which are not volatilised at a temperature of 212°, but which are decomposed at a red heat. The most important of these are, *urea*, *uric* or *lithic acid*, *hippuric acid*, with *urates* and *hippurates*, *mucus* from the bladder or other parts of the urinary mucous membrane ; *creatine* (?), *creatinine*, and various indeterminate uncrystallisable substances included under the head of *extractive matters*. *Colouring matters*, p. 147, and certain peculiar organic acids, traces of *sugar*, with perhaps traces of *leucine*, *tyrosine*, *see* part III, and one or two other less important organic matters, might be included in this class.

In the third class are found various *saline matters* which remain fixed after the organic matter has been destroyed by a red heat, and the carbon which results removed by prolonged exposure to a dull red heat in contact with the air. These inorganic constituents consist principally of *chlorine*, *sulphuric*, and *phosphoric acids*, in combination with *sodium*, *potash*, *soda*, *lime*, *magnesia*, *iron*, and sometimes *alumina*, with traces of *silica*.

I.—VOLATILE CONSTITUENTS OF HEALTHY URINE.

Water.—Healthy urine contains from 940 to 960 grains, or even more, in 1,000. The proportion of water is much influenced by various circumstances, especially by the quantity taken in the food, the activity of the skin, and the presence of various substances which influence the chemical changes going on in the tissues, or affect the secreting action of the kidneys. The mode of estimating the proportion of water has been before alluded to. At first this would be supposed to be a very simple matter, but in practice it is found to be one of the most difficult operations in analysis, because many of the organic constituents of urine are prone to undergo change at a very moderate heat, and even at the temperature of the air, if the concentration is effected too slowly. Practically, it is the best plan to concentrate the urine at a temperature of 100° F., and then continue the evaporation *in vacuo* over sulphuric acid until the residue ceases to lose weight.

Carbonic Acid is held in solution in fresh urine : indeed, traces may be detected in all the animal fluids. Its presence may be shown by passing some pure hydrogen gas through urine. After the gas has traversed the fluid, it should be conducted into pure lime water, which will become turbid if there be an appreciable quantity of carbonic acid present. This experiment is founded upon the fact that, if one gas be passed through a solution of another gas, the latter will be displaced by it. By distillation, also, the presence of carbonic acid may be shown; but, in this process, great care must be taken to prevent the production of carbonate of ammonia, which would, of course, cause a precipitation of carbonate in lime or baryta water. The fluid may be made to boil at a temperature of 120° F., if the air be exhausted. There are certain peculiar volatile acids which will be described with the other acids of the urine, p. 152. *See* also p. 118.

Ammonia and Ammoniacal Salts.—Another volatile constituent of urine is *ammonia.* The presence of this substance in healthy urine has been doubted by many; but Heintz has shown that the addition of chloride of platinum to fresh urine causes a precipitate which consists of the potassio-chloride of platinum, with a certain quantity of the ammonio-chloride of platinum; the amount of the latter being estimated by determining the quantity of the potassio-chloride in a separate experiment. Neubauer has obtained thirteen grains of ammonia from the urine passed in twenty-four hours. Ammonia exists as urate; it is also found in combination with hydrochloric acid, with phosphoric acid and soda, and with phosphoric acid and magnesia. Chloride of ammonium is also present. Neubauer and Kerner estimate the quantity of chloride of ammonium at about 35 grains in twenty-four hours.

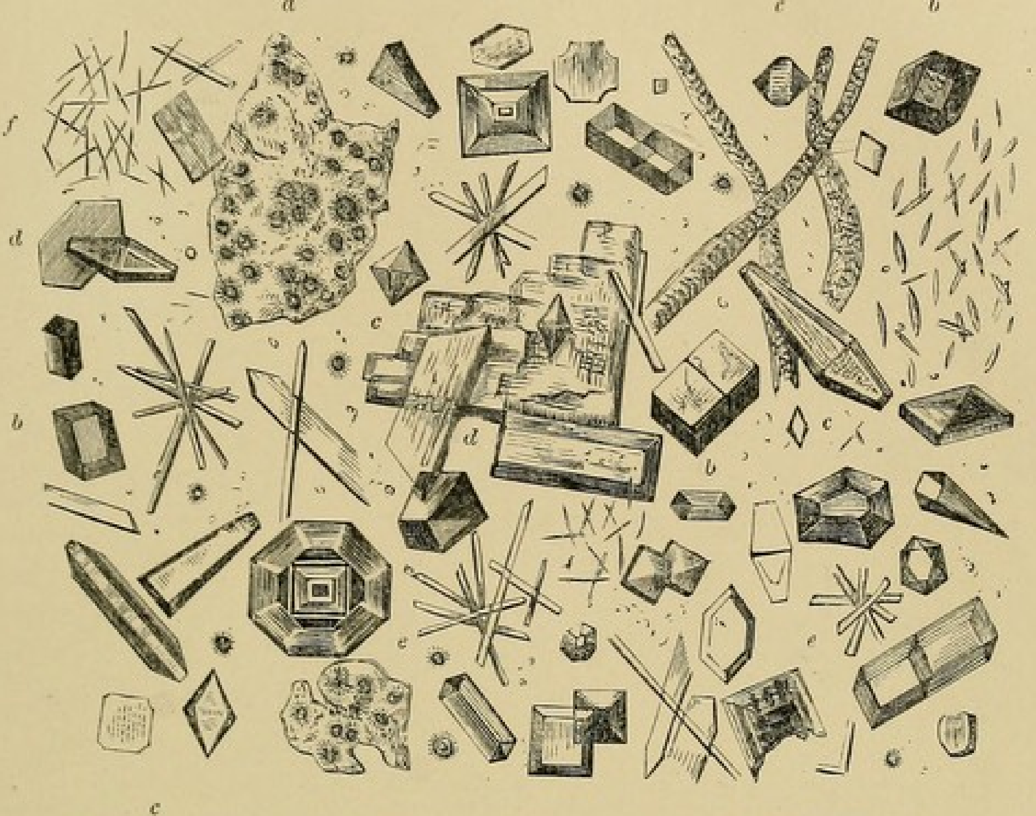
Ammonia is likewise given off during the decomposition of several of the organic constituents of the urine by heat, as indeed it is from many other nitrogenous organic substances. Thus, if a portion of the solid residue of urine be exposed to a temperature short of redness in a small glass tube, much very offensive vapour will be given off, and a carbonaceous residue will remain in the tube. If a piece of reddened litmus or turmeric paper, moistened with distilled water, be applied to the mouth of the tube as soon as it is heated, the blue colour of the former will be restored, and the latter will assume a dark brown tint—reactions which indicate the existence of volatile alkali or ammonia, which arises from the decomposition of nitrogenous matters.

II.—ORGANIC CONSTITUENTS OF HEALTHY URINE.

Many of the constituents of healthy urine may be obtained in a crystalline form by allowing a few drops to evaporate, at a moderate temperature (about 140° F.), upon a glass slide, or in a shallow oval glass cell. In this manner, crystals of urea, urate of soda, chloride of sodium crystallised in cubes and octahedra, phosphates, and sulphates,

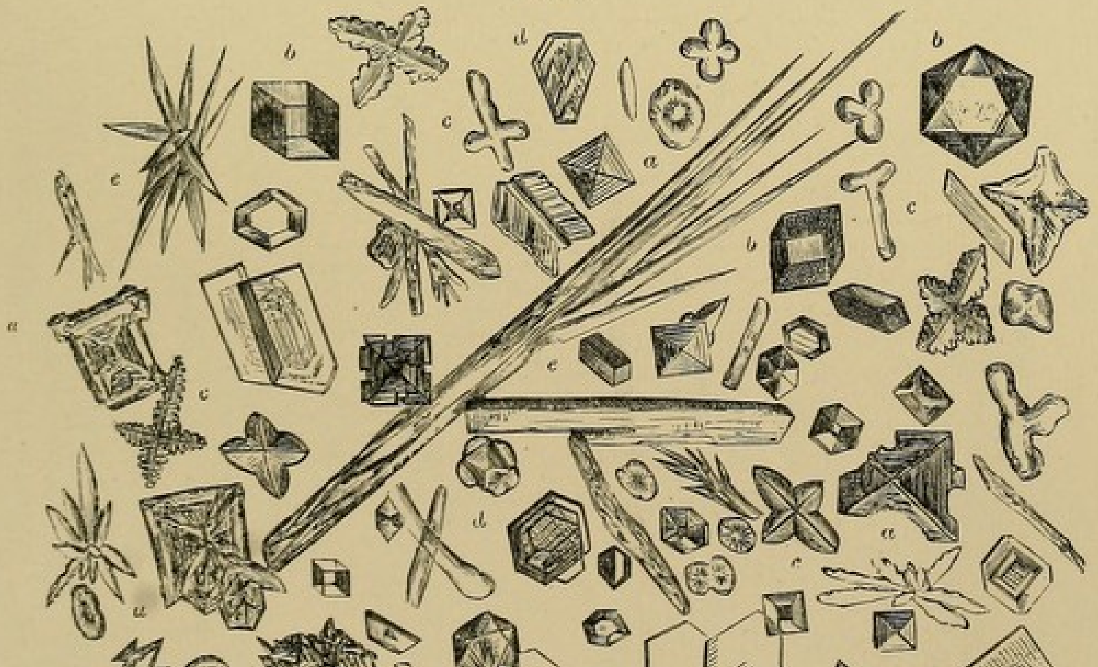
ILLUSTRATIONS OF URINE.

Fig. 1.



Crystalline residue of healthy urine, obtained by concentrating the liquid over a water bath *a*, spherical masses consisting of aggregations of crystals of urate of soda. Many of these are seen deposited upon a film consisting of phosphate of lime and ammoniaco-magnesian phosphate *b*, cubical crystals of chloride of sodium *c*, octahedral crystals of chloride of sodium, which crystallizes in this form in the presence of urea. *d*, large crystals of common phosphate of soda. *e*, sulphates. *f*, urates. × 40. p. 131.

Fig. 2.



Crystals of inorganic salts of healthy urine, obtained by incinerating the dry residue, decarbonizing it, and extracting it with water The solution being concentrated to the proper degree, readily crystallizes. *a*, crystals of common salt, obtained by evaporating the solution nearly to dryness. *b*, crystals of common salt formed in a concentrated solution. *c*, crosslets of common salt obtained by evaporating the solution very rapidly to dryness *d*, crystals of phosphate of soda. *e*, crystals of sulphates. p. 156. × 130.

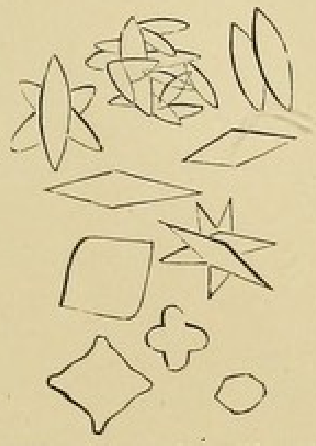
[To face page 130.

ILLUSTRATIONS OF URINE.

Fig. 3.

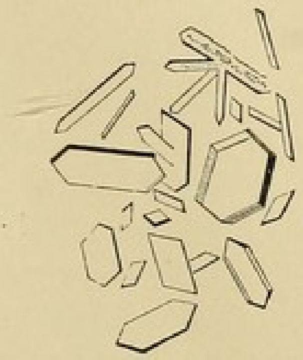
Chloride of ammonium.
× 215. p. 130.

Fig. 4.



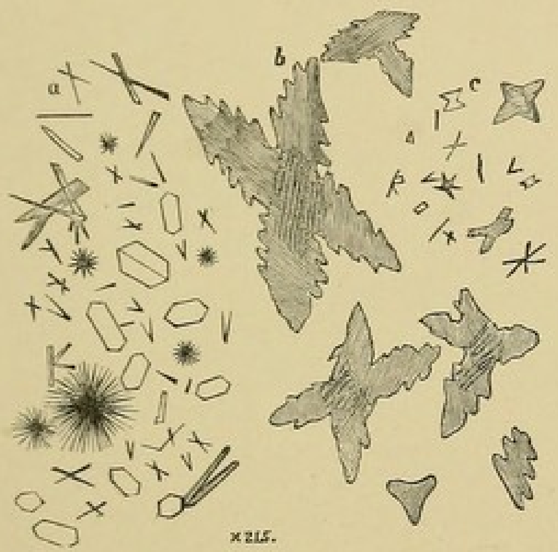
Crystals of uric acid. × 215. p. 139.

Fig. 5.



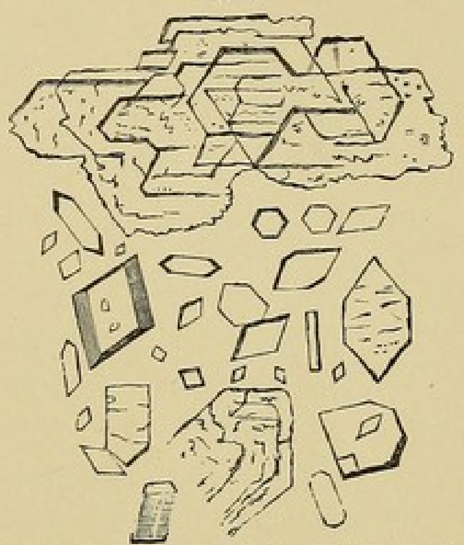
Oxalate of urea, obtained by adding oxalic acid to concentrated urine.
× 215. p. 132.

Fig. 6.



Crystals of indigo, *a* and *b*, obtained by sublimation.
c, small crystals in fluid. p. 148.

Fig. 7.

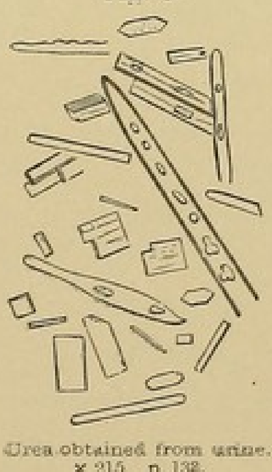


Nitrate of urea. *a*, crystals obtained from urine; *b*, crystals of pure nitrate of urea. × 215. p. 132.

Fig. 8.

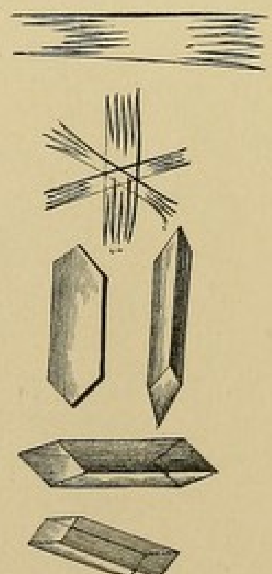
Crystals of uroglaucine from the urine. *a*, small masses of a blue colour; *b*, composed of small spherical particles. *c*, crystals of uroglaucine of a deep purple or violet colour.
× 403. p. 148.

Fig. 9.



Urea obtained from urine.
× 215. p. 132.

Fig. 10.



Crystals of hippuric acid.
Robin and Verdeil.
p. 142.

[To follow PLATE I.

may be readily obtained. The observer should make himself familiar with the appearance of these crystals.—" Illustrations of Urine," &c.; *Urine*, pl. I, fig. 1.

The quantity of the organic constituents varies very much, as would be supposed. In healthy urine, about three fourths of the solid matter consist of organic substances, and there may be found from 12 or 14, to 45 or 50 grains in 1,000 grains of urine. The mode of estimating the amount of solids has been already referred to, p. 129. The quantity of the organic constituents is easily obtained by burning a weighed portion of the solid matter, and by subtracting from the amount the quantity of saline residue which remains after incineration. The result gives the quantity of organic matter.

Urea ($C_2H_4O_2N_2$).—The most important of the organic constituents of urine is urea. It is a crystalline substance, very soluble in hot water, and in four or five parts of cold water, soluble in alcohol, but insoluble in pure ether, deliquescent, readily crystallised if pure, but the presence of certain organic substances seriously interferes with its crystallisation. Good crystals of urea may nevertheless be obtained by simply evaporating some specimens of urine upon a glass slide, at a moderate temperature. Urea has a cool saline taste, is perfectly colourless when pure, but is highly retentive of the colouring matter of urine. In order to obtain perfectly colourless urea from urine, it is necessary to expose it in a diluted state to the prolonged action of animal charcoal.

Quantity.—Urine in health contains from 12 or 15 to 30 or 40 parts of urea per 1,000; and as much as from 400 to 600 grains of solid urea are excreted from the body of a strong healthy man in twenty-four hours. The solid matter of healthy urine contains half its weight of pure urea. The amount of urea excreted in twenty-four hours, corresponding to each pound weight of the body, is about 3·5 grains. So that a healthy man, weighing about 140 lbs., ought to secrete during the twenty-four hours nearly 500 grains of urea. In infants and children, however, a much larger quantity in proportion to the weight of the body is secreted. From some calculations of Dr. Parkes, based on analyses made by Scherer, Bischoff, and Lecanu, it appears that a child, weighing about 30 lbs., and four years of age, will excrete for each pound weight of the body nearly 6 grains of urea in twenty-four hours.

The Rev. S. Haughton (in a paper read before the Association of the King and Queen's College of Physicians, Dublin, 1860) has endeavoured to show that, of the urea secreted, certain proportions represent respectively the *vital*, *mechanical*, and *mental* work performed in the organism. Men employed in ordinary routine bodily labour may be well fed on a vegetable diet, and discharge 400 grains of urea daily, of which 300 grains are spent in *vital*, and 100 grains in *mechanical* work.

If the work is of a higher order, better food must be supplied, and 533 grains of urea are excreted. Of this quantity 300 grains are spent in *vital*, and 233 grains in *mental* work and *the mechanical* work necessary to keep the body in health.

Detection.—Nitrate of Urea ($C_2H_4N_2O_2,HO,NO_5$).—The presence of urea is very easily detected, if the solution be moderately strong. If a few drops of strong nitric acid be added to urine which has been slightly concentrated by evaporation, and afterwards allowed to cool, a number of beautiful sparkling crystalline lamellæ immediately make their appearance. These crystals of *nitrate of urea* are not very soluble in the solution, and are easily recognised by their microscopical characters, pl. III, figs. 1 to 6, pl. IA, fig. 7.

The character of the crystals varies slightly according to the amount of acid added, and the degree of concentration of the urea solution.

Not unfrequently, especially in cases of acute disease, in this country, the urine contains so much urea when passed, that it crystallises upon the addition of nitric acid without previous evaporation. It appears from the observations of foreign authorities that such examples are rarely if ever met with on the continent.

The ordinary test for the presence of urea depends upon the slight solubility of the crystals of nitrate of urea in water, and the readiness with which this salt is formed when nitric acid is added to a solution containing urea. When, however, only traces of urea are present in an animal fluid, as in blood, it is better to evaporate to dryness in the first instance, and extract the dry residue with alcohol. After filtration, the alcoholic solution is evaporated to the consistence of a syrup, and, if necessary, a few drops of water are added. If urea be present, the characteristic crystals will be formed upon the addition of nitric acid. By this process the urea is separated from most of the saline matters, from albumen and other substances, which would interfere with the formation of good crystals of the nitrate.

Oxalate of Urea ($C_2H_4N_2O_2,HO,C_2O_3$).—If, instead of nitric acid, a concentrated solution of crystals of oxalic acid be added to the concentrated urine, numerous crystals of *oxalate of urea* would be formed. The oxalate is also a very insoluble salt, and, like the nitrate, crystallises in rhomboidal plates; but the crystals are more perfectly formed, and the inclination of the angles is different, pl. IV, figs. 1 and 2, pl. IA, fig. 5.

A solution of pernitrate of mercury (mercuric nitrate) also forms a precipitate with urea; but in order to apply this test, all the chloride of sodium and phosphates must be removed. Liebig has proposed a most simple and highly efficacious plan for estimating the quantity of urea by ascertaining the amount of a solution of pernitrate of mercury, of known strength, which is required to throw down the whole of the urea in a given volume of urine. This process for estimating

[*To face Page* 132.

ILLUSTRATIONS OF URINE.

Plate II.

Urea, $C_2H_4N_2O_2$.

Fig. 1. Urea obtained from urine crystallized in its own mother liquor.

Fig. 2. The same examined in the dry way.

Fig. 3. Small crystals of urea formed in a concentrated solution of natural urea.

Fig. 4. Similar crystals of larger size.

Fig. 5. Artificial urea crystallized. Examined in the dry way.

Urea.

Pure urea may be easily obtained by the decomposition of the nitrate or oxalate of urea. The crystals represented in fig. 1 were made by decomposing pure oxalate of urea with common chalk. An oxalate of lime is formed, which is separated by filtration, and the urea remains in solution. From the nitrate, urea may be obtained by adding carbonate of baryta — nitrate of baryta and urea result; the latter may be separated by evaporation to dryness, and extraction with alcohol, which dissolves the urea and leaves the nitrate of baryta.

For the mode of preparing the nitrate and oxalate of urea, see page 132. Pure urea may also be obtained artificially by evaporating cyanate of ammonia to dryness.

URINE-II

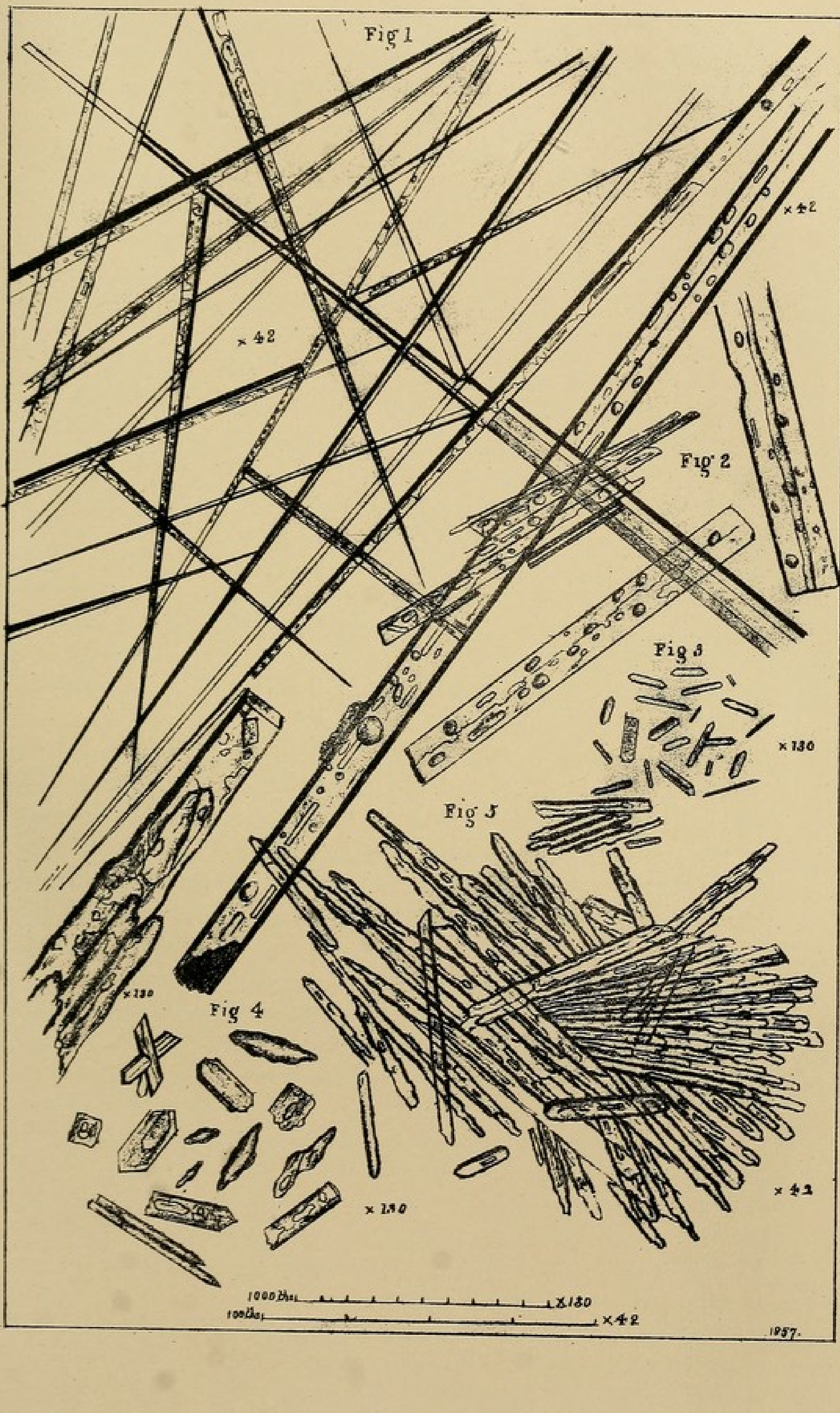


Fig 1
× 42
× 42
Fig 2
Fig 3
× 130
Fig 5
× 130
Fig 4
× 130
× 42
1000 lbs.
× 130
100 lbs.
× 42
1857.

the quantity of urea, as well as the simple plan proposed by Dr. Davy, has been described in p. 113. Other plans of estimating urea have been proposed, but they are more complicated than the above. Urea in solution is decomposed by nitroso-nitric acid—carbonic acid and nitrogen being rapidly given off. Draper's process is founded upon this fact ("Phil. Mag.," vol. VI, series IV, p. 290). Bunsen and Ragsky have recommended other methods based upon the decomposition of urea into carbonate of ammonia. By ascertaining the quantity of carbonic acid or of ammonia formed, the proportion of urea can be calculated ("Quarterly Journal of Chemial Science," vol. I, p. 420).

Characters.—Urea crystallises in four-sided prisms, which seem to be composed of a number of acicular crystals, "Illustrations of Urine," pl. II, fig. 1. Hollow spaces are usually present in the interior of the crystals in considerable number. These contain a fluid differing considerably in refractive power from the crystal itself. When the crystals are dried, these spaces are occupied with air. They are seen in almost all the crystals represented. It is curious that urea causes common salt, which, under ordinary circumstances, crystallises in cubes, to crystallise in octahedra; and chloride of ammonium, which crystallises in octahedra, to crystallise in cubes, "Illustrations of Urine," pl. I, fig. 1.

Urea melts at 248° F., and is decomposed at a higher temperature; cyanate of ammonia and carbonate of ammonia being among the products of the decomposition. It is not decomposed by being boiled in pure water, but mere traces of putrescent animal substances excite rapid decomposition even in the cold. Yeast also exerts the same effect; and mucus and pus produce this decomposition very rapidly, as already remarked under the head of "volatile alkali," p. 120. The rapid evolution of carbonate of ammonia from urine which has been placed in a dirty vessel, is explained in the same manner.

In the laboratory, urea may be formed artificially (Urine, pl. II, fig. 5). By allowing cyanate of ammonia to evaporate to dryness, it becomes converted into urea, in which neither cyanic acid nor ammonia can be detected. Urea is one of the products formed by the action of peroxide of lead on uric acid, and it is also produced by the action of alkalies upon alloxan and creatine. Béchamp stated that he had obtained urea directly from the action of oxidising substances on protein compounds, as permanganate of potash upon albumen. This experiment has been many times tried in my laboratory without success, and several chemists have failed to confirm Béchamp's results; so that we may consider that, up to the present time, no one has succeeded in producing urea directly from the tissues, or from albuminous substances. It is certain that the idea of all oxidised substances being formed by the direct oxidation of chemical compounds already existing in the blood and animal juices is quite erroneous. For the most part the presence of living germinal matter is necessary to the chemical change.

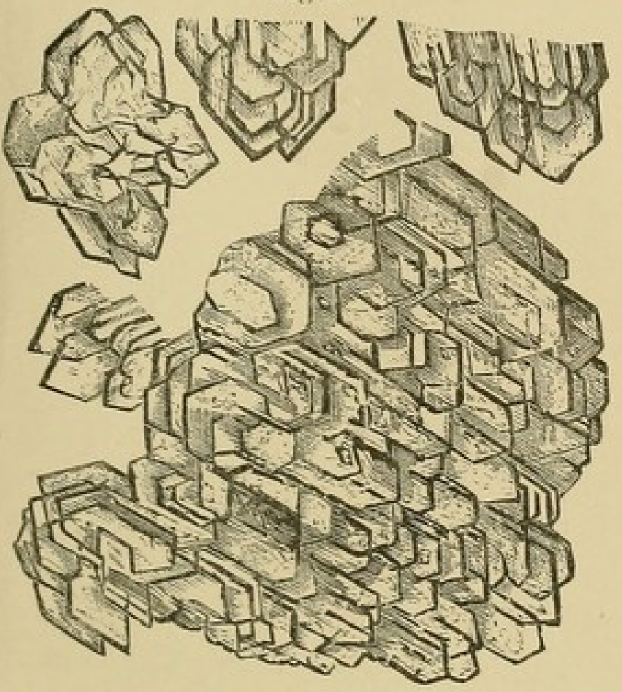
If it is desired to obtain a specimen of pure urea from urine, an *oxalate* or *nitrate* is first prepared, purified by being recrystallised, dissolved in water, and heated for some time in contact with pure animal charcoal. When the solution is colourless, it is decomposed with chalk or carbonate of barytes. The solution of urea is evaporated to dryness on a steam-bath, extracted by alcohol, and the solution concentrated, so that crystals may form. The pure crystals are very deliquescent; but they may be dried and preserved for any length of time, if carefully excluded from the air. They form beautiful microscopic objects. "Illustrations of Urine," pl. II.

Rich in nitrogen, very soluble in water, readily diffused through large quantities of fluid, and possessing considerable power of permeating animal membrane, urea may be regarded as the principal product resulting from the disintegration of nitrogenous tissues, through the agency of living matter, and as one of the most important excrementitious substances found in the animal organism. Not only is urea derived from the products resulting from the disintegration of muscular fibre, but any excess of albuminous materials taken in the food is removed from the body chiefly in the form of urea. It must, however, be borne in mind, that the urea does not exist in the fluid expressed from the muscles. Part of the urea excreted is probably formed in the blood, but the greater proportion is formed in the kidneys.

Circumstances affecting the Formation of Urea.—The quantity and nature of the food, and all circumstances which affect the nutrition and repair of the tissues, will exert an influence upon the quantity of urea formed in a given time. A liberal diet, rich in albuminous substances, and active exercise, combined with a healthy state of the organs of respiration and circulation, cause the formation of a large quantity of urea; while indolent habits, a diet rich in carbon and poor in nitrogen, insufficient food of any kind, an unhealthy state of the lungs and circulatory organs, and an imperfect supply of good air, will diminish the proportion formed. It need hardly be said that a greater quantity of urea is formed while we are awake than during sleep; by strong muscular persons, than by weak ones; by men than by women; in winter, when a small quantity of excrementitious substances is removed by the skin, than in summer, when the perspiration is abundant.

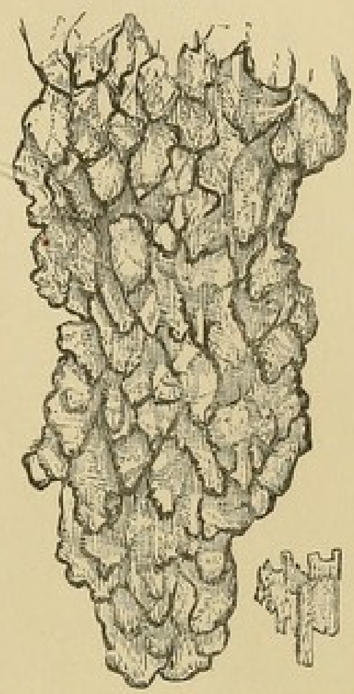
It has been supposed that urea is formed in the organism by the oxidation of uric acid and other substances, but it is more probable that if the fluids are rich in oxygen, urea results from the changes occurring in germinal matter, while, if little oxygen be present, uric acid and other less highly oxidised matters are formed in larger proportions. A certain quantity of oxalic acid, and substances of a lower degree of

Fig. 1.



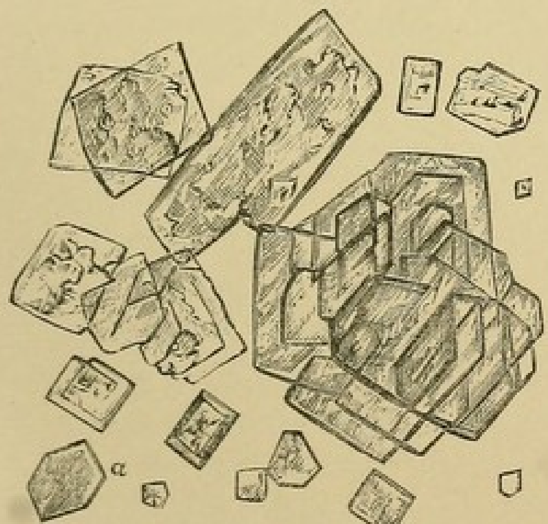
Crystals of nitrate of urea ($C_2H_4N_2O_2$, HO, NO_5) formed by adding excess of nitric acid to concentrated urine. × 130. p. 132.

Fig. 2.



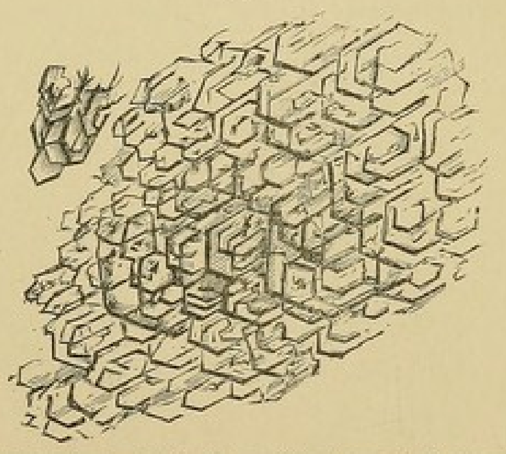
Nitrate of urea formed by adding a quantity of nitric acid not sufficient to combine with the whole of the urea present. × 130. p. 132.

Fig. 3.



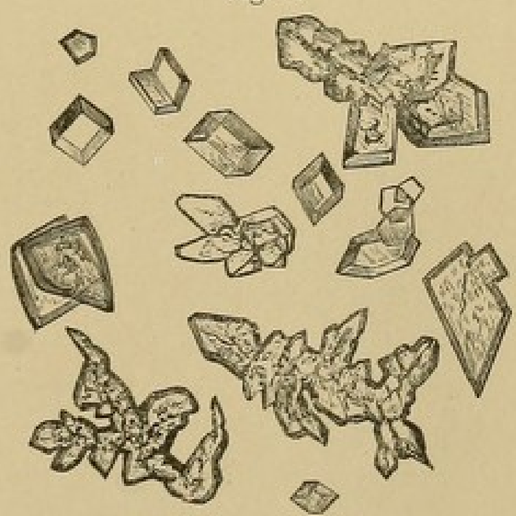
Nitrate of urea, obtained by adding a moderate quantity of nitric acid to slightly concentrated urine in a test tube, and allowing it to crystallize slowly. × 130.

Fig. 4.



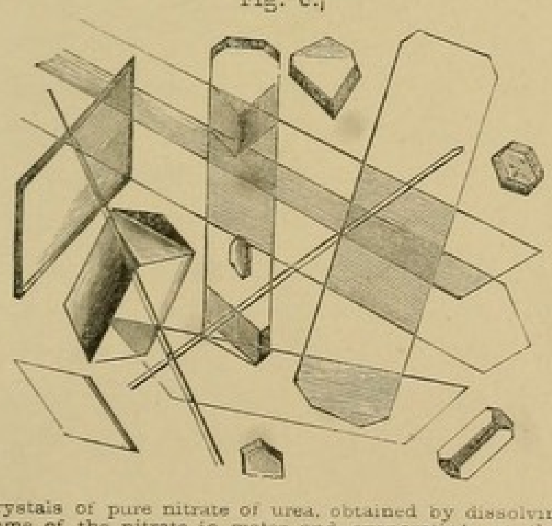
Nitrate of urea, obtained by adding a marked excess of nitric acid. × 130.

Fig. 5.



Nitrate of urea, formed by adding only two drops of nitric acid to highly concentrated urine. × 130.

Fig. 6.



Crystals of pure nitrate of urea, obtained by dissolving some of the nitrate in water and evaporating, so that crystals may form. × 130.

[To face page 134.

oxidation than urea, may also be produced. Wöhler and Frerichs have shown that, if uric acid be taken at night, oxalate of lime is found in the morning urine ; and Neubauer found that, when rabbits were made to take a considerable quantity of uric acid with their food, the urea in their urine increased from 1·34 to 4 grammes (from 20·67 to 61·72 grains). Large quantities of fluids cause an increase in the proportion of urea formed in the organism. A dilute state of the solids is favourable to their oxidation ; and in certain conditions, where these changes are but imperfectly carried on, and in consequence uric acid accumulates in the blood, or at most is resolved into oxalic acid, the further oxidation is promoted by the administration of increased quantity of fluid, especially of fluids containing alkalies which not only increase the activity of the changes, but effect the solution of the insoluble uric acid and urates. Hence the benefit of alkaline waters, baths, moderate exercise, and plenty of good air, in gout and other conditions in which much more uric acid is formed than can be, under ordinary circumstances, converted into urea.

Influence of Salt.—The quantity of urea excreted is also increased by common salt (Bischoff). It is probable that chloride of sodium not only, so to say, filters through the different tissues, like other saline substances, and thus drives out other materials which are contained in their interstices ; but that it also facilitates the occurrence of chemical change in the body, and directly influences the quantity of urea formed. The importance of chloride of sodium in cell-growth, during the development of different textures, and its value in nutrition generally, are well known.

Influence of Alkalies.—The beneficial effect of alkalies in different cases is acknowledged by all ; and it is probable that this is in part to be explained by the influence they have been proved to possess in promoting chemical change in the body, and especially in favouring the oxidation of albuminous substances. Dr. Parkes has shown conclusively, in an elaborate series of experiments, that liquor potassæ exerts a direct influence of this kind. (" On the Action of Liquor Potassæ on the Urine in Health," British and Foreign Medico-Chirurgical Review, vol. XIV, p. 258, January, 1853.) The percentage of solids in the urine is increased ; the urea seemed to be increased somewhat ; but Dr. Parkes considers this only a probable effect of the alkali. The proportion of sulphates was augmented in all the experiments. Franz Simon long ago showed that the sulphates were always increased whenever an increased proportion of urea is formed ; and the researches of Dr. Bence Jones and my own analyses lead to the same conclusion. In Dr. Parkes' experiments, the acidity of the urine was hardly affected by the liquor potassæ ; and the whole of the potash taken (2 drachms) was entirely excreted in the urine, in the form of sulphate, in a very short time,—if taken on an empty stomach, in from thirty to ninety minutes. Such facts assist in the most important degree to elucidate some of the most complicated chemical changes going on in the organism, and afford valuable information as to the nature of various morbid changes, as well as suggest the means by which these may be modified or counteracted.

Influence of Alcohol.—On the other hand, both the solids (urea, extractives, uric acid, sulphuric acid by 13 grains daily, phosphoric acid, chloride of sodium very considerably), and fluid of the urine are diminished by alcohol; so also is the proportion of carbonic acid exhaled. Tea causes a diminution both in the quantity of urine and fæces, as the beautiful researches of Dr. Böcker have conclusively proved. ("Beiträge zur Heilkunde," vol. I, "Medico-Chirurgical Review," vol. XIV.) Hammond's observations confirm Böcker's in the most important particulars ("American Journal of Medical Science," October, 1856). Coffee exerts a similar effect, which seems to be due, not to the caffein, but, according to Julius Lehmann, to the empyreumatic oil which it contains. These substances, tea, coffee, and alcohol, in moderate quantity, affect the disintegration of tissue, and directly diminish the quantity of the excrementitious substances formed in the process. Supposing the food to be insufficient, the loss of weight which must necessarily take place in the body would be lessened; and they may, therefore, be regarded as advantageous, not only in economising the food, but in limiting to some extent the waste of the albuminous tissues. Probably these substances directly interfere with the disintegration of the blood corpuscles.

Origin.—It used to bestated that no urea was formed in the kidneys, because it had been shown to exist in the blood. It was held that urea was merely selected or separated from the nutrient fluid by the cells of the uriniferous tubes, but it is now almost certain that much of the urea is actually *formed* in the kidneys. Urea is with difficulty detected in healthy blood, because it is prevented from accumulating in that fluid in sufficient quantity by the selective power of the renal epithelium.* If the secreting action of the kidneys be impaired by disease, or if the blood be prevented from flowing through them, urea will accumulate in the blood to a considerable extent, and interfere with the function of other organs, especially the brain; and may in many cases be very readily detected by chemical tests. Under these circumstances, an incomplete removal of the urea will take place through other channels. It has been detected in the fluids of the intestinal canal, in vomited matters, in the

* Dr. Thudichum attributes the failures of observers to detect urea in the blood, to their precipitating the albumen by heat. If the blood be treated with strong alcohol, the urea is dissolved, and the albumen rendered insoluble at the same moment. The former can be detected in the alcoholic solution.

[*To face Page* 136.

ILLUSTRATIONS OF URINE.

PLATE IV.

Oxalate of Urea, $C_2H_4N_2O_2$, HO, C_2O_3.

Fig. 1. Crystals of oxalate of urea, obtained by re-crystallizing nearly pure oxalate of urea from an aqueous solution. *a.* Dendritic masses, in which the form of the crystal is not very distinct. *b.* Masses of well formed crystals. *c.* Perfect crystals of oxalate of urea.

Fig. 2. Crystals of oxalate of urea obtained by evaporating healthy urine to dryness, and extracting the residue with alcohol; the alcoholic solution was then evaporated to dryness, and water added until the residue had a syrupy consistence; to this oxalic acid crystals were added in sufficient quantity to form an oxalate with the urea present. *d.* Represents the general character of the crystals of oxalate usually formed in this manner. *e.* More perfect crystals.

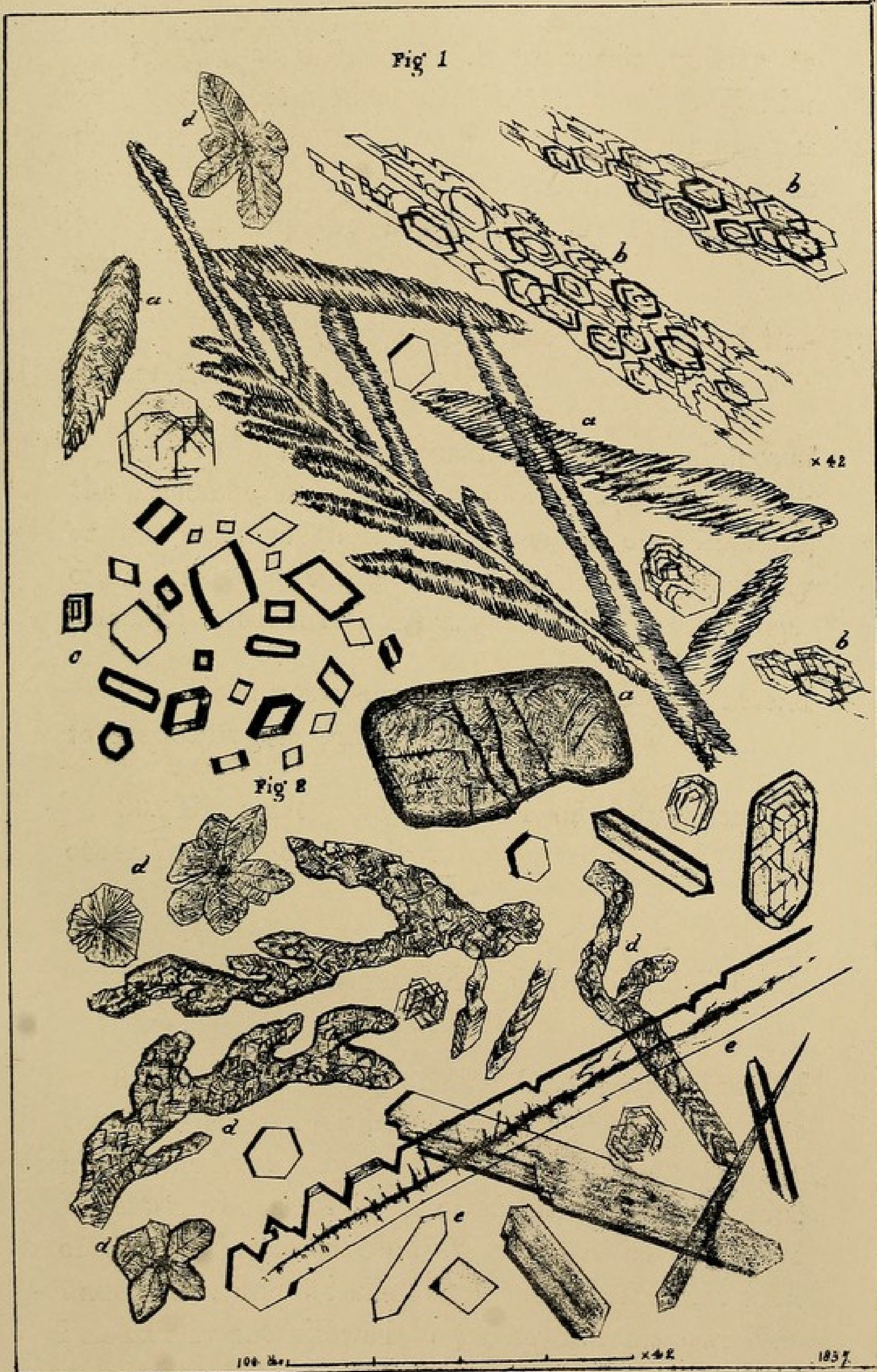


Fig 1
d
b
b
a
a
× 42
c
b
a
Fig 2
d
d
e
d
e
d
× 42
1857

saliva, tears, milk, bile, and sweat, in serous fluids in different localities, in the liquor amnii, and in the fluids of the eye.

The researches of Perls, p. 36, prove what was rendered almost certain by another order of facts, that at least much of the urea is *formed* in the kidneys; and it is most likely that in many cases of disease, in which a large quantity of urea exists in the blood, much of this has been re-absorbed from the renal structure, instead of being carried away from the organ by the ureter.

Urea cannot be detected in the muscles, but can be readily produced from several substances found in them. Removed from the body, very slight causes are capable of effecting its decomposition, and resolving it into ammonia and carbonic acid—substances of the highest importance to the growth of plants.

It has been generally concluded that any albuminous matters taken in the food, in excess of what is required for the nutrition of the system, is at once converted into urea. Bischoff and Voit have endeavoured to show, on the other hand, that in this and in all cases the urea results from tissue metamorphosis. My own researches render it probable that all pabulum entering the system must, before its elements can be applied to the nutrition of the tissues or removed by the organs of respiration and secretion, be first of all taken up by cells (chyle corpuscles, white blood corpuscles), and become living or *germinal matter*, which, after passing through certain definite stages of existence, becomes serum of the blood and the *formed* matter of the red blood corpuscles. The products resulting from the disintegration of this formed matter may be taken up by the germinal matter of tissues, and at length become tissue, or by that of secreting cells, in which case it is removed in the form of the constituents of various excretions from the body altogether.

Creatinine ($C_8H_7N_3O_2$) is crystalline. The crystals take the form of right rectangular prisms, according to Robin and Verdeil. It has a strongly alkaline reaction, and is soluble in water. It is very soluble in warm alcohol. It combines with different acids to form salts. With chloride of zinc a crystalline compound is formed, composed of roundish wart-like masses, made up of minute radiating crystals, which have been already referred to.—"Illustrations of Urine," pl. VII, fig. 4.

Creatinine is found in the urine in large proportion, and must be considered as an excrementitious substance. Neubauer states that normal urine contains as much creatinine as uric acid. It is not destroyed in the decomposition of urine, while the creatine undergoes conversion into creatinine. Dr. Thudichum obtained as much as from 5½ to nearly 10 grains of creatinine from the urine of a healthy man in twenty-four hours.

Creatine ($C_8H_9N_3O_4$).—The presence of creatine in urine was discovered by Heintz, who, however, considers that it does not exist preformed in the fluid, but that it results from the chloride of zinc compound of creatinine by the assimilation of HO. Creatine gives no precipitate with chloride of zinc until after conversion into creatinine. Liebig and Dessaignes have confirmed Heintz. Liebig obtained from dog's urine, which had stood long in contact with milk of lime, only *creatine*, and from the fresh urine only *creatinine*. *Creatinine* in aqueous solution was converted into *creatine* by eight months' contact with milk of lime. Dr. Thudichum has obtained from 3·45 to 6·32 grains of creatine from the urine of a healthy man in twenty-four hours. The average is 4·7 grains. Creatine has a pungent taste, is very soluble in hot water, but requires about seventy-five parts of cold water for its solution. It is very slightly soluble in alcohol, and quite insoluble in ether. It crystallises in right rectangular prisms and rhomboidal crystals. "Illustrations of Urine," pl. VII, fig. 3. By being boiled with baryta water, it is converted into urea and sarcosine; with strong acids, into creatinine.

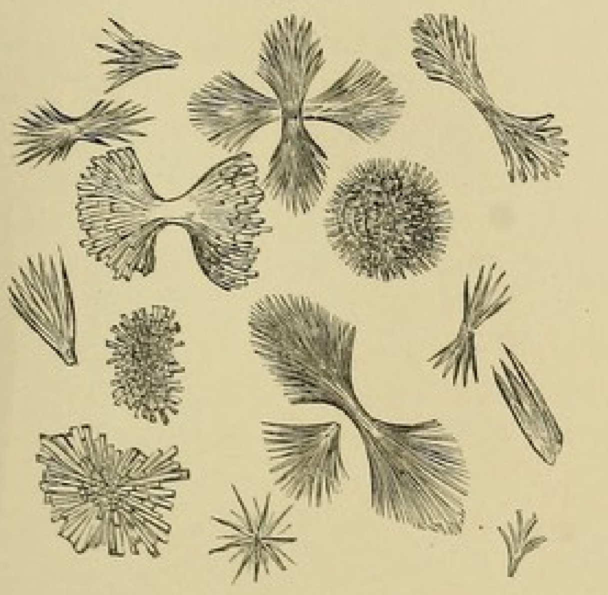
Creatine may be obtained from urine by the following process, proposed by Liebig. Lime water and chloride of calcium are first added to the urine, which is then filtered and concentrated by evaporation in order to remove most of the salts. The liquid from which the salts have been separated is decomposed with one twenty-fourth of its weight of a syrupy solution of chloride of zinc. After the lapse of some days, a number of round granules make their appearance. These consist of chloride of zinc and creatinine, with which creatine is mixed. "Illustrations of Urine," pl. VIII, figs. 1 and 2. They are dissolved in hot water, and treated with hydrated oxide of lead until the reaction is alkaline. The oxide of zinc and chloride of lead are to be removed by filtration; and, after being decolorised by animal charcoal, the solution is evaporated to dryness. The residue is to be treated with boiling alcohol, which dissolves the creatinine very readily, but leaves the creatine, which may be recrystallised by solution in hot water. Crystals of creatine are also represented in pl. VI, fig. 4.

Creatine is obtained from all kinds of lean meat, but exists in larger proportion in that of mammalia than in birds, reptiles, and fishes. Gregory obtained 0·14 from 100 parts of bullock's heart, 0·08 in 100 parts of pigeon's flesh, and 0·06 in the same quantity of the flesh of the skate. Although the flesh of fishes contains less creatine than that of the higher animals, it is more favourable for extraction. I obtained more than seventeen grains of creatine from two pounds of the flesh of the crocodile. The presence of creatine has been detected in the blood by Verdeil and Marcet. Traces of it have been discovered in the amniotic fluid.

Its existence in the juice of muscular tissue, and its presence in the urine, would lead to the conclusion that creatine was one of the nitro-

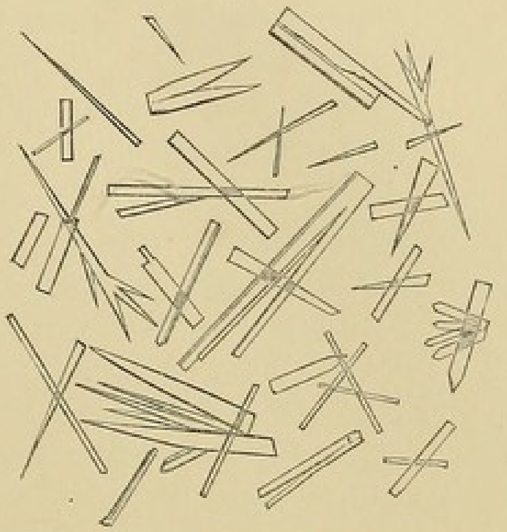
ILLUSTRATIONS OF URINE.

Fig. 1.



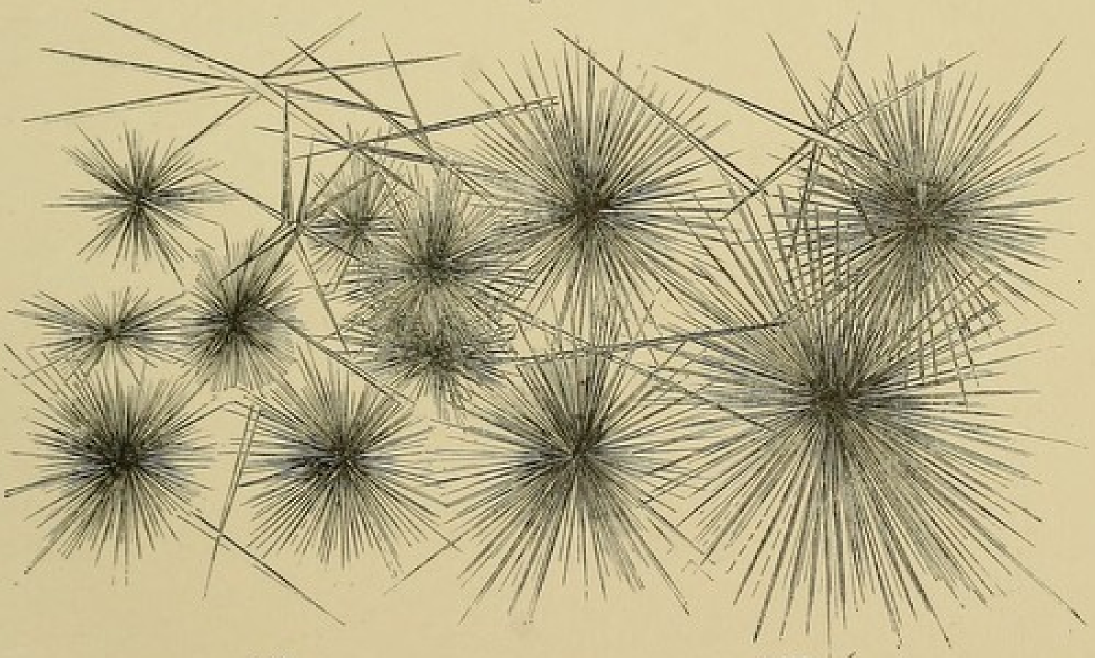
Urate of magnesia. $MgO, C_{10}H_3N_4O_5 + 6$ aq. Crystallized in tufts. × 130

Fig. 2.



Urate of magnesia, showing the separate forms of the crystals. × 215.

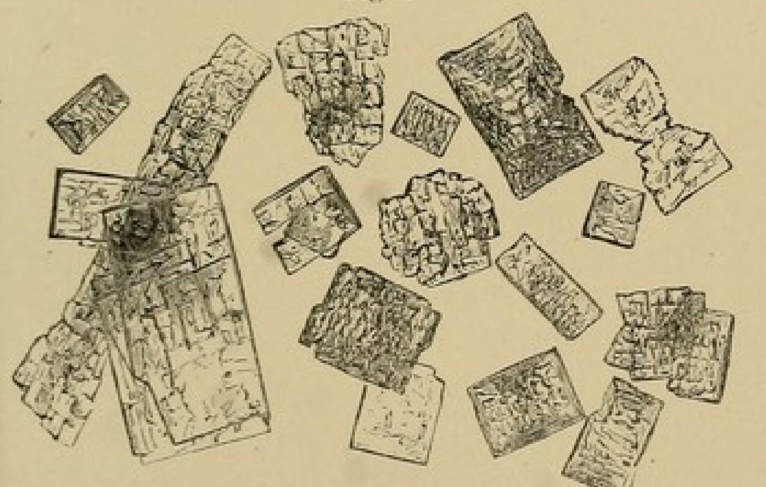
Fig. 3.



× 130. × 215.

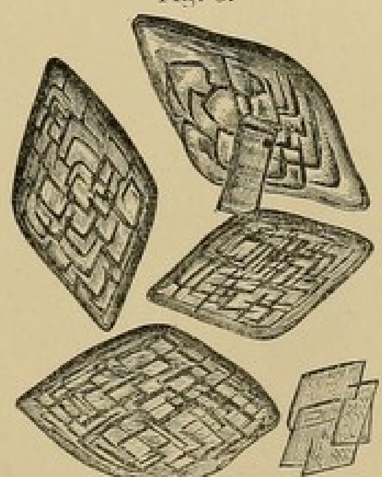
Urate of lime. $CaO. C_{10}H_3N_4O_5 + 2$ aq. Crystallized in tufts composed of long acicular crystals.

Fig. 4.



Uric acid. $C_{10}H_4N_4O_6$. Precipitated by adding hydrochloric acid to urate of potash. × 130.

Fig. 5.



Uric acid deposited from urine. × 130.

$\frac{1}{1000}$ of an inch |__| × 130.

" " |___| × 215.

[To face page 138.

genised products resulting from the disintegration of muscular tissue; and such a view of its nature is supported by the readiness with which it is decomposed into urea, creatinine, and sarcosine. It is found in greater quantity in muscles which have been in active exercise during life, than in those which have been quiescent. The heart yields a large quantity; and more is found in animals which have been hunted to death than in those destroyed without being subjected to violent exercise. Creatine may, like urea, be regarded as an excrementitious substance.

Guanine ($C_{10}H_5N_5O_2$), *Sarcine*, *Inosite* ($C_{12}H_{12}O_{12} + 4Aq.$).—Strahl and Lieberkühn have discovered a substance in urine which they considered to be xanthine, but which, from its behaviour with reagents, may probably be regarded as guanine. Strecker has detected in urine a substance closely resembling sarcine, found in muscular fibre; but its exact nature is at present doubtful. Inosite has been found in the urine of a man suffering from Bright's disease by Cloëtta, but it has not yet been detected in healthy urine. Crystals of inosite are represented in "Illustrations of Urine," pl. VI, fig. 5.

Uric or Lithic Acid ($C_{10}H_4N_4O_6$).—The organic constituent of the urine which ranks next in importance to urea is uric or lithic acid. In healthy urine its presence cannot be detected, unless a small quantity of a stronger acid, as nitric or hydrochloric, be first added to decompose the soluble urates. After the mixture has been allowed to stand for some time, the uric acid separates in the form of small red crystalline grains, which adhere to the sides of the glass vessel. Upon microscopical examination, these are found sometimes to be composed of separate crystals, and sometimes of small stellate groups; the individual crystals varying in form from the lozenge-shape to that of an elongated crystal with sharply pointed extremities. (*See* plates of Uric Acid, part IV). Uric acid is a very weak acid, and is perfectly separated from its salts by acetic acid. It is soluble in solutions of alkaline lactates, acetates, carbonates, phosphates, and borates. Uric acid has the power of decomposing the alkaline phosphates. It takes a part of the base, forming a urate, and leaves an acid phosphate, as I mentioned when speaking of the acid reaction of urine. The colour of the crystals of uric acid which have been obtained from urine is derived from the proper colouring matters of the secretion, and must, therefore, be regarded as an impurity. It can easily be obtained perfectly pure and colourless; and, in three or four instances, I have observed perfectly colourless crystals of this substance, which have separated spontaneously from urine holding in solution scarcely a trace of colouring matter.

Pure uric acid crystallises in the form of very thin rhomboidal laminæ; but the sides of the crystals, instead of being perfectly straight, are usually more or less curved. The angles, again, are often rounded, so that the crystal has an oval form. In the "Illustrations of Urine," pl. IA, fig. 4, and pl. V, figs. 4, 5, some crystals of pure uric acid are represented. Some of these crystals were obtained by the addition of acid to the solution. Although uric acid may be perfectly pure, the crystals vary much in size and form. Experiments show what very slight variations in the conditions under which they are produced are sufficient to determine great alterations in the form of the crystals.

Quantity.—Healthy urine contains from half a grain to a grain of uric acid in 1,000 grains of urine. The solid matter contains about 1·3 per cent. of this substance, and probably from five to eight grains are excreted by a healthy adult man in twenty-four hours. Dr. Thudichum gives the latter as the average quantity. The quantity of uric acid excreted in twenty-four hours, for every pound weight of the body, amounts to ·059 grain, according to Parkes.

Detection.—The chemical characters of uric acid are well marked.

1. If to a deposit consisting of uric acid, placed on a glass slide, a drop of nitric acid be added, a brisk effervescence ensues; and, when the mixture is slowly evaporated over a lamp, a reddish residue is left. Upon the addition of a drop of ammonia, a rich purple tint is produced, owing to the formation of murexide, the so-called purpurate of ammonia. This test is exceedingly delicate: it was first applied by Dr. Prout. One other substance produces a similar reaction, and this is caffeine; but uric acid is at once distinguished from it by its microscopical characters.

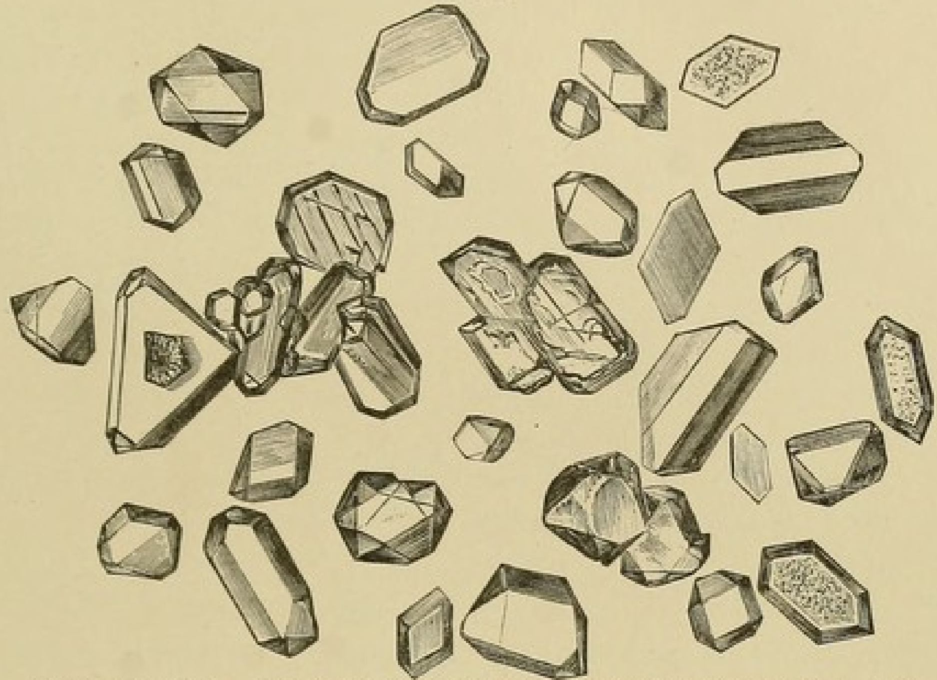
2. The deposit suspected to contain uric acid, or a urate, may be dissolved in a drop of solution of potash, in which it is very soluble. Upon adding excess of acetic acid, and leaving the mixture for some hours, small crystals of uric acid will form. These may be recognised by their microscopical characters.

3. Uric acid may be detected in animal fluids, when mere traces of this substance or of urates are present, by a plan proposed by my colleague, Dr. Garrod. The fluid suspected to contain the urate is treated with a few drops of strong acetic acid (glacial acetic acid is best) in a watch glass. A few filaments of tow or very thin silk are placed in the mixture, and the whole set aside under a glass shade, in a warm place, for twenty-four or forty-eight hours. Gradually uric acid crystals separate, and are deposited upon the filaments. Their characters may be recognised by microscopical examination. Some crystals of uric acid deposited upon a hair in urine are represented in one of the plates in part IV.

The quantity of uric acid is estimated by collecting the crystals separated by the addition of an acid, and weighing them after they have been carefully washed and dried. Dr. Thudichum recommends

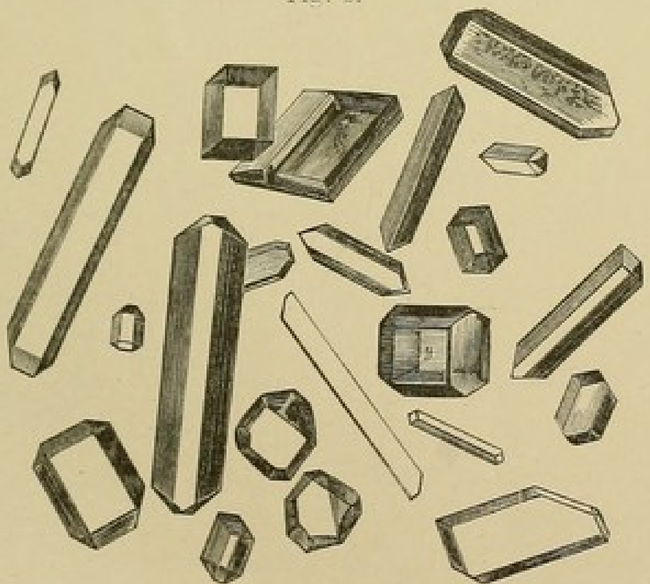
ILLUSTRATIONS OF URINE.

Fig. 1.



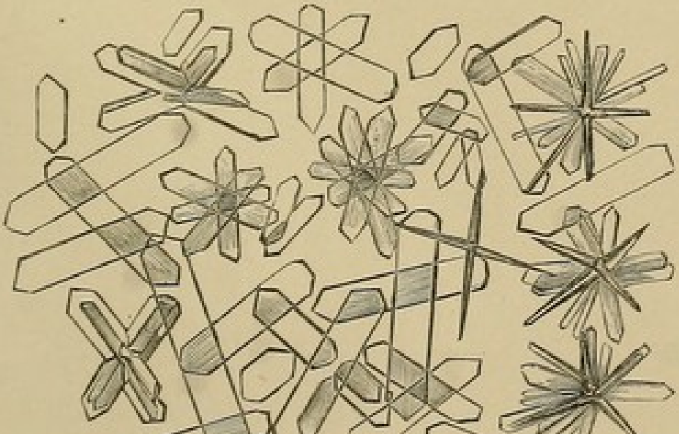
Alloxan. $C_8H_2N_2O_8$. Crystallized from an aqueous solution obtained from uric acid. × 42.

Fig. 2.



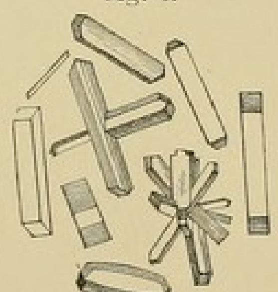
Alloxantin. $C_{16}H_4N_4O_{14} + 6$ aq. Prepared from uric acid. × 130.

Fig. 3.



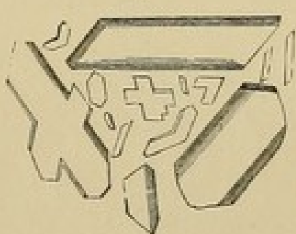
Parabanic acid. $C_6H_2N_2O_6$. Obtained from uric acid. × 130.

Fig. 4.



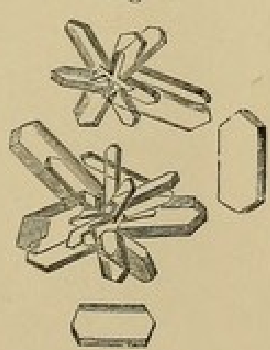
Crystals of creatine. p. 138.

Fig. 5.



Crystals of inosite p. 280.

Fig. 6.



Lactate of copper. p. 153.

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the use of nitric acid, because the uric acid is less soluble in it, and there is not so much tendency to the development of fungi as if hydrochloric be employed.

Mode of Formation.—Uric acid is found in the urine of most carnivorous animals, and in that of young herbivora while sucking, and, therefore, feeding upon a diet rich in nitrogen. It is not found in the urine of the pachydermata, not even in that of the omnivorous pig. It is abundant in the urine of birds, and is found in that of many reptiles and insects. Uric acid exists in the blood, and is only *separated* from that fluid by the kidneys. Dr. Garrod has detected it in the blood of men in health, and in cases of gout in considerable quantity. In such instances, uric acid crystals may be separated from the fluid obtained from a blister, according to the plan just described. It has been detected in the juice of the spleen in considerable quantity by Scherer, but Mr. Gray failed to confirm these observations. Cloëtta has found it in the pulmonary tissue of bullocks' lungs, associated with taurine, inosite, and leucine. It has also been found in the brain and in the liver.

Uric acid, like urea, is one of the products indirectly resulting from the disintegration of albuminous tissues. Prout held "that a very large proportion of the urate of ammonia found in the urine on common occasions, appears to be developed from the imperfect albuminous matters formed during the assimilating processes." This is rendered probable by the researches of later observers, especially by those of Bidder and Schmidt. Uric acid may be deposited, in combination with soda and lime, in various structures. It may accumulate beneath the skin, so as to form large collections, which are familiar to us under the name of chalk-stones. It is curious that these depositions should take place in areolar tissue, in white fibrous tissue, and in connexion with cartilage. Perhaps this may be connected with the very slight vascularity of these tissues when fully formed, although they are highly vascular during the early period of their growth; and it must be borne in mind that the deposits usually occur at a time of life when they are fully developed, after which they probably undergo very slight changes, and the processes concerned in their decay and regeneration are slowly and, perhaps, in sedentary persons, very imperfectly carried on. These circumstances would favour the separation of a slightly soluble substance from the blood, and its deposition in an insoluble state. Lehmann has shown that, after attacks of disturbed digestion, the proportion of uric acid to the urea becomes increased. Alcoholic liquors seem to have the same effect. In normal conditions of the system, the urine contains about 1 part of uric acid to 28 or 30 parts of urea; but, under the circumstances just mentioned, the ratio becomes 1 to 23 or 26. Alcohol causes a diminution in the quantity of carbonic acid exhaled; and, in such cases, an increased proportion of uric acid, urates, and usually oxalates, is found in the urine.

A highly nitrogenised diet, with insufficient exercise—confinement in ill-ventilated rooms—all circumstances interfering with the healthy action of the respiratory apparatus, or preventing the proper amount of blood from being carried to the pulmonary surface, active exercise in confined air, &c., are conditions favourable to the formation of an increased quantity of uric acid and urates. The formation of urea and oxalic acid from uric acid in the organism, or artificially by the action of peroxide of lead, has been previously alluded to. Ranke has shown that, at a high temperature, in the presence of yeast and an alkali, uric acid also becomes converted into urea and oxalic acid.

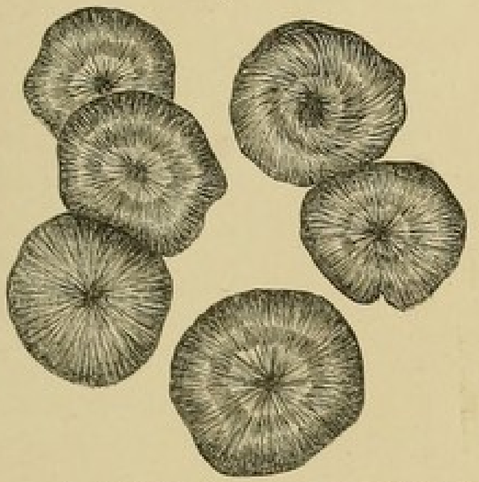
Urates.—Uric acid is separated from the blood by the kidneys, in the form of a urate, which is readily soluble in water. After its separation, however, this salt may soon undergo decomposition, and insoluble uric acid will be deposited. In the majority of cases, this decomposition does not take place until after the urine has left the bladder; but sometimes it occurs in the bladder itself. The causes of the precipitation of uric acid are well worthy of attentive study, as they are intimately connected with the formation of uric acid calculi. The quantity of urates in healthy urine is very small, but not unfrequently enough is present to form a very abundant deposit after the urine has been allowed to stand for some time. The characters and composition of these salts will be referred to, when the subject of urinary deposits is brought under notice, in part IV.

Hippuric Acid ($HO, C_{18}H\ NO_5$) was first detected in horses' urine by Liebig, and was proved by him to exist in healthy human urine in small quantity—a statement which has been confirmed by Lehmann, and more recently by Kühne and Hallwachs. It is not found in the urine of carnivorous animals, but among herbivora it occurs in considerable quantity. It does not exist in large quantity in the urine of calves while sucking, but cows' urine contains as much as 1·3 per cent. Lehmann has detected it in considerable quantity in the urine of the tortoise (*testudo græca*).

Hippuric acid is soluble in about six hundred times its weight of cold water. It is very soluble in hot water, and also in alcohol, but is insoluble in ether. It crystallises very readily in various forms, which are derived from the right rhombic prism, "Illustrations of Urine," pl. IX, fig. 1. It is very easily decomposed with formation of benzoic acid, especially in the presence of extractive matters, and other constituents of the urine. In testing for this substance, the perfectly fresh urine only should be employed. It is curious that benzoic acid, when taken into the organism, is eliminated in the urine in the form of hippuric acid—a fact which was first made known by Mr. Andrew Ure.

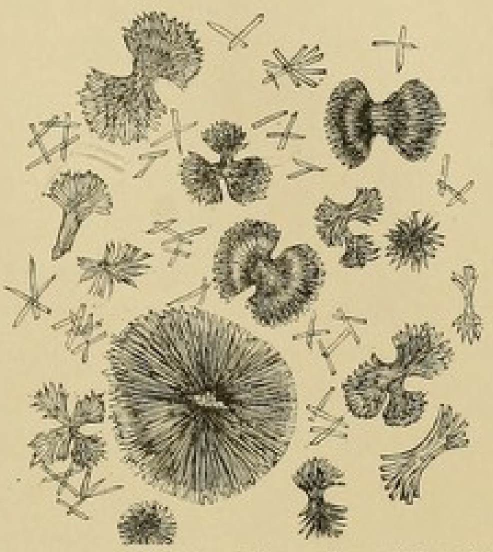
ILLUSTRATIONS OF URINE.

Fig. 1.



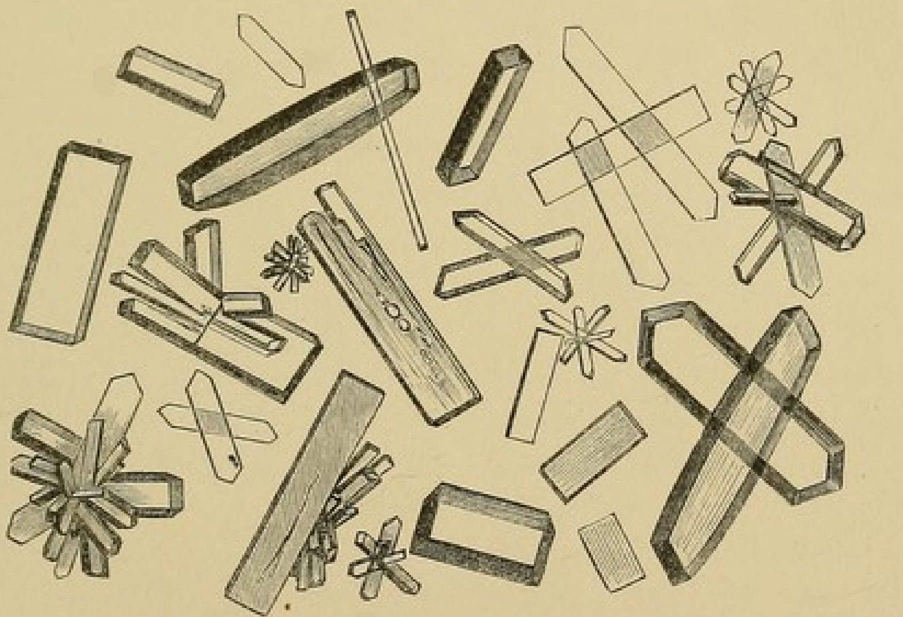
Compound of chloride of zinc and creatinine, as it is obtained from urine. ($C_8H_7N_3O_2$, Zn Cl.) × 29.

Fig. 2.



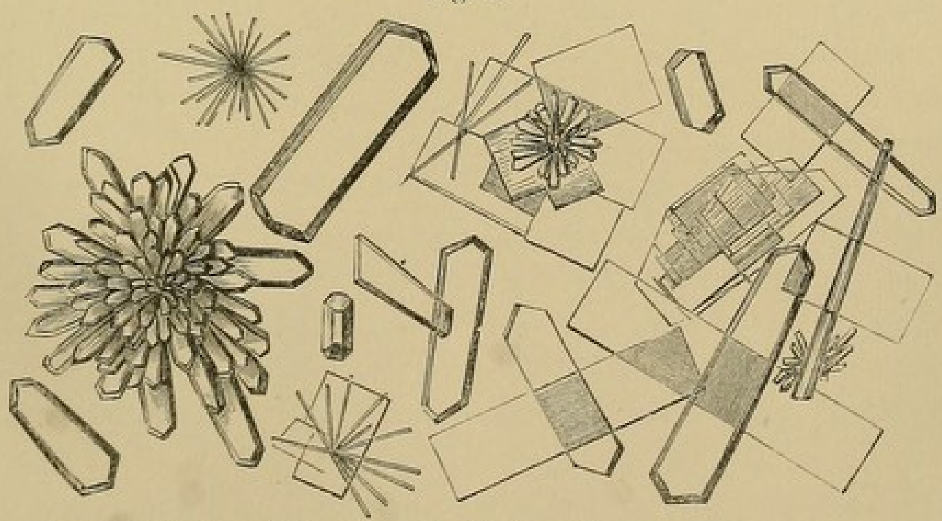
Compound of chloride of zinc and creatinine after re-crystallization in water. × 215. p. 137.

Fig. 3.



Crystals of creatine obtained from the chloride of zinc compound. Crystallized from an aqueous solution. × 130. p. 138.

Fig. 4.



Crystals of creatinine obtained from the chloride of zinc compound. × 130. p. 137.

$\frac{1}{1000}$ of an inch |__| × 130.

" " |___| × 215.

[To face page 142.

Hippuric acid may be prepared by adding milk of lime to fresh cows' urine. The mixture is to be boiled for a few minutes, strained, and exactly neutralised with hydrochloric acid. The solution is next to be boiled down to one eighth of its original bulk, and considerable excess of hydrochloric acid added, when brown crystals of the acid will be deposited. These may be purified by solution in water, through which a current of chlorine is to be transmitted, in order to decolorise the liquid. The crystals may always be readily obtained from human urine, passed after taking ten grains of benzoic acid.

The quantity of hippuric acid is increased when a purely vegetable diet is taken; but it is certain that the whole of the hippuric acid formed in the organism is not derived from this source. The proportion of hippuric acid in human urine was formerly considered to be so small, that it was scarcely possible to make a satisfactory quantitative determination; but Hallwachs has lately shown that *thirty grains* or upwards are excreted in twenty-four hours. Weissmann obtained as much as 34·5 grains from his own urine in the course of twenty-four hours, when he was on a mixed diet.

Very little is known concerning the formation of hippuric acid; and, although the subject has been very carefully investigated by Kühne and Hallwachs, who have published two very elaborate memoirs, there still remains much to be discovered. These observers hold that the hippuric acid is produced from the glycocol formed in the liver. Hallwachs has been led to conclude, from numerous experiments, that the production of hippuric acid is determined rather by the chemical changes going on in the organism, than by any peculiarities of the food; for, if a purely animal diet was taken, hippuric acid was still found in the urine.* Lehmann found much hippuric acid in the urine of fever patients, and always detected it in diabetic urine.

Robin and Verdeil give drawings of some crystals which they found in the urine of a man aged 30, who took little exercise, but lived on highly nitrogenised diet; and which they considered to be hippuric acid—a statement apparently founded upon the resemblance of these crystals to those produced by the decomposition of hippurate of soda. They do not mention that the crystals were subjected to any chemical examination; and, in the absence of any stronger evidence than mere resemblance in form, we are hardly justified in assuming that the crystals were composed of hippuric acid. It is very doubtful if this acid ever crystallises in urine spontaneously.

Extractive Matters.—Under the head of extractive matters used to be included certain organic substances which had never been obtained

* An excellent review of these researches will be found in vol. XIV, p. 156, of the "Medico-Chirurgical Review."

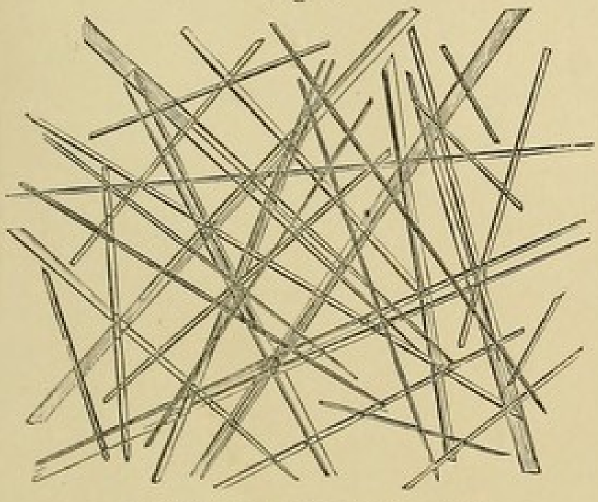
in a state of perfect purity—uncrystallisable—not volatile without decomposition—and incapable of being isolated. Chemists have described several kinds of extractive matters characterised by their behaviour with solutions of acetate of lead, bichloride of mercury, tincture of galls, &c. Within the last few years, several bodies, formerly included under this indefinite term, have been separated, and their chemical properties accurately determined. As instances, albuminate of soda, binoxide and teroxide of protein, creatine and creatinine, hippuric acid, lactic acid and lactates, and certain colouring matters may be mentioned. But, after the removal of such bodies, there still remains a true extractive substance, "which cannot be further resolved without decomposition." (Schunck, 1866.)

The extractive matters in urine are entirely excrementitious; but it seems most probable that those present in the blood represent a certain stage of the metamorphosis of some of the constituents of that fluid—intermediate between the nutritive pabulum and the germinal matter of the tissue into which it is to be converted, or a product of the disintegration of tissue to be eliminated. The extractive matters of urine used to be divided into three kinds. 1. *Water extract*, because insoluble in absolute alcohol, and in spirit of specific gravity ·833, but soluble in water. It exists only in small quantity. Infusion of galls and bichloride of mercury produce scarcely any effect upon it, but neutral and basic acetates of lead give copious precipitates. 2. *Spirit extract*, because insoluble in absolute alcohol, but soluble in water, and in spirit ·833. It contains much chloride of sodium. The solution of this extract is unaffected by infusion of galls, bichloride of mercury, and neutral acetate of lead; but a bulky precipitate is caused by basic acetate of lead. 3. *Alcohol extract*, soluble in water, in spirit ·833, and also in absolute alcohol. Its chemical reaction appears to be very similar to the last.

These are the extractive matters which are met with in healthy urine. In certain diseases, however, extractives, which are not present in a state of health, drain off from the blood, and sometimes in very large quantity. My friend, Dr. G. O. Rees, many years since showed that this extractive could be detected in morbid urine by adding tincture of galls; and that the proportion varied greatly in different cases. Healthy urine is scarcely affected by tincture of galls, but this blood-extractive is at once precipitated by it. In order to detect it, tincture of galls is to be added to the filtered fluid; and if this extractive is present, a precipitate is *at once* produced. Should the urine contain albumen, this must, in the first instance, be separated by boiling and filtration. It is only the precipitate which *immediately* follows the addition of the tincture of galls that must be noticed. In some cases, the extractive drains away from the blood, without the escape of albumen. ("Lettsomian Lectures," by G. O. Rees, M. D.,

ILLUSTRATIONS OF URINE.

Fig. 1.

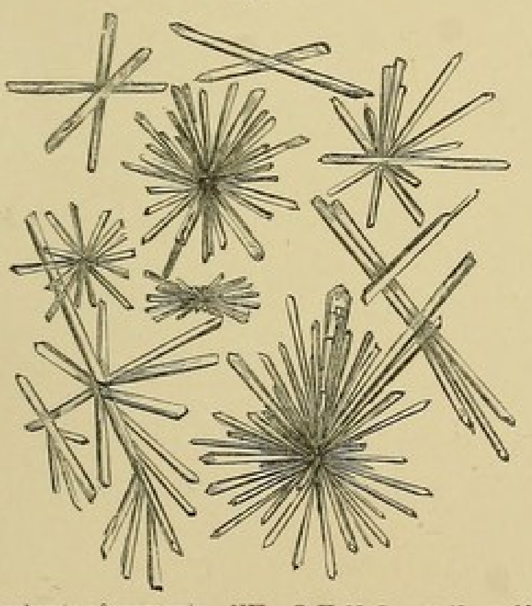


Alloxanic acid. $C_8H_4N_2O_{10}$. × 130.

Fig. 2.

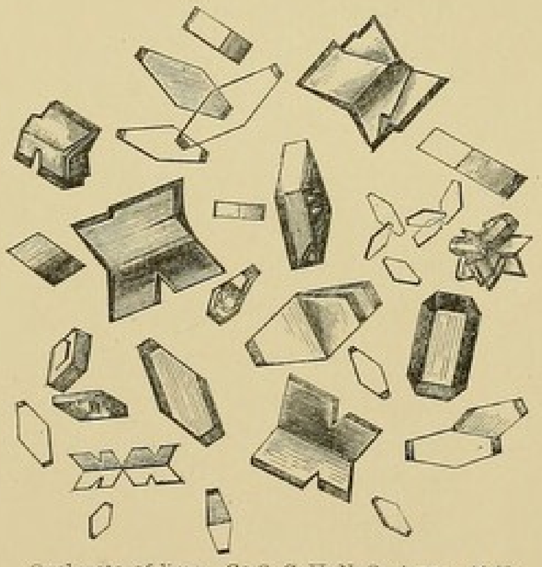
Oxaluric acid. $C_6H_4N_2O_8$. × 215.

Fig. 3.



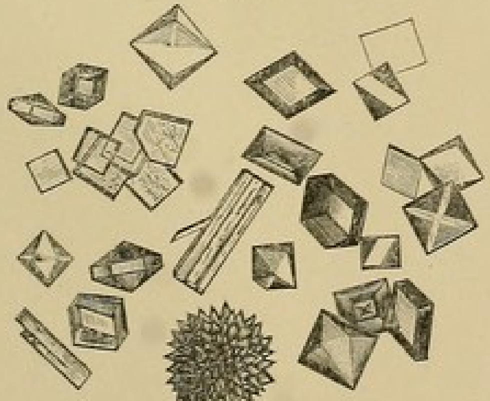
Oxalurate of ammonia. NH_3, $C_6H_4N_2O_8$. × 42. p. 153.

Fig. 4.



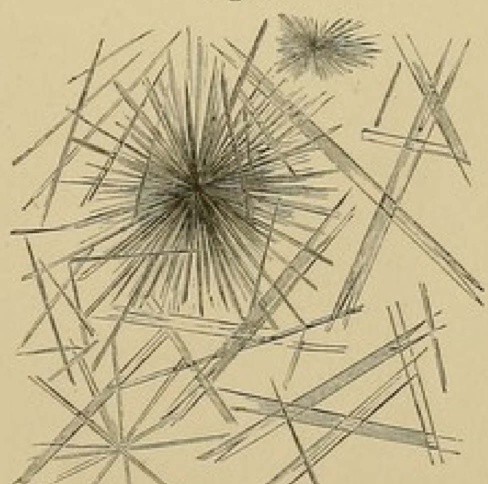
Oxalurate of lime. Ca O, $C_6H_3N_2O_7$ + aq. × 42.

Fig. 6



Oxalurate of magnesia MgO, $C_6H_3N_2O_7$ + aq × 215.

Fig. 5.



Uramile. $C_8H_5N_3O_6$. × 130.

[To face page 144.

F.R.S.; "Medical Gazette," 1851.) I shall have occasion to recur again to this interesting subject, when discussing the characters of the urine in disease, part III, p. 198.

One thousand grains of healthy urine will contain from fifteen to twenty grains of extractive matters. The solid matter contains from 15 to 40 per cent. of these substances. In twenty-four hours, about 200 grains of extractive matters are eliminated in the urine.

The physiological importance of extractive matters is quite unknown, and hitherto no one has been able to discover the part which they play in the animal economy. Their presence in the blood, and in all the animal fluids, as well as in the solid organs and in the excretions, clearly prove them to be substances of importance; and it must be remembered that, in the urine, the proportion of extractive matter is often greater than that of the urea itself. The amount and composition of extractive matters in the different fluids and secretions of the body is a subject well worthy of investigation, and likely to yield valuable results.

Dr. Schunck's recent Researches on the Extractive Matters.— Dr. Schunck proves that there are only two extractive matters in urine. Berzelius' third extractive matter insoluble in alcohol, is not a distinct substance, and invariably contains alkaline or earthy bases, on the removal of which the organic matter with which they were combined becomes soluble in alcohol. In order to obtain the "extractives," Dr. Schunck precipitates them by adding basic acetate of lead. They are then combined with oxide and chloride of lead. One extractive is soluble in alcohol and ether, the other soluble in alcohol only, but they are very similar to one another in all other respects. Dr. Schunck has also discovered the interesting fact, that a substance which has the composition and some of the properties of *glucose* may also be obtained. This is probably a product derived from one or both of the extractive matters, and does not pre-exist in the urine or even in the lead precipitate itself.

Some idea may be formed of the elaborate character of Dr. Schunck's researches from the following account which he gives of the examination of one of the lead precipitates. "The series of experiments consists of a renewed examination of three lead precipitates, in which the urinary extractive matters are contained; that produced in urine with the neutral acetate of lead, that with basic acetate of lead in the liquid filtered from the first, and that with ammonia in the liquid filtered from the second precipitate. The precipitate with acetate of lead was treated in the manner described in giving an account of the experiments of series B. After being washed it was decomposed with sulphuric acid, the excess of the latter was removed from the filtered liquid by means of caustic baryta, and the phosphoric acid was precipitated by adding milk of lime. The filtered liquid having been mixed with an excess of acetic acid, acetate of lead and ammonia were added to it, producing a cream-coloured precipitate. This was filtered off, washed with water, and treated with dilute sulphuric acid. The excess of the latter having been removed by means of carbonate of lead, the filtered liquid was evaporated in the air current. The chloride of lead which was deposited during evaporation was filtered off, and the syrupy residue which was left at last was treated with cold alcohol. The liquid was poured off from the undissolved portion and evaporated, and the syrupy residue having been again dissolved in a little alcohol, the solution was mixed with a large quantity of ether, which threw down a portion of the matter in solution. The liquid, which was of a golden yellow colour, was poured off from the insoluble deposit and evaporated to a syrup. This syrup was poured into a flask and agitated with a quantity of ether. After standing for some time the ether which had dissolved a portion of the syrup was poured off and evaporated. The residue, which was free from compounds of chlorine, was dissolved in alcohol, and to the solution there was added an alcoholic solution of acetate of lead, which produced a precipitate of the usual colour. This was filtered off, washed with alcohol, dried in vacuo and analysed, the following results being obtained :—

I. 1·1080 grm. gave 0·9095 grm. carbonic acid and 0·2500 grm. water.
1·5635 grm. gave 0·1360 grm. chloride of platinum and ammonium.
0·7160 grm. gave 0·5430 grm. sulphate of lead.

These numbers lead to the following composition :—

C	22·38
H	2·50
N	0·54
O	18·78
Pbo	55·80
	100·00"

From the experiments described in his paper published in the Proceedings of the Royal Society, vol. XVI, No. 95, p. 73 to p. 135, Dr. Schunck draws the following conclusions :—

1. Human urine contains under all circumstances two distinct and peculiar extractive matters, one of which is *soluble* in alcohol and ether; while the other is *soluble* in alcohol but *insoluble* in ether.

2. The composition of these bodies is almost always the same, the slight variations which are found to occur being due not to any difference in the quality or source of the urine employed at various times, but rather to the decomposition which takes place during the process of preparation, and which cannot be entirely avoided.

3. Both substances contain nitrogen as an essential constituent,

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Plate IX.

Fig. 1. Alloxanic acid, $C_8H_4N_2O_{10}$.

Fig. 2. Oxaluric acid, $C_6H_4N_2O_8$.

Fig. 3. Oxalurate of ammonia, NH_3, $C_6H_4N_2O_8$.

Fig. 4. Murexide, $C_{16}H_8N_6O_{12}$.

Fig. 5. Thionuric acid, $C_8H_5N_3O_8 + 2SO_2$.

Fig. 6. Thionurate of ammonia, $2NH_3$, $C_8H_5N_3O_8$, $2SO_2 + 2$ aq.

The alloxanic acid was prepared by adding baryta water to a solution of alloxan. The alloxanate of baryta so formed was decomposed by sulphuric acid, and the clear solution filtered from the precipitate of sulphate of baryta was evaporated and crystallized.

Oxaluric acid was obtained by treating a solution of oxalurate of ammonia with hydrochloric acid. The oxaluric acid was precipitated.

Oxalurate of ammonia was prepared by dissolving parabanic acid in ammonia. Upon heating the solution to the boiling point oxalurate of ammonia was formed, and crystals were obtained upon evaporation.

Murexid. Carbonate of ammonia was added to a warm solution of alloxan and alloxantin. The murexid separated in its characteristic dark red crystals as the solution cooled.

Thionuric acid. A solution of thionurate of ammonia in hot water, was precipitated by acetate of lead. The precipitate was suspended in water and decomposed by sulphuretted hydrogen. The sulphuret was separated by filtration, and the clear solution yielded crystals on evaporation.

Thionurate of ammonia. A cold strong solution of alloxan was mixed with a solution of sulphurous acid in water until the smell of the latter ceased to disappear after agitation. The fluid was then supersaturated with carbonate of ammonia, and kept boiling for nearly half an-hour. Upon cooling, the salt crystallized in considerable quantity.

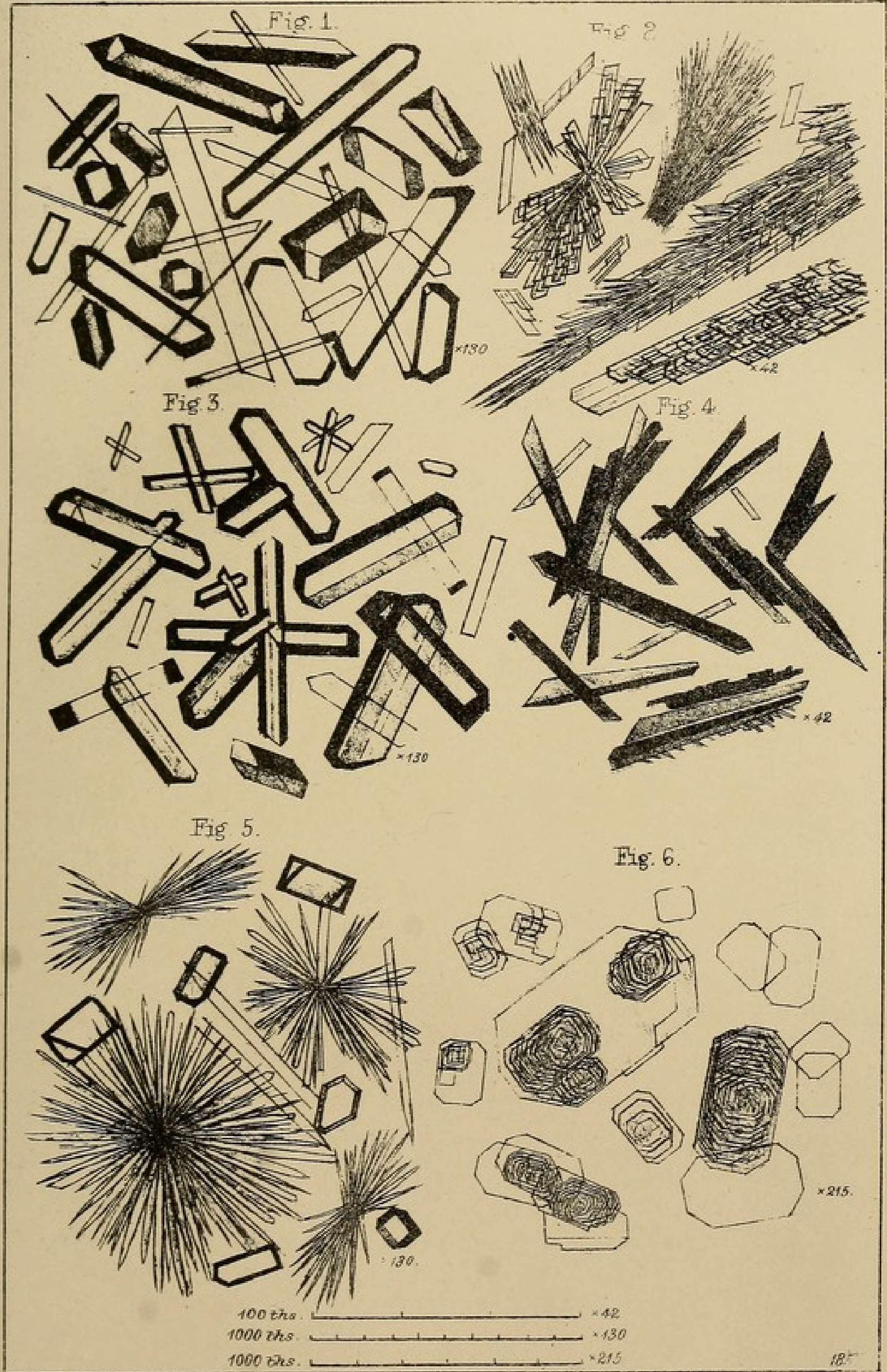


Fig. 1.
×130
Fig. 2.
×42
Fig. 3.
×130
Fig. 4.
×42
Fig. 5.
×130.
Fig. 6.
×215.
100 ths.
×42
1000 ths.
×130
1000 ths.
×215
185

but in so small a proportion as to show their atomic weight must be very high.

4. Both substances have a tendency to take up water, especially when their aqueous solutions are heated or mixed with strong acids and evaporated.

5. The extractive matter insoluble in ether takes up a certain proportion of oxygen, and is converted into a product which does not differ in its appearance or its most obvious physical properties from the original substance.

6. There exists no extractive matter insoluble in alcohol, the substance hitherto so-called consisting in most cases of compounds of one of the true extractive matters with various bases.

The Colouring Matters of Urine have formed the subject of numerous elaborate investigations by most distinguished chemists, and although many very important discoveries have been made, we have got much to learn concerning these bodies. A full account of the urinary colouring matters will be found in Dr. Schunck's memoir, to which frequent reference will be made. According to this observer, most of the colouring matters of urine, as well as the *alkapton* discovered by Bœdecker, and the *colloid acid* described by Dr. Marcet, p. 154 ("Proceed. Royal Society," vol. XIV, p. 1), are derived from the extractive matters, and result from the decomposition of these bodies. Schunck divides the colouring matters of urine into three classes :—1. Those which are occasionally present from disease or some abnormal condition of system. 2. Those produced by decomposition or by the action of reagents on substances either coloured or colourless, pre-existing in the urine. 3. The colouring matter or matters in normal urine, and to which its usual colour is due.

Heller was the first observer who obtained artificially from urine *blue and red colouring matters*. From the urine in *certain diseases* he obtained a yellow substance which he called *uroxanthine*, which by oxidation, even by exposure to air, became resolved into blue colouring matter which could be obtained in a crystalline form, *uroglaucine*, and a red colouring matter, *urorhodine*. Hassall likewise regarded the blue deposit as the result of pathological changes, and stated that indigo was not to be obtained from healthy urine. It remained for Dr. Schunck to prove that Heller's uroxanthine was to be obtained from healthy urine, and that it was identical with the *indican* obtained from certain plants, and his *uroglaucine* and *urorhodine* respectively with the indigo blue and indigo red obtained from that substance. Carter, "Edinburgh Med. Journal," August 1859, and Kletzinsky, Schmidt's Jahrb. b. CIV, s. 36, confirm Schunck's experiments.

Schunck, who first separated indigo blue and indigo red, found as much uroxanthine or indican in healthy as in morbid specimens of urine; and he detected it in the urine of thirty-nine persons out of forty.

The quantity of this colouring matter is exceedingly small. Schunck, by working on the urine of two persons for several weeks, only obtained one grain of indigo blue. Dr. Carter recently detected it in the urine of three hundred persons (some suffering from disease, others healthy), and in the blood of several patients—in fact, in every case in which he sought for it. It was also found in the blood of the ox.

On the other hand, Dr. Thudichum in his Hastings Prize Essay, "Brit. Med. Journal," Nov. 5, 1864, asserts that "from healthy human urine neither indican nor uroxanthine, nor any substance yielding, by decomposition with acids, indigo red and indigo blue can be extracted," but Dr. Schunck remarks that after the operations to which Dr. Thudichum subjected the urine had been carried out, it was impossible that any trace of indican, or any body resembling it, could remain undecomposed.

Uroglaucine ($C_{16}H_5NO_2$) may be obtained from all specimens of urine, and in disease this substance sometimes forms a visible deposit, a fact known to some of the observers of the last century, although its nature was only discovered so very recently.

My friend Dr. Eade, of Norwich, sent me a specimen of urine containing a deposit of uroglaucine obtained from a man eighty-three years of age ("Archives of Medicine," vol. I, p. 311). Some of these crystals are represented in *Illustrations of Urine*, pl. IA, fig. 8, and in fig. 6 are shown some crystals of indigo.

Indigo blue contains C, H, N and O in nearly the same proportions as hæmatine, and is probably formed from it. Leucine often found in urine may also be produced in the formation of indigo blue from the uroxanthine of urine.

Tests for Uroxanthine.—When sulphuric acid is added to urine containing much uroxanthine, a dark blue colour is produced. The mode of employing this test, recommended by Dr. Carter, who has made some important investigations on the subject, is as follows:—Urine is poured into an ordinary test-tube, to the depth of half an inch; one third of its volume of sulphuric acid, specific gravity 1,830, is allowed to subside to the lower part by letting it fall gradually down the side of the tube; the acid and urine should then be mixed well together. The colour produced varies from a faint pink or lilac to a deep indigo blue colour.

Process for obtaining Indican from the blood.—The serum was poured off, and a strong solution of diacetate of lead added to it as long as a precipitate was produced. The mixture was then thrown upon a linen filter, and the filtrate was brought to the boiling point as rapidly as possible, in a small flask, in order to coagulate the albumen that had not been precipitated by the lead salt. The solution was then filtered through paper, into a vessel placed in cold water; and, when the liquid was cold, a slight excess of caustic ammonia was added. The deposit thus produced, when collected and slightly washed with water, was of a faint yellowish buff colour. The moist precipitate, upon being treated with excess of concentrated sulphuric acid, developed a distinct red colour, owing to the formation of indigo red. The colour was taken up by ether, after the acid had been neutralised by ammonia. The oxide of lead precipitate, from an ounce and a half of blood-serum from a man, forty-three years of age, suffering from acute pleurisy, struck with the acid a distinct lavender colour, which in half an hour passed into a deep red purple. ("On Indican in the Blood and Urine," by J. A. Carter, M.D.; "Edinburgh Medical Journal," August, 1859.)

Uroërythrine is another colouring matter described by Simon, and always associated with uric acid and urate of soda. This substance is probably the *rosacic acid* and *purpurate of ammonia* of Prout, and the *purpurine* described by Dr. Golding Bird. It has been analysed by Scherer, who finds that it contains about 65 per cent. of carbon. Angelini, in 1825, noticed that the pink colour of urinary deposits sometimes changed to blue. It would seem that, when the elimination of substances from the liver, rich in carbon, is interfered with, an increased quantity of this substance is excreted in the urine. A green colour has been noticed in certain cases (Parkes). Creosote and tar, when taken internally, occasionally cause the urine to be of a very dark colour.

By the action of acids upon the colouring matters of urine, a brown resinous substance has been obtained. This was first investigated by Proust, who called it the *resin of urine.* "Annales de Chimie," t. XXXVI, p. 274. Berzelius repeated Proust's experiments, with the same results, but concluded that the substance in question did not exist preformed in the urine, but was produced by the action of the acid upon the extractive matters. Scherer afterwards examined the same product, and obtained, by the action of hydrochloric acid on urine, a dark blue powder, which must have been indigo blue, although, like Heller, he failed to recognise it. Harley also obtained a resinous body, of a brownish red colour, which he called *urohæmatine.* This contains iron, and Harley infers that it is closely allied to the hæmatine of the blood. It possesses many characters in common with the resin derived from certain plants, and closely resembles draconine, which is obtained from dragon's blood, the exudation from one of the resin bearing palms.

The relation of the colouring matters of the urine to those of the bile has been dwelt upon, and Berzelius long ago drew attention to the resemblance of the latter to the chlorophyll of plants. Certain chemical reagents cause the same change in both these colouring matters. A red colouring material is not unfrequently seen in the cells in the central part of the lobules of the liver, and Dr. Bence Jones met with a gall-stone of a brick-red colour. There is much reason for believing that the formation of these colouring matters is connected with the disintegration of blood corpuscles, and the quantity formed and the intensity of the colour probably depend upon the activity of the oxidising processes going on in the organism; but the whole subject of the production of the peculiar colouring matters in the living body is still involved in the greatest obscurity.

In 1852 Marcet obtained a resinous material, which he considered existed in a free state in the urine, and Tichborne, who has more recently studied the subject, has described a brown amorphous urinary pigment, which he thinks is derived from the hippuric acid.

Dr. Thudichum, in the "Hastings Prize Essay," for 1864, published in the "British Medical Journal," first described a substance, which he named *uromelanine*, on account of its origin and black colour, and which he supposed to result from the decomposition of urochrome, the yellow ingredient of urine. This uromelanine contains neither iron nor sulphur, while its atomic weight (733) is higher than that of any other product of decomposition of animal or organic matter known. From subsequent highly interesting researches, and from numerous analyses of the substance in question, Dr. Thudichum is led to think that it is derived solely from the coloured part of the blood, perhaps from the cruorine or hæmato-crystalline, but not, however, from the hæmatin. He believes it to be possible to measure the quantity of blood disintegration going on in the body, by determining the amount of uromelanine obtainable from given quantities of urine excreted in given times. *See* "Proceedings of the Royal Society," vol. XVI, p. 215.

The brown resinous matter obtained by the action of muriatic or sulphuric acid upon urine, has been carefully examined by Dr. Schunck. "Proceedings of the Royal Society," 1867, vol. XVI, p. 83. Schunck has discovered, 1, that the composition of the brown pulverulent substance "stands in a definite relation to the indigo blue," and, 2, that the urine from which this matter has been separated contains glucose in solution. "The brown pulverulent substance was prepared in the following manner:—Urine was mixed with hydrochloric acid and allowed to stand. The uric acid which was deposited was separated by filtration, and the liquid was boiled for some time. The black powder which separated during the boiling was filtered off, washed with water, dried, and treated with cold alcohol, which extracted the easily soluble resinous portion, thereby acquiring a brown colour. The portion left undissolved by the cold alcohol was dissolved in boiling alcohol to which a little ammonia was added. The brown solution was filtered and mixed with an excess of hydrochloric acid, which produced a brown precipitate, the supernatant liquid remaining coloured. This precipitate was collected on a filter, washed with cold alcohol until the acid and sal-ammoniac were removed, and dried. It had then the appearance of a dull, black, amorphous mass, which yielded a brownish black powder, strongly resembling some of the products of decomposition of indican. When heated in a crucible it gave off a smell like that of burning horn, and then burned without previously fusing, giving much charcoal, which disappeared without leaving any ash. I need not describe its other properties, as they are in no way characteristic or interesting. Its composition, which is a matter of more importance, was determined by several analyses, the results of which give the formula $C_{14}H_7NO_4$."

Moreover, Dr. Schunck states that by the direct action of alcohol, acetate of soda, and caustic soda on indigo blue, he obtained products which much resembled the *uromelanine*, the brown pulverulent matter resulting from the action of acids on urine. "The liquid filtered from the insoluble matter formed by the action of acids on urine I found to possess the property, after being made alkaline, of dissolving oxide of copper and converting it into sub-oxide on being boiled. This reaction, which had never been previously observed, I attributed to the presence of glucose, which, together with the brown colouring matters, had been formed at the expense of the extractive matters. The correctness of this inference has been doubted, since the same reaction may be produced by other substances as well as glucose; but whether it be correct or not the fact remains, that normal urine, free from sugar, acquires the property of reducing oxide of copper as soon as it has been boiled with the addition of a strong acid."

Sulphur Compounds.—In certain cases of disease, urine, soon after it is passed, evolves a very powerful odour of sulphuretted hydrogen, probably resulting from the decomposition of substances rich in sulphur. This fact has been observed by many, and I noticed frequently, in examining the urine of insane patients, that a piece of paper, moistened with a solution of acetate of lead, soon became blackened from the formation of sulphuret. Considerable quantities of unoxidised sulphur have been obtained even from healthy urine. Ronalds, in five different cases, obtained from 3 to 5 grains of sulphur in the twenty-four hours ("Philosophical Transactions," 1847), and Griffiths found 4 grains in healthy urine. These observations are confirmed by Dr. Parkes, and Bischoff and Voit have stated that a large quantity of sulphur is constantly present in the urine of dogs.

I have seen cases in which the urine had the most offensive odour of sulphuretted hydrogen at the time it was passed, and in one instance the patient's life seemed rendered wretched from this cause. The general health was good. The offensiveness of the urine ceased after the exhibition of a few purgative doses of grey powder or calomel, but recurred again. When the bowels and skin were made to act freely the smell quite disappeared. The secretion of the materials which decompose soon after the urine is passed, probably depends upon derangement of the stomach and liver.

Sugar.—Brücke has lately again stated that traces of sugar always exist in healthy urine, and his observations have been confirmed by Dr. Bence Jones ("Trans. Chem. Soc.," April, 1861). This subject will come under notice subsequently.

Crystalline Fatty Acid from Urine.—Dr. Edward Schunck, in a paper presented to the Royal Society, Sept. 21, 1866, and published in the "Proceedings," vol. XVI, No. 95, p. 135, states that the fatty matter existing in urine may be separated from that fluid by allowing successive portions to percolate through purified animal charcoal. The charcoal through which the urine has been passed is washed with water until every trace of chlorides and phosphates has been removed, and then dried. When dry, it is treated with boiling alcohol. This liquid is filtered, and the process repeated, until the whole or nearly the whole of the soluble contents of the charcoal have been extracted. The alcoholic solutions are to be evaporated, and the brown syrupy residue mixed with water. A quantity of dark brown fatty matter is left undissolved. This may be separated by filtration. In order to purify the fat thus obtained, which is of a dark brown colour, with a highly urinous odour, it must be dissolved in alcohol, the filtered solution evaporated, and the residual mass of fat pressed between folds of blotting paper. It is then redissolved in alcohol, agitated with a little animal charcoal, filtered and evaporated, and afterwards treated with weak spirits of wine, when an almost white solid fat is obtained. How this fatty acid comes to be dissolved in the urine Dr. Schunck is unable to say. He has not been able to determine if the urine itself is capable of dissolving the fatty acid, or if the latter exists in combination with some base, or to ascertain if the extractive matters of the urine promote the solubility of the fatty acid in the water. The quantity of this peculiar fatty acid obtained by Dr. Schunck was not sufficient for ultimate analysis, but there are some reasons for thinking that it is a mixture of stearic and palmitic acids.

Vesical Mucus.—Vesical mucus exists in very small quantity in healthy urine. It forms a faint flocculent cloud, which settles towards the lower part of the fluid, after the specimen has been allowed to stand for some time. *See* Part IV.

Lactic Acid ($HO, C_6H_5O_5$).—Lactic acid is not constantly present in healthy urine in quantities sufficient to be recognised; but it is sometimes found in the urine of persons who may be considered to be in tolerably good health. Liebig believes that he proved the entire absence of lactic acid from healthy urine altogether; but its presence in this fluid—at least under certain physiological conditions, as stated many years ago by Berzelius—has been confirmed by Franz Simon, Lehmann, and others; although, on the other hand, it appears nearly certain that the salt assumed to be lactate of zinc by many observers was not really of this nature, but probably consisted of a combination of another acid, which, unlike lactic acid, contains nitrogen.

In order to ascertain the presence of lactic acid, a baryta salt should be first prepared, as Lehmann has recommended, from which a lime salt is easily formed by the addition of sulphate of lime. The lactate of lime crystallises in double brushes, as seen by the microscope. From the lime salt a copper salt is prepared by the addition of sulphate of copper. This is examined by the microscope. The lactate of copper is decomposed by placing a small bar of zinc in the solution; and upon this, in a short time, crystals of lactate of zinc are deposited, whose angles may be measured in the microscope. *See* "The Microscope in Medicine," third edition, p. 118, pl. XIII, figs. 89, 90, 91.

According to some observers, the phosphate of lime and the ammoniaco-magnesian phosphate are held in solution by lactic acid. They may also be dissolved by the chloride of ammonium, according to Dr. G. O. Rees. MM. Cass and Henry have endeavoured to prove that the lactic acid exists in the form of lactate of urea. Lactates of soda and ammonia may perhaps be present in some cases.

Oxalic Acid (HO,C_2O_3) **and Oxalurate of Ammonia** ($NH_3, C_6H_4N_2O_8$) have been found in healthy urine by Strahl and Lieberkühn. Böcker estimated the quantity at 1·42 grain in twenty-four hours. Dr. Leared has shown that if lime water be taken overnight, an abundant deposition of oxalate of lime occurs in the morning's urine. *See* a paper by Dr. Dyce Duckworth in the "Medical Times" for March 2, 1867. Oxalate of lime deposit is also produced in the urine if oxalic acid be taken in very small quantity, from half a grain to a grain dissolved in an ounce or more of water. This deposit is almost invariably met with for many days in cases of attempted poisoning by oxalic acid. *See* part IV.

Oxalurate of Ammonia.—Dr. Edward Schunck, in a paper read before the Royal Society, Nov. 15, 1866, states that by allowing urine to percolate through charcoal, as before described, several organic substances besides the fatty acid may be separated. If the liquid obtained after treating the charcoal with boiling alcohol, be evaporated, a syrupy residue will remain, of which part is soluble in water, while the fatty acid remains insoluble. The soluble portion, after evaporating and washing with alcohol, is found to yield yellowish crystals of oxalurate of ammonia. "Illustrations of Urine," pl. VIII, fig. 3. Drawings of other oxalurates are given in the same plate.

Dr. Schunck is unable to say whether the oxaluric acid is a normal constituent of human urine or not, but he inclines to the opinion that it will be found to be a constituent of the healthy secretion.* On the

* In a note, Dr. Schunck recommends the following process for the detection of oxaluric acid:—"The matter, if soluble, should be dissolved in water, but if it is insoluble in consequence of the presence of some base, a little sulphuric acid should be added to set at liberty the oxaluric acid, after which the solution should be mixed with acetate of lead, and if any precipitate is thereby produced this must be filtered off, and

other hand, he says there can be no doubt that the presence of oxaluric acid in human urine serves to explain in a satisfactory manner the formation of oxalate of lime which is so common a constituent of the secretion. Oxaluric acid may be considered as a compound of oxalic acid and urea *minus* water, its composition corresponding to that of oxamic acid. By the action of acids, alkalies, or even water, at a high temperature, it becomes decomposed, yielding oxalic acid and urea. As soon as the oxalic acid is formed, it combines with the lime which is always present in human urine, and the well-known deposit of oxalate of lime results. It is very difficult to understand how oxalate of lime as such could be dissolved in the urine, but if it results from the decomposition of oxalurate, its presence is easily explained.

Peculiar Organic Acids.—Besides carbonic acid, urine contains, according to the observations of Städeler, a peculiar acid to which the name of *damaluric acid* has been given. It has a powerful odour; but little is yet known of the circumstances under which this volatile acid occurs. *Phenylic* or *carbolic acid*, a constituent of *creasote*, has also been detected in urine; but this acid with the *damolic* and *taurylic acids*, as they occur in urine, have as yet been so little studied, that we know nothing of any practical importance concerning them. Campbell and Lehmann state that urine contains traces of formic acid ($C_2H_2O_4$).

Colloid Acid of Dr. Marcet.—In the "Proceedings of the Royal Society," vol. XIV, p. 1, May, 1864, Dr. Marcet describes a new non-volatile organic acid, of a colloid nature. It is obtained in combination with lead, and Dr. Marcet has succeeded in preparing baryta and lime salts. From 8 litres of urine 4·46 grammes of the colloid acid were obtained. Dr. Marcet thinks it probable that the acid results from some transformation of the glucogenic substance of the liver.

Although the urea and some other constituents of the urine may be most conveniently and quickly estimated, by the volumetric process, p. 99, the practitioner is strongly recommended to carry out the routine plan of analysis given on p. 171.

INORGANIC CONSTITUENTS OF HEALTHY URINE.

The saline or inorganic constituents of healthy urine are composed of those substances which remain after the solid matter has been exposed to a red heat, and the carbon burnt off so as to leave a pure white ash. If a little of the solid matter of urine or other animal fluid be placed in a platinum capsule, or upon a piece of platinum foil,

the liquid left to stand, when it deposits small shining crystals. The residue obtained by evaporation of the mother-liquor of creatine obtained from urine in the usual manner by means of chloride of zinc, p. 137, gave, when treated in this way, crystals which could not be distinguished by their form from oxalurate of lead. Oxalurate of silver, distinctly crystallised, can be obtained from perfectly pure oxaluric acid."

which should be very large in proportion to the quantity of solid matter operated on, and exposed to the red heat of a spirit or gas lamp, it will melt and boil up, offensive gases will be evolved, which result from the decomposition of the organic constituents. When this has ceased, a charred mass, consisting of carbon and the saline matters indestructible at a red heat, of the urine, remains. After this black spongy mass has been kept in the open capsule, at a dull red heat for a few hours, the carbon will have gradually disappeared, in consequence of the action of the oxygen of the air, which at this temperature combines with it, and forms carbonic acid. A pure white ash, which has an alkaline reaction, alone remains; and this consists entirely of saline or inorganic material, which is indestructible at a red heat.

Changes effected in the Composition of the Salts by Incineration.— Now, it must not be concluded that the salts which we find in the ash existed in precisely the same state in the urine previous to incineration; for we know that many of these salts, when heated together, undergo mutual decomposition. Some of them may even be volatilised, if kept for a considerable time at a red heat. A mixture of carbonate of soda and chloride of ammonium is easily decomposed by heat. Chloride of sodium remains behind, while carbonate of ammonia is evolved. Any lactates, oxalates, and salts of other organic acids present in the urine, will be found in the ash, in the form of carbonate, although no carbonate existed in the urine originally. The ammoniaco-magnesian or triple phosphate will be found in the ash as phosphate of magnesia; the phosphate of soda and ammonia, as phosphate of soda. Other phosphates also become completely changed by the process of incineration, and by the action of other salts present in the ash upon them. During the incineration, a considerable loss of chlorine also takes place in the forms of chloride of ammonium and chloride of sodium which is also slowly vaporised at a red heat.

Again, unoxidised substances, such as sulphur and phosphorus, and partially oxidised compounds, in combination with organic materials, will become oxidised in the process of decarbonisation; and will, therefore, be found in the ash in the form of sulphuric and phosphoric acids. These will react upon some of the bases present, and sulphates and phosphates will be formed.

Professor Rose, of Berlin, in a beautiful series of experiments, has proved that the mineral constituents exist in very different states in various organic substances. From the carbonaceous residue (or charcoal) of some organic matters, the greater proportion of the salts can be extracted with water or acids; while, in other cases, but little saline matter can be separated, unless the mass be exposed to the oxidising action of the air for some time. This shows that the substances must have originally existed in an unoxidised or in a partially oxidised state, probably in combination with some organic material. In certain substances, then, the greater quantity of the mineral material is perfectly oxidised (*teleoxidic*); in others, it exists partly in an oxidised state (*meroxidic*). Professor Rose was not able to discover any substance in which it occurred completely unoxidised (*anoxidic*). In blood, milk, yolk of egg, and flesh, whose chemical constitution approximates to that of vegetable substances, a considerable portion of the mineral constituents are *meroxidic;* while in urine, and bile, and solid excrements, which are originated mainly by the process of oxidation in the animal body, they are almost entirely *teleoxidic.*

Proportion of Saline Matter in Urine.—About one fourth of the solid matter of healthy urine consists of saline constituents, which are not destroyed by a red heat.

One thousand grains of healthy urine, containing from forty to sixty grains of solid matter, will give from ten to fifteen grains of fixed salts. Of the salts, more than nine tenths are soluble in water (alkaline salts); while the remainder can only be obtained in solution by adding an acid (earthy salts). A mere trace remains behind, which is insoluble in water, acids, and alkalies. This consists of silica, with, perhaps, a little carbon which has resisted oxidation. These numbers are, of course, only approximative, as the amount of salts is liable to great variation.

The saline constituents, soluble in water, are the following:—

Sulphates of potash and soda.
Phosphates of potash and soda.
Chlorides of potassium and sodium.

The salts may be readily obtained in a crystalline state by dissolving the residue in hot water, and evaporating a few drops of the solution on a glass slide. The crystals are represented in "Illustrations of Urine," pl. I, fig. 2.

The mineral constituents insoluble in water are composed of the following acids and bases:—

Phosphoric acid.	Lime.
Carbonic acid (occasionally.)	Magnesia.
Silicic acid, or silica.	Alumina (sometimes).

In disease, the mineral constituents have been found to vary in quantity quite as much as the organic substances; and other salts are not unfrequently found, which will come under notice at a future time: while occasionally one or more of the mineral compounds mentioned in the above list are altogether absent.

The organic constituents of the urine have hitherto received a greater share of attention than has been given to the inorganic salts; but, from recent investigations, it seems probable that, before long, the physician will regard a departure from the healthy standard in the saline constituents, with as much attention as he has been accustomed to observe an increase or diminution in the quantity of the urea, uric acid, or other organic ingredients.

Phosphates.—The phosphates are a very important class of salts, which exist in greater or less quantity in all the tissues of the body, in the secretions, and in considerable proportion in the blood. The salts of phosphoric acid which are carried off from the organism in the urine may be divided into two classes.

1. The *alkaline phosphates* are *soluble* in water, and are not precipitated from their solutions by ammonia or other alkalies. When ammonia is added to healthy urine, the *alkaline* phosphates are not thrown down. Some of the most important alkaline phosphates are *phosphate of soda*, *acid phosphate of soda*, and *phosphate of soda and ammonia*.

2. The earthy phosphates are *insoluble* in water, but are dissolved by the mineral acids. Most are soluble in organic acids, although they dissolve very slowly if the acids are dilute. They are held in solution even by carbonic acid. Most albuminous substances have the power of dissolving earthy phosphates; and casein holds in solution a considerable quantity of phosphate of lime. The earthy phosphates, as phosphate of lime and phosphate of magnesia, are always precipitated when ammonia is added to healthy urine.

Of the phosphoric acid eliminated in the urine in the form of phosphates, the greater proportion is taken in the food; but a certain amount is formed in the organism by the oxidation of the phosphorus of albuminous tissues, which takes place during their disintegration. Some of the phosphoric acid formed in the organism is probably produced in the nervous tissue.

Phosphoric acid is known to exist in three forms—the monobasic, bibasic, and tribasic acids, which combine respectively with one, two, or three equivalents of base, to form three different classes of salts. The phosphates of soda are given as examples.

Tribasic phosphates	$3\ NaO,\ PO_5$
	$2\ NaO,\ HO,\ PO_5$
	$NaO,\ 2\ HO,\ PO_5$
	$NaO,\ NH_4O,\ HO,\ PO_5$
Bibasic or pyrophosphates	$2\ NaO,\ PO_5$
	$NaO,\ HO,\ PO_5$
Monobasic or metaphosphate	$NaO,\ PO_5$.

Now, the phosphates found in the organism are all *tribasic phosphates*, and consist of three equivalents of base, combined with one equivalent of phosphoric acid, with different proportions of water of crystallisation (Aq.) The elements of the base of a tribasic phosphate may be various. Thus they may consist of three equivalents of soda or other base, or two equivalents of soda and one of water acting the part of a base, or one equivalent of soda and one of ammonia and one of water acting the part of a base, combined with one equivalent of phosphoric acid.

The chemical composition of the phosphates occurring in urine is represented in the following table :—

Common or rhombic phosphate of soda, having an alkaline reaction	2 Na O, HO, PO_5 + 24 Aq.
Acid phosphate of soda, having an acid reaction	2 HO, Na O, PO_5 + 2 Aq.
Alkaline phosphate of soda, having a highly alkaline reaction	3 Na O, PO_5 + 24 Aq.
Phosphate of potash*	3 KO, PO_5.
Phosphate of ammonia and magnesia, ammoniaco-magnesian or triple phosphate	2 Mg O, NH_4O, PO_5 + 12 Aq.
Acid phosphate of lime	2 Ca O, HO, PO_5 + 3 Aq.
Phosphate of lime (bone-phosphate) ...	3 Ca O, PO_5.

Alkaline Phosphates.

Common Phosphate of Soda (2 Na O, HO, PO_5+24 Aq.).—This salt exists in healthy urine in the proportion of about two grains in one thousand. The fixed salts contain perhaps from 20 to 30 per cent. of ordinary phosphate of soda. Its presence in healthy urine may be proved by adding absolute alcohol to the syrupy fluid obtained by evaporating the urine over a water bath. This concentrated fluid is poured off from the salts which have crystallised, and placed in a small glass vessel. The alcohol is added, and, after the mixture has stood for some time, the crystals are deposited upon the sides of the glass. This method is given by Robin and Verdeil. ("Traité de Chimie Anat. et Physiol.," par Ch. Robin et F. Verdeil.)

Acid Phosphate of Soda (Na O, 2 HO, PO_5+2 Aq.)—This salt has only been found in the urine ; and to it, at least in many cases, the acid reaction of the urine is due. This acid phosphate of soda may be formed from the common phosphate (which has an alkaline reaction), by the addition of uric acid, which removes from the common phosphate one equivalent of soda, forming *urate of soda;* and the reaction of the mixture becomes acid, in consequence of the formation of the *acid phosphate.*

The acid phosphate of soda may be obtained from the concentrated urine treated with absolute alcohol, after the separation of the

* It is doubtful if phosphate of potash usually exists in urine, as chloride of sodium and phosphate of potash decompose each other, forming chloride of potassium and phosphate of soda. It is not improbable that it may exist in urine in which the chloride of sodium is present in very small quantity, or altogether absent, as in pneumonia and some other acute diseases.

common phosphate. The acid salt, which is much more soluble, becomes deposited in the course of a few days; but its separation may be expedited by the addition of ether. This phosphate has been separated from the urine by MM. Robin and Verdeil, who attribute the acid reaction of urine to its presence. ("Comptes Rendus. Mém. de la Soc. de Biologie," Paris, 1850, p. 25; also "Traité de Chimie Anat. et Physiol.," 1853.) The crystals of this salt are figured in Robin and Verdeil's "Atlas," pl. IX, fig. 2.

Triphosphate or Subphosphate of Soda ($3\ Na\ O, PO_5 + 24\ Aq.$)— This phosphate is considered by some to be present in urine; but it is so readily altered by other salts present, that it is impossible to obtain it from the animal fluids in a state of purity. In the presence of carbonic acid, it is decomposed: one equivalent of soda unites with the carbonic acid to form carbonate of soda, and common phosphate of soda is formed, both which salts have an alkaline reaction—$3\ Na\ O, PO_5 + CO_2, HO = 2\ Na\ O, HO, PO_5 + Na\ O, CO_2$.

Liebig has shown that it is not present in healthy urine, as was stated by Heller; and Messrs. Robin and Verdeil do not enumerate this phosphate as one of the constituents of urine; indeed, if this phosphate were formed, it would, in all probability, be at once resolved into salts of a more stable nature.

Phosphate of Soda and Ammonia ($Na\ O, NH_4O, HO, PO_5, + 8\ Aq.$)— This salt, although probably not present in perfectly fresh urine, is usually enumerated as one of the phosphates found in the secretion. The crystals of phosphate of soda and ammonia, or microcosmic salt, are beautiful transparent four-sided prisms.

Phosphate of Potash ($3\ KO, PO_5$) is probably not present in healthy human urine; but it has been detected by Boussingault in the urine of the pig, in the proportion of 1·02 per 1,000.

Many vegetable tissues contain a large quantity of phosphate of potash; and it is met with in the juice of muscle in considerable amount.

Quantity.—The proportion of alkaline phosphates in the organism varies very greatly according to the nature of the food, amount of exercise, &c. Generally, the proportion is smaller in herbivorous than in carnivorous animals. Muscular fibre contains a large amount of phosphates. Wheat, and the seeds of the cerealia generally, contain a considerable quantity of alkaline phosphates. Robin and Verdeil found in the ash of the blood of a dog fed upon flesh, as much as 12 per cent. of phosphoric acid, combined with soda and potash; while the ash of the blood of the ox did not contain more than 3 per cent. When the dog was fed upon potatoes, the proportion fell to 9 per cent. The ash of the blood of man contained about 10 per cent. of phosphoric acid. In urine, Berzelius found 2·94 per 1,000; and Simon, from 1·25 in slightly acid urine, to 2·75 in very acid urine.

Breed and Winter estimate the quantity of phosphoric acid removed from the organism in the urine, in the course of twenty-four hours, at from 59·48 to 79·97 grains. The proportion increased considerably after taking food. This quantity corresponds to from 120 to 100 grains of phosphatic salts. Dr. Parkes estimates the phosphoric acid at 48·80 grains in 24 hours.

The quantity of phosphoric acid increases for some hours after a meal. Vogel, Winter, and others have made numerous experiments on this point; and their researches show that the hourly variation in the excretion of phosphate is regular. The morning urine contains the smallest quantity. In some of Dr. Bence Jones's analyses, however, the quantity of alkaline phosphates is even greater in the urine passed before than in that secreted after a meal. (" Animal Chemistry," p. 81.)

The proportion of phosphates in the urine depends much upon the nature of the food. It has been said that the quantity is increased if phosphorus be taken, proving that this substance does become oxidised in the organism. That the greater proportion of the alkaline phosphates present in the urine is derived from the food is rendered evident from the amount introduced into the organism in this manner. A man taking about fourteen ounces of bread and twelve ounces of meat, with half a pound of potatoes and half a pint of milk, would take about 130 grains of alkaline phosphates.* As we have seen, he would eliminate, in his urine, about the same quantity. These numbers are only to be regarded as rough approximations to the truth; but I think, at present, it must be admitted that the quantity of phosphate excreted in the urine, and formed in the organism, is so small in comparison with that derived from the food, of which the amount is liable to great variation, that, in the present state of animal chemistry, it is quite impossible to form an estimate of the amount derived from the former source, or to separate this from the phosphates taken in the ingesta.

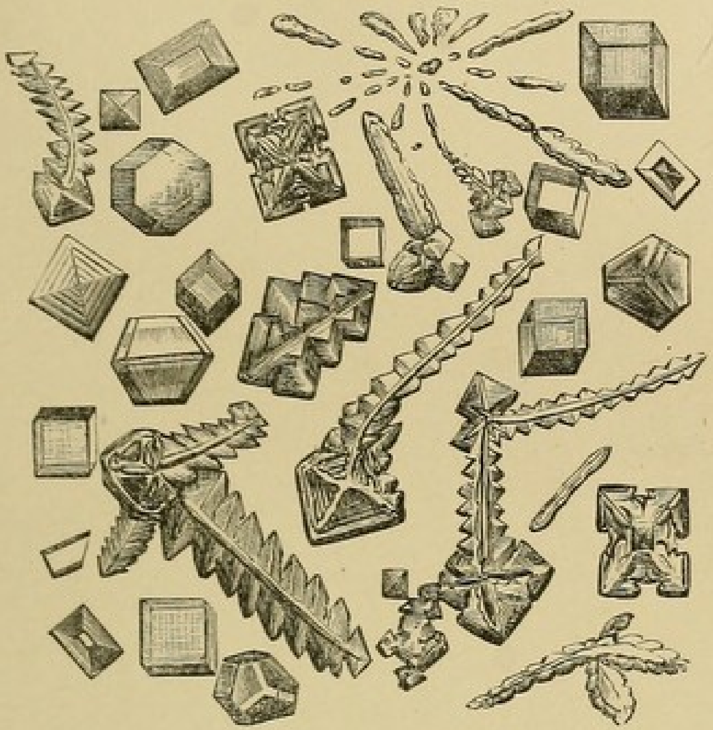
Still it is certain that some of the phosphoric acid is formed within the organism, by the oxidation of the phosphorus of the albuminous tissues, though this must bear but a small proportion to the whole amount of phosphate removed in the urine, as the above data conclusively show.

The fluid which surrounds the elementary fibres of muscle has an acid reaction, depending probably upon the presence of acid phosphate of soda, produced by the action of lactic or some other organic acid upon phosphate of soda. Du Bois Reymond has, however, shown that

* 14 oz. of bread	contain	53·2 grs.	of phosphates.
12 oz. of beef	,,	40·7 ,,	,,
½ lb. of potatoes	,,	11·0 ,,	,,
½ pint of milk	,,	32·0 ,,	,,
		136·9 grs.	of mixed phosphates.

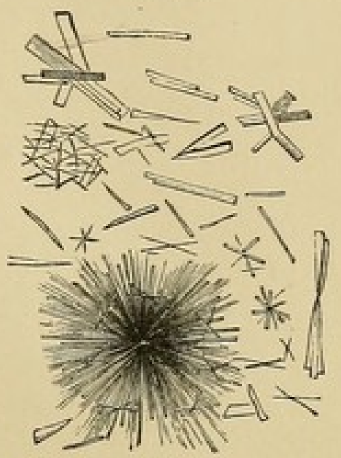
ILLUSTRATIONS OF URINE.

Fig. 1.



Crystals of chloride of sodium, examined in their own mother liquor. × 215. p. 167.

Fig. 2.

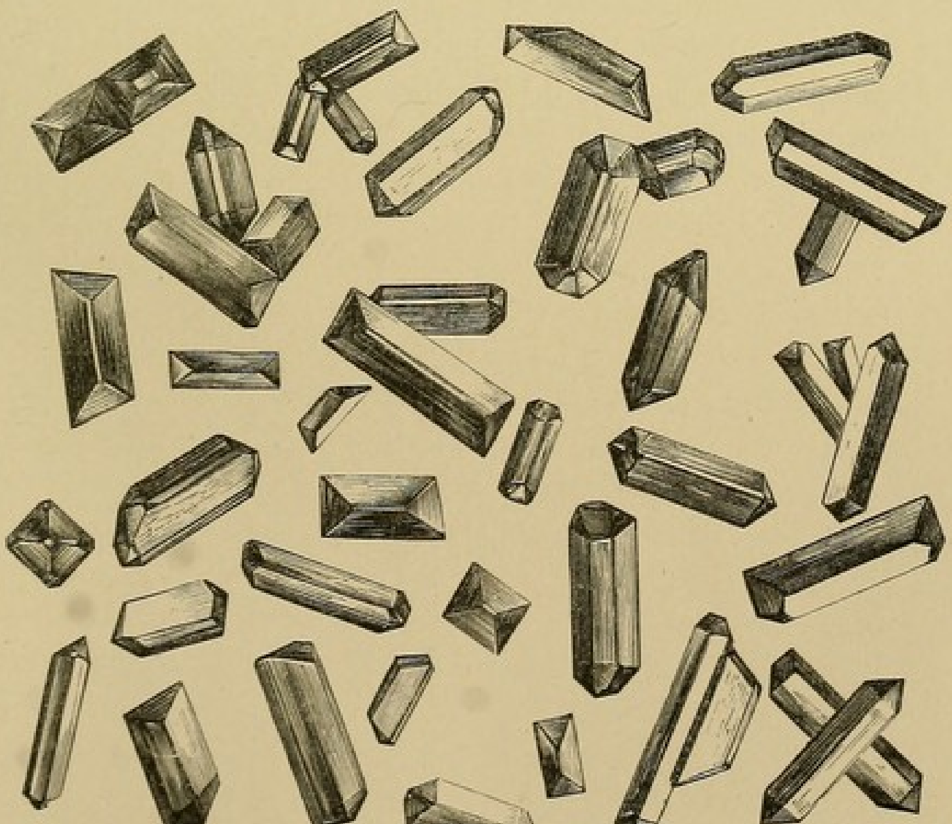


Phosphate of lime in a crystalline form. × 215. p. 163.

Fig. 3.

Phosphate of lime. × 215. p. 163.

Fig. 4.



Crystals of triple phosphate in the form of triangular prisms, with obliquely truncated extremities, as they frequently occur in urine. × 45. p. 164.

[To face page 160.

this acid reaction is not met with when the muscles are at rest. Recent experiments have shown that the amount of disintegration taking place in muscular tissue during its activity is much less than was supposed. It is very probable that very much of the material generally ascribed to the disintegration of the muscle is really due to the chemical changes produced in the nerves ramifying on the surface of the elementary fibres. The ashes of most tissues contain phosphates in large proportion; and Schmidt has shown that a considerable quantity of phosphate is always present in young tissues. The quantity of alkaline phosphate required by the organism is considerable; for, besides the large proportion which is excreted in the urine, the ash of the solid excrements alone contains as much as 20 per cent. The phosphoric acid required is, no doubt, supplied principally by the food, partly in the form of phosphatic salts, partly as phosphorus, as in albuminous matters, which is oxidised in the organism. We shall recur to this subject when we have to consider the elimination of the phosphates in disease.

Earthy Phosphates.—The earthy phosphates met with in urine are—1, the *ammoniaco-magnesian phosphate*, also termed *triple phosphate*, or *phosphate of ammonia and magnesia*; 2, *Basic phosphate of ammonia and magnesia*; 3, *Phosphate of lime.*

These earthy phosphates occur in very small quantity in urine. The secretion in health contains not more than from 1 to 1·5 parts in 1,000, and the solid matter contains from 1·5 to 2 per cent. The quantity present in different cases undergoes but slight variation, and seems to be determined, to a great extent, independently of the chemical changes going on in the body. Most of the solids and fluids of the organism contain small quantities of the earthy phosphates. The amount depends, in great measure, upon the quantity of alkaline earths present. Kletzinsky has shown that in urine there are two parts of phosphate of lime to one part of phosphate of magnesia.

In healthy urine, these earthy phosphates are held in solution, in all probability, by the free acid of the urine, and in some measure by the acid phosphate of soda. The chloride of ammonium present may also contribute to maintain the earthy phosphates in solution in the urine (Dr. G. O. Rees). Very slight changes are sufficient to cause the precipitation of the ammoniaco-magnesian phosphate; and beautiful crystals of this salt are sometimes formed in urine which has a decidedly acid reaction.

It is important to distinguish between *excess* of phosphates in the urine and a *deposit* of earthy phosphate: for a large quantity of earthy phosphate in the urine may pass unnoticed by the practitioner, because it is in a state of *solution*; while a smaller quantity in an *insoluble* state, and therefore very conspicuous, is likely to receive from him a larger share of attention than its slight importance demands.

Precipitation of Earthy Phosphates by Heat.—It is very important to bear in mind that the earthy phosphates are precipitated from some specimens of urine by heat. This precipitate closely resembles that which is produced, in many specimens of albuminous urine, upon the application of heat. It is, however, at once distinguished from albumen by the addition of a few drops of nitric acid, which instantly dissolves the phosphate, while albumen is unaffected by it. Such a mistake has many times been made; and I need hardly say how important it is to avoid the possibility of such an error, as it may lead the practitioner to form an unfavourable prognosis in a case in which there is really no cause whatever for anxiety. The cause of this occasional precipitation of earthy phosphate is obscure. By Dr. Rees it is attributed to an excess of the phosphates being held in solution by chloride of ammonium. Dr. Brett considers that in these cases it is dissolved by carbonic acid; while Dr. Bence Jones attributes this precipitation to the excess of free acid of the urine being neutralised by an alkali, or by common phosphate of soda.

Phosphate of Lime ($3\ Ca\ O,\ PO_5$) exists in healthy urine dissolved in acids, in certain salts, or in organic matters. Phosphate of lime is somewhat soluble in a solution of carbonic acid, in bicarbonates, and in chloride of ammonium. Albumen and fibrine always retain a certain quantity, and casein holds a large amount in solution. It is found in almost all the tissues, and, when separated, usually occurs in an amorphous state. In urine it sometimes crystallises. The ash of urine contains between 2 and 3 per cent. of this phosphate, and that of excrements upwards of 12 per cent. It may be obtained in quantity from bones.

Acid Phosphate of Lime ($2\ Ca\ O,\ HO,\ PO_5 + 3\ HO$).—The existence of this phosphate in urine constantly, is questionable; but, as before remarked, the composition of the phosphates is constantly altering; and an acid phosphate of lime is readily formed by the action of an organic acid on the neutral phosphate of lime.

Phosphate of Ammonia and Magnesia, Triple, or Ammoniaco-Magnesian, Phosphate ($NH_4\ O,\ 2\ Mg\ O,\ PO_5 + 12\ HO$).—The presence of this salt, which is frequently met with in the animal fluids, usually depends upon decomposition having commenced, in which case the ammonia set free combines with the phosphate of magnesia to form the triple phosphate. At the same time there can be no doubt that crystals of triple phosphate are sometimes found in acid urine—not merely forming a pellicle which alone is alkaline, while the fluid beneath retains its acidity (Thudichum)—but as a distinct deposit, leaving a clear supernatant fluid. Lehmann and other observers doubt the correctness of this observation; but the fact has been observed in this country several times, and I have noticed it myself more than once or twice.

It is quite possible that the acid reaction may depend upon chloride of ammonium, or some other salt which reddens litmus, and not upon the existence of free acid.

Crystals of triple phosphate are slightly soluble in pure water. It is generally stated that triple phosphate is insoluble in solutions of ammoniacal salts, but Fresenius has shown that this statement is erroneous. He finds that 1 part of triple phosphate requires 15,293 of pure HO, 44,330 of liquor ammoniæ, 15,627 of NH_4 Cl with free NH_3, and only 7,548 of NH_4 Cl alone, for solution. Crystals of triple phosphate give beautiful colours when examined with a ray of polarised light.

Phosphate of Magnesia (**3 Mg O, PO_5+5 Aq.**).—This phosphate is found in considerable quantity in the urine of certain herbivorous animals, and it appears to be a constituent of certain urinary calculi. It is doubtful if it is often present in human urine; but Robin and Verdeil have discovered it in several organs, and also in morbid products. In animal fluids generally, the phosphate of magnesia combines with ammonia, forming the salt which has just been described. When discussing the deposits of phosphates, part IV, I shall have to revert to this subject.

Microscopical Characters of the Earthy Phosphates.—The phosphate of lime is usually deposited from urine in an amorphous form. Under the microscope, even when the highest powers are employed, the deposit when first formed is found to consist of minute granules. *See* plates in part IV. Occasionally it occurs as round or oval particles of a high refractive power. Sometimes two of these small particles are connected together, and produce a crystal of the dumb-bell form. They vary much in size, but are usually very small.

After some time has elapsed, the amorphous granular deposit of phosphate of lime assumes a crystalline form. Dr. Hassall has found that the crystals formerly regarded as a rare form of triple phosphate are really composed of phosphate of lime. Dr. Bence Jones has also obtained crystals of phosphate of lime from urine by adding chloride of calcium, and Dr. Roberts has written a paper on the same subject. I have found that beautiful crystals of phosphate of lime can always be obtained by allowing solutions of phosphate of soda and chloride of calcium in glycerine gradually to mix together. In this manner very perfect crystals may be produced. Many days may elapse before large crystals are formed.

The *phosphates of magnesia and ammonia* crystallise in several different forms, which seem to be determined by a slight change in circumstances. The first is the stellate form, which occurs when ammonia is added to healthy human urine. The crystal consists of from four to five feathery rays, with a minute oval mass situated at the origin of each ray from the centre. These crystals gradually assume the more common form of the triple phosphate: secondly, that of a beautiful triangular prism, with obliquely truncated extremities. Great variation, however, is observed in the form of these crystals; sometimes they appear almost square; and frequently they might be mistaken for octahedra, in consequence of the approximation of the obliquely truncated ends, and the shortening of the intermediate portion of the crystal. Prisms or knife-rest crystals of triple phosphate are represented in pl. X, fig. 3. The feathery crystals of triple phosphate are represented in the "Illustrations of Urinary Deposits," Part IV. After standing for some time, the rays alter in shape, and gradually little triangular crystals begin to make their appearance. After the lapse of some days, they are entirely converted into the ordinary triangular crystals. Other forms of triple phosphate crystals are described and figured under the head of *urinary deposits*, part IV.

Estimation of the Earthy and Alkaline Phosphates.—The *earthy phosphates* (*phosphate of lime* and *phosphate of magnesia*) are easily detected by ammonia. If a few drops of solution of ammonia are added to a specimen of healthy urine, a turbidity is soon observed, owing to the precipitation of phosphate of lime in an amorphous form, and triple or ammoniaco-magnesian phosphate in flocculent snow-like crystals, which increase in size for some time after their first precipitation. Stirring favours the separation of the phosphates; but the form of the crystals must, of course, be studied in a mixture which has been allowed to remain quiet. If it is required to estimate the proportion of these earthy phosphates, it is only necessary to separate them by filtration, after standing for a few hours, to wash them with ammoniacal water, ignite in a platinum capsule, and weigh the ash.

Alkaline Phosphates.—The phosphoric acid combined with the alkalies may be precipitated from the fluid filtered from the earthy phosphates by the addition of a salt of lime or magnesia, when an insoluble deposit, composed of phosphate of lime or phosphate of ammonia and magnesia, is produced. If it is desired to ascertain the quantity of alkaline phosphates, it is only necessary to filter the precipitate, dry, ignite, and weigh it. From the phosphate of lime or phosphate of magnesia it is easy to calculate the proportion of phosphoric acid present; but, for ordinary purposes, it is enough to consider the weight as corresponding to the quantity of alkaline phosphates present in the urine, the results of different analyses being thus rendered comparable. The volumetric method of estimation, in which the phosphate is precipitated by nitrate of uranium has been described in page 106. Nitrate of silver produces in urine a yellow precipitate of tribasic phosphate of silver, which is soluble both in excess of ammonia and also in nitric acid. Upon adding a few drops of the former to the yellow deposit in the test-tube, it instantly dissolves. If nitric acid, just sufficient to neutralise the ammonia present, be added, the yellow precipitate reappears; but, when one drop more falls in, it is immediately redissolved. This might be repeated many times. The precipitate of *chloride* of silver is quite *insoluble* in nitric acid, although soluble in ammonia; so that, in testing for chloride of sodium in urine, it is always important to add a few drops of nitric acid, to prevent the precipitation of the phosphate of silver.

Alkaline Sulphates.—Unlike the phosphates, the sulphates are present in very small quantities in the fluids of the body generally. The urine, however, contains a large quantity. This class of salts is not present in the milk, bile, or gastric juice. The blood contains only ·20 per 1,000; while, in healthy urine, sulphates exist in the proportion of from 3 to 7 parts per 1,000.

The proportion of sulphates undergoes a considerable increase after violent exercise, and under the influence of a purely animal diet —conditions under which the urea suffers a considerable augmentation. In fact, in all those states which are associated with an increased formation of urea, a large proportion of sulphates will also be observed. It would appear that the oxygen, hydrogen, carbon, and nitrogen of the albuminous substances, are eliminated in the form of urea; while the sulphur is removed in the state of sulphuric acid.

Dr. Bence Jones's experiments have shown that both vegetable and animal food increase the proportion of sulphates in the urine. When sulphuric acid, sulphur, or sulphates are taken internally, the amount of these salts is augmented. Such facts prove that the sulphates found in the urine are in great part formed during the disintegration of tissues. They must be regarded as excrementitious, and are probably not concerned in nutrition.

The sulphuric acid eliminated in the urine occurs in the form of sulphate of potash and soda.

The urine contains about 3·5 grains per 1,000 of sulphate of potash, and about 3·0 grains of sulphate of soda. About thirty grains of sulphuric acid, corresponding to about fifty-seven grains of the mixed sulphates, are excreted by a healthy man in twenty-four hours.

The sulphates present in the urine are all soluble, like the alkaline phosphates; and, in order to prove their presence in a fluid, it is only necessary to add some salt, the base of which forms an insoluble precipitate with sulphuric acid. Baryta salts are the most convenient for this purpose. Either the nitrate of baryta or the chloride of barium may be employed. In testing for sulphates in urine, it is necessary to add a little free nitric or hydrochloric acid previous to the addition of the baryta salt, in order to prevent the precipitation of a *phosphate* as well as a *sulphate* of baryta. The former is very soluble in free acid; the latter quite insoluble. If the quantity of sulphate is to be estimated, it is necessary to boil the mixture, or to drop the baryta salt into the boiling solution; otherwise the precipitated sulphate of baryta will pass through the pores of the filter. The phosphoric acid may be estimated in the clear fluid which passes through the filter, by the addition of ammonia, which throws down phosphate of baryta. The contact of the air must, in this case, be avoided.

Sulphate of Lime has not been detected in human urine, but it has been found in that of animals, and is a constituent of some urinary calculi. I have seen crystals of sulphate of lime in the uriniferous tubes; and it is probable that it may be present in the urine, in some cases, in appreciable quantity. Traces of sulphate of lime are found in the blood. It is found in the pancreatic juice which has been kept for a few hours in a warm place, to favour decomposition of some of the organic materials.

Carbonates.—Carbonate of soda is not usually reckoned as a constituent of healthy urine, as its presence is entirely dependent upon the kind of food which the person has taken. For instance, carbonate of soda will often be found in the urine after large quantities of fruit have been eaten, in consequence of the salts of the vegetable acids becoming converted into carbonates during their passage through the organism. In the urine of herbivorous animals, alkaline carbonates are found; and frequently the carbonate of lime is also present. In the urine of rodents, these salts, particularly the latter, are abundant. Moreover, carbonate of soda may actually have been present in the urine, although it cannot be detected in the ash; for, if common phosphate of soda be heated with carbonate of soda, the carbonic acid is expelled, and the tribasic phosphate of soda remains. On the other hand, a carbonate may be detected in the ash, although none was present in the urine, in consequence of the decomposition of urates, oxalates, &c., during incineration.

Testing for Carbonate.—The presence of carbonic acid is very easily recognised, by the effervescence set up, immediately a little dilute acid is added to the ash. The best plan to test for carbonate in the ash is the following. A small portion of the dry ash is placed on a glass slide, and covered lightly with an ordinary square of thin glass. A drop of acid is then allowed to fall on the glass, so that it will gradually pass between the glasses by capillary attraction, and come into contact with the salt. If any bubbles of gas escape in consequence of the action of the acid, they will be confined beneath the thin glass, and one cannot fail to see them. If they be very small, the specimen may be subjected to microscopical examination. In this manner, the slightest trace of carbonic acid can hardly escape notice.

If the quantity of carbonate is to be estimated, the ash must be placed in a little apparatus, from which the gas is conducted by a tube into another vessel containing lime or baryta water; or it may be caused to pass through the potash apparatus used in organic analysis. From the weight of the carbonate, that of the carbonic acid is easily calculated. In the last case, its weight is obtained directly.

Chloride of Sodium ($NaCl$).—Common salt is always present in healthy urine, although the proportion is liable to great variation, owing to the circumstance that the chloride of sodium is always derived from the food. The importance of this substance to the organism is sufficiently proved by the fact that all kinds of food contain a certain quantity, and almost every specimen of water holds some proportion in solution. Again, it is well known that the health of animals deprived of the proper amount of salt, deteriorates. It is to be detected in nearly all the tissues of the animal body, and is found in large quantity wherever cell-development is actively going on. This is true both with regard to healthy tissues and morbid growths. Common salt crystallises in cubes; but, in the presence of urea and some other organic substances, it assumes the form of a regular octahedron. As is well known, it is readily soluble in water (31·84 parts in 100), diffuses itself rapidly through a large bulk of fluid, and, in a dilute state, permeates tissues with great facility.

Besides common salt, urine also contains a certain quantity of chloride of potassium.

Quantity.—Healthy urine contains from three to eight grains of chloride of sodium in 1,000; the solid matter, about 6 per cent.; and the fixed salts, about 25 per cent. or more. Under ordinary circumstances, from 100 to 300 grains of salt are removed from the body in twenty-four hours; but the proportion is influenced by a great variety of circumstances, and is especially affected by the quantity of fluids taken. Dr. Parkes estimates the quantity of *chlorine* at from 92 to 124 grains in twenty-four hours. The amount is very variable in different individuals, according to the proportion of salt taken with the food. The secretion of chloride of sodium, as would be supposed, attains its maximum a few hours after a meal, and but little is eliminated during the night.

Detection.—Chloride of sodium is very easily detected in urine. It is only necessary to acidulate the specimen with a few drops of nitric acid, and then add nitrate of silver. The white precipitate of chloride of silver is quite insoluble in nitric acid, but soluble in ammonia. In order to make a quantitative determination, the chloride of silver is to be dried; and it should be fused in a *porcelain* capsule before being weighed. The volumetric process, however, is the most accurate, p. 99.

Circumstances affecting the Excretion of Salt.—Chloride of sodium is not formed in the organism, but seems to exert some important and beneficial effects during its passage through the tissues; and whenever the nutritive changes are very active, there seems to be an unusual demand for chloride of sodium. But the precise part which the substance plays is at present unknown. The quantity of salt excreted in the urine undergoes great changes in certain diseases. The proportion also varies considerably from day to day, under the influence of an ordinary diet in health; and the ingestion of large quantities of water causes the elimination of a greatly increased amount of common salt. Thus, in one experiment, continued for four days, the following results were obtained: during the first three days, about thirty-six ounces of urine were passed per diem; the specific gravity varied from 1,015 to 1,024. The total quantity of solid matter passed in twenty-four hours was about 750 grains, and the chloride of sodium amounted to 113 grains. On the fourth day a large quantity of water was taken; 258½ ounces of urine, of specific gravity 1,003, were passed, containing a total of 1134·48 grains of solids, and 232·8 grains of chloride of sodium. The phosphoric acid was diminished, and the sulphuric acid was increased by upwards of one third.

Soda and Potash (NaO & KO).—In healthy urine but a very small quantity of potassium is present in the form of chloride; but of soda salts there is a large proportion. The potash salts, as was first pointed out by Liebig, are found in considerable quantities in the muscles, while the soda salts predominate in the blood. Although phosphate of potash be taken in the food, the corresponding soda salt, which is necessary to the blood, is still found in that fluid; and there can be no doubt that, in the organism, the chloride of sodium is decomposed by the phosphate of potash—a phosphate of soda and a chloride of potassium being formed.

To separate the sodium from the potassium in urine, a somewhat tedious analysis, of which I will just give a rough outline, is necessary. After destroying the organic matter by ignition, the whole of the phosphoric and sulphuric acids are removed, and the potassium and sodium converted into chlorides. A solution of bichloride of platinum is then added, and a chloride of potassium and platinum, and a chloride of sodium and platinum are formed. The potassium salt is most insoluble, and separates after a time in the form of small octahedra, which do not polarise light. These may be separated by filtration. The sodium salt remains in solution, and may be obtained in the form of crystalline needles by concentrating the solution. These crystals exhibit the most beautiful colours when a ray of polarised light is transmitted through them.

Lime (CaO) may be detected in urine by dissolving the salts in acetic acid, and adding a little oxalate of ammonia to the filtered solution. Oxalate of lime is precipitated as a white, granular powder, which passes through the pores of a filter, unless the mixture be boiled previous to filtration. As already mentioned, lime occurs in urine as a phosphate, and occasionally as a carbonate. The latter forms a urinary calculus very rarely met with in man, but not uncommon in some herbivorous animals. The urine of the horse always contains a number of spherical masses, composed of carbonate of lime, which may be regarded as microscopic calculi. It has been proved by Mr. Rainey that the spherical form which crystalline matter sometimes assumes, depends upon the presence of viscid substance in the solution which contains the crystalline matter. These spherical crystals of carbonate of lime, so constantly found in horse's urine, may be exactly imitated by causing carbonate of lime to crystallise artificially from gum water or other viscid fluids. "The mode of formation of shells," &c.

Magnesia (MgO) must be precipitated as ammoniaco-magnesian phosphate, from a concentrated solution of the salts after the separation of the lime. The fluid should be evaporated to a small bulk, and when quite cold a little of the solution of phosphate of soda should be added to the mixture, rendered alkaline by the previous addition of ammonia.

The solution should be stirred in all cases, for by this means a precipitate can often be produced, although before not the slightest turbidity was observable.

Iron (Fe).—Traces of iron may be detected in healthy urine if a large quantity of the secretion be operated upon. Like many other mineral substances, iron passes off in small quantities in the urine, and is generally found in the urine of persons taking preparations of iron. Dr. Harley has shown that iron is a constituent of one of the colouring matters of the urine. (*Uræmatine.*)

Silica (SiO_2).—Berzelius, many years ago, demonstrated the presence of *silicic acid*, or silica, in urine. Mere traces are met with in the ash after the removal of the salts insoluble in water, by the addition of strong nitric acid. The silica remains undissolved. This substance is derived principally from wheat, which, like other plants belonging to the cerealia, contains a considerable proportion of silica. Silica has been occasionally met with in urinary calculi, in appreciable quantity.

Alumina (Al_2O_3).—It has been stated by authorities that this substance does not pass off from the system in the urine at all; but from several observations which I made some years since, and which I have lately repeated, I have been led to conclude that it is very commonly present in the ash of urine. The alumina detected in the urine is in great part, if not entirely, derived from the alum taken in the bread. Some time since, while in the habit of eating pure home-made bread, I was unable to detect the presence of this substance in the manner presently to be described; but afterwards, when my diet consisted of baker's bread, I found very decided indications of its presence.

The test which has been employed is the ordinary blow-pipe test. A little of the fixed saline residue, which has been perfectly decarbonised, is moistened with a solution of nitrate of cobalt, and heated gradually in the blow-pipe flame to a bright red heat. If alumina be present, the bead, upon cooling, is found to be of a beautiful *bright blue* colour. As is well known, there is great difficulty in separating phosphate of alumina from phosphate of lime; and the ordinary process of analysis is not sufficiently delicate to detect this substance in the small quantity in which it ordinarily occurs in the ash of urine. When the ash contains as much as one-fiftieth part, however, I have been able to detect it by the liquid tests. The blow-pipe test, above referred to, is not without objection, inasmuch as any bead containing phosphates exhibits a blue colour when heated in the blow-pipe with nitrate of cobalt. The blue colour produced is certainly very different to that developed when alumina is present. A bead, consisting of phosphates of soda, lime, and magnesia, gave a very dull grayish blue colour with the cobalt; but, when the slightest trace of alumina was added, a very bright and decided colour resulted. I have applied this test, therefore, to the urine salts before and after alum was taken in the food. In the first case, the blue tint was very undecided, or was not at all manifested, while in the last it was bright and distinct.

At a time when I was taking home-made bread, perfectly free from alum, I examined the urine. The ash was tested for alumina, with nitrate of cobalt, in the usual manner, but only a faint blue colour was produced. Immediately after evacuating the bladder (12, noon), five grains of alum were taken, dissolved in an ounce and a half of distilled water. At 6 P.M., about fifteen ounces of urine were passed. A portion of this was evaporated to dryness, and the residue incinerated and decarbonised. A small quantity of the ash was treated with nitrate of cobalt, and heated in the blow-pipe flame. The bead, on cooling, was of a very bright blue colour. This experiment was repeated, with the same result. A similar reaction is met with in a great many specimens of ash obtained from the urine of hospital patients. Although this is not a perfectly accurate test, it indicates the presence of alumina in some specimens of urine in which one would expect a salt of this base to be present; while, in urine which was perfectly free from alumina, no indication of its presence was afforded by the test. I think, therefore, if the cobalt test be employed carefully, it is worthy of more trust than most chemists seem disposed to place in it. A further series of researches is required to prove the proportion of alumina removed in the urine to that which escapes by the intestinal canal, when salts of this base are taken with the food. But I think there can be little doubt that a certain amount of this substance is really carried off in the urine. The urine salts of most persons give a very decided reaction, indicating the presence of this substance, a considerable quantity of which is taken with many kinds of bread. Although there are many objections to mixing alum with the bread, and the practice ought clearly to be put an end to, I am not aware that any deleterious effects have been produced by its introduction. Some have attributed habitual constipation to this cause.

It is necessary that the student should be acquainted with the principal characters of the most important inorganic salts of urine; and it has been considered desirable to give the following short course of systematic analysis. When it is required to estimate the proportion of chlorides, phosphates, or sulphates, quantitatively, the volumetric process will, however, be found the most accurate, as well as the most expeditious.

SYSTEMATIC QUALITATIVE OR QUANTITATIVE ANALYSIS OF HEALTHY URINE.

Organic Constituents.—1. In the first place, the reaction and specific gravity of the specimen are to be taken, and any general points noticed, pp. 117, 93.

2. Two portions of urine (500 or 1,000 grains) are to be placed in separate porcelain capsules, and evaporated to dryness with the cautions previously given, p. 92. In the first portion, A, the *organic constituents* are to be estimated; in the second, B, the proportion of *salts* is to be ascertained. A, when dry, is to be weighed; and thus the quantity of *water* is obtained. The residue is known to be quite dry when *two successive* weighings exactly correspond. The solid matter is to be treated with successive portions of boiling alcohol, until nothing more is taken up. These are decanted into another basin, or passed through a filter; and the alcoholic solution, containing urea and extractives, is to be evaporated nearly to dryness. This alcohol extract is C; the residue insoluble in alcohol is D.

C. The alcohol extract is to be treated with a few drops of water, and placed over the water-bath. Crystals of oxalic acid are to be added until they are no longer dissolved. It is important to add *excess* of oxalic acid crystals. A drop of the solution may be placed on a glass slide, and the crystals of oxalate which form, subjected to microscopical examination, *Illustrations of Urine*, pl. IV. The mixture is allowed to cool, and the impure crystals of oxalate of urea with excess of oxalic acid are to be slightly washed with ice-cold water, and pressed between folds of bibulous paper, to absorb the extractive matters. The crystals are to be redissolved in a small quantity of water, placed in a half-pint beaker, and carbonate of lime added until effervescence has entirely ceased. After the mixture has been allowed to stand for some time, it is to be thrown upon a filter.

The solution separated from the oxalate of lime consists of *urea* with a little colouring matter. It is to be carefully evaporated to dryness, and weighed. If the residue is not entirely soluble in alcohol, it contains impurity which must be deducted from the weight of the *urea.*

Or, the alcohol extract, C, may be treated with a few drops of water, so as to form a thick syrup; and nitric acid added by drops, while the basin which contains the extract is plunged in a freezing mixture. A little of the mixture should be examined in the microscope, *Illustrations of Urine*, pl. III, figs. 1, 2, 3. When sufficient nitric acid has been added to combine with all the urea present, the whole is to be allowed to stand for some time; the crystals carefully washed with a very little ice-cold water, and placed on a porous tile, in order that the excess of nitric acid and the extractive matters may be absorbed. The crystals of *nitrate of urea* which remain, are to be carefully dried and weighed. 123 grs. of the nitrate correspond to 60 grs. of pure urea.

D. The residue insoluble in alcohol is to be treated with boiling water and thrown upon a filter. There remain upon the filter, *mucus* from the bladder and other parts of the urinary mucous membrane; *uric acid; phosphate of lime;* and *ammoniaco-magnesian phosphate*, with a mere trace of *silica.* This residue is to be carefully dried and weighed. It is then to be incinerated; and, after the ash has been completely decarbonised, its weight is to be deducted from that of the residue insoluble in alcohol; and thus the proportion of uric acid and vesical mucus is ascertained. By deducting the united weight of all these different substances—urea, uric acid, mucus, and earthy phosphate—from the solid matter, we calculate the quantity of extractive matter present.

Inorganic Salts.—The portion of urine B, p. 171, is also to be evaporated to dryness, and the dry residue incinerated in a large platinum capsule, and maintained at a dull red heat until it is perfectly decarbonised, and nothing remains but an almost perfectly white ash. This, consisting of the fixed salts, is now to be examined as follows. Boiling distilled water is to be poured upon the saline residue, and the mixture thrown upon a filter.

The *solution* contains the *alkaline salts.*

The *insoluble matter*, consisting of *phosphate of lime*, *phosphate of magnesia*, and *silica*, remains behind on the *filter.*

1. The residue *insoluble in water* is to be treated with nitric acid, and boiled if necessary. *Silica* remains undissolved. If effervescence occurs upon the addition of the acid, *carbonate of lime* was present in the ash. Filter; add excess of ammonia to the filtered solution, and redis-

solve the precipitated phosphates by adding excess of acetic acid. Next precipitate the lime as oxalate, by the addition of oxalate of ammonia. If the *quantity* of lime is required, the oxalate must be heated, exposed to the action of a dull red heat in a platinum capsule, and weighed as carbonate, after being moistened with carbonate of ammonia and dried at a moderate heat.

After the separation of the oxalate of lime by filtration, concentrate the clear solution by evaporation, and add ammonia in excess. Stir the mixture, and set it aside, that crystals of *triple or ammoniaco-magnesian phosphate* may form.

2. The *original solution*, containing the urinary salts, soluble in water, is divided into two portions, 2*a*, 2*b*.

2 *a*. The first portion is acidified with nitric acid, and treated with *nitrate of silver*. *Chloride of silver*, indicating the presence of chlorine, is precipitated. The chlorine originally existed in combination principally with sodium.

2 *b*. The second portion is also to be acidified with nitric acid, and an excess of solution of nitrate of baryta added; a precipitate of *sulphate of baryta*, proving the presence of sulphuric acid, occurs.

The mixture is boiled and filtered; and, upon the addition of ammonia to the solution, *phosphate of baryta*, showing the presence of phosphoric acid, is precipitated, care being taken to prevent the formation of carbonate of baryta by exposure to the air.

Next the phosphate of baryta is to be separated by filtration; and the solution, which contains nitrate of baryta, ammonia, and the fixed alkalies, is to be concentrated. Excess of carbonate of ammonia and ammonia is to be added, and the mixture boiled and filtered. The solution is evaporated to dryness, and the residue heated to redness in a platinum or porcelain capsule. The residue is to be treated with water, and filtered. The solution contains the salts of the alkalies, *potash* and *soda*. The former is thrown down in the form of minute octahedral crystals of the *potassio-chloride of platinum*, upon the addition of a solution of bichloride of platinum. After stirring, and standing for some time, these may be filtered off. The solution contains the *sodio-chloride of platinum*. It is to be concentrated, in order that the beautiful acicular crystals of this substance may form.

Many of the processes above described are imperfect, and likely to give results which are not quite accurate; still the plan is one which is practically useful, and, when a series of results is required, answers very well. In the analysis of animal fluids, it is impossible to attain to perfect accuracy, owing to the changes taking place in the ingredients of the fluid, which are produced by the analytical processes to which they are subjected. But, in such enquiries, it is more useful to know the change which takes place, under various circumstances, in the quantities of the different constituents, than to be acquainted with the exact absolute proportion of each present.

The presence of the following substances in the specimen of urine submitted to examination, has been proved, and we have ascertained the proportion of the following constituents in 500 or 1,000 grains of urine.

Water ...	...
Solid matter ...	...
Urea ...	...
Extractive matters ...	...
Mucus and uric acid ...	...
Earthy phosphate and silica ...	...
Fixed salts ...	...
Lime ...	...
Magnesia ...	...
Potash ...	...
Soda ...	...
Chlorine ...	...
Phosphoric acid ...	...
Sulphuric acid ...	...

The constituents not included in the above list, require special processes for their demonstration; and, as many of them exist in very minute quantity, it is not desirable that the student should attempt to test for them in the small amount of urine usually operated upon. The substances alluded to are the following:—

Creatinine.	Ammonia.
Sarcine.	Hippuric acid.
Uræmatine.	Iron.
Uroxanthine.	Alumina.*
Carbolic acid } ?	Carbonic acid.
Damaluric acid } ?	Leucine } †
Traces of sugar ?	Tyrosine } †

The characters of several of these have already been discussed, and the methods for separating them from the urine described.

* Not necessarily present in healthy urine.

† In urine in certain diseases. Probably not in healthy urine.

PART III.

URINE IN DISEASE AND ITS EXAMINATION.

EXCESS OR DEFICIENCY OF NORMAL CONSTITUENTS OF SOLUBLE MATTERS NOT FOUND IN HEALTHY URINE.

Morbid Urine.—Before I describe in detail the particular characters in which a specimen of urine may differ from the secretion in its normal state, it is desirable to consider one or two matters of general interest, which can be advantageously discussed in this place.

Many alterations in urine, which have been termed "morbid," really depend upon increased or diminished activity of the chemical changes which occur in health. It is often very difficult to decide how far an alteration in the quantity or quality of the constituents should be attributed to physiological changes, or referred to morbid actions; and it is quite impossible to separate, by a distinct line, healthy from morbid processes. An excess or deficiency of the ordinary normal changes must precede, and may lead to, disease. There are many alterations in the urine, depending upon a temporary derangement of those actions which occur in a state of health, which would not be properly described under the term healthy, but which, nevertheless, cannot properly be called morbid. I do not, therefore, attempt to divide *accurately* healthy urine from morbid urine, and only wish the arrangements followed in this work to be regarded as a sort of rough artificial division, adopted for convenience alone. Indeed, all such divisions are quite artificial; and no one attempts to assign rigid and exact limits, even to large and important branches of natural science, as anatomy, physiology, histology, botany, medicine, surgery, &c., which are nevertheless treated of as separate subjects.

The functions of digestion, respiration, and circulation are intimately concerned in the production of those substances which are removed from the system in the urine. The characters of the secretion are much affected by the state of the skin and the action of the liver; and there are many other circumstances which may cause an alteration in the urine, independently of those numerous affections to which the urinary organs are exposed. Disease of the secreting structure of the kidney, or of any part of the complicated and extensive efferent channel by which the urine is carried off from the gland, may cause very important alterations in the characters of the secretion. It is of great consequence to us, as practitioners, to know that an examination of the urine may materially help us in our endeavours to ascertain the exact nature and precise seat of the derangement in cases of renal affections, and in diseases of the mucous surface and organs connected with the urinary apparatus. Sometimes we are able to diagnose the morbid alteration from an examination of the urine alone; but, in almost all cases, such an examination will afford important information bearing on the nature of the case. Certain substances, which are ordinarily eliminated in the urine, may, in consequence of morbid actions having been set up, be attracted to other parts of the body, or be eliminated through other channels. Important changes often occur *after* the urine has been passed, and may be due to the action of the air, fermentation caused by the presence of fungi, and a number of other circumstances.

When the kidney itself is affected, the morbid condition may be temporary or permanent; and this can often be ascertained with certainty by examining the urine. The mucous membrane of the pelvis of the kidney, of the ureter, or of the bladder, may be the seat of the lesion; or, lastly, a certain effect may be produced by the growth of adjacent tumours, by causing pressure, altering the structure of the organs, &c.

The *ordinary constituents* may be in greater or less proportion than in health, or certain *soluble substances* not met with in the healthy secretion may find their way into the urine. As I have before remarked, a little mucus from the urinary passages is the only *deposit* which occurs in health. In disease, *insoluble deposits* are commonly met with. Substances which are comparatively, though perhaps not absolutely, insoluble (being soluble in a very large quantity of the secretion), may float upon the surface of the urine, or may be suspended throughout the fluid.

By *microscopical examination*, combined with chemical tests, the nature of a deposit is made out, *see* Part IV. By *chemical analysis* alone, an abnormal proportion of substances present in health, and the presence of such as are not found in the healthy secretion can be detected, and the amount estimated.

The various alterations occurring in the urine in disease, included in Part III, will be discussed in the following order. First, excess or deficiency of any of the *normal constituents* of urine. Secondly, the characters of certain soluble substances in the urine in disease, which are never met with in a state of health.

Diathesis.—The word *diathesis* is very frequently used in connection with certain abnormal states of the urine; and, before the characters of the urine in disease are considered, it is desirable to discuss what ought to be understood by this word. The "uric acid," the "phosphatic," the "oxalic," the "sulphuric" *diatheses*, and others, are constantly spoken of, but the word *diathesis*, although employed by very high authorities since the time of Dr. Prout, is very objectionable if regarded in any way as explanatory of the production of urinary deposits.

In the first place, with reference to the *uric acid diathesis;* this term has been applied to all cases in which the urine habitually contains deposits of uric acid and urates; but the precipitation of uric acid in an insoluble form is due to a change taking place in the urine, at least in the majority of instances, *after* it has been secreted. Excess of uric acid may exist in the urine in two states, *dissolved in the fluid*, and in the form of *insoluble deposit*. In the first case, the practitioner would not be cognisant of the excess; and a person may be passing a very considerable quantity of urates, in a state of solution, for a long time, without any notice being taken of the fact. On the other hand, a patient's urine may contain only the healthy proportion of uric acid; but this, owing to a change taking place *after* it has left the bladder, might be deposited in an insoluble form. From this circumstance alone it would be inferred by some that the last patient had a disposition to the formation of a large quantity of uric acid (*uric acid diathesis*), while really a much larger amount may have been produced and excreted in the former instance.

Secondly; persons whose urine has deposited triple phosphate and phosphate of lime have been said to suffer from the phosphatic *diathesis*, although the deposition of the sediment depends, at least in the great majority of cases, upon a change occurring in the urine after it has left the secreting part of the organ, and has not necessarily anything to do with any habit of body or peculiarity of constitution, or with the state of the blood. But the deposition may be associated with actual and positive excess. Dr. Bence Jones defines the phosphatic diathesis and the sulphuric diathesis in the following terms:—"What I wish to impress upon you now is, that the true phosphatic diathesis—that is, the occurrence of an excess of alkaline and earthy phosphates in the urine—may not make itself apparent to the eye. The alkaline phosphates may be present in an inordinate excess; and, as in the sulphuric diathesis, the sulphates may be immensely increased," &c. (Lectures on Digestion, Respiration, and Secretion, "Medical Times and Gazette," March 27, 1852.) Now, in these cases, what is observed is, that a greater proportion of certain constituents is excreted in the urine than occurs in perfect health. The different physiological conditions under which an excess of some of these substances is produced are well understood, and the result cannot be referred to any peculiar *habit* or *diathesis*. If we speak of the *sulphuric acid diathesis*, we must, of course, admit the *urea diathesis;* for usually, when the sulphates are in excess, a corresponding increase in the proportion of urea exists. On the same principle, we might speak of the *extractive diathesis* and the *water diathesis.* It would be quite as reasonable to talk of the *carbonic acid diathesis* when an increased proportion of carbonic acid was exhaled.*

Thirdly ; many of the above remarks will apply to the so-called *oxalic diathesis.* The presence of oxalate of lime, and the increase of certain of the materials which exist in health, depend upon the action of well-known chemical changes, and result as the natural consequence of confinement, exposure to cold, taking particular kinds of food, &c. No peculiar diathesis can be discovered in persons who pass urine having these characters : in fact, in the majority of cases, the alteration is only of temporary duration, and it therefore seems to me that the term *diathesis* is quite inapplicable.

We may, in the present state of knowledge, with propriety, perhaps, speak of the *gouty diathesis*, of the *tubercular* and *cancerous diathesis*, and, perhaps, of the *rheumatic diathesis*, because there certainly is a peculiarity of constitution which may be transmitted from parent to offspring, and which is characterised by the invariable presence of certain morbid actions which exist in the conditions known to us as *gout*, *tubercle*, *cancer*, and *rheumatism*. But of the actual state of the blood, and of the nature of the processes which lead to the symptoms we really know very little, and if we did understand these things we should discard the word diathesis, so that it seems to me better to say, that a patient suffers from attacks of gout, of tubercle, cancer, or rheumatism, than to hide our ignorance of the essential nature of these morbid states by using a learned term, the meaning of which cannot be well defined. I shall venture, therefore, to discard altogether the use of the word *diathesis* in discussing morbid states of the urine; and I think, by so doing, we shall be in a better position to investigate the causes of changes occurring in the secretion in disease, and to study the manner in which urinary deposits are formed.

EXCESS OR DEFICIENCY OF WATER, AND OF THE ORGANIC CONSTITUENTS OF URINE.

The varying quantities of water removed from the body, in different physiological states of the system, have been already referred to. Every one is familiar with the compensating action existing between the functions of the skin and intestinal canal, and the kidneys. If the kidneys be diseased, and the intestinal canal, the skin, and the respiratory apparatus be tolerably healthy, they, to some extent, fulfil the work of the kidneys. In skin diseases, and in certain affections of the intestinal canal, increased work is thrown upon the renal apparatus. In the treatment of such cases, the practitioner must bear in mind the existence of these relations.

* It is remarkable that a physician who attributes almost every derangement of health to mere chemistry, and considers that all diseases are either *mechanical* or *chemical* should employ the word *diathesis* at all ; but Dr. Bence Jones, like many other writers, uses this word very freely, without attempting to explain what he means by it.

There are certain affections in which the quantity of water removed from the body is greatly increased. In various hysterical and other emotional states, large quantities of pale urine, containing but a small quantity of solid matter, are frequently voided. Some persons habitually pass very dilute urine, which is not very easily explained, but is probably to be looked upon as an individual peculiarity, corresponding to the constant sweating, and to the unusual amount of action of the alimentary canal, occasionally met with in individuals who enjoy good health.

It has been already remarked that, within certain limits, water increases the disintegration of tissue; and, when a large amount of fluid is taken, the total quantity of solids removed in the urine is greater than in health. When the solids, as well as the water, are greatly increased in quantity, we should be led to fear the existence of diabetes. An unusual quantity of urine, of very high specific gravity, and therefore containing a large amount of solid matter, is almost characteristic of this condition.

Excess of Water.—The majority of the so-called instances of *diabetes insipidus* are cases in which there is great thirst, and a large amount of water is removed from the kidneys daily (*diuresis*); but the total quantity of solid matter is not above the normal standard. In a few of the cases recorded, however, it would appear that the latter is also much increased. Thus, in one referred to by Dr. G. Harley, a man, aged 56, passed 130 ounces of urine in the twenty-four hours. This quantity contained 1311·76 grains of urea. ("Medical Times and Gazette," April 23, 1864.) There is generally no sugar in these cases, but I have met with a few instances in which urine of very low specific gravity (1,004), contained an appreciable amount of sugar. Persons have stated that the urine they passed amounted to two or three times the quantity of fluid they took with the food; but I am sure that in some instances deception has been practised, and that the patients got water by stealth. In some cases, however, in which very large quantities of urine are voided, there is undoubted evidence of chronic renal disease. In vol. II of my "Archives," Dr. Eade alludes to several cases of this disease, and gives notes of two which occurred in men of the ages of 65 and 40. Two of the cases were children. The urine passed by the men amounted to from five to seven pints. Its specific gravity varied from 1,003 to 1,004. The man aged 65 suffered from severe irritation of the bladder, and died in eighteen months. The *post mortem* revealed a bloodless state of the viscera generally. The coats of the bladder were much thickened; the infundibula and pelves of the kidneys much dilated; the left kidney was of the natural size; the right, one half larger, the cones very hard, pale, and flaccid. In the other fatal case, both kidneys were much wasted. The cones "converted into dense fibrous tissue, containing many large cystiform spaces;" the pelves much enlarged, and the ureters a little dilated. Both supra-renal bodies were "converted into flaccid cysts, capable of containing each some half ounce of fluid, with their walls having a bile-coloured granular appearance." Dr. Eade sent me the kidneys for examination, 'Urine Illustrations,' p. 252, pl. XI, fig. 4. I found that many of the tubes in the cortical portion were narrow and much wasted; others were twice the diameter of the tubes in health. The walls of the tubes were thick and firm; the Malpighian bodies were smaller than in health; the epithelial cells smaller and more numerous. The state of the supra-renal bodies in this case has led Dr. Eade to offer the suggestion, that the condition might have originated in some irritative disorder of these particular organs. ("Archives of Medicine," vol. III, p. 127.)

The following analysis, 19, represents the composition of the urine in one of these cases of Hydruria, or diabetes insipidus. It was obtained from a man aged 45, in King's College Hospital, under Dr. Todd. This patient was passing about eleven pints of urine *per diem,* while he was drinking about thirteen pints of liquid. Reaction feebly acid; specific gravity 1002·8.

ANALYSIS 19.

			In 24 hours.
Water	995·91	—	—
Solid matter ...	4·09	100·00	394
Organic matter	2·79	68·22	268
Fixed salts ...	1·30	31·78	125

The quantity of urea excreted in twenty-four hours in this case was very small, which confirms the observation of Bischoff, that the ingestion of a large quantity of water diminishes the excretion of urea. At first, the total quantity passed in twenty-four hours is above the average, because much is washed out from the tissues by the large quantity of fluid; but afterwards it falls, because less is formed in the organism than under ordinary circumstances. The proportion of inorganic salts to the organic constituents of the urine is very high, though the total quantity is less than is passed in health.

In one of Dr. Eade's cases, an analysis of the urine was made by Mr. Sutton. It contained only 9·3 grs. of solid matter in 1,000 grs.; of this, 5·57 grs. consisted of urea. The composition of 100 grs. of the *solid residue* was as follows:—

ANALYSIS 20.

Urea	60·00
Potash	5·63
Lime	·49
Soda and magnesia	11·14
Silica	·43
Ammoniacal salts, &c.	8·62
Sulphuric acid	3·07
Phosphoric acid	2·97
Chlorine	7·66

Dr. Strange, of Worcester, has published a very interesting case of diabetes insipidus ("Archives of Medicine," vol. III, p. 276). The patient was a boy aged 18, with excessive thirst. He was of small build, but moderately stout. The urine amounted to twelve pints in twenty-four hours, and this large quantity had been passed for years. The specific gravity was 1,007. There was no albumen or sugar. The complexion was ruddy, and there was no pallor or puffiness indicative of renal disease. On admission into the infirmary he was only allowed a limited quantity of fluid to drink, and he was treated with phosphoric acid and nux vomica. Catechu and laudanum were afterwards given to restrain the diarrhœa from which he was suffering. About ten days after admission he became drowsy. A fortnight after admission he was seized with convulsions, and soon became comatose, with dilated pupils and stertorous breathing. The insensibility passed off after he was bled, but again recurred two days afterwards, and soon became profound He died with symptoms of cerebral effusion. Both kidneys were reduced to "mere sacs, of from twice to thrice the extent of the healthy kidney! There was complete absence of all proper parenchymatous structure, both tubular and cortical, the sacs being divided into a number of cells by the septa which occur in the fœtal state." The *circumference of the ureters varied from three to four and a-half inches.* No urea was found in the fluid in the ureters and sacs. Dr. Strange considers that the condition of the kidneys was mainly due to congenital malformation. He thinks it probable that the sacs were only capable of separating the urea from the blood when in a very dilute form, and considers that the diarrhœa and the diminished quantity of fluid ingested may perhaps have somewhat hastened the fatal result. In all cases of this condition, there is an abundant flow of urine, depending upon the sufferers being excited to drink largely to allay the excessive thirst which they experience. There are languor, debility, loss of appetite, often nausea and vomiting, with weak heart's action, and general loss of power, and sometimes an irritable state of bowels, with diarrhœa. It is certain that many very important points connected with this very interesting disease are yet to be discovered.

Clinical Observations.—The physician should always very carefully investigate cases in which very watery urine is *habitually* passed, and although it is frequently impossible to ascertain exactly the conditions which give rise to the change, it betokens in many a very serious state. Those who suffer in this way seldom bear an attack of acute disease, and a slight injury which would scarcely disturb a healthy man may be fatal to them. I once saw and carefully examined a well-nourished and not unhealthy looking man, for the purpose of ascertaining if he was suffering from any organic disease, without being able to detect anything wrong save the fact that the urine was of very low specific gravity, 1,005. He died in less than two months after I saw him, apparently from an ordinary cold; but unfortunately no examination was made, so that I am unable to state anything concerning the state of the kidneys. Cases of a similar kind have been reported to me by other practitioners. I am therefore anxious to impress upon the reader the importance of expressing a very guarded opinion in any cases which may fall under his notice.

Treatment.—In cases in which the secretion of the watery urine does not depend upon organic disease of the kidney, benefit often results from the use of quinine, iron, and other tonics steadily persevered in for months. Plenty of fresh air is important in the treatment of these cases. Where the excessive diuresis is associated with long standing disease of the kidney, as in the cases reported by Dr. Eade and Dr. Strange, there is little hope of permanent relief, and the treatment must be directed to improving the general health in the hope of prolonging life. Two of Dr. Eade's cases improved under tonics and iron. The quantity of fluid allowed to patients suffering from diabetes insipidus should be reduced very cautiously. Its sudden reduction to a very small amount may prove almost immediately fatal. Dilute mineral acids, especially phosphoric acid, sometimes allay the thirst. If chronic renal disease exists, the treatment must be conducted according to the general plan followed in this condition, *see* page 83. The practitioner will, of course, study the general state of the patient, and not attempt merely to diminish the excessive diuresis only.

Deficiency of Water is, in the great majority of cases, associated with an abnormal quantity of solid matter. The ingredient which is usually in excess, and to which the urine owes its great density, is urea; so that urine of this character will be more conveniently considered presently (*see* "Excess of Urea"). There are, however, cases in which a very small quantity of urine, containing but a low percentage of solid matter, is passed; but in these *albumen* is generally present, and they will be referred to under this head, *see* page 220. When the total amount of urine is very small, and the secretion contains but little solid matter, the secreting structure of the kidney is generally much impaired.

Acid Urine—Nitric Acid.—Dr. Bence Jones ("Philosophical Transactions," 1851, p. 399) has been led to the conclusion that ammonia, in its passage through the organism, gives rise to the production of a certain quantity of nitric acid, which is eliminated in the urine. He found that the acidity of the urine was not diminished by giving large quantities of carbonate of ammonia; and that, in some instances, the acid reaction seemed to be increased. While tartrate of potash soon rendered the urine alkaline, this effect was not produced by the corresponding salt of ammonia.

The following test, suggested by Dr. Price, was employed for the detection of the nitric acid, in preference to the indigo test. By this plan, one grain of nitrate of potash dissolved in ten ounces of urine was detected with the greatest certainty. From four to eight ounces of urine were mixed with half an ounce of strong and pure sulphuric acid, free from nitrous acid. Two thirds of the mixture were distilled over; and, after being neutralized with pure carbonate of potash, the distillate was evaporated to a very small bulk. From a drop, to half of the residue, was mixed with the following test solution. To a solution of starch, a drop or two of a solution of iodide of potassium, specific gravity 1,052, and very dilute hydrochloric acid, specific gravity 1,005 were added. If nitric or nitrous acid is present, the iodine is set free, and a blue iodide of starch is at once formed. Another portion of the residue was placed in a basin, and a very small quantity of indigo, with excess of sulphuric acid, added. If nitric acid was present, upon applying heat for a few minutes, the colour of course disappeared.

From numerous experiments, varied in many ways, Dr. Bence Jones came to the conclusion that ammonia in the organism is partly converted into nitric acid. Urea and caffein, and other substances containing nitrogen, give rise to the formation of a small quantity of nitric acid. Although Lehmann has failed to confirm these results, he has not, I think, succeeded in shaking the evidence in favour of the conclusions.* Dr. Bence Jones brings forward several cases of healthy persons whose urine did not yield a trace of nitric acid; but, three or four hours after they had taken carbonate of ammonia, evidence of the presence of the acid was afforded by the starch and also by the indigo test. After twelve hours, only a trace could be detected; and, in twenty-four, even this ceased to be perceptible. The urine was examined in precisely the same manner in every case. A small amount of ammonia in the organism is converted into nitric acid; and it is not improbable that, under certain circumstances, the quantity of nitric acid formed in this manner may be very much increased.

Clinical Remarks on the Increased Acidity of Urine.—The causes of the reaction of healthy urine have been already considered in p. 118, and it is therefore unnecessary to pursue this part of the subject further. Vogel states that, in chronic and acute diseases, the quantity of free acid is diminished for the most part. In many cases of pneumonia and rheumatic fever, however, the quantity of free acid is much greater than in health.

* Professor Lehmann attributed the action upon the iodide of potassium to the presence of *sulphurous acid*. Jaffé performed some experiments in Lehmann's laboratory, and obtained sulphurous acid, but no nitrous acid from healthy urine and from urine passed after taking ammoniacal salts. Dr. Bence Jones has subsequently repeated his experiments, and finds that Jaffé's experiments do not invalidate Price's test for nitrous acid as Lehmann supposed. ("*Proceedings of the Royal Society*," vol. VII, p. 94.)

A highly acid condition of the urine, persisting for a long period of time, may cause the precipitation of uric acid, and so lead to the formation of a calculus. Acid urine not unfrequently causes irritable bladder. In some cases the patient cannot retain his urine for more than an hour; and the pain is so great that the case is sometimes mistaken for inflammation of the bladder. The acid urine sometimes occasions the deposit of urates in the bladder, and may thus give rise to the formation of stone. Alkalies in small doses with plenty of water usually counteract the acidity of the urine. In many cases, the salts of the vegetable acids (citrates, acetates, tartrates), will be found more efficient in counteracting this acid state of the urine, than alkalies or their carbonates, and are less likely to interfere with the digestive process. There are, however, low conditions of the system in which the acid state of the urine, and a tendency to the deposition of uric acid in large quantity, are not relieved by this method; on the contrary, such cases are often much benefited by an opposite plan of treatment—tonics and the mineral acids before meals, a nourishing diet, with a moderate supply of simple stimulants with a little alkali, or with alkaline waters. Many of these cases seem to be intimately connected with impaired digestive power. I have sometimes found pepsine, p. 86, a valuable remedy. The acid state of the urine may depend upon very different conditions of the system, and these must be carefully considered in each individual case before any plan of treatment is suggested.

Alkaline Urine.—An *alkaline condition* of the urine may be due to several causes, and requires, therefore, to be treated on different plans. The connection between an alkaline state of the urine, depending upon fixed alkali, and the secretion of a highly acid gastric juice, has been already referred to, p. 119. In such cases, attention must be paid to the state of the digestive process; and when this is set right, the urine will regain its normal characters. Dr. Bence Jones ("Medico-Chirurgical Transactions," vol. XXXV,) alludes to three cases of dyspepsia with vomiting of a very acid fluid (two of them rejecting sarcinæ), in which the urine became alkaline from the presence of fixed alkali when the quantity of acid set free at the stomach was very great; but, when this was small, the reaction of the urine was acid. It must, however, be borne in mind that the very acid nature of the materials rejected in many cases of vomiting, and especially in cases of sarcina ventriculi, arises, not from the secretion of an acid fluid by the glands of the stomach, but from the decomposition or fermentation of the food, when acids are developed, among which may be mentioned acetic, lactic, and butyric acids. At the same time, there can be no doubt that, in some cases of dyspepsia, the feebly acid or alkaline condition of the urine arises from the secretion of an abnormal amount of acid by the stomach. "The degree of the acidity of the urine may, to a certain extent, be regarded as a measure of the acidity of the stomach." (Dr. G. O. Rees, "Lettsomian Lectures," 1851.)

Dr. Rees has drawn attention to a large class of cases in which he explains the alkaline condition of the urine as follows:—Urine which is highly *acid* at the time of its secretion, irritates the mucous membrane of the bladder, and causes it to secrete a large quantity of *alkaline fluid.* This mucous membrane in health secretes an alkaline fluid, to protect its surface, just as occurs in the case of some other mucous membranes. Under irritation, more alkaline fluid than is just sufficient to neutralise the acid of the urine is poured out; and hence the urine, when examined, is found to have a very alkaline reaction. In such cases, this highly alkaline condition is removed by giving liquor potassæ or some other alkali, or a salt of a vegetable acid which becomes converted into an alkali in the system. The urine is not secreted so acid, and, therefore, according to Dr. Rees, does not stimulate the mucous membrane to pour out as much alkaline fluid. I know no observations to disprove Dr. G. O. Rees' explanation of the fact, that in some cases *alkalies cause the urine to become less alkaline, or even restore its acid reaction;* yet one would hardly expect, if this be the true explanation in cases generally, that the natural reaction of urine would be acid. If there was danger of the healthy mucous membrane suffering from the contact of a fluid only a little more acid than that destined to be continually touching it, should we not expect it to have been of such a character as to resist this action like the mucous membrane of the stomach, instead of being excited to secrete a fluid which might seriously damage it? It must be remembered that the mucous membrance of the bladder bears very well the contact of acids fluids which are sometimes injected; and it cannot be denied that patients may for years pass intensely acid urine, without the secretion of this excess of alkaline fluid from the mucous membrane.

Excess of Urea.—From what has been already said with reference to the variations in the proportion of urea secreted, under different circumstances, in a state of health, it will be inferred that, in disease, the quantity of this constituent varies greatly. The total amount formed in a given time may be much greater or less than in health; and the proportion which this substance bears to the other organic constituents varies greatly in different cases. The phrase "*Excess of Urea*," is not applied to those cases in which the total quantity excreted in the twenty-four hours is much greater than in health; but a specimen of urine which yields crystals of nitrate of urea when an equal bulk of nitric acid is added to it in the cold, without having been previously concentrated, is said to contain "excess of urea." The quantity of urea dissolved in the fluid is so great, that nitrate of urea is formed, and crystallises just as if the urine had been concentrated by evaporation. This result may be brought about in several ways. In cases in which but a small quantity of fluid is taken in proportion to the urea to be removed—when an unusually large amount of water escapes by the skin and other emunctories—and in cases in which an unusual amount of urea is *formed* in the organism, we shall frequently find excess of urea in a specimen of the urine.

Dr. Golding Bird has drawn attention to the frequency of the occurrence of oxalate of lime deposits in urine containing excess of urea. The quantity of oxalate of lime, however, is in all cases so very small that it is hardly possible to believe that the formation of this substance can be very important. It will be shown that the oxalate is one of the commonest urinary deposits; that it may result from decomposition of urates, and that there is no reason for believing it to be indicative of any peculiar diathesis or habit of body. Excess of urea affords no explanation of the presence of oxalate of lime, nor this latter of urea. Each condition may exist without the other. *Cæteris paribus*, we should expect to find oxalate of lime most frequently present in highly concentrated urine.

Excess of urea is frequently found in the urine of persons suffering from acute febrile attacks. It is very common in cases of acute rheumatism, and is often met in pneumonia and acute febrile conditions generally. In England, we meet with these cases very frequently; but, on the continent, they appear to be so rare that many authorities seem to doubt the truth of what English observers have stated with regard to this point. Lehmann, I think, states that he had not seen a case in which crystals of nitrate of urea were thrown down upon the addition of nitric acid, without previous concentration.

The amount of urea excreted is often very great. Vogel mentions a case of pyæmia, in which 1,235 grains of urea were removed in the course of twenty-four hours. Dr. Parkes obtained as much as 885 grains in a case of typhoid fever. These quantities are very large, if the patients did not exceed the average weight of adult men; but, unfortunately, the weight was not recorded.

The large proportion of urea excreted in fevers and inflammations has been supposed by some authorities to be proof of excessive oxidation, and necessarily connected with the high temperature of the body, and in spite of the blood being stagnant in the vessels, and the lungs choked up, this ill-considered theory has been so forced upon us, that it will probably be some time before any view more in accordance with well-known facts will be accepted. It need scarcely be said that a rise in temperature may be brought about in many ways besides oxidation, while it may be regarded as certain that the increased heat in fever and inflammation, and the increased quantity of urea formed, do not depend upon peroxidation. There is usually a very large excretion of urea in diseases in which the activity of the oxidising processes is much reduced.

Urine containing excess of urea is generally perfectly clear, of rather a dark yellow colour, and of a strong urinous smell. Its specific gravity is about 1,030, and it contains 50 or 60 grains, or more, of solid matter per 1,000. At ordinary temperatures, an aqueous solution must contain at least 60 grains of urea per 1,000, to form crystals of the nitrate upon the addition of nitric acid without previous evaporation; 50 grains of urea per 1,000 hardly gave the slightest precipitate after the lapse of a considerable time. But it would seem that the salts, extractive matters, &c., in urine, favour the crystallisation of the nitrate when even a smaller quantity of urea, than 5 per cent., is present. It should be mentioned, that the above experiments were performed in the summer, in very hot weather. In one case, in which the urea readily crystallised on the addition of nitric acid, the urine had a specific gravity of 1,028, and contained—

ANALYSIS 21.

Water	940·18
Solid matter	59·82
Organic matter	50·57
Fixed salts...	9·25

Urine containing excess of urea is generally acid, but I received a specimen from Dr. Fergus, of Marlborough, which was alkaline, and contained crystals of triple phosphate. It came from a patient, 18 years old, who was feverish with gastric and biliary disturbance. The urine was highly coloured, sp. gr. 1·033, and became nearly solid upon the addition of an equal bulk of nitric acid, from the formation of crystals of nitrate of urea. (April, 1862.)

Clinical Observations.—There are some peculiar and not very common cases in which the urine contains this excess of urea; and at the same time more than the healthy amount is excreted in twenty-four hours. The patient is weak, and grows thin, in spite of taking a considerable quantity of the most nutritious food. He feels languid and indisposed to take active exercise. In some cases digestion is impaired; in others, the patient eats well, experiences no pain or uneasiness after food, and perhaps has a good appetite. Sometimes there is lumbar pain. It would seem that most of the substances taken as nutrient material become rapidly converted into urea, and are excreted in that form. The waste of the tissues is not properly repaired, and the patient gets very thin. To refer these symptoms to the existence of a particular diathesis, affords no explanation of the facts. The pathology of these remarkable cases has not yet been satisfactorily investigated. Mineral acids, rest, shower-baths, and good air, often do good; but some of these patients are not in the least benefited by remedies, and they continue for years very thin, passing large quantities of highly concentrated urine, while the appetite remains good, and a considerable quantity of nitrogenous food is digested. In some which have resisted the usual plans of treatment, benefit has been derived from the use of pepsine (*see* p. 86), with diminished quantity of meat, and a larger amount of farinaceous food.

It is very remarkable, that in many instances the secretion of the urine, which is so rich in solid constituents, occurs only at one time during the twenty-four hours. The variation in the activity of the secreting process is very great. At a particular period of the day, usually in the afternoon or evening, there is coldness of the surface of the body, generally, soon followed by lumbar pain, and some congestion of the kidneys. The secretion of urine of very high sp. gr. soon takes place, and not unfrequently a small quantity of albumen is found in it. When the patient gets warm and perspires the symptoms pass off, and the free secretion of normal urine follows. Some of these cases are closely allied to ague, and are cured by those remedies which act favourably in intermittents generally, as quinine in five or ten grain doses.

Deficiency of Urea.—Sometimes the quantity of urea excreted is very small. A lady suffering from an ovarian tumour only excreted 75 grains of urea in 200 fluid drachms of pale faintly alkaline urine in the course of twenty-four hours. (Thudichum.) In a case of cancer of the uterus, under the care of Dr. Arthur Farre, only a few drachms of fluid were passed from the bladder during a week; and this contained a small quantity of solid matter, in which no urea was detected.

In chronic disease of the kidney, the urine is of very low specific gravity, and but a very small proportion of urea is excreted in the twenty-four hours. This arises from the alteration in the gland-structure, and the amount of urea separated may be regarded as a rough indication of the extent of the organ involved. In some cases, the morbid condition affects the whole structure; but in others the greater part of the kidney remains healthy. In the latter case, a fair amount of urea will be excreted; and, although the urine contains albumen, the case may be looked upon as a hopeful one.

In certain cases, urea almost entirely disappears from the urine, and is replaced by leucine and tyrosine. Frerichs mentions a case of acute yellow atrophy of the liver, in which only a trace of urea could be detected, while a very large quantity of leucine and tyrosine crystallised from the concentrated urine. ("Klinik der Leberkrankheiten." Erster Band. Seite 221.) In low forms of typhoid fever, the urine also frequently yields leucine and tyrosine in considerable quantity.

In a case of chronic yellow wasting, which came under my own notice (F. C., vol. VI, p. 37), the liver was of a yellow colour, and weighed 1½ lb. The patient was a young woman, age 26. Jaundice had existed for six weeks, but urgent symptoms—delirium and coma—

had only supervened a few days before death. Leucine was obtained from the urine by evaporation, but only in small quantity. In a remarkable case of enlarged spleen under my care, much leucine was found in the urine. In many cases there is a deficiency of urea in the urine in consequence of its not being formed in the body. This is remarkable in cholera, in which disease only a mere trace of urea is sometimes produced during many hours.

Uræmia is the term applied to that condition of the system which soon follows the retention of the excrementitious urinary substances in the blood. The condition generally results from long-continued organic disease of the kidneys, but it may depend upon acute disease. The nervous phenomena are generally considered to depend upon the accumulation in the blood of urea, but later researches have shown that neither urea, carbonate of ammonia, nor nitrate of potash injected into the blood of animals prove speedily fatal, unless the kidneys be previously extirpated (Hammond). If, however, the quantity of urea injected be very large, death does take place. Stannius, on the contrary, states that urea injected into the blood is harmless; and Petroof has injected a large quantity into the blood without causing coma. Dr. Hammond has shown that *the urine, as a whole*, is more poisonous than a simple solution of urea. He has proved most conclusively that Frerichs' notion, that the urea became decomposed into carbonate of ammonia, is erroneous; and Johnson, Richardson, and others are of the same opinion. Hoppe finds that in uræmia the extractives are increased to three times, and the creatine to five times the normal amount.

Dr. Richardson has shown that even water in excess in the blood will produce symptoms resembling those present in uræmia ("Clinical Essays," vol. I, p. 171), but he agrees with most other observers in considering that the condition uræmia depends upon the retention of urea in the blood, and its action upon the tissues of the body as a poison.

In many cases of severe uræmia there is, however, no urea to be detected in the blood, and various hypotheses have been, from time to time, advanced to explain the fact, but none of them are entirely satisfactory. The extractives are very much increased in some cases, and their relation to the albumen rises from 5 : 100 to 40 : 100, according to Schotten.

It is probable that in those cases in which a large quantity of urea is detected, the formation of this substance has been going on actively in the kidney, and the urea has been absorbed into the blood or has passed more directly into that fluid by the rupture of a vessel and secreting tube, its escape by the ordinary channel having been prevented—while in those cases of death from uræmic coma, in which no urea is to be obtained in the blood, it is most likely that the secreting structure of the kidney has ceased to be active altogether, and that urinary constituents are not even formed—death resulting from the accumulation in the blood of those materials which it is the duty of the kidneys to separate, or from the presence of compounds resulting from the decomposition of these.

In considering this question, it must be borne in mind not only that the renal disease has gradually advanced, and the kidneys, perhaps, have become almost inefficient, but that most important alterations have been slowly taking place in the blood. Many tissues in the organism have been secondarily affected, and are probably much altered in structure. At present, we are but very imperfectly acquainted with the normal changes occurring in the blood, or with the consequences immediately resulting to the tissues, especially the nervous system, from the retention of certain excrementitious matters; and we know very little of the remote or immediate effects resulting from certain excrementitious substances not being formed at all. The question is a more difficult one than at first appears, and requires more searching chemical and microscopical investigation than it has yet received. One writer on this subject concludes a very elaborate essay thus: "Enfin, cette altération chimique du sang est encore mal définie, et la science attend sur ce point de nouvelles recherches." ("De l'Urémie," Thèse, par Alfred Fournier, 1863.)

We may conclude that "uræmia" depends not upon the presence of one constituent of the urine in the blood, but is due rather to the accumulation of a number of products resulting from the disintegration of the nitrogenous tissues which ought to be separated by the kidneys. This is the general conclusion arrived at by the latest writer on the subject, M. Rommelaere, whose memoir contains records of valuable original observations. ("De la Pathogénie des Symptômes Urémiques," par Dr. W. Rommelaere. Bruxelles: Henri Manceaux, 20, Rue de l'Etuve.) The general treatment of uræmia has been referred to in p. 89.

Ammonia.—Numerous experiments seem to show that in health a small quantity of ammonia escapes in the urine. Neubauer has conclusively proved that certain ammoniacal salts pass through the organism, and may be detected in the urine unchanged. Ammonia, as is well known, is very easily produced by the decomposition of the urea; but it is almost certain that a small quantity passes into the urine from the blood, independently of that derived from this source.

In disease, the quantity of ammonia present in the urine is often so great as to be smelt all over the room in which the patient lies; but in these cases the ammonia arises from the decomposition of the urea after the urine has left the bladder, and in some it is decomposed even while it yet remains in this viscus.

It is doubtful if a large amount of ammonia under any circumstances accumulates in the blood afterwards to be excreted in the urine, as it is probable that, if formed, it would escape more rapidly from the lungs or intestinal canal. The doctrine that the coma occurring as a sequel to many cases of kidney disease, depended upon the accumulation in the blood of ammonia produced by the decomposition of urea, was originally put forward by Frerichs. In some of these cases of renal coma, ammonia is present in abnormal quantity. In others, neither urea nor ammonia can be discovered in the blood, while sometimes urea can be detected without difficulty.

I have examined the serum in many cases for urea. Half an ounce of blister serum from a man suffering from renal coma yielded ·54 gr. of nitrate of urea. The patient died shortly afterwards, and urea was detected in the blood and in the brain substance. In another instance, it was detected in the serum of a blister from a man who had one epileptic fit, depending upon renal disease. In the case of a boy, aged 18, who suffered from epileptic fits, I also detected it in blister serum; as well as in eight ounces of serum from a man suffering from acute dropsy of a week's duration; and I might refer to others in which I obtained undoubted evidence of the presence of urea. There are, however, other cases of the same character in which I failed to detect urea, or ammonia resulting from its decomposition.

I have several times examined the breath of such patients, without being able to obtain indications of a larger quantity of ammonia than is afforded by healthy persons. I think, therefore, that we must admit that there are many cases of the so-called *uræmic poisoning* which have not yet been satisfactorily explained. It may, however, be urged, that in many cases, although ammonia was formed, it might have been rapidly eliminated from the skin or intestinal canal, so as to escape detection. Bernard and Barreswil have performed some experiments which prove that, after extirpation of the kidneys, urea escapes into the intestinal canal in the form of an ammoniacal salt; and they found that it could not be detected in the blood in less than from twenty-four to forty-eight hours after the operation, when the animal had become weak and exhausted.

Dr. Garrod has detected urea in the blood and blister serum of several cases of gout. ("Med. Chir. Trans." 1848.) His results have been confirmed by Dr. W. Budd, who has detected urea in the blister serum, in nine cases of acute gout in which there was no indication of renal disease. ("Med. Chir. Trans." vol. XXXVIII, p. 242.) In chronic lead poisoning this substance is sometimes detected in the blood. Dr. Garrod has remarked that the majority of persons suffering from gout amongst the poor, have been the subjects of lead poisoning.

On detecting Urea in the Blood or Serum.—The urea may be detected by concentrating the serum, after adding a few drops of acetic acid, and extracting with strong alcohol; or the fluid may be evaporated to dryness, and the dry residue treated with boiling alcohol. The alcoholic solution is evaporated to dryness, treated with a drop of distilled water, and two or three drops of strong colourless nitric acid allowed to fall into the syrupy solution. If urea be present, crystals of the nitrate of urea are formed after a time, and may be readily distinguished by microscopical examination. Crystals of nitrate of urea are represented in "Illustrations of Salts of the Urine," pl. III.

On detecting Ammonia in the Breath.—The method of examination which Dr. Richardson recommends is the following:—An instrument in the form of a straight breast-pump is employed to breathe through; a drop or two of hydrochloric acid is placed in the bulb, and a perfectly clean slip of glass placed across the trumpet extremity of the tube, and secured by an India-rubber band. The alkali, as it passes over the bulb, combines with the acid, but some of the acid and alkaline vapours pass over together and condense on the microscope glass. As this becomes dry, crystals are formed. In health, traces of ammonia are always found in this manner, "Illustrations of Urine," pl. IA, fig. 3.

Colouring Matter.—The variation of colour of the urine in disease is a matter of great interest; and, although the causes of the change, and the exact nature of the substances which give rise to the peculiar tints often observed, are not yet understood, there are many valuable observations connected with this subject, some of which I propose to refer to in this place. The colour of urine depending upon blood corpuscles will be discussed under the head of urinary deposits; and now I shall only refer to colouring matters formed in the body and excreted in *solution* in the urine.

The principal substances to which the colour of urine is due are probably derived from the blood corpuscles, which are continually undergoing disintegration, and from the extractive matters. The colouring matter becomes altered under different conditions. Much of it is converted into a colouring matter which is separated in the urine, and termed uræmatine (uraphæin, hæmaphine), which is soluble in ether.

It is impossible to estimate directly the quantity of the colouring matter present; but Professor Vogel calculates the proportion by ascertaining how much water may be added to the urine to produce a particular tint, which is arbitrarily fixed as the unit of comparison. The quantity of this substance affords an indication of the activity of the disintegration of the blood-corpuscles. In typhoid fever, and many other conditions, this disintegration takes place to such an extent as to produce an anæmic condition. In many acute diseases, as pneumonia, acute rheumatism, peritonitis, a very large amount of colouring matter occurs in the urine. The formation of the urine pigment is intimately connected with the action of the liver; and, as is well known in diseases of this organ, the urine is frequently very highly coloured. Of course, I am speaking of colour independent of the colouring matter of the bile. The deep colour of the urine in diseases of the liver has been often remarked by physicians practising in India; and quite recently my friend Dr. Payne has made some interesting observations on this point, which will be found in the "Indian Annals of Medical Science" (Calcutta, Sept. 4, 1858). In order to detect the colouring matter, Dr. Payne boils the urine, and then adds a drop of nitric acid. Various shades of colour are produced, but at last the mixture becomes of a ruby red.

Colouring Matter of the Blood.—The colouring matter of the blood-corpuscles may be present in urine without any corpuscles. In many cases, owing to the rapid disintegration of blood-corpuscles, the serum is highly coloured, and the dissolved colouring matter is excreted by the kidneys. Blood may escape from the vessels into the tubes of the kidney, the corpuscles may gradually become disintegrated, and the colouring matter be dissolved. Sometimes the colouring matter forms an abundant granular deposit containing also urates or uric acid, or large collections of granules and minute dark red angular particles may exist.

That bile acids and their salts were powerful solvents of blood-corpuscles, was long ago proved by Hühnefeld, Plattner, and Simon; and it has lately been shown by Kühne that, by the action of the colourless biliary acids or their salts upon the blood-corpuscles, bile-colouring matter is produced. The bile acids themselves are not converted into the colouring matter, as Frerichs held; for they pass through the system unchanged. Now, in certain cases where these processes are deranged, it is very probable that the blood-corpuscles are disintegrated in abnormal quantity, and rapidly converted into pigment, which escapes in the urine. The complicated mutual reactions which would ensue when varying proportions of biliary acids, hæmatine, and oxygen, are presented to each other in the living blood, would fully account for the different characters and tints which the colouring matters in urine assume in various instances. Professor Vogel alludes to a case in which the colour of the urine became very dark after the inhalation of arseniuretted hydrogen. Some experiments were made upon a dog, and it was found that the dark colour was due to the disintegration of the blood-corpuscles. Albumen was present, but no blood-corpuscles could be detected. A similar disintegration of blood-corpuscles seems to take place in typhoid fever, and in several other diseases. In many cases the dark brown colouring matter found in urine probably results from the disintegration of red blood-corpuscles in the blood, and the excretion of the resulting products. It is not uncommon to find distinct crystals of hæmatoidin amongst the brown colouring matter. These were no doubt formed in the upper part of the uriniferous tubes where the colouring matter had remained quiescent for some time.

In such cases the exhibition of alkalies or salts of vegetable acids, or a course of alkaline waters with an occasional dose of grey powder or blue pill, affords relief.

Black Pigment.—Dr. Marcet, Med. Chir. Trans., 1822, describes a black pigment which was present in the urine of a child. After the addition of an acid, some black flocculi were deposited. The colouring matter was dissolved by alkali, and Prout called it melanic acid. Professor Dulk gives a case in which a black deposit was separated from the urine by filtration. Other examples are recorded by Dr. Hughes. In three of these cases, creasote had been taken internally; and in two, tar had been applied externally. In one case, a dense black precipitate was thrown down by heat and nitric acid, which was examined by Dr. Odling, who found that, by exposure, it became converted into indigo blue. He draws attention to the close alliance between indigo and the creasote series of compounds, and suggests that, in the above cases, it was derived from the tar or creasote. Guy's Hospital Reports, 3rd ser., vols. II and III.

Dr. Stevenson refers to a case of melanuria in vol. XIII of the third series of the Guy's Hospital Reports, 1867. The urine, which was black, and in thin layers brownish black, like a mixture of Indian ink and water, was passed by a woman whose thigh had been amputated by Mr. Bryant. The stump had been dressed with a solution of carbolic acid. In most of the cases of black urine which have been reported, pitch, tar, or other substance containing carbolic acid had been taken, or applied externally.

In this case, Dr. Stevenson proved that the colour did not depend upon any compounds allied to albumen or hæmatine, and indigo blue was carefully sought for, but none could be detected. The colouring matter was freely soluble in potash. After the urine had been boiled with hydrochloric acid for some time, it acquired the property of reducing oxide of copper, and Dr. Stevenson therefore infers the presence of a substance capable of yielding sugar. This was probably a colouring matter allied to that formed by the action of concentrated acids on the extractive matters. *See* p. 150.

Sometimes the urine is made black by remedies prescribed by the physician. If large doses of gallic acid be given, and the urine passed be tested with a solution of a salt of iron, a black colour like ink results. Sometimes patients taking gallic acid pass urine of a dark colour, and it has been noticed that if iron is administered at the same time, the urine is occasionally perfectly black. My friend, Dr. George May, of Reading, sent me a specimen of urine passed by a patient who was taking lactate of iron and gallic acid. The urine was almost as dark as ordinary writing ink.

It should be observed, that pyrola, sumach, and some other substances, alter the colour of the urine. Dr. Hughes mentions cases of dark pigment occurring in the urine of patients taking iodine. These cases, however, are of course not dependent upon morbid changes in the organism.

Uric Acid and Urates are present in certain proportion in healthy urine, but in disease a large increase is very frequently observed. These substances usually form urinary deposits, either from existing in too large a proportion to be dissolved in the urine when cold, or, as is probably the case in the majority of instances, from the development of an acid in the urine, which causes them to be precipitated from their solutions. We shall consider the microscopical characters of these bodies under the head of urinary deposits. In many acute febrile diseases, the proportion of uric acid is increased, and the period of resolution of the inflammation is marked by diminished frequency of the pulse and respiration, by a fall in the temperature, by free perspiration, and by a very abundant deposit of urates. In health, from 5 to 8 grains of uric acid are excreted in twenty-four hours; but, in some acute diseases, the proportion may amount to 20 grains. In a case of fever, Dr. Parkes found that 17·28 grains of uric acid were excreted in twenty-four hours. Dr. Sansom has estimated the quantity of uric acid in 1,000 grains of the morning urine in health and several cases of disease. The results are as follows:—

	Grain.
Health	·250
Acute gout	·830
Acute rheumatism	·802
Heart disease	·711
Erysipelas	·679
Phosphatic urine	·140
Chronic gout	·120
Excessive debility	·078

Urate of soda is very readily caused to deposit crystals of uric acid. If the amorphous deposit be merely dissolved by warming the urine, the urate often becomes decomposed; and, as the solution cools, crystalsof uric acid are deposited. In some cases, the quantity of uric acid held in solution is so great that, upon the addition of a drop of nitric acid to the urine, an abundant amorphous precipitate, exactly resembling albumen, is formed. Such precipitate has many times been mistaken for albumen (*see* "Albuminous Urine," p. 223), and, even if examined under the microscope immediately after it is formed, its nature cannot be made out; but if it be allowed to stand for some time, the amorphous particles gradually increase in size, and assume the well-known crystalline form of uric acid. The instances in which I have met with urine exhibiting these characters have almost all been cases of liver disease. Although the reaction is acid, no precipitate takes place upon the application of heat, which at once distinguishes urine of this character from albuminous urine.

The presence of an increased quantity of uric acid in the urine shows that more of this substance or its salts is formed in the blood or in the kidney than in health. It would appear that, in consequence of certain conditions, a large proportion of the uric acid resulting from the disintegration of albuminous substances combines with ammonia, soda, or lime, forming urates of these bases, which are excreted in the urine.

In gout, the presence of uric acid in the blood has been shown to be constant by Dr. Garrod, who considers that in this condition "the kidneys lose, to some extent, their power of excreting uric acid, although they eliminate urea as in health." ("The Nature and Treatment of Gout, p. 167.) *During* the attack there is less in the urine than in health; but *after* it is over, a large quantity of uric acid and urates are often carried off from the system in the urine.

Treatment of Cases in which the Uric Acid is in Excess.—In cases characterised by a tendency to the formation of much uric acid, the principal objects to be attained by treatment are, to favour oxidation, and to promote the solution, of the uric acid already existing, and its elimination from the blood. Good air and moderate exercise, with attention to the action of the skin, will fulfil the first object; and the solution and elimination of the urates will be encouraged by giving alkalies in solution in a considerable quantity of water. Seltzer, Vichy, and Vals waters, which contain carbonates of potash and soda, or Lithia water may be given with advantage. Even plain water does good if as much as three or four tumblers be taken daily for a week or two. Lemonade is sometimes advantageous, and cider and perry suit some persons, who suffer from excess of urates, exceedingly well.

The satisfactory change which in chronic gouty and rheumatic cases frequently ensues from following some of the much vaunted "systems," or going through a course of bathing in Germany or elsewhere, obviously arises from the increased action of the skin, and the improvement of the health generally, effected by the exercise, good air, simple diet, and temperance, wisely enforced in the establishments. If patients could be induced to retire to a pleasant part of the country, where they could take moderate exercise and be free from mental anxiety, meet with agreeable society, live regularly, take small doses of alkalies, and soak themselves for an hour or two a-day in warm water in which some carbonate of soda had been dissolved, they would probably get as much benefit as by travelling several hundred miles to a famous watering-place, and at much less trouble and expense. I am convinced that there are many patients who would prefer to carry out such a simple plan, rather than submit themselves to all the useless routine and absurd formalities involved in many of the professed universal systems, such as homœopathy, hydropathy, &c., which cannot but be extremely offensive to their common sense,—while they are claimed as converts and supporters of doctrines which they do not really believe in. There are some who, for the sake of the advantages derived from the regular system of living, air, exercise, &c., express no disbelief in doctrines and propositions which they probably feel to be absurd, and which a little reflection must prove to be false.

In all such cases, the nature of the derangement of the physiological processes should be carefully considered before any plan of treatment is adopted. We must ascertain in what points the condition differs from a healthy state, and then consider how the deranged actions may be restored. It is obviously quite useless to attempt to relieve the patient by giving drugs, without enforcing attention to all the circumstances which are likely to improve his health. Neither will it be wise to attempt to treat the case as if the presence of the urid acid deposit were the most important symptom, for the reasons I referred to when considering the subject of diathesis, p. 177.

Hippuric Acid, as before mentioned, never forms a deposit.* In diabetic urine, it is often found in large quantity, and seems to take the place of uric acid. It is also present in the acid urine of fever patients (Lehmann). This fact is of great interest, when considered in connection with the sugar-forming function of the liver, and the absence of hippuric acid in the organism in certain cases of liver disease. Kühne has shown that no hippuric acid can be detected in the urine in cases of jaundice; and benzoic acid, which in health is converted into hippuric acid, escapes unchanged in the urine. Benzoic acid has been prescribed in doses of from three to five grains three or four times a-day as a remedy for jaundice. There can, therefore, be little doubt that hippuric acid is formed in the liver, whether by the action of glycin or glycocholic acid on benzoic acid, or some other substances, has not been determined. When febrile urine is evaporated over the water-bath, crystals of benzoic acid often form on the sides of the basin. This arises from decomposition of the hippuric acid.

To Lehmann's statement, that hippuric acid takes the place of uric acid in diabetic urine, there are many exceptions. I have found a con-

* Dr. William Budd, in certain specimens of urine in cases of gout, has observed a flocculent precipitate, which was found to consist of benzoic acid, doubtless resulting from the decomposition of hippuric acid.

siderable proportion of uric acid in the urine of many diabetic patients, and in several there was an abundant deposit of uric acid crystals.

Extractive Matters.—The extractive matters present in healthy urine have been previously described; and I have mentioned that Dr. G. O. Rees has discovered in the urine, in certain cases, an extractive matter which has drained away from the blood, and which is distinguished by producing an abundant precipitate with tincture of galls. Now, although in many cases albumen exists in the same specimens of urine, this blood-extractive sometimes escapes without albumen; and thus the exhaustion and emaciation, in some obscure cases in which there is no hæmorrhage or escape of albumen, are accounted for. The method of testing urine supposed to contain this extractive matter has been described in p. 144. The conclusions at which Dr. Rees has arrived are as follows:—

1. That whenever albumen was present in quantity in the urine, it was always accompanied by the extractives of the blood in large proportion.

2. That the cases in which the extractives of the blood were in the urine in large proportion, were generally those marked by debility.

3. That cases of anasarca with disease of the heart, and *unconnected with albuminuria*, also showed the extractives of the blood to be excreted by the urine in quantity.

4. That cases of chlorotic anæmia and hysteria give copious precipitates.

5. That when, in albuminuria, the albumen became deficient in the urine, which we know often happens in advanced cases, the blood-extractives also decrease in quantity.

6. That, in cases of anæmia, the proportion of blood-extractives observed in the urine diminished as the cure was proceeding, under the use of ferruginous tonics (Lettsomian Lectures, "Medical Gazette," 1851).

In many cases where the urine contains an abnormal quantity of water, the proportion of blood-extractives is unusually great. Schotten proved that in uræmia there was a large increase of extractives in the blood. In cases of kidney disease, the relative proportion of extractive matter to the urea is very much greater than in healthy urine. It would seem that extractives merely filter from the blood in certain cases, and that these substances might escape into the urine when the structure of the kidney was impaired; but that, for the separation of the urea, a healthy condition of the secreting structure is necessary.

The extractive matters are not capable of being converted, by further oxidation, into urea, carbonic acid, or ammonia; and must, therefore, be regarded as excrementitious substances. Scherer (" Würzburg Verhandl.," b. II, Heft III, s. 180) found that the urea, salts, &c., in the urine of a madman who took no food, were very much diminished, while the extractive matters, although less than in healthy urine, were not diminished in nearly the same proportion as the other urinary constituents.

We know nothing of the circumstances under which the extractive matters may be formed in greater quantity than in health, nor the effects which would result from their accumulation in the blood, but in cases of uræmia, in many fevers and acute diseases, the quantity of extractive matters is increased.

EXCESS OF THE ORGANIC CONSTITUENTS.

The circumstances under which these constituents are excreted in increased quantity have been already considered, and I propose now to direct attention to a few analyses of the urine in cases of disease in which this character is observed. In almost all forms of fever, in internal inflammation, in acute rheumatism, in many skin diseases, and in all conditions in which there is increased action of the muscular system, the solids are considerably above the healthy standard; but the various constituents do not suffer augmentation in an equal degree. In the conditions just referred to, the increase principally affects the organic matters. Sometimes all the ordinary constituents of the urine are excreted in increased proportion. Dr. Lehmann ("Archiv des Vereins für gem. Arb. zur Forderung der wissensch. Heilkunde." Erster Band, s. 521), has shown that immersion in the sitzbath, at a temperature of 48° to 60° Fahr., for a quarter of an hour, causes an increase in the quantity of urine, not only of the water, but also of the solid matter. The uric acid, the urea, and the fixed salts, were considerably increased. These results were obtained by estimating the constituents in urine passed during six hours on certain mornings when a bath was taken, and upon others when the observer did not bathe.

The mean of eight analyses of the urine passed during six hours is as follows:—

	Mornings on which the bath was taken.	Mornings on which the bath was not taken.
Water	443·454 grams.	258·458 grams.
Solids	19·403 ,,	14·459 ,,
Urea	10·396 ,,	7·080 ,,
Uric acids	0·130 ,,	0·108 ,,
Fixed salts	6·682 ,,	4·821 ,,
Volatile salts and extractive	1·89 ,,	2·45 ,,
Chloride of sodium	5·814 ,,	4·319 ,,

Urine in Skin Diseases.—In the following analyses of urine in cases of skin disease, the solid matter is increased; and it will be noticed that the proportion of fixed salts to the organic matters is greater than in health. In No. 23, the quantity of the extractive matter exceeds that of the urea. *Analysis* 22.—Urine from a case of eczema, with crusts over the whole body: specific gravity, 1,025. *Analysis* 23.—From the same patient on the following day. *Analysis* 24.—From a case of eczema, in a boy, aged 18: specific gravity, 1,033; acid, pale colour. Contains much uric acid. *Analysis* 25.—From a case of ichthyosis, in a girl, aged 15: acid; specific gravity, 1,032.

Urine in Chorea.—In the series of analyses of the urine in chorea, the principal points to be noticed are the large amount of solid matter, the increase being caused principally by the organic matters. In Analysis 30, the proportion of sulphates is seen to be increased. This increase of sulphuric acid is always observed in cases where the urea is increased.

Analysis 26.—From a girl, aged 10, recovering, after having been ill for several weeks. The urine contained a great number of Cayenne pepper crystals of uric acid. *Analysis* 27.—From a girl, aged 12: specific gravity, 1,033; no albumen; much deposit of urates. *Analysis* 28.—From a girl, aged 14: specific gravity, 1,035; acid; turbid, from the presence of urates. Uric acid deposited in the urine=·46 per 1,000 parts. *Analysis* 29.—From a girl: specific gravity, 1,030; acid; pale in colour. *Analysis* 30.—From a boy, about 10 years of age. *Analysis* 31.—From a boy, aged 14: acid; specific gravity, 1,034·2.

EXCESS OR DEFICIENCY OF THE INORGANIC CONSTITUENTS.

In disease, the inorganic salts vary greatly in quantity, and are sometimes very deficient. In cases of diabetes, there are often but mere traces of fixed salts. This deficiency may depend upon the nature of the food, or be due to the *formation* of a diminished proportion of some of the salts in the organism.

In some conditions of the system, when much disintegration of tissue or red blood corpuscles takes place, a greater quantity of sulphur and phosphorus is oxidised, and sulphuric and phosphoric acids are formed in unusually large proportion, and excreted in the urine.

In certain inflammatory conditions of the system, it would appear that the chloride of sodium, being required in considerable quantity at the seat of the inflammatory change, is prevented from passing away from the system in the urine. In disease of the kidney, it is important to notice if the proportion of the saline constituents to the organic matter is very much increased. In some states of renal disease, in which the secreting structure of the kidney is so much impaired that the separation of urea and organic matter is interfered with, the solids consist almost entirely of saline matter.

Urine in Pneumonia. Chloride of Sodium.—The fluctuations observed in the quantity of common salt excreted in the urine are very great even in health. The circumstances which affect the proportion of

ANALYSES

	22		23		24		25		26	
Water	948·7		926·1		935·4		929·70		918·75	
Solid matter	51·3	100·00	73·9	100·00	64.6	100·00	70·30	100·00	81·25	100·00
Organic matter	27·9	54·6	51·70	69·97	47·91	74·17	48·35	68·77	66·53	82·05
Saline matter	23·4	45·40	21·20	30·03	16·69	25·83	21·95	31·20	14·62	17·95
Urea	—		24·03	32·51	—		} 48·35	68·77	30·09	37·03
Extractives	—		27·21	36·82	—				35·27	43·40
Uric acid	—		·46	·62	—				1·27	1·5
Alkaline salts	} 23·4	45·4	21·23	28·72	} 16·69	25·83	21·95	31·2	13·53	16·65
Earthy salts...			·97	1·31					1·09	1·3
Chloride of sodium	—		—		3·99	6·17	1·74	2·47	—	
Sulphates	—		—		9·45	14·62	—		—	
Phosphoric acid	—		—		2·64	4·08	—		—	

	27		28		29		30		31	
Water	917·90		930·4		936·8		922·60		915·44	
Solid matter	82·10	100·00	69·6	100·00	63·2	100·00	77·40	100·00	84·56	100·00
Organic matter	68·50	83·45	51·95	74·65	48·75	77·14	50·79	78·55	65·68	77·68
Saline matter	13·60	16·55	17·65	25·35	14·45	22·86	16·61	21·45	18·88	22·32
Urea...	41·10	50·06	25·33	36·39	29·78	47·12	34·29	44·30	} 64·69	76·50
Extractive matter	} 27·4	33·37	26·16	37·58	18·52	29·30	26·21	33·85		
Uric acid			·96	1·30	·45	·71	·29	·38	·76	·89
Urate of soda	—		—		—		—		·43	·50
Alkaline salts	12·83	15·62	17·16	24·94	13·69	21·66	16·07	20·76	} 18·88	22·32
Earthy salts	·77	·93	·29	·41	·76	1·20	·54	·69		
Chloride of sodium	—		—		—		3·35	4·32	2·78	3.29
Sulphuric acid	—		—		—		3·54	4·57	5·81*	6·87*
Phosphoric acid	—		—		—		1·17	1·51	—	

* Sulphate of soda.

chloride of sodium are very numerous, and these are greatly increased in disease. It was noticed by Redtenbacher, many years ago, that in pneumonia the quantity of chloride in the urine gradually decreased as the inflammation advanced; and that in many instances, when the lung became hepatised, not a trace could be detected in the urine. In 1852, I determined quantitatively the amount of chloride in the urine from day to day, in several cases of acute pneumonia. (" Med. Chir. Trans.," vol. XXXV.) The following case illustrates very well the changes which occur in the urine in this affection.

The patient was a plasterer, aged 24, and was under the care of Dr. Budd, in King's College Hospital. On the third day of the disease, there was dulness two inches below the left mamma in front, and behind over the space below the spine of the scapula. Bronchial breathing and bronchophony were audible over the lower angle of the scapula. Expectoration viscid, frothy, and slightly rusty. Pulse 144, small and weak. Respiration 52.

On the fourth day of the disease, bronchial breathing and bronchophony were more distinct. Pulse 116. Respiration 28. He was treated with small doses of antimonial wine, and was placed upon milk diet and beef tea. Turpentine stupes were applied to the chest. He progressed favourably, was convalescent within three weeks after the commencement of the attack, and was discharged well in little more than four weeks.

Analysis 32. *Fourth day* of the disease. Urine high coloured; acid; specific gravity, 1,017; contained a little albumen. *Analysis* 33. *Fifth day.* Acid; specific gravity, 1,013; natural colour. *Analysis* 34. *Sixth day.* Acid; specific gravity, 1,016; pale; still contained a trace of albumen. *Analysis* 35. *Tenth day.* Acid; specific gravity, 1,022; no albumen. *Analysis* 36. *Twenty-second day.* Acid; specific gravity, 1,016; pale; no albumen.

ANALYSES	32		33	34		35		36	
Water	956·60	—	957·40	954·00	—	955·00	—	968·40	—
Solid matter ...	43·40	100·00	42·60	46·00	100·00	45·00	100·00	31·60	100·00
Organic matter	40·28	92·82	—	44·64	97·05	42·12	93·64	23·26	73·60
Fixed salts ...	3·12	7·18	—	1·36	2·95	2·88	6·4	8·34	26·39
Chloride of sodium	0	—	traces	0	—	0	—	4·56	14·43

The decrease of the fixed salts generally, during the stage of hepatisation is remarkable. The last analysis of the urine, when the patient was well, shows the healthy proportion. In vol. XXXV of the " Medico Chirurgical Transactions " will be found several other cases showing similar results. In some of the cases, it was shown that, although there was not a trace of chloride in the urine, and the blood contained less than its normal proportion, the *sputa were very rich in chloride of sodium.* In one case, the proportion amounted to upwards of 18 grains in 100 of the solid matter of the sputum. In a fatal case, much chloride was found in the products effused into the air-cells of the lung. In most exudations, and in growing tissues, there is a considerable amount of chloride of sodium. In acute inflammations generally, the proportion of chloride in the urine gradually diminishes until the disease is at its height. When resolution occurs, the chloride reappears, and gradually increases as convalescence advances, until it attains its normal standard. The amount of chloride in the urine is much influenced by the nature of the food, and by the quantity of fluid taken, as I remarked when treating of the chloride in healthy urine; but the results above described cannot be explained in this manner; for, although patients take less food when they are ill, and therefore less salt, the same results are observed if salt be given to them. Moreover, the disappearance is gradual, and the reappearance is marked by a change in the symptoms of the disease, although the food has remained the same during the whole period of the illness.

There can be little doubt that, in these cases, the chloride is gradually separated from the blood in undue proportion at the point where the inflammatory changes are taking place; and that, instead of passing through the organism as it does in health, it accumulates at this point until a certain stage of the morbid process is passed, when the cells, which have been growing and multiplying so fast, die and become disintegrated and dissolved; the products thus formed with the chloride of sodium being reabsorbed into the blood, are afterwards altered and at length excreted by the ordinary channels. The precise office which the salt plays in these processes is not understood; but certainly, in all the specimens of inflammatory lymph that I have examined, I have always found this substance present in large quantity. In many cases of bronchitis, acute rheumatism, pleurisy, in some cases of skin disease, and in some other instances in which its absence would appear to be merely an accidental circumstance, no salt can be detected in the urine. We cannot, therefore, regard this diminished proportion or absence of chloride in the urine as a point of any value in the *diagnosis* of pneumonia, although it must be looked upon as a fact of great interest with reference to the morbid changes which are taking place at the time. The conclusions at which I arrived, after examining the urine, blood, sputum, and inflammatory products, in several cases of pneumonia, are as follows:—

1. That in pneumonia there is a total absence of chloride of sodium from the urine at or about the period of hepatisation of the lung.

2. That, soon after resolution of the inflammation, the chloride is again present in the urine, and often in considerable quantity.

3. That, at this period (resolution), the serum of the blood is found to contain a greater amount of chloride than in health.

4. That the presence of chloride of sodium in the urine may be taken as evidence of the existence of a greater quantity of the salt in the blood than is required for the wants of the system generally, or, at least, of an amount sufficient for that purpose; and that the absence of the salt from the urine indicates that the circulating fluid contains less than the normal quantity.

5. That the sputa in pneumonia contains a greater quantity of fixed chloride than healthy pulmonary mucus, if there be not much less than a normal amount in the blood, although there be complete absence of the salt from the urine. In all cases, however, there is found in the sputa a quantity many times greater than exists in an equal amount of blood at the same period of the disease. The absolute amount present is subject to variation at different periods of the disease, and in different cases.

6. That, in one case which was fatal, the proportion of chloride present in the sputum underwent a decrease, while the amount of solid matter, and especially the extractive matters, increased. At the same time, the sputum became acid; and in the matters expectorated within the last few hours of the patient's life, a large quantity of grape-sugar was found; but, in that obtained on the day previous to his death, none could be detected.

7. The absence of chloride of sodium from the urine during the stage of hepatisation seems to depend upon a determination of this salt to the inflamed lung; and, when resolution occurs, this force of attraction ceases, and whatever salt has been retained in the lung is reabsorbed, and appears in the urine as usual.

Principles of Treatment—On the Effects of Diuretics and Sudorifics in certain Acute Inflammations.—The increased secretion of urine, the profuse sweating, often accompanied with increased action of the bowels, which mark the occurrence of resolution of the inflammation, that is of the death of the cells, or masses of germinal matter which enter largely into the formation of the "inflammatory lymph," are undoubtedly encouraged by giving acetates, citrates, carbonates, and some other salts. Indeed, it is almost certain that, in many cases, critical discharges take place at an earlier period in consequence of the action of the remedies. If profuse sweating and diuresis can be brought about quickly, it is even a question if the disease may not sometimes be cut short. How can the action of this class of remedies be explained? There can be no doubt that, by an increased action of the excreting organs, many substances which would have been absorbed by the growing cells are eliminated, but it is probable that the salts given in these cases act favourably in another and not less important manner. Chloride of sodium seems absolutely necessary to the growth of the inflammatory products, while the salts given as medicines exert an unfavourable influence, and, the latter being in the blood in considerable quantity, would perhaps be poured out at the seat of inflammation, and take the place of the chloride of sodium, driving out the latter. Under these conditions the cells would soon cease to multiply, die, and undergo disintegration, the resulting products being absorbed and afterwards excreted.

Urine in Elephantiasis Græcorum.—Analysis 37 represents the composition of the urine in an extreme case of *elephantiasis Græcorum*, occurring in a boy about twelve years of age, who was in the hospital some years ago, under Dr. Todd. The emaciation was extreme, and there were a great number of large ulcerated tubercles all over the body, which discharged freely. The absence of the chloride may, perhaps, be accounted for by the presence of exudation and cell development at the bases of these numerous ulcers. The urine was acid; specific gravity, 1,020.

ANALYSIS 37.

Water	960·0	—
Solid matter	40·0	100·00
Fixed salts	·51	11·27

The ash consisted of sulphates and phosphates, with a mere *trace of chloride.*

Another specimen about two months after the last. Specific gravity, 1,014; acid.

ANALYSIS 38.

Water...	965·1	
Solid matter	34·9	100·00
Urea	13·79	40·02
Extractives	16·06	46·01
Uric acid	·31	·88
Alkaline salts	4·0	711·66
Earthy salts	·49	1·40
Sulphuric acid	·422	1·20
Phosphoric acid	1·389	3·98
Chloride of sodium	not a trace.	

Urine in Hysterical Coma.—It is difficult to account for the absence of the chloride in the following analysis. The urine was obtained from a woman, aged 31, suffering from hysterical coma. About eleven ounces were drawn off by a catheter. The patient was quiet; skin cool; tongue covered with a thick white fur; pulse 135; respiration 18; sensation very much impaired. The patient did not notice a very severe pinch with the nails.

ANALYSIS 39.

Water	921·41	—
Solid matter	78·59	100·00
Uric acid	·57	·72
Urea, extractives, &c.	67·70	86·15
Fixed salts	10·32	13·13

The salts contained sulphates and phosphates, but *not a trace of chloride* was present.

Excess of Sulphates: Action of Liquor Potassæ.—I have already observed that the proportion of sulphates usually varies according to the urea; and it follows that, in diseases characterised by violent nervous and muscular action, we shall find an unusual amount of sulphate in the urine. In *chorea*, the increase of the sulphates and urea is often very considerable; but there are conditions in which the increase of the sulphates does not appear to be associated with the formation of urea to a correspondingly large amount. An increase in the quantity of sulphate in the urine, in cases of *rheumatic* fever, is noticed in some of Dr. Bence Jones' analyses. In one case, on the fifth day, the urine had a specific gravity of 1,026, and yielded 11·89 grains of sulphate of baryta.

Dr. Parkes has shown, by some very careful experiments on four cases, that in rheumatic fever the sulphuric acid is greatly increased. In one case, 52½ grains of sulphuric acid and 5½ grains of unoxidised sulphur were excreted in twenty-four hours. The urea was not increased in the same degree. This increase of sulphate is not observed in typhoid fever and scarlatina. It *does not*, therefore, depend merely on increase of temperature. Dr. Parkes suggests that in the blood, in acute rheumatism, there may exist a material richer in sulphur than albumen. Potash increases the tendency of this substance to disintegrate; and hence, whenever liquor potassæ is given, the proportion of sulphates in the urine is augmented.

Urinary constituents.	Condition in Rheumatic Fever.	Effect produced by Liquor Potassæ in large doses.
Solids	Increased	Still more increased.
Water	Greatly diminished	Slightly increased.
Uric acid	Increased	Slightly increased.
Sulphur	In considerable quantity	Probably increased.
Chlorine	Diminished	Unaffected.
Sulphuric acid	Greatly increased	Still more increased.*

In many cases of skin disease, I have found the relative proportion of the sulphates to be considerably augmented. This is well illustrated in Analysis 24, p. 201, which gives the composition of the urine of a boy suffering from eczema.

* The influence of liquor potassæ on the urine in rheumatic fever. ("Med.-Chir. Review," vol. XIII, p. 248.)

Excess and Deficiency of Alkaline Phosphates.—Much has already been said upon the origin of the alkaline phosphate in the urine, and the variation in the amount excreted; and I have brought forward evidence to show that the greater part of the phosphoric acid eliminated, is carried into the organism in the food. A certain proportion, however, there can be little doubt, is formed in the body by the oxidation of the phosphorus of albuminous textures only. It is probable that the amount formed in the nervous texture is exceedingly small. In diseases generally, the alterations which have been observed in the quantity of phosphate removed in the urine is to be attributed mainly to the altered diet of the patient. It is, however, but reasonable to suppose that, in some conditions of the system in which a more than usual disintegration of tissues rich in phosphorus takes place, more phosphoric acid is formed in the organism than in health. This excess should be found in the urine in the form of alkaline phosphate, and the amount ought to correspond to the activity of the changes taking place. By ascertaining the proportion, we should be able to form an estimate of the quantity of phosphorus oxidised—and therefore of tissue disintegrated. The really difficult part of the enquiry is to ascertain how much of the total proportion of phosphate present is derived from the food, and how much is actually formed in the organism. The sulphuric acid is almost entirely produced in the body; and there is not, therefore, the same difficulty in estimating the amount of sulphur oxidised, as there is in the case of the phosphorus.

Of late, the importance of this subject has been much increased by attempts to advance the experimental results already obtained, in favour of the hypothesis, that the amount of phosphate excreted in the urine is to be regarded as an index of the activity of the nervous system. Those who labour to prove that all the changes in the body are the direct result of certain chemical decompositions, have not hesitated to bring forward these results in favour of their theory. It seems by some to have been accepted as a settled point, that the quantity of phosphate in the urine varies according to the amount of nervous tissue disintegrated; and it has been assumed that the quantity of work done by the brain is in direct proportion to the activity of the chemical changes going on in the nervous tissue. But it has not yet been proved that the phosphate does vary according to the activity of the changes occurring in nerve tissue. This question is obviously a most important one, and much more is involved in it than at first appears. I propose, therefore, to examine some of the most important facts which have been ascertained; and I think I shall be able to prove that, in this matter, speculation has, to a great extent, taken the place of reasoning founded upon facts and experimental observations.

Dr. Bence Jones' Observations on the Alkaline Phosphates.—

Dr. Bence Jones, as is well known, has written several important papers on this subject. The general conclusions to which he has arrived are the following :—

"In delirium tremens, and in other delirium, a remarkable increase in the amount of sulphates in the urine was frequently observed; and the total *phosphates were in the same cases occasionally remarkably diminished.*

"In acute inflammatory diseases of the nervous structures, during the most febrile symptoms, an increase was observed in the amount of sulphates in the urine; and the total amount of *earthy and alkaline phosphates in these diseases appeared to be increased in the same proportion as the sulphates were increased.* ("Phil. Trans.," 1850, p. 66.)

"In fractures of the skull, the phosphatic salts increase only when any inflammatory action occurs in the brain; and in *acute phrenitis, an excessive increase takes place. In delirium tremens, there is a marked deficiency of phosphates,* unless they are introduced with the ingesta; an excess is, however, met with in some functional affections of the brain."

These conclusions are founded upon analyses of 1,000 grains of urine, in eleven cases of delirium tremens, and eight cases of acute inflammatory affections of the nervous centres. From these I select a few of the extremes.

Delirium Tremens and other forms of Delirium.

Case	Sulphate of baryta per 1,000 grains of urine.	Specific gravity.	Total phosphates.
8. Delirium Tremens—thirteenth day	13·10	1037·4	9·83
10. Poisoned by laudanum; delirium and excitement—second day	7·83	1026·8	7·53
4. Delirium Tremens—tenth day	17·31	1024·74	0·87
11. Delirium with phthisis—fourth night	6·97	1024·2	0·72
Inflammatory diseases of Nervous Structures, with Head Symptoms.			
2. Inflammation of the brain—twelfth day . . .	3·96	1018·7	5·14
Ditto—thirteenth day . .	11·23	1027·26	11·13
6. Inflammation of lungs, with tubercles and violent head symptoms—fourth day . . .	8·55	1027·85	7·19
Ditto—sixth day . . .	7·81	1026·1	6·43

The quantity of urine passed by the patients in twenty-four hours is not stated, nor is the amount of solid matter in 1,000 grains of urine given. It is, therefore, not possible, from the above data, to form an estimate of the total quantity of phosphate *removed from the organism in twenty-four hours.* Although many of the results, as far as they go, certainly favour the theory adopted, and especially when the numbers are considered with reference to the amount of solid matter estimated from the specific gravity, the increased excretion of the phosphates, in cases of inflammation of nervous structures, is not established by these observations.

The Observations of Dr. Sutherland and the Author on the Phosphates in Cases of Insanity.—I have estimated the quantity of phosphate in urine in various cases of disease. Some time since, I examined the urine of many patients in St. Luke's Hospital, for Dr. Sutherland, with the view of ascertaining the proportion of phosphates excreted in different cases of mania, dementia, paralysis of the insane, &c. ("Med. Chir. Trans.," vol. XXXVIII, p. 261.) Forty-two analyses were made, and the following formula was filled up in each case.

Water	
Solid matter	
Organic matter	
Saline matter	
Phosphate precipitated by chloride of calcium and ammonia	

Some interesting facts were made out, and the quantity of phosphates relatively to other constituents of the ash differed much from the healthy standard. Some of the results confirmed, as far as they went, Dr. Bence Jones' statements; but I do not think we can form a very positive conclusion from these data, seeing that, in some of the cases, the solid matter contained 10 or 12 per cent. of mixed phosphate; while in others only 3 or 4 per cent. was found; and this variation did not always correspond to a difference in the symptoms. I subjoin a few of the most interesting results from two of the series of cases.

Paralysis of the Insane.—*Analysis* 40.—From a man, aged 36. First attack. It lasted two months. Complete recovery. *Analysis* 41.—From a man, aged 45. First attack, of one month's duration. Not relieved. *Analysis* 42.—From a man, aged 42. The specimen was taken on a day when he was very violent and noisy. *Analysis* 43.—From the same, about three weeks afterwards, when the excitement had passed off.

ANALYSES	40		41		42		43	
Reaction	Acid.		Feebly alkaline.		Neutral.		Acid.	
Specific gravity	1,030	—	1,015	—	1,008	—	1,016	—
Water	912·6	—	959·4	—	988·6	—	958·2	—
Solid matter	87·4	100·00	40·6	100·00	11·4	100·00	41·8	100·00
Fixed salts	21·42	24·50	13·31	32·7	4·744	1·57	8·45	20·21
Phosphate of lime precipitated by chloride of calcium and ammonia ...	5·18	5·92	1·57	3·86	2·90	25·44	2·86	6·84

It is important to observe that, in Analyses 42 and 43, 1,000 grains of urine contained almost exactly the same quantity of phosphates, but that the proportion to the other constituents was very different; the solid matter, in the first case, containing the very large proportion of 25·44 per cent.; in the second, only 6·84 per cent.

Acute Mania, with Paroxysms.—Analysis 44.—From a man, aged 18, with meningitis. The present is the first attack, and has lasted three months. He recovered. *Analysis* 45.—From a woman, aged 55. First attack, which has lasted about three months. She recovered. *Analysis* 46.—From a man, aged 26. First attack, which has lasted six days. There was much exhaustion and emaciation. Weighs 7 st. 12 lb. Discharged uncured. *Analysis* 47.—From a girl, aged 18. Second attack. Weighs only 6 st. 6 lb.

ANALYSES	44		45		46		47	
Reaction	Acid.		Feebly Acid.		Acid.		Acid.	
Specific gravity	1,020	—	1,023	—	1,033	—	1,028	—
Water	945·8	—	943·00	—	908·00	—	931·6	—
Solid matter	54·2	100·00	57·60	—	92·00	—	68·4	—
Fixed salts	12·91	23·81	15·10	26·49	13·18	14·32	20·33	29·72
Phosphate of lime precipitated by chloride of calcium and ammonia ...	6·05	11·16	7·14	12·52	9·73	10·57	4·49	6·56

The conclusions at which Dr. Sutherland arrives, in his paper above referred to, are the following:—

1. A plus quantity of phosphates exists in the urine in the paroxysms of acute mania.

2. A minus quantity exists in the stage of exhaustion in mania, in acute dementia, and in the third stage of paralysis of the insane.

3. The plus and minus quantities of phosphates in the urine correspond with the quantitative analysis of the brain and of the blood; for a plus quantity of phosphorus is found in the brain, and a slight excess of albumen in the blood of maniacal patients; and a minus quantity of phosphorus and albumen are found in the brains of idiots, and a minus quantity of albumen in paralysis of the insane.

4. The plus quantity of phosphates in the urine of cases of acute mania denotes the expenditure of nervous force, and is not a proof of acute inflammation in this disease.

Dr. Adam Adamson's Observations.—This physician has made more complete observations upon the urine of the insane than Dr. Sutherland and myself, having accurately determined the total quantity of urea, chloride of sodium, phosphoric and sulphuric acids excreted in the twenty-four hours. Dr. Adamson's paper is published at length in the volume of the "British and Foreign Medico-Chirurgical Review," for April, 1865. I have extracted from the memoir some of the most important of the results obtained.

The following table represents the minimum, mean, and maximum daily excretion of certain urinary constituents in health, as estimated by Dr. Parkes.

	Males.				Females.			
Constituent.	Minimum.	Mean.	Maximum.	1 lb. excretes in 24 hours in grs.	Minimum.	Mean.	Maximum.	1 lb. excretes in 24 hours in grs.
Chloride of sodium...	...	177·0	...	...	...	...	...	...
Urea...	286·1	512·4	688·4	3·53	...	390·0	...	2·96
Phosphoric acid ...	24·70	48·80	79·80	0·336	...	56·2	...	0·464
Sulphuric acid... ...	17·34	31·11	31·11	0·214	...	30·2	...	0·25

Dr. Parkes points out that in the women the phosphoric acid is probably set down as too great in consequence of the small number of cases taken for the average. The range above and below the mean of the chloride of sodium is very great, from 30 to 60 per cent. This probably depends upon the varying amount taken in the food. Parkes observes that "the limits of variation above and below the mean excretion, according to weight, are certainly considerable. If we compare two persons we find that one may excrete in twenty-four hours only 0.390 grammes (Beneke in one series), and another 0·529 grammes of urea to each kilogramme; and variations as great occur in the other ingredients. Also, in the same person the amount of urea excreted by each pound weight of the body at different times varies rather largely (even occasionally as much as 20 per cent.), so that certainly we must allow a wide range of mean, maximum, and minimum excretion above and below the mean recorded in the table. In the other ingredients the maximum and minimum excretion of each pound weight is even greater than in the case of the urea."

Acute Mania.—During the first twenty-four hours of an attack of acute mania the quantity of the urine was not diminished, and the amounts of the constituents under investigation were larger than the daily average after recovery; but on the second day the quantity of the urine and its constituents fell greatly, in an inverse ratio to the development and intensity of the mania; and this relation was continued throughout the course of the attack. As regards the phosphoric acid, though the amount passed on the first day was large, it was not equal to the quantity excreted in the normal state. The absolute amount excreted during mania is very far below that excreted in an equal time after recovery had taken place. In eleven cases the amount of sulphuric acid excreted during convalescence was greater than during mania; in five cases it was larger in the latter condition.

The following table shows the mean of the average daily quantities of the urine and its constituents excreted by all the cases during mania and convalescence:—

	During mania.	During Convalescence.
Quantity of urine	23·9 oz.	58·4 oz.
Specific gravity	1,025	1,016
Cl Na...	35·94 grs.	59·98 grs.
Urea	328·14 ,,	475·70 ,,
PO_5	22·14 ,,	30·54 ,,
SO_3	21·42 ,,	23·07 ,,

Melancholia and Monomania of Fear.—Dr. Adamson has shown that all cases of chronic melancholia and monomania of fear give results *very far below the mean in healthy men and women*. In two cases the amount of urea is about normal. The following table gives the mean of the daily average excretion in nine cases.

Cl Na	36·67 grs.
Urea	270·44
PO_5	20·04
SO_3	13·08

Mean excretion according to weight, in eight cases:—

	1 lb. excretes in grs. in 24 hours
Cl Na	0·267
Urea	1·961
PO_5	0·139
SO_3	0·090

Dementia.—The following table gives a comparison of the mean daily excretion of 12 cases of dementia, with the mean amounts in health:—

Constituents.	In dementia.	In health.
Cl Na	64·92 grs.	177·00 grs.
Urea	517·24	512·40
PO_5	35·20	48·80
SO_3	27·03	31·11

The next shows the mean excretion in eleven cases by 1 lb. of body weight in twenty-four hours, compared with the normal mean found in the same way:—

	In dementia 1 lb. excretes in grs. in 24 hours		In health 1 lb. excretes in 24 hours
Cl Na	0·557		
Urea	4·311	Urea	3·53
PO_5	0·291	PO_5	0·336
SO_3	0·216	SO_3	0·214

It will be seen from these tables that the differences between the quantities in dementia and in health are not greater than occur in individual healthy cases.

In states of maniacal excitement Dr. Adamson found that the quantities of chloride of sodium, urea, phosphoric and sulphuric acids were less than in the quiescent state. In the demented cases quantities are about normal—some slightly above, and some below, the mean. In two cases the excretion, according to weight, was also very near the mean healthy standard, and in one the phosphoric acid was above it when compared without reference to weight. In the last stage of general paralysis it was found impossible to obtain the twenty-four hours' urine, but there is no reason to suppose that the result would differ much.

The conclusions arrived at by Dr. Adamson are as follows :—

1. That the quantities of the urine, of the chloride of sodium, urea, phosphoric and sulphuric acids, excreted during the course of a maniacal paroxysm, occurring in acute mania, epilepsy, general paralysis, melancholia, or dementia, are less than the amounts excreted in an equal time during health.

2. That in chronic melancholia the quantities of the chloride of sodium, urea, phosphoric and sulphuric acids are reduced below the mean, and sometimes the minimum, of health.

3. That in idiocy, dementia (paralytic and common), the urea, chloride of sodium, and sulphuric acid range above and below the normal mean of health; that in some cases the amount of phosphoric acid is greater than the mean according to weight, but in the majority of cases it ranges between the minimum and mean found in healthy adult men.

The Author's Analyses in Chronic Inflammation of the Brain, Epilepsy, Delirium Tremens, Puerperal Mania, and in Health.—I have selected the following analyses from my note-book :—

Chronic Inflammation of the Brain.—Analysis 48 shows the proportion of phosphates in the urine of a man, aged 34, who had been suffering from a tumour pressing on the veins of Galen, causing dropsy of the ventricles of the brain. There were many symptoms of chronic inflammation. Specific gravity, 1,018; acid. *Analysis* 49.—Three weeks after the first analysis; acid, clear, pale; specific gravity, 1,015. *Analysis* 50.—After another interval of three weeks; clear, natural colour; specific gravity, 1,016.

ANALYSES	48		49	50	
Water	962·10	—	1000·00	956·3	—
Solid matter...	37·90	100·00		43·70	100·00
Organic matter	27·09	74·12	—	33·72	77·17
Fixed salts	9·81	25·88	—	9·98	22·83
Phosphate of lime precipitated by chloride of calcium and ammonia	2·74	7·22	3·53	3·92	8·97

Urine in Epilepsy.—Analysis 51.—From a man suffering from epileptic fits, occurring every five or ten minutes, for seventeen hours. He breathed stertorously the whole time, and no urine could be obtained during this period. Urine was obtained on the next day (June 10th); acid; specific gravity, 1,024. Contained an abundant deposit of urates. *Analysis* 52.—From the same patient, on the 12th; acid, 1,024. Contains a good deal of pus. *Analysis* 53.—From the same patient, on the 19th; alkaline, 1,017. *Analysis* 54.—From a very intemperate patient, aged 59, who had epileptic fits every few minutes for thirty hours, followed by exhaustion (twelve hours) and death. There was complete loss of consciousness. *Analysis* 55.—From a man, aged 53, suffering from slight general paralysis, with impaired speech (slight), intellect, and memory. Duration of illness, three years. Urine pale, clear; no albumen; feebly acid; specific gravity, 1,009.

ANALYSES	51		52		53		54	55	
Water	931·2	—	927·2	—	958·8	—	1000	976·7	—
Solid matter ...	68·80	100·00	72·80	100·00	41·20	100·00		23·30	100·00
Organic matter ...	58·35	86·27	51·01	85·18	34·68	84·18	—	17·46	75·94
Fixed salts ...	9·45	13·73	10·79	14·82	6·52	15·82	—	5·84	25·06
Phosphate precipitated by chloride of calcium and ammonia	6·96	10·11	3·92	5·38	2·15	5·21	8·86	1·79	7·68

The quantity of phosphate in the first analysis is very great, especially when the small proportion of saline matter in the urine is taken into consideration. In Analysis 51, the ash contains as much as 73·63 per cent. of phosphates; in 52, 36·30 per cent.; and in 53, the proportion is further diminished to 32·93 per cent.

Urine in Delirium Tremens and Puerperal Mania.—Analysis 56.—From a man, aged 36, on the fifth day of a slight attack of delirium tremens. He had had three severe attacks previously. Clear, high coloured; specific gravity, 1,015. The saline matter contained much sulphate, but not a trace of chloride. *Analysis* 57.—From a man, aged 31, with delirium tremens of a fortnight's duration. Acid; specific gravity, 1,020. *Analysis* 58.—From a woman with puerperal mania. Acid; specific gravity, 1,012.

ANALYSES	56		57	58
Water	959·32	—	1000·00	1000·00
Solid matter	40·61	100·00		
Organic matter	—	—	—	—
Fixed salts	6·30	15·48	—	—
Phosphate precipitated by chloride of calcium and ammonia ...	2·93	7·20	7·66	3·40

Phosphates in the Urine in Health.—The following analyses show the varying quantity of the phosphates in the urine of a healthy man, 23 years of age. The large proportion of fixed salts depended upon the presence of much chloride of sodium.

Analysis 59.—Passed at half-past 2 P.M., immediately after dinner. Clear, natural colour; acid; specific gravity, 1,015. *Analysis* 60.—Passed at 6 P.M. on the same day, after three hours' reading. Acid; specific gravity, 1,011. *Analysis* 61.—Passed at 2 P.M., immediately before dinner, on another day. Feebly acid; specific gravity, 1,022. *Analysis* 62.—Passed at half-past 6 P.M., four hours after dinner. Acid; specific gravity, 1,026.

ANALYSES	59		60		61		62	
Water	963·60	—	972·4	—	943·80	—	936·80	—
Solid matter	36·40	100·00	27·6	100·00	56·20	100·00	63·20	100·00
Organic matter ...	14·75	68·00	19·89	72·07	37·80	67·26	36·30	63·84
Fixed salts	11·65	32·00	7·71	27·93	18·40	32·74	22·82	36·16
Phosphate of lime precipitated by chloride of calcium and ammonia	2·62	7·19	1·92	6·95	2·40	4·27	6·22	9·84

Conclusions.—In the above analyses, can any relation be shown to exist between the symptoms present and the proportion of phosphoric acid? In some, there is, undoubtedly, an indication of such a relation; but in others, the proportion of phosphate is as great, although there was no evidence whatever of increased cerebral action or of inflammation. Without discussing the abstract question, I cannot think that the evidence at present obtained is sufficient to enable us to form a general conclusion. The enquiry is more difficult than it at first sight appears to be. Before any reliable conclusion can be drawn, we must determine how much phosphate is derived from the food, and how much from the oxidation of phosphorus. We have also to ascertain the proportion formed in the muscular system, as well as in the nervous structures. Dr. Hammond, who has carried on very many valuable researches upon subjects of this nature, has found that the phosphates in the urine are greatly increased after active exercise.

In any case of disease in which the excretion of an increased quantity of phosphates in the urine is suspected, we should ascertain—

1. The total quantity of phosphoric acid, in combination with alkalies, in the urine passed in the twenty-four hours.

2. The amount taken in the food within the same period of time.

To be more exact, the earthy phosphate in the urine should also be estimated, as well as that which passes off in the fæces.

I have not been able to ascertain that the quantity of phosphate excreted in the urine has ever been compared with the amount taken in the food, in diseases in which we should expect an increased disintegra tion of nervous tissue. Until experiments have been conducted so as to furnish us with positive data on this point, I do not think we are in a position to determine the question at issue. One can hardly suppose that, in cases in which the greatest possible amount of disintegration of nervous tissue was occurring, a very great increase in the phosphate would be observed, considering how very much of the total quantity is derived from the food; and, of the comparatively small amount *formed* in the organism a considerable proportion may originate in the muscular tissue. Very exact observations upon the in and out going phosphates have therefore to be made before we can hope to have the fact established conclusively. The evidence which has been adduced so far, compels us to conclude that the action of the brain exerts little or no influence upon the excretion of phosphates; while the nature and amount of the food, the weight of the body, and the state of the organism, may produce very considerable variation in the excretion of phosphate. While I do not deny that increased nervous action may be associated with the formation of an increased quantity of phosphoric acid, which is eliminated in the urine, I think that the facts hitherto advanced in favour of this view are by no means conclusive; and I therefore hold that we are not yet in a position to form any theory upon the nature of the changes occurring in health or disease, in cerebral action, regarded from this point of view.

When a long train of theories is constructed, the truth of which entirely depends upon the accuracy and correct interpretation of the experimental results from which it starts, it behoves us to examine rigorously into the nature of this foundation; for, until the fundamental facts have been firmly established, we ought not to allow ourselves to be led by the reasoning, however logical it may be; and we should not accept the conclusions, however closely they may follow on the premises. For this reason I have ventured to devote more space to the consideration of the details of this question than, in the opinion of many practical men, it merits.

Variation in Earthy Phosphates.—The proportion of earthy phosphates does not seem to vary much in any diseases. Much of the earthy phosphate eliminated in the urine in health is doubtless derived from the food, but a certain proportion is set free in the disintegration of the tissues, especially the osseous tissues. An increase of earthy phosphate is observed in the urine in some very rare cases of disease, in which the earthy matter of the bones is absorbed (*mollities ossium*). In one acute case of this disease, Dr. Bence Jones (" Phil. Trans.," 1848) obtained indistinct evidence of the presence of chlorine, and suggests that in future this substance should be searched for, as it may possibly be directly concerned in the removal of the earthy material from bones. The specimen of urine in question contained a peculiar substance of an albuminous nature. In 1,000 grs., there was 1·20 gr. of earthy phosphate, and the solid matter contained 1·18 per cent. For analysis *see* p. 227.

Mollities Ossium.—I have had opportunities of making analyses of the urine in two cases of mollities ossium. They were both well marked and fatal, and the specimens of urine were obtained shortly before death. The patients were quite bedridden, and the bones were so soft as to be readily indented by the finger.

Analysis 63.—This specimen of urine, from a woman suffering from mollities ossium, was sent to me by Dr. T. K. Chambers. The deposit contained oxalate of lime, with numerous stellate masses and separate crystals of earthy phosphate. Reaction, acid; specific gravity, 1,014.

Analysis 64.—From a case under the care of Dr. Greenhalgh. Morning specimen.

Analysis 65.—Night specimen.

ANALYSES	63		64		65	
Water	971·9	—	965·2	—	960·88	—
Solid matter	28·1	100·00	34·8	100·00	39·12	100·00
Urea	5·0	17·7	—	—	—	—
Extractives	10·22	36·3	—	—	—	—
Fixed salts	12·88	45·81	14·44	41·49	5·25	13·42
Earthy phosphates precipitated by ammonia	1·185	4·21	·79	2·27	·4	1·02
Alkaline phosphates precipitated by sulph. magnesia and ammonia	1·13	4·21	·86	2·47	1·3	3·32
Triple phosphates filtered from the urine	—	—	·058	·16	—	—

The large proportion of earthy phosphate in these analyses is a very interesting fact. In the first, the earthy actually exceeds the alkaline phosphates; and in the second, it is nearly equal to it. In healthy urine, the alkaline phosphate usually amounts to from ten to fifteen times as much as the earthy phosphate. The inorganic salts, generally, are in considerable excess.

Excess as distinguished from, mere Deposits of Earthy Phosphate.—*Excess of Earthy Phosphate*, which has been shown to be so uncommon, must be carefully distinguished from the mere deposit of a certain amount in an insoluble form. The earthy phosphates very often form an insoluble deposit in the urine. The characters of these salts will be described in part IV. It is important to observe, that the deposition of insoluble matter does not depend necessarily upon the excretion of an excessive quantity, but usually arises in consequence of a change having occurred in some of the constituents, by which these salts are ordinarily retained in solution. A small quantity of deposit of earthy phosphates makes a great show in urine; and it is obvious that a very large proportion might be held in solution and thus escape detection, unless an analysis were made. In the case just cited, the greater part of the earthy phosphate was in *solution* in the urine.

It is common enough to find a deposit of earthy phosphate in cases of dyspepsia and overwork, and this is often spoken of as if it was indicative of the destruction of much nervous matter. In many conditions the urine becomes neutral or slightly alkaline, and this causes the precipitation of the phosphate. As before remarked, the quantity of the earthy phosphates is not perceptibly affected by those circumstances which influence the quantity of the alkaline phosphate; and, although in many cases an excess of earthy phosphate is of some importance, its existence depends upon morbid actions of a different nature to those which are supposed to give rise to excessive excretion of alkaline phosphates. A diet composed of much sugar caused diminution in the quantity of earthy phosphate in the urine (Böcker).

Of the principal Points to be ascertained from a Quantitative Analysis of Urine in Disease.—In clinical investigation, the principal points which it is important to ascertain with regard to the characters of the urine are the following:—

Quantity passed in twenty-four hours. Specific gravity of specimens passed in the morning and evening. Reaction of specimens in the morning, before and about three hours after meals. Colour; smell; consistence.

Presence or absence of a deposit. If present, its microscopical characters. *See* Part IV.

Presence of any of the substances next to be described—albumen, colouring matter of bile, sugar, leucine, tyrosine, alkapton, &c.

Estimation of the quantity of constituents in 1,000 grains of the mixed urine of twenty-four hours. From these data, the quantities passed in twenty-fours are to be calculated. These points are included in the following form which may be easily committed to memory.

Quantity in 24 hours	
Specific gravity of the urine passed during 24 hours	
Reaction before and after meals	
Colour, smell, consistence	
Deposit	
Albumen, biliary colouring matter	
Sugar, &c.	

ANALYSIS OF URINE.

	In 1,000 grs.	Per 1 lb. of body.	In 24 hours.	In 100 grs. of solid matter.
Water	—	—	—	—
Solid matter	—	—	—	—
Organic matter	—	—	—	—
Saline matter	—	—	—	—

	In 1,000 grs.	Per 1 lb. of body	In 24 hours.	In 100 grs. of solid matter.
Urea	—	—	—	—
Uric acid	—	—	—	—
Free acid	—	—	—	—
Extractives, &c.	—	—	—	—
Alkaline phosphates, or phosphoric acid	—	—	—	—
Earthy phosphates	—	—	—	—
Sulphates, or sulphuric acid ...	—	—	—	—
Chloride of sodium, or chlorine ...	—	—	—	—

In special diseases, it is very desirable to ascertain the quantity of one or two constituents removed in the twenty-four hours; and it is probable that very much valuable information with regard to the nature of many diseases might be obtained by a number of careful and exact analyses of this kind. It is not necessary to fill up the above scheme in every case. In some, it would be desirable to know the amount of urea and uric acid with precision; in others, the amount of urea and sulphates. In diseases of the nervous system, the exact amount of alkaline phosphates passed in the twenty-four hours should be noted.

Before the investigation is commenced, the observer should determine exactly the points he wishes to ascertain, construct a table, and fill up the several columns daily from his analysis-book. Every analysis should be made in precisely the same way, and careful notes of the case should be recorded daily. If possible, analyses of the urine should be made after the patient is restored to health; so that the quantity of the various constituents eliminated from the body in a state of health, may be accurately compared with the amount removed during the disease. The patient should be weighed at intervals while under observation, p. 128.

PRESENCE OF SOLUBLE SUBSTANCES WHICH DO NOT EXIST IN HEALTHY URINE.

I now pass on to the consideration of certain *soluble* substances which are never found in healthy urine. The presence of these is to be ascertained by the application of *chemical tests*. In many cases, however, our first suspicion of the existence of one or more of the substances in question, is excited by the deposit or the colour of the urine, or by its peculiar smell or unusually high or low specific gravity.

The matters referred to, being perfectly soluble in the fluid, cannot be detected by microscopical examination; but, in some instances, we may infer their presence from the microscopical characters of certain bodies in the deposit. Thus, the detection of epithelial cells of a yellowish colour would lead us to test the urine for *biliary colouring matter;* if casts were found upon microscopical examination of the deposit, we should test for *albumen*: if the urine was pale and of high specific gravity, we should have a suspicion that it contained *sugar*. In all cases, our conclusions must be verified by the application of appropriate tests, which will be presently considered. Under this head will be included *albumen*, *biliary constituents*, *sugar*, *leucine*, *tyrosine*, and a few other substances very rarely met with in morbid tissues in a state of solution. The clinical importance of the first three of these is so great, that they deserve thorough study.

ALBUMEN.

Of Albumen in the Urine.—The occurrence of albumen has been regarded as a most important symptom ever since Dr. Bright showed that albumen was present in the urine in cases of disease of the kidneys, and pointed out the intimate connection between renal disease and dropsy. Albumen, it need scarcely be said, is absent from the urine of healthy persons, although now and then it may be detected for a short period of time in the urine of individuals who are not suffering from any serious or permanent derangement of the health. The presence of albumen must always be regarded by the physician as a point of serious importance, although at the same time, *per se*, it cannot be taken as evidence of the existence of any organic lesion, unless it has been clearly detected from day to day for a certain time. Many of the causes which give rise to the escape of serum from the vessels in other parts of the body, independent of disease, will determine its transudation through the walls of the renal capillaries, and, as a matter of course, it will be found in the urine.

To recognise with certainty the presence of a substance in the urine having so important a bearing upon the discovery and interpretation of certain grave morbid processes, is obviously a point of the utmost importance to the practitioner. In the examination of the urine of patients, the application of one or two simple tests enables us to determine at once if this substance be present or absent. Occasionally, however, an instance occurs in which, without great care, an erroneous conclusion is likely to be arrived at, although the proper tests have been applied to the urine. As this question is one of very great practical importance, and of much interest, I propose to consider it at somewhat greater length than is usual in works devoted to the clinical examination of urine.

The reactions to which I shall refer are not imaginary, but have actually occurred to me. I have known instances in which albumen was stated to be *absent* when the urine contained a very large quantity; and other specimens have fallen under my notice, which, although they really *contained none*, yielded a precipitate having many of the characters of albumen. It will, therefore, be well to consider the facts in regular order, and first with regard to the ordinary tests.

1. **Nitric Acid.**—*Albumen is usually precipitated from its solution upon the addition of a few drops of nitric acid.* Heller recommended that the acid should be allowed to flow to the bottom of the tube containing the urine. In this manner, three strata are formed, the lowest stratum consisting of the pure acid, above which is the precipitated albumen, while the upper stratum consists of the fluid containing the albumen uncoagulated.

It must be remembered that two or three drops of nitric acid to about a drachm of albuminous urine in a test tube will produce a precipitate of albumen which will be *dissolved on agitation*, while, on the other hand, about half as much strong nitric acid as there is of urine will re-dissolve the precipitate of albumen, unless the quantity present be excessive. Albumen precipitated by nitric acid is *soluble* in *weak nitric acid* and in a considerable *excess of urine*, and it is also *soluble* in *strong nitric acid. It is therefore necessary, in employing the nitric acid test, to add from ten to fifteen drops of the strong acid to about a drachm of the urine suspected to contain albumen.*

2. **Heat.**—*Albumen is generally coagulated by the application of heat* (140° to 167 Fahr.). If very dilute, a higher temperature is required. The best way of testing urine by heat is the following :—An ordinary test-tube is about half filled with the urine, and is to be held between the finger and thumb by the lower part. Heat is applied to a point near the *surface* of the fluid ; the tube being shaken a little at the time, to prevent the glass from being cracked. The slightest precipitate cannot fail to be observed, as the fluid below remains perfectly unchanged. When urates are present, this plan is very useful, as we get three distinct strata ; the upper one more or less turbid or milky, consisting of *coagulated albumen ;* the next clear, in consequence of the *solution of the urates* at a temperature somewhat below that necessary for the coagulation of the albumen ; and lastly, at the lower part of the tube, *the unchanged deposit of urates.*

3. **Effect of Heat on Alkaline Albuminous Urine.**—*If the solution of albumen be alkaline, no precipitate will be produced by heat. We are, therefore, generally directed to neutralise the alkali by an acid before heat is applied.* If excess of acid (ten or fifteen drops of the strong acid to a drachm of urine) be added, the albumen is, of course, precipitated in the insoluble form, without the application of heat.

Discrepancies.—Frequently specimens of urine are met with which exhibit one or more of the following peculiarities, tending to make us believe either that albumen is present when it is not, or to cause us to conclude that it is absent when the urine contains it.

1. Upon the application of heat, the specimen may become turbid,

in consequence of the precipitate of phosphate. The reaction of the urine in this case would generally be neutral or feebly alkaline ; but sometimes urine depositing phosphate on the application of heat is of a decidedly acid reaction, p. 162.

2. Upon the addition of nitric acid, the specimen becomes turbid, in consequence of the decomposition of the urates held in solution in the urine, and the deposition of *uric acid* in a granular state. If the acidified urine be boiled, it usually becomes clear, with the development of a pinkish or brown colour, consequent upon the decomposition of the uric acid and certain colouring matters.

3. Upon adding nitric acid to some specimens of urine of high specific gravity, an abundant precipitate of a crystalline character is produced. This consists of *nitrate of urea* and is easily recognised by its crystalline character. It seldom appears immediately, and is hardly likely to be mistaken for albumen. Microscopical examination will at once determine the nature of the precipitate. "Illustrations of Urine," pl. III, fig. 1.

4. After adding a drop or two of nitric acid to urine suspected to contain albumen, in order to render it distinctly acid, no precipitate is produced upon boiling, although a large quantity of albumen may be present. *This is constantly observed in all specimens of albuminous urine, and shows the importance of never boiling urine, suspected to contain albumen, in a tube which may contain, by accident, a drop or two of nitric acid.*

5. Cubebs, copaiba, and some other resinous substances, taken internally, are said to give rise to precipitates in the urine which are liable to be mistaken for albumen.

We have, then, to consider—

1. Cases in which a precipitate is produced in urine containing no albumen.

2. Cases in which no precipitate is produced, although the urine contains albumen.

1. *A Precipitate Produced in Urine containing no Albumen.*

Phosphate resembling Albumen.—The precipitate of phosphates is very readily distinguished from albumen by its solubility in a little acid. Upon the addition of a few drops of nitric acid, the turbidity produced by heat instantly disappears, and the solution becomes perfectly clear.

Uric Acid resembling Albumen.—When a precipitate of uric acid in a minute state of division is caused in consequence of the decomposition of the urates by nitric acid, its nature may be ascertained by allowing the mixture to stand for some time, for the minute granules will gradually increase in size, and at length become crystals, the nature of which is at once recognised upon microscopical examination. In some cases, the crystals may be seen to form under the microscope. This precipitation of uric acid on adding nitric acid often leads to mistakes, and albumen is stated to be present in urine which really does not contain a trace. Several cases of this precipitate have occurred to myself, and I have heard of many others in the practice of friends. It has happened in the wards of our hospital, that a precipitate produced by nitric acid, has led the clinical clerk to state that albumen was present in the urine, when, upon being submitted to examination subsequently before the class, no precipitate could be obtained. The fallacy was explained as above.

Dr. G. O. Rees has met with urine affording this precipitate of uric acid on the addition of nitric acid, in cases of typhoid fever. Most of the instances which I have observed occurred in cases of liver affection. I extract two or three as examples.

Specimens of Urine yielding a Precipitate resembling Albumen but composed of Uric Acid.—Urine from a Patient suffering from large Hydatid Tumours of the Liver. A small quantity of the urine was filtered, and, upon the addition of a little nitric acid, a precipitate was produced. After standing a little while, this was examined by the microscope, and found to consist of minute crystals of uric acid. These were dissolved upon the application of heat; but, as the solution cooled, they were deposited again in the form of much larger crystals.

A specimen of urine exhibiting the same peculiarity contained excess of urea. Upon the addition of half its bulk of nitric acid, the mixture became nearly solid, from the formation of crystals of nitrate of urea. The deposit in this instance consisted partly of urate of soda.

Another example, of which I have kept notes, occurred in a man, aged 49, suffering from *rheumatic fever*. The urine was acid, specific gravity 1,027, and contained much urate of soda. The practitioner who first saw the case boiled a portion of the urine. It remained clear; and he said, therefore, that it contained no albumen. A physician afterwards tested a portion of the same urine with nitric acid; and, finding that an abundant precipitate was produced, affirmed that much albumen was present. The deposit produced by nitric acid was found, by subsequent examination, to be dissolved by heat; and, when a portion was examined in the microscope, its true nature was decided by the presence of numerous uric acid crystals.

I could refer to many other examples in which the same facts were noticed.

2. *No Precipitate produced in Urine containing Albumen.*

Albumen *not coagulated by heat when a little nitric acid is present.*—Upon the careful addition of a drop of nitric acid, the precipitate at first formed when the acid comes in contact with the urine, slowly dissolves as it descends towards the bottom. Upon boiling this *acidified solution, no precipitation of albumen will take place.* Upon the further addition, however, of nitric acid, the albumen is precipitated.

This reaction has often led to mistakes. Not unfrequently albuminous urine has been poured into a test-tube which contained a trace of the nitric acid remaining from some previous experiment; and, upon boiling the mixture under these circumstances, no precipitate of albumen has occurred. In some cases, two or three drops of acid are added, according to the directions often given for the very purpose of acidifying the urine previous to boiling it. This fact must not be forgotten;—that *if a few drops of a dilute solution of nitric acid be added to a portion of albuminous urine in a test-tube, and the mixture boiled, no precipitate will be produced.* In fact, the addition of a little dilute nitric acid will *prevent* the coagulation of albumen by heat.

Explanation of this Reaction.—Dr. Bence Jones was, I believe, the first to offer an explanation of this fact in a communication to the editor of the "Medical Gazette" (vol. XXVII, p. 289). Dr. Jones thinks that the solution of the albumen is owing to the formation of a nitrate of albumen which is soluble in a weak solution of nitric acid, even although boiling, but insoluble in a mixture of acid of moderate strength. Dr. Bence Jones has also shown that albumen is not always precipitated from very acid urine upon the application of heat.

From observations I have made, however, I have been led to conclude that the above result depends rather upon the decomposition of the phosphates by the nitric acid, and the consequent development of free phosphoric acid in which acid albumen is freely soluble. This view was confirmed by some experiments which I made some time since on the subject, and which have been many times repeated. A weak solution of albumen was treated with a few drops of chloride of calcium, and afterwards with a little ammonia. After having stood for twenty-four hours, it was filtered. In this manner, any soluble phosphates present were removed. The solution was then tested as follows:—

1. Albumen was precipitated by the application of heat, or by the addition of nitric acid, as usually occurs.

2. A very small quantity of dilute nitric acid did not prevent the coagulation of the albumen by heat.

3. After the addition of a few drops of phosphoric acid, the fluid no longer coagulated upon being boiled.

Some of the same solution as the above, which had not been treated with chloride of calcium and ammonia, afforded the same results upon the application of the tests as other albuminous solutions. A few drops of a weak solution of nitric acid, or a little phosphoric acid, prevented the precipitation of the albumen by heat. The addition of phosphoric acid to an albuminous solution, or a soluble phosphate and a little nitric acid, prevented the precipitation of the albumen by heat.

These results, therefore, led me to conclude that a trace of nitric acid prevents the coagulation of a moderately strong solution of albumen by heat, in consequence of decomposing the phosphates and setting free phosphoric acid, in which the albumen is soluble. When, however, excess of nitric acid is added, its action predominates over that of the phosphoric acid, and the albumen is precipitated.

Other Tests for Albumen.—Albumen is precipitated from its solutions by alcohol, alum, and many metallic salts, as those of lead, mercury, copper, and silver. The presence of grape sugar prevents albumen from being precipitated by sulphate of copper and liquor potassæ. The mixture forms a dark blue solution. In its turn the albumen prevents the reduction of the oxide to the state of suboxide when the mixture is boiled (*see* Test for Sugar). Bichloride of mercury is employed as a test, and ferrocyanide of potassium precipitates a solution of albumen to which *acetic acid has been added.* These salts will, however, produce precipitates in solutions of other substances allied to albumen.

On Estimating the Quantity of Albumen in Urine.—The quantity of albumen varies much in different cases, sometimes amounting to a mere trace; while, in other instances, a proportion not much inferior to that present in serum has been met with. In one case as much as 545 grains were excreted in 24 hours (Parkes). In order to estimate the quantity of albumen, it is only necessary to add a little acetic acid, by which any combination of albumen with alkali is decomposed, and heat the urine in a water-bath to a temperature of 194°, or until it boils. Or the fluid containing albumen may be allowed to drop into boiling water acidulated with acetic acid. The precipitate is to be collected on a weighed filter, well washed, dried, and weighed. The albumen always contains a small quantity of earthy salts, which are obtained by incineration. The residue must be deducted from the weight of the dried precipitate.

Albuminous Urine, from a patient with acute inflammation of the kidney.

ANALYSIS 66.

		In 100 parts of solids.
Water	952·00	—
Solid matter	48·00	100·00
Urea	13·052	27·19
Albumen, mucus, and uric acid ...	19·204	40·00
Extractives	12·864	26·80
Alkaline salts	2·784	5·80
Earthy salts	·096	·20

The deposit contained numerous granular casts, but no fat-cells were present; specific gravity, 1,015; acid. The albumen coagulated by heat and nitric acid.

On removing Albumen from Urine and other Organic Fluids.—It is necessary in some cases to remove albumen from a solution before applying tests for the detection of other substances. There are several ways of separating albumen. By boiling the fluid, albumen is coagulated, but in many instances, and especially when the solution is slightly alkaline or neutral, a small quantity of albumen, free or in combination, may still remain in solution. A little acetic acid may be added before the application of heat. When the precipitated matters have been separated by filtration, the acid may be exactly neutralised. Albumen is precipitated by alcohol, but extractive matters allied to albumen may still remain in solution after the addition of this reagent. Acetate of lead, bichloride of mercury, and some other metallic salts may be employed for the purpose of removing albumen from an organic fluid, but in many investigations the excess of salt has to be removed before testing for other organic matters, and these last may themselves be changed or destroyed by the chemical operations necessary for the purpose. If an albuminous solution be heated with a few crystals of sulphate of soda, the albumen and allied substances may be completely removed without injury to other organic matters dissolved, and without interfering with the application of other tests. When we wish to test an albuminous solution for sugar this is the most satisfactory process, and being very simple and of easy application it is now generally adopted.

Peculiar Forms of Albumen.—Scherer describes a variety of albumen which is only imperfectly coagulated by heat. It is perhaps more probable that many of the peculiar reactions met with from time to time, depend upon the presence of other substances dissolved with the albumen, than upon any peculiar properties of the albumen itself, or the existence of a variety of this substance. The reaction of different solutions of albumen is a subject well worthy of minute investigation.

It has been stated that a modified kind of albumen is present in healthy urine, but it need scarcely be said this substance is coagulated neither by heat nor by nitric acid, and it is therefore doubtful if it ought to be regarded as a form of albumen.

New Substance allied to Albumen.—Dr. Bence Jones obtained a new substance allied to albumen from the urine of a patient (under the care of Sir Thomas Watson and Dr. MacIntyre) suffering from mollities ossium. The urine was slightly acid; specific gravity, 1,034·2, "Phil. Trans." for 1848, p. 55. The deposit consisted of phosphate of lime, oxalate of lime, and tube casts. Phosphates were precipitated by heat; but the urine was cleared by adding a drop of acid. No precipitate was produced by nitric acid; but, after being heated and left to cool, the urine became solid. The solid material was redissolved by heat, and precipitated again when the mixture became cool. On some days, the urine coagulated by boiling; on others, prolonged boiling produced no change. A specimen, which did not coagulate by boiling, was carefully examined. It was acid; specific gravity, 1,039·6. It contained much urate of ammonia, phosphate of lime, and oxalate of lime. The urine contained—

ANALYSIS 67.

		In 100 parts of solids.
Water	890·72	—
Solid matter	109·28	100·00
New substance	66·97	61·28
Urea	29·90	27·36
Uric acid	·96	·87
Earthy phosphate	1·20	1·18
Chloride of sodium	3·83	3·50
Sulphate of potash	2·10	1·92
Alkaline phosphate	4·45	4·07

The new substance was precipitated from the urine by alcohol, well washed, and ultimate analyses were made. It contained 1·09 per cent. of sulphur, and ·20 per cent. of phosphorus. This substance is the *hydrated deutoxide of albumen.* It was soluble in boiling water, and the precipitate produced by nitric acid was redissolved by heat, and formed again as the mixture cooled. A similar substance occurs in small quantity in pus, and in the secretion from the vesiculæ seminales. The urine contained 66·97 parts per 1,000 of this substance—an amount equal to the quantity of albumen in the blood. The patient was passing about thirty-five ounces of urine daily, which would contain upwards of 1,000 grains, or more than two ounces of this new material.

Dr. Leared sends me the following note on a case of albuminoid precipitate in the urine, which is of interest.

"A gentleman, of slight make, 27 years of age, who had returned from the East Indies on sick leave, consulted me on account of the following symptoms. A sinking sensation before meals, and at times a ravenous appetite; but he had no proper dyspeptic symptoms. A soft murmur was found to have replaced the first sound of the heart. He never had rheumatism.

"The *urina cibi* was found to be faintly acid; spec. grav. 1,035. It contained opaque casts of tubes, and oxalate of lime crystals.

"On the cautious addition of nitric acid, it became perfectly white and opaque, like chylous urine, but cleared as perfectly by a further addition, or on being sufficiently heated. It behaved in the same way when acted upon by hydrochloric, phosphoric, or acetic acid; but, when a precipitate was caused by bichloride of mercury, it was not redissolved by excess of the bichloride, nor by heat."

Dr. Leared remarks that "it is plain that the precipitate was not albumen, although allied to it. As the patient was born in the West Indies, its alliance with the deposit which occurs in chylous urine also suggested itself, but the distinction was here again sufficiently marked. Albuminoid precipitates in the urine have been recorded in a few instances, and would probably be found more frequently if distinguished from those of albumen. They possess great interest in their bearing on nutrition and other questions, and for this reason it seemed to me worth placing the present case on record."

Fibrine in the Urine.—Mr. A. W. Stocks, of Salford, relates a curious case of spontaneous coagulation of the urine ("Med. Times and Gaz.," Jan. 21, 1865). The patient was suffering from eczema, accompanied with falling off of the hair. The mucous membrane of the mouth was red and tender, and the conjunctivæ were inflamed. There was frequent micturition, with some pain over the kidneys and about the anus. Masses of firm fibrine were removed from the urethra three or four times a-day for a week. The urine was highly albuminous, and coagulated spontaneously into "yellow transparent masses, like half melted calf's foot jelly, floating in the fluid part of the urine—about half the urine being solid and half liquid." The masses exhibited wavy lines under the microscope, entangling epithelium, pus, and blood corpuscles.

Of the Importance of Albumen in the Urine in a Clinical Point of View.—The presence of albumen in the urine may be due to—1, temporary or permanent changes in the secreting structure of the kidney itself; 2, to pressure of a tumour upon the vena cava, or renal veins; 3, to temporary turgescence of the renal capillaries, consequent upon internal inflammations, fevers, &c.; 4, to affections of the mucous membrane of the urethra, bladder, ureter, or pelvis of the kidney; or, 5, to alterations in the characters of the blood.

1. *Albumen in the Urine due to Changes in the Kidney.*—In the majority of cases in which the urine contains a very large quantity of albumen, and especially if the urine be of specific gravity of 1,020, or higher, and of a dark brown or smoky hue, caused by the action of the acid of the urine upon the colouring matter of the blood,—the inference will be that the case is an acute one, and that this large quantity of albumen has not been passing away from the kidney for any length of time. In very many of these cases, blood and numerous casts of the uriniferous tubes (part IV) are present. Whenever blood escapes from any part of the kidney or mucous tract, albumen will, of course, be detected in the urine, for serum will certainly pass through fissures which permit the passage of red blood corpuscles. But, in some instances there is a dark brown colouring matter, resembling blood if examined with the unaided eye only, but consisting of granular matter, probably resulting from the disintegration of blood corpuscles. *See* p. 193. In

these cases also albumen is usually present, and it is of course found if the blood colouring matter escapes into the urine in a state of solution.

In chronic fatty degeneration of the kidney, there is often also a very large quantity of albumen, but the urine is pale and of low specific gravity. The history of the case, the appearance of the patient, the symptoms present, and the microscopical characters of the deposit (Part IV), render it almost impossible to mistake a case of chronic fatty degeneration for one of acute inflammation of the kidney, caused by cold, or following scarlet or other eruptive fever. *See* Illustrations of Urinary Deposits, Part IV, and Diseases of the Kidney, Part I.

In cases of fatty and contracting kidney, the quantity of albumen is often considerable, but the specific gravity of the urine is 1,020, or higher. The characters of the deposit, and the history of the case, will usually enable us to distinguish this disease from fatty kidney, and from simple contracted kidney.

If the quantity of albumen be small, amounting merely to milkiness or opalescence when heat is applied, or nitric acid added to the urine, and especially, if the urine be pale and of specific gravity 1,012 or lower, we should suspect that the lesion giving rise to the escape of the albumen was chronic, and due to contracted, wasted, or cirrhosed kidney, p. 52.

In the majority of cases, in which the presence of albumen in the urine is due to structural changes in the kidney, the vessels of the Malpighian tuft doubtless form the precise seat of the escape of albumen; but there are reasons for believing that serum sometimes passes from the capillaries surrounding the convoluted portion of the uriniferous tubes, and in some instances from those in contact with the straight portion ("Archives of Medicine," vol. I, p. 300). *See* also p. 37 of this work.

In most cases of renal disease in which albumen occurs in the urine, casts of the uriniferous tubes are also found; for with the serum a certain quantity of coagulable material transudes from the blood or is formed in the tube itself. This becoming solid, takes a mould of the tube, and any loose bodies, as particles of epithelium, &c., which may happen to be in the tube at the time, are entangled in its meshes. The casts often afford evidence of the exact nature of the morbid changes in the kidney, but this question will be considered in Part IV.

Clinical Remarks.—As a general rule, if the proportion of the urea to the other constituents of the solid matter is large, we should form a more favourable opinion than if the percentage of urea in the solid matter were very much less than in health. In the latter case a great part of the renal structure would probably be involved; but, in the former, there would be reason to think the disease had only affected a certain number of the secreting tubules. There are, however, many exceptions to these general statements. In short, we must not permit ourselves to form an opinion upon the characters of the urine only, but must consider all the facts in connection with each individual patient. Patients have passed small quantities of albumen in the urine for many months, and yet it has entirely disappeared. In other cases, the progress of the disease is exceedingly slow. I have known a man pass urine of the character above mentioned for upwards of twelve years; and I believe that in some cases this goes on for twenty years, or even longer, and the patient at last dies of some other malady. If organic disease of one organ of the body progresses so very gradually that ample time is allowed for alteration in the activity of other functions to take place, the duration of life may not be affected, and if the patient lives under favourable circumstances, he may long outlive persons who were in good health some years after he became the subject of fatal organic disease. It must, however, always be borne in mind, that such persons are more likely to suffer from exhausting influences, cold, fatigue, &c., than others in whom the kidneys are healthy, and therefore they should always place themselves under medical supervision.

2. *Albumen in the Urine due to Pressure on the Veins.*—In cases in which the albumen in the urine depends upon pressure upon the veins, the quantity may vary very much at different times. Wherever any physical impediment to the return of blood in the emulgent veins or inferior cava exists, and in some cases of obstructed portal circulation, as in cirrhosis of the liver, traces of albumen may be detected in the urine. No casts or at most only a few transparent mucus casts, are to be found in the deposit, and for the detection of albumen we must rely on chemical tests. In some instances, the tumour may be distinctly felt, and then the nature of the case is at once demonstrated, but when it is situated in the posterior mediastinum or behind the liver, the diagnosis is often extremely difficult. A number of other circumstances which cannot be referred to here, must of course be carefully considered by the practitioner before a conclusion can be arrived at.

The pressure of the gravid uterus occasions albuminous urine in some cases of pregnancy, but the presence of albumen cannot always be referred to this cause, for it is sometimes found at an early period of pregnancy, when the uterus is too small to exert sufficient pressure. Dr. Tyler Smith considers that in some cases in which there is no organic disease, it is to be accounted for by an influence exerted upon the nerves. Out of 112 specimens of urine from pregnant women, Dr. H. Van Arsdale and Dr. Elliott only found albumen present in two instances ("New York Journal of Medicine," 1856.)

3. *Albumen in the Urine due to temporary turgescence of the Renal Capillaries, resulting from Internal Inflammations, Fevers, &c.*—Albumen may be detected in the urine in many cases of pneumonia, pleurisy, and

pericarditis, especially when the inflammation is extensive. It is almost constantly found in the urine passed by patients suffering from cholera, when the suppression, which usually continues while the stage of collapse lasts, ceases and urine is again secreted. I have often found it in the urine in bad cases of acute rheumatism, and especially when there was pericarditis, with pneumonia and pleurisy. In continued fever, it is not unusually discovered in the urine. In puerperal fever it is often met with, and, as is well known, it is almost constantly present in cases of puerperal convulsions. Indeed, Dr. Lever failed to detect it in but one case out of fifty.

4. *Albumen in the Urine due to changes in the mucous membrane of the Genito-urinary Passages.*—Urine which contains pus invariably exhibits traces of albumen. In inflammation of the mucous membrane of the kidney (pyelitis), of the bladder, or urethra, traces of albumen are commonly found; and when the proportion of pus is considerable, a very distinct precipitate is produced when the ordinary tests for albumen are applied. In urine in which spermatozoa are present, traces of albumen are occasionally found; and where the seminal tubules secrete much mucus, and long transparent casts are formed in them (Part IV), this substance is usually detected. Great irritation and inflammation of the seminal tubes give rise to the escape of serum from the blood, as occurs when other organs are the seat of the same pathological changes.

5. *Albumen in the Urine due to alterations in the character of the Blood.*—In some of the cases mentioned in the preceding sections, the escape of the albumen from the blood is no doubt due as much to alterations in the composition of that fluid as to the causes referred to. Albumen may appear in the urine, and be detected for a considerable period of time (two years or more) without the existence of renal disease. It is well known that the state of blood following exhausting hæmorrhages, which gives rise to œdema and various kinds of dropsy, also occasions, in many cases, the escape of serum from the renal vessels. After continued fevers, as well as intermittents, after extensive inflammations of important organs, after fever, diptheria, and all exhausting diseases, the blood serum may become so much modified that it very readily permeates the vascular walls. Not unfrequently much blood extractive matter escapes in the urine as well as albumen. Little is known concerning the exact changes which take place in the characters of the serum in these cases, but the mere accumulation of water and chloride of sodium in the blood, which invariably occurs when the action of the kidneys is impeded, is in itself sufficient to account for the fact, although no doubt many more important alterations are induced. It has been shown that if albumen be injected into veins, albumen passes off in the urine, but it is doubtful if the albumen here acts differently from many other bodies. Certain serious lesions of the nervous system

sometimes cause temporary albuminuria indirectly, by influencing the circulation through the kidney.

Treatment.—The treatment of cases of acute and chronic renal disease has been already considered, p. 80. It is unnecessary to refer here to the treatment of cases in which the albuminous urine is due to congestion depending upon the pressure of internal tumours, or the gravid uterus, or to those in which it depends upon the existence of pneumonia, cholera, puerperal fever, &c.

The influence of iron upon the general health, and indirectly upon the reabsorption of serum, is very remarkable. In one patient (W. S., vol. III, p. 7), each leg measured *eighteen inches* in circumference and the effusion seemed to be increasing. Soon after he was put upon iron the appetite improved, the blood became more healthy, and the effused serum began to disappear. In a month after the treatment had been commenced, the circumference of the legs had diminished to *thirteen inches,* and in this short time several pints of serum must have been removed from the areolar tissue of the body generally. The quantity of urine increased from about twenty to fifty ounces in the twenty-four hours.

After exhausting hæmorrhages, in low conditions of the system, after low fevers, every effort must be made to improve the general health, and iron is especially valuable in these cases. I need scarcely say there is no indication for the use of remedies specially influencing the kidney. The improvement consequent upon the use of remedies which are known to affect the general state of the blood is often very remarkable, even when there is long standing disease.

There are some other cases of albuminuria which have not been alluded to, as for example, cases of chylous urine, and cases of temporary congestion of the kidney, but these will be discussed in the proper place. *See* Part IV.

BILE.

When much bile is present in urine, it gives to the secretion a very dark yellow colour, which is even more distinct when thin layers are placed upon a perfectly white surface, as on a plate, than where a considerable bulk of urine is examined. This arises from the presence of the colouring matter, which has received the name of *biliverdin.* It may be completely removed from any solution containing bile by causing it to filter through a layer of charcoal. The presence of bile in urine is commonly observed in cases of jaundice. From some cause or other, as from pressure upon, or obstruction of, the common duct, bile, after it has been secreted, is partly or entirely prevented from escaping into the intestine. The gall-bladder and large and small ducts soon become distended by the accumulation of the secreted bile, which, finding no escape, is reabsorbed, chiefly perhaps by the numerous lymphatics which are so freely distributed to the gall-bladder and all the large and small gall-ducts. The constituents in a state more or less altered, pass into the blood, and are partly deposited in the tissues and partly carried off in the urine. That scarcely any bile passes into the intestine in many cases of jaundice, is proved by the pale colour, offensive odour, and clay-like consistence of the fæces.

Several tests have been proposed for the detection of bile in urine. The efficacy of some of these tests depends upon a change being produced in the colouring matter; others produce changes in the resinous acids of the bile.

For Detecting the Colouring Matter of the Bile.—*The Nitric Acid Test.*—This may be applied in two ways: (*a.*) A few drops of the biliary urine are to be poured upon a white plate, and a drop of nitric acid allowed to fall upon it. As the acid gradually mixes with the surrounding fluid, a play of colours, commencing in green, passing through various shades, and terminating in red, will be observed.

(*b.*) A portion of the urine is to be placed in a test-tube, and treated as before. If much bile be present, a bluish-green colour at first appears. This is succeeded by various shades, until the play of colours terminates in red.

Heller's Test consists in adding to the suspected urine a few drops of a solution of albumen, and, after agitation, a little nitric acid. If the colouring matter of bile is present, the flocculi of albumen which are precipitated will possess a dull green or bluish colour.

Not unfrequently, the albuminous flocculi, when thrown down by nitric acid in urine destitute of bile, are more or less coloured in consequence of the action of the nitric acid on the colouring matter of the urine (uroxanthine). The colour is sometimes reddish, sometimes bluish. This change is not unfrequently observed in albuminous urine; and Dr. Basham considers it a condition of very unfavourable significance, and states that he has met with it most frequently in the acute forms of renal disease ("On Dropsy connected with Disease of the Kidneys," p. 48). This reaction must not be mistaken for that dependent upon biliary colouring matter.

Colour of Phosphates.—After exposing urine to the air for a day or two, crystals of triple phosphate are formed, as is well known. If bile pigment be present, these crystals have a yellow tinge. Hassall ("The Urine," p. 27).

Acetate of Lead.—In urine containing bile, the precipitate produced by the addition of acetate of lead has a yellowish colour.

Evidence of Bile obtained by Microscopical Examination of the Deposit.—If the urine contain any epithelial cells from the kidney, as is usually the case, microscopical examination of the deposit will at once show the presence of bile, as the cells have a bright yellow tinge. The existence of this tinge proves conclusively the presence of bile colouring matter; but its absence cannot be regarded as satisfactory proof of the urine being free from bile. In cases of kidney disease, when bile is present in the urine, the casts, as well as the cells they contain, when examined in the microscope, are seen to have a deep yellow tinge. Cells of vaginal and bladder epithelium even, are often intensely coloured in cases of jaundice. In one case of jaundice, associated with wasting of the liver, I found a vast number of dumb-bells of oxalate of lime in the urine. These dumb-bells were coloured of an intense yellow colour, but the octahedral crystals, which were also present in considerable number, were colourless.

The five tests just described enable us to detect only the colouring matter of the bile.

For Detecting the Biliary Acids.—*Pettenkofer's Test.*—If albumen be present, this must first be coagulated, and separated by filtration. About a drachm of the urine is to be treated with about two thirds of its bulk of strong sulphuric acid, which is free from sulphurous acid, the acid being added drop by drop, to prevent the temperature rising much above 100°; a piece of sugar, about the size of a large pin's head, or a drop or two of syrup may now be added to the mixture, and in the course of a minute or two a violet tinge will occur if bile be present. This test is not perfectly satisfactory, since it is very easy to obtain a reddish colour by the action of the acid upon the sugar if albumen and no bile is present; moreover, oil of turpentine, oil of lemons, and of cloves, with other substances, yield similar results. In all these cases, however, the colour is not bright like that produced by the acids of the bile. The action of the sulphuric acid upon the sugar alone produces a brownish red, but this cannot be mistaken, as the colour is very different from that developed by the biliary acids. I recommend everyone to become familiar with these colours, by going through the experiments for himself by daylight with a diluted solution of bile.

Hoppe's Method for Testing for Bile.—The method of applying Pettenkofer's test has been modified by Dr. Felix Hoppe, whose plan answers exceedingly well, and is so delicate that the smallest quantity of biliary acid can be detected with the greatest certainty. The urine suspected to contain bile is to be treated with excess of milk of lime, and boiled for half an hour. The clear fluid obtained by filtration is evaporated nearly to dryness, and then decomposed with excess of strong hydrochloric acid. The mixture is to be kept boiling for half an hour, and the acid is to be renewed from time to time, to prevent the spurting which would occur if the mixture became too concentrated. When completely cold, the mixture is to be diluted with from six to eight times its volume of water. The turbid solution is to be thrown on a filter, and the resinous mass washed until the water runs through quite colourless. The insoluble mass is next to be dissolved in spirit containing 90 per cent. of real alcohol, decolourised with animal charcoal, again filtered, and evaporated to dryness over a water-bath. The yellowish resinous residue is pure *choloidic acid.* By warming it, it emits a peculiar musk-like odour. It is to be dissolved in a little caustic soda and warm water, a little sugar added, and three drops of concentrated sulphuric acid are allowed to fall slowly into the mixture. The resinous acid is at first precipitated; but afterwards, the flakes adhering to the glass are slowly dissolved by the addition of more sulphuric acid, and a perfectly clear fluid, of a beautiful dark violet colour, is produced. (Virchow's "Archiv," vol. XIII; "Archives of Medicine," vol. I, p. 346; Abstract of Kühne's Paper on "Icterus," by Dr. G. Scott.)

On the Clinical Importance of Bile in the Urine.—The consideration of this question necessitates brief reference to the subject of jaundice, upon the causes of which condition there is great difference of opinion. Indeed, observers are not even agreed as to the mere structure of the organ principally concerned. Henle confirms the view of Dr. Handfield Jones, who maintains that the liver-cells are situated outside the ducts, and are concerned rather with the formation of amyloid matter or sugar, than with the production of bile. More recently, numerous anatomists in Germany have tried to prove that minute ducts or biliary capillaries ramify around each individual liver-cell. This view results from examining very incomplete injections of the duct in the livers of rodents, and is contradicted by many general facts which have been indisputably demonstrated both in the vertebrate and invertebrate liver. Frerichs, in his work on Diseases of the Liver, does not even discuss the structure of the healthy organ, but seems to consider that the liver-cells lie between the capillaries in connective tissue, and have no definite relation with the ducts. In his numerous drawings he has ignored the existence of the ducts. He has described and figured in cirrhosis as "bindegewebe" (connective tissue), cell-containing tubes to be seen as distinctly in properly prepared specimens, as any uriniferous tubes, and he has omitted to represent the relation of the liver cells to the ducts in one single instance. Until these simple questions of elementary anatomy be decided, it is impossible that we can argue concerning the nature of the changes occurring in the liver in disease. Professor Frerichs' injections have been made with opaque injection, a mode of preparation which renders the demonstration of the healthy structure of any organ or the changes which have occurred in disease, impossible.

I possess many specimens of the liver injected with transparent fluid ("Archives," vol. I), which prove most conclusively, that the liver-cells lie in tubes continuous with the ducts. This view has been received by many experienced observers. The bile formed by the cells passes directly into the ducts, and is carried away by the larger ducts. In jaundice there are impediments to its escape from the large ducts outside the liver, or from smaller ducts within the organ. In either case the bile accumulates, the ducts become stretched, a certain quantity passes through their coats, and is taken up by the blood vessels, or what is more probable, is absorbed by the numerous lymphatic vessels, ramifying in the portal canals, and in the transverse fissure of the liver.

It is, however, held by Dr. Budd, that jaundice may result—1. From *obstruction to the escape of bile* after it has been formed, and, 2. From what is termed *suppressed secretion*, in which case it is supposed that the substances, which should be separated from the blood and converted into bile, remain in the blood. Frerichs has brought forward arguments opposed to this view, but it has recently received support from the observations of Dr. Harley, who observes that certain constituents (biliverdin, cholesterine) of the bile, are to be detected in the blood, and are only separated and not *formed* by the liver, while there are other constituents (glycocholic and taurocholic acids) which are actually produced in the liver. From this he argues, that where the colouring matter alone is found in the urine, the case is one of jaundice from *suppression*, while, if the biliary acids are present, it is clear these substances which are *formed* by the liver, must have been reabsorbed into the blood, and excreted in the urine. The case is said therefore to arise from *obstruction*.

It must, however, be borne in mind that the proportion of biliverdin and cholesterine in bile is very small, and that although biliverdin can be formed from the colouring matter of the red blood corpuscles, and might tinge the tissues and the urine, no one has shown that it is ever produced in sufficient quantity to give rise to the intense general staining often seen in jaundice. There are facts also which favour the view that colouring matters as well as the resinous acids are actually formed in the liver. In many cases the coloured material may be seen in the liver-cell itself. Moreover, it is difficult to conceive, that a large and important organ like the liver, can cease to perform its functions for three weeks or a month, without giving rise to the most serious constitutional symptoms, and without itself suffering most serious alterations in structure. Nor have those who support the *suppression theory* attempted to explain what becomes of the large quantity of material, which would, under other circumstances, have undergone conversion into biliary acids. On the other hand, in certain cases of cirrhosis, where there is a most positive and gradual wasting of the secreting structure of the liver, there is no jaundice. How is it that the biliverdin, formed in the blood, does not tinge the tissues in these cases?

Nor are we justified in placing the same reliance upon Pettenkofer's test when applied to the urine, as some observers are inclined to do. Ought we to feel satisfied that in those cases in which we fail to obtain indications of the resinous acids, that they are *really* absent. Kühne has detected the presence of bile acids in many specimens of icteric urine, by following Dr. Felix Hoppe's method, p. 234. Although all recent observers, who have studied this subject, agree that the detection of the biliary acids is most difficult and requires the greatest care, Dr. Harley seems to consider it a very simple matter, and places implicit reliance upon Pettenkofer's test, applied in the ordinary way, in distinguishing a case of jaundice from obstruction from one depending upon suppression. For full information upon this subject the reader is referred to an abstract of Kühne's observations by Dr. Scott, "Archives," vol. I, p. 342.

It seems to me that the view that in certain cases of jaundice there is suppression of the action of the liver,—that the liver does not produce bile, and that no biliary acids are formed, is opposed to very many facts, and I have been led to the conclusion that in all cases of jaundice the bile has been formed by the liver cells, and has been reabsorbed after its formation, and perhaps much of it again excreted in an altered form by the intestines, by the kidneys, and other organs. It is easy to conceive that the relative proportion of the biliary acids and colouring matters produced, may be very different in different cases—that the quantity of the acids formed, may vary greatly—that their composition may be affected, taurocholic acid being produced instead of glycocholic acid (Kühne) —that the quantity of blood corpuscles disintegrated by the presence of bile compounds in the blood varies—and that other chemical derangements may be caused although the action of the liver *cells* is not suspended even for a very short time.

On the Treatment of Cases of Jaundice.—The cases of jaundice, which occur so commonly during the summer months, are not connected with organic disease, and require but very simple treatment. The jaundice usually lasts for a period varying from a fortnight to five or six weeks, and then gradually disappears. The pathology of these common cases is not at all understood, but it is probable that some of them depend upon the duct being obstructed partly or completely by mucus, or by very viscid bile, while in others the temporary occlusion results from contraction of the muscular fibres round the common duct where it enters the intestine. In many cases there is scarcely any constitutional disturbance, although the urine is very highly coloured and sometimes contains biliary acids, and the fæces are perfectly colourless. Gentle laxatives and small doses of hydrochloric acid or ammoniacal salts seem to do good, but the remedial measure in which I have the greatest confidence consists in mild counter-irritation over the liver. Even the application of cold wet cloths for half an hour now and then will relieve the pain, sense of fulness, or uneasiness, about the hepatic region; but rags steeped in equal parts of strong hydrochloric acid and water applied for half an hour daily form the best application. This practice, which I learned from Dr. Blakiston, is of great service, not only in actual jaundice, but in cases of temporary biliary derangement generally. The acid may, perhaps, act through the cutaneous nerves, by exciting the biliary ducts and gall bladder to contract. It also causes action of the colon. Small doses of mercury once a-week seem to give relief in some of these cases. Muriate of ammonia (20 grains three times a-day) and benzoic acid (3 to 6 grains three times a-day) are favourite remedies on the continent. In health, benzoic acid is excreted in the urine in the form of hippuric acid; but in jaundice Kühne has shown that benzoic acid and benzoates pass unchanged into the urine. I have given podophyllin (½ grain every other day) in several cases, but can offer no opinion as to the advantages of the remedy. In some cases inspissated bile appears to do good. Dr. Harley has it prepared by Savory and Moore, enclosed in gelatine capsules—a very useful suggestion, as the bile is not set free until it reaches the duodenum. The inspissated juice of taraxacum, and dandelion coffee, prepared by Hooper, Pall Mall, seem to benefit some cases, and have been very often prescribed for jaundice and hepatic derangement.

In cases of jaundice depending upon permanent closure of the duct, as from pressure of a tumour, impaction of a gall stone, &c., the jaundice continues, and bile passes off in the urine as long as the liver retains the power of secreting it. It would be out of place to pursue the consideration of this subject in the present volume. *See* the Author's work on "Diseases of the Liver," to be published shortly.

SUGAR IN THE URINE—DIABETES.

Sugar in Healthy Urine.—Traces of sugar are stated to be present in healthy urine, by Brücke, whose observations have been confirmed by Dr. Bence Jones. The proportion is, however, not sufficient to be recognised by the ordinary tests, unless some of the other urinary constituents are first separated. It is possible that the colouring matter in healthy urine may be the source whence the small quantity of sugar present is derived. Schunck has shown that the substance from which indigo is obtained exists in the plant as indican. This indican, when heated with strong acids, splits up into indigo blue, indigo red, and a kind of sugar ($C_{12}H_{10}O_{12}$). My friend Professor Bloxam has shown that specimens of urine which give no indications of the presence of sugar (copper test), when heated with sulphuric or hydrochloric acid, deposited a brown precipitate of the same composition as anthranilic acid ($C_{14}H_7NO_4$), a product of the decomposition of indigo blue. These deposits being separated by filtration, it was found that the clear fluid gave *decided indications of sugar*. (Bowman's "Medical Chemistry," fourth edition, p. 15.) The formation of glucose from the extractive matters has been effected by Dr. Schunck, as already stated on p. 151.

Occasionally decided traces of sugar may be detected in the urine of persons who are not suffering from any particular symptoms. It may be excreted for days, or even for a few weeks at a time, in small proportion. Such cases do not, as a general rule, pass into confirmed diabetes, but they should be carefully watched by the practitioner. It occasionally happens that after abstinence from food for some hours, a meal, consisting entirely of starchy matter, will cause sugar to appear in the urine, and if a healthy person, under these circumstances, takes a quantity of cane sugar, a temporary diabetic condition will almost certainly be induced.

Diabetes, also called *mellituria* and *glucosuria*, may last for many years, and the subject of it may even enjoy fair health, but it is sometimes fatal in a few months. It should, however, be known that sugar has been detected in the urine of patients almost daily for several weeks, and yet the diabetic condition has entirely passed off. Although much light has been thrown upon the production of sugar in the animal body of late, no satisfactory explanation of the disease has yet been offered, nor do we know anything of the condition of the system which precedes and ushers in this remarkable malady.

Two kinds of diabetes have been described—*diabetes mellitus* and *diabetes insipidus*. I have already had occasion to allude to the latter, p. 180, and have mentioned that in this condition large quantities of pale urine, containing little solid matter, and, it need scarcely be repeated, no sugar, are passed; it is therefore quite unnecessary to regard this condition as a distinct disease. It has nothing to do with true diabetes. But it should be known that sometimes urine containing decided traces of sugar is of very low sp. gr. I have known it in several instances below 1,005.

It is important to distinguish at least two forms of true diabetes which differ from one another in many important particulars, one being a distressing malady which is generally fatal in the course of a few months or years, while the other seems scarcely to affect the patient's health or longevity.

General Characters of Diabetic Urine: Colour: Smell.—Diabetic urine usually possesses a peculiar smell, which has been compared with that of violets, apples, new hay, whey, horses' urine, musk, and sour milk. Such comparisons serve only to show how difficult it is to give by description a correct idea of a particular odour. The *colour* of diabetic urine is generally pale. Sometimes, but not usually until after two or three days, the surface becomes covered with a whitish film, owing to the development of the *Sugar fungus* and *Penicillium glaucum*, and gradually the urine becomes opalescent in consequence of these fungi multiplying in great numbers in every part of the fluid, pl. XI, figs. 1, 2, 3. Diabetic urine has a sweet taste, and often numbers of flies are attracted to it, which fact sometimes leads the patient to suspect that his urine is not healthy. Diabetic sugar occasionally disappears, and *Inosite*, a substance nearly allied to sugar, but obtained normally from muscles, takes its place.

Specific Gravity — Reaction — Deposits.—The specific gravity of diabetic urine is usually very high, almost always above 1,030, and it sometimes reaches 1,050. In some cases, however, the specific gravity does not differ from the healthy standard, and may be as low as 1,005. This fact shows that we must not conclude that sugar is necessarily absent in urine of low specific gravity, especially if the urine examined was passed shortly after the patient had drunk a large quantity of water. Its reaction is generally acid, sometimes excessively so.

Deposits are not often met with in diabetic urine; those which have come most frequently under my own notice are deposits of the *phosphates*, and deposits of *uric acid.* The fixed salts are generally present in small quantity, and chloride of sodium is often altogether absent. The extractive matters are, as a general rule, relatively much diminished in quantity; but in some cases they exist in considerable proportion.

The Quantity of urine secreted by patients suffering from diabetes is sometimes enormous, and in many cases this is the first point to attract the patient's attention. Some have passed as much as twenty pints of urine *per diem*, and P. Frank mentions a case in which the enormous quantity of fifty-two pounds was discharged in twenty-four hours. The proportion of solid matter passed in twenty-four hours varies greatly in different cases; it not unfrequently exceeds two pounds, the greater part of which is composed of sugar.

Of the Urea and other Constituents.—The quantity of urea varies greatly in different cases of diabetes. In advanced cases it is diminished, but a considerable excess is often excreted. In one case, reported by Prof. Sydney Ringer, that of a woman weighing 104 lbs., 764 grains of urea were excreted in 24 hours, which corresponds to 7 grains per pound of the body weight, the quantity in health being only 3·5 for each pound weight of the body. In one of Dr. Garrod's cases as much as 1,085 grains of urea and 3,500 grains of sugar were eliminated in 24 hours. The excretion of this very large quantity of urea is difficult to explain in all cases. In some it no doubt depends upon the large proportion of meat taken, but in many it cannot be thus accounted for and must result from changes in the albuminous compounds of the blood and tissues.

The observation of Lehmann, that diabetic urine invariably contains *hippuric acid* and *never uric acid* is undoubtedly erroneous. In this country, at least, it is not uncommon to meet with an abundant deposit of uric acid. Dr. Prout regarded the presence of uric acid as a favourable sign. The cases in which I have observed it have not been very severe cases, but in several I have seen an abundant deposit. *Hippuric acid* is said to be present in diabetic urine (Lehmann and others), and I have found it in one instance; but in some specimens of urine, in which Dr. Garrod sought for it, he failed to detect it. (Gulstonian lectures, "Brit. Med. Jour.," 1857.)

Sulphocyanogen has been detected in diabetic urine by Schultze. Perchloride of iron strikes a red colour if sulphocyanides be present. Heller states that the *uroxanthin* is increased, and Schunck obtained much indigo from diabetic urine. A reddish tint is often produced by the addition of nitric acid to diabetic urine, but, as is well known, this is often observed in various specimens of urine which do not contain sugar.

Albumen is sometimes present in diabetic urine. Garrod detected it in ten per cent. of the cases. Dupuytren and Thénard considered it a favourable symptom. Rayer, on the other hand, correctly regarded it as an evidence of renal disease. A patient some time since came to consult me for indigestion, flatulence, and slight pain after eating. The only symptoms were those common in dyspepsia, and the secretion of rather a large quantity of urine (3 pints). Diabetes was not suspected, but not feeling satisfied as to the nature of the case, I examined the urine, and found an abundant precipitate of albumen, with a large quantity of sugar. I expressed a very unfavourable opinion as to the result of the case although emaciation had scarcely commenced. The patient died about six months after I had seen him. Albumen was detected during six months, and may have been present at an earlier period. The first specimen of urine was of specific gravity 1,028, and contained albumen and sugar. The former was not estimated. A second specimen examined a month afterwards, the diet having been properly restricted, had a specific gravity of 1,023, and was highly coloured. The most important constituents are given in Analysis 69.

ANALYSES	68	69
Water	922·00	936·80
Solid matter	78·00	63·20
Urea...	12·00	8·16
Sugar	38·00	46·15
Fixed salts	10·60	1·40
Albumen	—	2·21

In a case of death from cancer of the liver, Sir D. Gibb found albumen in the urine in the pelvis of one kidney, and sugar in that present in the other. The urine containing albumen had a specific gravity of 1,015, and that containing sugar a specific gravity of 1,026.

Albumen should always be sought for in diabetic urine; and it should be borne in mind that its presence interferes with the reaction of the copper test. Before the application of the latter, the albumen must be separated.

If a mixture containing sugar be boiled with about an equal weight of sulphate of soda in crystals, the whole of the albuminous matters are separated, while the sulphate does not in any way interfere with the application of the sugar tests. By this process, the presence of sugar may be detected in blood, or in the solid organs of the body. Bernard recommends animal charcoal for separating albumen, uric acid, casein, and fatty matters, from solutions which are suspected to contain sugar. The latter substance filters through the animal charcoal unchanged. Boiling, after the addition of a few drops of acetic acid and filtration, is another process by which albumen may be separated from saccharine urine. Before applying the copper solution, the free acid must however be neutralised by the addition of a few drops of solution of potash.

Diabetic Sugar is easily obtained from the urine in cases in which but little urea, extractive matters, and salts, is present. That particular form of grape sugar or glucose which is obtained from diabetic urine differs both from the sugars of fruits, and also, in some particulars, from the sugar obtained from the liver. It generally appears as a treacle-like mass, but of a pale brown colour, which does not crystallise, especially if heat be employed in evaporating the solution. If, however, some of the urine of specific gravity 1,050, from a bad case, be allowed to evaporate at a temperature of 100°, small warty masses, of a rounded form, soon make their appearance. Under the microscope, these are seen to have projecting from the surface very beautiful crystalline plates. When a considerable quantity of the sugar has crystallised, it may be washed with ice-cold water, well pressed between folds of bibulous paper, and dried over sulphuric acid. It is now in many cases, nearly colourless, and, after two or three crystallisations, from distilled water, it becomes nearly pure. Diabetic sugar forms with chloride of sodium a compound which readily crystallises, and it has been concluded by many that the sugar never crystallises except in the presence of chloride. In pl. XII, p. 280, fig. 2, some beautiful crystals of grape sugar are represented. These were obtained by allowing a few drops of diabetic urine, containing a mere trace of urea and salts, to evaporate *spontaneously* on a glass slide. Similar crystals were obtained from the tears of the patient (case reported by Dr. Gibb, in "Archives of Medicine," vol. I, p. 250). I have obtained crystals from several specimens of diabetic urine. These crystals are very beautiful objects when examined by polarised light. When burned they leave scarcely a trace of residue. It is curious that crystals of diabetic sugar have not been figured before. Some have regarded the crystals which appear as a compound of diabetic sugar and chloride of sodium, but those figured were free from salt.

Of the Torulæ developed in Diabetic Urine.—There are two kinds of fungi which are developed in diabetic urine—the yeast fungus, and the penicillium glaucum. *See* pl. XI, figs. 1, 2, 3. The former is characteristic of saccharine urine, and Dr. Hassall considers the development of this fungus a most valuable test. It is necessary, however, to set the urine aside for a few days, before the fungus will form, so that it is inapplicable as a test, if we desire to determine within twenty-four hours if the suspected urine contains sugar. In many cases, no fungus whatever is to be found, even in two days. Moreover, the young sporules of the sugar fungus cannot be distinguished from those of penicillium glaucum; the aërial fructification of the two species is however very different. The microscopic characters of these fungi will be described in Part IV.

Tests for Diabetic Sugar.

The presence of grape sugar in urine is readily ascertained by the application of certain tests, and if moderate care be taken in the examination, the detection of this substance is not open to many fallacies, unless mere traces are present, in which case the points referred to in pp. 246, 249, must be carefully borne in mind.

Moore's Test for grape sugar consists in adding, to the urine suspected to contain it, about half its bulk of liquor potassæ. If sugar be present, the mixture becomes of a rich brown colour upon boiling, which increases in intensity if the boiling be prolonged. The brown colour of the solution is owing to the formation of mellassic or sacchulmic acid; glucic acid is also produced in the decomposition. If cane sugar be boiled with an alkali, no such decomposition occurs. If excess of nitric acid be added, a strong treacle-like odour results, and the solution becomes pale. This test, however, cannot be depended upon for detecting the presence of small quantities of sugar; and there are some other substances besides sugar which will cause the development of the colour in a slight degree.

Trommer's Test.—Of all the tests which have yet been proposed, that originally suggested by Trommer, or some slight modification of it, will be found of the greatest practical value for showing the presence of sugar in diabetic urine, in clinical investigations. Trommer's test is applied as follows:—A small quantity of the urine is poured into a test-tube, a drop or two of a solution of sulphate of copper is to be added, and about half as much liquor potassæ as there is of urine. If sugar be present in any quantity, the precipitate at first formed will be redissolved, and the solution will be of a *dark blue* colour. If only traces of sugar are suspected to be present, one drop of the sulphate of copper solution will be sufficient. The dark blue fluid is now to be heated to the boiling point, and, if sugar be present, a pale *reddish brown precipitate of suboxide of copper* is immediately thrown down. Instead of boiling the mixture, it may be allowed to stand for some time, when a similar deposit will gradually subside. If the suboxide is only reduced after prolonged boiling, *this cannot be taken as good evidence of the presence of sugar*, for under these circumstances there are some other substances which will cause the reduction of the oxide of copper. Again, if the solution simply *change colour* by boiling, *without the occurrence of a distinct precipitate or the production of an opalescence*, we must not infer that the change is necessarily due to the presence of sugar, for almost all specimens of urine exhibit it. A flocculent precipitate of earthy phosphate, which always takes place, cannot be mistaken for the suboxide of copper, as it is quite colourless, or of a pale greenish tinge. The reaction alone characteristic, is the production of a brown or yellowish precipitate (varying in quantity according to the amount of sugar the urine contains), either after the mixture has stood for some time, or upon boiling it not longer than for a minute.

If albumen be present, the reduction of the oxide of copper does not take place, so that in using the copper test we must ascertain that this substance is absent. Albumen may be removed by precipitation by heat and acid and subsequent filtration, the free acid being neutralised with potash or soda, but *not by ammonia*, before the application of the test; or the albumen may be separated by sulphate of soda, p. 226. Ammonia also dissolves suboxide of copper. Urate of ammonia sometimes prevents the precipitation of the suboxide. *See* p. 246. It has been shown that leucine, allantoin, creatine and creatinine, cellulose, tannin, and chloroform, have the power of producing a precipitate of suboxide of copper, like grape sugar; and more recently M. Berlin has proved that uric acid possesses to some extent the same property.

Modifications of Trommer's Test have been proposed by Barreswil and others, the most applicable, however, according to Lehmann, being that of Fehling. (Lehmann's "Physiological Chemistry," by Day, vol. I, p. 288. Cavendish Society.) The action of these test solutions is the same, and depends upon the following circumstances:—The protoxide of copper is not dissolved by an alkali alone; but, if certain organic matters be present, complete solution occurs. Tartaric acid and bitartrate of potash do not cause the reduction of the suboxide at the temperature of ebullition, and these are the salts usually employed. If grape sugar be present, however, the protoxide is reduced to the state of suboxide of copper when the mixture is boiled. The composition of

Barreswil's solution, which was used by Bernard in his experiments, is given below. These tests are more easily applied than the sulphate of copper and potash. I shall, therefore, give the composition of three of the best solutions. Fehling's solution is made as follows :—69 grains of sulphate of copper are to be dissolved in 345 grains of distilled water; to this solution a concentrated solution of 268 grains of tartrate of potash, and then a solution composed of 80 grains of carbonate of soda in an ounce of distilled water are to be added; the mixture may be poured into a 1,000-grain measure, and filled up with water.

Barreswil's solution is composed of the following constituents :—

Cream of tartar	96 grains.
Crystallised carbonate of soda	96 ,,
Sulphate of copper	32 ,,
Caustic potash	64 ,,
Water	2 fluid ounces.

Dr. Pavy recommends the following modification of Fehling's solution. Half a grain of sugar exactly reduces the oxide contained in 100 minims of the solution.

Sulphate of copper	320 grains.
Tartrate of potash (neutral)	640 ,,
Caustic potash (*potassa fusa*)	1,280 ,,
Distilled water	20 fluid ounces.

The tartrate of potash and caustic potash are to be dissolved together in one portion of the water, and the sulphate of copper alone in the other. The two solutions are then mixed. (*See* Dr. Pavy's work "On Diabetes.")

In using these tests, it is only necessary to add about an equal bulk, or less when only slight traces are present, to the urine in a test tube, and then to boil the mixture. If sugar be present, the precipitate of suboxide occurs immediately. The application of this solution to the quantitative determination of sugar has been considered under *volumetric analysis*, p. 99.

Trommer's, or one of the above-mentioned modifications, will be found the most delicate test which can be used when only small quantities of sugar are present, and the tartrate of copper solutions are applied as easily as the liquor potassæ test, while the results obtained are far more to be depended upon. The tartrate solutions become decomposed by the action of the light, and some suboxide is deposited. In this case, the strength is of course impaired. They will also, after having been kept for some time, deposit suboxide when boiled alone, in which case a little fresh potash should be added before testing urine.

Circumstances interfering with the action of Trommer's Test.—Some years since, I endeavoured to ascertain the cause of certain anomalous results which were occasionally met with in employing the test; and as these to some extent explain the discrepancies of different authorities with reference to the presence or absence of sugar in the urine in certain cases, it is well to allude to them here. The following results were obtained :—

1. The precipitate of suboxide of copper was readily dissolved by acetic, hydrochloric, and nitric acids. It was also dissolved by ammonia.

2. The precipitate was insoluble in a solution of chloride of sodium, but was readily dissolved by a weak solution of chloride of ammonium.

3. The addition of a few drops of chloride of ammonium previous to boiling entirely prevented the precipitation of the suboxide, the mixture retaining its greenish colour. Upon adding some solution of potash, however, the precipitate of suboxide was produced, and ammoniacal fumes were given off at the same time. If a moderate quantity of solution of chloride of ammonium was present, the precipitate did not occur upon the addition of potash, even after very prolonged boiling.

4. If a drop of a very dilute solution of the chloride of ammonium was added to a pretty strong solution of sugar, and, after the addition of the tartrate, the mixture was boiled, no precipitate took place, but the solution became of a pale brown tint; the suboxide being immediately thrown down upon the addition of a few drops of a solution of potash, with the development of ammoniacal fumes. In the above cases in which no precipitate occurred, it was ascertained that there was the usual excess of alkali present in the test solution.

5. A solution of oxalate of ammonia also prevented the precipitation of the suboxide, but a greater quantity of this salt than of the chloride of ammonium was required.

6. A neutral solution of urate of ammonia (artificially prepared) also prevented the reduction of the suboxide, and dissolved the precipitate if added to it. On carrying out this experiment further, it was found that the *precipitate of suboxide of copper was dissolved by urine containing an excess of urate of ammonia.*

7. A solution of grape sugar in water was prepared, and by a preliminary experiment it was ascertained that, upon being boiled with the tartrate test, an abundant precipitation of suboxide took place.

To a portion of the precipitate of suboxide produced in this way, about a drachm of healthy urine, immediately after it was passed, and while yet warm, was added, and the reddish precipitate was instantly dissolved, forming a perfectly clear solution. Upon further boiling, a slight precipitate of phosphate took place. The suboxide, however, could not be precipitated by the further addition of potash and prolonged boiling.

8. Upon mixing a small quantity of grape sugar with the same specimen of healthy urine, and boiling the mixture with the tartrate test, *no precipitate*, except a little phosphate was produced. About half an ounce of the same mixture of urine and grape sugar was placed in a test tube, mixed with six drops of yeast, and inverted over mercury. The whole was then placed in a temperature of from 70° to 100° for about twelve hours, at the end of which time the tube was found quite filled with gas, and all the liquid was expelled into the vessel in which it had been placed. The specimen of urine with which the above experiments were tried, was allowed to stand in a still place; and when it had become quite cold, an abundant precipitate of urates of soda and ammonia was found to be present.

9. A portion of the aqueous solution of grape sugar was mixed with a strong solution of urate of ammonia (artificially prepared), and then a certain quantity of the tartrate solution was added, and the mixture boiled. The characteristic precipitate, or opalescence, was not produced, but the mixture became of a pale fawn colour. In a weak solution of urate of ammonia, the characteristic precipitate appeared after boiling the mixture for some minutes.

So that, although much sugar is present, the colour of the mixture may be merely changed to brown, and no precipitate whatever may take place.

10. A solution of grape-sugar was treated with a drop of dilute solution of chloride of ammonium, and boiled with the tartrate solution. The mixture became of a brown colour, but no precipitate occurred. Upon the addition of a few drops of solution of potash, the precipitate of suboxide was produced.

A solution of grape sugar treated with Trommer's test, according to the usual method, behaved in the same way, in the presence of chloride of ammonium, as when treated with the tartrate of copper solution; but in this case a greater quantity of the chloride was necessary, for when only traces were present, ammoniacal vapours were given off, and the precipitate of suboxide subsided, as before remarked.

From the results of the above experiments, the following conclusions with reference to the practical application of Trommer's test, and Fehling and Barreswil's solutions, and other modifications of the copper test, may be drawn;*—

1. That if the urine contain chloride of ammonium (even in very small quantity), urate of ammonia, or other ammoniacal salts, the sub-

* Professor Brücke has more recently directed attention to the action of ammonia in preventing the precipitation of the suboxide of copper, and other points connected with this subject. Probably he had not seen the results of my experiments which were made in 1852, and published in the "Med.-Chir. Review," Jan. 1853, vol. XI, p. 113.

oxide of copper would not be precipitated if only a small quantity o sugar were present.

2. That unless there be a considerable quantity of one of the above salts present (in which case the blue colour will remain), the mixture will change to a brownish hue upon boiling, but no opalescence or *precipitate* of suboxide of copper will occur. When only a moderate amount of sugar is present, I have been unable to obtain a precipitate, under these circumstances, by the addition of potash to the solution, and prolonged boiling. By observation 8, it appears that a specimen of urine exhibiting this reaction may contain a large quantity of sugar, as ascertained by the yeast test.

3. That in many cases in which the precipitation of the suboxide is prevented by the presence of ammoniacal salts, the addition of potash to the solution, and subsequent boiling, will cause the production of a precipitate with the evolution of ammoniacal fumes. Hence, care should always be taken that there is a considerable excess of free alkali present.

4. When only small quantities of sugar are present in the urine, and the precipitate of suboxide of copper is not decided, the fermentation test should be resorted to.

Upon treating different specimens of diabetic urine with Trommer's test, or its modifications, it has often been noticed that in one case the precipitate is produced as soon as the mixture reaches the boiling point, or even before; while, in other instances, it is necessary to keep it in active ebullition for some minutes, before any precipitate is produced. This circumstance receives explanation from the facts above detailed with reference to the presence of ammoniacal salts; and other anomalous results, which must have occurred to many in the habit of employing this test, become explained.

Specimens of urine in which sugar is suspected to be present, and no decided precipitate of suboxide (which must be carefully distinguished from phosphate *) occurs, should be carefully fermented with yeast, p. 249, before any conclusion is arrived at.

On Testing for Sugar when only Traces are Present.—In fluids which are suspected to contain only mere traces of sugar, it is necessary to separate some of the other constituents before applying the test. The plan recommended by M. Leconte is the following:—Excess of acetate of lead is added, and the precipitate separated by filtration. The solution is concentrated by evaporation, treated with ammonia, and again filtered. The copper test is then applied. The objections to applying the reduction test to solutions containing ammonia has been already discussed. It is better to employ carbonate of potash, or soda, instead of

* The precipitate of suboxide may be distinguished from phosphate by its solubility in ammonia.

ammonia. The excess of lead salt may also be removed from the filtered solution by passing sulphuretted hydrogen through it. The precipitate of sulphuret of lead is removed by filtration, and the liquid, after evaporation to a small bulk, may be tested.

Another plan recommended by M. Leconte, is to treat the urine with acetic acid, and evaporate it to about the fifth of its bulk; it is then treated with alcohol, and after filtration from the salts, &c., the alcoholic solution is evaporated and tested. This plan is free from the objection that ammonia may cause the destruction of the sugar where only traces are present.

Brücke's Test for Traces of Sugar.—Neutral acetate of lead is first added to the urine, and afterwards basic acetate of lead. The precipitate is to be separated by filtration, and ammonia added to the solution.

The precipitate, by ammonia, is decomposed by oxalic acid, or suspended in water, and sulphuretted hydrogen passed through it. The filtered solution contains the sugar, which may be detected by any of the tests already mentioned. By this process, the seventh of a grain of sugar may be detected, when diluted with upwards of six ounces of water, and two thirds of the total quantity of sugar present in a solution can be separated by this process.

The Yeast Test.—This is one of the most satisfactory tests for the presence of sugar, and if tried with proper care can hardly fail in its results. Two test tubes, of the same form, and of equal size, are to be taken. One is nearly filled with water, and into the other a corresponding quantity of the urine is to be poured. An equal amount of yeast is now to be added to the liquids in the tubes, and after pouring in just sufficient fluid to fill the tubes, the thumb is to be carefully placed over the opening, and the tube inverted in a small cup of mercury.

The plan which I have found most convenient is the following:—A little India-rubber pad, slightly larger than the upper extremity of the tube, is to be cut out of a sheet of India-rubber. When the tubes have been filled up to the brim with a little water, the pad is allowed to float on the surface; next a little cup or beaker is inverted, and carefully placed over the end of the tube. The India-rubber being pressed against the open end, the fluid is prevented from escaping. The whole may be inverted, and a little mercury having been poured into the beaker, the India-rubber may be removed with forceps, without any escape of the fluid. The tubes may be supported in position by a wire stand. Both tubes are then to be exposed, for a few hours, to a temperature of from 80° to 90°, and the comparative size of the bubble of gas in the upper part of each may then be noted. If an appreciable quantity of sugar be present, the bubble of gas in the tube containing the urine will be many times larger than that in the tube which contains the yeast and water. In the latter tube the bubble of gas merely arises from the small quantities of air previously mixed with the yeast, becoming disengaged, and floating to the surface. Fermentation, when carefully performed, is positive evidence of the presence of sugar, although it does not indicate the kind of sugar present.

The *carbonic acid* can be detected in the fermented liquid by potash. A fragment of potash is placed in the tube, and the end immediately closed with the thumb. If carbonic acid be present, it is soon absorbed by the potash, and upon the closed end being placed under the surface of water, and the thumb removed, a quantity of water will rise in the tube equal to the volume of the carbonic acid absorbed.

The *alcohol* may be separated from the fermented liquid by distillation. After a few drops have passed over, they may be tested for alcohol, with the bichromate of potash test, as follows:—The solution suspected to contain the alcohol is poured into a test tube, and mixed with a little dilute sulphuric acid. A drop of solution of bichromate of potash is added, and the mixture heated. If alcohol be present, the brownish colour changes to a bright emerald green.

Maumené's Test.—A little woollen rag, as merino, is cut into strips, and soaked for four or five minutes in a solution of perchloride of tin (one part of the perchloride to two parts of water). The slips are then dried over the water bath. A drop of the urine suspected to contain sugar is allowed to fall on a small slip of the prepared merino, which is then dried, and exposed to the dull red heat of a spirit-lamp. If a trace of sugar be present, a black spot is produced.

Bismuth Test.—Böttger has lately proposed a new test for sugar. This consists in adding first of all potash, then a small quantity of subnitrate of bismuth; lastly, the mixture is boiled. If sugar is present, the oxide is reduced to metallic bismuth, which is precipitated in the form of a black powder. It has been asserted that sulphuret of bismuth is formed, but this seems not to be the case. Brücke shows that this test is more delicate than Trommer's (or the modification of it by Fehling); and he finds that the black precipitate is produced to some extent in specimens of healthy urine. The bismuth test may be also applied thus: A solution of carbonate of soda (crystallised carbonate 1 part, water 3 parts) is prepared, and a certain quantity added to an equal amount of the urine. A little basic nitrate of bismuth is then added, and the mixture heated to the boiling point. If sugar be present, a black precipitate is produced.

MM. Francqui and Van de Vyvere ("Gazette Médicale," March, 1867) propose a modification of the same process. The reagent is to be prepared by precipitating a solution of acid nitrate of bismuth by a great excess of caustic potash; the latter is to be poured, drop by drop, into the moderately heated solution until the precipitated hydrate of bismuth is completely redissolved. To recognise sugar in urine, a portion is to be heated with the above solution. After a few minutes' ebullition, the mixture becomes brown, and metallic bismuth is then precipitated in the form of a black powder of crystalline appearance, adherent to the glass if sugar be present. Urea and uric acid do not precipitate the above reagent. Albumen only causes a brown colour and a slight turbidity, which is due to the formation of sulphide of bismuth. Sulphuretted urines also give a black precipitate in a solution of oxide of bismuth in potash and tartaric acid; but this reaction cannot be confounded with that caused by glucose.

Chromate of Potash Test.—If equal parts of neutral chromate of potash and solution of potash be boiled with diabetic urine, a green colour, owing to the presence of oxide of chromium, is produced (Horsley). Luton's test is a modification of this. A solution of bichromate of potash is decomposed by excess of sulphuric acid, and, upon the urine being boiled with the mixture, a beautiful green colour results. This reaction is not affected by urea, albumen, or the urates.

On Estimating the Quantity of Sugar.

The quantity of sugar is easily determined, though not with absolute accuracy, by fermentation. The quantity of carbonic acid formed may be measured, weighed directly, or its weight may be determined by ascertaining the loss of weight the urine has sustained from fermentation. The volumetric process is described in p. 99.

On Estimating the Quantity of Sugar by the Process of Fermentation.—If the carbonic acid is to be measured, the mixture of yeast and urine must be placed in a graduated tube inverted over mercury. When the fermentation is complete, which is generally the case in from six to twelve hours, at a temperature of 100°, the volume of gas may be read off, and, after correction for temperature and pressure (Miller's "Elements of Chemistry," vol. I), the amount of sugar calculated. One grain of sugar corresponds to nearly one cubic inch of carbonic acid.

The carbonic acid may be weighed by causing it to pass through a solution of liquor potassæ, specific gravity 1,250, in an ordinary Liebig's potash tube. One grain of carbonic acid corresponds to about two grains of grape sugar. The urine (about 500 grains) with the yeast may be placed in a small retort, to the end of which is adapted a chloride of calcium tube, or a tube containing pumice-stone moistened with sulphuric acid, for the purpose of drying the gas. To the extremity of the drying tube the potash apparatus is connected. This is weighed just before and immediately after the fermentation, which should be allowed to proceed at a temperature of from 80° to 100° for twelve hours.

The increase of weight is due to dry carbonic acid. Or, lastly, about 200 grains of urine with a little yeast are placed in a flask, to the mouth of which a small drying tube is adapted, as shown in pl. XI, fig. 6. The disengaged carbonic acid passes through the little tube containing chloride of calcium or fragments of pumice-stone moistened with strong sulphuric acid, and escapes; while the watery vapour, which would otherwise pass away with it, is retained. The apparatus is to be carefully weighed before and after the experiment, and the loss indicates carbonic acid. The results afforded by fermentation are not so accurate as those obtained by the volumetric process of analysis, p. 99.

Determination of Sugar by the Polarising Saccharimeter.—Biot, many years ago, proposed a plan for estimating the proportion of sugar in fluids, depending upon the influence which the solution of sugar exerted upon a ray of polarised light made to pass through a thick stratum. Under these circumstances, a succession of colours is produced in the following order: *yellow*, *green*, *blue*, *violet*, *red*. If, in order to produce this series of changes, the hand must be turned towards the right, the solution is said to divert the plane of polarisation to the right, or to exhibit *right-handed polarisation;* but if to the left, *left-handed polarisation.* Cane sugar and diabetic sugar have the first property; the sugar of fruits the second. The amount of rotation varies according to the quantity of sugar present. Two or three different forms of apparatus have been made. Mitscherlich's and Soleil's are well known. A modification of Mitscherlich's, made for me by Mr. Becker, of the firm of Elliott, Brothers, Strand, is represented in pl. XI, fig. 5. The urine or saccharine fluid is placed in the long tube. At the end near the lamp is a prism of Iceland spar, the *polariser:* and at the other extremity another prism, the *analyser.* The latter crystal is connected with a moveable bar, which can be rotated with the hand, and the arc through which it is carried can be accurately measured on the graduated circle with the aid of a vernier. The instrument is placed with the posterior aperture about two inches from a homogeneous light,* and the prisms adapted to zero, which is found by arranging the posterior prism so that the tube being empty when the arm stands at zero, the little spectrum is quite dark. It is then ready for use. The tube is filled with the solution carefully filtered; and, if dark coloured, it is to be decolourised in the first instance by animal charcoal. Upon moving the arm towards the right, it will be found that after it has passed through a certain number of degrees, the colour of the spectrum becomes blue, and gradually violet

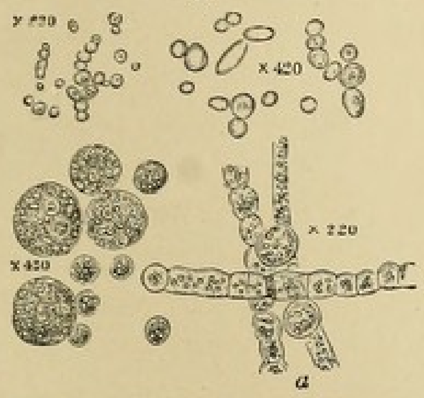
* The best light is a very good Argand or Leslie's burner, with a piece of white porcelain, like a reflector, but having a dull surface, behind; or a piece of thin ground-glass, or semi-opaque white glass, may be placed in front of the lamp.

ILLUSTRATIONS OF URINE.

Fig. 1.

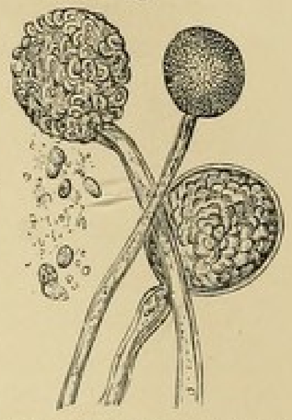
Fructification of penicillium glaucum. p. 243.

Fig. 2.



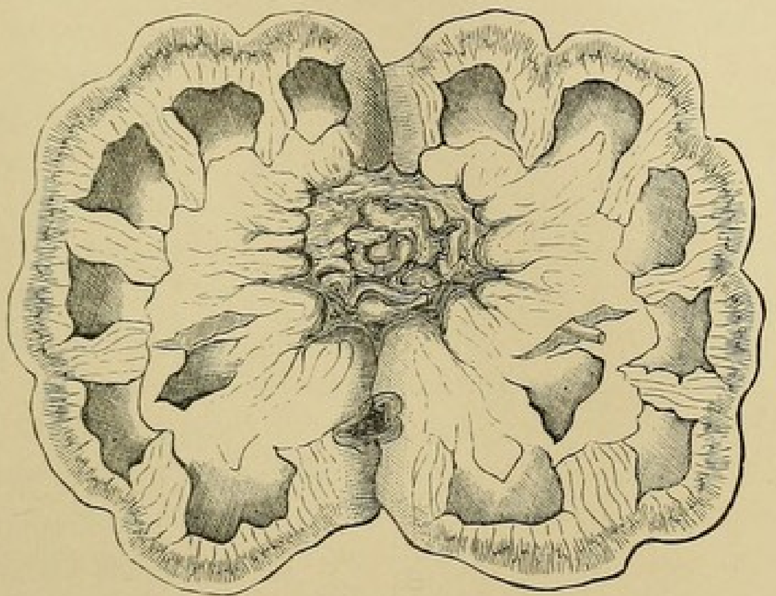
The sugar fungus from diabetic urine. p. 240

Fig. 3.



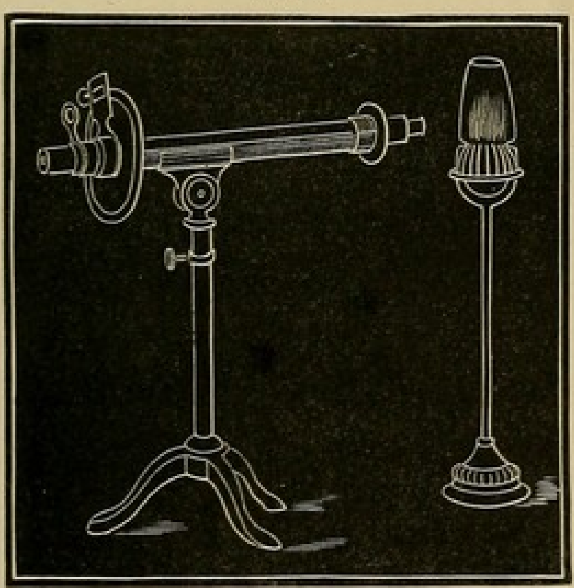
Fructification of yeast fungus. p. 243.

Fig. 4.



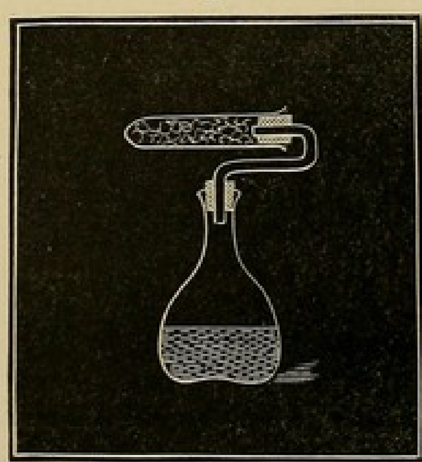
Human kidney, showing greatly dilated pelvis and calyces, shrunken pyramids, and diminished cortical portion p 180.

Fig. 5.



Modification of Mitscherlich's polarising saccharimeter for determining the proportion of sugar in fluids. p. 252.

Fig. 6.



Flask adapted for the estimation of carbonic acid gas, used in determining the proportion of sugar in fluids by the fermentation test. p. 252.

[To face page 252.

and red. Now, the exact degree at which the colour passes from the violet to the red is to be noted; and the number will vary according to the quantity of sugar. The value of each degree is ascertained by examining in the first instance a few solutions having known quantities of sugar dissolved. Supposing that 50 grains of sugar, dissolved in a certain quantity of water, require a rotation of 20°, 100 grains in the same quantity of fluid will require a rotation of 40° before the violet colour would appear. This method is very simple and accurate.

M. Clerget ("Annales de Chimie," iii, XXVI, 175) used Soleil's instrument, which was also employed by Dr. Bence Jones for determining the quantity of sugar in wines and in diabetic urine. ("Med. Times and Gazette," vol. XXV, 1852, p. 102.) The apparatus consists of a polariser and an analyser, made of Iceland spar. The light, which should be bright, white, and homogeneous, is placed behind the polariser. Between the polariser and analyser is placed the tube containing the saccharine solution, as in the other apparatus. Before reaching the saccharine solution, the rays of light pass through a circular plate of quartz, "composed of two half circles possessing equal and opposite rotatory power." The colour of the two plates will be the same before placing in the sugar, but afterwards the colour varies much; and by moving the compensator, composed of two wedges of quartz, which can be slipped over each other, the colour will be equalised. The amount of movement required, or the thickness of the quartz, varies according to the amount of sugar present; and thus the proportion may be determined.

One of the most simple and efficient polarising saccharimeters, for medical purposes, is that of Dubosq of Paris. This is now made very small and light. It can be held in the hand and requires no stand. It should, however, be graduated on both sides of zero. This instrument may be obtained of Messrs. Elliott, of the Strand, and other Philosophical Instrument Makers.

Mr. Wild, of Berne, has lately invented a new saccharimeter which can be held in the hand when an observation is made. This instrument is much more delicate and cheaper than those in general use. It is made by M. Hofmann, 3, rue de Bucy, Paris. The construction of the apparatus is described in "Les Mondes," for 1865, p. 691.

Dr. Garrod's Plan of Estimating the Quantity of Sugar.—Dr. Garrod has lately devised an instrument for estimating the quantity of sugar in urine, founded on the principle that the alteration of colour caused by boiling a mixture of diabetic sugar and carbonate of potash varies in intensity according to the quantity of sugar present. A standard solution is prepared for comparison, by boiling with the carbonate of potash a solution containing half a grain of sugar to the fluid ounce. This is placed in a clear glass tube of about half an inch in diameter. The solution of carbonate of potash is prepared by dissolving four ounces of the carbonate in six ounces of water, and filtering the solution.

In the first place, Moore's test is applied; and if the colour produced after boiling for a few minutes be deeper than an amber red, it is necessary to dilute the urine before making the quantitative determination. The darker the colour produced, the more the urine is diluted. An equal bulk, twice or three times its bulk, of water is to be added, according to circumstances; the exact proportion added must, of course, be carefully noted.

Thirty minims, by measure, of the urine, diluted or not, as the case may be, are mixed with an equal quantity of the carbonate of potash solution, and poured into a small flask. The measure is to be washed out with about a drachm and a half of water, which is also to be mixed with the solution. Next, the whole is to be boiled over a spirit-lamp for five minutes. When cool, the mixture is transferred to a graduated tube of the same calibre as that which contains the standard solution, and diluted with water until its tint is exactly the same as that of the standard solution. By a simple calculation, the quantity of sugar is easily found. Suppose it has been necessary to make the urine, by dilution, forty times its original bulk, in order to obtain the exact tint, it will contain forty half grains of sugar per ounce, or twenty grains of sugar. From these data, the proportion passed in the twenty-four hours is easily calculated. The apparatus was made by Messrs. Coxeter.

Dr. Roberts' Mode of estimating the quantity of Sugar.—Dr. Roberts estimates the quantity of sugar in urine by ascertaining the difference in density of the fluid before the destruction of the sugar by fermentation, and after this process is complete. Two portions of urine, of four ounces each, are placed in separate bottles of about 12 ounces capacity. To one is added a piece of German yeast, about the size of a walnut; the other is tightly corked. Both are placed in a warm place for twenty-two hours, when fermentation will be complete. The bottles are then removed to a cooler part of the room, and when two hours have elapsed, the density of the fluid in each bottle is ascertained by the ordinary urinometer. Every degree of density lost by the fermented specimen indicates one grain of sugar in each fluid ounce of urine ("Edinburgh Medical Journal," October, 1861).

OBSERVATIONS UPON THE NATURE OF DIABETES.

It is not possible to discuss this question, without entering upon the consideration of the physiological changes which occur in the healthy liver, and I shall therefore venture to bring under the reader's notice several points, which are not only of physiological interest and importance, but which really have a most important bearing upon the pathology of diabetes.

It is almost needless to say that the sugar, found in the urine in diabetes, is not formed by the kidney, since it may be detected in the blood and in many of the secretions. In 1848, Bernard proved conclusively that the liver was the organ in which sugar is formed from a glucogenic or amyloid substance, and that the diabetic liver contains a great excess of saccharine matter.

Amyloid or Glucogenic Matter.—In many animals, and in many different tissues of the same animal, a substance is found which is closely allied to starchy matters, and which very readily undergoes conversion into sugar. This amyloid matter is constantly present in the liver, and it is produced by the liver cells. It was discovered by Bernard in 1857. It may be obtained by allowing a concentrated decoction of liver to drop into glacial acetic acid. The amyloid or glucogenic matter is precipitated, while the albumen remains in solution. It is probable that, in the adult mammalian animal, in perfect health, this amyloid matter is formed in quantity in the liver alone; but in certain morbid states it is found in many different tissues, in the muscles, in the coats of the arteries, veins, and capillaries, and in various glandular organs. Even in health there seems to be a certain quantity of amyloid material produced in certain parts of the nervous system, and in several of the fœtal tissues it is to be detected in considerable quantity (Rouget). The amyloid or glucogenic matter very readily undergoes conversion into sugar. If injected into the blood of an animal, it undergoes this change, and the sugar thus formed is carried off in the urine. By warming the solution with a little saliva or pancreatic fluid, or with a little sulphuric acid, the glucogenic matter is converted into sugar.

The demonstration, by Bernard, of the presence of a large quantity of sugar in the liver of all animals, his discovery of the glucogenic material or amyloid matter, which becomes converted into sugar, and the proofs he has adduced in favour of the view that the formation of sugar in the liver is influenced by lesions of the nervous system, as for instance, by irritating the floor of the fourth ventricle or injury to some other parts of the nervous system are, without doubt, the most important discoveries which have been made in physiology during the present century. Bernard considers that in health the sugar resulting from the glucogenic material or amyloid matter is at length oxidised and probably becomes resolved under ordinary circumstances into carbonic acid. Certain altered conditions, however, interfere with the destruction of the whole of the sugar, and much therefore accumulates in the blood, and is at length separated from the circulating fluid by the action of the kidneys; or, the formation of sugar may be more active than usual without any corresponding increase in the destructive processes, so that a large amount circulates in the blood and is continually being carried off in the urine.

It has been stated by Dr. Pavy that the conversion of the amyloid matter into sugar never occurs during life in the healthy state, but that the change takes place constantly in the liver after death and in disease, and after injury to the nervous system during life. Bernard and others have found that the blood of the portal vein often contains no sugar, while that of the hepatic vein always contains a considerable quantity, but Dr. Pavy asserts, on the other hand, that only the *merest trace* of sugar is to be detected in the blood of the right side of the heart during life, if proper precautions are used in obtaining the blood. He says, that it is necessary that the animal should be perfectly tranquil at the time of the operation, as much sugar is always found if any struggling occurs. Again, if the vessels of the liver of an animal, immediately after death, be injected with a strong solution of potash or citric acid (100 grs. to each ounce of water), sugar is not found. Or if small pieces of the liver, taken from an animal the instant it is killed, be quickly frozen, according to Dr. Pavy, the *post-mortem* formation of sugar is prevented, and sugar is not to be detected in the liver thus treated. If woorari or strychnine be injected beneath the skin of an animal near the medulla oblongata, diabetes is induced, and Dr. Pavy has shown that section of the medulla oblongata, artificial respiration being kept up, also causes it. The division of the sympathetic in the thorax, or even the branches ramifying on the carotid and vertebral arteries, produces the same result. This observer entertains the opinion that, in the normal state, the medulla oblongata, through the branches of the sympathetic, exerts an influence upon the changes going on in the liver, and prevents in some way the conversion of amyloid matter into sugar.

Dr. Harley, on the other hand, supports the statement of Bernard that the formation of sugar does proceed during life, and by several experiments he has shown that sugar exists in the liver, although the greatest expedition has been employed in removing portions the instant death has taken place. Dr. Sharpey took part in these experiments, and concurs in the conclusion that the presence of sugar in the liver is a natural condition, and not the result of *post-mortem* change. In one experiment the portal blood, at the instant of death, contained no sugar, while there was distinct evidence of its presence in the hepatic blood, as Bernard has affirmed. (" Proceedings of the Royal Society," vol. X, 1860, p. 290.)

Dr. Thudichum has raised many objections to Dr. Pavy's method of analysis, and has proved that when air, potash, and sugar, are mixed together, the sugar is decomposed. This observer concludes that Dr. Pavy failed to discover sugar in the liver when he injected potash into the portal vein while the liver was yet warm, because the sugar had been destroyed; while if the liver was allowed to cool first, sugar would be detected, because the whole of what was present would not have been destroyed. (" British Medical Journal," March 17, 1860.)

Dr. McDonnell (" Proceedings of the Royal Society," vol. XII, 1863, p. 476), expresses himself in favour of the views of Dr. Pavy as to the amyloid matter not being transformed into sugar, under normal circumstances, during life, and endeavours to ascertain what becomes of this amyloid substance which is formed, not only in the healthy liver, but at least in the fœtus in many other tissues, such as the skin, horny tissues, muscles, &c. During active digestion, Dr. McDonnell has found, that the blood which leaves the liver, contains a protein compound resembling caseine, in larger quantity than ordinary arterial or venous blood. This he thinks results from the union of the nitrogen of the fibrin and albumen decomposed in the liver, with the amyloid material. He conceives that the hydro-carbonous substances resulting from the disintegration of fibrin and albumen in the liver are thrown out as bile, while the nitrogen of these same substances reunites with amyloid to form this new material like casein, which passes away in the hepatic blood.

I have myself many times been surprised at the very distinct reaction which is obtained by testing cat's liver the instant death has occurred; and until Dr. Pavy has succeeded in obtaining portions of the healthy liver of the cat and dog without a trace of sugar, I think his doctrine, that the liver does not form sugar during life in the healthy state, cannot be accepted. The least that can be said is that more conclusive experiments are undoubtedly required, before we shall be justified in giving up Bernard's view.

It seems to me almost certain that the changes which continue to take place in the liver for a short time after death are of the very same nature as those which occurred in the organ during life. I have noticed that warm water may be caused to traverse the capillaries of the liver for several hours after death, and still indications of sugar exist in that which is received from the hepatic vein. Much more sugar can in this way be obtained than existed in the liver at the time of death. The blood is soon washed out, so that this can have nothing to do with the conversion of the amyloid into sugar. During life, under normal circumstances, one would only expect to find mere traces in the blood, as the sugar would be carried off as fast as it was formed, and probably itself decomposed as fast as it was carried off. Nor does it seem to me reasonable to conclude that the life of the animal can make all the difference which is supposed in the action of the liver. Surely, if a considerable quantity of sugar can be demonstrated to exist in the liver *immediately* after death, we are not justified in considering this a mere post-mortem change. A piece of cat's liver, the instant death has taken place, exhibits the presence of sugar in precisely the same manner as a piece of the same liver removed during life. It is doubtful if the death of the great central organs of the nervous system produces that immediate change in many of the nutritive and secreting operations of the body, which the supposed necessity for this very quick removal of the liver seems to argue.

Nor is it an answer to this objection to say, that as certain of the nerve cells cease to manifest any activity the instant death takes place, it is possible that the liver cells may as instantly cease to perform their functions. We know that there are some cells which may exhibit their actions for a long time after death, and which will retain their vitality, so that they can even be removed in a living state from one organism to another. The liver cells are more likely to agree in character with the cells of glands and secreting surfaces generally than they are with those of the very highest tissue in nature. There is no reason for supposing that the liver cell, unlike many other cells connected with different secreting organs, dies the instant the death of the animal takes place. The continuance of ciliary action for some time after the death of the animal, justifies us in concluding that other important operations connected with nutrition and secretion may proceed after the organism as a whole or as an individual has ceased to live.

Moreover, it is most probable that the changes taking place in the amyloid matter of the liver cell are not *vital changes* at all, but changes due rather to chemical and physical actions only. The outer part of the formed material of a liver cell in the living body is no more alive than the outer part of the formed material of a soft epithelial or of a cuticular cell. That physical and chemical changes may go on at a different rate, according as the blood is flowing quickly, slowly, or not at all, is reasonable, but actual demonstration is required before a view, which supposes that the changes occurring a few seconds before death are essentially different from those taking place a few seconds after death, can be accepted. The opinion that the conversion of amyloid into sugar is essentially a post-mortem or abnormal change, may be entertained, but no one has yet succeeded in demonstrating that this opinion is correct.

On the Formation of Amyloid, Fat, &c., in the Liver Cell.—The different substances taken as food are not simply reduced to a soluble state in the stomach and intestines, and then absorbed; nor are they alone rendered soluble, and altered in physical and chemical characters by the secretions of the different glandular organs which are mixed with them, but they are taken up by the living matter of the cells, and completely new substances at length result; so that the fat, amyloid, and sugar, which may be obtained from the liver, are not the same substances as were absorbed from the intestines, nor are they the substances absorbed somewhat modified, but it is probable that they are new bodies altogether, possessing definite characters. The general opinion now held by physiologists is, undoubtedly, that the substances absorbed at the intestinal surface simply undergo change. But how is the change effected? Most physiologists seem to consider that change is effected while the materials are in solution in the blood, or during their passage through narrow channels on their way towards the chyle or blood. Attempts have been made to show that minute channels exist through the epithelium of the intestine, which lead by the narrow extremity of the cell into the connective tissue corpuscles of the villus. But even admitting this arrangement, are we any nearer to an explanation of the fact? What are the agents that effect the change in the fluid as it passes through the minute channels or traverses the cells? The converting power is generally ascribed to the nuclei; but there is no evidence whatever to show that nuclei have any power of exerting an influence upon, or changing, matter which passes by them, and it would be absurd to suppose that the properties and composition of substances were completely altered by their passing through very fine capillary tubes.

I have endeavoured to show that the changes in question consist in the conversion of the soluble pabulum into the living germinal matter often called the nucleus. The absorbed matter goes to increase the living or germinal matter. At the same time the outer particles of the germinal matter become resolved into the new constituents. The mass of germinal matter or nucleus may remain of the same size, although a vast amount of nutrient matter has been taken up, and a corresponding proportion of new substance has been formed.

This is the meaning of the vast amount of germinal matter existing in connection with every absorbing surface and in every gland. The pabulum does not simply pass between these nuclei or cells, but it passes into their substance, and *becomes living germinal matter.* Its whole relations are changed, and it becomes endowed with powers like that of the living matter which existed before it. *The older living particles, in dying, become resolved into new but inanimate substances.* Their elements are entirely re-arranged, and are made to form new combinations. These compounds result, not from any changing powers of the nucleus acting at a distance, but depend upon the relation which the elements were caused to assume just before the death of the living matter, and the external conditions which existed at the time the death of the particles occurred.

Any fat, starchy matter, and sugar, after disappearing from the intestines, becomes completely changed, and entirely loses all its characteristics. These substances served but as pabulum to certain cells, which lived upon them and grew. The living particles of these cells at length died, and among the substances formed might be other kinds of fatty, amyloid, and saccharine matters; but these last are new bodies, not merely the starch, fat, and sugar, which were absorbed somewhat altered.

When sugar is absorbed from the intestine, the quantity of amyloid in the liver is increased; and this has been used by Dr. Pavy as another argument against the glycogenic theory. He says that: "Instead of the liver *allowing sugar to pass through* it, and also *producing sugar itself*, it transforms that which reaches it into amyloid substance." But this fact of the increase of the amyloid seems to be no argument against the conversion of amyloid into sugar under normal circumstances, unless it can be shown that the amyloid afterwards gradually disappears *without* undergoing conversion into sugar.

It is quite true that the supporters of the glycogenic theory have failed to show in what form the sugar is ultimately eliminated or applied to further purposes in the economy; but there seems to be a greater difficulty in accounting for the subsequent changes in the amyloid matter, if we suppose that, normally, it does not undergo conversion into sugar. The conclusion that the amyloid undergoes conversion into fat requires to be supported by stronger evidence than has yet been adduced, before it can be accepted.

It must be borne in mind that the cells, at the circumference of the lobules of the liver, are those which become first gorged with fat in fatty liver, and that these are the cells which are principally concerned in the formation of bile. In cases of amyloid liver, the cells near the *centre* of the lobules are those which become so enormously enlarged in consequence of the accumulation of this amyloid matter. Are we to infer that, normally, amyloid is formed principally in the central part of the lobule, and bile and fat are produced at the circumference; or that the amyloid formed in the central part gradually becomes resolved into bile and fat as the cells gradually pass from the centre towards the circumference of the lobule? This cannot be so, because, to render it possible, the cells must move in a direction, from the centre to the circumference of the lobule, much more rapidly than is actually the case.

Looking at the question from an anatomical point of view, many facts lead us to infer that the marginal cells are those mainly concerned in functional activity, and that those near the centre are being developed, and will gradually take the place of the former as they are removed. In the normal state, the central cells are certainly not actively concerned in secretion. ("On the Anatomy of the Liver," and papers in vol. I of my "Archives.") I incline to the view that, in health, the amyloid matter is formed in the same cells with the fat, and that the matter constituting the outer part of these cells is being gradually resolved into two classes of substances—biliary matters which do not permeate the ducts—and certain substances which readily permeate animal membrane, and are re-absorbed with the fluid which is removed from the bile soon after it is formed, while it passes along the ducts. Further provision for the removal of such soluble substances exists in the gall bladder, where further inspissation takes place. Amyloid, as has been already stated, readily becomes converted into sugar, but no one has succeeded in causing it to split up into sugar and fatty or biliary matters; but it is quite possible that the matter of which the outer part of the liver cell consists, may split into the above two classes of substances—the one class permeating animal membrane, the other possessing but very slight permeating properties.

The amyloid or glucogenic matter is found in the cells when no saccharine or starchy materials are taken in the food, and this is a strong argument against the view that it results from some assumed and unexplained metabolic action of the nucleus or cell wall, upon starchy or saccharine matters brought to the liver in the portal blood. In fact, we can obtain, among other substances, from the liver cell, amyloid matter, albuminous matter, and fatty matter. Each of these constituents may vary greatly in quantity in the cells, but it has not been shown that the fat or albuminous matter results from changes occurring in the amyloid substance, or that the albuminous matter is resolved into fatty and amyloid. The germinal matter of the liver cell gives rise to certain substances, of which the outer part of the cell or *formed material* is composed. There is no limitary membrane, or "cell wall," to the liver cell. Among these may be recognised, *albuminous matters*, *fatty matters*, *amyloid matters*, *colouring matters*, but these are themselves undergoing change. It appears that the principal substances resulting from the disintegration of this formed material, under normal conditions, are *biliary matters*, which are excreted, and other substances which again pass into the blood. Among these latter are an albuminous material closely allied to casein, and a substance which probably takes part in the production of heat. This, according to the theory of Bernard, is sugar resulting from changes occurring in amyloid matter; while Dr. Pavy considers that the substance resulting from the amyloid is more nearly related to the fatty class.

There can be no doubt that the relative proportion of the different constituents, which can be recognised in the formed material of the liver cell, differs greatly in different animals, and in the same animal under different circumstances and at different times. The proportion of these constituents is greatly influenced by the nature of the food. It is clear that the varying proportion of oxygen in the blood, transmitted to the liver, will influence the proportion of the several constituents, resulting from the disintegration of the formed material in a remarkable degree. The diminished supply of oxygen may cause the accumulation of a large quantity of fat in the liver cells, while a large supply would have resulted in the secretion of an increased quantity of bile. This subject requires most extended research, but it seems to me that observations should be made from this point of view :—that the substances formed in the liver, some of which pass to the intestines in the form of bile, while others pursue an opposite direction and are carried in the blood to the lungs, result from the disintegration of the material, of which the outer part of the so-called liver cell is composed, and are not due to any action exerted by the nucleus upon matters passing by, or simply coming into contact with, the cell, nor to any peculiar powers exerted by the supposed cell wall itself.

The formation of sugar in the liver, like the formation of various substances in the different glandular organs, has been considered to be due to direct nervous action, and it has been supposed that a nerve centre, with afferent and efferent nerve fibres, presides over the actual process of secretion in some as yet unascertained manner. Strange too, as it may appear, those who accept this view and maintain that nerves influence secretion in some mysterious way, and thus support the idea of a mysterious and peculiar nerve force, are for the most part most violent opponents of all other fictitious entities or agents. It is obvious that when the pneumogastric is divided and other injuries to the nervous system are inflicted upon a living animal, the circulation of the blood through the liver is affected ; and it seems more reasonable to refer the results, as regards the secreting process, to the disturbances in the circulation, than to seek for an explanation of the fact, by assuming the existence of some mysterious nerve secretory action, notwithstanding the familiar fact that the secretion of most complex substances is effected in plants where there is no nervous system.

As to the ultimate changes of the sugar, supposing it to be produced normally, or of the amyloid, or the fat supposed to result from it, nothing positive is known. Bernard without attempting to explain the successive changes, concludes that the sugar is at length destroyed and excreted in the form of carbonic acid ; and even Dr. Pavy, in his earlier experiments showed that blood which exhibited strong indications of a quantity of sugar, was found to contain only traces after it had been caused to traverse the capillaries of the lungs. It is true that a solution of pure sugar is not decomposed by the direct action of oxygen, but this is no argument against the view that sugar in the venous blood is ultimately resolved into carbonic acid ; for it is quite obvious that oxidation, as carried on in the body, occurs under conditions very different from those we are able to bring about in our laboratories. In fact, Dr. Pavy himself showed that the destruction of sugar by respiration occurs only in blood which contains fibrin.

No one has any doubt that, in the majority of diseases known to us, this very process of oxidation is at fault. There may be quite oxygen enough in the fluids of the body, but the state in which it exists may be different ; the conditions favouring its combination may be absent ; or the substances may not be presented to its action in the normal manner, and so they are not decomposed. There are probably many compounds between the sugar which passes from the liver and the carbonic acid which is evolved from the lungs. This sugar may, under normal conditions, be taken up by the masses of germinal matter (cells, nuclei) existing in such great number in relation with the capillaries of the lungs, and the particles of which these cells consist may become resolved into carbonic acid, among other substances; or the sugar may be taken up by the blood corpuscles, and the matter of which these bodies are composed resolved into carbonic acid and other matters. I merely offer these speculations for the purpose of showing that there yet remains much to be decided before we shall know precisely how fat, sugar, amyloid, and many other substances, become oxidised in the living organism.

To sum up: it seems to me that, in the present state of knowledge, the greatest caution ought to be exercised in forming a general conclusion with regard to this most difficult and highly interesting question. But as far as I am able to judge, the evidence is at present strongly in favour of Bernard's view, that, in health, sugar is produced in the liver, and destroyed whilst it is in the blood. In the normal state the destruction of the sugar occurs at the same rate as its formation; while in certain lesions of the nervous system, and under other circumstances, more sugar is formed than can be destroyed—or the quantity formed remaining the same, the normal conditions under which its decomposition takes place being absent or modified, it accumulates in the blood, and is excreted by the kidneys and other secreting organs, thus producing diabetes. Whether the excretion of a large quantity of sugar in the urine depends upon increased activity of the sugar-forming process, or results from the cessation of the destructive changes which occur normally, has not been determined. There can be no doubt that certain parts of the nervous system are seriously implicated in all cases, but whether the nerves exert a direct influence upon the sugar-forming or sugar-destroying processes, or only affect these operations indirectly through the control they exert upon the calibre of the arteries, and therefore upon the quantity of arterial blood distributed to the capillaries, is not known; but there are, I think, many facts which favour the latter view, while it has never been shown that nerves exert any *direct* influence upon the growth or action of any cells whatever. It is true that Pflüger professes to have traced nerve fibres into the secreting cells of the salivary glands, but his drawings are alone sufficient to justify us in receiving his statements with the greatest doubt. I cannot admit that any one has yet traced a nerve fibre into an epithelial cell. We must not lose sight of the fact that highly complex substances are formed in organisms where there are no nerves, and it is therefore absurd to conclude that secretion is essentially a nerve operation. Nerves influence the processes of growth, formation, and secretion, indirectly by regulating the supply of nutrient material; but the cells probably grow and form new substances independently of the nervous system altogether. The process of disintegration is affected by the quantity of the soluble constituents of blood, rich in oxygen, that is permitted to bathe by the cells, and this like the access of nutrient matter to the growing cells is regulated by nerve action.

Of the Clinical Importance of Sugar in the Urine.—The existence of sugar as a normal constituent of urine has been already considered, p. 238, but it is not uncommon to meet with specimens of urine from persons apparently in the enjoyment of good health, which exhibit unmistakeable evidence of the presence of diabetic sugar, there being sufficient to estimate quantitatively. I have often found from one to two grains of sugar in 1,000 of urine, in cases where all traces of the presence of this substance have disappeared in a few days, without any of the usual restrictions as to diet; and I have noticed the presence of small quantities of sugar in the urine more frequently during the summer than during the winter months. I know other practitioners have made the same observation, and in such cases there is often much difference of opinion as to whether a patient has diabetes or not. A short time since, I found very positive indications in the urine of a gentleman, who I ascertained, upon enquiry, had been in the habit of eating a large quantity of sugar with fruit tarts. Brown bread, little sugar, and salines, soon caused the sugar to disappear from the urine. But in cases of fatty liver, and in that common condition in persons who live too well, where the liver is somewhat wasted as well as fatty, it is very common to find sugar in the urine. The diabetic condition, in these cases, may persist for weeks or months and then pass off entirely.

In diabetes, the quantity of sugar is always much influenced by the quantity and nature of the food. It increases shortly after a meal, and it is undoubtedly augmented when much starch is taken. A meat diet, with bran or gluten bread, always causes a diminution of the sugar. Total abstinence from food, and rest, diminish the proportion; and it is increased by exercise, and by a large quantity of food. As much as two pounds of sugar may be excreted daily; but about one pound is the more usual quantity. In 1858 I had under my care a girl, aged 19, who excreted daily about one pound and a half of sugar.

The dry harsh skin, the intense hunger and thirst, the emaciation, the tendency to the formation of tubercle in the lungs and other organs, are familiar to all who are acquainted with the clinical history of this disease. In many cases, however, I have remarked that the skin is moist, and in some there was excessive perspiration; nor do we find either intense thirst or hunger in all instances. Dr. Garrod observes, that œdema of the legs is always present in diabetes. I have, however, failed to observe it in more than one instance. Diabetes is one of those diseases which runs in certain families, and there is no question that it is hereditary.

Sugar has been found in the urine in cases of cholera, by Dr. Hassall and also by Heintz, but the former observer suggests that, as Heller has shown that in this disease the uroxanthin is in abnormal quantity, it is very probable that the sugar may be derived from this substance from decomposition. The same change may account for the presence of traces of sugar in many cases. *See* p. 238. Diabetes is a disease which does not occur in animals. Dr. Prout regarded diabetes as a form of dyspepsia, characterised by difficulty in assimilating the saccharine alimentary principle.

I have myself found sugar in the urine in pneumonia and phthisis, and have frequently met with it in cases of gradual contraction of the liver, accompanied with a corresponding condition of the kidneys, with albuminous urine. In one case the sugar and albumen seemed to alternate. Sugar would be present for a few days, while no albumen could be detected, and then albumen would appear and the sugar would cease for a time. Diabetes is generally accompanied with emaciation, but I have seen cases in which the patient was not only well nourished but corpulent. Not long since, I was consulted by a very robust and healthy-looking man, a farmer, weighing 13 stone 6 lbs., who appeared to be suffering from dyspepsia. It was, however, found, upon examination, that the urine was of specific gravity 1,028, contained a considerable quantity of sugar (38 grains in 1,000), and was loaded with albumen. There were no casts of the uriniferous tubes or other indications of renal disease. This case gradually became worse, although the proportion of sugar in the urine became reduced, when he was put upon a properly regulated diet.

In cases of carbuncle, sugar sometimes appears in the urine, and towards the close of chronic exhausting diseases it has been detected. When diabetes occurs in old people, it is usually quite under control, and not unfrequently partial recovery occurs. The specific gravity is often 1,030 or 1,040, but not more than from three to five pints are secreted. There is no ground for anxiety, even if the urine contains very much sugar, provided the quantity of urine passed is not excessive.

The highly important and interesting observations lately made by M. Hohl, in a case of diabetes where inosite, p. 280, was passed in large quantities, and seemed to take the place of the urea and sugar, must not be passed over.

Diabetes has been of late years considered by many to depend upon some important change in the nervous system, and there are many facts in favour of this view. Bernard induced temporary diabetes by slight injury to the upper part of the medulla oblongata, and it has been shown by him and others that injury to the nervous system in other parts will produce similar effects. Injuries to the head and spine have in man been soon followed by the secretion of saccharine urine, and cases have been referred to by Drs. Gull and Barlow in which diabetes followed an attack of hemiplegia, a violent shake, actual concussion, epilepsy, over mental work, or was due to the presence of tumours in the brain. But it must be borne in mind that irritation of the peripheral branches of the pneumogastric in the lungs, stomach, or liver will induce diabetes as well as irritation in any part of the trunk of this nerve. Harley showed that if alcohol was injected into the vessels of the liver, diabetes was induced.

This disease, like many other serious maladies, has been attributed to the influence of stimulants, but it need scarcely be said that thousands indulge too freely in alcohol without getting diabetes, for one who suffers in this way. And on the other hand, of diabetics, comparatively few have indulged in excess of alcohol. It is utterly unreasonable to attribute a disease which occurs in the young, which affects both sexes, and which is remarkable for hereditary transmission, to the direct effects of alcohol, and it need scarcely be said that the fact of the increase of sugar in the urine after the administration of alcohol to a diabetic, cannot be fairly advanced in favour of the above view, since many other things, and even injury to nerves, direct and indirect, will act in precisely the same way.

The occurrence of this remarkable disease is not due to mere peculiarity in diet or to the mode of life, and up to the present time we are quite ignorant of the reason why sugar is not present in healthy urine, and what conditions lead to the excretion of so large a quantity as we meet with in many cases of diabetes; neither can we tell why one case dies in a very short time while another lives for many years and passes very much sugar during the whole time. Diabetic livers are often much heavier than healthy organs and contain much blood, but these changes may be secondary. No constant anatomical alterations have been discovered in the liver in diabetes.

Cataract in Diabetes.—It is well known that cataract is very frequently observed in diabetes, and sometimes at any early stage of the disease. Mr. Bowman has often diagnosed diabetes from the presence of cataract. Dr. G. Weir Mitchell and Dr. Richardson showed that cataract was caused in the frog, if syrup was injected under the skin, and they arrived at the conclusion that the opacity of the lens depended only upon the increase in the density of the fluids which bathed and permeated it. It has not, however, been shown that in cases of cataract the density of the serum of the blood is invariably increased, and it is improbable that cataract, as it occurs in diabetic patients, is due solely to this cause, seeing that it is not present in some of the worst cases, while it is sometimes well marked in persons who are suffering from a very mild form of the disease.

The experiments of Dr. Bence Jones and M. Dupré, showing the great rapidity with which saline substances pass into the crystalline lens, have been too hastily advanced in favour of the notion that the lens is the seat of active *nutritive* changes. The phenomena in question have probably nothing whatever to do with the nutritive process, and are examples of simple diffusion. Were it not for the determination on the part of some persons to prove, in face of a vast array of facts pointing to a very different conclusion, that cataract and other diseases result from physical changes only, the mere circumstance of the very slow and gradual progress of the opacity alone would be regarded as conclusive evidence against such a doctrine.

In diabetes wounds do not always heal satisfactorily, and surgical operations should, if possible, be avoided. Slight injuries are not unfrequently fatal, and life is sometimes cut short by the exhaustion consequent upon large boils or carbuncles.

Origin of the large Quantity of Urea in Diabetes.—There can be no doubt whatever that, in many cases of diabetes, the sugar excreted in the urine is not derived solely from the starchy matters taken in the food; for although the patient may be restricted to a diet consisting entirely of proteine and fatty substances, sugar is found in the urine.

The recent observations of the Rev. S. Haughton have confirmed this conclusion. He shows, in some cases which he investigated with the greatest care, that the sugar excreted had a double origin, having been in part derived from the starch in the food, and partly from the decomposition of proteine substance. He considers that the proteine compounds resolve themselves into glucose and urea without giving out work, the total work done in the body in diabetes being at a minimum. The large excretion of urea depends not upon *the work done in the body*, as in health, but results merely from decomposition. In this way the large excretion of urea is explained; and this cannot be accounted for upon the usual theory, that the urea is derived solely from the disintegration of tissue. ("On the Phenomena of Diabetes Mellitus." Dublin, 1861.)

Ringer draws the following conclusions on this subject, "On the Relative Amount of Sugar and Urea in the Urine of Diabetes Mellitus," Trans. Med.-Chir. Soc., 1860, p. 323.

1. After the influence of food on the urine has entirely disappeared, a constant ratio is maintained between the sugar and urea.

2. After a purely non-amylaceous and non-saccharine meal, both

the sugar and urea are increased, but that during this increase the same ratio between them is observed, this ratio being 1 of urea to 2·2 of sugar.

3. Under both these circumstances the sugar could only be derived from the nitrogenous elements of the body, and therefore some ratio might on *à priori* grounds, have been expected.

Sugar in the Urine in Disease of the Respiratory Organs.—Sugar has been detected in cases of disease of the respiratory organs, as pneumonia and bronchitis. In extreme cases of phthisis sugar is occasionally detected in the urine, and towards the close of many exhausting diseases, a meal of starch is followed by the excretion of saccharine urine. I have shown the presence of a considerable quantity of sugar in the sputum in a case of acute pneumonia, just before the patient's death. It has been asserted by some observers, that sugar can always be detected in the urine after anæsthesia produced by chloroform, and in cases of bronchitis and emphysema. I have carefully tested for sugar in the urine of several patients who had taken chloroform, but did not succeed in detecting it in a single instance. The presence of sugar is accounted for under these circumstances, on the supposition that in disease of the pulmonary organs the sugar is not further oxidised, and carried off as carbonic acid. But Bernard has shown that this theory has no foundation, and has proved that the condition of temporary diabetes produced by irritation of the floor of the fourth ventricle, close to the origin of the pneumogastric nerves, is not due to the impaired action of the respiratory organs, as Reynoso and others have supposed.

Bernard has brought forward various facts which militate against the above view; as, for instance, no sugar appears in the urine after complete section of the pneumogastric nerves, and in many other conditions where the respiratory function is impaired. Nevertheless, Reynoso ("Comptes Rendus," t. XXXIII, XXXIV) states that sugar is present in the urine of persons who have been placed under the influence of chloroform, bichloride and iodine of mercury, salts of antimony, opium and narcotics generally, quinine, and carbonate of iron. He also states that, in pleurisy, asthma, and chronic bronchitis, hysteria, and epilepsy, he discovered sugar in the urine. The test employed, it is very important to observe, was Barreswil's solution; but, before applying it, the extractive matters were removed. About 1,500 grains of the urine to be tested were treated with a solution of subacetate of lead. The precipitate was collected on a filter, and the excess of lead salt in the filtrate was decomposed by chloride of sodium; and the solution was again filtered. The clear fluid, after being concentrated, was treated with the copper solution. To another portion the yeast test was applied.

Michèa, who, it should be observed, employed Moore's test, failed to confirm the above conclusions. Déchambre (" Gazette Médicale," 1852) found sugar in specimens of urine obtained from several old people. The test employed was the same as Reynoso used, except that the excess of acetate of lead was decomposed with carbonate of soda instead of chloride of sodium. Dr. Bence Jones obtained "slight, but distinct," evidence of the presence of sugar in the urine of a patient who had been twenty-four hours under the influence of chloroform. The urine was examined according to Reynoso's directions. M. Blot also confirms Reynoso's observations to a great extent. He found sugar in the urine of a pregnant woman, and in those who are suckling children as soon as the milk was secreted. It is possible that affections of the respiratory organs may be instrumental in producing the diabetic condition ; but this may be due to the excitation of the peripheral extremities of the pneumogastrics, depending upon the altered state of the pulmonary membrane, being propagated along the trunks of nerves to that particular part of the medulla oblongata, the artificial irritation of which in animals is known to induce diabetes. There are many facts which support the doctrine that the processes concerned in the production of the sugar are capable of being excited in a reflex manner, and they may therefore be included in the excito-secretory actions.

These observations of Reynoso and others seemed to be so important, that it was very desirable to repeat them. I therefore tried numerous experiments, but was unable to confirm the results. I often found the fluid change to a brown colour when heated with the copper solution ; but, as I have shown, this is not a proof of the presence of sugar. I never conclude that sugar is present in a specimen of urine, unless a decided precipitate of the suboxide of copper is produced. Though this *precipitate* be very slight, it is characteristic. If it only amount to an opalescence, as I have before stated, it is sufficient ; but a change of colour even to a dark brown, the solution still remaining clear, does not, I believe, indicate the presence of sugar. These unsatisfactory results led me to institute the experiments upon the action of Barreswil's and Fehling's solutions, and different forms of the copper-test, which have been already described in pp. 246, 248.

The Experiments of Reynoso and Déchambre repeated with Negative Results.—The urine was tested as in Reynoso's experiments, except that carbonate of soda was used to precipitate the excess of subacetate of lead, instead of chloride of sodium. The specimens of urine passed by six patients under the influence of chloroform, for periods of time varying from ten minutes to half an hour, that of an old lady aged 87, of an old man aged 96, and of two children suffering from epilepsy, were carefully examined. In most, the solution became brown upon being boiled ; but no opalescence or precipitate was produced. The urine of a healthy man, aged 24, was also subjected to examination, and became brown upon being boiled with the copper test. The results of numerous other experiments upon specimens of urine known to contain no sugar led me to the conclusion that, in all the above cases, the urine was perfectly free from this substance. Kletzinsky has repeated Reynoso's experiments, and has failed to confirm his conclusions. Dr. Moore of Dublin (Heller's "Pathological Chemistry of the Urine," translated by W. D. Moore, A.B., M.B.T.C.D.) has examined the urine of twelve men and women whose ages varied from sixty to eighty-three, but was unable to detect sugar. We may, therefore, conclude that there is at present not sufficient evidence to prove that sugar is *habitually* excreted in the urine of old people, or by patients suffering from chest-disease, or by those under the influence of chloroform, &c. It is probable that it may be occasionally met with in some of the above cases.

Analyses of Diabetic Urine.—It is difficult to estimate the urea in diabetic urine by the old process; but the proportion may be ascertained by the volumetric method, which has been described, *see* p. 99. The following analyses show the composition of the urine in some cases of diabetes.

Analysis 66.—Urine from a girl aged 19. Specific gravity, 1,037; acid, clear, pale.

Analysis 67.—From the same. Specific gravity, 1,036; acid.

Analysis 68.—Kidney from a girl aged 19, whose urine is given in Analyses 66, 67. The weight of each kidney was 7½ ounces. The cortical substance was pale, but the pyramids were much congested.

ANALYSIS 68

Water	75·53
Solid matter	24·47
Extractives	7·13
Fatty matter	3·51
Alkaline salts	·92
Earthy salts	a trace
Albumen and renal tissue	12·91
	100·00

Analysis 69.—From a man aged 30, about one month before death. Specific gravity, 1,023.

Analysis 70.—From a woman aged 28, a week before death. Acid; specific gravity, 1,027.

Analyses 71 and 72.—Kidneys from a woman age 28, the composition of whose urine is given in Analysis 70. The tubes clear and well defined, containing epithelium of a circular form. The Malpighian bodies were large, their vessels containing blood. No fat could be detected. All the structures were unusually well marked (M.B., vol. II, 410).

ANALYSES	71 Cortical portion.	72 Medullary portion.
Water	81·52	83·55
Solid matter	18·48	16·45
Fatty matter ...	2·21	1·48
Fixed salts	·99	·88

Analysis 73.—From a patient who was passing sixty ounces of urine daily. Reaction acid; specific gravity, 1,021.

ANALYSES	66		67		69		70		73	
Water	916·50	—	894·90	—	946·8	—	934·2	—	946·00	—
Solid matters ...	83·50	100	105·10	100	53·2	100	65·8	100	54·00	100
Urea ...	—	—	}		—	—			}	
Extractives ...	—	—	82·29	78·2	—	—	16·94	25·74	21·54	39·18
Uric acid ...	—	—	—	—	—	—	1·64	2·49	}	
Alkaline salts } Earthy salts... }	10·66	12·96	3·82	3·63	5·44	10·22	5·82	8·84	3·76	6·96
Sugar ...	not estimated		18·99	18·08	20·24	38·04	41·40	62·91	28·50	52·7

Analyses 74, 75, 76, represent the composition of the urine in a case of diabetes under my care in the hospital. The patient was a healthy-looking girl, only eighteen years of age. She had been suffering from the disease for about three months. Various plans of treatment were tried, without any marked results. She remained under treatment for six weeks, and then left the hospital. She drank from four to six pints of fluid daily; and, when living on a moderate meat diet, with a small quantity of bread, passed rather under a gallon of urine. The urine was analysed from day to day; and I select three specimens for illustration. When the last was obtained, her diet was restricted to bran-biscuits and milk. The results are expressed in grains, and represent the quantities passed in twenty-four hours.

ANALYSES	74		75		76	
	March 20th.	In 100 of solid matter.	April 2nd.	In 100 of solid matter.	April 23rd.	In 100 of solid matter.
Quantity of fluid drank in 24 hours	64708·75		36968·75		36968·75	
Specific gravity of Urine ...	1,037		1,043		1,043	
Reaction	Acid.		Acid.		Acid.	
Water	78653·75		69364·50		50857·625	
Solid matter ...	8846·25		8510·50		6017·375	
Urea			512·30	5·430	455·000	7·561
Sugar	8750·00	98·910	7549·12	88·703	4889·326	81·253
Organic matter			141·07	2·447	501·287	8·333
Fixed salts ...			308·11	3·620	171·762	2·853

THE TREATMENT OF DIABETES.

In the treatment of a case of diabetes, careful regulation of the diet is of the first importance. That starchy and saccharine substances taken in the food, cause an increased quantity of sugar in the urine, is proved beyond question, while, on the other hand, every practitioner is familiar with the improvement that invariably takes place in the condition of the diabetic patient, even a very short time after the allowance of these and allied substances has been reduced.

There are many cases of slight diabetes, which recover directly starchy and saccharine matters are avoided, or even reduced in quantity. In such cases it would seem that the sugar is derived from these substances only, while, in severe cases, the excretion of sugar continues although the patient is restricted to a diet consisting of albuminous matters and bran. Patients suffering from the first form of the malady live for many years, and if proper precautions are taken, the disease may be long kept in abeyance, if it cannot be completely cured. In many cases the diabetic condition passes off, and after an interval reappears. The disease may continue for many years, or it may carry off the patient in a few months. It is, however, rare for a *confirmed case* to recover completely.

Except in very severe forms of the disease, it is neither expedient nor necessary to insist too strongly upon a very strict diet immediately the patient comes under treatment, for many rebel if this is attempted at once, who might be induced to submit to a fully restricted diet if the system was introduced gradually. The quantity of wheaten bread may, at first, be reduced, and the proportion of meat may be increased, and brown may be substituted for white bread. Then some of the bran food may be tried, and gradually substituted for bread, and by employing a little ingenuity in using bran, eggs, cream, and glycerine, a perfectly restricted diet may be enforced without distress to the patient. In truth, every individual case of diabetes must be considered and carefully treated according to the symptoms present. To put every one upon a rigid diet, because there is sugar in the urine, is as absurd as it is useless and cruel, and it is probable that some cases would live much longer upon an ordinary diet than upon a rigidly exclusive one.

The diabetic may be allowed to take his tea and coffee with cream instead of milk; we may allow jellies of various kinds, but of course they should not be sweetened with sugar. We are not, however, compelled to deny even sweet flavours to the diabetic, for he may use glycerine; the preparation now made so largely by Messrs. Price (Price's glycerine) is so pure, and its taste is so perfectly sweet, that it can hardly be distinguished from sugar.

Glycerine may be used for sweetening tea, coffee, and cocoa; it may be introduced in custards; and with eggs and gluten bread well softened, a very palatable kind of pudding may be prepared; glycerine, eggs, and bran may also be made into a light sort of cake or pudding, which may serve to vary the monotony of a strict diet.

The diabetic patient may take a moderate quantity of milk, but it should be borne in mind that milk contains a form of sugar, and, therefore, is not to form a staple article of food in this disease. Various kinds of meat and white fish may be taken. Oil, fat, cream, and butter are advantageous in some cases. Eggs may be taken if they agree with the patient, but sometimes they upset the stomach. Soups of various kinds—but not containing flour. Cheese, cream cheese, ham, and bacon may be eaten by diabetic patients.

The best vegetables are cabbage, French beans, lettuce, and water-cresses. Asparagus should not be taken, as, according to Dr. Harley, when eaten in quantity, temporary diabetes may be induced. Potatoes and all vegetables containing much starch, and fruits, both fresh and dried, as they contain sugar, must not be eaten.

It is scarcely necessary to particularise the individual articles of food which may be taken by the diabetic patient. Long lists have been given in many works, but some of these bills of fare are more amusing than useful. The most curious of any that I have seen is the carte of Prof. Bouchardat, Paris, 1859, which has been translated by Dr. Bence Jones, and strongly recommended by him. I cannot, however, help thinking that a number of the dishes enumerated for diabetics would derange the strongest stomachs. The complete list would extend over six or seven pages, and I shall therefore content myself with giving as examples a few of the strange compounds which are not likely to be very popular in this country. I should not have the courage even to ask my patients to try them, unless they could be prepared by a most experienced French cook.

"Pickled pork, with cabbage, also with sour-kraut. These should be washed in much water, and well dried.

"Black pudding, ham, and spinach.

"Fresh herrings, with butter, or with sauce piquante.

"Black beetles (!), with butter, garlic, and other herbs.

"Sardines, pickled in oil. Salt herrings, with olive oil.

"Mesentery of the calf, in oil (very good).

"Calves' ears, plain.

"Calves' brains, with butter à la poulette, or fried with gluten flour.

"Slices of goose, with olives.

"Fried oysters. Carp's roe. Fried legs of frogs. Fried crabs' tails.

"Pike, with caper sauce and oil.

"Herring, with butter or oil, or mustard sauce.

"Ray, with butter or caper sauce. Sea eel, with oil or butter. Cod, with oil or butter.

"Mussels, à la poulette or pickled. Frogs. Lobster salad. Crabs. Prawns; or beetles or crab sausages.

"Young green walnuts, in salt water without vinegar; the same dried." *See* "Medical Times and Gazette," Jan. 28, 1865.

Substitutes for Bread.—Some of the best substitutes for wheaten bread are *Bouchardat's gluten bread*, or *M. Durand's Toulouse gluten bread* (Callard's English gluten), but the *bran biscuits*, prepared as Dr. Camplin directs, are far superior to either. The first contains about 25, and the Toulouse bread 26 per cent. of starch, while the last contains only traces of this material when properly prepared.

Formula for making Bran Cakes.—Dr. Camplin, who has himself suffered from diabetes, has proposed a most valuable kind of food made from bran. The bran is ground fine in a mill, sifted, and can then be made into a kind of cake. The directions Dr. Camplin gives are as follows:—"Take a sufficient quantity (say a quart) of wheat bran, boil it in two successive waters for a quarter of an hour, each time straining it through a sieve, then wash it well with cold water (on the sieve) until the water runs off perfectly clear; squeeze the bran in a cloth as dry as you can, then spread it thinly on a dish, and place it in a slow oven; if put in at night let it remain until the morning, when, if perfectly dry and crisp, it will be fit for grinding. The bran thus prepared must be ground in a fine mill, and sifted through a wire sieve of such fineness as to require the use of a brush to pass it through; that which remains in the sieve must be ground again until it becomes quite soft and fine.* Take of this bran powder 3 ounces (some patients use 4 ounces, the other ingredients as follows), three new-laid eggs, 1½ ounce (or two ounces, if desired) of butter, about half a pint of milk; mix the eggs with a little of the milk, and warm the butter with the other portion; then stir the whole well together, adding a little nutmeg and ginger, or any other agreeable spice. Bake in small tins (pattipans), which must be well buttered, in a rather quick oven for about half an hour. The cakes, when baked, should be a little thicker than a captain's biscuit; they may be eaten with meat or cheese, for breakfast, dinner, and supper; at tea they require rather a free allowance of butter, or may be eaten with *curd* or any of the soft cheeses. It is important that the above directions as to washing and drying should be exactly followed, in order that it may be freed from starch, and rendered more friable." ("On Diabetes," p. 86.) The mill may be obtained from Mr. Gollop, 149, Cheapside. The bran powder and biscuits cost 1*s*. 6*d*. a-pound. The gluten biscuits cost 2*s*. 6*d*. a-pound.

* This is particularly necessary in cases of irritable bowels.

An excellent form of bran, very finely powdered, has been recently introduced by Messrs. Chapman and Co., of the St. James' Mills, Hatcham, S.E. This is to be obtained retail of Mr. Bonthron, baker, Regent Street, and is sold in small tins.

The same firm also prepares a capital kind of flour for making ordinary bread. This is called whole meal flour, in consequence of the bran being ground up with other parts of the grain. The bread is, of course, more nutritious than ordinary baker's bread. The price of this flour is the same as that of the best white flour.

New Glycerine Sponge Cake.—It occurred to me, some time since, that the bran, with eggs and glycerine, might be made into a form of sponge cake, and I tried some experiments with this view. Mr. Blatchley succeeded in making for me a most excellent diabetic food of these ingredients. It is not only palatable, but really nice. When freshly made, the cakes are as soft as ordinary sponge cake. They may be dried, and will keep for any length of time. In the dry state they can be readily softened in soup, tea, or coffee. They can be flavoured with lemon, or other flavour, according to taste. A similar kind of food can be made with savoury gravy; and in cases where the digestive powers of the stomach are impaired, a few grains of pepsin can be added with advantage. Food made on a similar principle with ordinary flour, concentrated extract of meat, and pepsin, is valuable in many cases when the stomach is very weak and irritable.

The sponge cakes are prepared by Mr. Blatchley, 362, Oxford Street. When fresh they cost 2*s.* 6*d.*, and when dry 3*s.* 6*d.* per pound. They form by far the most palatable diabetic food I have ever tried.

Almond Cake.—Dr. Pavy ("On Diabetes," p. 154), has recently added another substitute for wheaten bread—almond cake and bread. A very palatable kind of biscuit has been prepared with egg and blanched almond powder, according to Dr. Pavy's suggestions, by Mr. Hill, of Bishopsgate Street.

Patients often desire to change their diet from time to time, and they may be allowed to try one substitute for bread after another.

Manufacturers of Gluten Bread, &c., for Diabetic Patients.—The various substances required for diabetic patients may be obtained of the following firms, which are arranged alphabetically:—

Van Abbott, G., and Co., Howford Buildings, 148½, Fenchurch Street, and 5, Princes Street, Cavendish Square—Gluten Bread—Toulouse Gluten Bread, &c.

Bell, 338, Oxford Street—Gluten Bread, &c.

Bewley and Evans, 3 and 4, Lower Sackville Street, Dublin—Gluten Bread, &c.

Blatchley, E., 362, Oxford Street—Bran and Gluten—Bran and Gluten Cake and Biscuits—The Glycerine Sponge Cake.

Bonthron, J., baker, 106, Regent Street.

Bullock and Reynolds, 3, Hanover Street, W.

Gollop, 149, Cheapside—Maker of Mills for Grinding Bran.

Hill, W., 60 and 61, Bishopsgate Street, E.C.—Almond Cakes, Biscuits and Rusks.

Smith, baker, Gower Street, N.—Bran Biscuits, &c.

Wines.—Of wines containing little sugar, amontillado, mansanilla, and Manilla, may be taken, and good claret may be recommended. In dry sherry and Madeira there is comparatively little sugar, from 4 to 20 grains in an ounce. Champagne contains, according to Dr. Bence Jones' estimate, from 6 to 28 grains in the same quantity. Claret, Burgundy, Moselle may be obtained without sugar. Brandy and whiskey are the best spirits. Vichy, or other alkaline water may be taken in moderate quantity, but it is well to restrain the diabetic patient from taking too much liquid. Lime, potash, soda, and lithia water may be given with the stimulant.

Alcohol is said to increase the sugar, but moderate quantities of brandy or whiskey seem to be of service in some cases. I am accustomed to order two or three ounces of whiskey daily, if the patient is weak. I have never seen any bad effects resulting, and many cases have improved while taking this stimulant.

Medicines.—Various medicines have been prescribed in cases of diabetes, and there can be no doubt that benefit often results from the use of ordinary tonics. The mineral acids are sometimes of service. Phosphoric acid allays the thirst. A very agreeable drink may be made as follows:—acid phosph. dil. a drachm, glycerine an ounce, water half a pint; mix: a few tablespoonfuls of this may be taken occasionally during the day. Various bitter infusions, and citrate of potash and ammonia, sometimes appear to do good. Opium is with some a very favourite remedy, but in most of the cases in which it has been given the diet has been altered as well, so that, with regard to this and many other remedies, it is impossible to say how far the benefit has resulted from the remedy, or has been due to the diet. Of all the remedies I have tried, the old tincture of sesquichloride of iron has, I think, been of the most use. I give from ten minims to half a drachm, two or three times a-day, in infusion of quassia, and make the patient continue taking the medicine for months. Under its use, I have found in many cases that the strength has improved, and the patient has gained in weight. Sulphate of zinc has been recommended. Hydrocyanic acid is valuable in cases when there is any irritability of stomach. Cod-liver oil is very serviceable in some cases.

Sugar has been given in large quantity in diabetes, and, as would be supposed, has been found worse than useless.

Alkalies have been administered without decided benefit. I have given large doses of liquor potassæ (ʒiij per diem) without any alteration in the quantity or density of the urine. Vichy water is a very favourite remedy with some, and this and other alkaline waters are exceedingly grateful to the patient. For this reason they may always be ordered, but I doubt if any real effect is produced upon the disease by their use.

Rennet and Pepsin have been given in diabetes. Dr. James Gray ("Glasgow Medical Journal," vol. IV) states that, of twenty-eight persons treated by rennet, seven "completely recovered," but they were also placed upon a restricted diet. Dr. Roberts tried rennet, but although the patient improved while taking it, he improved quite as rapidly before he commenced taking this remedy. ("Brit. Med. Journ.," Nov. 17, 1860.) According to Leubuscher, the quantity of urea, chloride of sodium, and sugar were increased by the administration of pepsin, and Dr. Parkes also found that this substance increased the sugar. On the contrary, in one case in which I tried it, benefit resulted, but then there was some dyspepsia, and I thought that the diet was imperfectly assimilated. In a very bad case of diabetes pepsin is of little use, but in various conditions in which the digestive power of the stomach is impaired, either temporarily or permanently in any disease, it is a most valuable remedy. Really good pepsin has not yet been fairly tried. The method of preparing pepsin is given in page 86. The powdered pepsin may be kept in a well-stoppered bottle for three years without its active powers being in any way impaired. Four fifths of a grain with ten drops of dilute hydrochloric acid and an ounce of water dissolve 100 grains of hard-boiled white of egg. ("Archives of Medicine," 1856, vol. I, pp. 269, 316.) It is prepared by Messrs. Bullock & Reynolds, and costs a shilling a drachm, which may be divided into fifteen or twenty doses.

ALKAPTON.

Bödecker has found in the urine of a patient a substance which possesses many of the reactions of sugar. This is termed alkapton. It is of a pale yellow colour, and does not crystallise. It contains a large quantity of nitrogen. It reduces copper, like sugar, but does not reduce oxide of bismuth, nor is fermentation excited in it by yeast. Urine containing it becomes of a brown colour upon exposure to the air, if an alkali be present, without the application of heat. This change occurs if potash be added. *Sugar and potash* change colour only when the solution is boiled.

Alkapton was separated by Bödecker from the urine by the following process :—After precipitation with acetate of lead, the mixture was filtered, and the solution mixed with tribasic acetate of lead, avoiding excess. The precipitate was washed, suspended in water, and decomposed by sulphuretted hydrogen. The solution filtered from the sulphuret of lead was evaporated to dryness over the water bath, and the residue extracted with ether. The alkapton remained after the ether had evaporated. (Bödecker: "Zeitschrift. f. rat. Med." VII, 128; "Ann. Ch. Pharm.," Jan. 1861; Bowman's "Medical Chemistry," edited by Prof. Bloxam, p. 51.) Alkapton was found in the urine of an infant by Dr. Johnson, his attention being called to it by the brown stains on the linen (quoted in Bowman's "Med. Chem.," by Bloxam, p. 52).

LEUCINE.

Leucine ($C_{12}H_{13}NO_4$) occasionally occurs as a deposit from the urine; but more generally it is held in solution, and can only be obtained by concentration of the fluid, when it crystallises out in the form of small spherules, which are composed of acicular crystals which radiate from a common centre. This substance has of late been found in many of the solids and fluids of the animal body. It is not very soluble in water (one part in twenty-seven), but more so in alcohol. It crystallises from aqueous solutions, for the most part in spherical masses, which exhibit a radiated arrangement. From alcohol, leucine is deposited in the form of pearly scales, somewhat resembling cholesterine; but these are composed of small spherules. Dry leucine can be sublimed without change. Leucine has been found in the saliva, pancreatic juice, and in the pulmonary tissue of the ox (Cloëtta, "Chemical Gazette," 1856, p. 61). Frerichs and Städeler have detected leucine in the blood, urine, and bile of patients suffering from typhus, small-pox, and other exanthemata. Dr. Thudichum found leucine in the urine of a man whose liver yielded a large quantity of it ("Treatise on the Pathology of the Urine," 1858). It was obtained by concentrating the urine. This substance is probably formed in the liver. In certain diseases, it is to be detected in very considerable quantity. Crystals of leucine may often be seen in sections of livers of patients who have died of jaundice. It is said to occur especially in the urine of patients suffering from acute yellow atrophy of the liver. I have detected leucine in the urine in many cases of chronic wasting of the liver accompanied with jaundice, and have obtained it from the tissue of the kidney. *See* pl. VII, fig. 32, p. 17.

No satisfactory tests for leucine are yet known. If it can be obtained pretty pure by repeated recrystallisation, the dry leucine may be sublimed. The sublimate, composed of aggregations of rhombic plates, could not be mistaken for anything else. Urate of soda and many other substances crystallise in spherical globules, like leucine. Crystals of this form, however, which are soluble in alcohol, and again crystallise in spherules from an aqueous solution, can hardly be anything but leucine.

Of Obtaining Crystals of Leucine from the Urine.—The extractive matters often interfere with the crystallisation of the leucine from urine, and the concentrated extract often remains for days without undergoing any change. Frerichs ("Klinik der Leberkrankheiten," Band I, s. 221) recommends that the concentrated urine should be digested for some time with cold absolute alcohol. By this means, the extractive matters are gradually dissolved out. The residue is then to be treated with boiling spirits of wine; and leucine crystallises out as this solution cools. It may be purified by recrystallisation. The extractive matter may be in great part separated by precipitation with acetate of lead. If much leucine is present it crystallises if the urine be concentrated. Crystals of leucine are represented in "Illustrations of Urine," pl. XII, figs. 3 and 4. The crystals at *a* were crystallised from water. The rest were obtained from an alcoholic solution.

TYROSINE.

Tyrosine ($C_{18}H_{11}NO_6$) has been detected in the urine of typhus fever by Frerichs and Städeler. Like leucine, it is probably produced in the liver. It has been detected in this organ by Frerichs, Dr. Thudichum, and many other observers. It has been extracted from several animal fluids. Tyrosine crystallises in long white needles, and is very slightly soluble in cold water. Crystals of tyrosine are represented in "Illustrations of Urine," pl. XII, fig. 5. It is dissolved by boiling water, alcohol, ether, the mineral acids, and alkalies. It may be prepared by boiling horn, feathers, or hair, with dilute sulphuric acid, for forty hours. The dark brown liquid is to be made alkaline with milk of lime, warmed, and then filtered. Sulphuric acid is added to neutralisation, and crystals are deposited upon evaporating the liquid. A very delicate test for this substance has been proposed by Hoffman. A solution of mercuric nitrate, nearly neutral, is to be treated with the solution suspected to contain tyrosine. If this body be present, a reddish precipitate is produced, and the supernatant fluid is of a very dark rose colour. Frerichs tests for tyrosine as follows:—The matter supposed to be tyrosine is mixed with sulphuric acid in a small capsule. After the lapse of half an hour water is added. The solution is then boiled, and excess of carbonate of lime added. To the filtered solution a few drops of a solution of perchloride of iron which is free from acid are added. A dark purple colour is produced if tyrosine is present. In order to obtain tyrosine from urine it is necessary to add a solution of acetate of lead until a precipitate is no longer produced. Sulphuretted hydrogen is passed through the filtered liquid. The sulphuret of lead being separated by filtration, the clear solution may be concentrated by evaporation, when tyrosine, if present, will crystallise out. Tyrosine crystallises in long white needles, which are aggregated to form brush-like masses. De la Rue found tyrosine in the cochineal insect. This is doubtless one of the substances resulting from the disintegration of albuminous matters. I have found it in considerable quantity in urine which contained much uric acid, and had been left to stand in a warm place for many weeks.

Leucine and tyrosine have been detected by Dr. Harley in the urine of a dog four days after dog's bile had been injected under the skin.

INOSITE.

Inosite ($C_{12}H_{12}O_{12}+4HO$) was discovered by Scherer in the juice of muscle, after the creatine and creatinine had been separated. It is termed muscle sugar, and may be obtained in the form of colourless prismatic crystals, which are efflorescent. Crystals of inosite are represented in "Illustrations of Urine," p. 140, pl. VI, fig. 5. Inosite does not reduce the oxide of copper to the state of suboxide, as is the case with diabetic sugar and grape sugar. It tastes sweet, and has the same composition as the latter substance. Inosite may be detected by evaporation nearly to dryness in a platinum basin, when, if a little ammonia and chloride of calcium be added, a rose colour is produced, especially if the mixture be again concentrated by evaporation.

Cloëtta has found inosite in the urine in Bright's disease, but has failed to detect it in the healthy secretion. He has discovered it in the lungs, liver, spleen, and kidneys. The lungs also contain traces of uric acid, taurine, and leucine. M. Hohl has lately recorded a case of diabetes in which a large quantity of inosite was obtained from the urine ("Gazette Hebd. de Méd. et de Chir.," 1859, p. 221; "Journal de la Physiologie," No. VI, p. 344). In this case, the proportion of sugar gradually diminished, and at the same time the quantity of urea excreted became less, while the inosite gradually increased in amount until upwards of *three hundred grains* of this substance were passed in the twenty-four hours. This observation is one of great interest in connection with the pathology of diabetes.

ACETONE.

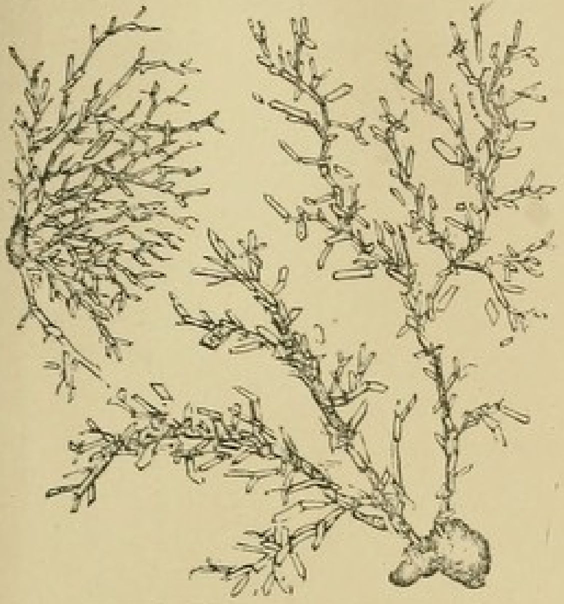
Acetone ($C_6H_6O_2$).—Dr. Petters, at the suggestion of Dr. Lerch, of Prague, sought for acetone in the urine in a case of diabetes, and discovered it both in the blood and urine ("Vierteljahrsch. für die Pract. Heilkunde," Prag. 1857, vol. LV, p. 81). The peculiar smell of diabetic urine is to be attributed to the presence of acetone, according to this observer.

CYSTINE.

Cystine ($C_6H_6NS_2O_4$) is found in a state of solution in the urine in some cases, although it more usually occurs as a deposit. We shall,

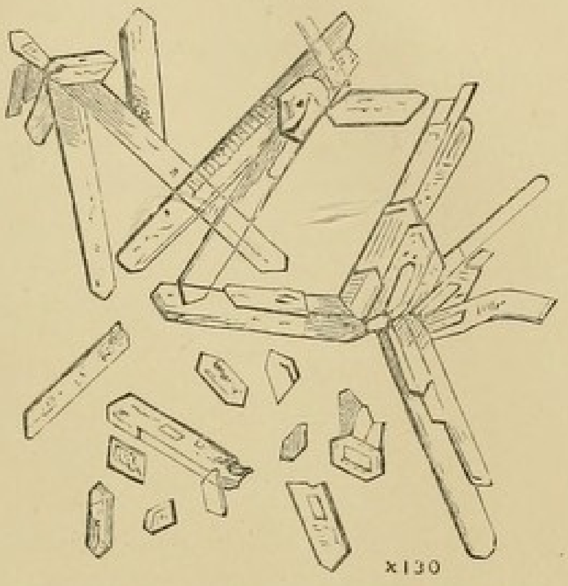
ILLUSTRATIONS OF URINE.

Fig. 1.



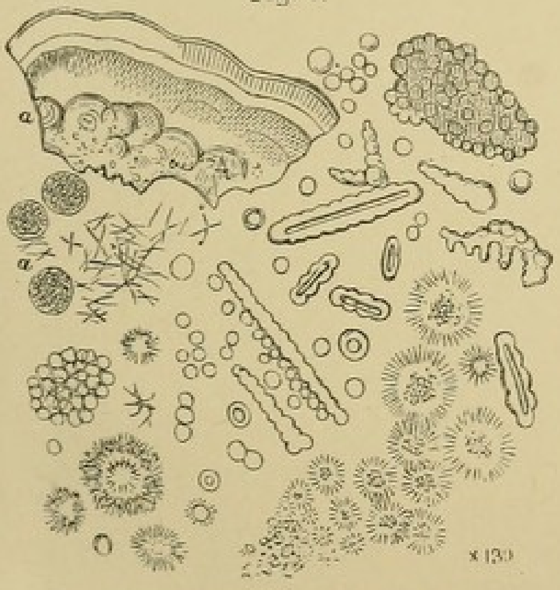
Crystals of diabetic sugar. × 42. p. 242.

Fig. 2.



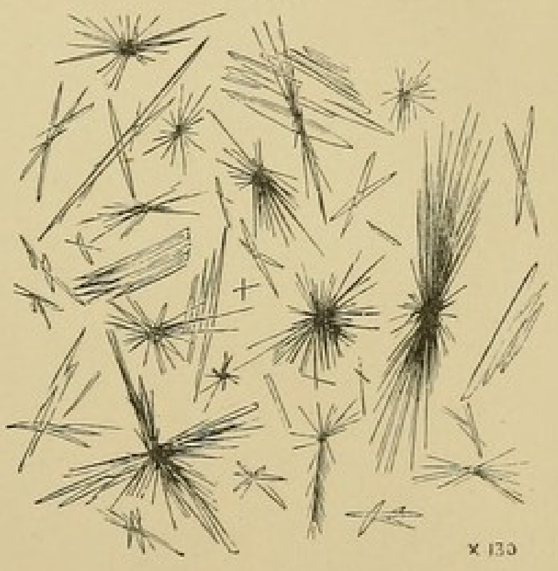
Separate crystals of diabetic sugar. × 130. p. 242.

Fig. 3.



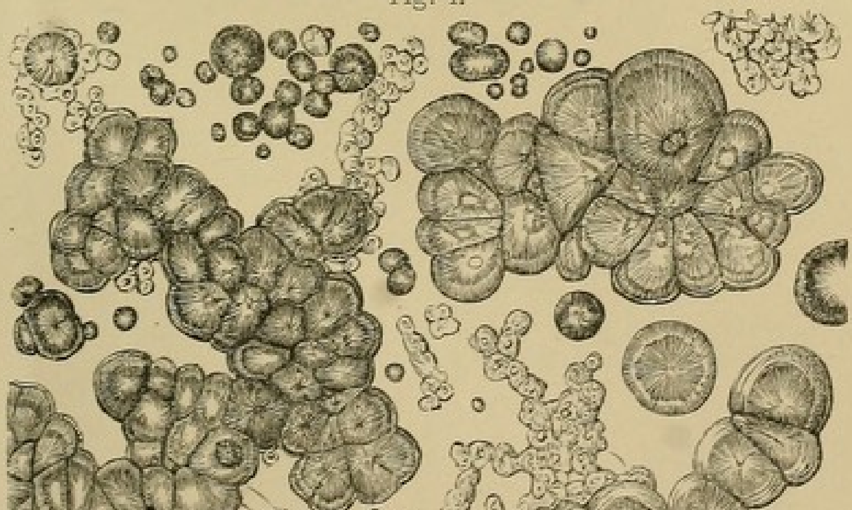
Crystals of leucine from urine. × 130. p. 278.

Fig. 5.



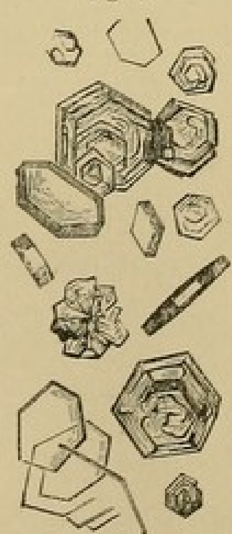
Crystals of tyrosine × 130. p. 279

Fig. 4.



Crystals of leucine from urine of a case of leucocythemia × 215 p 278

Fig. 6.



Cystine from urine.
× 215 p 280.

$\frac{1}{1000}$ of an inch ⊔ × 130
" " ⊔ × 215.

[To face page 280.

therefore, consider it more particularly under the head of urinary deposits. Julius Müller ("Archiv der Pharmacie") obtained some urine from a boy 6½ years of age, which contained cystine in solution. The urine was alkaline. The cystine was precipitated in the crystalline form by the addition of excess of acetic acid. Thoel mentions the occurrence of cystine in the urine of many members of the same family (Liebig and Wöhler's "Annalen," 1856). Crystals of cystine are represented in "Illustrations of Urine," pl. XII, fig. 6. *See* also "Illustrations of Urinary Deposits" in Part IV.

Taurine ($C_4H_7NS_2O_6$) has been found in the urine of jaundice.

Allantoin ($C_8H_6N_4O_6$) has never been detected in human urine, but it was present in the urine of a dog into whose lungs oil had been injected by Frerichs and Städeler. It may, perhaps, exist in the urine of young children (Parkes). It is always present in the urine of calves while sucking, but afterwards it is replaced by hippuric acid.

Guanin, Sarkosin, and Kynurenic Acid (the peculiar acid of the urine of the dog), have never been positively detected in the urine of man (Parkes).

Hypoxanthin ($C_{10}H_4N_4O_2$), or sarkine, is found with xanthine. It has been detected by Scherer in the urine in leucocythemia.

I have ventured to occupy some time in the consideration of the characters of certain substances the presence of which in urine has only very recently been demonstrated. Probably, when the various materials removed in this excretion shall have been more thoroughly investigated, and when we know more relating to the precise conditions under which they are formed in the animal economy, the treatment of many diseases will be placed on a sounder basis, and we shall be able to relieve sufferings and prevent the progress of morbid changes over which we have now very little control. It is true, there are some who consider all this minute scrutiny and scientific investigation to be useless, or at least unnecessary and unpractical, but it is difficult to understand how any one who has properly studied his profession can hold such an opinion, for is it not obvious that the more minutely our investigation of diseased processes is carried out, the more we shall know about them, and the better able shall we be to suggest plans of treatment to combat the abnormal changes? That scientific work will ultimately lead to great practical results in treatment is certain; and every one must feel that time devoted to original research is most usefully and advantageously spent.

PART IV.

URINE IN DISEASE AND ITS EXAMINATION.

THE MICROSCOPICAL EXAMINATION OF URINE—OF THE VARIOUS URINARY DEPOSITS—OF CALCULOUS DISORDERS.

The examination of urinary deposits is a subject of the greatest importance, and the advantages derived from it are so generally admitted that I need scarcely refer to its value in assisting us to form a diagnosis in many cases of disease. Within the last fifteen or twenty years, the methods of investigating urinary deposits have been much simplified, and the results obtained by the conjoint use of the microscope and chemical analysis have been so accurate and decided, that the nature of the greater number of deposits has been definitely determined.

When the student commences to examine urinary deposits for the first time, he will doubtless meet with many difficulties; and in some specimens which he examines, he will perhaps discover no deposit whatever; whilst in other cases the whole field of the microscope is seen to be occupied by substances of various shapes and colours, the nature of which he will be unable to ascertain. Many of the substances which lead to this difficulty have obtained entrance into the urine accidentally; and the observer should therefore be warned against mistakes easily made, which are serious, and may bring great discredit upon his powers of observation. Portions of hair have been mistaken for casts of the renal tubes; starch-granules for cells; vegetable hairs for nerve fibres; casts for the basement membrane of the uriniferous tubes; and many other substances of extraneous origin, such as small portions of woody fibre, pieces of feathers, wool, cotton, &c., often take the form of some of the urinary deposits, and to a certain extent resemble the drawings given of them in their general appearance, so as to mislead the student in his inferences, and retard his progress in investigation.

Collecting Urine for Microscopical Examination.—Urine, which is to be submitted to examination, should be collected in considerable quantity, in order to obtain sufficient of the *deposit* for examination. In many instances, the amount of sediment, even from a pint of urine, is so small that, without great care in collecting, it may be altogether passed over. The amount of deposit from a measured quantity of urine should always be roughly noted. The space occupied by the deposit may be compared with the total bulk of the fluid, and we may say the deposit occupies a fifth, a fourth, half the bulk of the urine, &c.

Bottles used for carrying specimens of urine should be made of white glass, with tolerably wide mouths, and capable of holding at least four ounces; but if the sediment only of the urine is required, the clear supernatant fluid may be poured off, after the urine has been allowed to stand for several hours, and the remaining deposit may then be poured into small bottles of an ounce capacity, or even less. The only objection to this latter mode of collecting urine is, that no estimate of the *amount* of sediment deposited by a given quantity of urine can be formed. The bottles may be arranged in a case capable of containing two, four, or six. They may be obtained of Messrs. Weiss, in the Strand; Mr. Highley, Portland Street, W.; Mr. Matthews, near King's College Hospital; and other instrument makers.

Period when the Urine should be Examined.—In all cases the urine should, if possible, be examined within a few hours after its secretion; and, in many instances, it is important to institute a second examination after it has been allowed to stand for twenty-four hours or longer. Some specimens of urine pass into decomposition within a very short time after they have escaped from the bladder; or the urine may be actually decomposed when drawn from the bladder. Under these circumstances, we should expect to find the secretion highly alkaline, having a strongly ammoniacal odour, and containing crystals of triple phosphate, with granules of earthy phosphate; and upon carefully focussing, numerous vibriones may generally be observed. In other instances, the urine does not appear to undergo decomposition for a considerable period, and may be found clear, and without any deposit, even for weeks after it has been passed.

In those cases in which *uric acid* or *octahedral crystals of oxalate of lime* are present, the deposit increases in quantity after the urine has stood for some time. These salts are frequently not to be discovered in urine immediately after it is passed, but make their appearance in the course of a few hours. The deposition of uric acid is said by Scherer to depend upon a kind of acid fermentation.

In order to obtain sufficient of the deposit from a specimen of urine for microscopical examination, we must place a certain quantity of the fluid in a conical glass, in which it must be permitted to remain for a sufficient time to allow the deposit to subside into the lower part, pl. I, p. 92.

Removal of the Deposit from the Vessel containing it.—In order to remove the deposit from the lower part of the vessel in which it has subsided, the upper end of the *pipette* is to be firmly closed with the forefinger, the tube being held by the thumb and middle finger. Next, the lower extremity is to be plunged down to the bottom of the deposit.

The forefinger may now be raised very slightly, but not completely removed, and a few drops of the fluid with the deposit slowly pass up into the tube, 'Apparatus' pl. I, fig. 1. When a sufficient quantity for examination has entered, the forefinger is again pressed firmly upon the upper opening, and the pipette carefully removed. A certain quantity of the deposit is now allowed to flow from the pipette on to the glass slide or cell, by gently raising the forefinger from the top. It is then covered with the thin glass cover, and subjected to examination in the usual way. Dr. Venables recommends that the deposit should be obtained by inverting a corked tube into which the urine has been previously poured. A small quantity of the deposit adheres to the cork, and may be removed to a glass slide. The pipette is, however, the more efficient, and by its use the deposit may be separated from a very large quantity of urine.

Of Collecting a very small Quantity of a Deposit from a Fluid.—When the quantity of deposit is very small, the following plan will be found of practical utility. After allowing the lower part of the fluid, which has been standing, to flow into the pipette, as above described, and removing it in the usual manner, the finger is applied to the opening, in order to prevent the escape of fluid when the upper orifice is opened by the removal of the finger. The upper opening is then carefully closed with a piece of cork. Upon now removing the finger from the lower orifice, the fluid will not run out. A glass slide is placed under the pipette, which is allowed to rest upon it for a short time. It may be suspended with a piece of string, or supported by the little retort stand. Any traces of deposit will subside to the lower part of the fluid, and must of necessity be collected in a small drop upon the glass slide, which may be removed and examined in the usual way.

Another plan is to place the fluid, with the deposit removed by the pipette, in a narrow tube, closed at one end, the bore of which is rather less than a quarter of an inch in diameter. This may be inverted on a glass slide, and kept in this position with a broad elastic India-rubber band. The deposit, with a drop or two of fluid, will fall upon the slide, but the escape of a further quantity of fluid is prevented by the nature of the arrangement, which will be understood by reference to 'Apparatus' p. 92, pl. IV, fig. 32.

Magnifying Powers required in the Examination of the Urine.—Urinary deposits require to be examined with different magnifying powers. The objectives most frequently used are the inch and the quarter of an inch. The former magnifies about 40 diameters ($\times 40$); the latter from 200 to 220 ($\times 200$, $\times 220$). Large crystals of uric acid may be readily distinguished by the former, but crystals of this substance are sometimes so minute that it is absolutely necessary to use high powers. Octahedra of oxalate of lime are frequently so small that they cannot be seen with any power lower than a quarter; and, in order to bring out the form of the crystals, even higher object glasses than this are sometimes necessary. Spermatozoa may be seen with a quarter, but they then appear very minute. In these cases, an eighth of an inch object glass, which magnifies about 400 diameters ($\times 400$), will be of advantage. The casts of the tubes, epithelium, and the great majority of urinary deposits, can, however, be very satisfactorily demonstrated with a quarter of an inch object glass.

Some deposits, the nature of which is doubtful, must be subjected to examination in fluids possessing different refractive powers, such as water, serum, mucilage, glycerine, turpentine, Canada balsam, &c.

Of the Chemical Examination of Urinary Deposits.—In the investigation of those deposits which are prone to assume very various and widely different forms, such as uric acid, it will often be necessary to apply some simple chemical tests, before the nature of the substance under examination can be positively ascertained.

Suppose, for instance, a deposit which is found, upon microscopical examination, not to possess any characteristic form, be suspected to consist of uric acid, or of an alkaline urate, it is only necessary to add a drop of solution of potash, which would dissolve it, and then excess of acetic acid, to obtain the crystals of uric acid in their well known rhomboidal form. Other chemical tests which should be considered necessary may be applied afterwards.

When it is requisite to resort to chemical reagents, a drop of the test-solution is to be added to the deposit, which is placed in the cell, or upon the glass slide. The little bottles described in p. 97 will be found most convenient for this purpose. If necessary, heat may be applied to the slip of glass by a spirit-lamp, and, with a little practice, the student will soon be able to perform a qualitative analysis of a few drops of urine, or of a very small portion of a deposit.

Examination of the Deposit in the Microscope.—The drop of urine, with the deposit, is to be placed in a thin glass cell, or in one of the animalcule cages, pl. III, fig. 23, p. 96. These instruments will be found convenient for examining urinary deposits, as a stratum of fluid of any degree of thickness can be very readily obtained. A simple form of compressorium may be also conveniently used for the examination of urinary deposits.

Various parts of the specimen are to be brought into the field of the microscope. It is better to examine the object as regularly as possible, commencing on one side, and moving it up and down, until the whole has been traversed. After one specimen has been examined, and the nature of its contents noted, another may be treated in a similar manner. Specimens should be taken from the deposit at different levels, for while some substances soon sink to the bottom, others are buoyed up, as it were, either by the small quantity of mucus which the urine contains, as is the case with small crystals of oxalate of lime, or by the flocculent nature of the deposit itself.

As each part of the deposit is brought under the field of the microscope the observer should endeavour to recognise every object as it passes under his view. This, however, will for some time be found a matter of considerable difficulty, arising partly from the number of deposits which commonly occur together, and partly from the very various forms which many of these substances assume, but chiefly, I believe, from the great number of things present accidentally, which are found in almost every specimen of urine, and especially in urine obtained from the wards of a hospital, upon which the first microscopical observations are usually made. Accurate copies of the different urinary deposits, drawn on wood, with the aid of the glass reflector, are represented in the succeeding "Illustrations of Urinary Deposits."

I cannot too strongly recommend the observer to sketch the appearances of the different objects which come under his notice, for he will, by so doing, become familiar with the characters of urinary deposits much more quickly than if he merely instituted a hasty and imperfect examination. The methods of obtaining sketches of the exact size of the image in the microscope, are described in "How to Work with the Microscope." *See* also p. 97, and "Microscopical Apparatus," pl. III, fig. 26, of the present work.

ON THE PRESERVATION OF URINARY DEPOSITS AS PERMANENT MICROSCOPIC OBJECTS.

A desire has been generally expressed that a series of the most important urinary deposits should be kept for sale, so that practitioners might have an opportunity of readily obtaining named specimens, with which the deposits that from time to time fall under notice might be compared, and their nature recognised. Persons who prepare and sell microscopic objects have experienced great difficulty in preserving urinary deposits satisfactorily; and many specimens which have been purchased have been found to lose their characters after a few months, and have soon become quite useless objects. Feeling strongly the real practical value of preparations of this kind, it seems to me very desirable that a few rules with regard to the preservation of urinary deposits should be laid down; and I therefore propose to allude briefly to the different plans which I have found to succeed best. I hope that, shortly, there will be no difficulty in obtaining series of well-mounted and illustrative specimens.* At the same time, any one attending hospital practice,

* Specimens of urinary deposits may be obtained of Messrs. Smith and Beck, Coleman Street, City; Mr. Baker, Holborn; Mr. Tennant, 149, Strand; Mr. Wheeler, 48, Tollington Road, Holloway, N.; and Mr. Matthews, surgical instrument maker, Carey Street, Lincoln's Inn Fields.

who has a little time at his disposal, can, without much trouble, prepare such preparations for himself.

The different characters of urinary deposits require different plans of preservation. It is, therefore, desirable to consider the general nature of the deposit before we attempt to preserve it. Some deposits may be preserved *dry*, others may be mounted in *Canada balsam*. A certain number exhibit their characters very well if preserved in *glycerine*, while many can only be kept in certain *aqueous fluids*.

Of placing the Deposit in the Preservative Fluid.—After the deposit has been allowed to settle in a conical glass, the supernatant fluid is to be poured off; and if it is to be mounted *in fluid*, a quantity of the preservative solution, equal in bulk to the urine and deposit that remain, is to be added. After the deposit has again settled, the fluid is to be poured off and replaced with an equal portion of fresh preservative solution. In this way the deposit is washed clean, and properly impregnated with the preservative fluid.

When preparations are to be preserved in a fluid medium, a small shallow water-tight cell is to be used. The specimen and its preservative fluid being placed in the cell, the thin glass is applied, and the cover cemented in its place with the aid of Brunswick black or other cement. *See* "How to Work with the Microscope." In washing urinary deposits prior to mounting them, it is often necessary to add to the water used for this purpose a solution of some salt, in which they are known to be insoluble; and sometimes it is desirable to add something to increase the density of the fluid; for which purpose, certain salts, syrup, or glycerine may be employed, according to circumstances. Many deposits, although soluble to some extent in pure water, are quite insoluble in a weak acid; others are insoluble in a weak alkali and in certain saline solutions. Again, it is sometimes desirable to separate certain substances in the deposit from others, and this may be effected by special chemical solutions which have the power of acting on the one and not upon the other; or, in cases where one is more dense than the other, the same object is gained by agitating the deposit with water, and, after allowing time for the heavier particles of the deposit to settle, pouring off the lighter one into another vessel, to subside there. From this, it may be collected in the usual way, and afterwards mounted as a permanent object.

Urinary Deposits preserved as Dry Objects.—If the preparation is to be preserved as a *dry object*, water is to be added in the first place; and a portion of the deposit, which has thus been carefully washed, is to be removed with the aid of a pipette to the glass slide, and the fluid allowed to evaporate, the whole being covered with a bell-jar, and placed over a dish of strong sulphuric acid. When dry, it is to be protected from dust by a thin glass cover. The glass cover is easily prevented from pressing upon the preparation by interposing a thin piece of paper or cardboard; or a thin India-rubber ring, which may be easily fixed to the glass slide and thin glass cover, by a little gum made into a thick paste with whiting, may be used.

Preservation in Canada Balsam.—If the specimen is to be mounted in *Canada balsam* or turpentine, it is to be dried in the manner just described, warmed slightly, wetted with turpentine or balsam, and mounted with the usual precautions. For details, *see* "How to Work with the Microscope."

Refractive Power of the Medium in which Deposits are Mounted.—The appearance of objects in the microscope depends very much upon the medium in which they are immersed; and many structures are so altered in character by different media, that they would hardly be recognised as the same object. It may be said, generally, that the darker the object, and the more dense its structure, the higher should be the refractive power of the medium in which it is mounted—thus the dark-coloured uric acid, or the thick spherical crystals of carbonate of lime, and the dumb-bells of oxalate of lime, exhibit their structure to the greatest advantage when mounted in the highly refracting *Canada balsam*, or in *strong syrup* or *glycerine;* while the beautifully transparent octahedra of oxalate of lime would be scarcely visible in these media, and require to be mounted in an aqueous fluid which possesses a lower degree of refractive power. Many objects when mounted dry, appear quite dark, and scarcely exhibit any structure at all, in consequence of the great difference in the refracting power of their substance, and the air by which they are surrounded. From what has been said, it will be evident how important it is to examine the same object in different media—indeed, it is quite impossible to form an idea of the real structure of many specimens, without proceeding in this manner. *See* "How to Work with the Microscope," or "The Microscope in its Application to Practical Medicine."

Media in which Urinary Deposits may be preserved.—Urinary deposits may be mounted in *air*, in *turpentine*, *oil*, or *Canada balsam; in glycerine*, in *gelatine* and *glycerine*,* in *solution of naphtha and creosote*, in *certain saline solutions*, in *weak spirit*, and in some other aqueous solutions, which will be alluded to. The *glycerine* which I use is "*Price's patent glycerine*," diluted with one-third part, or more, of water. In making more dilute solutions of glycerine, it is well to employ camphor water, as this prevents the formation of fungi. Many urinary deposits may be preserved in strong glycerine, if care be taken to increase the density of the solution gradually, and sufficient time be allowed for the deposit to be thoroughly permeated with the fluid. The best plan is to

* The best gelatine and glycerine is prepared by Mr. Rimmington, chemist, Bradford, and is sold in bottles at 1*s*. and 2*s*.

add a little glycerine to the deposit which has been allowed to collect in the conical glass. After the deposit has settled, pour off the supernatant fluid and add fresh glycerine. Repeat the same process two or three times. Every deposit to be mounted in fluid must be allowed to remain in it for some days before it is mounted permanently. The deposit should be well stirred with the preservative solution placed in a conical glass. I have kept specimens preserved in strong glycerine for fifteen years with very slight change; and probably they will retain their character for a much longer time than this.

The composition of the naphtha and creasote fluid, above referred to, is as follows :—

Solution of Naphtha and Creasote.

Creasote	3 drachms.
Wood naphtha	6 ounces.
Distilled water	64 ounces.
Chalk, as much as may be necessary.	

Mix first the naphtha and creasote, then add as much prepared chalk as may be sufficient to form a smooth thick paste; afterwards add, very gradually, a small quantity of the water, which must be well mixed with the other ingredients in a mortar. Add two or three small lumps of camphor, and allow the mixture to stand in a lightly covered vessel for a fortnight or three weeks, with occasional stirring. The almost clear supernatant fluid may then be poured off and filtered, if necessary. It should be kept in well-corked or stoppered bottles. A 1 per cent. solution of carbolic acid may be used instead of the above.

Of keeping the Urinary Deposit for subsequent Inquiries.—In cases where it is desirable to retain a certain quantity of the deposit in the preservative solution for subsequent examination, or for the purpose of making more preparations, it should be kept in a small glass tube, with a tight-fitting cork, and carefully labelled. Most urinary deposits may be kept for a longer time in this manner than if mounted in thin cells. I propose now to describe briefly the various plans adapted for the preservation of urinary deposits which I have found to succeed best.

Preservation of Special Deposits.

Mucus.—It is very difficult to preserve the character of the so-called "mucus corpuscles," or imperfectly formed epithelial cells, nuclei, and granules, which constitute the slight flocculent deposit met with in healthy urine, and termed "mucus." The naphtha and creasote solution is best adapted for the purpose, and it is desirable to place the specimen in a cell about the twentieth of an inch in depth.

Epithelium.—The different varieties of epithelium are easily preserved, although, after the lapse of some time, minute oil globules make their appearance in them. They may be kept in naphtha and creasote fluid, to which one fourth of its bulk of glycerine has been added. It is well to put up specimens of epithelium from the urethra, bladder, ureter, and pelvis of the kidney, removed from the organs of a healthy man who has been killed accidentally. They should be mounted in very thin cells. Specimens of the epithelium from the vagina, which can generally be obtained from the urine of females, should also be preserved.

Vegetable Growths: Fungi.—I have found that fungi may be preserved most satisfactorily in glycerine, for although they appear somewhat more transparent in this fluid than in urine, they preserve their general character better than when immersed in other preservative fluids. It is necessary to add weak glycerine in the first instance, and to increase the strength gradually, otherwise the fungi become collapsed, owing to the great density of the strong solution. A solution composed of equal parts of water and Price's glycerine is sufficiently strong to preserve fungi. The sarcinæ which are met with in vomit as well as those occasionally found in urine and other fluids keep perfectly well, and preserve their recent characters in glycerine.

Spermatozoa are sometimes mounted in the dry way; but although their general form is preserved, their refractive power and transparent appearance are so different from what is observed when they are immersed in urine, that little is gained from such preparations. Spermatozoa keep very well in glycerine, although they appear rather more faint than in an aqueous fluid. They should be examined with the *eighth of an inch object-glass* (× about 400), or the twelfth (× 700); but when the eye of the observer has become familiar with the general appearances, they may be readily recognised with a quarter of an inch object-glass (× about 200).

Casts.—It is not difficult to preserve the character of some varieties of casts. The transparent casts often become covered with numerous minute granules and oil globules, and their characters much altered. Granular casts and epithelial casts often keep very well in the naphtha and creasote solution; but altogether I prefer glycerine, with one-third part of water or glycerine jelly. Although, in many instances, the cells they contain are altered, and oil globules appear much more transparent than when in urine, this alteration in character may be easily allowed for. The specimens in glycerine, of course, keep admirably. I have some specimens of large waxy casts and epithelial casts which have been kept in the naphtha and creasote solution for upwards of seven years, and still preserve their characters well. Casts may be coloured slightly with an ammoniacal solution of carmine or with magenta, and preserved in glycerine. The very transparent casts, which are hardly visible under ordinary circumstances, can thus be demonstrated very clearly and preserved. Any nuclei in the cast are intensely coloured by the carmine.

Pus.—Recent specimens of pus may be so readily obtained that it is hardly necessary to attempt to preserve the corpuscles permanently. Their characters alter so much in all the aqueous preservative fluids that I have tried, that after they have been put up for some time, it would be difficult to recognise the nature of the preparation. I have, however, succeeded in preserving some specimens of pus in glycerine by observing the precautions mentioned in p. 289. Cancer cells, which are sometimes found in very large quantities in the urine in cases of cancer of the bladder, may be preserved in the same way. I have several specimens which have been mounted for upwards of ten years.

Phosphates.—The phosphate of lime, in its amorphous form, in globules and minute dumb-bells, is easily preserved in weak spirit, naphtha and creasote fluid, or glycerine; but the character of the crystals of the triple or ammoniaco-magnesian phosphate could not be retained in this solution. As is well known, this salt is quite insoluble in solutions of ammoniacal salts, and these make the best preservative solutions for it. Crystals of triple phosphate may be kept for any length of time with their smooth surfaces and their lustre unimpaired, in distilled water, to which a little chloride of ammonium has been added. Phosphate of lime and the stellar form of triple phosphate may be dried carefully, and mounted in Canada balsam; but, of course, the appearance of the crystals is a good deal altered.

Urates.—As the urates are so commonly met with, and as they are generally deposited in the form of granules, there is scarcely any need of mounting them as permanent objects. If desired, however, deposits of this kind may be preserved by adding a little naphtha and creasote fluid to the deposit, which should be left in it for a considerable time before it is put up. Urates which crystallise in small spherical masses (a form in which they often occur in the urine of children), and more rarely in irregular branched processes, may be preserved very well in Canada balsam, or, if preferred, they may be kept in the naphtha and creasote fluid, or glycerine jelly.

Blood Corpuscles become more or less altered in most preservative fluids. I think that those which I have mounted in glycerine (one part water to three parts of glycerine) and in gelatine and glycerine, have undergone the least change.

Uric Acid Crystals are easily preserved as permanent objects. The usual plan is to mount them in Canada balsam. They should be washed, in the first instance, with a little water, to which a few drops of acetic acid have been added. When pretty clean, they may be placed upon a glass slide, with the aid of a pipette, and the greater quantity of the fluid absorbed with a small piece of bibulous paper.

After the crystals have been properly arranged on the slide with a needle, they may be dried by exposure under a bell jar over a dish containing sulphuric acid. When quite dry, they may be moistened with a drop of turpentine, and mounted in Canada balsam. In this operation, a very slight heat should be employed, otherwise the crystals will become cracked in all directions, and more or less opaque. Uric acid crystals, as a general rule, do not keep well in glycerine. In cases where we wish to preserve other substances in the deposit as well as uric acid crystals, the naphtha and creasote fluid will be found to answer very well. I have some preparations mounted in this manner, which were put up six or seven years ago. Uric acid is also well preserved in gelatine and glycerine.

Cystine.—Crystals of cystine may be preserved in Canada balsam, the same care being taken in mounting them as mentioned under uric acid, or they may be kept very well in distilled water, or in the naphtha and creasote fluid, to which a little acetic acid has been added. Cystine is most easily preserved in gelatine and glycerine.

Oxalate of Lime.—Both the octahedra and dumb-bells may be preserved for many years in the naphtha and creasote solution and also in glycerine. The octahedra look very transparent in the latter fluid. The dumb-bells may also be mounted in Canada balsam, in which medium the octahedra are almost invisible. When required for examination by polarised light, these and other crystals should be put up in balsam.

On Preserving Crystalline Compounds obtained from Urine.—It is exceedingly difficult to preserve many of the crystalline substances obtained from urine in a moist state; but several of them form beautiful microscopic objects when carefully dried. *Urea*, *nitrate of urea*, *oxalate of urea*, *creatine*, *creatinine*, *alloxan*, *hippuric acid*, *murexid*, and many others, may be kept as permanent objects in this manner. In order to prepare them, it is better to cause them to crystallise upon a glass slide; allow the mother liquor to drain off, and immediately place the slide under a bell-jar over sulphuric acid. Sometimes the crystals which have formed in a small evaporating basin, may be well drained and dried, and a portion of them removed to a glass cell, and covered with a piece of thin glass to exclude the dust. Many crystals may be examined and preserved for a considerable time in their own mother liquor, especially when they are very slightly soluble in fluid; but, as a general rule, this plan does not answer very satisfactorily, for, independently of the escape of the fluid from the edges of the cell, a few of the largest crystals grow still larger at the expense of the smaller ones, and the beauty of the specimen is destroyed. The different forms of these crystals as they appear in the microscope, are given in the "Illustrations of Urine," pls. I to XII, p. 130 to p. 160.

OF EXTRANEOUS MATTERS.

Importance of recognising Extraneous Matters.—In the microscopical examination of urinary deposits, the observer often meets with substances the nature and origin of which he cannot readily determine. This is due, in many instances, to the presence of bodies which have fallen in accidentally, or which have been placed in the urine for the express purpose of deceiving the practitioner. The importance of recognising matters of an extraneous origin can scarcely be sufficiently dwelt upon, for until the eye has become familiar with the characters of the substances, it will obviously be quite impossible to derive such information from a microscopical examination of the urine as will enable the observer to distinguish between those bodies, whose presence denotes the existence of certain morbid conditions, and certain matters which have accidentally found access, which, clinically speaking, may be entirely disregarded. Practitioners who use the microscope for investigating the nature of urinary deposits, will derive advantage from subjecting many of the substances referred to, separately to microscopical examination, so that, when met with in the urine, their nature may be at once recognised. As most of the undermentioned substances are readily obtained and easily subjected to examination, a brief notice of their character will be sufficient. Attention should be especially directed to the fact of the frequent occurrence of many of these extraneous substances in urine, and the observer should particularly notice those characters in which they resemble any insoluble substance derived from the bladder or kidney, or deposited from the urine.

The following are some of the most important of these extraneous matters which have fallen under my own notice :—

Human hair.	*Splinters of wood.*	*Wheat starch.*
Cat's hair.	*Portions of feathers.*	*Rice starch.*
Blanket hair.	*Fibres of silk.*	*Tea leaves.*
Worsted.	*Milk.*	*Bread crumbs.*
Wool.	*Oily matter.*	*Chalk.*
Cotton and flax fibres.	*Potato starch.*	*Sand.*

The microscopical appearances of some of these substances are given in the "Illustrations of Urinary Deposits," pls. I to IV. It would hardly be believed what curious and unexpected substances are sometimes found in the urinary secretion. Some time since, a specimen of urine was sent for examination, which contained several white bodies, about half-an-inch in length, like maggots. Upon microscopical examination, I found that these contained tracheæ, and they ultimately proved to be *larvæ of the blowfly*, although it had been stoutly affirmed that they had been passed by the patient from his bladder.

Sesquioxide of Iron.—A few years ago, Dr. Stewart informed me that a man had brought some urine to him for examination, with a thick brick-red deposit, which was analysed by Prof. Taylor, and proved to consist of sesquioxide of iron. The urine containing this deposit was of specific gravity 1,011; and upon the addition of ammonia, a brown flocculent precipitate (hydrated sesquioxide of iron) was thrown down. Dr. Stewart tells me that a considerable quantity of the powder (jeweller's rouge, or sesquioxide of iron) remained suspended in the urine after it had stood for many hours, and that the fluid was still turbid after it had been passed through a double filter. The man who brought this urine has been endeavouring for some time to impose upon different hospital physicians.

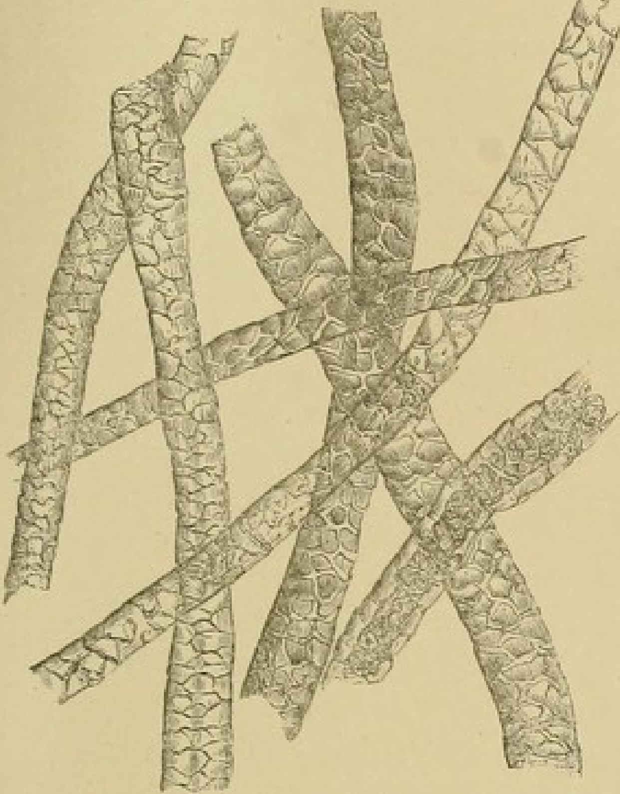
Hair of various kinds is very frequently found amongst urinary deposits, but, as its microscopical appearance is so well known, it is not necessary to enter into a description of the characters by which it may be distinguished. The varieties of hair most commonly found are human hair, blanket hair, and cat's hair. Not unfrequently portions of coloured worsted will be met with; but the colour alone will often remove any doubts with reference to the nature of the substance. Portions of human hair are sometimes liable to be mistaken for transparent casts of the uriniferous tubes, which are quite destitute of epithelium or granular matter, and which present throughout a homogeneous appearance. The central canal, with the medullary cells within it, in many cases, will be sufficient to distinguish the hair from every other substance likely to be mistaken for it, pl. I, fig. 2; but sometimes this cannot be clearly made out, and the marks on the surface may be indistinct; when attention must be directed to its refracting power, well-defined smooth outline, and also to the sharply truncated or fibrous ends, or to its dilated club-shaped extremity in the case of the hair-bulb. In the latter points, small portions of hair will be found to differ from the cast, for this latter does not refract so strongly; the lines on each side are delicate, but well defined, and the ends are seldom broken so abruptly as in the case of the hair. Cat's hair (pl. I, fig. 3) can scarcely be mistaken for any urinary deposit with which I am acquainted, and its transverse markings will serve at once to distinguish it with certainty.

Cotton and Flax Fibres are very often found in urine, pl. II, figs. 6, 7. When broken off in very short pieces, they may be mistaken for casts; but the flattened bands of the former (fig. 22 *c*), and the somewhat striated fibres of the latter (fig. 22 *d*), will generally be found sufficiently characteristic.

Portions of Feathers are often detected in urinary deposits upon microscopical examination, and are derived, no doubt, from the bed or pillow, pl. II, fig. 8. The branched character of the fragments will always enable the observer to recognise them with certainty, pl. IV, fig. 22 *g*.

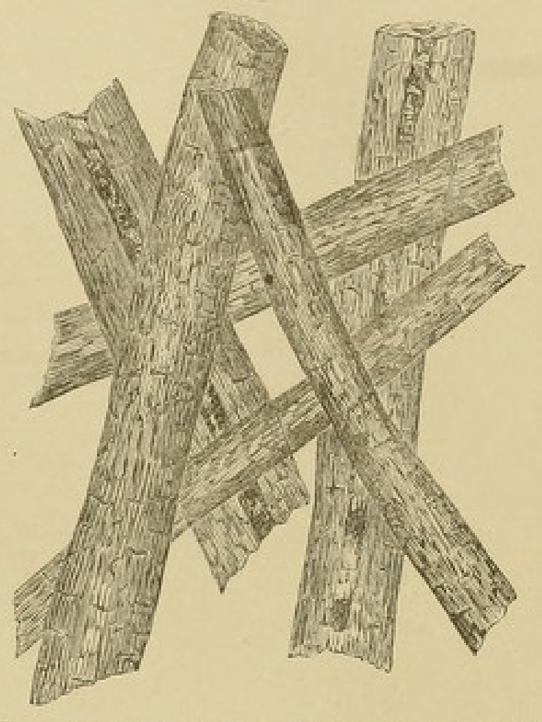
URINARY DEPOSITS.—EXTRANEOUS MATTERS.

Fig. 1.



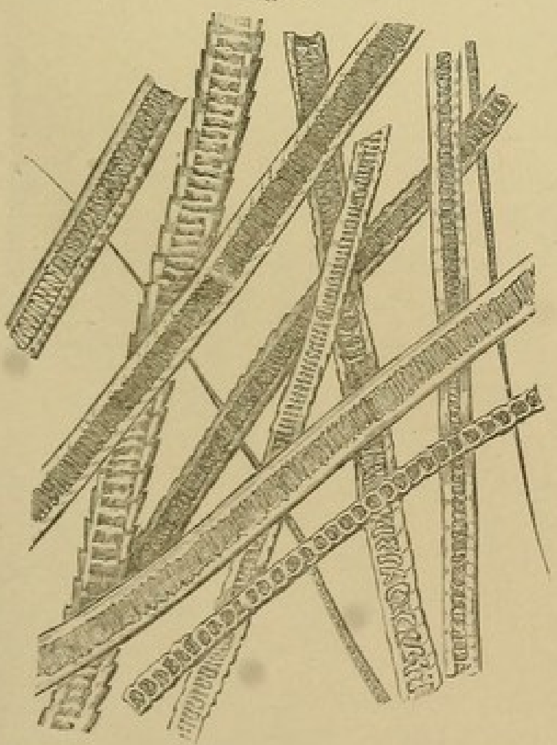
Portions of hairs from a blanket. × 130. p. 294.

Fig. 2.



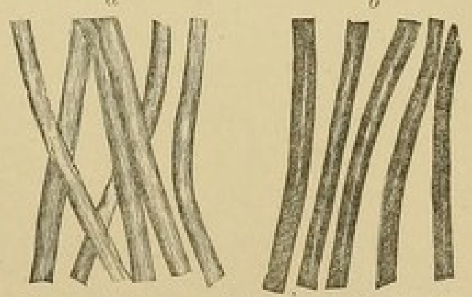
Fragments of human hair In two the central canal occupied with the soft cells of the medulla is represented. × 130. p. 294.

Fig. 3.



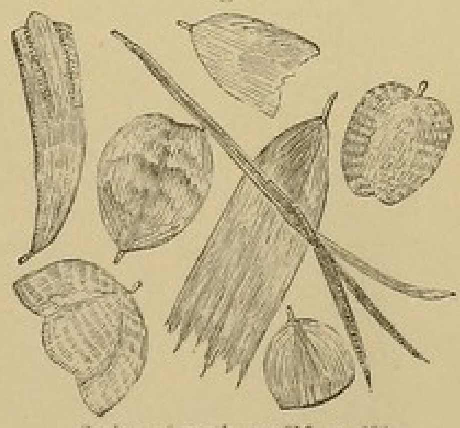
Fragments of cat's hair. Some of them near the apex, and others close to the root of the hair. × 130. p. 294.

Fig. 4.



Fibres of silk. a. white silk; b, black silk. × 215. p. 295.

Fig. 5.



Scales of moth. × 215. p. 295.

$\frac{1}{1000}$ of an inch ⌴ × 130.

" " ⌴ × 215.

[To face page 294.

Pieces of Silk are not unfrequently present, but these can scarcely be mistaken for any substance derived from the kidney or urinary passages. Their smooth glistening appearance and small diameter, at once distinguish them from small portions of urinary casts, and their clear outline and regular size from shreds of mucus, &c.

Fibres of Deal from the Floor.—Of all the extraneous matters likely to be met with in urine most calculated to deceive the eye of the observer, none are more puzzling than the short pieces of single fibres of deal, pl. II, fig. 9. In hospitals, where the floor is uncovered, and frequently swept, portions of the fibres of the wood are detached, and, being light, very readily find their way into any vessel which may be near. In fact, these fibres enter largely into the composition of the dust which is swept up. I was familiar with the appearance of these bodies for a long time before I ascertained their nature; for, although the peculiar characters of coniferous wood are sufficiently well marked, when only very small portions are present, and in a situation in which they would scarcely be expected to be met with, their nature may not be so easily made out. Often only two or three pores may be seen, and not unfrequently these are less regular than usual, in which case they may be easily mistaken for a small portion of a cast with two or three cells of epithelium contained within it. I have very frequently met with these fibres amongst the deposit of various specimens of urine which have been obtained from private as well as from hospital patients.

Starch Granules are very commonly found in urinary deposits, and indeed in all matters subjected to microscopical examination; usually their presence is accidental, but large quantities of starch have often been added for purposes of deception. Their true nature may be discovered, either by their becoming converted into a jelly-like mass on being boiled with a little water in a test-tube, by their behaviour upon the addition of free iodine, or by their well-defined microscopical characters. Certain cases have been recorded, in which it was maintained that the starch granules present in the urine had passed from the kidney; but it need scarcely be said that such an origin is very improbable, if not quite impossible. In cases where due care has been taken to prevent the access of starch globules after the urine has been passed, none were observed. We learn by experience that we can seldom receive the statements of patients upon these matters, however positive they may be. They often deceive themselves as to the actual occurrence, in their own case, of what never has occurred and never can occur. The three kinds of starch most likely to be met with in urine are potato starch, pl. III, fig. 11, wheat starch, figs. 12, 15, and rice starch, fig. 13. They are readily distinguished by microscopical examination. Small portions of potato, or pieces of the cellular network in which the starch globules are contained, have been occasionally met with, fig. 16

Under the head of starch may also be included bread-crumbs, fig. 15, which are very commonly present in urine, and have a very peculiar appearance, which may be so easily observed, that a description would appear superfluous. Many of the starch-globules will be found cracked in places, but their general characters are not otherwise much altered.

Portions of Tea-leaves are occasionally found in urine, pl. IV, fig. 17. The beautiful structure of the cellular portions, and the presence of minute spiral vessels, distinguish this from every other deposit of extraneous origin. A small piece of a macerated tea-leaf will be found to form a most beautiful microscopic object.

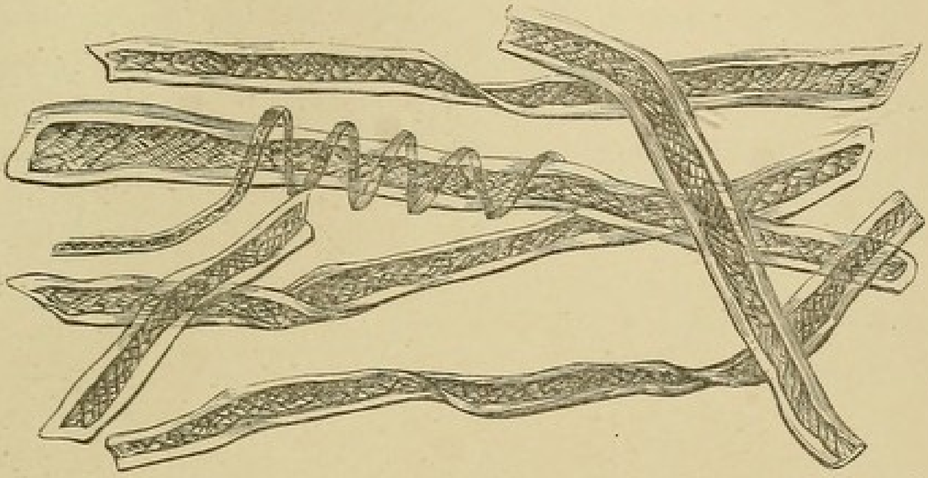
Dust is a very common urinary deposit, and in this "dust" are found many of the extraneous matters already mentioned, as well as small particles of soot, fig. 10, starch-globules, portions of hair, filaments of thread, and occasionally the scales from the wing of the common clothes moth.

Milk and certain Colouring Matters are sometimes purposely added to urine, with the intention of deceiving us. Colouring matters, such as logwood and indigo, when taken into the stomach may be absorbed by the vessels, and eliminated from the system in the urine. A form of indigo, there can be no doubt, is actually produced in the urine. *See* p. 148, and fig. 8, pl. I A *opp.* p. 148.

Urine, to which milk has been added, can be distinguished from the so-called chylous or milky urine by its microscopical characters. The presence of small oil globules, with a well-defined dark outline, can always be detected in milk by the aid of the microscope, while in chylous urine nothing but a great number of very minute and scarcely visible granules, composed of fatty matter can be made out. I have had several specimens of milky urine sent to me for examination, upon the supposition that they were examples of chylous urine, and in some the milk had been added in sufficient quantity to yield a firm curd, after standing for a day or two, and a precipitate upon the addition of acetic acid. Where only a very small quantity of milk is added, the difficulty of deciding positively is greatly increased. The globules are, I believe, characteristic. Some cases of chylous urine are recorded, in which the fatty matter existed in distinct globules; and therefore we cannot unfortunately lay it down, that in *all* cases of this disease the fatty matter is in a *molecular state.* In the six or seven true cases of chylous urine, which have been brought under my own notice, the fatty matter was in this very minute state of division; and in several supposed ones, in which *oil globules* were present, they were proved to have resulted from the addition of milk for the purpose of deception, or from the use of an oiled catheter. Every microscopical observer should also be familiar with the appearance of oil globules under the microscope.

URINARY DEPOSITS.—EXTRANEOUS MATTERS.

Fig. 6.

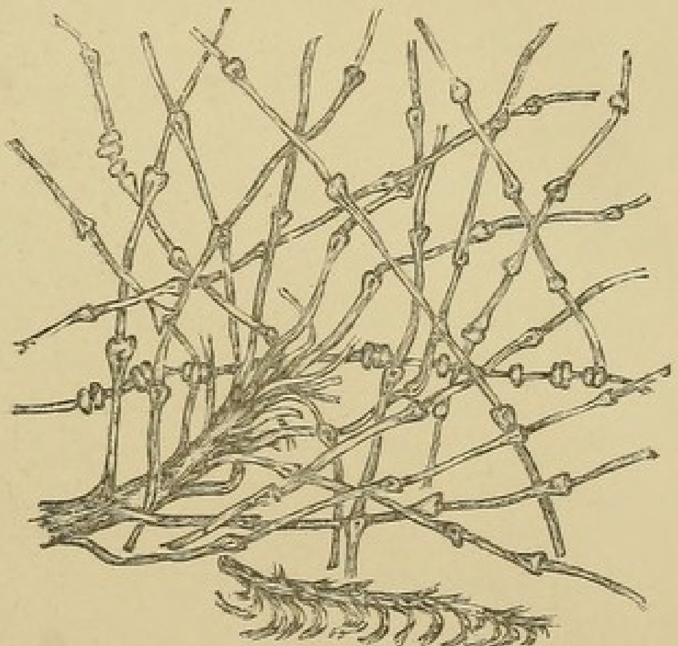


Cotton fibres. A very small fibre in the upper part of the figure is seen to be twisted round a larger one. × 215. p. 294.

Fig. 7.

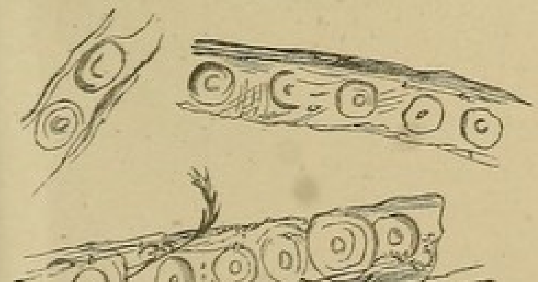
Portions of flax fibres. × 215. p. 294.

Fig. 8.



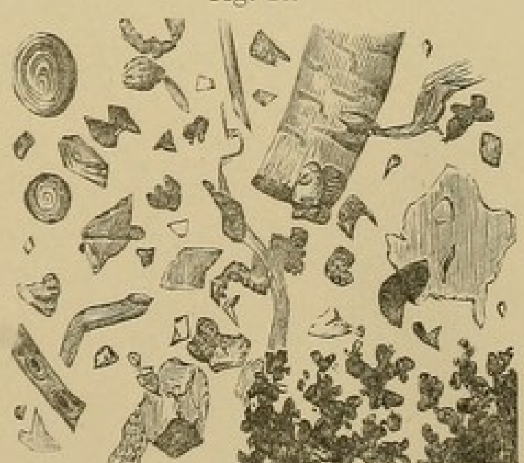
Portions of feathers. The knotted pieces represented are obtained from the lower part of the shaft of the feather. × 215. p. 294.

Fig. 9.



Fibres of deal wood, swept from the floor. × 215. p. 295.

Fig. 10.



Elements of dust swept from a shelf. × 215. p. 296.

$\frac{1}{1000}$ of an inch |____| × 215.

Sputum : Epithelium from the Mouth : Vomit. It must be remembered, too, that the epithelium from the mouth is often found in urine. All the cells met with in sputum are occasionally found, and a vast number of different substances, which are rejected by vomiting, are from time to time detected. The observer must not be surprised at finding now and then some well-defined elementary fibres of striped muscle, fig. 24. It is most difficult to prevent these different substances from being mixed with urine. They often cause the microscopist some trouble, and before the eye has become quite familiar with their appearance, they are likely to give rise to the greatest confusion, and lead the observer, unfamiliar with their appearance, to make the most ludicrous mistakes.

SUBSTANCES FLOATING ON THE SURFACE OF THE URINE, OR DIFFUSED THROUGH IT, BUT NOT FORMING A DEPOSIT.

Thin Pellicle formed upon the Surface of Urine.—Several different substances are found from time to time floating on the surface of urine; but, for the most part, these are merely buoyed up by a thin pellicle, which is probably formed by the action of the air upon some of the constituents of the urine and their decomposition. Earthy phosphates mixed with organic matter may form a thin pellicle, in which crystals of triple phosphate are numerous. Some of these are often exceedingly minute, although they exhibit their well-known characters. A similar pellicle may always be formed, if urine be somewhat concentrated by evaporation; but in this case a large quantity of urate of soda is entangled in it. The urate crystallises in the form of small spherical masses, from all sides of which little spicules project, "Illustrations of Urinary Deposits," pl. V, fig. 25, p. 312. Sometimes uric acid is also present.

Fatty matter is occasionally found floating upon the surface of urine. One form has been described under the name of kiestein, and this it has been said is constantly present in the urine of pregnant women.

It must, of course, be borne in mind that fatty matter often gets into the urine accidentally.

Opalescent Urine.—The turbidity or opalescence of urine is most frequently due to the presence of urates in an exceedingly minute state of division. The precipitate may be so fine and buoyant that it will not sink to the bottom and leave a clear supernatant fluid. The urine may be perfectly clear when passed and become turbid afterwards. If upon the application of a gentle heat the turbidity is instantly removed, we may be sure of the presence of urate. In urine of high specific gravity, many substances are held in suspension which would form a deposit in fluids of the usual density. It is not uncommon to meet with pus or blood thus diffused through the urine. If ordinary mucus be present in unusually large proportion, many substances which would otherwise form deposits will be buoyed up as it were, and evenly diffused through the fluid instead of subsiding.

Opalescence produced by Vibriones.—Some specimens of urine become decomposed very soon after they have been passed; others are voided in a state of incipient decomposition. The urine looks as if it had been mixed with a very small quantity of milk. Upon microscopical examination, it will be found that this turbidity depends entirely upon multitudes of some of the lowest organisms, consisting of different forms of fungi and other little elongated bodies termed vibriones, which are considered by some authorities to be of an animal, by others of a vegetable nature.

Milk is sometimes added to urine for the purpose of deceiving us. It is of course diffused through the fluid, and the degree of opalescence varies according to the quantity of milk added. Milk can always be detected upon microscopical examination by the presence of the numerous oil globules, and by the circumstance of the milky fluid becoming quite clear after agitation with a little ether and a few drops of acetic acid or carbonate of potash, by which the envelopes of casein around the globules will be dissolved, and thus the oily matter exposed to the solvent action of the ether. By the addition of a little acetic acid to urine containing much milk, the casein may be precipitated.

It is astonishing with what pertinacity some patients adhere to the statement that the milk which we detect has really been passed in the urine, in spite of its true nature having been demonstrated most conclusively. A case was brought under my notice, some time since, of a young girl, who convinced all her friends that she passed more than a pint of milk and water a-day in the form of tears! The fluid was proved to be milk, and in it were found epithelial cells from the mouth. It was long before the patient could be prevailed upon to admit that she had been imposing upon her friends.

Oil, it must be remembered, is often found in urine in the form of free globules, and invariably, of course, after the use of an oiled catheter. Butter and other fatty matters sometimes fall into the urine accidentally. *See* p. 296, and pl. IV, figs. 19, 20.

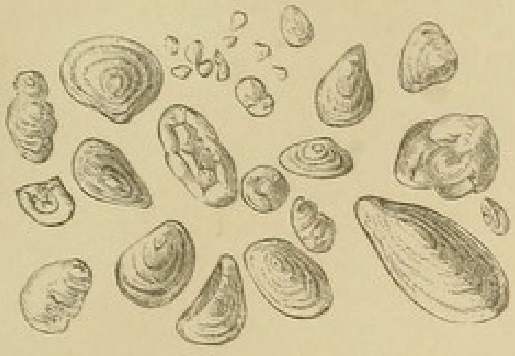
Fatty Matter in Urine.

The different conditions in which fatty matter has been found in urine, may be summed up under the following heads:—

1. *In a molecular state*, as in chylous urine.
2. *In the form of globules*, as when oil, fatty matter, or milk, have been added to urine.

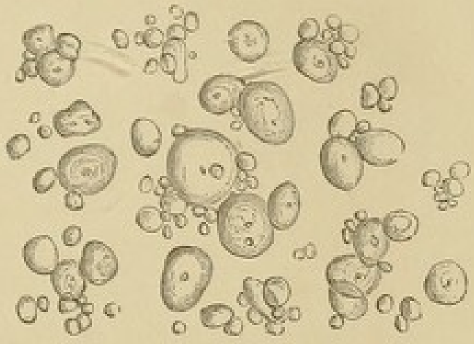
URINARY DEPOSITS.—EXTRANEOUS MATTERS.

Fig. 11.



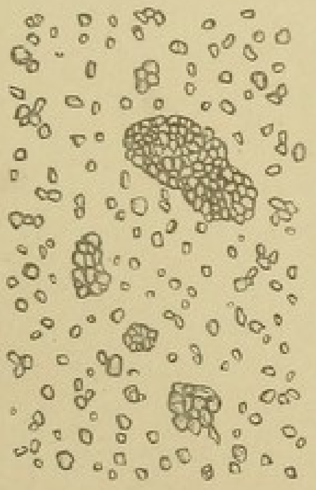
Potato starch. Its appearance in water. × 215 p. 295

Fig. 12.



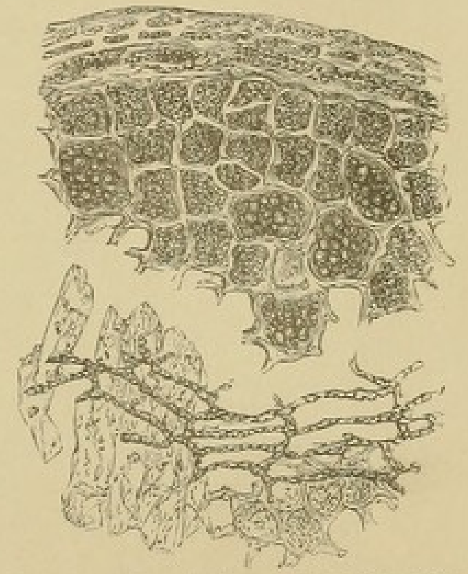
Wheat starch in water. × 215. p. 295.

Fig. 13.



Rice starch in water. × 215. p. 295.

Fig. 14.

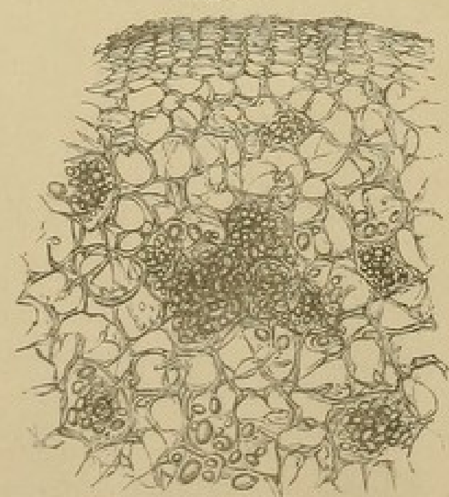


Testa and inner tunics of the wheat grain. × 130 p. 295.

Fig. 15.

Bread crumbs in water. The starch granules are swollen and softened, but still preserve their form. × 215. p. 295.

Fig. 16.



Cells of tissue of potato, in which the starch is contained. A few of the cells are filled with starch granules. × 40. p. 295.

$\frac{1}{1000}$ of an inch |__| × 130.

„ „ |___| × 215.

3. *In the form of globules,—a,* free in the deposit, *b,* enclosed in cells (fat-cell), or, *c,* entangled in casts.

4. *Dissolved* in small quantity by other constituents, so that its presence can only be detected by chemical examination.

5. *In the form of concretions* (urostealith, as in a case given by Heller and in one or two others.) *See* p. 314.

6. *In a fluid state,* of which two cases are reported by Dr. C. Mettenheimer. *See* p. 315.

CHYLOUS URINE.

The most important substance which gives to urine an opalescent appearance, and makes it look as if milk had been added to it, is fatty matter in a state of extremely minute division—in a *molecular state,* as it has been termed. Such urine, under the microscope, is seen to contain a considerable quantity of very minute particles, exhibiting active molecular movements, and a few small granular cells very much like white blood or chyle corpuscles, pl. V, fig. 26, p. 312. These minute particles are not altered by a moderate heat, but are in great measure dissolved, if the urine be agitated with ether. Urine possessing these characters is termed chylous urine. Blood is often found in it, and this gives to the urine a pinkish hue. Cases of chylous urine are very seldom met with in this country, but they are comparatively common in Brazil, Cuba, the West Indies, the Mauritius, and India. The following interesting case occurred in the practice of my friend Mr. Cubitt, of Stroud, to whom I am indebted for the notes, and also for the specimens of urine which I analysed.

Mr. Cubitt's Case of Chylous Urine.—"Mrs. S., aged 50, native of Norfolk, in which county she had always resided, has been married twenty-nine years, and has had five children, the last of whom died in its second year. The youngest now living is 20. The catamenia ceased at 43.

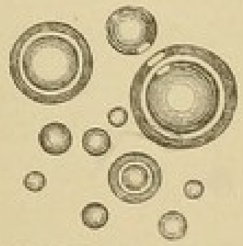
"Till within the last four years, she has usually enjoyed good health, but at that time had a severe attack of influenza. She continued more or less out of health during the six or nine following months, and soon after this period her urine assumed a milky appearance, which character it has retained up to the present time (November, 1849), except at intervals of unfrequent occurrence and of short duration. The disorder would seem to have been gradually progressive, as the urine, which was at first only turbid and opalescent, has become by degrees more and more opaque, so that when I saw it, the unassisted eye could not distinguish between it and milk; moreover, after the lapse of a few days, a rich kind of cream rises to the surface. It is almost entirely free from any urinous odour, and has a faint, sweetish smell, something resembling that of ripe apples. In the mean time, the general health has been more and more failing, and the digestive functions imperfectly performed; the patient has complained of loss of appetite, pain at the epigastrium after eating, slight headache with nausea, palpitations, and other dyspeptic symptoms. She has been losing flesh, suffers from pain in the back and loins without tenderness, from aching of the limbs, incapability of exertion, and other evidences of general debility; but still when the duration of the disease is taken into account, the general health may, upon the whole, be said to have suffered little. She states that, throughout the affection, fatigue, whether of mind or body, unusual exertion, excitement, late hours, distress, anxiety, immediately render the milky character of the urine more marked. She has been under the care of several medical men, as well as of some professed quacks (none of whom have ever examined the urine), without benefit; nevertheless, she has found that, for the time, brandy and isinglass, or compound spirits of lavender, have never failed to clear the urine, but without at all improving the general health. She seems to derive *temporary relief from all kinds of stimulants.* Occasionally and without any apparent cause, the urine resumes its ordinary appearance, but this is of rare occurrence, and its duration never exceeds two or three days. At no one time has she passed milky urine *during the day*. It is only the urine passed in the morning, after the night's sleep, which has ever presented a milky character. Occasionally, this urine settles down into a tremulous jelly, which takes the shape of the containing vessel, and more than once this spontaneous coagulation has taken place within the bladder itself; and in consequence of the impaction of small masses in the urethra, the patient has suffered from temporary retention of urine. She has tried various kinds of diet, but without any visible effect upon the urine. The quantity secreted appears normal, and there is no unusual frequency of micturition. The appetite has never been inordinate, or the thirst unnatural; the bowels are inclined to be costive. There is nothing remarkable about the state of the skin. She has suffered a good deal from pain in the back and loins, but there is no tenderness in this locality, and the uneasiness seems to depend upon exertion, and appears to be connected with general debility. There has never been any dropsy, and she has suffered from no cardiac or pulmonary symptoms, but such as may be accounted for by the dyspepsia; but I have not had an opportunity of examining the chest. She has never had severe headache, vertigo, vomiting, or other cerebral symptoms. Has never had rheumatism, fever, or any inflammatory attack, has not been salivated, and has no reason to suppose she has suffered from exposure to cold. At the time when I saw her, the tongue was slightly furred, pulse 70, small and soft, respiration 20, and the skin cool; but there was a haggard appearance about the countenance, and

URINARY DEPOSITS.—EXTRANEOUS MATTERS.

Fig. 17.

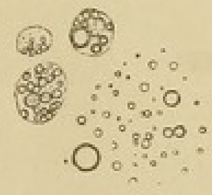
A portion of tea-leaf. Fragments of spiral vessels are seen projecting from several parts of the margin. × 215. p. 296.

Fig. 18.



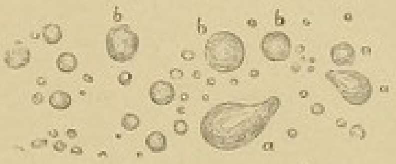
Air bubbles. Appearance in water. × 215.

Fig. 20.



Oil globules. Some free and some contained in cells. × 215.

Fig. 19.

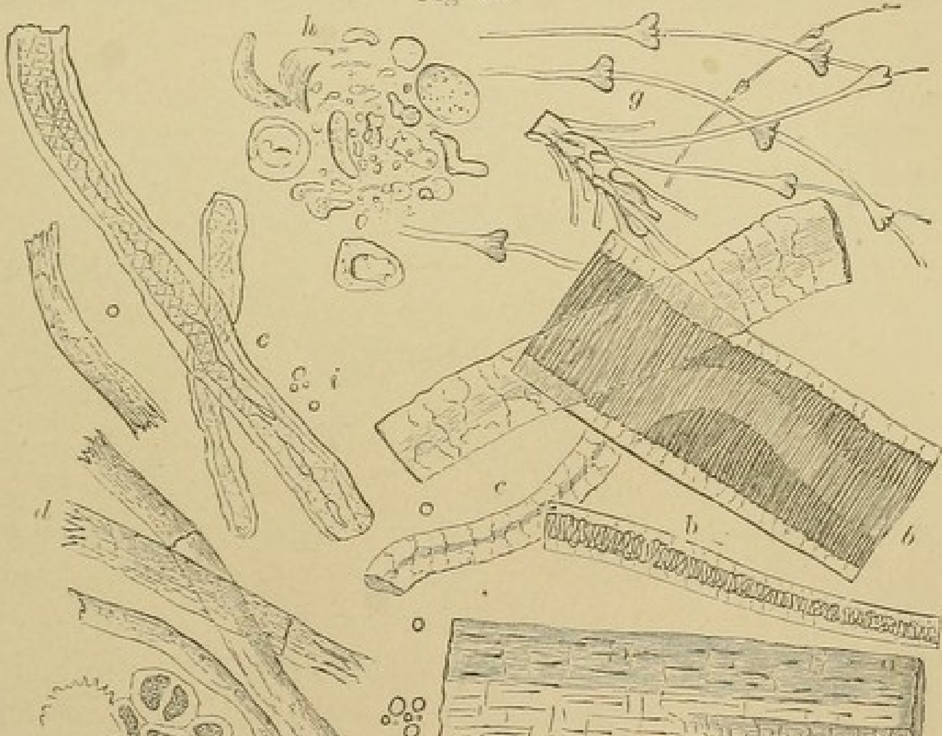


Oil globules. Milk. × 215. p. 296.

Fig. 21.

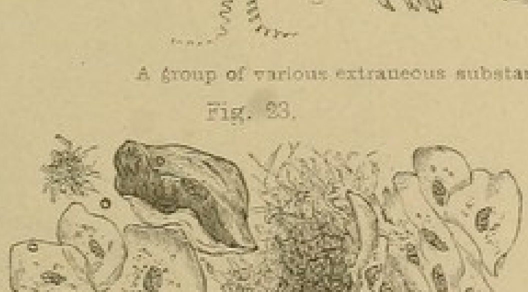
Globules, consisting of phosphate of lime. Urine. × 215.

Fig. 22.



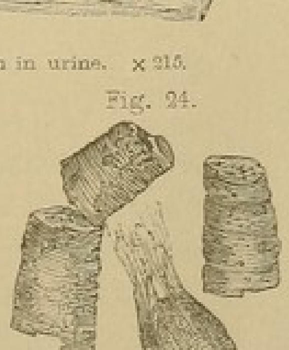
A group of various extraneous substances frequently met with in urine. × 215.

Fig. 23.



Epithelium and fungi from the mouth. × 215. p. 297.

Fig. 24.



Portions of partially digested striped muscle. From vomit. × 215. p. 297.

$\frac{1}{1000}$ of an inch ⌊___⌋ × 215.

[To face page 300.

a dark circle around the eyes, with slight bagging of [the skin in this situation."

Mr. Cubitt enquired as to this patient's state in April, 1857, and informed me that occasionally she passed chylous urine, but only for a short time. The symptoms seem to have become less marked. She has been taking no medicine, and latterly has been in better general health than for several years past.

The first specimen of urine was passed in the morning, *Analysis* 77. It was perfectly fluid, and had all the appearance of fresh milk. It had neither a urinous smell nor taste. Upon the addition of an equal volume of ether it became perfectly clear: but when the ether was allowed to evaporate by the application of a gentle heat, the fatty matter could be again diffused, by agitation, through the urine, which regained its milky appearance, although it appeared rather more transparent than before the addition of the ether. Upon examination, however, by the microscope, instead of the minute *granules* visible in the first instance, *numerous large and well-defined oil globules* were observed.

Specific gravity, 1,013. *Reaction*, neutral.

A little of the urine was evaporated to dryness. The dry residue was very greasy to the touch. It was treated with ether: and, upon evaporating the ethereal solution, a considerable quantity of hard and colourless fat was obtained.

ANALYSES	77		78
Water	947·4		978·8
Solid matter	52·6		21·2
Urea	7·73		6·95
Albumen	13·00		——
Uric acid	——		·15
Extractive matter with uric acid	11·66		7·31
Fat insoluble in hot and cold alcohol, but soluble in ether	9·20	13·9 (9·20, 2·70, 2·00)	
Fat insoluble in cold alcohol	2·70		·0
Fat soluble in cold alcohol	2·00		
Alkaline sulphates and chlorides	1·65		5·34
Alkaline Phosphates	4·66 (both)		1·45
Earthy Phosphates			·15

The second specimen (*Analysis* 78) was passed during the same day. It was slightly turbid, but contained a mere trace of deposit, consisting of a little epithelium, with a few cells larger than lymph corpuscles, and a few small cells, probably minute fungi. Not the slightest precipitate was produced by the application of heat, or by the addition of nitric acid.

Specific gravity, 1,010. *Reaction*, very slightly acid.

The presence of so large a proportion of fatty matter, perhaps, combined with the albumen (13·9 grains) in the first specimen, and its complete absence in the second, which was passed only a few hours afterwards, is very interesting, and bears upon the pathology of this strange condition. The fatty matter was carefully examined for cholesterine but not a trace could be detected. The characters of this substance are described in p. 310.

The proportion of the constituents in 100 grains of the solid matter of these two specimens of urine, is given in the following table. 77 is the chylous, 78 the clear specimen —

ANALYSES	77	78
Solid matter	100·00	100·00
Urea	14·69	32·78
Albumen	24·71	—
Extractive matter, uric acid...	22·17	35·18
Fatty matter	26·43	—
Alkaline sulphates and chlorides	3·14	25·18
Phosphates	8·86	7·54

Microscopical Characters of the Deposit.—The slight deposit which formed after the chylous urine had been allowed to stand for some time in a conical glass vessel, consisted of a small quantity of vesical epithelium, and some small slightly granular circular cells resembling chyle or lymph corpuscles.

No oil globules could be detected upon the surface of the urine or amongst the deposit, and the fatty matter, which was equally diffused throughout, was in a molecular or granular form. By examining the urine with the highest powers, only very minute granules could be detected. These exhibited molecular movements. Indeed, it may be said that the microscopical characters of this urine closely resembled those of chyle. *See* pl. V, fig. 26.

Only a few of the granular cells could be discovered in the clear specimen, in which there was scarcely any visible deposit.

In a case which occurred in the practice of Mr. Gossett, and which is related by Dr. Golding Bird, an alternation in the character of the urine similar to that noticed in the present case occurred. As in this case, the urine which was passed in the morning was *chylous*, while that secreted some hours afterwards was *clear*, *pale*, *and transparent*. The clear specimens, however, contained albumen. The chylous specimen which I examined did not coagulate spontaneously, as often occurs in these cases. In the case reported by Dr. Bence Jones, specimens of urine were frequently passed which were perfectly clear.

L'Hèretier, and the late Dr. Franz Simon, of Berlin, state that these specimens of milky looking urine contain *oil globules;* but the greater number of authors who have met with such cases have like myself failed to detect oil globules in the urine. In the instance under consideration they were certainly absent, and the fatty matter existed in a molecular form only. In Dr. Bence Jones' case, *oil globules* were found in one or two instances; but in other specimens the fatty matter was present in a molecular state. Dr. Waters states that *oil globules* were present in the urine in a case he had under his care, and that the urine contained mucus and pus corpuscles.

In true cases of chylous urine, the fatty matter, in a molecular state, seems to escape at once into the urine; while in cases of fatty degeneration of the kidney, in which *actual globules* are observed, the fatty matter exists in the interior of the cells, where it remains a sufficient time to become converted into distinct oil globules. Globules thus formed may afterwards become separated from each other, and may appear in the urine as free oil globules. Such *oil globules* make their appearance in all cells which have been kept for some time in 'preservative fluids.' The change in question is unfortunately too familiar to microscopists. It would seem to show that the oil globules result from the decomposition of matter which, under the conditions present in the healthy living body, would be resolved into perfectly soluble constituents, and it is not improbable that when this change occurs in cells in the living body, it is due to diminished activity of the chemical changes, and especially to diminished oxidation.

After chylous urine has been allowed to stand for some time, the granular fatty matter may become aggregated in masses, so as to form distinct oil globules.

Dr. Bence Jones' Cases.—In a case of albuminous and fatty urine, reported by Dr. Bence Jones ("Medico-Chirurgical Transactions," vol. XXXIII), oil globules and streaks of oil were detected upon the surface of the urine which was passed in the morning, by microscopical examination. In two other specimens passed later in the day, fatty matter in a molecular form, but no oil globules, was discovered. Upon standing, a coagulum formed in the urine. These specimens contained about 50 grains of solid matter in 1,000 of urine. The patient was a Scotchman, aged 32. His work was hard, and he was subject to privations. The urine was first observed to be thick and white about Christmas, 1848; and at this time the chief symptom from which he suffered, was acute pain in the loins.

Lehmann is, as far as I know, the only observer who states that chylous urine never owes its opacity to fat ("Physiological Chemistry," vol. III, p. 544). I have now seen and heard of several cases, and in *every one* the opacity was due to *fatty matter*. Authorities generally are quite agreed upon this point; but some state that the fat is sometimes in the form of *globules*. In the cases I have seen, it was in a *molecular state* only.

The following are two analyses of the urine in Dr. Bence Jones' case. The first was made on October 19, 1849, and the second was passed some time afterwards, on the same day on which the patient was bled.

ANALYSES	79	80
Water	955·58	943·13
Solid matter	44·42	56·87
Albumen	14·03	13·95
Urea...	13·26	24·06
Fatty matter	8·37	7·46
Saline residue	8·01	10·80
Loss	·75	·60

The chylous urine contained blood corpuscles. The serum of the blood was not milky, but the blood contained in 1,000 parts 240·03 of solid residue, which contained of fatty matter ·62; fibrine, 2·63; blood globules, 159·3; solids of serum, 78·1. Dr. Bence Jones showed, in some valuable experiments on this case, that during complete rest, albumen was not passed. ("Phil. Trans.," 1850.) The urine was not chylous from February 14, 1850, to October 4, 1851, when it was again slightly chylous. The beneficial change was entirely attributable to gallic acid. At first, twenty grains three times a-day were given, but this was afterwards diminished.

Dr. Bence Jones mentions another case of a gentleman, aged 40, who passed the greater part of his life in the West Indies. The chylous condition of the urine was increased both by mental and bodily exertion. The urine was sometimes clear for several days together, sometimes white after dinner, and clear all the rest of the day. It was more frequently chylous after *animal* that after *vegetable food*.

Dr. Waters' Case.—Dr. Waters, of Liverpool ("Medico-Chirurgical Transactions," vol. XLV, for 1862), reports the case of a young seaman, a native of Bermuda, in whom retention of the urine was caused by the coagulation of chylous urine within the bladder. The urine had the usual characters of chylous urine, but coagulated into a tremulous mass exactly resembling *blanc-mange*. The urine contained blood corpuscles. Analysis 81 shows the composition of the urine in Dr. Waters' case of chylous urine. It was made by Dr. Baker Edwards, of Liverpool. Specific gravity, 1,012. This specimen of urine, it will be observed, contained a certain proportion of albumen, though much less than is met with in many.

ANALYSIS 81.

Water	967·3
Solid matter	32·7
Urea	6·0
Albumen, with traces of uric acid	6·0
Fat	9·9
Vesical mucus	4·5
Animal extractive	4·1
Fixed alkaline salts	2·0
Earthy salts	·2

Dr. Priestley's Case.—The patient was a boy who was only 11 years of age. ("Medical Times and Gazette," April 18, 1857.) He was born at the Cape of Good Hope, and was taken as a child to the Isle of France, and while there had frequent attacks of hæmaturia and chylous urine. The attacks came on at intervals of weeks or months. He was placed, in the autumn of 1855, under the care of Dr. Simpson, of Edinburgh. Various plans of treatment were tried in vain. He was confined to the house, and passed as much as from fifty to fifty-five ounces of chylous urine daily. He gradually became weaker, and died apparently from asthenia. A fortnight before death, the urine lost its milky appearance, and the feet became œdematous. Every tissue appeared bloodless, and there was considerable emaciation. The kidneys were pale, rather larger than natural. Throughout the greater part of both kidneys the epithelium was found to contain numerous oil globules. Dr. Priestley suggests the possibility that this case of chylous urine may have been associated with Bright's disease.

Dr. Carter's Cases.—The observations of Dr. Carter ("Medico-Chirurgical Transactions" for 1862, vol. XLV) are strongly in favour of the view that chyle obtains *direct* entrance into some part of the urinary channels. In three cases reported by him, there was accumulation in the lymphatics. In the first the chyle was occasionally discharged from the cutaneous surface, the urine being unaffected. The opening in the lymphatic vessel, from which the chyle escaped, was situated a few inches below Poupart's ligament, and sometimes a pint could be collected in a day. In the second case there was an external discharge of *chyle,* and the urine was frequently *chylous.* The third was a case of *chylous urine* without any external discharge of chyle.

These cases prove the existence of a dilated condition of the lymphatic vessels. The dilatation clearly extending as high as the thoracic duct, thus allowing the chyle to pass from this tube into the lymphatics. In such a case the tube would be stretched so as to render the valves useless.

Dr. Buchanan's Case of White Fibro-Serous Discharge from the Thigh.—Dr. Buchanan has reported a very interesting case in which a fluid like chyle was discharged from the surface of the thigh, in vol. XLVI of the "Med. Chir. Trans.," 1862. The patient was a woman in humble circumstances, forty-six years of age, pale, but not emaciated. She was weak in consequence of an excessive discharge which could not be cured, from the inner and posterior aspect of the left thigh. The fluid which escaped resembled milk. It flowed from a semi-excoriated surface about the size of the palm of the hand. Over this space were numerous pearly vesicles, and from the excoriations resulting from the rupture of some of these there was a *constant stream* of milky fluid, more copious and more persistent when the patient was in the erect posture and moving about. In the after part of the day, so free was the flow that her "garments were drenched, even through the cloths which were applied to protect them." Five ounces of the fluid were collected in the course of an hour. The affected thigh was much swollen, its girth being nineteen inches, while the opposite limb only measured sixteen inches. The inguinal glands were not enlarged. Variation in the food produced no alteration either in the quantity or quality of the secretion. The patient had had several attacks of phlebitis in the affected limb which commenced after her second confinement. A few vesicles made their appearance about fifteen years ago. The number of these increased on a subsequent attack. She seems to have had many attacks of inflammation of the left inguinal region ushered in by shivering fits. Dr. Buchanan advised the patient to wear an elastic stocking, which relieved her very much although the discharge recurred whenever the pressure was removed.

The discharge resembled chyle. Fibrin coagulated from it. Its specific gravity ranged between 1,011 and 1,015. Bodies like white blood corpuscles were detected upon microscopical examination, and the fluid contained minute particles which exhibited molecular movements and were soluble in ether. Professor Anderson analysed the fluid with the following results. One of my analyses of chylous urine, p. 301, is given for comparison.

ANALYSES	82	83
	Discharge from skin.	Chylous urine.
Water	94·57	94·74
Solid matter	5·43	5·26
Fatty matter	·71	1·39
Albumen	2·88	1·30
Other organic matters ...	·6	1·94
Ash	1·24	·63

Dr. Buchanan refers to records of but three cases similar to his. The first occurred in Germany during the 17th century, and was recorded by Dr. L. Sigismund Grass. The second in the north of France, and is referred to by Haller. The third is related by Dr. Rommel. In the tropics, however, such cases, like those of chylous urine, are far from uncommon.

Dr. Buchanan arrives at the conclusion that this milk like fluid discharged from the thigh must be *white serum from the blood.* He evidently feels the force of the objection, that in this case the serum ought to be milky in every part of the body, and is driven to adopt the remarkable hypothesis that the determination of the fatty matter to the part of the skin from which the white serum transuded depends upon " the morbid activity of multitudes of epithelial cells, the function of which has become perverted." He thinks the sudoriparous glands take a chief part in the process. Dr. Buchanan speaks of Dr. Carter's theory as "anatomically impossible and pathologically unnecessary." It seems to me that his own hypothesis is absolutely untenable. Can Dr. Buchanan bring forward any facts whatever to justify the conclusion that the epithelial cells of the skin, sudoriparous glands and sebaceous glands in a space the size of the *palm of the hand* secrete five ounces of fluid containing more than 5 per cent. of solid matter, in the course of an hour? I cannot help saying that to my mind this appears the least satisfactory of all the hypotheses yet advanced in explanation of this interesting affection.

Of the Nature and Treatment of Chylous Urine.

The very large quantity of fatty matter present in the first specimen of urine, Analysis 77, p. 301, and its total absence in the urine passed only a few hours afterwards, Analysis 78, is remarkable in Mr. Cubitt's case, and confirms the conclusions which previous observers have arrived at with reference to this condition; viz., that the fatty matter appears in largest quantity after the absorption of chyle; although in Dr. Bence Jones' case it did not seem to be associated with any fatty condition of the blood. In Mr. Cubitt's case, we may, I think, conclude that there is no organic disease of the kidneys,—first, from the absence of any symptoms; secondly, from the microscopical characters of the deposit; and, thirdly, from the fact that albumen was only present when the urine contained the fatty matter.

Many of the patients whose cases are recorded, have suffered from severe pain in the region of the kidneys; but this may be accounted for by general debility, associated with this condition of urine, as well as on the supposition of the existence of organic disease of the kidneys. Indeed, the pain referred to in this locality, seems to partake more of the character of muscular pain than of pain seated in the kidneys themselves.

No lesion likely to account for the production of the chylous urine has been met with in the *post-mortem* examinations of the cases of this condition which have been made; and most observers consider that the chylous condition of the urine does not depend upon a morbid state of the kidneys. Dr. Elliotson, on the other hand, inclines to the view that the kidneys are to be regarded as the seat of the affection. He gives the history of a very interesting case in the "Medical Times and Gazette," for September 19, 1857.

Dr. Waters, grounding his conclusions upon the apparent effects of treatment in one case, considers that the disease depends upon "A relaxed condition of the capillaries of the kidneys." He thinks that the fibrin, albumen, fat, and blood corpuscles, simply filter away from the blood vessels. The results of the two analyses recorded on pp. 301, 302, are, however, quite inexplicable upon such a view.

Dr. Carter has remarked, that in some analyses—as, for example, in mine already referred to—the relative proportion of albumen and fatty matter precisely accords with that in chyle, as shown in the following analyses:—

	Rees' Analysis of Chyle.	*My Analysis of Chylous Urine.*
	Per 1000.	Per 1000.
Fatty matter ...	36·01	13·9
Albuminous matter	35·16	13·0

In both the proportions are nearly equal, but chyle varies somewhat in composition, there being sometimes two parts of albumen to one of fatty matter. Dr. Bence Jones' analysis of chylous urine shows a similar relation existing between the fatty and albuminous matters present.

I have long suspected that the chyle passed into the urinary tract by a course more direct than was usually supposed, and the two concluding paragraphs of this section which are left, with the exception of the words in brackets, as in the first edition of this work, clearly show that I considered it important to search for a *direct communication* between the lacteal vessels and the urinary tract. Dr. Carter seems to have misunderstood my observation, that the "chylous character of the urine was intimately associated with the absorption of chyle." The meaning I intended to convey was, that after chyle had been undergoing absorption by the *lacteals of the intestine*, the chylous state of the urine was observed in some of the cases recorded.

The cases of Dr. Carter are exceedingly important, and bear, in a most interesting manner, upon the pathology of chylous urine. There remains, however, the fact to be demonstrated, that coloured fluid injected into the thoracic duct will pass into the pelvis of the kidney, ureters or bladder, in this disease. Post-mortems occur so rarely in this country, that it may be long before an opportunity of making the experiment offers itself.

Upon reviewing the chief points in these and other cases, one is led to conclude that the condition does not depend upon any permanent *morbid* change in the secreting structure of the kidney, and that the chylous character of the urine is intimately connected with the absorption of chyle (by the lacteals ramifying on the intestines.) The debility and emaciation show that the fatty matter, albumen, and other nutritive substances, are diverted from their proper course, and removed in the urine, instead of being appropriated to the nutrition of the system. Whether these materials are separated from the blood by the kidneys, or find their way to these organs by some more direct course, cannot now be decided. Dr. Buchanan's hypothesis that the chylous fluid is formed by a perverted action of the epithelial cells, I consider quite untenable. *See* p. 307.

I trust that practitioners who have opportunities of examining many of these cases in the West Indies, will afford us assistance in endeavouring to ascertain the nature of this curious condition. Careful reports of the most marked cases are much to be desired. In *post-mortem* examinations, the serum of the blood should be collected and allowed to stand, in order to see if it be milky or not. The state of the mesenteric glands, lacteals, and receptaculum chyli, should be particularly examined, and it would be desirable to inject the thoracic duct, first with transparent fluid injection, and afterwards distend it with a little strong size, when the course of the absorbent trunks might be traced, and, if necessary, parts subjected to microscopical examination.

Of the Treatment of Cases of Chylous Urine.—Various plans of treatment have been tried in cases of chylous urine, but without very satisfactory results. Astringents have proved useful in many instances; and in one of Dr. Bence Jones' cases, the pressure of a tight belt "relieved the pain, and rendered the urine slightly less chylous."

Dr. Prout found that in some of his cases temporary relief resulted from the use of mineral acids and astringents, as alum and acetate of lead. Opium also arrested some of the symptoms for a while. Dr. Bence Jones has tried a variety of remedies, but the greatest advantage seems to have been derived from the use of astringents. Tannic acid, acetate of lead, and nitrate of silver, were employed. Matico afforded some relief, but the most valuable remedy in Dr. Bence Jones' hands was gallic acid. Its good effects were probably due to its astringent properties, and not to any specific action. The chylous character of the urine and the albumen disappeared two days after the commencement of the use of this drug; and in one case the patient seems to have been cured by its long continued use. (For the results of a daily examination of the urine for some weeks while the patient was on gallic acid, *see* "Phil. Trans.," 1850.)

In Dr. Priestley's case, the gallic acid caused such nausea that it was considered expedient to abandon its use. Gallic acid was also tried by Dr. Goodwin of Norwich, in a case which came under his care. He says—"Gallic acid appeared to exert great influence in restraining the milky appearance of the urine. The patient took it for about nine months in 1855 and 1856; and I found his water perfectly normal in colour after six months steady use of it in doses of half a drachm three times a-day. He then discontinued its use, and went to work. In four or five days, the same milky appearance presented itself, and was again removed by taking the gallic acid. He could at any time render the urine nearly normal in appearance by taking this drug; but it was necessary to avoid hard work. He only complained of occasional dimness of sight and deafness; but it was not easy to make out to what cause these symptoms were due. He left off attending the hospital in September last, when my note is as follows:—Has not had any gallic acid for three weeks, and the urine is now slightly opaline in appearance. Specific gravity, 1,010; the temperature of air was about 50°. He passes seven pints and a half daily on the average. It does not coagulate with heat or nitric acid, or both combined." Dr. Goodwin has not been able to ascertain anything of the further history of the case. In Dr. Waters' case gallic acid was given in doses commencing at 30 grains a-day, gradually increased to 135 grains a-day, and then gradually reduced. The patient was under treatment less than nine weeks and got quite well. His weight increased from 8 stone 6 lbs., to 10 stone 6 lbs. Four months after his discharge from the hospital he continued in good health. There was no albumen or fatty matter in the urine. The general debility in these cases will be relieved by iron, tonics, and carefully regulated diet.

OF CHOLESTERINE IN URINE.

Composition of Fatty Matter passed in Cases of Fatty Degeneration of the Kidney.—Some years ago (1850), when examining the fatty matter which accumulates in the epithelial cells and casts passed in the urine in great number in some cases of fatty degeneration of the kidney, I was surprised to find that it contained a considerable quantity of cholesterine. The only cases in which cholesterine seems to have been detected in urine, are those which are referred to in Simon's "Animal Chemistry." Gmelin is said to have found cholesterine in the urine in a case in which the flow of bile was impeded; and Möller twice detected it in kiestein, the film which rises to the surface of the urine of pregnant women, and contains sometimes much fatty matter. (Casper's "Wochenschr.," Jan. 11—18, 1845; quoted in Franz Simon's "Animal Chemistry," vol. II, pp. 313, 333.) It is not stated, however, in these cases, if the crystalline form of the crystals was made out; nor is it certain that the matter referred to was cholesterine at all.

Other authorities, among whom is Lehmann, state that cholesterine has never been detected in urine.

The first case which I examined was that of John Ryan, a patient in King's College Hospital, in 1850, under the care of Dr. Todd. The urine was pale, of acid reaction; specific gravity 1,020, and contained albumen. The pale flocculent deposit consisted principally of fat cells.

The deposit from upwards of seven gallons of urine was collected upon a filter. It was dried over a water-bath, and digested in a mixture of alcohol and ether. The solution was filtered, and after being concentrated by evaporation, was allowed to cool. Crystals of cholesterine were found in considerable number. These were subjected to microscopical examination. The fatty matter in this case was composed of at least three distinct forms of fat; but, in consequence of the very small quantity obtained for observation, it was not possible to investigate their characters very minutely. The deposit from this urine contained—

1. A dark brown fat in very small quantity, which was soluble in ether, but insoluble in hot and cold alcohol.

2. A light brown saponifiable fat, soluble in hot but insoluble in cold alcohol.

3. A considerable quantity of pure *cholesterine*, which originally existed in the urine, dissolved in the other fats, pl. V, fig. 28, p. 312.

The next case of fatty degeneration of the kidney submitted to examination was that of a man named Tiedeman, also a patient of Dr. Todd's, in King's College Hospital. The case is published in Dr. Todd's "Clinical Lectures" (Case 107). *See* also "Archives of Medicine," vol. I, p. 8. The fatty matter obtained from twenty-four pints of urine weighed only ·47 grains, but from this a great number of crystals of cholesterine were obtained by extraction with alcohol.

The deposit of the urine of a third case of fatty degeneration of the kidney has been submitted to examination, and cholesterine has been discovered in this instance also.

In another case in which the deposit had been kept for some time in a preservative fluid consisting of naphtha, creasote, and water, the cholesterine had separated spontaneously from the other constituents of the oil globules, in the form of rhomboidal tablets.

The fatty matter deposited in the kidney in these cases also contains a large proportion of cholesterine; and I have detected the presence of cholesterine in the fatty matter of so many organs in a state of fatty degeneration, as to justify the conclusion that the formation of this substance is intimately connected with the changes taking place in this morbid process.

When cholesterine occurs in the urine, it is always dissolved in other fatty matters, so that its presence cannot be detected except by extraction with alcohol and subsequent crystallisation, pl. V, fig. 28. It is one of the constant constituents of the minute fat globules produced in the epithelial cells and casts of the uriniferous tubes, which are so characteristic of this form of kidney disease.

Surprise has often been excited by observing that oil globules passed in the urine in these cases, sink to the bottom of the vessel, when we should expect rather to find the fatty matter rising to the surface by reason of its lightness. That the cell-walls and casts are not the sole cause of this subsidence is proved by the fact that individual globules, quite free from these structures, are frequently found at the bottom of the vessel with the deposit. This subsidence is probably in some measure due to the quantity of the cholesterine entering into the composition of the fatty matter. Crystals of cholesterine sink in fluids of a specific gravity even some degrees above 1,000.

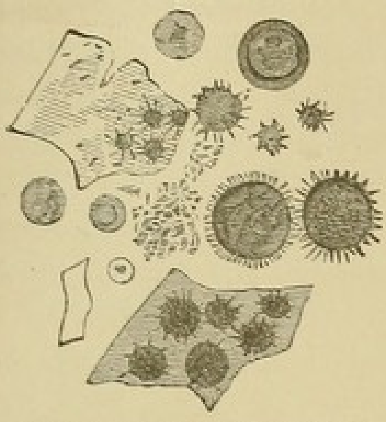
Cholesterine said to be obtained from the Urine in other Diseases.—I have not been able to detect cholesterine in the urine in any other morbid condition than in that above referred to. Although I have at present only searched for it in four cases of fatty degeneration, in consequence of the difficulty of obtaining sufficient quantity of the deposit to work upon, the circumstances which I have enumerated render it very probable that it is a constituent of the fatty matter present not only in the urine in all cases of fatty degeneration of the kidney, but that it is a constant constituent of the fatty matter present in all cells and tissues in a state of fatty degeneration.

It has been stated recently by some observers that cholesterine was to be obtained from the urine in several different forms of disease. Dr. Salisbury ("American Journal of the Medical Sciences," April, 1863) states that he detected cholesterine in eighteen specimens of morbid urine, but he does not appear to have chemically tested the crystals he obtained, which in their general form certainly resembled cholesterine. This observer asserts that from diabetic urine he obtained a very large quantity of cholesterine. From a specimen of diabetic urine, which I examined by the process recommended by Dr. Salisbury, I certainly obtained crystals very much resembling plates of cholesterine, but they were *soluble in boiling water*, and were found to consist of hippuric acid. Dr. Salisbury has not stated if the crystals he obtained were insoluble in boiling water, nor has he shown that they consisted of cholesterine. It has not yet been proved that cholesterine is ever excreted in a state of solution in the aqueous constituents of the urine, and it is very improbable that such a body should be so excreted. (*See* a paper of mine in the "British Medical Journal," 1863.)

I have shown that cholesterine is a very constant constituent of the

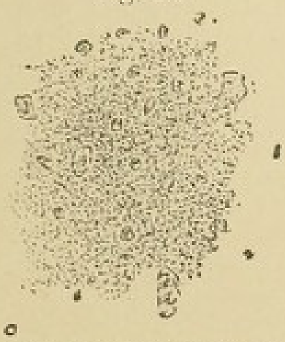
URINARY DEPOSITS.

Fig. 25.



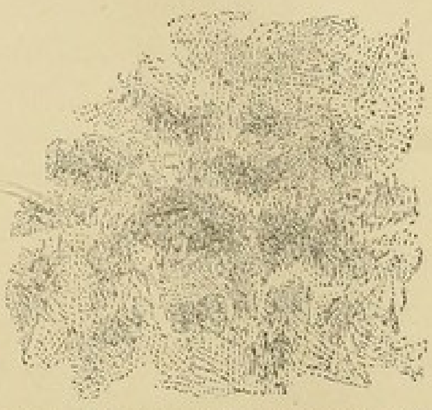
Urate of soda, obtained by concentrating healthy urine × 215. p. 297.

Fig. 26.



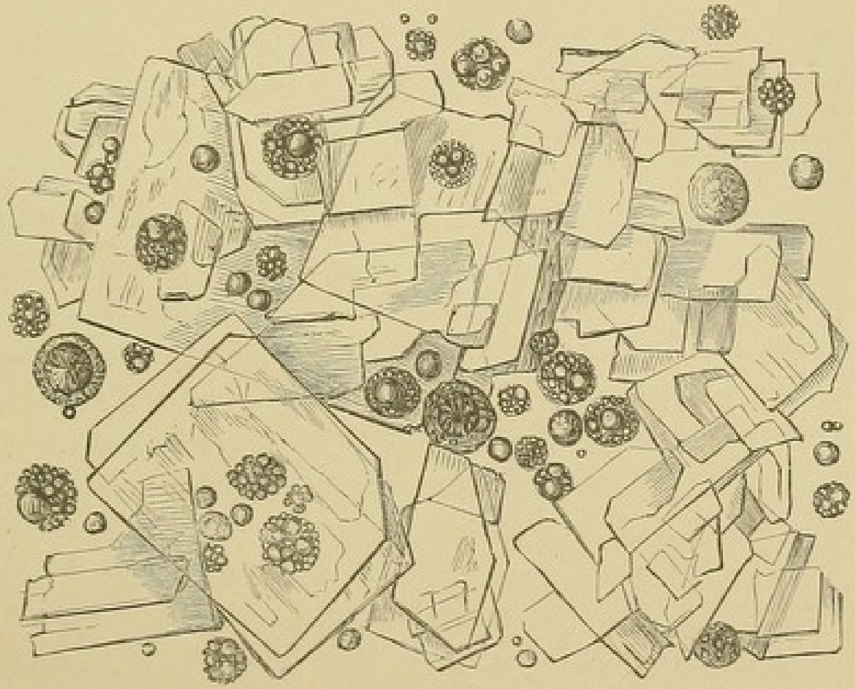
Molecular fatty matter of chylous urine. p. 299.

Fig. 27.



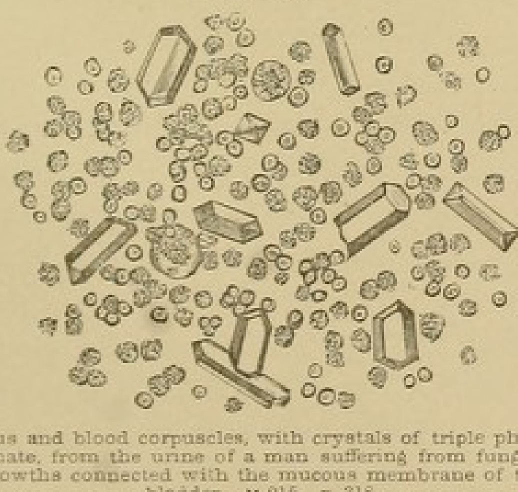
Urate. Ordinary granular deposit, usually termed urate of ammonia. p. 297.

Fig. 28.



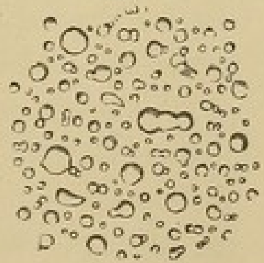
Crystals of cholesterine, obtained from the fatty matter in casts separated from the urine of a case of fatty degeneration of kidneys. × 215. p. 311.

Fig. 29.



Pus and blood corpuscles, with crystals of triple phosphate, from the urine of a man suffering from fungus growths connected with the mucous membrane of the bladder. × 215. p. 318.

Fig. 30.



Oil globules of milk. × 215.

$\frac{1}{1000}$ of an inch |____| × 215.

[To face page 312.

large cells (*granular corpuscles*) containing oil globules, which are abundant in the fluid of *ovarian dropsy, and sometimes in hydrocele*, and in that found in cysts generally;* in similar cells, which are common in *sputum*, and are derived from the surface of the mucous membrane of the bronchial tubes; in the cells which are frequently very numerous about the *small arteries of the brain* in cases of *white softening*, in those found in cases of the so-called *fatty degeneration of the placenta*, and in other situations.

Cholesterine is not specially *formed* in the liver, nor can it be regarded as a special excretion separated from the blood by the liver. It is probably a substance of far less importance physiologically and pathologically than Dr. Flint and Dr. Salisbury are disposed to think. Nor is there reason to believe that the cholesterine found in the nerves is constantly being removed. It exists in largest proportion in the fatty matters of which the white substance of the nerve-fibres is composed, and there is no reason for believing that this white substance undergoes active change. It is true cholesterine and the allied lipoid, or not-saponifiable fatty matter, serolin, are found in the blood, but only mere traces are present. It is probable that these substances result from the disintegration of some of the tissues, but there is no reason for assuming that either of them perform any very important office, or that certain important symptoms sometimes present are due alone to excess of cholesterine in the blood. I cannot admit that Dr. Flint has made out "a new excretory function of the liver," consisting of the removal of cholesterine from the blood, or that he is justified in introducing the term "*cholesteremia*" as applicable to a newly discovered disease. Every one knows that cholesterine is one of the constant constituents of bile; but, to assert that the symptoms occurring in fatal jaundice, depend upon the poisonous effects of an insoluble substance like cholesterine accumulating in the blood, is not justified by the facts. The symptoms have been explained much more satisfactorily already, without resorting to such an hypothesis, (*see* Dr. Flint's paper—"American Journal of the Medical Sciences," October, 1862).

Kiestein.—Of this peculiar substance I can give no very satisfactory account. Some years since numerous observations were made by Nauche, and repeated by Dr. Golding Bird and several other observers, with the view of ascertaining if there was any foundation for the statement that, in pregnant women, certain elements of the milk found their way into

* The bodies described as *granular corpuscles*, *inflammation globules*, *compound granular cells*, *exudation corpuscles*, and known by other names, are really composed of a number of minute oil globules, aggregated together in the form of a spherical mass which not unfrequently becomes invested with albuminous matter, resembling a cell-wall; but I believe that usually the albuminous material is deposited with the oil globules, and therefore that no true envelope or *cell-wall* exists.

the urine, and, after the lapse of a short time (twenty-four hours to five or six days), a thin pellicle, consisting of fatty matter, a substance allied to casein, and crystals of triple phosphate, formed upon the surface. Some went so far as to say that the presence of this pellicle was sufficient to indicate the existence of the pregnant state. This statement has, however, long since been proved to have no foundation in actual observation. In some of the cases brought forward by Dr. Golding Bird, the pellicle was absent; in others, the pellicle was observed; and the conclusion he arrived at was, that, in cases in which the pellicle was formed, it was due to the presence of certain constituents of the milk, which, from not escaping from the gland in the usual way, had been reabsorbed and separated from the blood by the kidneys.

I have not unfrequently seen a pellicle composed of animal matter, in which vibriones and fungi were abundant, and crystals of triple phosphate, formed upon the surface of various specimens of urine which had been left to stand for a day or two, both from the male and from the female. Whether this is exactly the same sort of pellicle as that said to form upon the urine of pregnant women, I cannot say; but it possessed the characters usually assigned to the so-called kiestein. The animal matter has not been satisfactorily isolated, and is in many cases undergoing decomposition. In the absence of more exact information, we can attach no importance whatever to the presence or absence of this pellicle in the diagnosis of pregnancy. It may be absent in the pregnant state; and it may be present in the male, and in the unimpregnated, as well as in the impregnated female.

OTHER FORMS IN WHICH FATTY MATTER OCCURS IN URINE.

Urostealith.—Dr. F. Heller reports a very remarkable case, in which small concretions, composed of fatty matter, were passed in the urine. The patient was a man, twenty-four years old, who suffered from symptoms of stone in the bladder. He passed several small solid bodies, which were found by Dr. Heller to consist of a peculiar form of fatty substance, to which he gave the name of urostealith. The man, who was treated with carbonate of potash, got quite well in a fortnight (quoted in Dr. Golding Bird's work, edited by Dr. Birkett, p. 422; Heller's "Archiv," 1844, s. 97, 1845, s. 1). Dr. Moore, of Dublin, has confirmed Heller's observations on urostealith. He examined specimens of this curious substance, which he received from Dr. Robert Adams, of Dublin, and Dr. Little, of Sligo ("Dublin Quarterly Journal of Medical Science," May, 1854, vol. XVII, p. 473). I have had two or three specimens of solid fatty matter sent me, which were stated to have been passed in the urine, but the evidence was not conclusive. It was not certain, in one case, if the pellets of fat passed along the urethra at all; and, in others, it was not proved that they were not passed up in the first instance.

Fluid Yellow Fat and Oil Globules.—Dr. C. Mettenheimer gives two cases in which large quantities of fluid yellow fat were passed in the urine. The first was a man suffering from cancer of the lungs, who was taking a tablespoonful of cod-liver oil twice a-day. The second was that of a woman who was recovering from acute inflammation of the kidneys, and was taking a mixture of henbane and hemp ("Archiv des Vereins," B. 1, Heft 3).

Dr. Henderson, of Clifton ("Brit. Med. Journ.," May 22, 1858), reports three cases, in which fatty matter in the form of free oil globules was suspended through the urine. The patients suffered from heart affection. The oil globules were only seen on one or two occasions. The nature of the fatty matter could not be ascertained. From six drachms of the urine, of one case, Dr. Herapath obtained ·015 grains of an oily fatty matter. Dr. Herapath refers to a case in which "a large dose of castor-oil was gradually, almost wholly, eliminated by the kidneys, during several days after administration." Dr. Henderson believed that the bottles in which the urine was collected were perfectly clean, and he considers that perhaps the fatty matter was derived from the chyle, although no albumen was detected, which would have been the case if this supposition were correct. Dr. Henderson kindly sent me a little of the ethereal solution of the fat obtained from one of his cases; but the amount was too small for a careful chemical examination.

Fatty Matter in Rabbit's Urine.—Dr. Siegmund found a quantity of fatty matter in the urine of rabbits to which cubebs had been given. The excretion of fatty matter continued as long as the cubebs were administered. It disappeared when the cubebs were omitted, but reappeared when they were administered again. The same observer also found that, although cantharides and cubebs irritated the kidney, they did not diminish the proportion of urea excreted. After death, no morbid change was discovered.

Erroneous Observations connected with the Presence of Fatty Matter in Urine.—Numerous other instances, in which fat has been said to have been passed in considerable quantity, are on record; but there can be little doubt that, in many of these cases, the chemical characters of the substance supposed to be fatty were not carefully ascertained. There is reason to believe that the iridescent pellicle, which really consists principally of fungi, vibriones, and crystals of triple phosphate, from its general resemblance to a thin film of oily matter, has been mistaken for fat. Small portions of oily matter not uncommonly become mixed with the urine accidentally, and now and then the urine is put into an oil bottle and sent for examination. Even a single drop of oil, shaken up with three or four ounces of urine, becomes divided into a great number of minute oil globules, and upon microscopical examination there appears to be a much larger quantity of fatty matter present than is really the case. Many practitioners have been deceived in consequence of the admixture of milk with urine. This is not an uncommon practice, and we should be very careful not to be misled by impositions of this kind. It is hardly credible what trouble some patients will take to deceive us; and very often deception is practised and carried on for a long time without detection. From not being able to discover any reasonable motive, we are sometimes too ready to conclude that our suspicions are unfounded; and thus we may be led to believe statements which are really false, and report cases apparently of a very exceptional character, which only prove that great ingenuity has been employed for the mere purpose of imposing upon us.*

* I am much interested in the question of the removal of fatty matter by the kidneys; and I shall be very much obliged to any one who will send me specimens of urine containing fatty matters in any unusual form, or reports of well-authenticated cases.

OF URINARY DEPOSITS.

It will be convenient to arrange in some order the insoluble substances forming deposits in the urine. I think that the subdivision I have adopted will in some measure assist the memory, and may help the observer to discover quickly the nature of the different insoluble substances he is likely to meet with. I shall not attempt to devise a natural classification, but merely propose to arrange deposits in the order in which they can be practically treated of most conveniently. There are objections to this, as to every other artificial system; but it is simple, and as the general characters which can be observed by the unaided eye form the basis of the classification, I think it will be found useful.

Insoluble substances may *float on the surface of the urine*, or may be *diffused throughout the fluid*, or they may *sink to the bottom*, forming *deposits* of greater or less density.

Insoluble Matter floating upon the Surface of Urine, or diffused through the Fluid. Fatty matter in a very minute state of division, as it occurs in cases of *chylous urine*, is one of the most important substances contained under this head, and has already been considered. *See* p. 302. *Urate of Soda* is another substance which is often suspended in a molecular state through the fluid, rendering it turbid; but this also forms a deposit, and it will therefore be more convenient to consider it under that head. Phosphates are found not unfrequently in the pellicle upon the surface of urine; but in this case they are merely buoyed up, as it were. This substance will be described under *earthy phosphates*, p. 355.

1. *Light and flocculent Deposits, usually transparent, and occupying considerable volume.* Under this head I shall include mucus, with different forms of epithelium derived from the kidney, ureter, bladder, urethra, vagina, &c.; certain well-defined forms of fungi and vibriones; sarcinæ; spermatozoa; casts of the uriniferous and seminal tubes; rarely, benzoic acid in small quantity (*see* note on page 197).

2. *Dense and opaque Deposits, occupying considerable bulk.* This class includes only deposits of urates, pus, and phosphates.

3. *Granular or crystalline Deposits,* occupying a small bulk, sinking to the bottom, or deposited on the sides of the vessel. This division includes a great many different substances. Among the most important are uric acid, oxalate of lime, certain forms of triple phosphate and phosphate of lime, cystine, carbonate of lime, blood corpuscles, and very rarely, cancer cells, tubercle corpuscles, and small spherical cells.

Many of the different substances comprised in the first class of urinary deposits occupy a considerable bulk, although the actual quantity of matter entering into the formation of the deposit is exceedingly small. If dried, one of the most bulky of these deposits, separated from six or eight ounces of urine, would hardly weigh half a grain. The mode of separating urinary deposits from the urine, of examining and preserving them, is described in page 282, *et seq.*

I.—FIRST CLASS OF URINARY DEPOSITS.

Mucus.—If healthy urine be allowed to stand for a few hours after it has been passed, a bulky, flocculent, and very transparent cloud will be deposited towards the lower part of the vessel. Upon examining this in the microscope, a few oval or circular delicately granular cells, rather larger than a blood corpuscle may be seen, scattered sparingly through a transparent substance, in which only a few minute granular points can be detected. A little epithelium from the bladder, or from some other part of the urinary mucous membrane, is not unfrequently met with, but nothing more is observed in the mucus found in *healthy* urine. In disease, however, this mucus increases in quantity, and forms a more or less transparent deposit, containing numerous ill-defined cells, similar to those above referred to, with much epithelium, the character of which depends upon the particular part of the mucous membrane from which it has been derived. The characters of ordinary vesical mucus are represented in fig. 31, pl. VI. The larger bodies to the right of the figure are cells of bladder epithelium.

Little collections of mucus, with imperfectly formed cells, are not unfrequently seen in urine. These are generally derived from the follicles of the urethra, or from the prostate. Long shreds of mucus-like material are sometimes formed in the kidneys and in the seminal tubules, and escape with the urine. These may be regarded as casts, but it must be borne in mind that the import of mere *mucus casts* and *true casts* is very different. *See* p. 342.

Altered Pus, resembling Mucus.—The very thick glairy deposit, which is frequently found in the urine in cases of disease of the bladder, is often termed '*mucus*,' but its real nature is very different. It consists, in fact, of *pus* altered by the action of *carbonate of ammonia* which has been set free in consequence of the decomposition of the urea, caused by some animal matter acting as a ferment after the urine has left the bladder. In some cases, this change even commences in the bladder itself; and the expulsion of the glairy viscid matter often gives rise to serious inconvenience. When an attempt is made to draw off the urine with a catheter, the instrument sometimes becomes completely plugged up. Urine of this kind exhibits a highly alkaline reaction, evolves an ammoniacal odour, and frequently contains a considerable deposit of crystals of the triple or ammoniaco-magnesian phosphate, pl. V, fig. 29, with granules of phosphate of lime. Liquor ammoniæ and potash exert an action upon pus similar to that of carbonate of ammonia.

I have observed, in several cases, that when pus comes from an abscess in the kidney, or from the pelvis of the kidney, it is not accompanied with crystals of triple phosphate. On the other hand, when it is derived from the bladder, crystals of these earthy salts are almost invariably present. This point should be taken into consideration before arriving at a diagnosis in doubtful cases.

It should be borne in mind that, if basic phosphate of soda be added to urine, ammonia is always set free in considerable quantity. Dr. G. O. Rees suggests that the ammonia is often set free in this manner, and not by the decomposition of the urea. The same observer (Lettsomian Lectures, "Medical Gazette," 1851) considers that the alkalinity of the urine is dependent in certain cases upon the secretion of a large quantity of an alkaline fluid from the mucous membrane of the bladder. When the mucous membrane is exposed, it is always found to be moistened by an alkaline fluid. When irritated, a quantity of this alkaline fluid, supposed to be more than sufficient to neutralise the acidity of the urine, is poured out. Dr. Rees explains the fact that the acid reaction of urine not unfrequently becomes more intense after giving alkalies, by supposing that the alkali allays the irritable state of the mucous membrane, which, in consequence, secretes less of the alkaline fluid. In injuries to the spine, the beneficial action of alkalies is explained by supposing that the mucous membrane requires a greater quantity of alkali to protect it than in health. Still it is difficult to associate this explanation with the fact that healthy urine is *always* acid. If a slight increase of this *natural* acid really endangered the integrity of the mucous membrane, by exciting the secretion of excess of a *destructive* alkaline substance, one is almost forced to the false conclusion that the actual condition which exists is not so advantageous to the individual as the existence of a mucous membrane adapted to bear without change the constant action of an acid fluid would be. Moreover, it is certain that in a vast number of cases, urine containing a very considerable excess of acid does not produce the result just alluded to.

The mucus which is deposited from many specimens of urine often contains a great number of octahedral crystals of oxalate of lime, frequently so very minute as to appear, under a power of two hundred diameters, like a number of dark but square-shaped spots. Their crystalline form may be demonstrated by the use of a very high power; but they may be recognised with certainty with a little practice, as their square shape presents a characteristic appearance, with which the eye soon becomes familiar. They are insoluble in a solution of potash, and also in strong acetic acid. These crystals are commonly not deposited until after the urine has left the bladder; and if it be allowed to stand for a longer period, they frequently undergo a great increase in size. It is probable that the mucus excites change in the urates, causing their decomposition, and the formation of oxalate of lime. Fragments of hair, small portions of cotton fibre, and other substances of accidental presence, are not unfrequently encrusted with them.

Of the Clinical Importance of Mucus.—Although, as already stated, the great majority of cases in which the urine is said to contain large quantities of mucus, are really examples of pus in the urine, which has been rendered glairy and transparent by the action of ammonia, true mucus is sometimes found in the form of long transparent shreds, which are scarcely visible unless the field of the microscope be illuminated very slightly. Such transparent mucous shreds may be derived from several parts of the urinary surface; they may come from the follicles of the urethra or prostate, from the vesiculæ seminales, from the vas deferens, or from the seminal tubules. I have seen the most distinct branching cylindrical masses of mucus from the *uriniferous tubes* in many instances. These cases do not appear to have been noticed previously. The character of these "mucus casts" is discussed in p. 342. Their formation is sometimes associated with an irritable state of the urinary organs generally, and, in very many cases of irritable bladder, evidently not depending upon organic disease, small quantities of mucus, in the form of cylinders, may be detected in the urine.

This mucus is very soon destroyed by maceration in fluid, and, unless the urine be examined soon after it has been passed, the distinctive characters of such mucus casts will have disappeared. If urates be present in the urine they will be deposited in and upon the mucus, in which case the mucus casts form very prominent objects, pl. XII, fig. 82. Minute crystals of oxalate of lime are also frequently deposited upon these casts. There is no difficulty in distinguishing these bodies from the true casts.

True mucus is occasionally produced in very large quantity on the surface of the bladder, and quantities of triple phosphate and oxalate of lime crystals are sometimes found embedded in it.

Incontinence of Urine not dependent upon Organic Disease.—In irritable conditions of the bladder and urinary organs generally, there is sometimes an increased secretion of mucus, but this is not constantly the case; and all practitioners are familiar with cases of incontinence of urine, not dependent upon any organic disease whatever, in which the urine does not contain the slightest deposit of any kind. Some of these cases are very obstinate. The condition is frequently met with, but more commonly, in young and old people than in persons about the middle period of life.

Many of these cases depend upon unusual irritability of the nerves, and I believe not a few are closely allied to hysterical affections, so that anything which disturbs the mind may give rise to excessive irritability of bladder. I have seen many cases in which the urine was perfectly natural, and the bladder affection was purely nervous, and ought to be classed with nervous pains occurring in other parts of the body. Gout and rheumatism affect the nerves and muscles of the bladder occasionally.

As is well known, incontinence of urine is very common in young children, and may depend upon almost any peripheral irritation, such as dentition, intestinal worms, enlarged glands, &c., but very often it is connected with a naturally excitable state of the nervous system. Commonly enough, it occurs only during the night, and sometimes the child acquires a *habit* of thus voiding the urine, unless care is taken by the nurse to take him up regularly after certain intervals of time (three or four hours), so as to prevent much urine from accumulating in the bladder. In many cases the urine is a little too acid, when a few doses of bicarbonate of potash, lime water, or liquor potassæ, and attention to diet will relieve the troublesome affection.

In old age the bladder often becomes very irritable, although there may be no morbid change in its structure, and a patient is unable to retain his water for more than half-an-hour or an hour at a time. Patients who suffer thus, by concentrating their attention too much upon their ailment, often make matters worse. Any disturbance of the digestive organs will sometimes produce increased distress. In many cases the urine is too acid or too highly concentrated. I have often found the urine of sp. gr. 1,035 containing a very large excess of urea, p. 185.

Incontinence of urine may, of course, be produced by a great variety of conditions. Its occurrence in inflammation of the bladder, cancer, and some other conditions, will be referred to in the proper place, p. 367.

On the Treatment of Irritable Bladder and Incontinence of Urine, not dependent upon Organic Disease.—This affection will require different treatment according to the age at which it occurs. The irritable bladder of children generally depends upon peripheral nervous irritation, and is often relieved by gentle mercurial purgatives, and small doses of alkalies. When arising from teething, or from worms, the treatment is obvious. In very young children, incontinence occurring during the night need cause no alarm whatever, as it generally passes off as the child grows older.

This troublesome symptom occurs in young persons of both sexes, and is occasionally very obstinate. Not unfrequently it seems to be due to the habit of sleeping on the back, when a blister applied to the buttocks will generally cure the malady by compelling change of position. I have seen it in youths of scrofulous habit whose strength has suffered from growing too fast. Such cases are almost certainly cured by a generous diet, the tincture of perchloride of iron, quinine, and cod liver oil, but it is often necessary to keep the patient under this plan of treatment for two or three months.

Nervous old men often suffer a good deal of inconvenience from irritable bladder, not dependent upon organic disease. If they take a little more wine than they ought, or a richer diet than usual, or become a little more irritable in temper, they will be called up several times in the night. The state of urine causing this annoyance is generally dependent upon the stomach being a little out of order, and a few doses of liquor potassæ or bicarbonate of potash, after meals, a mild sedative and a gentle purge, will generally relieve the annoyance. Sometimes a small dose of blue pill or calomel cures the troublesome affection at once. If obstinate, it is well to try the effect of an opium or henbane suppository.

In many of these cases it is very important to prevent the patient from concentrating his attention upon the bladder, and it is probable that the advantageous effects following the application of a blister are due to the attention being diverted to another part.

Vibriones.—Bacteria.—When urine, containing a little epithelium or other animal matter, has been allowed to stand for some time, numerous elongated bodies, varying much in length and possessing active movements, make their appearance. These little bodies appear as simple lines, under a magnifying power of two hundred diameters; but, by careful focussing, under one of five hundred or six hundred diameters, the longest of them are seen to consist of filaments with numerous transverse lines. They sometimes very closely resemble the algæ ordinarily found in the mouth. Most observers agree as to the vegetable nature of the bodies in question; but Dr. Hassall has recently arrived at the conclusion that they are animal, and that the movements are voluntary (" Lancet," Nov. 19, 1859). That the movements are not merely molecular, is quite certain; but, to apply the term "voluntary" to such movements as these, is quite unjustifiable. There is not the slightest evidence in favour of such a conclusion. As investigation proceeds, the conclusion that many forms, which were considered animal, are really of a vegetable nature, is more frequently forced upon us than that organisms, hitherto held to be vegetable, are really animal. The time has, however, gone by, when attempts were made to draw an arbitrary line between the lowest classes of the animal and vegetable kingdoms.

These vegetable organisms are seen as minute lines under the microscope, and they exhibit very active movements in warm weather, and the longer ones twist about in a serpentine manner. They are sometimes developed in urine before it has left the bladder, and always occur in decomposing urine.

The mode of development of these bodies will be understood by reference to pl. VI, figs. 35 to 40. At first they appear as mere specks under the highest powers. The specks become oval bodies, which gradually increase in length, and exhibit a transverse mark, often the seat of fission. In this way filaments of some length may be formed.

Other living organisms are frequently met with in urine. Numerous forms of animalcules, one of which Dr. Hassall includes in the genus *bodo* (*bodo urinarius*), are also observed in various specimens. It is probable that many of these different forms merely indicate different stages of existence of one species.

Torulæ, including the Sugar Fungus and Penicillium Glaucum.— Certain forms of vegetable fungi or torulæ are developed in urine after it has been standing for some time. The period which elapses before the appearance of the fungi, and the particular species which is developed, vary much in different specimens of urine, and in different cases of disease. In diabetes, torulæ are sometimes found in considerable number within twenty-four hours after the urine has been passed; and their growth leads the observer to suspect the presence of sugar, which must be confirmed by the application of chemical tests, p. 243. Different forms of fungi are represented in pls. VI and VII.

Sugar Fungus. Dr. Hassall has communicated a paper upon the development of torulæ in the urine, to the Royal Medical and Chirurgical Society, which will be found in the volume of "Transactions" for 1853, in which he arrives at the conclusion that there is a species of fungus which is developed in specimens of urine, containing even very minute traces of sugar, which may be looked upon as characteristic of the presence of this substance, as it occurs in no other condition of the urine. This is the *sugar fungus*. But neither the characters nor the occurrence of the fungus are sufficiently constant to enable us to accept implicitly Dr. Hassall's conclusions as to its value as a test for the presence of sugar. The sugar fungus which grows in diabetic urine is identical with the yeast plant. *See* figs. 43, 44, pl. VI, after Hassall. The aërial fructification is represented in figs. 45, 47.

Penicillium Glaucum. Besides the sugar fungus, there is another species which is very commonly met with in acid urine containing albumen, if exposed to the air. This is the *Penicillium glaucum*, the same fungus which is developed in the lactic acid fermentation, pls. VI, VII, figs. 39 to 48. This species assumes many very different forms, which vary according to the conditions under which growth occurs. And there can be no doubt that many fungi regarded by some as separate species may all result from the same germ, pl. VI, figs. 32, 34.

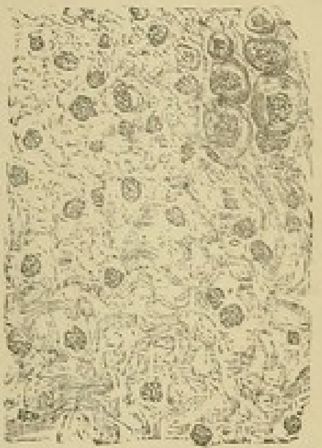
The microscopical characters of this fungus differ also according to the stage of development which it has reached. Thus, as Dr. Hassall has stated, in some specimens, the growth of the fungus is arrested at the sporule stage; in another, not until a thallus is formed; and in a third, it goes on until aërial fructification takes place, and new spores are produced. But it is only in the last condition that constant distinctive characters can be demonstrated. *See* pl. VII, figs. 45 and 47. The degree of acidity of the urine, and the length of time during which it has been exposed to the air, appear to determine, in a great measure, the stage of development which the fungus attains. Dutrochet long ago stated that an acid reaction and albumen were necessary for the development of penicillium; but Dr. Hassall, in some more extended experiments, proved that the fungus often appeared in acid urine which contained no albumen; and I have frequently confirmed this observation. Extractive matter no doubt serves the same purpose as albumen. The penicillium glaucum, as well as the sugar fungus, may be met with in saccharine urine, because all the necessary conditions for its development may be present, namely, exposure to air, an acid liquid, and a certain quantity of nitrogenous matter. More recent observations have confirmed the views of Mr. Hoffmann, of Margate, who showed that the spores of penicillium would, under favourable circumstances, give rise to the development of the sugar fungus. No microscopist could, I think, distinguish these fungi from one another, during the *sporule stage*, and although the thallus of well-developed penicillium differs from that of well-developed sugar fungus, I have seen thalli of these fungi which resemble each other in thickness, mode of branching, and in very minute characters. So that, although in their perfect condition the two fungi exhibit distinctive characters, it is only in this stage that they can be demonstrated to be distinct species. It is true that Dr. Hassall represents the sporules of the sugar fungus as being very much larger than those of penicillium glaucum, but I have seen many specimens in which they were the same size, and it is easy to find sporules of the sugar fungus which are very much *smaller* than those of penicillium.

From a careful consideration of this question, I think we may conclude that, although well-defined differences may be made out in the perfect state of development of *Penicillium glaucum* and *Torula cerevisiæ*, it must be conceded that there are also forms at certain stages of growth which could not be distinguished from one another. The large circular sporules of the sugar fungus are distinct enough from those of penicillium glaucum; but oval and circular sporules, which cannot easily be distinguished, are to be obtained under certain circumstances from each plant.

These and all other fungi, in their earliest and simplest condition, appear as minute sporules less than $\frac{1}{100000}$ of an inch in diameter. Such very minute germs can only be seen with the aid of the highest magnifying powers, the $\frac{1}{25}$ and $\frac{1}{50}$, and it need scarcely be said that no special characteristic differences which would justify any one in determining species, can be discerned.

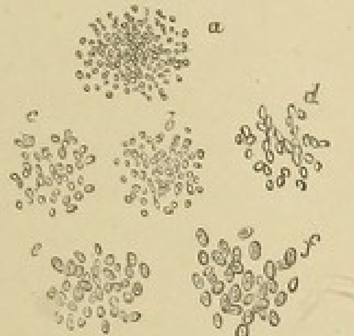
Sarcinæ are little vegetable organisms, in the form of cubes, which were first discovered by Goodsir, in 1842, in the matter rejected in

Fig. 31.



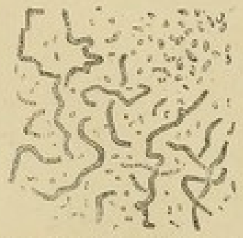
Mucus and mucus corpuscles Urine. In the upper part of the fig., to the right several cells of bladder epithelium are represented. × 215. p. 318.

Fig. 32.



Penicillium glaucum, developed in acid urine. *a*, within twelve hours after the urine was passed; *b*, one day after; *c*, two days after; *d*, four days after; *e*, five days after; *f*, after standing six days. p. 322.

Fig. 33.

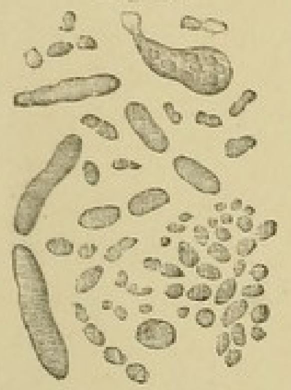


Algæ and vibriones from urine three days after it was passed. × 403.

Fig. 34.

Vegetable organisms met with in urine. *a*, different forms of fungi; *b*, vibriones. × 215.

Fig. 35.



Bacteria undergoing germination. × 1800.

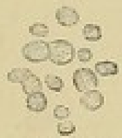
Fig. 36.

Bacteria germs in old epithelial cells of the mouth. × 3000.

Fig. 37.

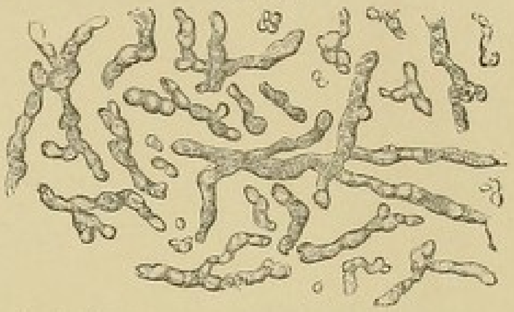
The same. × 1800.

Fig. 38.



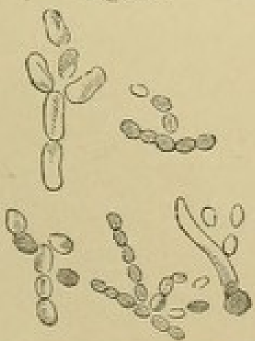
The same. × 3000.

Fig. 39.



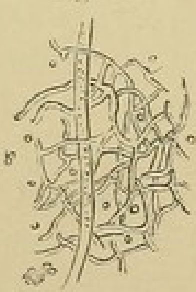
Penicillium glaucum, found in diabetic urine four days after it was passed. × 215.

Fig. 40.



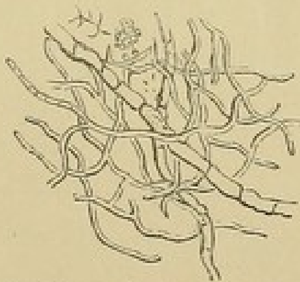
Penicillium glaucum, from acid urine.

Fig. 41.



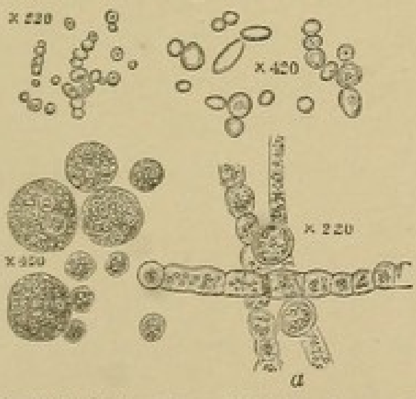
Penicillium glaucum × 215.

Fig. 42.



Penicillium glaucum, from acid urine. × 215.

Fig. 43.



The sugar fungus from diabetic urine. p. 323.

Fig. 44.

Yeast added to diabetic urine, and allowed to stand in a warm place forty-eight hours. Showing growth of the torula. p. 323. *a* × 215. *b* × 400.

$\frac{1}{1000}$ of an inch ⊢⊣ × 215.

" " ⊢——⊣ × 403.

" " ⊢————————————⊣ × 1800.

[To face page 324.

peculiar cases of obstinate vomiting. They have been observed, however, in several other fluids, and occasionally in the urine; but the sarcinæ which I have seen in the urine were smaller than those present in vomit; but it is doubtful if we should look upon the two forms as distinct species.

Sarcinæ have been met with in the urine by Heller, Neubauer and Vogel, Dr. Mackay, Dr. Johnson, and by myself, under circumstances which leave no doubt that this vegetable organism is sometimes *developed* in urine. I once analysed a specimen of urine containing sarcinæ, which was sent me by my friend Dr. Brown, of Lichfield. It was acid; specific gravity, 1018·6.

ANALYSIS 84.

Water	952·8
Solid matter	47·2
Organic matter	37·9
Fixed salts	9·3

The specimen was carefully examined for lactic acid, but not a trace could be detected. Sarcinæ in vomit are represented in pl. VII, figs. 53, 54.

Dr. Bateman, of Norwich, has published the following interesting case of sarcinæ in the urine :—

"During the summer of the year 1865, I was consulted by Mr. D——, a gentleman, aged 55, who for many years had been subject to rheumatism and neuralgia in various forms, and who was just then suffering from dyspepsia and general neuralgia—that is, pains of a neuralgic character in different parts of the body. He told me he had been in his usual health till a few days previously, when he ate heartily of *mitey cheese*, to the indiscreet use of which he attributed the dyspepsia and neuralgic symptoms which induced him to seek my advice.

"On examining this patient's urine, I found it loaded with sarcinæ, there being, however, no other peculiarity in this secretion beyond the presence of a few crystals of oxalate of lime. Being desirous of ascertaining whether the sarcinæ were present in the other secretions, I examined the fæces, but with a negative result. I also tried to persuade my patient to empty his stomach by an emetic, with the view of ascertaining whether these abnormal bodies were present in this organ; but, although formerly a lover of physiological investigation himself, he declined to assist science by the *experimentum in corpore humano*, as performed on his own person. Without entering into further details, suffice it to say that, under a purely dietetic treatment, in the course of a few days the dyspeptic and neuralgic symptoms subsided, and with them all traces of sarcinæ disappeared. A few weeks afterwards the same train of symptoms, viz., dyspepsia, neuralgia, and sarcinæ in the urine, again occurred after the indiscreet use of indigestible food; that is, after a hearty meal of *cucumber*, *hare*, *vinegar*, *and beer!*

"Early in April of last year, Mr. —— had another attack of indigestion, ascribed by him this time to having eaten very heartily of *potatoes*. On examining the urine passed the next day, it was found to contain sarcinæ, which were present also, but to a less extent, on the third day, but had disappeared altogether from the urine passed on the fourth day from the attack.

"The urine of this gentleman continued free from this curious growth till the end of August, when it again appeared as an accompaniment of dyspepsia, this time produced by, or at all events occurring after, partaking of *bread and cheese and small beer*, the patient having at the same time indulged in a pipe, although from past experience he knew that smoking invariably disagreed with him. I found the urine acid, of specific gravity 1,027, not albuminous; containing, besides sarcinæ, oxalates in abundance, and a considerable quantity of pus-cells. I also, on this occasion, made a volumetric analysis of the principal solid ingredients, with the following results:—

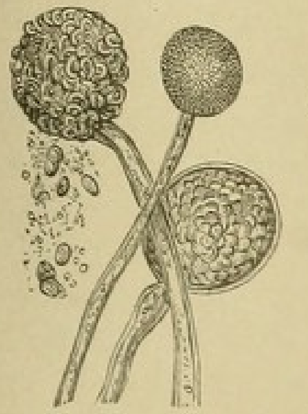
Chlorides	13 parts per 1000
Urea	17 ,, ,,
Phosphoric acid (in combination)	2·6 ,, ,,

"There are two other symptoms in the clinical history of this gentleman, which seem to me deserving of notice—viz., the existence of a stricture of long standing in the membranous portion of the urethra, and the frequent occurrence of severe prostatic irritation, relieved quite recently by the passage of several small *prostatic* calculi."

Trichomonas Vaginæ.—Donné some years ago described, under the name of *Trichomonas vaginæ*, an organism which he considered to be of an animal nature. It consists of a rounded cell, with vibratile filaments projecting from it, and was found in the urine of females suffering from leucorrhœa. Although Kölliker and Scanzoni state that they have detected the *trichomonas* in the vaginal mucus both of impregnated and of unimpregnated women, it is very doubtful if the bodies they have seen are peculiar to vaginal mucus. They are probably ordinary monads, or pus corpuscles with a projecting filament. I have met with both, but have never seen anything exactly resembling the figures of the so-called Trichomonas vaginæ. Other kinds of infusoria have been observed in urine.

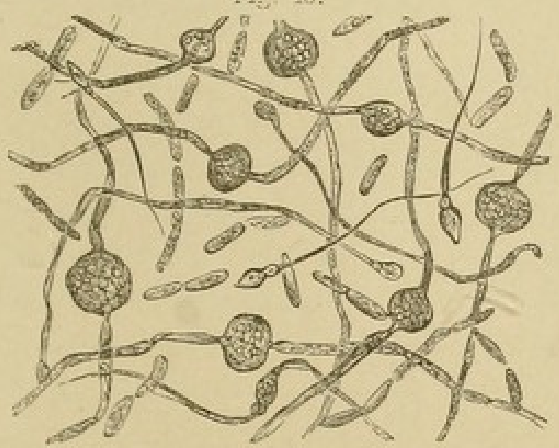
Epithelium of Kidney, Bladder, and Urethra.—The epithelium from the kidney has been already described in p. 13. The cells from the *ureter* are of the columnar form, and some are spindle-shaped, pl. VIII, fig. 57. *See* also pl. III, 'Anatomy of Kidney,' p. 6. In form, and indeed in their general appearance, these cells much resemble those found

Fig. 45.



Fructification of yeast fungus. p. 323.

Fig. 46.

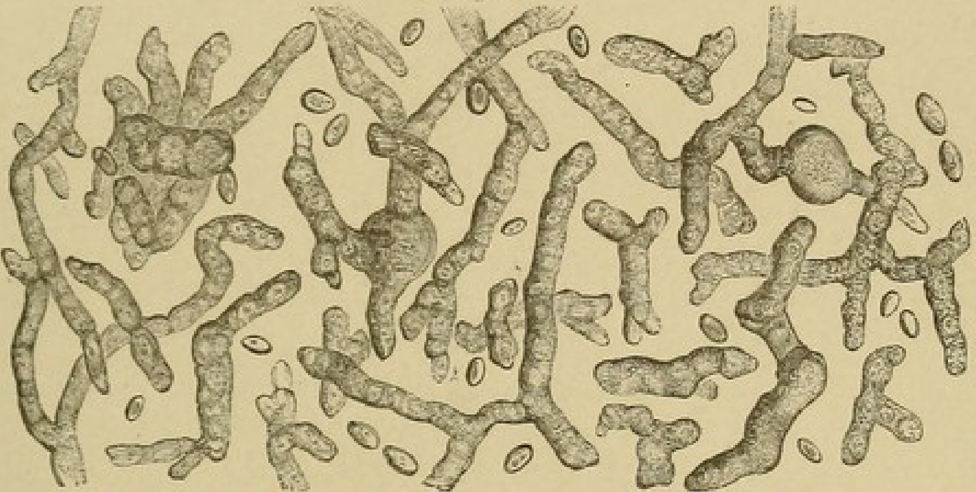


Fungi formed in acid urine. Several spermatozoa are seen amongst the fungous filaments. × 700.

Fig. 47.

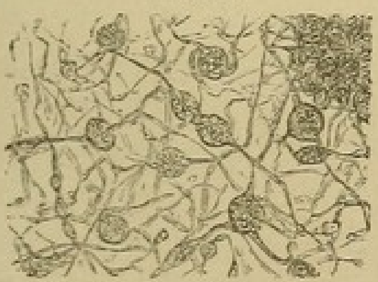
Fructification of penicillium glaucum. p. 323.

Fig. 48.



Penicillium glaucum. The oval spores growing into thalli. Developed in urine about fifty hours after it was passed. × 403. p. 323.

Fig. 49.

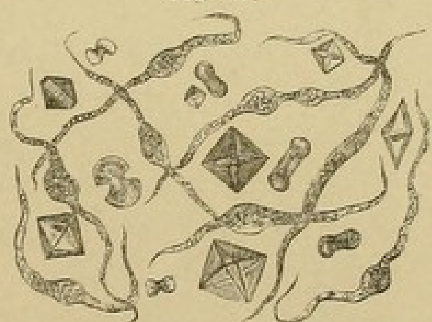


Fungi formed in acid urine. From the same specimen as Fig. 46. × 215.

Fig. 50.

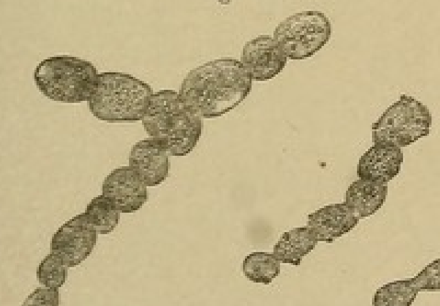
Sporules of fungi, resembling blood corpuscles. p. 231.

Fig. 51.



Curious fungi formed in the urine of a young man passing much oxalate of lime. × 215.

Fig. 52.



Penicillium glaucum, from vomit. × 700.

Fig. 53.

Sarcinæ ventriculi, ordinary size, from vomit. *a*, sarcinæ. *b*, starch granules partially dissolved and rendered transparent. *c*, minute oval fungi usually present in vomit containing sarcinæ. *d*, vibriones. *e*, oil globules. *f*, starch globule from bread, cracked but not as yet softened. × 215.

Fig. 54.

× 700. × 1900.

Sarcinæ, from vomit. 'Archives,' vol II., p. 285. p. 325.

$\frac{1}{1000}$ of an inch ⎣___⎦ × 215.

" " ⎣__________⎦ × 700.

[To face page 325.

in some scirrhus tumours. Care must be taken not to make the mistake in cases of suspected cancer of the kidney.

The epithelium of the *bladder* varies much in different parts of the organ. In the fundus, there is much columnar epithelium mixed with large oval cells; whereas, in that part termed the trigone, large and slightly flattened cells, with a very distinct nucleus and nucleolus, are most abundant. Columnar epithelium appears to line the mucous follicles, while the scaly lies on the surface of the mucous membrane between them. Many of the large oval cells of bladder epithelium lie upon the summit of columnar cells, and their under-surface exhibits corresponding depressions. Various forms of bladder epithelium are represented in pl. VIII, figs. 59, 61; and in fig. 63, the manner in which the young cells of vesical epithelium multiply, is represented under a power of 700 diameters. The young cells are composed of a perfectly soft granular material, and like other young cells possess no limitary membrane or cell-wall whatever.

The formation of pus from the germinal matter of epithelial cells may be well studied in inflammation of the bladder and urethra. The large cells of bladder epithelium grow very fast in cases of epithelial cancer, affecting this organ. *See 'Cancer Cells'* in the Urine.

The epithelial cells of the *urethra* are, for the most part, of the columnar form; but mixed with this there is also a good deal of scaly epithelium. Towards the orifice, the epithelium is almost entirely of the scaly variety. The epithelium of the *glans* is of the scaly variety, and mixed with it is a quantity of soft white matter, seen under the microscope to consist of granules and numerous globules of fat, rich in cholesterine, with granules and globules of earthy phosphate. This is the secretion from the modified sebaceous glands in the mucous membrane of the corona, the so-called *Smegma Preputii*, which accumulates in some cases to an enormous extent. In a specimen, which was removed by operation by my friend Mr. Bird, now of Melbourne, I found epithelial cells with many well-formed crystals of cholesterine. Upon analysis, the following constituents were detected and estimated in ten grains.

ANALYSIS 85.

Water	7·46
Solid matter	2·54
Extractives soluble in alcohol and cholesterine	·24
Epithelium, &c.	2·02
Fixed salts	·28

The smegma preputii mixed with epithelial cells from the surface of the glans, fatty matter and earthy phosphates which have been deposited in it, sometimes forms hard flaky masses which have been mistaken for fragments of a phosphatic calculus.

Vaginal Epithelium.—The large cells of scaly epithelium, so commonly met with in the urine of females, and derived from the *vagina*, are represented in pl. VIII, figs. 60, 62. They however vary much in size and form, and are sometimes very irregular in shape, with uneven ragged edges. It is very common to meet with cells of vaginal epithelium the germinal matter of which is much increased in size and is undergoing division and subdivision into pus corpuscles, fig. 64, pl. VIII.

Casts of the Uterus and Vagina.—A considerable thickness of the epithelial layer of the vagina, and according to some observers also that of the uterus, is sometimes shed in the form of a membranous cast or mould. I have seen such epithelial casts or moulds from the rectum, œsophagus, and from the stomach. They may be compared with the layers of cuticle which are detached from different parts of the cutaneous surface after scarlatina. It is only the superficial portion of the epithelial layer which is detached in these cases.

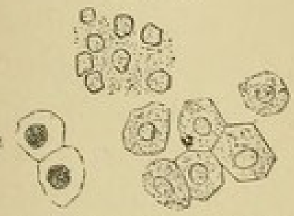
Dr. Arthur Farre has recorded some interesting cases of "exfoliation of the epithelial coat of the vagina," in vol. I of my "Archives." The appearance of the specimens referred to is represented in pl. XII of that work. Dr. Farre remarks that the act of exfoliation is usually repeated at certain intervals. The casts described by Dr. Farre are interesting in another point of view, as showing the real form of the vagina when in its ordinary empty and collapsed condition. Dr. Tilt ("Archives," vol. III, p. 26), has also described some interesting cases of the same kind. His opinion is, that some of these casts come from the uterus, while others are no doubt formed in the vagina. The beautiful specimen figured in pl. IX, figs. 66, 67, is one of those examined by Dr. Tilt and considered by him to come from the uterus, although it must be admitted that the characters of the epithelial cells of which it was composed, agreed more closely with those of the vaginal cells. Fig. 65 is a drawing of a cast from the vagina, also from one of Dr. Tilt's preparations.

Leucorrhœa.—In this condition very many imperfect cells of vaginal epithelium are formed upon the surface of the mucous membrane, as well as pus-corpuscles. Many pus-corpuscles originate in the cells of vaginal epithelium, even after the epithelial cells have assumed their distinctive form, but many of the younger cells of vaginal epithelium, and those in the numerous follicles of the mucous membrane, themselves divide and subdivide, giving rise at length to multitudes of the spherical granular cells we know as "pus-corpuscles," which multiply very rapidly if freely supplied with nutrient matter. The manner in which pus is formed from the germinal matter of vaginal epithelium will be at once understood by reference to pl. VIII, fig. 64, and in pl. XXIII the mode of multiplication of pus-corpuscles is represented.

Of the Treatment of Leucorrhœa.—Although it is not the province of this work to discuss the nature and treatment of leucorrhœa, it may

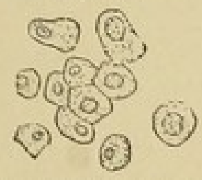
URINARY DEPOSITS.—EPITHELIUM.

Fig. 55.



Epithelium from the convoluted portion of the uriniferous tube. *a*, treated with acetic acid. × 215.

Fig. 56.



Epithelium from the pelvis of the human kidney. × 215.

Fig. 57.

Epithelium from the ureter. × 215.

Fig. 58.

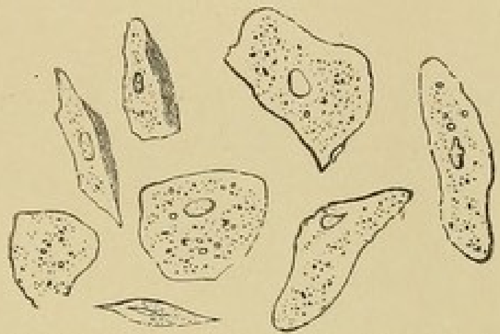
Epithelium from the urethra. × 215.

p. 327.

Fig. 59.

Bladder epithelium. *a*, from the general surface *b*, from the fundus. *c*, scaly epithelium from the bladder. × 215. p. 327.

Fig. 60.

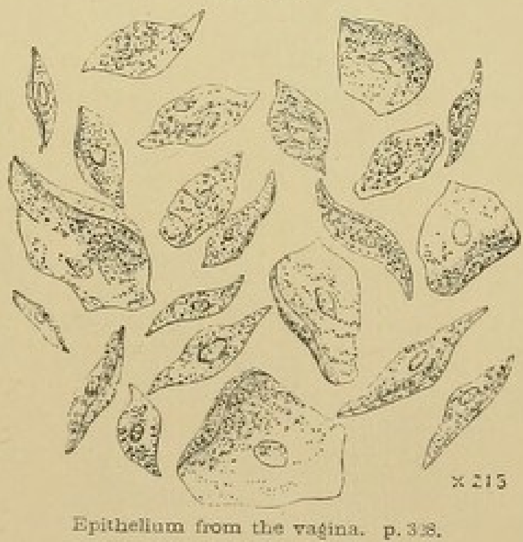


Vaginal epithelium from urine. × 215. p. 328.

Fig. 61.

Epithelium from the bladder, showing the hollows in some of the large cells into which the subjacent columnar cells fit. p. 327.

Fig. 62.



Epithelium from the vagina. p. 328.

Fig. 63.

Young epithelial cell from the bladder, undergoing division. × 700. p. 327.

Fig. 64.

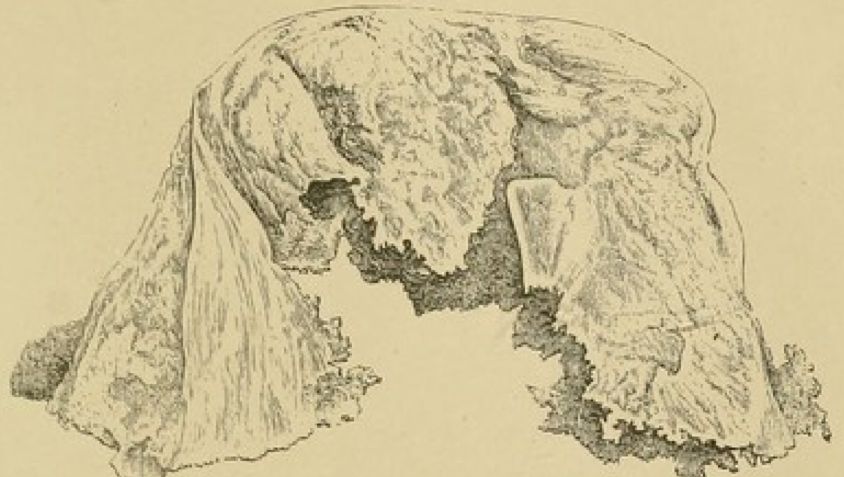
Formation of pus from germinal matter of epithelial cells. × 215. p. 328.

$\frac{1}{1000}$ of an inch ⎵ × 215.

" " ⎵ × 700.

[To face page 328

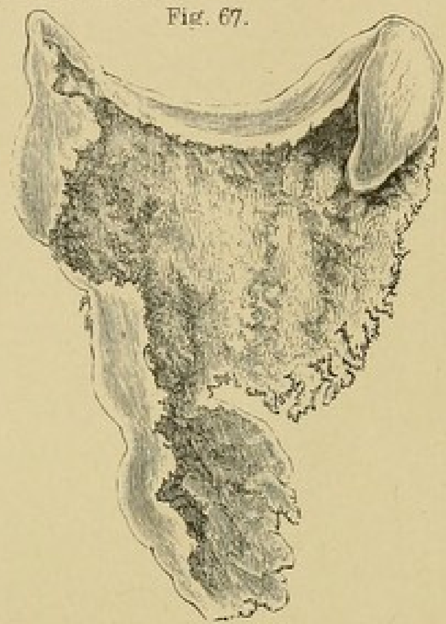
Fig. 65.



Membranous substance passed with a blood clot during the menstrual period, probably from the vagina. From a preparation of Dr. Tilt's.

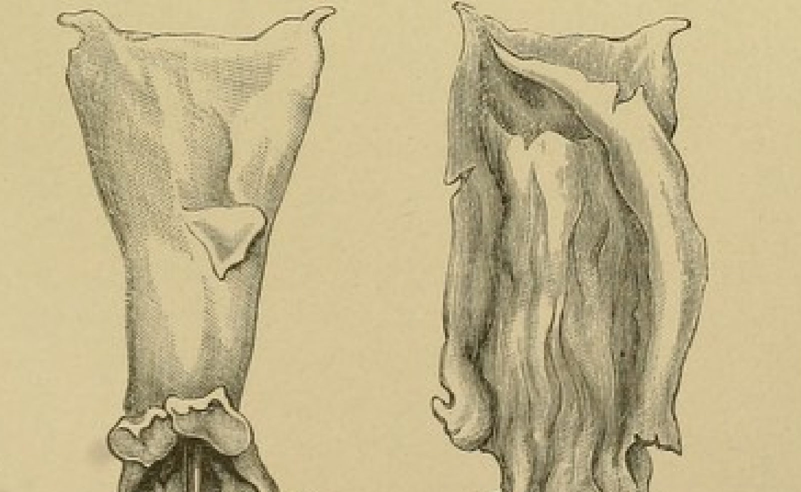
Fig. 66.

Fig. 67.



Two fragments of a uterine cast passed by a lady, age 25. These are composed entirely of epithelium.

Fig. 68.



Cast of the womb and vagina, the mucous covering belonging to the former cavity being inverted. From a drawing by Dr Vannoni, of Florence.

be well to state that many cases seem to depend upon an impoverished state of blood, and get quite well if attention be paid to the general health. Of all remedies the tincture of perchloride of iron is one of the most useful, and when there is any irritability of the mucous membrane, tincture of henbane, opium, or hop, or the extract of Indian hemp, will be found useful. The advantage of the local application of Goulard water with sedatives, and the injection of cold or tepid water, and the beneficial effects of the cold or tepid hip bath, in this condition, are so well known to practitioners, that it is almost needless to refer to them.

Spermatozoa.—In some specimens of acid urine, in which vibriones are not developed, spermatozoa may be preserved for days without destruction. They usually form a light flocculent cloud, suspended in the urine, but when few in number there is nothing in the appearance of the urine that would lead us to suspect the presence of spermatozoa. They may be distinguished with a power of about two hundred diameters, pl. X, figs. 69, 70, 71; but, unless the eye is familiar with them, it is better to employ one of from four to five hundred. In some cases I have met with spermatozoa covered with urate of soda, which renders them very easy of detection, pl. X, fig. 72. Curious crystals of phosphate of lime are sometimes found in seminal fluid, pl. XI, fig. 76.

By the use of very high powers, I have demonstrated some points of great interest concerning the structure of spermatozoa. The oval body or head of the particle is hollow, and contains a small quantity of germinal matter, which extends a short distance into the filament. This, like other forms of germinal matter, is easily tinged by carmine. The quantity of this germinal matter varies in different instances, but usually it does not extend higher than the middle portion of the body. It is always less in spermatozoa which have been passed a long while than in those only which have recently escaped, pl. X, fig. 75 *a*, *c*. The shape of the body of the spermatozoon varies according to the quantity of germinal matter present. Those bodies containing little being flattened towards the apex as compared with those which contain much. The amount of germinal matter undergoes gradual reduction after the spermatozoa have left the organism, and it is probable that its reduction is connected with their active movements.

This germinal matter constitutes the important part of the spermatozoon and in it alone probably reside the marvellous powers of the fertilizing element. The mass of the body consists of a hardened albuminous matter, not differing much in properties and composition from the outer part of epithelial cells generally. The vibrations of the tail like the movements of the cilia of ciliated epithelium are no doubt due to changes taking place in the germinal matter occupying the body of the cell. When the spermatozoon has made its way into the interior of the ovum, all this outer material becomes softened and dissolved, and the germinal matter of the spermatozoon or sperm cell thus comes into actual contact with the germinal matter of the ovum or germ cell, and probably the germinal matter of the two cells becomes incorporated. From this very intimate admixture of two kinds of germinal matter, each of which has at last resulted from the slow origin centre within centre of pre-existing masses of living matter, the germ of the new being possessing newly acquired powers, proceeds.

Preparation of Spermatozoa.—Spermatozoa may be preserved as permanent objects in some preservative solution such as naphtha and creasote, weak spirit, or glycerine. The latter fluid refracts the light rather too brightly to see them very distinctly. The specimen above described has been preserved in solution of naphtha and creasote, and the characters of the spermatozoa are well seen. The usual method adopted is to allow a little semen to dry on the glass slide; the forms of the spermatozoa are well retained by this simple process.

Medico-Legal Investigation.—We are sometimes called upon to examine stains upon linen, or the vaginal mucus, in cases of suspected rape. Such an investigation must be undertaken with the greatest care, and a positive opinion must not be expressed if the observer have the slightest doubt as to the nature of the bodies in question; neither should a positive conclusion be drawn from the presence of only *one* structure like a spermatozoon, nor from *supposed fragments* of their bodies. Fragments of cotton or linen sometimes assume forms very like those of spermatozoa. The mucus which has been dried on the linen, even after it has been kept for some time, in which they are suspected to be present, may be remoistened with distilled water, without the spermatozoa being destroyed. This is an investigation which should be conducted with the greatest care.

A little girl was brought into King's College Hospital in July, 1857, upon whom it was said a rape had been committed about three hours before. Mr. C. Heath, who was House Surgeon at the time, removed with a pipette a little of the mucus from the vagina at a point beyond the hymen, and after placing it upon a glass slide sent it to me for examination. It was not examined until six hours afterwards, and being uncovered it became quite dry. Nothing definite could be made out by submitting the dry mass to examination. It was therefore moistened with a drop of distilled water, covered with a piece of thin glass and examined with a quarter-inch object-glass. Numerous cells of vaginal epithelium were seen, and amongst them as many as six spermatozoa were discovered in various parts of the field. All these were well defined and free from the epithelium, but many others less perfect, the tails being broken or removed, were found. A careful drawing of these were made under the quarter of an inch object-glass. *See* pl. X, fig. 70.

URINARY DEPOSITS.

Fig. 69.

× 215

'Casts' of the seminal tubes. Spermatozoa embedded in them. From an old man upwards of 80 years of age. p. 331.

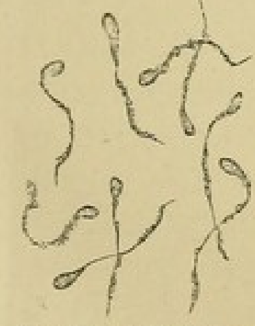
Fig. 70.

Spermatozoa and cells of vaginal epithelium, removed from the vagina of a little girl a few hours after a rape had been committed. × 215. p. 330.

Fig. 71.

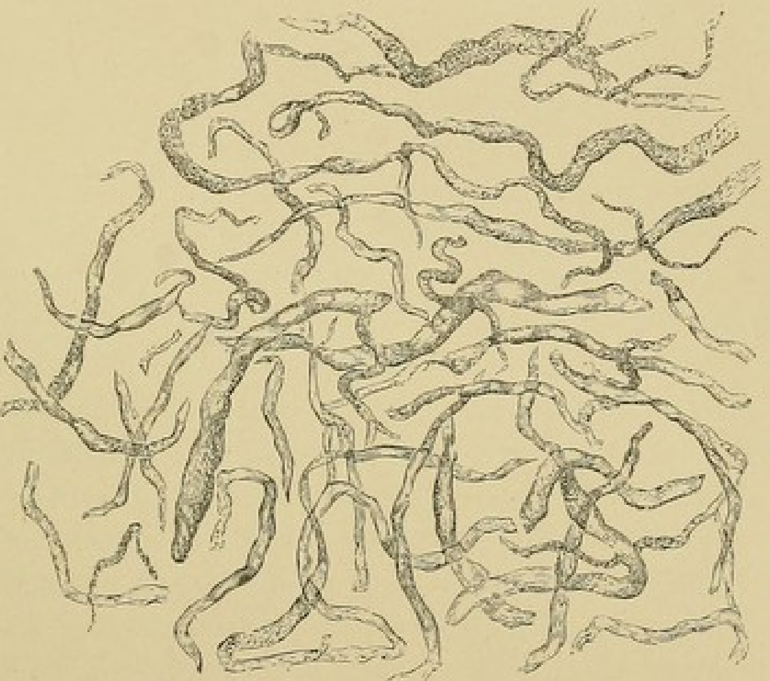
Spermatozoa from urine. × 215. p. 329.

Fig. 72.



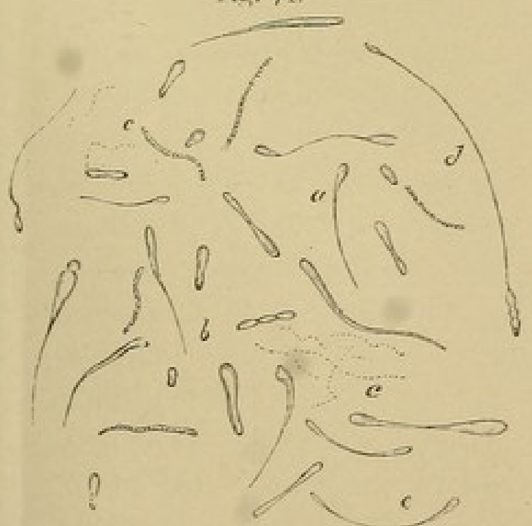
Spermatozoa with urate deposited upon them. × 700. p. 329.

Fig. 73.



Long narrow threads of viscid mucus, associated with the presence of spermatozoa in casts of the seminal tubules. From the urine of a case of slight irritability of the neck of the bladder. × 215. p. 331.

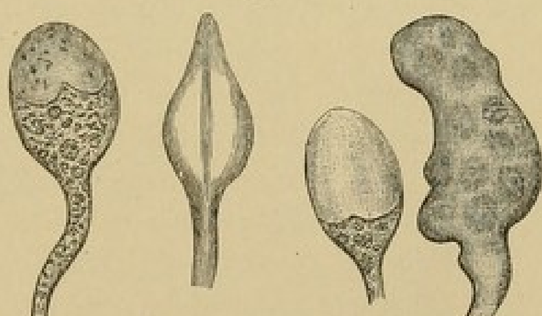
Fig. 74.



× 403

Filaments of a vegetable nature resembling spermatozoa. × 403. p. 331.

Fig. 75.



a *b* *c* *d*

Body and upper part of the tail of spermatozoon magnified upwards of 3000 diameters. *a*, spermatozoon containing much living germinal matter. *b*, the same seen edgeways. *c*, spermatozoon containing comparatively little germinal matter. *d*, spermatozoon crushed, showing separate spherical particles of germinal matter. p. 329.

$\frac{1}{1000}$ of an inch ⊢⊣ × 215.

" " ⊢⊣ × 3000.

Dr. Munroe, of Hull ("Archives of Medicine," vol. I, p. 139), reports a case in which by microscopical examination of spots on the linen three days after an alleged rape, he detected the presence of spermatozoa. Dr. Munroe thus describes the method of examination. "On cutting out some of the greyish and coloured stains, macerating them in distilled water for some time, and afterwards concentrating very much the solution and placing the same under one of Ross's best quarter-inch object-glasses, with an angle of aperture of 130°, and a magnifying power of 215 diameters with the lowest eye-piece, numerous whole spermatozoa were seen and also many others much mutilated,—here only a head, there only a tail,—indisputably proving the stain to be seminal."

Vegetable Bodies resembling Spermatozoa.—The only structure occurring in urine, or of renal origin, at all liable to be mistaken for spermatozoa, as far as I am aware, is a form of vegetable growth which I have only once met with, in a specimen of urine kindly sent to me by my friend Mr. Masters. Mr. C. Roberts, of St. George's Hospital, has taken very careful notes of the case. Some of the bodies in question very closely resembled spermatozoa, but their true nature was ascertained by comparison with many other specimens of the vegetable growth, pl. X, fig. 74. *See* also my "Archives," vol. I, p. 251.

Mucus Casts from the Seminal Tubules are sometimes found in the urine, and must not be mistaken for casts of the uriniferous tubes. Some of these casts are represented in pl. X, fig. 73. The casts of the seminal tubes are usually much longer than those of the kidney tubes. They are usually less than the 1-1000th of an inch in diameter and vary little. Not unfrequently spermatozoa are packed together in great number, so as to form, with the mucus in which they are embedded, casts of considerable dimensions. A very good specimen is represented in pl. X, fig. 69, from the urine of an old man of 80.

Of the Clinical Importance of Spermatozoa in Urine.—Spermatozoa are not uncommonly found in the urine in health. It is only when their appearance is constant, and accompanied with other more important symptoms, that the practitioner is justified in interfering. I would earnestly draw attention to the importance of exercising the greatest caution in these cases; for the mere suggestion that spermatozoa are present in the urine may do more harm to a nervous patient who has studied quack books and visited the demoralising museums which infest London and our large cities, than can be counterbalanced by the good produced by the most judicious medical treatment.

The occasional presence of spermatozoa in urine is no evidence of the existence of that condition to which the name of "*spermatorrhœa*" has been applied—a term which I am sorry to employ at all, but which cannot be abolished. There is, in fact, no *disease* which can be correctly termed "spermatorrhœa." The secretion of the testicle, like that of other glands, must from time to time escape, and when it is formed in undue quantity, and discharged too frequently, it is usually but one of a train of symptoms dependent upon changes in the general health.

Spermatozoa are very often found in the urine of young men in perfect health, and I have seen considerable numbers in the urine of a hale old man above 80 years of age. This was a decided case of "spermatorrhœa;" and there is no doubt, that if this old gentleman's urine had been examined by some of the quacks who pretend to make this "disease" a special study, he would have been favoured with a description of the frightful consequences of this escape of the secretion of the testicle, and have been subjected to treatment! In former editions of this work I have expressed in plain terms my own opinion upon the careless use of the word "spermatorrhœa," and I have found no reason to alter my view; but as there is some difference of opinion in the profession on this matter, it is desirable that I should state more fully the reasons upon which my opinion is based.

One author has complained that some of our hospital physicians have fallen into the '*error*' of making too light of this affection, and that one or two in particular have even gone the length of ignoring its existence altogether. I fall under this stigma, for I hold that there is *no such disease* as "spermatorrhœa," as usually defined.

It has been truly stated, that charlatans, for their own selfish purposes, too often work upon the fears of their patients, and exaggerate the evil consequences to be anticipated; but what encouragement does the practitioner afford, who, under the head of 'consequences of spermatorrhœa,' includes '*phthisis, cerebral congestion, epilepsy, general paralysis and insanity—lastly, enfeebled sexual power, and ultimately impotence*' (Hassall)? These have been stated to be consequences of "spermatorrhœa," but we are not informed whether '*possible*' or '*probable*.' Spermatorrhœa has been defined to be "all losses of seminal fluid not occurring as the result of sexual intercourse." Impotence it is said is not an uncommon consequence of "spermatorrhœa." I have seen many cases which have been called "spermatorrhœa," but I never saw one which ended in any of the above terrible consequences. Impotence, not depending upon some congenital defect, or some obvious structural morbid change, is a most uncommon affection; indeed, I have myself never met with a single case.

All practitioners are well acquainted with the real nature of the cases included under the head of *spermatorrhœa*. It is not necessary, and it would not be decent to allude to much that has been said upon the subject, or to recount the cruel and often useless and unnecessary means that have been proposed and adopted for the treatment of losses of seminal fluid. It cannot be too widely known that the importance attached to this so-called disease is not justified by observation—that those who pretend to have made a special study of the disease, and to have discovered means of cure unknown to the profession, are mere pretenders—and that every practitioner is well acquainted with the state of things, and fully conversant with the treatment that should be adopted.

It is almost useless to refer to the injuries inflicted by charlatans, physically, morally, and commercially, because our laws afford no remedy. But it is a disgrace to us that disgusting hand-bills, headed "Spermatorrhœa," should be thrust into the hands of passers by, in all parts of the town; and that most immoral exhibitions, under the title of "Museums," should be permitted to flourish in a city like this. It is monstrous that it should be possible in law for an impostor to mulct a poor, foolish, labouring man of £5 and £10 for a dozen bottles of something closely allied to mucilage in composition, for the relief of an imaginary ailment. Charlatans, in all departments, well know that obstinacy, indolence, and wilful ignorance, form a part of the character of all dupes, and that in all classes of civilised society there are persons with these mental characteristics in sufficient number to afford them a favourable reception, to court and patronise them, and to load them with flattery and liberal and material support. Quacks well know that when their true character is found out, those who have been deceived by them will feel too much ashamed of themselves to expose the quackery; and the utmost inconvenience that can ensue to the quacks will only necessitate a change in the seat of their operations. The public prosecution of an extortionate rogue involves the public confession of unutterable folly on the part of the dupe; and although nothing is more common than for people to be imposed upon, it is rare in deed for an individual to confess that he has been a victim.

If people generally were a little better informed upon physiology and the principles of medicine, they would be able to protect themselves successfully from the imposition of pretenders—medical, social, and scientific.

The besetting trial of our boys.—Of late a great deal has been written on what has been termed "the besetting trial of our boys," and Dr. Pusey has drawn attention to this very delicate subject in the columns of the "Times" newspaper. It seems to me, therefore, of great importance that the matter should be brought under the careful consideration of the profession, more particularly as great difference of opinion exists as to the best means of preventing boys from acquiring the habit, and of curing those who have already fallen under its baneful influence. In December, 1866, Dr. Pusey wrote two letters to the "Times," containing some very startling statements. One of these is as follows:—"Fifty years ago, before the intercourse with the continent had been much renewed, I have reason to believe that that sin was unknown at most of our public schools. Now, alas! it is the besetting trial of our boys; it is sapping the constitutions, and injuring in many the fineness of intellect."

If this statement be correct, or only in part correct, careful enquiry into the state of our public schools ought at once to have been instituted, while on the other hand, if it was merely a highly exaggerated account, the sooner it was contradicted and the actual state of things ascertained the better. I answered Dr. Pusey's remarks in the "Medical Times and Gazette," December 22, 1866, and stated that I believed Dr. Pusey had been misinformed and had taken a very exaggerated view both of the extent of the evil and the seriousness of its effects. I also considered it my duty to speak against the system of habitual confession to the priest which Dr. Pusey strongly recommended as a preventive of this sin, and as the best means of stopping the habit when it had been unfortunately acquired. The letter I wrote on the subject called forth observations from other members of the profession and a reply from Dr. Pusey. These are I think of sufficient interest and importance to be brought under the notice of my readers.

Dr. Meadows ("Medical Times and Gazette," Jan. 5, 1867) considers that Dr. Pusey has rather under than overstated the facts of the case with regard to the extent and prevalence of the habit, and joins issue with me in my statement that the evil had been much exaggerated. As to its preventability and cure he thinks something more is necessary than the "occupying the boy's mind and endeavouring to make him feel an interest in his work and play." Allowing that "the workshop, the lathe, and the laboratory" are very valuable adjuncts in the training of boys, he questions their value as remedies for this evil, and states that he has himself *witnessed their failure.* Moreover, that from the very early age at which this habit often commences such remedies are utterly inapplicable. Dr. Meadows has known of it in several cases as early as two years and one case was mentioned to him by a friend in which the practice commenced at the age of twenty months (!) He concludes by commending Dr. Pusey for alluding to this subject in the columns of the "Times," but it hardly seems to have occurred to him that the practical treatment advised by Dr. Pusey, confession, is scarcely applicable at the very early age at which the habit commences according to his own experience. Surely the nurse and the child's mother must be terribly deficient in common sense if they do not at once resort to the proper treatment in such a case.

The experience of the Rev. E. Thring, head master of Uppingham school is opposed to Dr. Pusey's statements ("Med. Times and Gaz.," vol. XXXIV, p. 49). Narrating his own personal experience as a schoolboy on the matter, he states that he was three years at a small private school which from some circumstances was eminently calculated to foster such an evil, yet he never became aware of anything of the kind, and during nine years' stay at Eton afterwards, the existence of Dr. Pusey's 'besetting sin' was unknown to him. "In other words, no boy at Eton," in Mr. Thring's time, "was of necessity exposed to temptation, and betrayed in this way, at least without full means of escape." Of his later experience, as head master of a large public school, he says, "I have now been upwards of thirteen years head master here, perfectly alive to the possible existence of such an evil, and have never seen any reason to suspect its presence." . . . "One boy did consult me on the subject, but I deny that it has ever formed a definite temptation here;" and adds, "I have spoken to my medical man, and he unhesitatingly confirms this." Speaking of what means should be taken to prevent or cure the vice, Mr. Thring "unhesitatingly condemns any precautions implying suspicion and all approaches to individual treatment unless an individual entirely voluntarily asks advice."

Now, I do not believe there is another school in the world where greater care is taken to ensure thorough work and thorough play and to permit each individual boy to work at that particular department of human knowledge which excites in him the keenest interest, than Uppingham. There are first-rate carpenters, zealous naturalists, as well as distinguished scholars, among the boys of Uppingham school, and altogether the associations are so thoroughly healthy, and the boy life so thoroughly active and happy, as to render the spread of the evil, in such a society, I think I may say, absolutely impossible.

Mr. James Dixon ("Med. Times and Gaz.," vol. XXXIV, p. 71) remarks that "Dr. Pusey is trying to persuade us that our hearty jolly boys are so many candidates for ruin of mind and body, if they are not forthwith made over to the questionings and closetings of priestly confessors. . . . The question is, how can the evil be best counteracted. Dr. Pusey says by priestly scrutiny. Dr. Beale says by opposing effeminate, solitary, moping habits, and by encouraging all that tends to openness of character and love of healthy pastimes. I for one agree with Dr. Beale."

Mr. Charles Orton ("Med. Times and Gaz.," vol. XXXIV, p. 133) does not believe the sin to be at all general in our English schools. He was at a school abroad, where one dirty lad had led away into this vice one or two of his younger schoolfellows, and was cut and despised by nearly every boy in the school in consequence. He says, "*confession was of frequent occurrence, but the effect was only to increase the evil,*" *since the boys used to say, and Mr. Orton thinks, believe,* "*that the priest forgave them whenever they paid their fees!*"

In answer to the charge of having "exaggerated the evil," Dr. Pusey reiterated his former statements and wished to God that he had exaggerated the evil ("Med. Times and Gaz.," vol. XXXIV, 1866, p. 126). Since the correspondence in the "Times," the receipt of numerous letters from medical men and others have confirmed him in all he had said. In this letter Dr. Pusey states the following facts :—

1. "I have been informed by one who knew it that the great success of one who had a considerable reputation for curing those who consulted him some years ago, and who did effect cures which surprised people, was in a great degree owing to this—that he brought the vice home to patients, and so by scaring them from it, as the cause of their bodily illnesses, checked the various illnesses which it entailed.

2. "A physician of very great medical name and in large practice, recently told a friend of mine, that when he observed certain symptoms of debility of system, he always charged the patients with it and so cured them.

3. "Many years ago I accompanied a person labouring under mental delusions to a lunatic asylum. The first question asked me by the resident medical officer was whether he had this habit. He told me that it had brought many there. (I have heard the like as to other lunatic asylums.)

4. "The medical head of a lunatic asylum lately told a friend of mine that the person labouring under mental delusion whom he placed there was (I think) at least the *tenth* whom he had had from that cause from *one* large school.

5. "The system then of 'ignoring' the habit has failed. It is the very system under which it has grown up, from a time subsequent to my own boyhood, when at a very large public school, boys (except two of whom I heard afterwards that one died of it at the school, the other was a half idiot) were wholly ignorant of it. We did not understand the poor half idiot's allusion to it."

With reference to 'fact' 1, it is only necessary to remark that Dr. Pusey's informant begs the whole question, and it is surprising that Dr. Pusey should regard what he said as evidence of the slightest value one way or the other. The physician referred to under fact 2, should have stated what he meant by the vague term 'debility of system,' and what evidence he had that his patients were *cured.* There is nothing to remark on fact 3. Every practitioner is aware of the existence of the habit. The question is concerning its extent. No. 4 is the most important of the facts adduced by Dr. Pusey and should be very carefully inquired into—but it is most extraordinary that Dr. Pusey has omitted to say during what period of time the ten cases were admitted, and the number of boys in the school from which they were taken. If the percentage of cases from one particular school is very high, commissioners ought to be appointed to investigate the matter. It requires no prophet to say the education pursued at that school will be found false and rotten to the very core. Dr. Pusey himself would not surely rely upon confession to eradicate the evil from that school. In 5, Dr. Pusey asserts that ignoring the habit has failed, but he advances no facts or arguments to prove this. The half idiot probably owed both the habit and his idiocy to one condition, congenital defects in the structure of the central organs of his nervous system.

If Dr. Pusey has not much exaggerated the evil, numbers who acquire this vice must be cured without confession, or its consequences must be less serious than he supposes. I think it is much to be regretted that one with his authority should have expressed himself so strongly upon this very delicate subject, for I fear that his remarks may have the effect of leading some silly persons to place more reliance upon many of the statements in disreputable books which may be forced under their observation than they would otherwise have done. His observations are calculated, seriously and most unnecessarily, to alarm parents. And I cannot help thinking that if he had been able to look upon the matter more from the medical point of view, he would not have arrived at the same conclusion. Judging from many of the cases which have been brought under my observation, I should say that the system likely to foster and intensify this evil is the very one recommended by Dr. Pusey for its destruction. The temperament of many of the sufferers to which their unfortunate condition must at least in some measure be attributed, will benefit under the influence of circumstances very different from those advocated. Of course I speak only as a student of physiology and medicine, but in this capacity I think it right to offer the opinion that frequent self-examination, as deemed necessary by dismal despairing men who have been disappointed with the world, and who take a too gloomy view of everything,—habitual confession to melancholy men trained to deplore the wickedness of man,—the frequent concentration of the attention upon one of the most mysterious and complex of all the phenomena of our being, are not under any circumstances supposable likely to benefit the majority of boys. All this is antagonistic to their very nature, and its effect on the developing mind must be, at least in many instances, to cramp and distort it. I believe that the system of habitual confession, advocated by some members of our church, is calculated to do irreparable mischief not only to the mind but through the mind to the health of the body. And of this I am sure that no physician who has had much opportunity of observing the gradual development of the mental powers in young persons, and has at all studied the marvellous influence of the mind upon the bodily health and vigour, would advocate habitual confession as a desirable part of the training of girls or boys. Those who aim at making our boys into upright, generous, hardworking, vigorous, thoughtful men, will laugh and rejoice, and work and play with their boys instead of encouraging asceticism. But Dr. Pusey does not object to what I have said concerning the value of healthy exercise, thorough and good, hard, cheerful work, manly games, and hopeful, happy associations, but he says that experience shows that these alone are not enough; all I can say is that case after case that comes before me exhibits defects in these very particulars, and I will challenge Dr. Pusey to produce an instance of a body of boys or men subjected to such a healthy system, given to this or other evil habits. Your active minded, hearty, busy boy never thinks of anything of the kind. His mind is well occupied and he is happily ignorant of every thing connected with the subject. He will probably remain so till he grows up if his attention be well occupied, his life happy, and filthy books be kept out of his way. He will instinctively shun the society of boys or young men who discourse upon such subjects and would, if they could, lead him wrong.

Treatment.—The general treatment of these cases has been adverted to already. With regard to medicines, the special state of each individual patient must be considered by the practitioner. Tonics and mild sedatives with an occasional dose of blue pill are often very useful.

It may be well in this place to say a few words on those cases in which the habit is due to some peculiar condition of the organs themselves. I have met with many instances in which the habit has unquestionably been self-taught. It affects sometimes weak sickly children, and is sometimes to be traced to irritation about the prepuce or glans. Occasionally accumulation of secretion seems to be the exciting cause, and sometimes a superabundant prepuce, eczema, or an over sensitive state of the delicate surface of the glans exists. Circumcision acts beneficially in some of these cases, and it has been remarked that masturbation is virtually unknown in Jewish schools, "Medical Times and Gazette," vol. XXXIV, p. 79, *note.*

Many boys and young men who have acquired the habit are weak, nervous, excitable persons with little energy or power of self-control, and little love for bodily or mental work. Such persons could no doubt have been easily persuaded to confess, but what can one think of the strong-willed man who thus condescends to aspire towards having undue influence over a very weak one. From what I know of these cases I feel sure that confession to a priest is neither good for the patient nor for the confessor. Whether confession is right for a healthy, vigorous-minded man I will not discuss, but it will not cure hypochondriacs or encourage weak-willed, nervous, lazy, fanciful persons to rely more upon themselves, and endeavour to do their work in this world honestly and well.

As for those sad cases which pass into our lunatic and idiot asylums, there is great reason for thinking that the masturbation so far from being the cause of their sad fate is but one of a long train of symptoms depending upon defects in the development of parts of the nervous system, or resulting from disease originating there. It is as much the consequence of disease as paralysis, loss of sight, or loss of consciousness.

CASTS OF THE URINIFEROUS TUBES.

In many cases of congestion, and in inflammation of the kidney, a spontaneously coagulable material is effused into the tubes, and coagulates there, forming a *cast or mould of the tube.* This cast is gradually washed out by the fluid which is secreted from the Malpighian body behind it, and thus it finds its way into the urine, from which it may be easily separated for examination, p. 340.

The coagulable material which is effused becoming solid in the tube, entangles in its meshes any structures which may be there at the time. The characters of the cast will, of course, vary very much in different cases, according to the state of the tubes and the part of the tube in which the effusion of the matter takes place. By observing the character of the substances entangled in the cast, we are often able to form a correct notion concerning the nature of morbid changes going on in tubes at the time the cast was being formed.

Great difference of opinion has been expressed with reference to the nature of the material of which the cast is composed. By some it has been termed fibrine; but the striated appearance always present in coagula of this substance is not found in the cast. Others have considered that the cast consists of albumen; but it is not rendered opaque by those reagents which produce precipitates in albuminous solutions. Not very many years since, it was stated by two observers in France and Germany of high reputation, at least in other branches of scientific enquiry, that the cast really consisted of the basement membrane of the uriniferous tube. Such a statement requires no comment, how it could be made by any one possessing even a slight knowledge of the anatomy of tissues, it is difficult to understand.

The transparent material probably consists of a peculiar modification of an albuminous matter possessing somewhat the same characters as the walls of some epithelial cells, the elastic laminæ of the cornea, the walls of hydatid cysts, &c., but not condensed like these structures. I think it not improbable that these casts of the uriniferous tubes may really be composed of the material which, in health, forms the substance of epithelial cells. In disease, this substance, perhaps somewhat altered, or not perfectly formed, collects in the uriniferous tubes, and becomes inspissated. This view receives some support from the fact that occasionally casts are formed although no albumen passes into the urine. According to this notion, it is possible that a cast might be formed quite independently of any congestion or morbid condition of the Malpighian tuft; but, as a general rule, there can be no doubt that serum escapes and albumen is found in the urine.

The diameter and general characters of the cast will be determined by the state of the uriniferous tube at the time of its formation, as the researches of Dr. Johnson have indisputably proved. If the epithelium be abnormally adherent, the cast will be very narrow; if, on the other hand, the epithelium be removed, it will be of the width of the tube. Should the epithelium be disintegrating, the cast will afford evidence of the change. If in a state of fatty degeneration, fat-cells will be entangled in it. In hæmorrhage from any part of the secreting structure, blood corpuscles are present; and, when suppuration occurs, the cast contains pus corpuscles. When the transudation of the coagulable material occurs in a tube to which the epithelium is intimately adherent, or in a tube whose walls are smooth, the cast will be clear and perfectly transparent. Different forms of casts are represented in pls. XI to XVII.

Professor Virchow thinks that casts are very constantly, if not invariably, formed in the straight portion of the uriniferous tubes; but many of the facts already referred to militate against this idea, and it is common enough in sections of diseased kidneys to see the casts in the tubes of the cortex. Moreover, as I have demonstrated in several cases, the cast receives successive layers upon its outer surface as it passes down the tube, pl. XII, fig. 83, pl. XIV. There is no doubt that casts are formed in the *straight* as well as in the *convoluted* portion of the uriniferous tubes, but the value of the characters of the cast formed in the former situation in connection with diagnosis cannot be questioned, while it is obvious that from casts formed in the straight portion of the tubes we can learn nothing as to the nature of morbid changes going on in the secreting part of the gland. In pl. XII, fig. 83, portions of casts from the convoluted portion of the tubes are seen embedded in transparent material. The drawing was taken from specimens found in the urine of a case of acute suppurative nephritis. It is probable that the small casts were formed in the convoluted portion of the uriniferous tubes, and that the transparent material in which they were embedded, coagulated in the straight portion of the tube, near its opening at the summit of a papilla, pl. XVII, fig. 92. We may, therefore, conclude that casts are generally formed in the convoluted part of the tube, although, in certain cases, the coagulable matter may be effused in the straight portion also, in which case the diameter of the cast will be very much greater than if it was formed entirely in the convoluted part of the uriniferous tube.

Casts of the renal tubes are seldom found unmixed with other deposits. Frequently they are accompanied with much epithelium, and in many cases blood globules are present in considerable number. Occasionally, however, we meet with a transparent and scarcely visible deposit, consisting entirely of casts. The connection between different renal diseases and the presence of casts in the urine has been demonstrated most conclusively by Dr. Johnson, but many who have not patiently studied the matter have confidently asserted that the characters of casts are not of that importance in diagnosis which he and others have

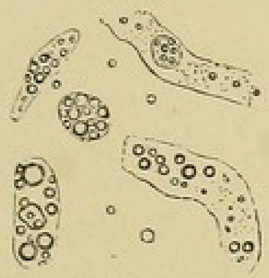
Fig. 76.

Spermatozoa and crystals of phosphate of lime, from the seminal fluid. × 215. p. 329.

Fig. 77.

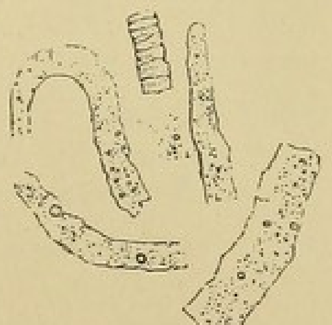
Waxy casts. *a*, of large size. *b*, small waxy casts. × 215.

Fig. 78.



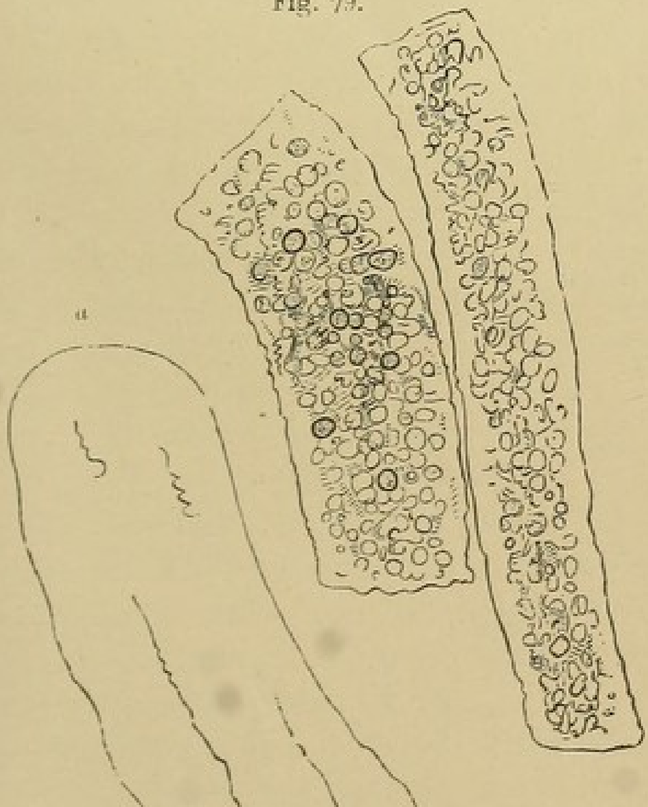
Casts containing oil-globules, and free fat-cells, from a case of fatty degeneration of the kidney. × 215.

Fig. 78A.



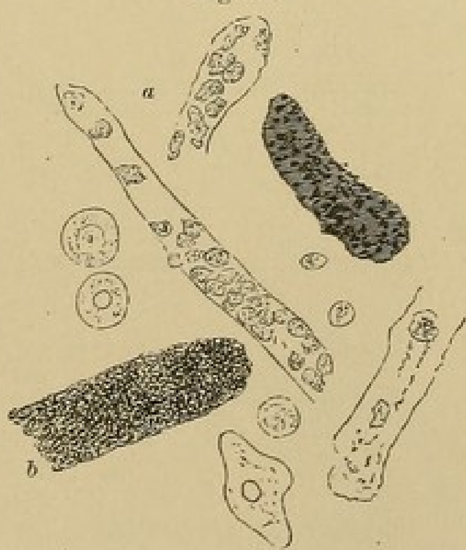
Small granular casts, from the urine of a patient suffering from chronic nephritis. × 215.

Fig. 79.



Large casts. Some containing many cells, others consisting of a perfectly transparent wax-like material. × 215.

Fig. 80.



Epithelial casts. *a*, casts containing cells of epithelium. *b*, cast containing granular matter. From urine of acute dropsy. × 215.

$\frac{1}{1000}$ of an inch |____| × 215. p. 341.

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maintained. It has been stated that the different morbid states of the kidney, familiar to everyone, are but different stages of one and the same disease. It is to be regretted that observation should be retarded by such hasty and confident assertions. All that need be said is simply that a few months' careful study in the wards of a hospital and in the dead-house, will serve to convince any unprejudiced person that the nature of renal disease may be diagnosed in many cases by the microscopical characters of the urinary deposit, and that there are several essentially distinct forms of renal disease. I can, from my own observations, testify strongly to the truth of the general conclusions arrived at by my colleague, Dr. Johnson, upon these questions.

Of casts there are several different forms, which are to some extent characteristic of the morbid changes taking place in the structure of the kidney. As has been shown, the cast varies in diameter with that of the canal of the uriniferous tube; but, probably, after its formation, it contracts slightly, and in consequence it readily passes from the tube, and escapes into the urine. In chronic disease, the diameter of the tube may be greater or less than in health. If, in a tube of normal diameter, the epithelial layer be of its ordinary thickness, we shall have a cast of medium size. If the cells be enlarged, and adhere firmly to the basement membrane, the cast will be fine and narrow; while, on the other hand, if the tubes be entirely stripped of epithelium, the basement membrane alone remaining, the diameter of the cast will be considerable. In describing the different varieties of casts it will be convenient to divide them into three classes, according to their diameter. In some cases the tubes of the kidney are so much wasted that casts could not be formed in them. *See* pl. XVII, fig. 95.

The figures of casts in pls. XI to XVII have been carefully traced from the objects under examination.

A. Casts of medium Diameter, about the 1-700th of an inch.

1. Mucus casts.
2. Epithelial casts.
3. Pale and slightly granular casts, with or without a little epithelium, or epithelial *débris.*
4. Casts appearing granular, in consequence of urates being deposited upon and in the substance of the cast.
5. Granular casts, consisting entirely of disintegrated epithelium.
6. Casts containing pus or blood.
7. Casts containing oil.

B. Casts the Diameter of which is about the 1-500th of an inch.

1. Large transparent "waxy casts."
2. Large and darkly granular casts.

C. Casts the Diameter of which is about the 1-1000th of an inch.

Small waxy casts.

A.—Casts of Medium Diameter.

Mucus Casts.—In certain cases in which there is evidence of considerable irritation in the kidneys, sometimes so much as to lead one to suspect the existence of calculus in the kidney, a number of flocculent shreds may be passed in the urine. I have seen several cases in which these were composed of a very transparent and slightly granular material, like ordinary mucus. In pl. XII, fig. 81, is represented such a cast which must have been entirely formed in the straight portion of the tubes. The ramifications from the larger mass extended into the fine tubes which open into the larger ones in considerable number. The drawing was taken from a specimen found in the urine of a patient under the care of my friend, Mr. Charles Hawkins, who had been suffering from renal irritation and affection of the bladder for many years.

Mucus casts are not unfrequently passed in cases where the urine is of very high specific gravity, 1,030 or higher, containing excess of urea and urates. It is probable that urine of these characters irritates the mucous membrane. Sometimes, in consequence of the urate being deposited in an insoluble form, upon and in the substance of the mucus, after the urine has been passed, the casts are dark and granular, and without care they may be mistaken for true casts indicative of chronic degeneration of the kidney. Some appear white if examined by reflected light. Such casts, dark and granular from the presence of urates, and often of a very brown colour, form a deposit in the urine not unlike that occurring in cases of acute nephritis, where there is hæmorrhage from the kidney, but although traces of albumen are found, actual blood corpuscles are not generally present as in that affection, and the colour is entirely due to altered blood colouring matter passed in a state of solution. Casts of the kind under consideration are represented in pl. XII, fig. 82.

Epithelial Casts are met with in great number in all cases of *acute nephritis;* and their presence is generally accompanied with a considerable deposit of uric acid, and also with much free epithelium and epithelial *débris*. These casts often contain many perfect cells of renal epithelium, and not unfrequently blood globules are entangled in them, pl. XI, fig. 80, pl. XII, fig. 85, pl. XIII, fig. 86, at *a*.

Besides these casts, however, some of the larger casts, comprehended in the second class, may often be observed, pl. XIV, fig. 88, *a*; and these have, as Dr. Johnson states, "a wax-like appearance;" or they may be dark and granular, or part of the cast may be so highly granular as to be quite opaque, while in another portion it may be perfectly clear and transparent. The very wide casts and fragments found in those cases of acute nephritis, in which the kidney was in a sound state before the attack, are probably, wholly or in part, formed in the wide portion

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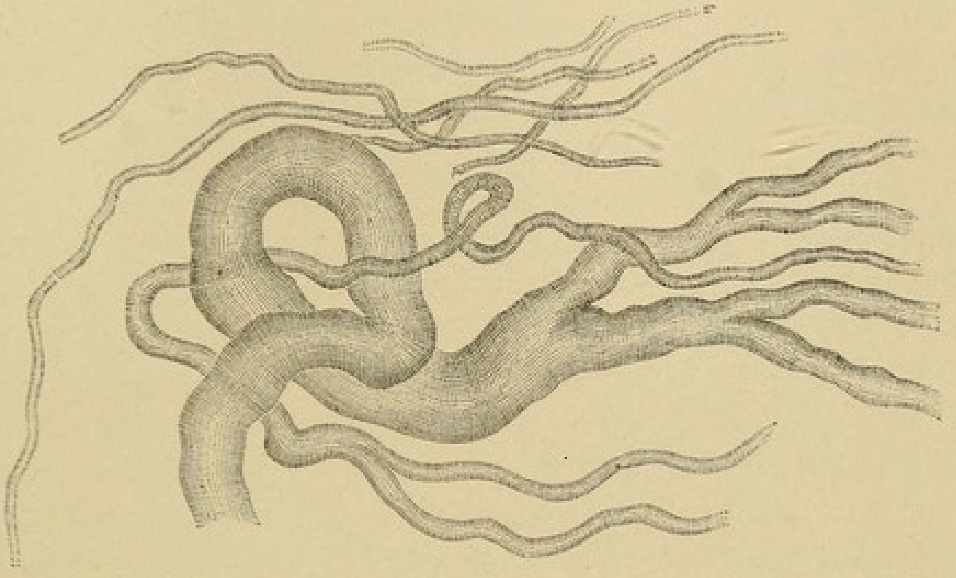
Fig. 81.

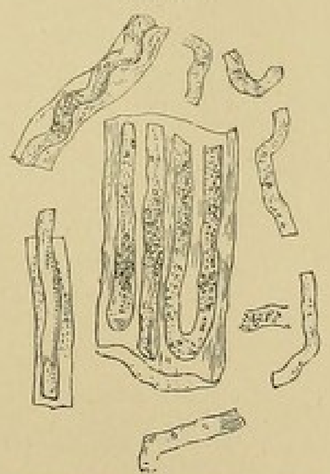


Mucus cast, from the straight portion of the urniferous tubes, showing the manner in which the large renal tubes divide and subdivide as they pass towards the base of the pyramids. × 75. p. 342.

Fig. 82.

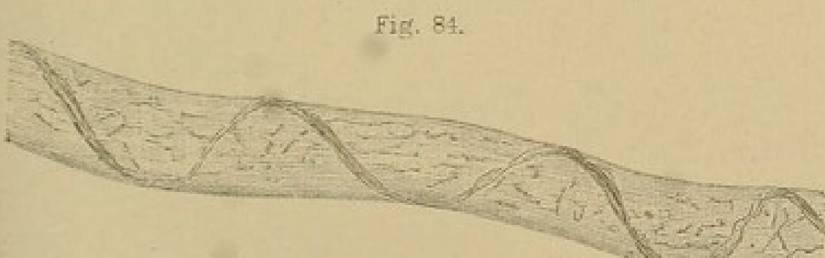
Mucus casts, with dark brown urate deposited upon their surface and in their substance. They became quite clear and transparent when warmed. × 215. p. 342.

Fig. 83.



Waxy casts of large and small diameter. In the centre of the larger ones casts of small diameter are seen to be embedded. × 50. p. 340.

Fig. 84.



Portion of a mucus cast, which has been formed around a smaller and serpentine one. × 215. p. 342.

Fig. 85.

Casts containing blood corpuscles, from a case of acute nephritis. × 215. p. 342.

$\frac{1}{1000}$ of an inch |___| × 215.

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of the uriniferous tubes near the papilla. Sometimes also a few of the small "waxy casts" may be observed, and rarely a few of the cells may be found to contain well-defined oil globules.

Granular Casts.—A considerable number of "granular casts," of medium diameter, will be present in the early stage of chronic nephritis. Afterwards they may become abundant, and occasionally are so numerous that they form a white deposit at the bottom of the vessel.

Dr. Johnson says that, in the third stage, there may be an abundant deposit composed of granular casts and disintegrated epithelium; or secondly, the granular casts may be mixed with large waxy casts, with a sharp and well-defined outline; or thirdly, the waxy casts may be in small number, and mixed with a few granular casts and disintegrated epithelium. Casts from a case of chronic nephritis are represented in pl. XI, fig. 78, and pl. XV.

Casts containing Oil.—In that condition of the kidney termed "fatty degeneration," the pale highly albuminous urine which is often passed in considerable quantity, frequently contains a number of casts which appear to be made up of oil globules, or composed of cells containing oil, pl. XI, fig. 78. In adults recovering from acute nephritis, it is not uncommon to find a few oil particles in the casts, pl. XIII, fig. 86, *g*, and cells crammed with small oil globules floating in the surrounding fluid; but at the same time, if there be a greater number of granular or epithelial casts, the presence of the oil need not excite any apprehension for the patient's safety. If, however, the oil casts increase during weeks or months while the other casts diminish in number, we shall probably find that the case will pass into confirmed fatty degeneration, and that the acute attack affected a kidney, not previously in a perfectly sound state. The composition of the oil in these cases has been alluded to in p. 310. *See* also pl. XVI, figs. 90 and 91.

Fat-Cells.—Besides the occurrence of fatty matter in casts, and in cells entangled in casts, it is very commonly met with in cells, or as small collections in the urine; and occasionally these are present without any casts. Many such bodies consist of altered epithelial cells of the kidney, enlarged and gorged with oil. Sometimes they contain a few oil globules, which are well defined, and are seen to be distinct from each other; while, in other instances, the globules are very minute, and so crowded together that the mass appears by transmitted light to be perfectly opaque and dark, resembling the so-called 'inflammatory globules,' while, if examined by reflected light, these bodies are perfectly white. Although I have used the term *cell*, it is not possible in many cases to demonstrate the presence of a *cell-wall*. Occasionally, "cells" containing oil globules are derived from some other part of the mucous surface of the urinary passages. I have seen epithelial cells, and collections of oil globules which have been removed from the membranous portion of the urethra. It is therefore important to bear in mind that cells containing oil globules are not invariably derived from tubes in a condition of fatty degeneration, and are not necessarily indicative of diseased kidney.

Casts containing Blood Globules are not unfrequently met with in the deposit of the urine in acute nephritis, pl. XII, fig. 85. They are usually of medium size, and often contain a certain quantity of epithelium besides blood.

The blood in many of these cases is undoubtedly poured out by the vessels of the Malpighian body. It is extraordinary how determined some observers are in asserting that this hæmorrhage from the Malpighian body into the upper part of the uriniferous tube does not occur, and that "casts" are not formed in this part of the tube. The blood has, however, been seen by Bowman, Johnson, and others in the convoluted part of the tube, near and in the Malpighian body, and also in the lower straight portion, and I have been able to verify these observations over and over again, and have often injected colouring matters through the capillaries of the Malpighian body into the tube.

White blood corpuscles sometimes grow and multiply in casts in considerable number, pl. XVII, fig. 94.

Casts containing Pus are not common, although some cells agreeing in many characters with the pus globule are not uncommonly present. Of these cells, some are no doubt modified cells of renal epithelium, the germinal matter of which is of much larger size than in health, the formed matter of the cell being nearly absent, while others are altered white blood corpuscles, pl. XVII, figs. 93, 94. Cases in which the urine contains bodies having these characters are generally acute, and terminate fatally in a short time. A beautiful specimen of the urinary deposit in one of these rapidly fatal cases is represented in pl. XIV. I have, however, seen many cases occurring in children and in adults where these casts and cells were most abundant, which have been completely recovered.

Casts containing Dumb-Bells.—In the urine of a patient suffering from cholera, after eighteen hours suppression of urine, I found a trace of albumen, with some very transparent casts entangling dumb-bell crystals of oxalate of lime, pl. XVII, fig. 96. Octahedral crystals of oxalate were also present in the urine; but none were seen in the casts. The presence of dumb-bells in casts proves clearly that these peculiar crystals are formed in the uriniferous tube.

Crystals of triple phosphate and octahedra of oxalate of lime are sometimes met with in casts.

B.—Casts of considerable Diameter.

Large Waxy Casts, of about the one five-hundredth of an inch in diameter, are derived from tubes which have been entirely stripped of epithelium, or have been formed in the straight part of the tube. They are often met with in small quantity in the urine of acute desquamative nephritis; but when present in considerable numbers, a condition of kidney to which Dr. Johnson has given the name of "waxy degeneration," from the peculiar glistening appearance of the substance with which the tubes are filled, is present. Large waxy casts are represented in pls. XI, XIV, figs. 77, 79, 88.

In some cases, it is certain that these casts of large diameter are formed in the lower part of the straight portion of the uriniferous tubes where these are very wide. The material of which the cast is composed is sometimes deposited in successive layers, and a small cast, formed high up in the convoluted portion, is occasionally seen in the centre of a large one formed below, pl. XII, fig. 83, pl. XIV. Although in some cases the convoluted portion of the uriniferous tube is wide enough to admit of the formation of one of these large waxy casts, I have never seen an instance where the tubes between the cortical and medullary portion of the kidney were large enough to permit so large a cast as that figured in pl. XII, fig. 83, to pass through. There is, however, reason to think that this part of the tube becomes much dilated in some cases. *See* my "Archives," vol. I, p. 303.

The largest transparent casts which are formed in the widest part of the tube are of little importance, clinically, and the physician must not be induced from the prominence of these objects to give an unfavourable prognosis. In some forms of temporary disease they are found in great number.

C.—Casts of Small Diameter.

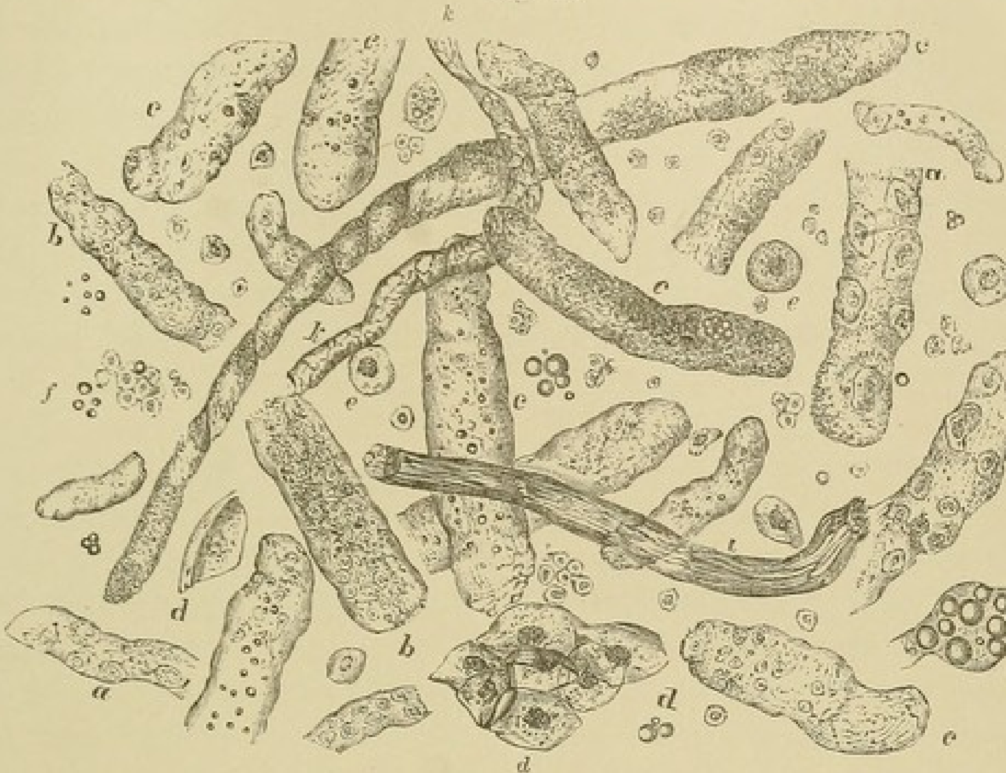
Small Waxy Casts are derived from tubes in which the epithelial lining is entire, or probably more commonly from tubes which have undergone considerable contraction. Dr. Johnson considers that the formation of casts of very small diameter depends upon the adherent state of the epithelial cells, which exhibit no tendency to desquamate—a condition which he describes under the name of "*non-desquamative nephritis*." The urine is either found to contain no deposit whatever, although albuminous, or only some of the small waxy casts, not more than one thousandth of an inch in diameter, can be found. In some of these cases, symptoms of blood poisoning come on, and a rapidly fatal result occurs. The casts have a perfectly smooth and glistening surface, and present in the microscope the same general appearance as a piece of the elastic lamina of the cornea, pl. XI, fig. 77, pl. XV. It is probable that some of these very fine casts are formed in tubes which have not attained full development.

Of Casts in a Clinical Point of View.—It is generally admitted that the treatment of kidney diseases has advanced very much within the last few years. Frequently we are able to say most decidedly what course should be followed in a given case; and we can indicate exactly the conditions under which the progress of the malady will be retarded, and warn the patient of those which will certainly hasten the extension of disease. I do not think I have at all exaggerated the improvement which has taken place in this department of medicine; and when we remember that we possess much positive knowledge of the anatomy and physiology of the kidney, and that its morbid changes have been more successfully investigated than those of other important organs, we can scarcely help attributing the improved treatment to our increased knowledge, and we have every encouragement to hope that ere long a similar result will be seen as distinctly in other branches of medicine. I am quite sure that many patients with chronic renal disease are now kept alive, and even enjoy life, for many years longer than was usual at a time when the exact nature of their malady was not understood, and when the treatment considered right was of a kind which no one, knowing anything of the physiology of the kidney, would now think of adopting.

Casts resembling those delineated in fig. 86, pl. XIII, are often found in cases of acute inflammation of the kidney coming on from exposure to cold, or following scarlatina. It will be observed, however, that there are several different forms of casts which might give rise to some confusion in the mind of an observer endeavouring to form an opinion as to the acute or chronic nature of the case. At the same time we must not express ourselves confidently, if only one or two casts of a particular kind are found. Thus we may meet with, in the deposit of the urine from acute cases which completely and perhaps rapidly recover, one or two cells containing oil, and one or two casts containing a few oil globules; but we must not, from the presence of these, be led into the error of concluding that the case will necessarily become one of fatty degeneration of the kidney. If, however, there were *numerous* cells and casts containing oil, such an inference would undoubtedly be correct. We must not expect to find in one case *epithelial casts* alone, in another *granular casts* alone, in a third *fatty casts* alone, in a fourth none but *large waxy casts*, and so on; but we must be prepared to meet with several varieties in one case, and must ground our opinion in great measure upon the relative number of any particular kind of cast, and upon the circumstance of other deposits being associated with the casts. For instance, the presence of uric acid crystals and blood corpuscles would render it very probable that the case was acute, and would be of short duration. The absence of these deposits, and the presence of a number of granular or perfectly transparent casts—which can only be seen when the greater part of the light is cut off from the field of the microscope—or the existence of *a number of oil casts*, render it certain that the case is

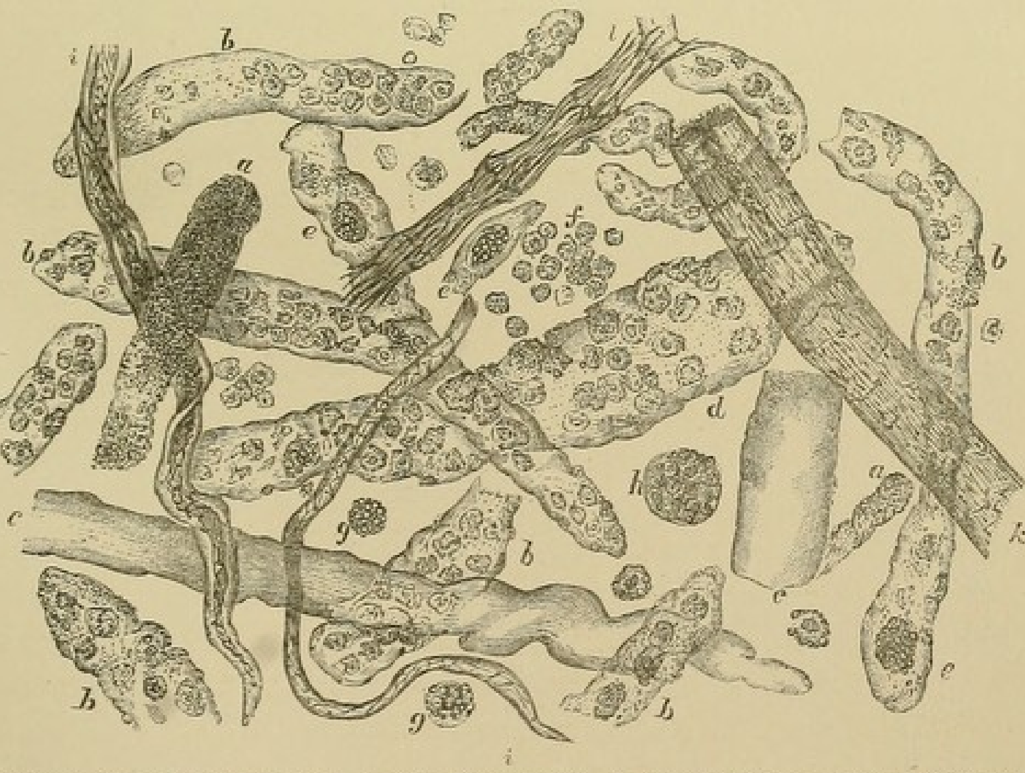
URINARY DEPOSITS.

Fig. 86.



Epithelial and granular casts from the urine of a woman suffering from acute nephritis with dropsy, of a fortnight's duration. *a*, epithelial casts; the cells of renal epithelium are very distinct, and their nuclei well defined. *b*, casts containing brown granular matter and blood corpuscles. *c*, granular casts of a brown colour, many of them containing a few oil globules. *d*, squamous epithelium from the vagina. *e*, epithelium from the bladder. *f*, cells containing oil globules. *g*, portion of a cast containing oil globules. *h*, circular granular cells, probably altered renal epithelium. *i*, fibre of flax, of accidental presence. *k*, blanket hair. × 215. p. 347.

Fig. 87.



Casts from a case of chronic nephritis. *a*, dark granular casts. *b*, casts containing small granular cells and white blood corpuscles. *c*, waxy casts, consisting of a perfectly clear glistening material. *d*, large cast, flattened by pressure, containing white blood corpuscles. *e*, portion of a cast containing a large cell filled with oil globules. *f*, pus corpuscles, probably derived from the bladder. *g*, collections of small oil globules. *h*, large cell containing smaller cells in the interior. Of the nature of this I am ignorant, but I have observed such in several specimens of urine. *i*, portions of cotton fibre. *k*, piece of very thin human hair. *l*, fragment of flax. × 215. p. 347.

$\frac{1}{1000}$ of an inch ⌴ × 215.

[To face page 346.

chronic. The former would indicate that the kidney was becoming small and contracted, while the latter variety of casts occurs when it is often of large size, and fatty. Such examples might be multiplied. When we consider how very numerous are the secreting tubes of the kidney, we cannot feel surprised that a different condition should exist in certain cases, in different tubes, at the same time; and, from careful *post-mortem* examinations, we know that very different morbid appearances are often seen in different parts of the cortical portion of one kidney. It is not difficult, therefore, to account for the fact of the presence of casts differing much in their diameter and characters in the same specimen of urine.

Dr. Basham thinks he can judge of the stage of Bright's disease by the character of the urinary sediment. I wish I could agree with him in this conclusion. The more carefully the matter is investigated the more convinced am I that it is unsafe in many cases to attempt to draw inferences as to the stage of the disease, from the character of the urinary deposit only. Nothing but a careful consideration of every point connected with the case will enable us to arrive at a general conclusion concerning the state of the disease, and this should be always expressed with considerable reservation, for however careful we may be we shall find that our opinion will turn out to be incorrect in some instances not only as regards the exact nature of the disease, but also as regards its duration and result. Dr. Basham says, "the most untractable and hopeless form of morbus Brightii is that represented by the presence of the fatty or oily cast." This statement requires some qualification, for although it is quite true that some of these cases are terribly and rapidly fatal, it must be admitted that some live for twenty years or more and die at last of other disorders. There are many cases in which it would be most unsafe to form a diagnosis from the character of the cast, and in some, terrible errors in prognosis would be the result of pursuing such a course.

The chief points to be noticed in the specimen delineated in pl. XIII, fig. 86, are—1. *The presence of casts containing well-marked and large cells of renal epithelium, as, a, which are never met with in chronic cases.* 2. *The existence of a number of casts, as b, containing blood corpuscles. The granular matter in the casts c, is of a brown colour, and consists of disintegrated blood corpuscles.* 3. *A great many cells of epithelium, and numerous blood corpuscles are seen in various parts of the field perfectly free.* 4. *The urine contains a large quantity of albumen.*

These points render it almost certain that the case is an acute one.

In fig. 87, a number of casts containing circular and faintly granular cells of altered epithelium are represented with a good deal of disintegrated epithelium. The chief points to be noticed here, are—1. *The presence of a number of granular casts, which are dark without any tinge* *of a brown colour.* 2. *The presence of perfectly transparent wax-like casts, c.* 3. *The existence of the altered epithelial cells, and the granular material resulting from their disintegration.* 4. *The pale colour of the urine, and the presence of a small quantity of albumen.* These characters point to the chronic nature of the case. The duration of the disease could not be ascertained, but from the number of casts containing epithelium, it was probably not of very long standing.

The casts represented in pl. XIV, are not very often met with. They are for the most part found in the urine of patients suffering from an uncommon, and very acute, form of inflammation of the kidney, which often goes on to the formation of pus in the uriniferous tubes, and is sometimes fatal in the course of a few days. The structure of the tubes in one part of the kidney may be so completely destroyed as to lead to the formation of small abscesses.

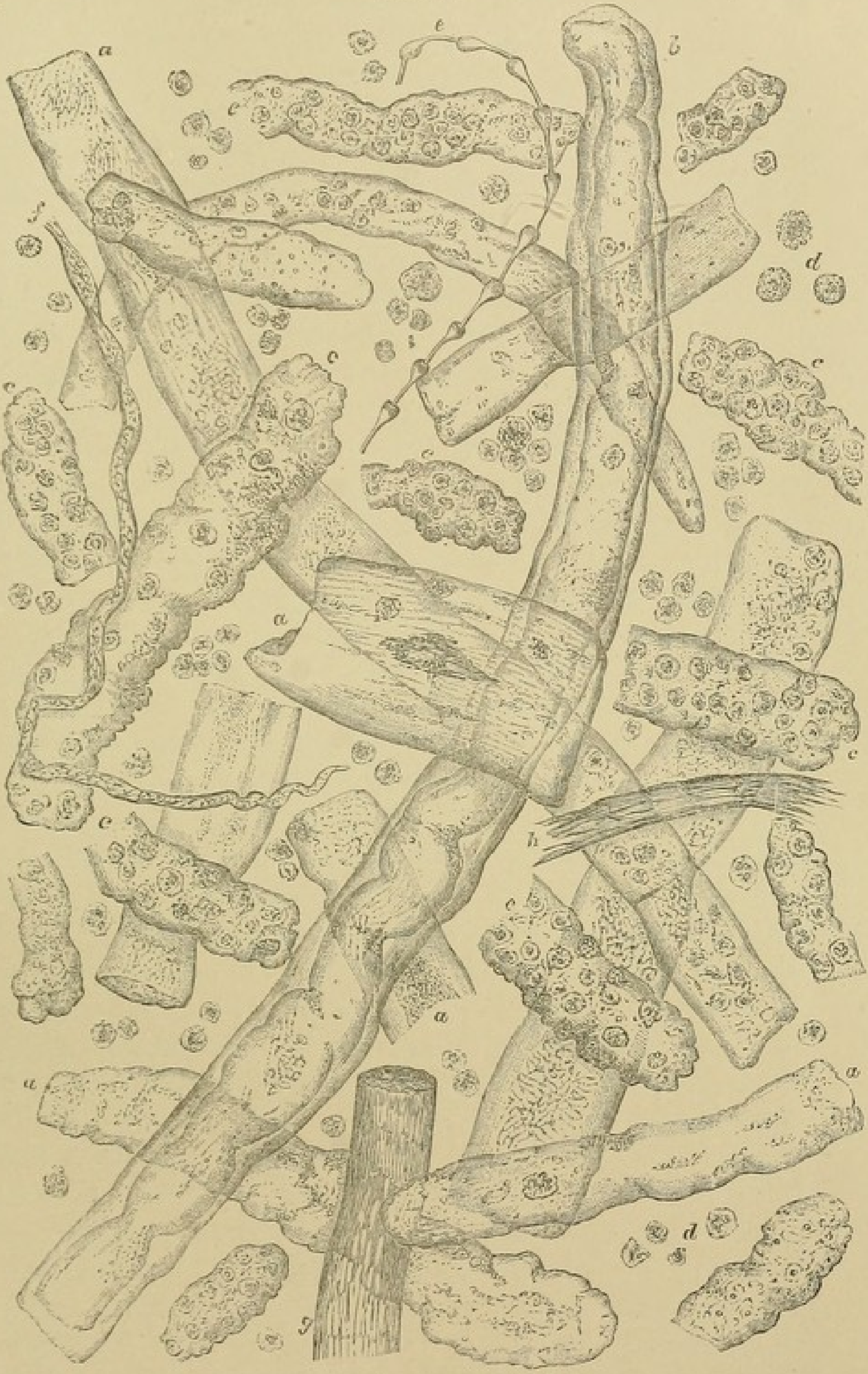
In this case, although there was no history or other evidence of long-continued kidney disease, it is most probable that the man had been suffering from chronic nephritis for a long period, and that the structure of the kidneys had been seriously impaired before the occurrence of the acute attack.

I have seen recovery take place in many cases in which cells not to be distinguished from pus corpuscles were present in the casts in considerable number, and also free in the urine. A very marked case of this kind was that of a boy suffering from dropsy after scarlatina, whose urine was loaded with pus casts and pus, or at least with cells exhibiting the two or three central bodies upon the addition of acetic acid, and presenting all the characters of pus corpuscles. Many large transparent waxy casts are observed scattered over the field, from which we should infer that the epithelium in many of the tubes had been destroyed, and the basement membrane rendered bare. At the same time it is probable that these very large casts were formed in the straight portion of the uriniferous tube in the pyramid, where its diameter is very great. That the cast is formed from a material which enters the tubes from the vessels surrounding it, as well as from the Malpighian capillaries, is rendered probable by the circumstance that new matter is often deposited upon the circumference of the cast as it passes down the tube. In this case we have a cast apparently within a transparent tube, a very good example of which is represented at *b*, fig. 88, and such specimens are not very uncommon. *See* also pl. XVII, fig. 92.

In the present case many of the tubes were denuded of their epithelium, while in others the epithelium was undergoing disintegration. In the latter instance the function of the tube as a secreting apparatus would have been temporarily impaired, while in the former it would have

URINARY DEPOSITS.

Fig. 88.



Casts, acute inflammation of the kidney.

Casts from the urine of a man, aged 45, suffering from acute inflammation of the kidneys. There was very slight œdema of the legs. The patient died comatose three weeks after the first symptoms appeared. The urine contained so much albumen that it became perfectly solid upon the application of heat and after the addition of nitric acid.

a, perfectly transparent wax-like casts. The shading should be more faint than in the drawing. *b*, a very long wax-like cast, consisting of material deposited at two different periods; the original cast in the interior was probably forced a certain distance further down the uriniferous tube, when a new layer of the coagulable material was deposited around it. *c*, casts filled with cells closely resembling pus corpuscles, but somewhat larger. *d*, the same cells free in considerable number; the greater part of the deposit consisted of these cells. *e*, portion of feather. *f*, piece of cotton fibre. *g*, portion of human hair. *h*, flax fibre.

× 215. pp. 344, 348.

$\frac{1}{1000}$ of an inch |____| × 215.

[To face page 348.

been destroyed; and the structure of the organ so much altered that the hope of any permanent improvement would be slight.

Transparent waxy casts are sometimes, but not invariably, present in cases of amyloid degeneration of the kidney. The changes occurring in this form of disease have been referred toi n p. 71. Although in some instances large and small waxy casts are detected in considerable numbers, not unfrequently the urine is entirely destitute of any deposit whatever, and although occasionally an abundant deposit of casts may exist, the urine throughout the greater part of the period during which the disease runs its course contains hardly any deposit.

Dr. Basham states that the fatty or oily casts, p. 343, are present in cases of the so-called amyloid degeneration of the kidney. It has been already stated that oil casts are to be detected in the urine both of chronic and acute nephritis, but it would be easy to adduce examples of amyloid kidney in which no oil casts were to be found amongst the deposit at any period of the disease.

In pl. XV, several forms of granular casts are represented. In the upper part, about the centre of the page, is seen one cast containing cells of epithelium. These casts were obtained from the urine of a man, age 34, who had been subject to chronic rheumatism for many years. The urine contained a small quantity of albumen. The kidney disease had probably existed for several years, but its duration could not be accurately ascertained. Such casts are very commonly met with. It will be observed that the casts in this specimen vary very much in diameter, some being scarcely more than the 1-2000th of an inch, while others are as much as the 1-500th of an inch. The former come from exceedingly narrow tubes, or from tubes in which the epithelium is abnormally adherent, while the latter are derived from tubes denuded of epithelium. In this case the kidney was much contracted, in the state which has been termed "gouty kidney" by Dr. Todd, because the condition is very common in persons who have suffered for many years from gout.* In the majority of cases there can be no doubt that spirit drinking lays the foundation of the mischief.

In *fatty* degeneration of the *kidney*, the urine is usually pale, and of low specific gravity. The deposit is light, bulky, and flocculent. It contains casts and cells containing oil globules. Although in other cases of disease of the kidney, a few casts and cells containing oil are not unfrequently present, a number of these never occur in the urine unless the condition is one of fatty degeneration.

When casts containing separate oil globules, or oil enclosed in cells, are found in any number in specimens of urine, from the same patients, which have been subjected to examination at intervals of a few days

* *See* Todd's "Clinical Lectures," edited by me, p. 383.

with or without cells containing oil, and free oil globules among them, we cannot be wrong in concluding that the condition is one of fatty degeneration of the kidney.

Some of the casts delineated in fig. 90, pl. XVI, contain epithelial cells which do not contain oil globules, as well as cells in which the process of fatty degeneration is far advanced.

II.—SECOND CLASS OF URINARY DEPOSITS.

Substances which are included in the second class of deposits form a bulky, dense, opaque, and often abundant sediment, which sinks to the bottom of the vessel, leaving a perfectly clear or more or less turbid supernatant fluid.

Urates, Phosphates, Pus.—The most important deposits of this class are those consisting of *urate of soda*, *earthy phosphate*, and *pus*; and these three deposits are very commonly met with. To the practitioner, they are especially interesting; and as their presence in the urine is characteristic of morbid conditions differing widely from one another, while the appearance of the deposits to the naked eye is very similar, it is a matter of great importance that he should be able to distinguish them with certainty, and at the same time with facility. Before entering upon a detailed description of these bodies, I will draw attention to an exceedingly simple method of distinguishing them. After the urine has stood for some time in a conical glass, the clear supernatant fluid is to be poured off, and a little of the deposit transferred to a test-tube. Upon the addition of about half the bulk of solution of potash, one of the three following points will be noted :—

1. The solution of potash may cause the mixture to become clear, but not viscid, in which case *urate of soda and ammonia* enter very largely into the composition of the deposit.

2. *No change* will be produced, in which case the deposit consists entirely of *phosphate*.

3. The mixture will become *clear*, and very *stringy* or *viscid*, so that it cannot be poured from the test-tube in drops. In this case, we may be certain that the deposit consists of *pus*.

If liquor potassæ gelatinises the mixture, but does not render it clear, it is probable that both *pus* and *phosphates* are present. In any of the above instances, our conclusion as to the nature of the substance should be confirmed by some of the tests presently to be mentioned, and by microscopical examination.

I have seen, but not on more than three or four occasions, deposits of *blood* and deposits of *cancer cells* in such large quantity, that they might be included in this class; but it would scarcely be possible, even

URINARY DEPOSITS.

Fig. 89.

Casts. Chronic nephritis.

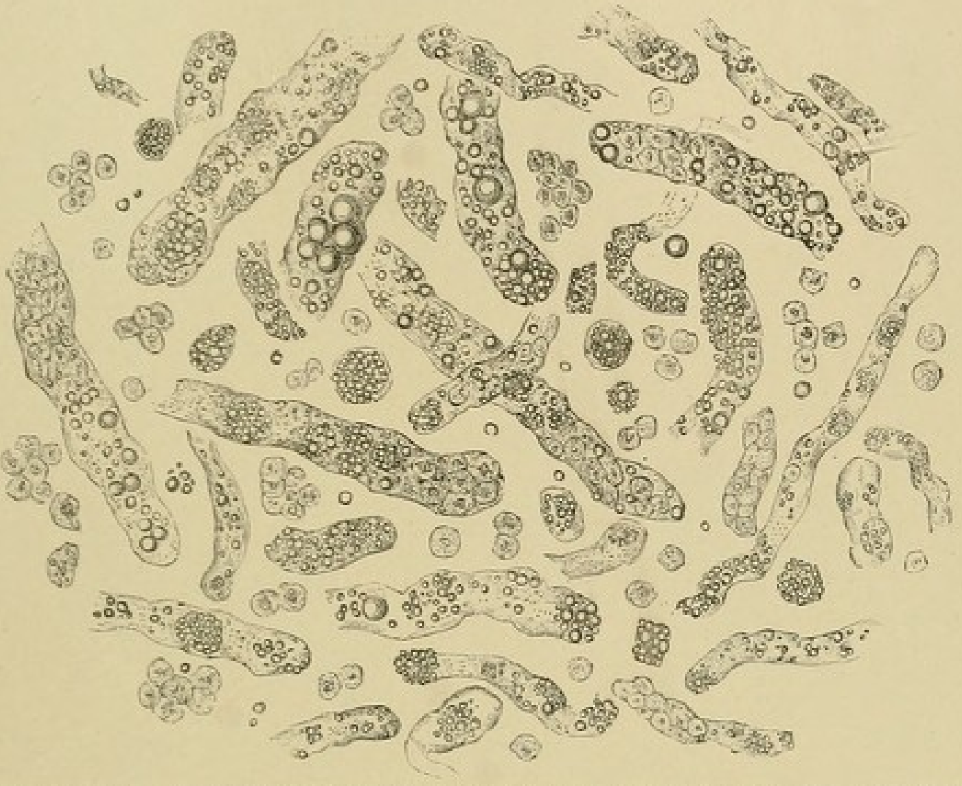
a, casts of large diameter, containing granular matter scattered through them unequally. *b*, a very long, clear and perfectly transparent cast, containing only a few minute oil globules here and there. *c*, dark granular casts, some of them containing a few oil globules. *d*, large masses of granular matter, many of them appearing like granular cells. Most of these are derived from the mucous membrane covering the glans. *e*, cells of renal epithelium, darker and more granular than usual. *f*, mass of squamous epithelium, probably from one of the follicles of the mucous membrane of the bladder. *g*, free oil globules. *h*, portions of cotton fibre. *i*, portion of feather. × 215. pp. 313, 319.

$\frac{1}{1000}$ of an inch ⌊___⌋ × 215.

[To face page 350.

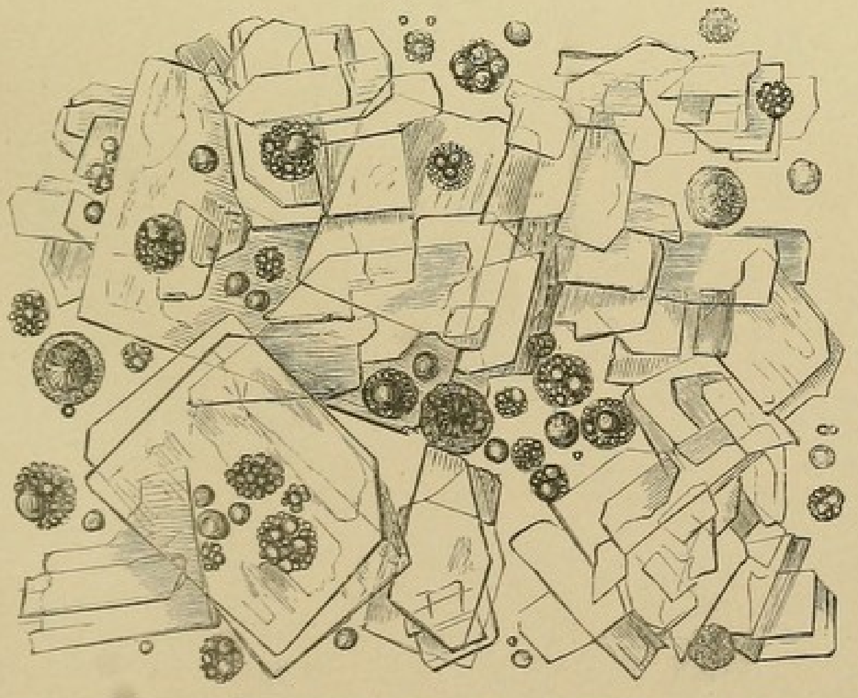
URINARY DEPOSITS.

Fig. 90.



Casts, containing oil from the urine of a case of fatty degeneration of the kidney of long standing. Many cells of epithelium contain no oil. × 215.

Fig. 91.



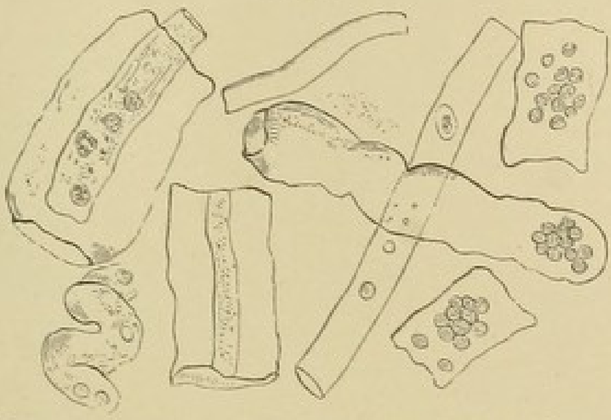
Cholesterine obtained from the fatty matter in casts separated from the urine of a case of fatty degeneration of the kidneys. Globules composed of non-crystallizable fat only are seen scattered in various parts of the field. × 215.

$\frac{1}{1000}$ of an inch ⌊___⌋ × 215.

[To follow PLATE XV.

URINARY DEPOSITS.

Fig. 92.

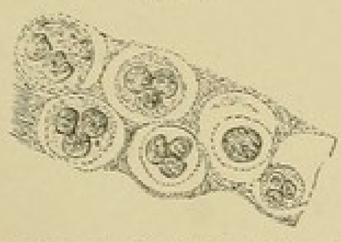


Casts of the uriniferous tubes, from a case of acute nephritis. × 215. pp. 345, 348.

Fig. 93.

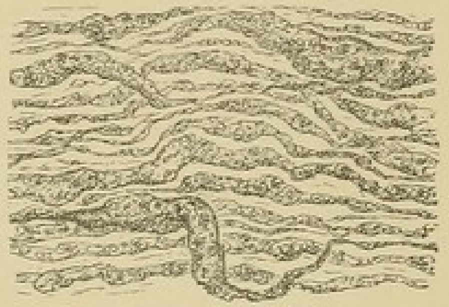
Portion of a cast, containing altered and growing white blood corpuscles. Acute nephritis × 700.

Fig. 94.



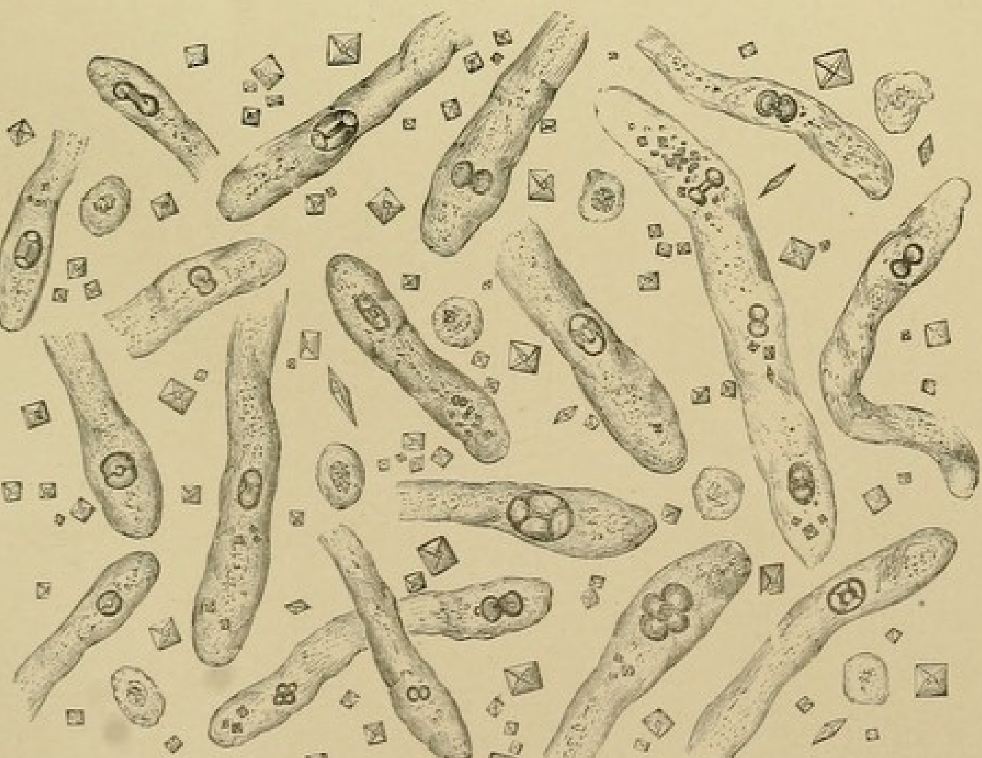
Portion of a cast with distinct cells, probably altered white blood corpuscles. × 700.

Fig. 95.



Shrivelled and wasted uriniferous tubes, from a kidney. No casts could be formed in these tubes. p. 341.

Fig. 96.



Dumb-bell crystals in casts, proving that these curious crystals are formed in the uriniferous tubes. From the urine of a case of cholera. The specimen containing these casts was the first portion passed after eighteen hours complete suppression. It contained a trace of albumen. Octahedra were present in the surrounding fluid. × 215.

p. 344.

$\frac{1}{1000}$ of an inch |____| × 215.

[To follow PLATE XVI.]

upon very cursory examination, to mistake either of them for pus, phosphates, or urates.

1.—*Urates of Soda, Ammonia, &c.*

Urates.—From the researches of Heintz ("Lehrbuch der Zoochemie") it appears that this deposit, usually termed *urate of ammonia*, really consists principally of *urate of soda*, with small quantities of *urates of ammonia, lime, and magnesia.* It forms the most common urinary deposit, and occurs from time to time in the urine of persons in the enjoyment of good health.

Heintz and Scherer have shown that upwards of 80 per cent. of the lateritious deposit consists of uric acid. Heintz finds more than 14 per cent. of soda, and less than 1 per cent. of ammonia; while Scherer, in three specimens, obtained only *traces* of soda, the ammonia varying from upwards of 2 to more than 8 per cent. Much difference of opinion exists as to the presence of free uric acid in this deposit. According to Heintz, the whole of the uric acid is combined as an acid urate, and, as remarked by Parkes, the constant proportion of uric acid present in this deposit would lead to the inference that it existed in some form of combination. Bence Jones ("Journal Chemical Society," 1862) found the urates in healthy urine to be composed of the following constituents. Three analyses were made.]

Uric acid	94·36	91·06	92·11
Potassium	3·15	3·78	5·06
Ammonium	1·36	3·36	1·61
Sodium	1·11	1·87	1·20

A small quantity of urate is held in solution in healthy urine; and, in slight derangement of the chemical changes going on in the body, it is often secreted in large quantity and is deposited soon after the urine is passed.

Spherules of urate of soda obtained by concentrating healthy urine are represented in pl. XVIII, fig. 99.

Urate of ammonia, when artificially prepared, crystallises in delicate needles, pl. XVIII, figs. 100, 102, 103; but in this form it is never found in the urine; for, as Bence Jones has shown, the slightest trace of chloride of sodium causes the salt to assume an amorphous character, and increases the solubility of the urate by one half. Crystals of urate of soda artificially prepared are represented in pl. XVIII, fig. 98. Urate of soda is sometimes found in the urine, forming globular masses, from different parts of which sharp spikes of uric acid project. It is probable that these crystals were formed after the globular masses. In pl. XIX, figs. 104, 105, 109, 110, some of the more rare and curious forms of urates of soda and ammonia are figured. I believe that in urine passed during a feverish state, the uric acid crystallises with some organic material which causes it to assume the form of spherical crystals. (*See* the observations on dumb-bells of oxalate of lime.) In the urine of children it is very frequently met with in the form of small spherical globules, pl. XIX, fig. 105, very like the crystals of carbonate of lime from horses' urine, and these sometimes occur in the adult. Some of the largest spherules I ever saw, which very closely resemble *leucine* in appearance, are figured in pl. XVIII, fig. 101. *See* also my "Archives," vol. I, p. 249.

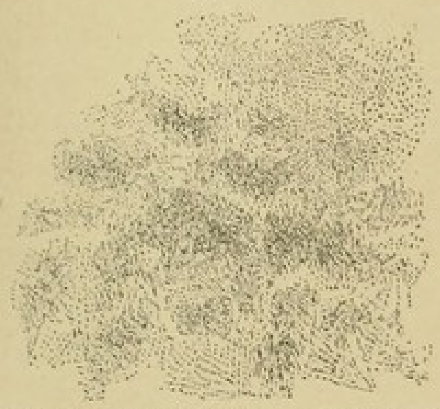
Urate of soda is not very soluble in cold, but is readily dissolved by a small quantity of warm water, from which, however, it is deposited as the solution cools. It is readily dissolved by alkalies, and also by solutions of alkaline carbonates and phosphates. Pure urate of soda crystallises in small acicular crystals, which are more or less aggregated together. In this form it is found in the pasty deposits forming chalkstones in cases of gout, fig. 98. This thick deposit contains much water. In one specimen I examined, the solid matter only amounted to 29·9 per cent., and consisted chiefly of urate of soda.

Deposits of urate of soda vary very much in colour, sometimes occurring as the white or pale "lateritious deposit," or "nut-brown sediment;" while, in other cases, the deposit has a pink, brown, or even dark reddish colour. The amorphous urate is represented in pl. XVIII, fig. 97. Upon the addition of moderately strong acids, the deposit of urate is slowly dissolved; but, in a short time, a slight granular precipitate may be observed, which, upon microscopical examination, is found to consist of rhomboidal crystals of uric acid. It is not uncommon to meet with specimens of urate which become decomposed after the urine has left the bladder, when numerous crystals of uric acid are deposited. If urate of ammonia be treated with nitric acid, and, after evaporation to dryness, ammonia be added, the beautiful purple colour, owing to the formation of murexide, is produced. This reaction will come under notice when the characters of uric acid are discussed. Rubbed with caustic lime, a perceptible odour of ammonia is evolved.

Urinary Deposits associated with Urates.—The deposit of amorphous urate is more frequently accompanied with oxalate of lime than with any other salt. It has been shown that urates may be readily decomposed into oxalates after the urine has been passed. The crystals of oxalate are often so minute as readily to escape detection in the abundant deposit of urate, unless the latter be dissolved by the addition of a few drops of solution of potash. *Triple phosphate* is not unfrequently met with amongst the urate, pl. XX, fig. 111, and occasionally a deposit of phosphate of lime has been observed, pl. XIX, fig. 106, in which case the reaction of the urine will be neutral, or even alkaline. Urate of soda is occasionally the cause of the dark granular appearance exhibited by some casts of the uriniferous tubes, as may be proved by slightly

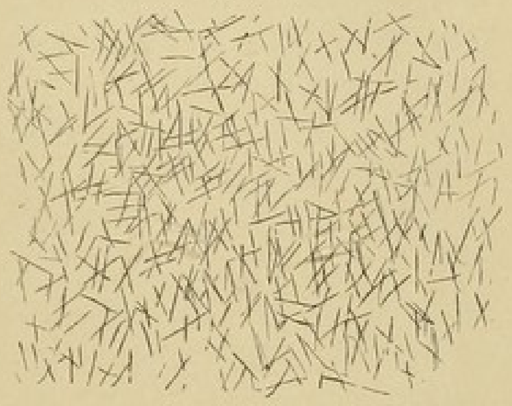
URINARY DEPOSITS.

Fig. 97.



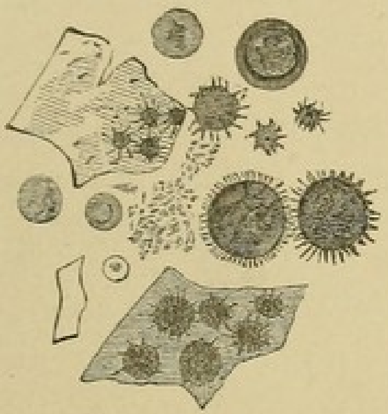
Ordinary granular deposit, usually termed urate or lithate of ammonia, but consisting of urate of soda with small quantities of urates of ammonia, lime, and magnesia. × 215. p. 351.

Fig. 98.



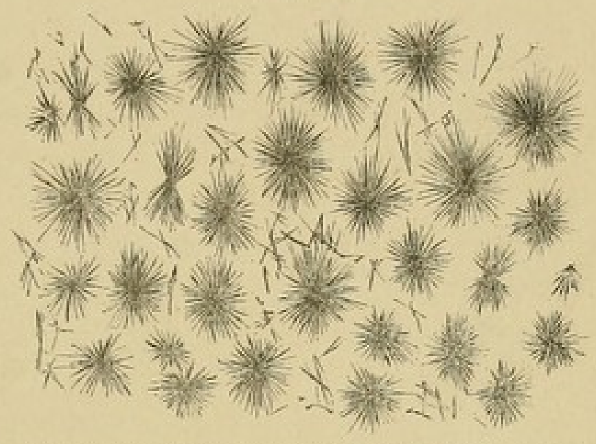
Urate of soda, prepared artificially. × 215. p. 351.

Fig. 99.



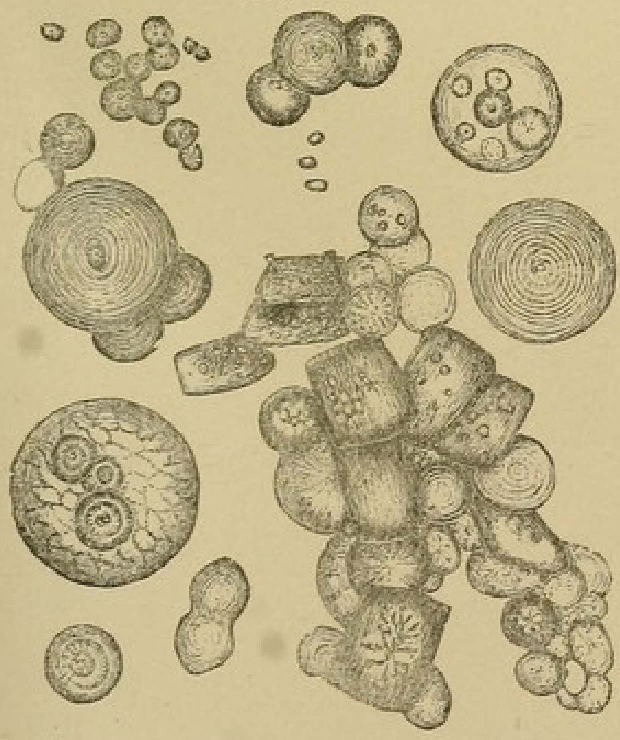
Urate of soda and films of triple phosphate, formed on the surface of concentrated urine. p. 351.

Fig. 100.



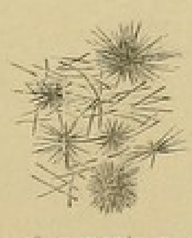
Urate of ammonia, prepared artificially. × 215. p. 351.

Fig. 101.



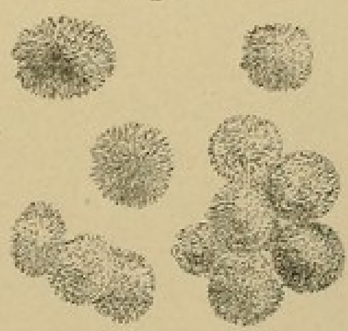
Spherules of urate of soda, with crystals of uric acid. From a case of long continued remittent fever. Sent by Dr. Kennion, of Harrogate. × 215. p. 352.

Fig. 102.



Urate of ammonia, prepared artificially. × 215. p. 351.

Fig. 103.



Urate of ammonia, prepared artificially. × 215. p. 351.

$\frac{1}{1000}$ of an inch |___| × 215.

[To face page 352.

warming the deposit, and then examining it with the microscope, when the casts will be found to have become clear. Spermatozoa, fungi, and other bodies present in urine are not unfrequently found completely covered with urate.

Urates diffused through the Urine: Albumen present.—Often the urate remains suspended in the urine without forming a visible deposit, and produces a decided opalescence. Sometimes the urine resembles in appearance the so-called chylous urine; but its true nature is readily made out by the application of some of the tests above referred to. *See* also *Chylous Urine*, p. 299. If albumen be present in urine containing urates, it will not become clear by heat, or rather, the urine will at first clear, but soon become turbid again, in consequence of the precipitation of the albumen. With a little care, however, in applying heat, the upper stratum of urine in the test-tube may be made hot enough to coagulate the albumen, the middle stratum being *cleared* by the solution of the urate without the albumen being thrown down, while in the bottom of the tube the deposit remains unchanged. In performing this experiment, the test-tube should be held by the lower part.

Analyses of Urine containing Deposits of Urates.—The urine of a child suffering from scarlatina, with delirium and unconsciousness, contained an abundant deposit of urates. It was acid; specific gravity, 1,025.

ANALYSIS 86.

Water	932·2	—
Solid matter	67·8	100·
Organic matter	59·03	87·07
Fixed salts	8·77	12·93
Uric acid	1·19	1·75

In a deposit, which was composed of rounded globules, with small sharp spicules projecting from them (uric acid), I found the following constituents: phosphate of lime, urate of soda, and other urates. A considerable quantity of these spherules existed in the urine of a man suffering from pneumonia, and they had the following chemical characters. There was distinct evidence of the presence of uric acid by the murexide test. The deposit was soluble in boiling potash; and when, to the alkaline solution, excess of hydrochloric acid was added, well defined crystals of uric acid were formed. Upon exposure to a red heat, an odour like that of burnt horn was exhaled; and, after decarbonisation, a moderate quantity of a white ash remained, which dissolved in acids with effervescence; and, from the acetic acid solution a precipitate was thrown down, upon the addition of oxalate of ammonia. I conclude, therefore, that urate of lime entered into the formation of these crystals. The quantity of crystals at my disposal was far too small to make a quantitative analysis.

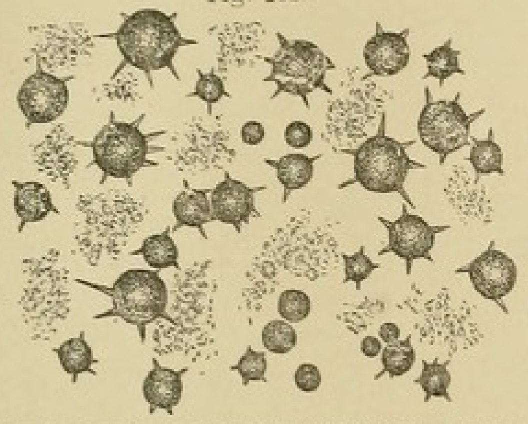
Of the Clinical Importance of Urates.—The amorphous deposit of urate is the commonest of all urinary deposits, and, indeed, is occasionally found in the urine of everyone, but it is much more frequently passed by some persons than others. If present in the urine from day to day, and especially if it be in considerable quantity, it is right to interfere, for it is a clear indication that the chemical changes connected with the process of oxidation are at fault. Imperfect action of the skin, a highly nitrogenous diet, little exercise, close rooms, too much wine or beer, will almost always cause this deposit to appear. In an ordinary cold, the deposit is very generally observed. The general conditions which determine the presence of an increased quantity of urates are the same as those which cause excess of uric acid. But with regard to "*excess*," the observations made in p. 217 must be borne in mind. There may be a *deposit* without *excess*, and there may be *excess* without any deposit whatever. Deposits of urates are very common in many cases of heart disease, emphysema, and chronic bronchitis. It is probable that the passive congestion of the liver and the slow circulation of blood through this organ has much to do with the formation.

These deposits are almost invariably present in acute febrile conditions; and an enormous deposit of urates, sometimes red, sometimes pale, marks the occurrence of 'resolution' of many acute inflammatory attacks. A "critical deposit of urates" is seen commonly enough in acute pneumonia, scarlatina, continued fever, rheumatic fever, &c. It need scarcely be said that no special treatment is required to prevent the formation of the deposit in such a case, but it is well to promote the solution of the deposit, and to favour elimination. In many cases of acute disease, I am in the habit of giving weak solutions of acetates or citrates. In pneumonia, I often give as much as 12 ounces of the liquor ammoniæ acetates in the 24 hours. No doubt by this treatment many imperfectly oxidised products, and urates amongst the number, are eliminated.

Of the Treatment of Cases in which Considerable Quantities of Urates are deposited from the Urine.—An increased quantity of fluid and a little bicarbonate of potash or soda, or liquor potassæ, will generally cause the disappearance of these deposits. Often the liver is inactive, in which case a small dose of calomel or blue pill, chloride of ammonium, or solution of acetate of ammonia, will set matters to rights. Some people make themselves very nervous about the appearance of this sediment. A little more exercise in the open air, moderation in diet, simple food, a little less wine than usual, with no beer, and a glass or two of Vichy or potash water with the dinner and the last thing at night, will generally have the desired effect. All sorts of remedies have been devised for the treatment of this condition. Benzoic acid and benzoate of ammonia, among other things, have been given with advantage.

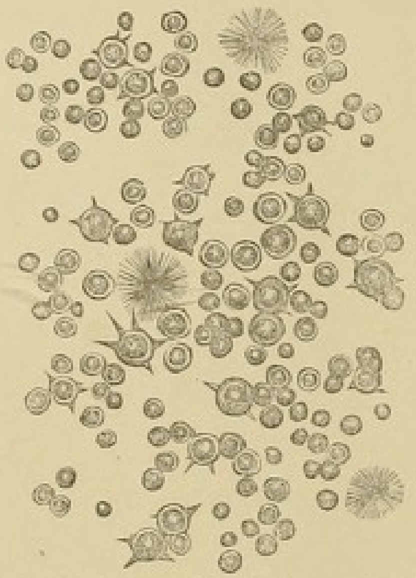
URINARY DEPOSITS.

Fig. 104.



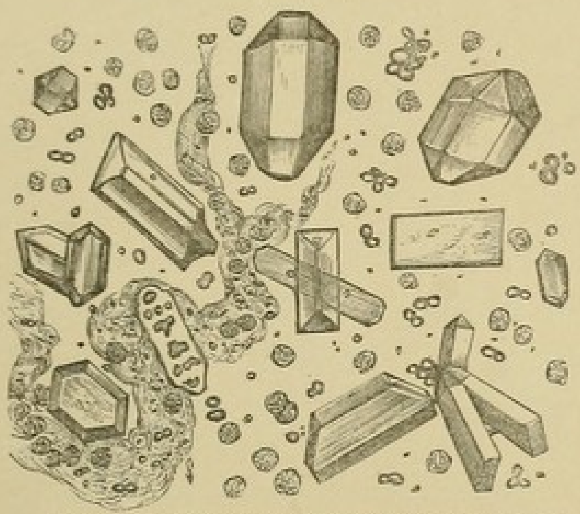
Urate of soda in spherical masses, from various parts of which minute acicular crystals of uric acid project. × 215. p. 352.

Fig. 105.



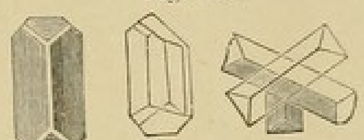
Urate of soda in a globular form, commonly found in the urine of children. × 215. p. 352.

Fig. 106.



Crystals of ammoniaco-magnesian phosphate, with urates, mucus and pus corpuscles. From a case of catarrh of the bladder of a man age 40. Three years' standing. p. 355.

Fig. 107.

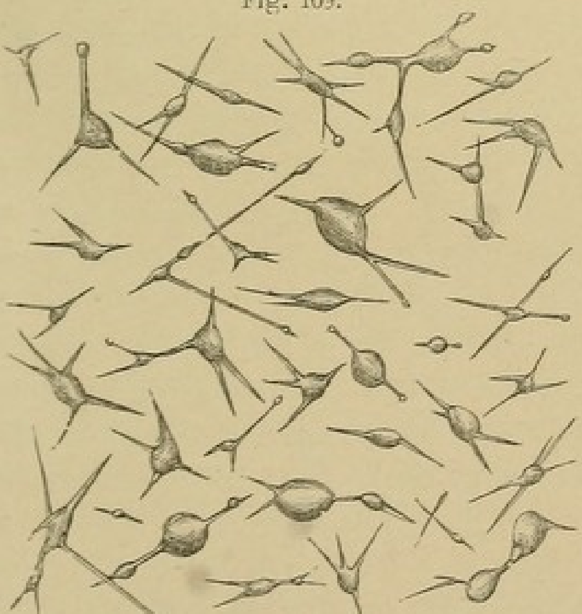


Prismatic crystals of triple phosphate, showing their form. p. 355.

Fig. 108.

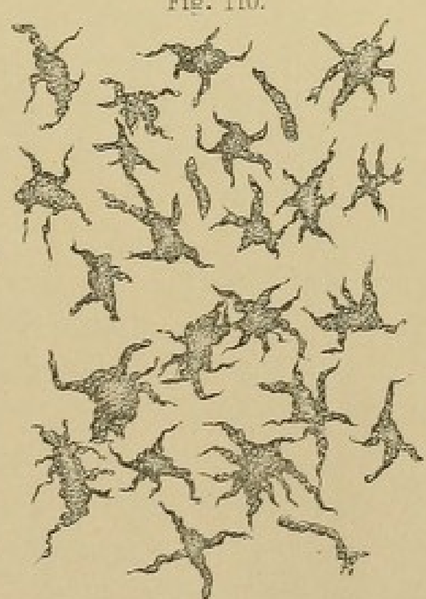
Triple or ammoniaco-magnesian phosphate, from acid urine. × 215.

Fig. 109.



Urate of soda, prepared artificially. × 215. p. 351.

Fig. 110.



Rare form of urate of soda, from urine of a patient suffering from peritonitis. × 215. p. 351.

$\frac{1}{1000}$ of an inch ⌊___⌋ × 215.

[To face page 351.

In cases where the ordinary remedies fail, a number of others which will suggest themselves to the practitioner may be tried if he bears in mind the conditions under which this deposit occurs, and enquires carefully into the general habits of the patient.

Many of the salts of vegetable acids do good in cases where urates are deposited day after day; and many fruits, such as apples, strawberries, oranges, lemons, grapes, &c., may be taken. The salts of these vegetable acids become converted into carbonates in the organism, and they may be given in cases in which alkalies derange the action of the stomach. Phosphate of soda is often prescribed, and benzoic acid has been strongly recommended by Mr. Ure; but it is of the greatest importance, when these deposits are constant, and especially when associated with rheumatic pains, to pay attention to the action of the skin and bowels. The vapour bath, the hot-air bath, p. 82, and the Turkish bath, are of great service by promoting sweating. The vapour bath is sufficiently potent, and does not produce depression.

2. *Deposits of Earthy Phosphates.*

The earthy phosphates soluble in acids, but insoluble in water and alkaline solutions, which are most commonly met with as deposits in urine, are the ordinary *triple* or *ammoniaco-magnesian phosphate*, or the *phosphate of ammonia and magnesia;* and *phosphate of lime.*

Of Triple or Ammoniaco-Magnesian Phosphate.—The triple phosphate crystallises in two or three different forms, pls. XIX, XX, XXI. When clear, and unmixed with other deposits, the crystals form beautiful microscopic objects, pl. XX, fig. 112. The most common form is that of the triangular prism, with obliquely truncated ends; but these are sometimes complicated by the bevelling of the terminal edges. Not unfrequently the crystal is found much reduced in length, and the truncated extremities become so closely approximated as to give the appearance of a square, the opposite angles of which are connected by straight lines; and thus an appearance very closely resembling that of an octahedral crystal of oxalate of lime is produced, pl. XXXII, fig. 180. The urine which contains phosphatic deposits is generally neutral or alkaline, but crystals of triple phosphate are sometimes deposited from *acid urine.*

Tests for the Earthy Phosphates.—If ammonia be added to fresh urine, or to a solution of phosphate of soda and sulphate of magnesia, ammoniaco-magnesian phosphate is precipitated in the form of beautiful stellate crystals, pl. XXI, fig. 113, and phosphate of lime is thrown down in the form of a fine granular amorphous precipitate.

Ammoniaco-magnesian phosphate is slightly soluble in pure water, particularly if it contain carbonic acid. It is said to be insoluble in solutions of ammoniacal salts, but this statement is not correct, *see* p. 163.

Heated in the blowpipe flame, ammoniaco-magnesian phosphate evolves a disagreeable odour of ammonia, and afterwards fuses, producing a whitish enamel. If the *phosphate of magnesia* thus formed be dissolved in a little dilute acid, the triple salt may be again formed upon the addition of ammonia. The presence of phosphoric acid can readily be proved by the appropriate tests.

Deposits associated with Triple Phosphate.—Ammoniaco-magnesian phosphate seldom occurs alone as a urinary deposit. Its presence is often associated with urate of ammonia, and sometimes with uric acid. I have also observed crystals of oxalate of lime mixed with those of triple phosphate. In highly alkaline urine, it is usually accompanied with pus and phosphate of lime.

Phosphate of Lime occurs commonly as minute granules, and small spherical masses or angular particles, and it may also be noticed in the form of minute dumb-bells—an appearance probably due to the adhesion of two little spherules, which afterwards become coated with a fresh deposit of the phosphate, pl. XXI, fig. 118. Phosphate of lime also occurs in urine in a crystalline form, as was first demonstrated by Dr. Hassall. It is usually associated with the triple salt—always, if deposited from alkaline urine. In cases of disease of the bladder, in which the urea becomes very rapidly decomposed into carbonate of ammonia, much amorphous phosphate of lime and crystals of triple phosphate are precipitated. It must not, however, be supposed that highly alkaline urine *necessarily contains* a very large *excess* of earthy phosphate; for often an excessive quantity of the salts has been found *dissolved* in acid urine, in which case the excess can only be discovered by chemical analysis. (*See* Analysis 63, p. 217.) When the secretion is alkaline, the phosphates are always precipitated, and become visible to the naked eye as a deposit.

Phosphate of lime dissolves in strong acids without effervescence; and from this solution is precipitated in an amorphous form, upon the addition of ammonia. The salt is infusible before the blowpipe, unless mixed with triple phosphate; and its fusibility increases according to the quantity of the latter salt present. The lime may be recognised in the usual way by the addition of a solution of oxalate of ammonia to a solution of the salt in acetic acid.

Phosphate of lime is soluble in albumen; indeed, it is by reason of its solubility in this substance that the phosphate of lime formed by the action of phosphoric acid on the egg-shell becomes applied to the formation of the osseous system of the embryo chick. Mucus also is a solvent of this salt, and from the mucus of the gall-bladder a considerable quantity is deposited as decomposition proceeds, pl. XXI, fig. 116.

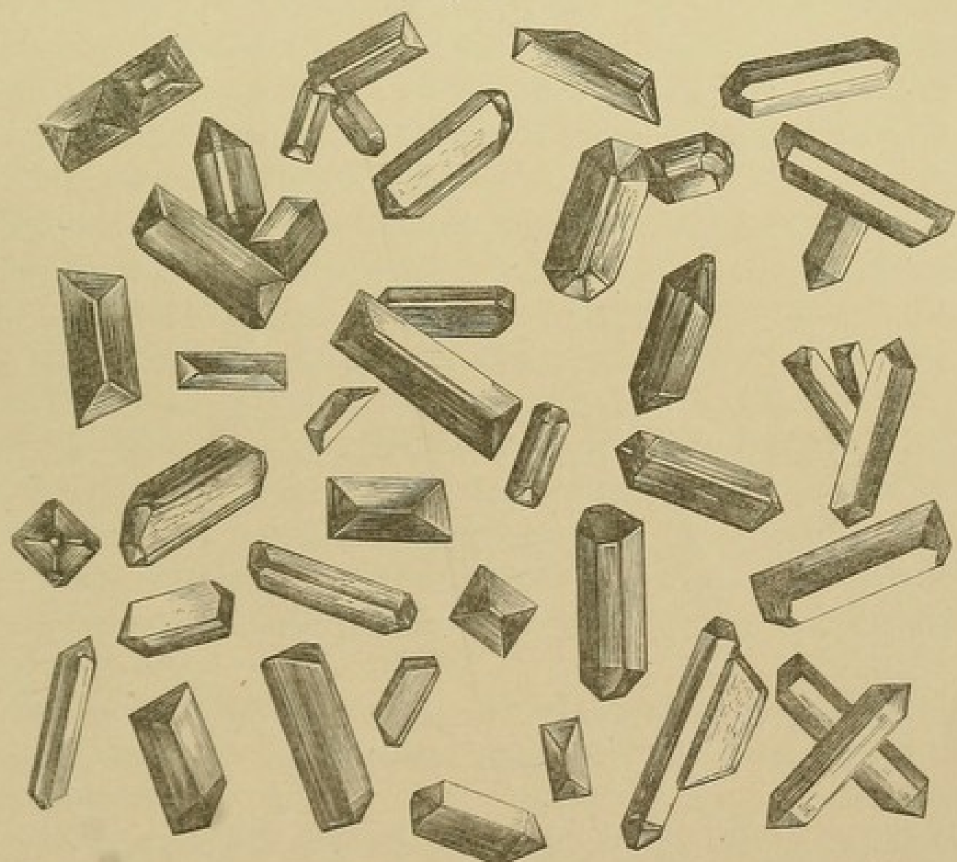
Phosphate of Lime in the Form of Spherules and small Dumb-

URINARY DEPOSITS.

Fig. 111.

Beautiful crystals of triple or ammoniaco-magnesian phosphate, and spherules of urate of soda.
× 215. pp. 352, 355.

Fig. 112.



Crystals of triple phosphate. $_2MgONH_4O, PO_5 + 12aq$. In the form of triangular prisms, with obliquely truncated extremities, as they frequently occur in urine. In many cases the crystals are four-sided. Not unfrequently the shaft of the crystal is so short that the two triangular extremities are seen quite close together, and the crystal, without care, might be mistaken for an octahedron.
× 45. p. 355. See also Pl. XXXIII, Fig. 180.

$\frac{1}{100}$ of an inch — ⌊__________⌋ × 45.

$\frac{1}{1000}$,, ⌊___⌋ × 215.

[To face page 356.

bells.—Deposits of phosphate of lime are generally granular; but after a deposit has been allowed to stand for some days, little spherules are very frequently found, and it is also not uncommon to meet with small dumb-bell crystals. Crystals of the latter character are very often deposited in decomposing mucus, derived from several mucous surfaces, as well as in that of the urinary mucous membrane. Some of the largest of these dumb-bell crystals of phosphate of lime are represented in pl. XXI, fig. 118. They were found in the urine of a patient suffering from continued fever, under the care of Mr. Carver, of Cambridge, to whom I am indebted for the specimen.

A peculiar form of deposit of earthy phosphate is represented in pl. XXI, fig. 117. It consisted partly of phosphate of lime, and partly of triple phosphate. There were no true crystals, neither was the deposit in a pulverulent form. The little angular masses represented, were the only bodies found in this peculiar deposit.

Of Phosphate of Lime in a Crystalline Form.—A phosphate of the form represented in pl. XXI, figs. 114, 115, is not uncommonly found in urine. I have not been able to connect its presence with any special state of the system, nor to ascertain the conditions upon which its deposition depends. It is very frequently associated with oxalate of lime, and occurs in acid urine, pl. XXI, fig. 115. A considerable quantity of these crystals were deposited from the urine of a man who had a rough oval calculus, composed of oxalate of lime, impacted in the ureter. The case is given in Dr. Todd's "Clinical Lectures," 2nd ed., p. 562. They were examined as follows:—

(March, 1851.) "The deposit from about a pint and a half of urine was well washed with water and alcohol, and filtered; it was then dried, incinerated, and decarbonised. The form of the crystals had not been materially altered by the ignition; for, when examined by the microscope, scarcely any change could be observed.

"A portion of the decarbonised crystals were dissolved in dilute hydrochloric acid (they were only very slowly soluble in acetic acid).

"1. Ammonia and potash produced gelatinous precipitates.

"2. Chloride of barium caused a slight precipitate in the acid solution; but, upon the addition of excess of ammonia, a bulky white precipitate occurred.

"3. After the addition of ammonia and re-solution of the precipitate by acetic acid, oxalate of ammonia was added, and a white granular precipitate was produced.

"4. After the addition of nitrate of cobalt and ignition in the blowpipe flame, a blue colour was given to the mass. This reaction usually occurs with phosphate of lime, as well as with alumina. These crystals then consisted principally of phosphate of lime."

In another case which I examined, the crystals also appeared to consist principally of phosphate of lime. They were dissolved in nitric acid, and ammonia added. An *amorphous* precipitate occurred; but no crystals were formed after the lapse of some hours. After separation of the lime by oxalate of ammonia, and filtration, ammonia and phosphate of soda were added. A very few crystals of triple phosphate formed after the lapse of some time. There was an abundant precipitate of oxalate of lime.

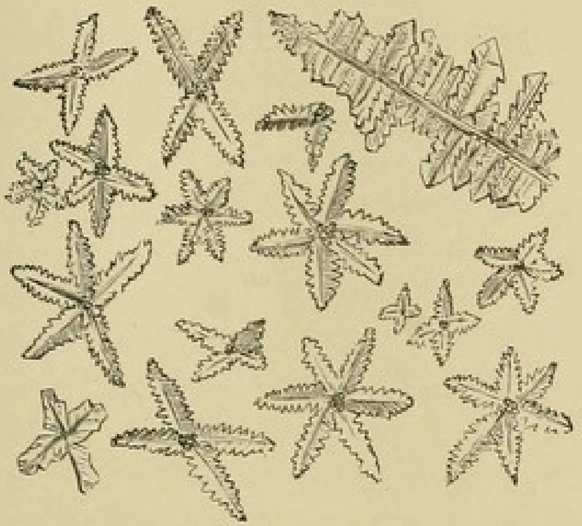
In other cases, a phosphate of magnesia seemed to predominate. From not being able to make satisfactory quantitative analyses, owing to the small quantity of salt obtained for examination, I was unable to determine the exact nature of these crystals. They are, as I before said, found in acid urine; and phosphoric acid, lime, and magnesia are present. These are probably the crystals which were regarded by the late Dr. Golding Bird as "small calculous concretions and simple stellæ of the neutral salt." I have seen these crystals in the urine of persons suffering from no particular malady whatever, and I have not been able to connect their presence with any particular pathological state. These crystals are not generally found for many days together, but in some cases they form a very bulky deposit, occupying half the volume of the urine.

Dr. Hassall's Observations on the Crystals of Phosphate of Lime.— Dr. Hassall, in an interesting paper published in the "Proceedings of the Royal Society," vol. X, p. 281, Jan., 1860, has stated that phosphate of lime is very commonly found in deposits from human urine in a crystalline form. He gives quantitative analyses of four specimens of deposit which contained the phosphates in the following proportions:—

Bibasic phosphate of magnesia	0·15	0·47	4·30	
Bibasic phosphate of lime	1·85	6·18	5·41	1·69
	2·00	6·65	9·71	

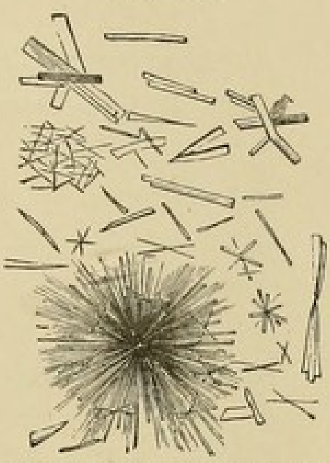
This author states that Dr. Golding Bird's "penniform" crystals of ammoniaco-magnesian phosphate are really a modification of those of phosphate of lime. The crystals represented by Dr. Hassall in fig. 1 appear to be similar crystals to those I have delineated in fig. 115, the chemical composition of which I have alluded to. *See* also pl. XXII, figs. 119 to 124. I have never obtained these crystals in sufficient quantity for a quantitative examination, but have examined several specimens qualitatively, and have found that they contained ammoniaco-magnesian phosphate, as well as phosphate of lime. The latter was by me erroneously regarded as the less important constituent of the crystals, and the form and crystalline properties of the salt were referred to the triple phosphate. If, however, the crystalline form of the pure salt in Dr. Hassall's fourth analysis is represented in his fig. 1, the composition of these crystals is determined, and the phosphate of magnesia obtained in

Fig. 113.



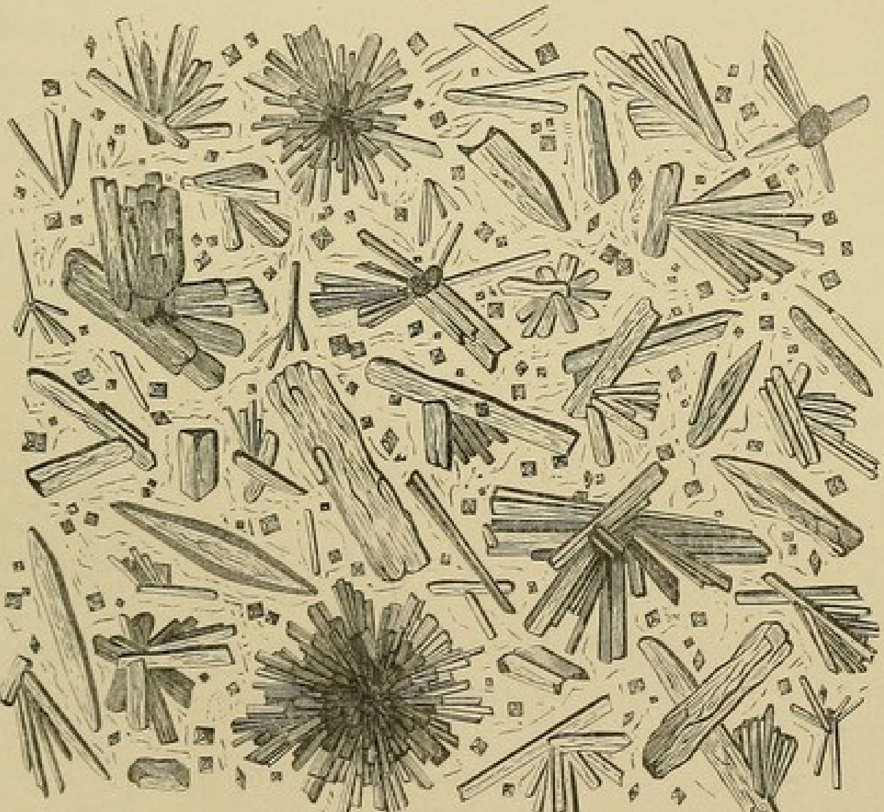
Crystals of triple phosphate formed by the addition of ammonia to urine. The crystals being rapidly developed are precipitated in this very beautiful star-like form. If, however, these remained for some time in the urine they would gradually assume the prismatic form. The more highly magnified drawing of one of the arms of a crystal in the upper part of the figure shows how this change in crystalline form takes place. × 215. p. 355.

Fig. 114.



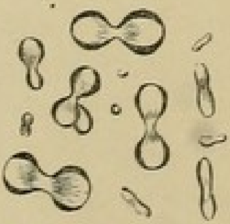
Crystals of phosphate of lime occasionally met with in urine. × 215. p. 356.

Fig. 115.



Drawing of a urinary deposit, consisting of crystals of phosphate of lime and numerous octahedra of oxalate of lime, with a little mucus. × 215. p. 357.

Fig. 116.

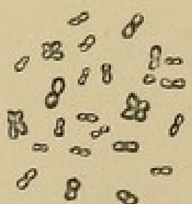


Phosphate of lime in the form of dumb-bells, from the mucus of the gall bladder. × 215. p. 356.

Fig. 117.

Unusual form of triple phosphate. From the urine of a patient suffering from indigestion in the very hot weather. × 215. p. 357.

Fig. 118.



Large dumb-bells of phosphate of lime. p. 356.

$\frac{1}{1000}$ of an inch |____| × 215.

[To face page 356.

some of my examinations must be regarded as an impurity, and not as a necessary constituent.

But Dr. Hassall, in the paper above referred to, goes so far as to say "that phosphate of lime, in the form of crystals, is of much more frequent occurrence in human urine than the triple phosphate, excluding those cases of the presence of the latter phosphate which are due to the decomposition of the urea of the urine subsequent to its emission;" and that "granular calcareous deposits are much more rare than the crystalline." Now, in these statements, I think he will find that few observers will agree; for that the ordinary crystals so commonly present in the urine, and usually termed triple phosphate, are actually composed of that salt, there cannot be the least doubt. Crystals of exactly similar form may be readily obtained artificially. The salt is easily obtained from any urine by precipitation by ammonia, and is often found very nearly pure, in large quantity, in urinary calculi. That these crystals, so familiar to every one, are more frequently met with than any other form of earthy phosphate, crystalline or non-crystalline, I conclude no one will deny. That phosphate of lime often occurs in urine in an amorphous form, and not unfrequently in little spherules and small dumb-bells, as have been figured; and that, when thrown down from its solutions, the deposit is amorphous; and that in calculi it is amorphous—are facts generally assented to, and they have been repeatedly confirmed. It seems to me that these circumstances militate against the conclusion arrived at by Dr. Hassall as to the relative frequency of the crystalline forms of phosphate of lime and triple phosphate. Nor have I been able to confirm Dr. Hassall's observations upon the pathological importance of these deposits of phosphate of lime. It is a fact that in the majority of cases in which real "excess" of phosphate of lime exists in the urine, it is excreted in solution, and does not form any deposit at all.

Phosphate of lime may be readily obtained in a crystalline form by adding a few drops of chloride of calcium to urine (Bence Jones). I have succeeded in causing this and many other substances which do not readily crystallise, to assume most perfect crystalline forms in glycerine. If a little chloride of calcium be dissolved in a drop of glycerine, and a little phosphate of soda in another drop, and the two drops be allowed to intermix very gradually under thin glass upon a slide, most beautiful crystals of phosphate of lime will make their appearance in the course of a few days.

On the crystalline forms of phosphate of lime in urine, *see* also the papers of Dr. Bence Jones ("Chem. Society's Trans.," 1861) and the paper of Dr. Roberts ("Brit. Med. Journ.," March 30, 1861).

Several different forms of these crystals are represented in pls. XXI and XXII.

Of the Clinical Importance of Deposits of the Earthy Phosphates.

—The conditions under which an excess of alkaline phosphates occurs, have been already considered in p. 207, and I have also referred to cases of mollities ossium, in which an excess of the earthy phosphates was excreted in the urine, p. 217. The remarks made upon the question of "*excess*" of a constituent and its precipitation as a visible deposit, must be borne in mind. In the great majority of cases in which there is a deposit of earthy phosphates, there is no "*excess*" at all, and the deposition depends upon the urine being neutral or less acid than usual, or upon the decomposition of the urea, and consequently, the formation of carbonate of ammonia after the urine has left the bladder. It is common enough to find triple phosphate in the urine in cases of dyspepsia, perhaps from the secretion of too large a quantity of highly acid gastric juice or from the formation of other acids.

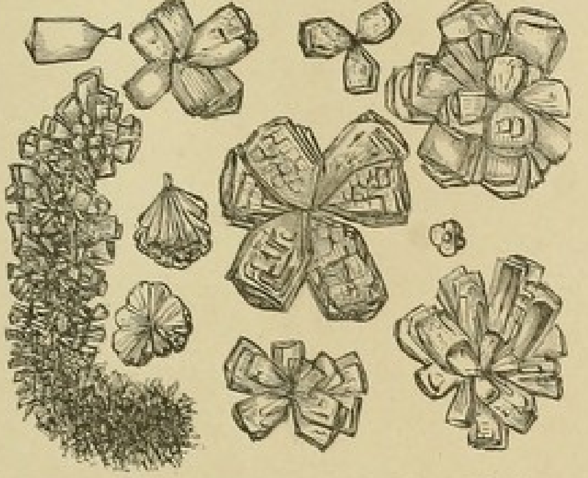
In various cases of disease, arising from more or less complete paralysis of the nerves, owing to changes occurring in the nervous centre itself, or at the distribution of the nerves in the mucous membrane, the action of the bladder may become impaired and it may fail to expel its contents completely. The urine thus retained sometimes undergoes change, and the mucous membrane suffers in consequence. Earthy phosphate is precipitated, and the condition thus induced gradually increases, unless proper preventive measures be adopted.

There are cases in which phosphates are deposited upon every part of the urinary mucous membrane,—bladder, ureters, and the pelvis of the kidneys, apparently depending upon changes which result originally from some affection of the nerves. Although the formation of epithelium and all the essential phenomena of nutrition and secretion may take place, independently of nervous action, it is quite certain that the regularity of these changes, the even flow of nutrient pabulum, and the regulation of the proper proportion distributed, are determined by the nerves. Hence it follows, that if the nerves, distributed to a structure, be destroyed, or their action impaired, directly or indirectly, the tissue soon suffers, its structure becomes altered, and its function imperfectly performed.

Some of these cases, perhaps the great majority, are due to local disease, for that condition known as chronic inflammation, affecting one part of the mucous membrane, is very prone to spread. It may extend from urethra to bladder, and even into the ureters and pelvis. A rough almost ulcerated state of the mucous membrane may spread in the opposite direction—from the kidneys towards the bladder. In all cases, the urine in contact with any portion of such altered surface would be decomposed and its earthy phosphates precipitated. These, with the epithelium and mucus of the part, would form irregular projections with intervening depressions, in which more urine would be decomposed; and so the process might proceed, unless the nutritive changes taking

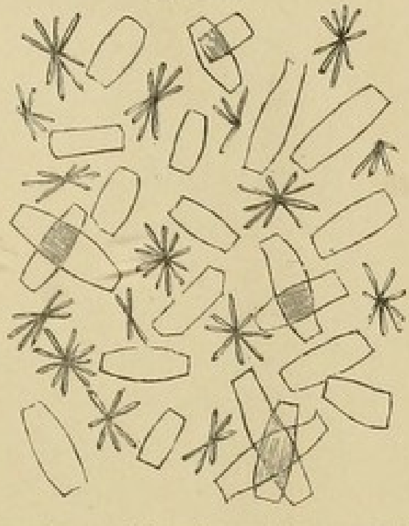
URINARY DEPOSITS.

Fig. 119.



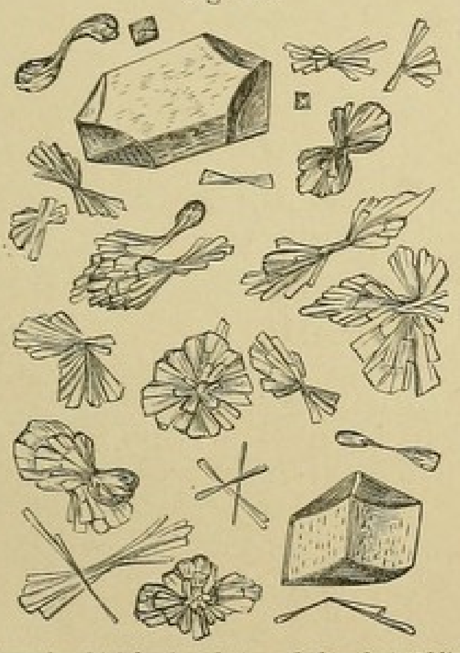
Phosphate of lime, crystallized in the form of fan-like plates. × 215. p. 358.

Fig. 120.



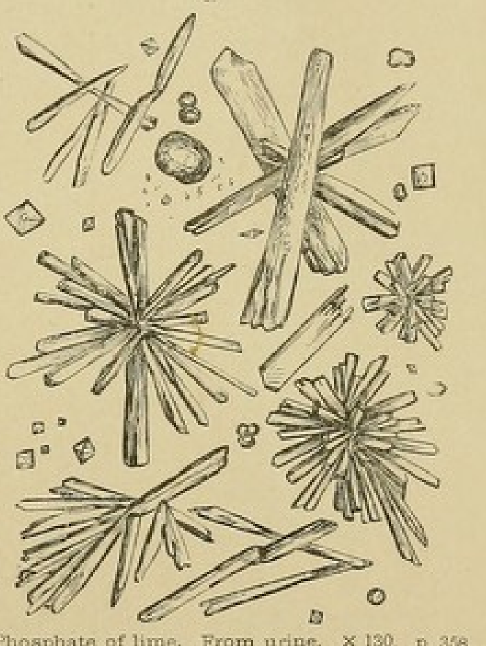
Two forms of phosphate of lime mounted in Canada balsam. × 215. p. 358.

Fig. 121.



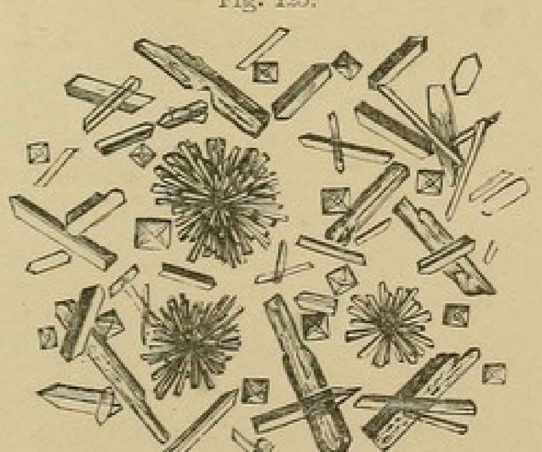
Crystals of triple phosphate and phosphate of lime. × 130. p. 358.

Fig. 122.



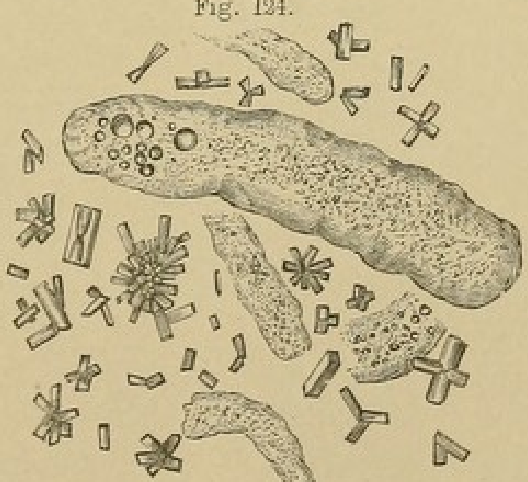
Phosphate of lime. From urine. × 130. p. 358.

Fig. 123.



Phosphate and oxalate of lime, from the urine of a young man enjoying good health, but taking little exercise. × 215. p. 358.

Fig. 124.



Deposit from the urine of a man suffering from gouty kidney, consisting of a peculiar form of phosphate of lime, with granular casts and casts containing oil. × 215. p. 358.

$\frac{1}{1000}$ of an inch ⌴ × 215.

[To face page 360.

place below the surface return to a perfectly healthy state, when the matter deposited would soon be thrown off, the even growth of new healthy epithelium would proceed below, and the surface would again assume its smooth healthy character. For this reason, in such cases, it is of the first importance to pay attention to the general health, for it is obvious that if the blood be in an unhealthy condition, the action and nutrition of the nerve-centres will suffer, in which case, the normal state of the mucous membrane cannot be regained.

Disease of the mucous membrane, and impaired action of its muscular coat, also result from disease of the central part of the nervous system, and some of these cases are among the most distressing which the physician is called upon to treat. The affection begins probably in the nerve cells of the posterior roots and those of the cord itself. These gradually undergo change, and many cease to act, or the nerves arising from them may be pressed upon or degenerate in structure at some distance from their point of origin. Over these structural changes we can exert little influence by remedial agents, and as the disease proceeds, the state of the patient becomes more painful to witness.

These structural diseases of the cord are of the utmost interest, and their pathology has only very recently been studied. I beg to refer the reader to some most interesting and very complete cases by my friend, Mr. Lockhart Clarke, in the "Archives of Medicine," vols. II and III.

Of the Treatment of Cases in which Phosphatic Deposits occur.—When the condition is only temporary, small doses of dilute acids in a bitter infusion before meals, or the tincture of the perchloride of iron, will generally cause the urine to become healthy by improving the action of the stomach. Pepsin (p. 86) may also be given with advantage in some of these cases. Benzoic acid and benzoate of ammonia have also been prescribed, and sulphate of zinc, and extract of nux vomica, are favourite remedies. If the intestinal canal be loaded, and the patient has been living too well, as is not unfrequently the case, a little blue pill and compound colocynth pill will cure him.

Alkalies, as Dr. Owen Rees was the first to show, undoubtedly do good in some of these cases of phosphatic urine, probably by their action in promoting the normal chemical changes in the blood rather than by direct action upon the kidney or any part of the genito-urinary mucous membrane. Dr. Rees' explanation has been already referred to, p. 185.

When the phosphate in the urine has persisted for some time, and is accompanied with any symptoms referrible to probable affection of the cord, especially if the bladder be irritable, and there be nervous twitching of the muscles, with tingling or numbness of the skin in any part of the lower half of the body, or diminished control over the voluntary movements, acids and tonics, with small doses of opium, should be given. The practitioner will, however, meet with many cases in which the symptoms would justify him in inferring disease of the cord, nevertheless get quite well as soon as the general health is improved. Before treating such cases we must find out how the patient lives, and ascertain if he is suffering from mental anxiety, excitement, over-mental work, &c. The patient must not be led to suspect that he is suffering from any organic disease, for not unfrequently people are terribly nervous, and too prone to dwell upon every ache or pain they may have, and they are foolish enough to refer to medical books, with the view of ascertaining the nature of their ailments. The diagnosis in these cases should be very guarded, unless the symptoms clearly and positively indicate the real nature of the disease. The consideration of this extensive subject cannot be further pursued here, and I must refer the reader to treatises on diseases of the cord.

The treatment of disease of the bladder, in which the urine contains pus as well as phosphate, is referred to on p. 367. *See* also the sections on the subject of Calculi.

3. *Deposits of Pus.*

Pus in the Urine.—Pus is not found in the urine of healthy children and adults, although it is very frequently met with in the urine of persons past the middle period of life whose general health is good. The changes which occur in the cells of a healthy mucous membrane when they give rise to pus corpuscles instead of to cells like themselves, are now well understood. The formation of pus in vaginal epithelium is readily studied. The change is represented in pl. XXIII, fig. 130. It is remarkable that such a change may take place without the essential purposes of the mucous membrane being interfered with. The portion of the genito-urinary mucous membrane most frequently affected in this way is undoubtedly the urethra, and I believe, next to this, that of the ureters and pelvis of the kidney, while the functions of the bladder, as a general rule, become more or less deranged before its mucous membrane produces much pus. To this last statement there are, however, some remarkable excepions.

That an enormous quantity of pus may be formed in the pelvis of the kidney and in the infundibula without seriously interfering with the general health of the patient, is a fact which has been proved by many cases. I particularly remember two female patients who, for upwards of a twelvemonth, had been passing urine a fourth part of the bulk of which consisted of pus. These patients had not suffered in nutrition or in general health, and one had gone through her occupation as servant during several months.

The urine of men after the age of forty often contains a greater or less number of pus corpuscles—a fact of which I was not aware until I had subjected the urine of a great many hospital patients indiscriminately to examination. In private practice the same point is noticed very frequently. It is, indeed, more common to find a few pus corpuscles in the urine after this period of life than to find it free from them. The fact is important, and shows that the existence of pus in the urine must not, *per se*, be regarded as evidence of serious disease.

Dr. Balfour, of Edinburgh, has published two cases, in which he thinks the pus came from the prostate gland, and considers that it is not unfrequently derived from this source in certain cases in which it is clearly not formed in the kidneys, ureter, or bladder ("Edinburgh Medical Journal," vol. I, p. 612, 1856). In confirmation of this conclusion, I may remark that I have often seen pus-like cells in the follicles of the prostate, and such cells often form the nucleus, around which the hard matter of prostatic calculi is deposited.

Characters of the Urine.—Pus generally forms an opaque cream-coloured deposit, which sinks to the bottom of the vessel, the supernatant fluid being generally slightly turbid from the presence of a few pus globules. The deposit, however, readily diffuses itself again by agitation. The urine will always be found to contain a little albumen derived from the liquor puris. If, however, the albumen exist in large quantity, it is probably derived from the kidneys.

If the urine be alkaline, the pus is no longer present as a cream-coloured deposit, but exists as a gelatinous or stringy mass, which adheres firmly to the sides of the vessel containing it. It is to this glairy mass that the term *mucus* has been, and even still is, carelessly applied. The viscid, glairy, mucus-like deposit arises from the carbonate of ammonia, set free by the decomposition of urea, reacting on the pus globules in a manner similar to that in which potash behaves.

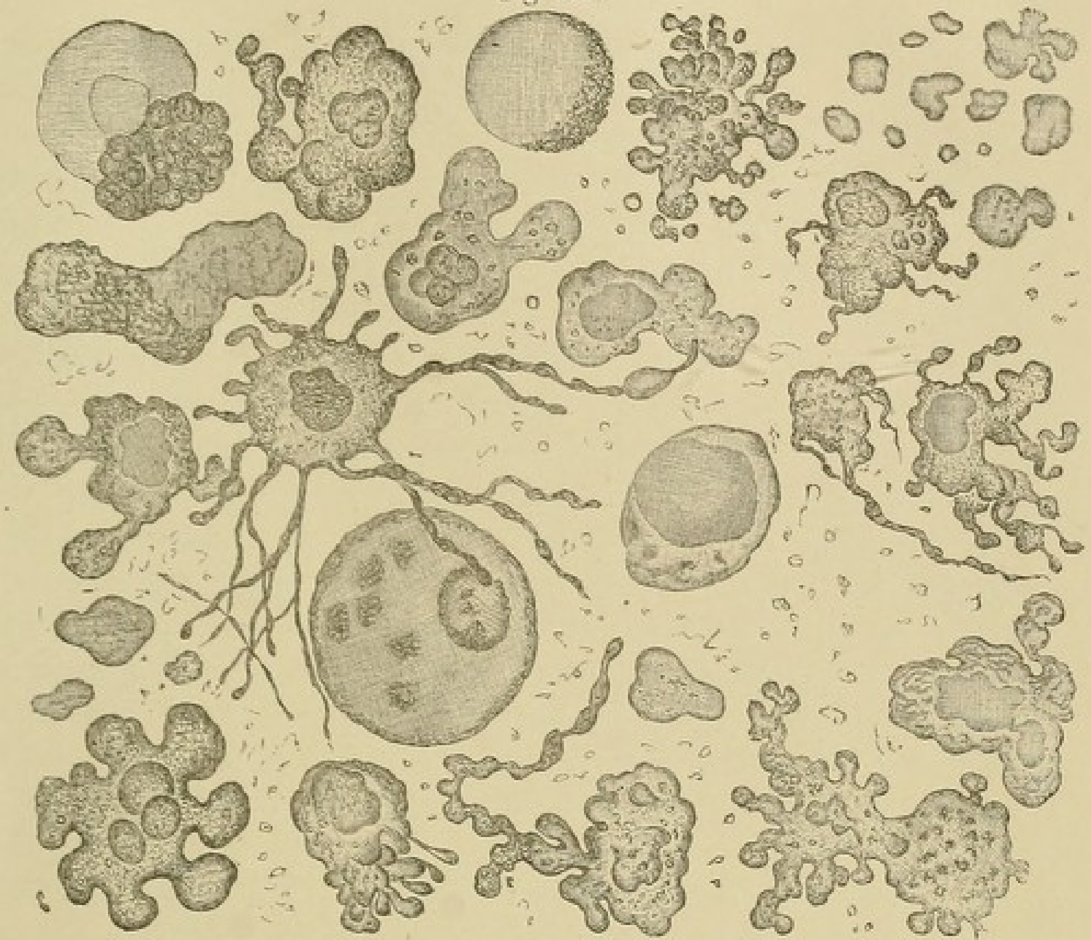
Tests for Pus.—The most reliable test for pus is liquor potassæ, which renders the deposit glairy and gelatinous, so that it will not drop. When poured from one tube into another it runs quickly as a very viscid and hardly separable mass. Heat and nitric acid may be employed for the detection of the albumen of the *liquor puris* in the supernatant fluid. Cases from time to time come under notice in which the amount of albumen in the urine containing pus although not great is nevertheless in too large a proportion to the pus cells present to be entirely derived from the liquor puris. In such a case the practitioner would be led to suspect kidney disease, and the deposit of the urine should therefore be very carefully examined for casts of the tubes, p. 339.

Microscopical Characters of Pus.—In those cases in which the pus is in too small quantity to be detected by chemical tests, we must rely upon the microscopical examination of the deposit. Pus globules which have been long removed from the body always have a granulated appearance in the microscope, and, when fresh, do not always exhibit a well-defined nucleus; the outline is usually distinct and circular, but it is finely crenated. Upon the addition of acetic acid, the globule increases somewhat in size, becomes spherical, with a smooth faint outline; and from one to four nearly circular bodies are developed in the centre of each. If the pus corpuscles have lain for some days in the urine, they will have undergone complete disintegration. Pus corpuscles are represented in pl. XXIII, fig. 126; and in figs. 127, 128, they are shown as they appear when treated with acetic acid. The so-called nuclei are well seen. Pus corpuscles formed upon the mucous membrane of the urethra, bladder, and vagina, exhibit little protuberances, and these are formed by the moving outwards of the living or germinal matter of which the pus corpuscle is almost entirely composed. The nucleus has nothing to do with these *vital movements.* The process occurs in precisely the same way in mucus corpuscles, young epithelial cells, and in every kind of germinal matter.

There is certainly no true cell wall in the case of ordinary pus, and this is proved by the fact that protrusions of the matter of which pus corpuscles consist may occur upon every part of the surface, and not only so, but some of these protruded portions, after moving a considerable distance away from the mass, become disconnected from it, and thus new pus corpuscles are produced. It is in this way that the very rapid multiplication of pus corpuscles is effected. In pus from the bladder, movements even more active than those in the mucus corpuscle are very easily observed, and when fresh, in consequence of the alterations in form, not a single *spherical* corpuscle can be found. *See* pl. XXIII, figs. 125, 129, 131, 132, representing some of the many different forms of pus corpuscles present in a very small quantity of pus. Every corpuscle exhibits a great number of these protrusions, and every protrusion might be detached and form a free pus corpuscle. In warm weather I have known the movements continue in pus corpuscles in urine containing little of the ordinary urinary constituents, for forty-eight hours, or more, after the urine had left the bladder. The very phenomena which take place upon the surface of the mucous membrane of the bladder may, in fact, be watched for hours under the microscope, and there are few things more beautiful or more instructive. When the corpuscles die—and their death occurs when they are placed in any fluid which is not adapted for their nutrition—the movements above described cease, and they invariably assume the spherical form.*

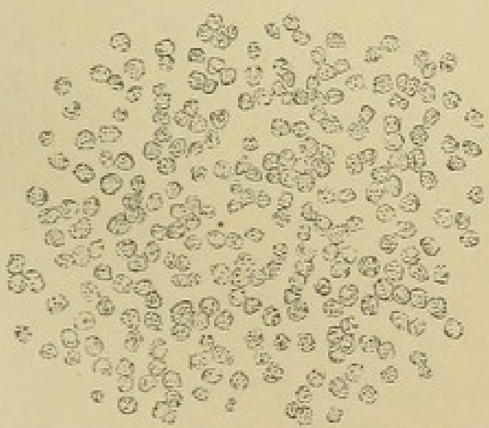
* Not only may active movements be observed in the masses of germinal matter above referred to, which have resulted from healthy germinal matter being supplied with a greater amount of nutrient pabulum than under normal circumstances, but they may be seen to occur in the white blood corpuscles, lymph and chyle corpuscles, as

Fig. 125.



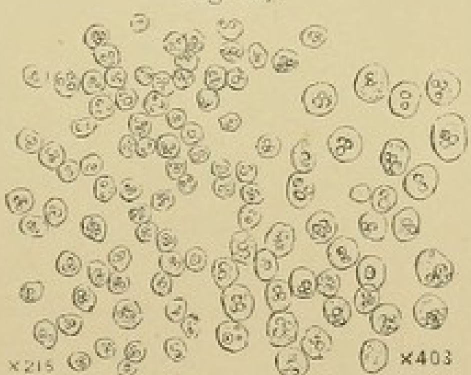
Pus corpuscles exhibiting very active movements. From the bladder of a patient suffering from chronic inflammation. Showing alterations in form due to (vital?) movements. × 1300. p. 364.

Fig. 126.



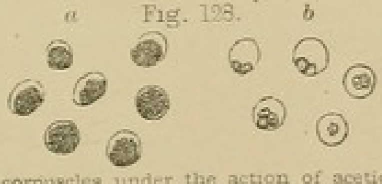
Pus corpuscles from urine. × 215. p. 364.

Fig. 127.



Pus corpuscles which have been acted upon by acetic acid. p. 364.

Fig. 128.

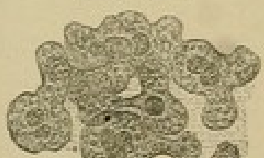


Pus corpuscles under the action of acetic acid *a*, action commencing. *b*, complete. × 215. p. 364.

Fig. 130.

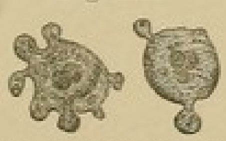
Formation of pus from germinal matter of epithelial cells. × 215. p. 363.

Fig. 129.



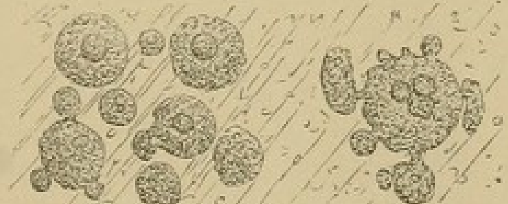
Pus corpuscles showing protuberances. × 700. p. 364.

Fig. 132.



Multiplication of pus corpuscles by detachment of protruding portions from each corpuscle. × 700. p. 364.

Fig. 131.



Growth and multiplication of pus corpuscles when free. p. 364.

[To face page 364.

Of the Clinical Importance of Pus in Urine.—From what I have already said it will be inferred that the presence of a few pus corpuscles in urine is a fact which need not excite alarm; that the mucous membrane of the urethra may become affected in a slight degree like some other mucous membranes, and that pus corpuscles may be formed in small number upon its surface, without any material impairment of structure or derangement of function resulting. In the urine of the female it is very common to find small quantities of pus, which are derived from the mucous membrane of the vagina, and in some women the formation of pus is almost constant. When, however, pus is found in the urine in sufficient quantity to form a deposit visible to the naked eye, it should excite our attention. The fact will probably bear in a very important manner upon the diagnosis of the case. Pus may be derived from any part of the genito-urinary mucous membrane; from the surface of the *urethra;* from the *prostate;* from the *bladder*, or from the *follicles of the mucous membrane* in these parts; from the *ureters;* from the *pelvis of the kidney*, or from the *secreting structure of the organ.* The pus may also come from an *abscess* opening upon any part of the surface of this mucous tract.

It is often difficult to form an opinion as to the exact seat of formation of the pus; and it must be obvious that we ought never to come to a decision on such a point until we have accurately weighed all the evidence that a careful investigation of the case will afford. Microscopical examination will give us important help; but we must not rely solely upon this, nor indeed upon any single mode of investigation. The question is an extensive one, and I shall only refer to one or two points connected with the evidence deduced from microscopical examination. Some idea of the locality from which the pus has been derived may often be formed by examining attentively the characters of any epithelial cells which may be mixed with it. When pus is derived from the bladder, it generally contains crystals of triple phosphate, and granules or small spherules of earthy phosphate; and the symptoms of the case will generally enable us to decide if the pus has been formed in this

well as the connective tissue corpuscles and the nuclei of various cells; and there is reason to believe, with greater or less activity, in every kind of living germinal matter. Such movements are not peculiar to the amœba, although from the circumstance that they were first observed in this creature they have been termed *amœbiform*. Some writers appear to have considered that there was some special relation between all such moving masses of matter and amœbæ. The movements of the amœba, like the movements of pus, mucus, &c., are *vital* movements. The conditions required for the maintenance of life being more complex in the case of some forms of germinal matter than in others, we should conclude that such movements would only continue for a considerable period of time in particles after removal from their natural habitat, in the lowest and most degraded forms. This is actually the case, just as some creatures are capable of supporting life under a great variety of conditions, although comparatively slight alterations would be fatal to others.

viscus. Large quantities of pus may escape from the bladder for a number of years. I know of one gentleman who has passed pus in considerable quantity from the bladder during a period of twenty-five years. The suppuration of the bladder may be due to gonorrhœa, to gout, and to a state of mucous membrane which is termed catarrh of the bladder. It commonly arises from stricture, the contraction interfering with the free escape of the urine from the bladder, and oftentimes preventing the complete evacuation of this organ. If the stricture be dilated, the state of the bladder is often completely relieved.

When the pelvis of the kidney is dilated and sacculated (a form of pyelitis), the quantity of pus passed in the urine is often enormous; and this may last for years, until the kidney becomes a mere pus-forming cyst, which, in favourable cases, gradually contracts,—the formation of pus ceases,—the cyst slowly wastes,—and the patient perfectly recovers,—the work of the two kidneys being performed by the remaining one, which has gradually undergone an increase in size corresponding to the increased work it has been called upon to perform. When pus is derived from the pelvis of the kidney, crystals of earthy phosphates are often absent. I have seen five cases of this condition occurring in domestic servants. One was under treatment for a twelvemonth, and completely recovered. I had, in 1863, a case of this disease in the hospital. The girl, who was also a servant, had been passing large quantities of pus daily for ten months. The proportion passed in twenty-four hours usually occupied the bulk of eight ounces, and sometimes amounted to even a larger quantity than this. It is very remarkable in these cases that the formation of this large amount of pus is not associated with hectic, and, in many cases, the general health continues good, the strength being supported with tonics and a generous diet.

There is a chronic state of ulceration of the ureters and pelvis of the kidney and bladder, in which pus is formed in considerable quantity, leading to the most distressing symptoms. Pus may depend upon the existence of old stricture. Abscesses form in the kidney as in other organs; and, after the abscess has burst, pus makes its way into the urine. The inflammation of the mucous membrane of the kidney often extends upwards from the bladder.

The presence of a calculus in the kidney, in the ureter, or in the bladder, may set up inflammation which may go on to the formation of pus. A very small calculus will sometimes excite great irritation in the kidney, so that pus, blood, and much mucus, in which microscopic calculi are sometimes embedded, are voided in the urine.

Pus may be derived from a sloughing process going on in the kidney. Sometimes a portion of the organ sloughs off entire in these cases. My friend, Mr. Newham, of Bury St. Edmunds, sent me some time since a piece of kidney which had sloughed off, and had passed with much pus into the urine. Pus may also depend upon the presence of cancer in the kidney or upon tubercle developed in the same situation.

Pus may come from an acute affection of the uriniferous tubes, and the corpuscles will be found free in the urine, and entangled in considerable number in casts. These cases are often very rapidly fatal, pl. XIV, fig. 88, p. 348.

Pus formed upon the mucous membrane of the vagina as takes place in leucorrhœa has been already considered.

In women, a large quantity of pus may be formed in burrowing abscesses amongst the pelvic viscera, and make its way into the bladder, ureters or vagina. These cases of *pelvic cellulitis* are not uncommon. I have seen patients reduced to an extreme state of emaciation from the long-continued drain, nevertheless completely recover, although there were openings, both into the rectum and upper part of the vagina, so that sometimes pus passed by the bowel, and sometimes it was found in the urine.

Of the Treatment of Cases in which Pus is found in the Urine.— The full consideration of this subject, it need scarcely be said, would occupy a volume. I shall, therefore only allude briefly to the treatment of some of the cases which naturally fall to the province of the physician to treat. But I would remark, generally, that the treatment of many cases which are usually considered to require special medicines, may be conducted successfully upon a much more simple plan than that usually recommended in treatises upon medicine. For example, how many remedies have been considered specifics in gonorrhœa, and yet the disease very frequently gets well very soon under complete rest, mild purgation, alkalies, and sudorifics. The most obstinate cases of gleet, which have been subjected to various remedies and injections of different kinds, often recover if the general health of the patient be improved by tonics. The common tincture of perchloride of iron and quassia, persevered in regularly for several weeks, is particularly valuable in these cases, and it is more than probable that the benefit results from the improvement in the general health.

Among the most obstinate of the conditions which give rise to the presence of pus in the urine, is chronic inflammation of the bladder, not dependent upon stone. This is often called catarrh of the bladder, and, in many cases, is undoubtedly connected with a gouty state of system. I have had considerable experience in the treatment of this condition, and am satisfied that by far the most successful plan is to attend to the general health, and not to trust to remedies which are considered to exert a specific action upon the diseased mucous membrane.

Many cases of chronic disease of the bladder that I have seen, have been subjected to all kinds of treatment, but not one plan has been persisted in for a sufficient time for any benefit to result. A patient is ordered, perhaps, uva ursi for a week;* then, being no better, it is changed to buchu or pareira; next acids are tried with or without some tonic infusion; then alkalies, and so on; while in the mean time, the patient has lost his appetite, and has gradually got weak, and perhaps has night sweats. As the disease continues unabated he begins to lose hope, and suffers more and more from pain and irritability of the bladder. The attention being necessarily directed to the ailing organ, the condition often seems to the patient far worse than it really is. If unchecked, the above-mentioned conditions react upon each other, and the patient gets worse. The quantity of pus formed in the bladder increases considerably, and the calls to micturate are incessant.

Now, in such a case, it often happens that, if the stomach be set right by dilute acids and pepsine—if stimulants, which, perhaps, have been withheld altogether, be given in moderation at meals—if the diet be simple but nutritious—if the patient take moderate walking or carriage exercise in the open air, especially if he be sent to a pleasant part of the country, or to the sea-side, where he can at the same time be amused—if he be ordered the tincture of the perchloride of iron, beginning with ten drops, and gradually increasing the quantity to half-a drachm three times a-day, in infusion of quassia,—a great improvement may take place in a few weeks. The night sweats cease, the patient gains in strength and increases in weight, and is able to retain his water for three hours or longer, while the proportion of pus formed is considerably lessened. I have seen patients put upon this plan steadily improve for six months, and I have given the iron regularly for a twelvemonth, in some cases, with real benefit. In fact, it will often happen, that a patient will resume the remedy himself, after having given it up,—than which there can be no stronger evidence of its usefulness. It is true that many patients get tired of taking one remedy for so long a time, unless the improvement is decided and obvious. It too often happens that, by giving way to a patient's caprice in trying this thing and that, valuable time is lost. The patient might have been relieved, by steady perseverance in one plan in less time than he has spent in trying first one reputed remedy and then another,

* An infusion of the root of common couch grass (*triticum repens*) has been strongly recommended by Sir Henry Thompson, as a useful remedy in cases of this kind. The proportion is an ounce of the dried rhizome to a pint of boiling water. Triticum repens has been incorrectly called the "common bindweed," but the plant usually known as "bindweed," is the large convolvulus with white flowers (*convolvulus sepium*). I cannot speak very strongly in favour of this remedy from experience, but Sir H. Thompson considers it of great value.

in the hope of relieving, immediately, a chronic malady, although it is physically impossible that healthy action can be restored, except by a very gradual progressive change, which requires considerable time for its completion.

It is clearly right, in such a disease as this, to tell a patient at once that he cannot recover in a week; and it is wrong to allow him to think that, by any special remedy, the disease can be cured as by an antidote. If patients, who are utterly ignorant of the nature of the malady from which they are suffering, will obstinately persist in acting according to their own prejudices, and insist upon being misled, to their own detriment, as some undoubtedly will, it is out of our power to help them. All that can be said is, that, if they had any real knowledge of physiology and medicine, they would have had more confidence in us than in an ignoramus who promises a rapid cure, and is ignorant of the nature of the disease.

In all bad cases, more especially if the pus is ever converted into the ropy mucus-like mass *in the bladder*, it is of the first importance to use injections of warm water. This is a very simple operation, and affords, even in extreme cases which cannot be cured, the greatest relief. Some use injections of dilute nitric acid (one drop of the strong acid to each ounce of water), but the chief benefit, I believe, arises from removing the decomposing matter which irritates the mucous membrane and excites decomposition in the fresh urine as fast as it reaches the bladder, so that plain water (warm distilled or rain water) answers, in almost all cases perfectly well. It may be injected through a double catheter, or through an ordinary catheter, and drawn off by the same instrument. The bladder should, of course, never be fully injected, as distension of its coats always does harm. In bad cases it is necessary to wash out the bladder in this way every day.

In all cases in which the formation of a considerable quantity of pus goes on in any part of the organism from day to day, it is of the first importance to pay attention to the general state of the patient's health, and experience has proved that the remedies which do most good are those included under the head of tonics. In many cases, too, stimulants are required. The quantity of pus varies from time to time, and it will be found that it increases if the blood becomes poor, while the formation of pus diminishes as the patient's health improves. A greater quantity of material becomes pus when the system is weak and low, than when the nutrition of the body is properly carried on. This fact has been explained in different ways. It seems to me probable that, when the blood is poor, transudation of nutrient matters occurs more freely than in the opposite condition; and it is, I think, mainly by diminishing the tendency of the fluids to transude that iron, many tonics, and alcohol, act favourably. Pus grows the faster the more freely nutrient matter is supplied to it, and it lives upon the pabulum which is really required for the nutrition of the healthy tissues. The pus lives faster than any healthy tissue.

Cases of sacculated kidney require perfect rest, nutritious diet, and tonics. For the treatment of the different forms of pelvic cellulitis, I must refer to works upon the diseases peculiar to women.

III.—THIRD CLASS OF URINARY DEPOSITS.

Uric or Lithic Acid.—Among the deposits which I have arranged in a third class, and which are characterised by their small bulk, by their crystalline or granular appearance, as well as by their density, may be mentioned, in the first place, *uric* or *lithic* acid—a substance which has already been brought under notice as a constituent of healthy urine, and of which the chemical properties and general characters were then briefly referred to, p. 139. Uric acid forms a crystalline deposit, and perhaps is more frequently met with than any other form of urinary sediment, with the exception of the urates; and although there seems reason to believe that, as chemico-pathological investigation advances, we shall no longer regard the presence of this, or indeed of any other substance in the urine, as evidence of the existence of a particular diathesis, its presence in many cases, especially when the deposit occurs very frequently and in considerable quantity, affords an indication that the chemical changes in the organism are more or less modified.

The *quantity* of uric acid in the urine depends, to a certain extent, on the activity of the skin; and, as a general rule, when there is profuse cutaneous perspiration, the amount of uric acid in the urine will be found to diminish. If, on the other hand, the function of the skin be in any way impaired, or perspiration be impeded by cold, a considerable increase in the quantity of uric acid will take place. Marcet found that the amount of uric acid diminished after severe perspiration; and Fourcroy noticed more uric acid in the urine of a man in winter than in summer. In this way may be explained the presence of the large quantity of uric acid in the urine of persons affected with acute dropsy, or dropsy after scarlatina, and it seems probable that the frequency with which these deposits are met with in the urine of persons affected with skin diseases (especially eczema and lepra) may be due simply to the impaired function of the skin. After increased muscular exertion, accompanied with imperfect respiratory action, uric acid occurs in abnormal quantity. It is present as a deposit in very many cases of chorea. It should, however, be borne in mind that uric acid is often dissolved in the urine as a urate at the time it is passed, but is afterwards precipitated, being perhaps separated from its combination with soda (urate of soda) by the process of acid fermentation.

Of the Crystalline Forms of Uric Acid.—In the great variety of crystalline forms which uric acid assumes, it is not surpassed by any other substance. Its true primitive form is not easily determined; but that in which it appears most constantly is the rhombic, although in many instances this occurs with two of its angles rounded. From its salts, however, the acid may be separated in rhombic tablets, or in six-sided plates, somewhat resembling crystals of cystine, by the addition of acetic, nitric, or hydrochloric acid.

The form of the crystal is much affected by the strength of the acid which is added. This subject has been investigated by Dr. A. E. Sansom ("Transactions of the Medical Society of King's College, London, Winter Session, 1856-57," p. 128). The following are the results :—

Acid in small quantity	Crystals regular; mostly tables and squares; lozenges.
Acid in large quantity, added to a strong solution of urate of ammonia	Large and long tables, with very elongated lozenges.
Acid strong; amorphous urate itself used	Acicular prisms most frequent.

The various forms which the substance assumes in urine may often be traced, by intermediate stages, from one into the other; but the conditions which determine the changes have not yet been satisfactorily explained. Doubtless the length of time occupied in the formation of the crystal and the extractive matters present have much influence in determining its form; for not unfrequently one crystal is observed to acquire entirely different characters if it be allowed to remain for a longer period immersed in the urine. Some of the commonest forms met with are represented in pls. XXIV, XXV, XXVI, XXVII, figs. 133, 142 to 147, 148, and 154. The most important crystalline forms, besides the rhombic, are the rectangular quadrilateral prisms with terminal planes, pl. XXX, fig. 164, and the dumb-bell crystal, pl. XXVIII, fig. 157. All other forms appear to be some modification of these three. The dumb-bell form of crystals is occasionally met with in deposits; but it may often be readily obtained by the addition of an acid to urine. These crystals must not be mistaken for dumb-bells of oxalate of lime, from which they may be distinguished by their large size and darker colour, and by their being readily soluble in alkalies. Pure uric acid often crystallises in micaceous plates. Uric acid deposited in urine can generally be distinguished by its colour from other crystalline deposits, although two or three instances have come under my notice in which the crystals were found to be perfectly colourless, pl. XXVIII, fig. 153.

In the accompanying plates as many as thirty-six different forms of uric acid are represented, but were the number greatly increased the practitioner who made frequent examinations of the urine would, from time to time, meet with crystals not exactly resembling any of my figures. I think, however, that anyone familiar with the representations here given, and with the most common forms as actually seen in the microscope, would be able to recognise without difficulty any forms of uric acid which he is likely to meet with.*

Uric acid is sometimes deposited very rapidly, when it forms a thin glistening film, in which no indication of crystalline form can be detected. A film of this kind was brought to me some time since by Dr. Chambers. After the lapse of a day or two, however, well-marked crystals made their appearance. Some of these films are composed of layers of small crystals, closely matted together, pl. XXIX, fig. 163. After the lapse of a short time, the larger crystals grow, while the smaller ones disappear; so that at length a number of large well-defined crystals are produced.

A deposit of uric acid sometimes resembles amorphous urate, and even under very high powers of the microscope nothing but minute granules can be detected, even for some hours after the urine has been passed. This deposit is not soluble in boiling water, and in the course of from 24 to 48 hours the granules will be found to have increased considerably in size, while many exhibit well-defined crystalline form. *See* p. 223.

Tests for Uric Acid.—When we are in doubt as to the nature of a deposit suspected to consist of uric acid, we may examine it as follows. If it consist of uric acid, it will be insoluble in hot water, but soluble in alkalies, potash, soda, and ammonia.

1. A portion of the deposit is to be dissolved in a drop of potash. The alkaline solution is then to be treated with excess of acetic acid. After the lapse of a few hours, crystals of uric acid will be formed, which must be subjected to microscopic examination.

2. A sediment, suspected to be composed of uric acid or a urate may be placed upon a glass slide, and treated with a drop of strong nitric acid. After evaporation to dryness at a gentle heat, the slide is to be exposed to the vapour of ammonia, or a drop of ammonia may be added to the dry residue. A beautiful violet colour, owing to the formation of murexide, proves the presence of uric acid or a urate.

Of the Clinical Importance of Uric Acid.—This substance exists in the blood, in combination with a base, as an alkaline or earthy urate, which is comparatively soluble. The soluble urate may be decomposed; 1, when it arrives in the uriniferous tubes; 2, subsequently, when the urine reaches the bladder; or, 3, the acid may not be set free until some time after the urine has been passed.

In the first case, the acid may accumulate and block up the tubes, *see* pl. VII, fig. 30, *opp.* p. 17, or perhaps form a small concretion. I have shown that oxalate of lime usually forms the nucleus of these

* I should esteem it a favour if those who may meet with specimens of uric acid differing decidedly from all my figures, will kindly forward me a specimen or a drawing.

uric acid calculi which are so common. In the second case, if a small concretion of any kind exist in the bladder, uric acid may be deposited around it, and a uric acid calculus become rapidly formed. The deposition of uric acid after the urine has been passed is often merely accidental, and depends, according to Scherer, upon the decomposition of the urates by a form of acid fermentation. The acid crystallises sometimes very soon after the urine has been voided, sometimes not for some days afterwards. I have before alluded to the importance of not regarding the *deposition* of uric acid crystals as in all cases depending upon *excess* of the acid in the urine. There may actually be less uric acid than is present in health, although it may be deposited entirely in an insoluble form.

I may state generally, that we are likely to meet with this deposit where a liberal meat diet is indulged in by those who take very little exercise, and in the urine of people who lead very sedentary lives it is not uncommon. In various gouty affections it is very frequently observed. In diseases of the liver it is especially common, and temporary congestion of that organ seems in many cases to occasion the formation of much uric acid. In chronic diseases of the respiratory organs we often meet with uric acid and urates in the urine. It is common in emphysema of the lungs and in chronic bronchitis. In pneumonia and rheumatic fever it is often found. It is seldom absent from the urine in chorea, and very often exists in various forms of skin disease and in cases of acute inflammation of the kidney. It is occasionally met with in diabetes.

There are many cases in which the tendency to deposits of uric acid is not very easily explained. Some children are very liable to suffer from these deposits, and their appearance is accompanied by frequent desire to pass urine. In cases where this state of urine is very frequent it is necessary for the practitioner to interfere.

On the Treatment of Cases in which Uric Acid is Deposited in the Urine.—Occasionally we meet with patients who appear generally in good health, but who complain of getting thin, although they live well, in many instances perhaps too well, and suffer from an almost constant deposition of uric acid. It is very difficult to explain this symptom in every case in which it occurs; but I feel sure that many of these persons overtax their digestive organs, and are in the habit of eating too much. They think that the only way to gain flesh is to consume a large quantity of food; and, in consequence of too much work being thrown upon their digestive organs, especially the liver, assimilation is not properly carried on, and a quantity of material is formed which is unfitted for the wants of the organism, and is perhaps got rid of in the state of urea, uric acid, and urates. By cutting off a certain part of the supply, their anxiety as to the gravel is soon relieved, and at the same time, to their surprise, they gain strength and increase in weight.

I have seen instances of uric acid deposits occurring in adults, in which ordinary remedies appeared to exert no effect. The urine of a patient suffering from emphysema of the lungs always contained a large quantity; and it appeared while she was taking considerable doses of alkalies, and also when she was put upon mineral acids. The connection between deposits of uric acid and gout has been referred to in p. 196.

The great objection of employing the term "uric acid diathesis" has been already alluded to, p. 177; and in p. 196, I have referred to the general principles by which we should be guided in the treatment of cases in which an excess of uric acid is eliminated in the urine. The occasional deposition of uric acid crystals from the urine requires no medical treatment, or at most a dose of bicarbonate of potash after meals or the last thing at night. In some cases in which these deposits are frequent, and in people of a gouty tendency, small doses of hydrochloric acid with pepsin before meals, and twenty grains of bicarbonate of potash in half a tumbler of water after meals, is a plan which answers admirably.

Xanthine ($C_{10}H_4N_4O$) or Uric or Xanthic Oxide is a substance closely resembling uric acid in many of its characters. It is very rarely met with in urine. It was described first by Marcet, and has since been detected in the blood, and also in the spleen, muscles, liver, and brain. It is rarely met with in the crystalline form, but Bence Jones reports the case of a boy, aged 9½ years, suffering from a feverish attack, in whose urine xanthine crystallised in lozenge-shaped crystals, which were first mistaken for uric acid. ("Journal of the Chemical Society," 1862.) The crystals were dissolved when the urine was boiled, and were found to be soluble in water, nitric and hydrochloric acids, and in alkalies. Douglas Maclagan also reports a case in which xanthine occurred in a urinary deposit. Xanthine is probably a common constituent of urine, but exists in very small quantity. A rare form of calculus is entirely composed of it. Xanthine is stated by Dr. John Davy to be the principal constituent of the urine of spiders and scorpions.

Dr. G. Durr, after bathing in natural sulphuretted waters, found xanthine in his urine, and also in the urine of a patient who had had strong sulphur ointment rubbed into his skin, but not after taking milk of sulphur into his stomach. In order to detect xanthine in the urine, the fluid is precipitated with caustic baryta, the filtrate is carefully neutralised, and then a solution of corrosive sublimate added; a white flocculent precipitate shows the presence of xanthine.

Oxalate of Lime was first shown to be a common urinary deposit by the late Dr. Golding Bird. It is seldom deposited in quantity sufficient to be recognised by the unaided eye, or to be subjected to chemical examination. This salt crystallises in well-defined octahedra, having one axis much shorter than the two others. The crystals vary much in size, and two or three forms have been described by authors, but some of these different appearances are due only to the position in which the crystals were viewed, as may be readily proved if a little glass model be constructed. The flattened octahedron is obviously the most common appearance, because the crystal lies most easily on one of its faces. If, however, it be turned with one of its long axes towards the observer, while the other is held upright, the short axis will necessarily be transverse, and the crystal will appear as a long and a very acute octahedron, pl. XXXI, fig. 172, *f*. If now one of the lines formed by the meeting of two opposite faces be turned towards the observer, there will still be the appearance of an acute octahedron; but it will be less acute than before, and no transverse line in the centre can be made out. Upon keeping the same line towards the eye, and by carefully turning the crystal, so that the two opposite faces are made quite parallel to each other, the appearance as of a long-shaped four-sided crystal will be produced. The different appearances produced by viewing the same crystal in different positions are represented in pl. XXXI, fig. 172, *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*. Crystals in all these different positions, appearing as different forms are commonly met with in the examination of urinary deposits, and may always be obtained by mounting oxalate of lime crystals in glycerine jelly.

In pl. XXXI, fig. 169, are represented octahedra in various positions, as well as dumb-bells, and circular and oval crystals of oxalate of lime, with two cells of bladder epithelium, deposited from the urine of a patient suffering from a tense state of the skin of the wrists and arms, a condition which is sometimes termed "hide-bound."

Many observers have figured the crystals of oxalate of lime incorrectly. Dr. Golding Bird considered that they belonged to the cubic system. Dr. Prout, however, had previously given a figure of oxalate of lime which clearly shows that he was aware of the exact form of the crystal. Prismatic crystals of oxalate of lime occur in some plants, and they have been observed by Beneke in urine. I found that some preparations of ordinary oxalate of lime, which had been kept for some years in preservative fluid, underwent a change in form, and were at length entirely replaced by beautiful prisms. Fig. 171, pl. XXXI, represents a rare form of crystal. The extremities resemble the two faces of an ordinary octahedron, but they are separated by an intervening quadrilateral prismatic portion.

Oxalate of lime may be obtained in its usual octahedral form from its solution in hydrochloric acid; and Neubauer states, that from a solution in phosphoric acid, crystals may be separated by neutralising the acid by soda or potash.

Dr. Thudichum has carefully examined the crystals of oxalate of lime obtained in different ways, and he brings all the different forms he has observed under the following heads: *quadratic octahedron*, *crossed octahedron*, *quadratic octahedron and prism* combined; *crossed prisms; triple twins*, with *tropia;* modifications of *crossed octahedra;* contortions and anomalies, including dumb-bells. He also shows, contrary to previous statements, that the salt actually possesses a polarising power, as should be the case if it belongs to the quadratic system. This is, however, difficult to demonstrate, and can only be brought out fully by reflecting a ray of sunlight through the crystal. I had long ago examined crystals by the polariscope which had been mounted in Canada balsam, and had noticed that they were often slightly illuminated when the field was dark. Although I had figured the form of the crystals correctly, I must confess that I was too ready to agree with the statements made by others as to the system to which this crystal belonged. In this matter Dr. Thudichum has corrected me; and after a re-examination of the question, I can thoroughly confirm Dr. Thudichum's statement, that the octahedra, mounted in Canada balsam, do polarise even with a good artificial light; and therefore no argument in favour of the view that the dumb-bell crystals are composed of oxalurate, and not of oxalate of lime, can be based on the conclusion that the octahedra do not polarise.

Dr. George W. Balfour recommends that the crystals be mounted in viscid glycerine when it is desired to examine them under the influence of polarised light, as this medium supports them in any position required. *See* "Medical Press and Circular," April, 1866.

Dumb-bell Crystals of Oxalate of Lime.—Oxalate of lime, however, occurs more rarely certainly, but still not uncommonly, in another very interesting form, which was also first pointed out by Dr. Golding Bird. From their resemblance to dumb-bells, these bodies are known as the dumb-bell crystals of oxalate of lime. Dr. Golding Bird thought that they were composed of oxalurate, and not of oxalate of lime; but the following points, in addition to what has been stated above, render this most improbable.

1. Octahedra, in all the cases I have observed, were deposited from the specimen of urine in which the dumb-bells were found, and invariably precede and follow the appearance of the dumb-bell crystals.

2. Minute calculi are often composed of dumb-bells, as may be shown by microscopical examination; and these calculi have been proved by analysis to consist of oxalate of lime.

Organic matter exists in every part of the dumb-bell. By the prolonged action of acetic acid the crystalline material may be dissolved out, leaving this organic matter. Mr. Rainey has shown that the presence of viscid organic matter prevents crystalline substances from assuming their usual form, and causes the crystalline material to be deposited in the spherical or dumb-bell form. Now when the crystalline matter is dissolved out, the organic basis remains, and its sharp outline looks like that of a cell-wall, pl. XXXI, fig. 175, *r* to *u*. The appearance of a cell-wall may be observed, if the earthy salt from the spherical and dumb-bell crystals of carbonate of lime in horses' urine be dissolved out by an acid. The same point may be demonstrated upon a larger scale by treating the small renal phosphatic calculi, sometimes found in the kidney in considerable number, or the well-known prostatic calculi, with dilute acid. In all these cases the outline of the transparent matrix may lead the observer to conclude erroneously that he sees a hollow transparent membrane or cell. A spherical mass of jelly or any other transparent solid substance would exhibit a similar well-defined outline. This sharp line has been accepted as evidence of a cell-wall in innumerable cases where no such structure really exists.

Some persons have stated that these dumb-bell crystals of oxalate of lime were composed of uric acid—a mistake for which it is very difficult to account, since, in their optical characters and chemical properties, these crystals differ very widely. The uric acid dumb-bell is instantly dissolved by dilute potash, and, by the addition of excess of acetic acid, rhombic crystals will be thrown down; while the dumb-bell of oxalate of lime is insoluble in a strong boiling solution of potash.

Besides the dumb-bell, it is common to meet with a number of closely allied forms, among which may be mentioned circular and oval crystals, pl. XXXI, fig. 173, *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*. In several of the cases which have fallen under my notice, the true and perfectly shaped dumb-bell was preceded by circular and oval crystals; and these also again appeared after true dumb-bells could no longer be detected in the urine. These crystals often disappear the day after multitudes have been found; and generally they are only noticed for a few consecutive days—a circumstance which may perhaps account for the comparatively few instances in which these crystals have been noticed. Two or three oval crystals are seen in pl. XXXI, fig. 169.

Of the Formation of the Dumb-bell Crystals.—It is well known that the octahedra of oxalate of lime are commonly deposited in the urine after it has left the organism; and if urine which contains very minute crystals be allowed to stand for a few days, these may often be observed to increase in size, until at length they became very large, while at the same time a number of new ones make their appearance. On the other hand, dumb-bell crystals are present in the urine when it is passed, and they do not increase in size or number if allowed to remain in it. These dumb-bell crystals are formed in the renal tubes. I have found them entangled in casts in the urine of a cholera patient passed after eighteen hours complete suppression during the stage of collapse. The specimen of urine in which these casts were found was very acid, of a dark colour, and specific gravity 1,024. It contained no albumen. The following report was made at the time of examination. "Deposit very slight, consisting of transparent, smooth, and hyaloid casts, for the most part homogeneous, but in a very few of them a small quantity of granular matter was observed. In others, dumb-bell, oval, and globular crystals of oxalate of lime were noticed. The dumb-bell crystals were seen only in the casts, but many octahedra were observed in the surrounding fluid," pl. XXXIII, fig. 181.

I have seen many times a number of dumb-bells impacted in the tubes of the kidney, especially in the pyramids. Indeed, if thin sections of this portion of human kidneys be made, these dumb-bell crystals will be observed not unfrequently. Often several may be seen in the wide portion of the tube, near to the point where it opens upon the surface of the mamilla.

It is probable that when *octahedral* crystals appear to be *in* casts, they were really deposited upon the surface or in the substance of the cast, some time after the urine had left the bladder.

Of the Conditions under which Dumb-bell Crystals occur.—I have met with a great many specimens of urine containing dumb-bells, but have been unable to associate the appearance of these crystals with any particular morbid condition. It may be interesting to refer to a few of the cases which occurred in the hospital some years ago. During six months, I met with ten or eleven instances, in which these peculiar crystals were present, out of about four hundred cases in which the urinary deposit was examined; but I have not observed that the urine containing them possessed any characters by which we might be led to suspect their presence, before resorting to microscopical examination; and, from my own observations, it does not appear that the dumb-bells are connected with any peculiar form of disease, or with any particular diathesis. They occur usually mixed with the ordinary octahedra of the oxalate, but I have found them alone; frequently they are accompanied by urate of soda and ammonia and crystals of uric acid, and often by both. Out of ten cases in which they were present, eight were men, and the remaining two were women, above the age of 21. Of these ten cases, nine occurred between the months of September and January, and one in April; but this may be accounted for by the fact, that during the winter I have always made a much greater number of microscopical examinations than during the summer months. The crystals were present in—

One case of chorea.

Two cases of cholera.

One case of chronic rheumatism.

One case of contraction of the skin of the neck and upper extremities, the condition to which the term "hide-bound" has been applied.

One case of boils, occurring in various parts of the body.

One case of paraplegia, depending upon diseased vertebræ.

One case of attempted poisoning by taking half an ounce of oxalic acid.

One case of eczema.

One case of epilepsy.

Out of these ten cases, in which the dumb-bell forms of crystal were present, it will be observed that only two instances occurred in which they were found in the urine of patients afflicted with a similar disorder. The others differ so entirely from one another, that it cannot be supposed that this curious form of crystal is in any way dependent upon the nature of the malady. We are rather led to conclude that these crystals result from certain conditions unconnected with any particular morbid state. The dumb-bell crystals often occur in the urine of persons not suffering from any special disorder at all, who consider themselves in good health; but generally there is languor and loss of appetite, with uneasiness after eating, and the individual, without suffering from any definite ailment, complains of not being quite well. Dumb-bells are often met with in the urine of persons who take little exercise, and indulge in rich diet, with too little water. The concentration of the fluids, and imperfect oxidation, will full account for the formation of these crystals in cases of cholera; and it is probable that similar conditions are present to a less extent, and due to a different cause in other cases in which dumb-bell crystals have been detected.

Sometimes several dumb-bells adhere together, forming an irregularly shaped mass, which gradually becomes smooth by the deposition of the same material in the interstices, until a small, nearly spherical or oval body is formed. *See* pl. XXXIII, figs. 182, 186. In other cases it would appear that one or two crystals grow at the expense of the rest, and a perfectly uniform oval crystal, composed of course of numerous acicular crystals, radiating from a common centre, results. Thus the dumb-bell crystal becomes the nucleus of a small calculus, and it is easy to see how this may increase in size by the deposition of new matter externally—at first, while it remains in the straight portion of the uriniferous tube, or in that system of irregularly shaped cavities at the apex of the mamilla, formed by the convergence of several of the large tubes; then in the pelvis of the kidney or ureter; and lastly in the bladder itself. *See* Calculi, p. 403.

Chemical Composition of the Dumb-bell Crystals.—The chemical composition of these crystals has long been a matter of dispute among chemists, but it may now be regarded as nearly certain that they consist of oxalate of lime; for since it has been shown that the dumb-bell may gradually grow into a small calculus, and that the latter is certainly composed of oxalate of lime, we are justified in inferring that the dumb-bell or *microscopic* calculus has the same chemical composition. No difference in chemical character, refractive power, or in the action of polarised light, can be detected between the minute dumb-bell or oval crystals, and the aggregations of dumb-bells which are from time to time met with, and which are really microscopic calculi. There cannot, in fact, be the slightest doubt of these being the same things at a different stage of formation. Nor can there be any question of the latter being, in their turn, an early condition of the small renal oxalate of lime calculi. The nucleus of a uric acid renal calculus almost always consists of oxalate of lime.

Deposits associated with Oxalate of Lime.—Oxalate of lime is often found associated with other deposits, particularly with urate of soda, in which case the minute crystals of oxalate are easily passed over amidst the amorphous deposit. The peculiar form of crystals of earthy phosphate, described in p. 357, are usually found in urine from which oxalate of lime is also deposited.

Crystals of oxalate of lime are so minute that, without care, they may be readily passed over in a microscopical examination; and very frequently the only appearance observed in the microscope is the presence of clusters composed of minute cubical or square-shaped crystals, which appear almost opaque, pl. XXXII, fig. 178. Indeed, such clusters of oxalate of lime crystals may be easily mistaken for urate of soda, from which, however, they may be distinguished by the fact of their not being dissolved upon warming the slide, and by their insolubility in potash and acetic acid. Crystals of this character are often found adhering closely to hairs and other substances. Deposits of oxalate of lime and uric acid are represented in pl. XXIV, fig. 133, and pl. XXIX, fig. 160, and of oxalate of lime and phosphate, pl. XXI, fig. 115, and pl. XXXII, fig. 178.

Of the Examination of Deposits of Oxalate of Lime by the Microscope, and of their Chemical Characters.—The larger crystals are readily recognised by their microscopical characters; and the only things I have known mistaken for them are crystals of triple phosphate, as I mentioned when speaking of the phosphatic deposits, p. 355, pl. XXXII, fig. 180. If, however, there be any difficulty, a drop of acetic acid will soon set the question at rest.

Oxalate of lime deposits seldom sink to the bottom of the vessel in which the urine is placed, but seem to be buoyed up by the slight mucous deposit present. When, therefore, a drop of urine is taken for examination, there is no necessity for taking it from the very bottom of the vessel; indeed the stratum of fluid slightly above this point is often richer in crystals.

Oxalate of lime seldom occurs in urine in sufficient quantity for chemical examination. If oxalate of lime be burnt in a platinum capsule, and the carbonised residue be exposed for some time to the dull red heat of a spirit lamp or other flame, a white deposit will remain, which will be found to be insoluble in water, but it will be dissolved in acetic acid with copious effervescence, showing that, by the process of combustion, the oxalate has been converted into carbonate. If, however, the carbonate has been exposed to a bright red heat, there will be danger of its partial or complete conversion into lime, in which latter case no effervescence will occur upon the addition of an acid In the acetic acid solution, the presence of lime may be detected upon the addition of oxalate of ammonia, oxalate of lime being quite insoluble in acetic acid.

Of Oxalate of Lime in a Clinical Point of View.—There is still much difference of opinion among practitioners as to the clinical importance of oxalate of lime. There can be no doubt that, in the majority of instances, the crystals form after the urine has left the bladder; and there is good reason for thinking that the oxalic acid is often produced by decomposition of the urates after the urine has been passed. The experiments of Dr. Aldridge, of Dublin, show that uric acid and urates are easily decomposed into oxalic acid and oxalates. Dr. Owen Rees entertains the opinion that this substance is derived from the urates, and that, when present in the urine, it indicates the existence of urates in the blood. Oxalate is often deposited in the urine of gouty cases, and it is certainly very often found among urate deposits. Although there are certain conditions of the system in which both oxalates and urates are very common, both deposits may be present —indeed very commonly are present—in the urine of healthy persons. Hence it is obvious that such deposits do not indicate the existence of any particular diathesis. The fact seems to be rather that, in what is termed the "*oxalic diathesis*," among many other symptoms, oxalate of lime is present in the urine; but this is not the most important symptom, and the practitioner cannot make a greater mistake than to direct attention in such a case to the urinary deposit alone, or consider this as a special indication for treatment. In the same case, at one period we may find uric acid and urates; after a time, these mixed with oxalates; and, lastly, oxalate alone.

Wöhler and Frerichs injected uric acid into the blood of a dog, and found oxalate of lime in the urine. Oxalate of lime passes through the alimentary canal unchanged; but oxalic acid is in part excreted in the urine, while part is decomposed in the system. Bucheim and Piotrowsky have shown that small repeated doses of oxalic acid (fifteen grains every hour for six hours) are not poisonous. I should, however, strongly dissuade anyone from repeating such an experiment. Not more than 12 per cent. of that taken by the mouth appears in the urine. I have detected oxalate of lime in the urine of several persons who have attempted to poison themselves with oxalic acid. In pl. XXXII, figs. 176, 177, are some very marked six-sided crystals, obtained from the urine of a patient who had taken a large quantity of oxalic acid. They were insoluble in water, and were not dissolved by potash or acetic acid. The refraction of the crystals corresponded with that of oxalate.

Oxalate of lime is, however, not *always* formed *after* the urine has reached the bladder. I have shown that it is deposited in the tubes of the kidney in certain cases, in the form of dumb-bell crystals; and it must therefore have been formed at the time of the separation of the urine from the blood, if it did not exist in solution in the blood itself.

It appears, then, that oxalate of lime may be excreted in the urine when oxalic acid or oxalates are taken in the food. It may be formed in the organism itself; and it may be produced by the decomposition of uric acid and urates after the urine has left the bladder.

Beneke has shown that the earthy phosphates and oxalates increase in direct proportion to each other. The nutrition of the tissues generally would be impaired under the same circumstances; and a larger amount of earthy phosphate would pass off in the urine dissolved by the oxalic acid. ("Archiv des Vereins," Band I, Heft 3.)

It must be borne in mind that oxalate of lime is often discovered in almost opposite conditions. Thus it is sometimes present in poor broken-down subjects, and it is found in the urine of well-to-do country gentlemen. It will appear when we live too well and take too little exercise. It is common in chronic pulmonary affections, as bronchitis, and it is often observed in old cases of emphysema. It is common enough in dyspeptics, and is usually met with in cases of jaundice. In various forms of general debility, in cases of over-fatigue, and in men who have overworked their minds, it is perhaps the commonest urinary deposit. Lastly, I have found it many times, and in very large quantity, in the urine of men who appear to be in all other respects in perfect health.

Of the Treatment of Cases in which Oxalate of Lime is deposited from the Urine.—The remarks made in the last section render it almost unnecessary to devote a special section to the subject of treatment of oxalate of lime deposit. As a general rule, it will be found that anything which improves the general health and promotes oxidation will diminish the tendency to the deposition of this substance. Cold bathing, exercise, attention to diet, and the mineral acids, bitter tonics, and iron, are usually prescribed with advantage. I feel that by many writers too much has been made of the indications for treatment afforded by many of these urinary salts. Many cases of what has been called the 'oxalic acid diathesis,' because the urine contains octahedra of oxalate of lime, may in truth be treated by the practitioner just as successfully without taking into consideration the presence of the oxalate as by laying stress upon this fact. The patient will probably, in either case, be treated with tonic infusions and dilute acids (nitric or hydrochloric, or both), with a gentle purgative now and then. Pepsin may also be given. The diet should be simple, and small quantities of whisky or brandy in seltzer or Vichy water may do good.

Although the octahedra of oxalate of lime afford no special indication for treatment, the *dumb-bells*, on the other hand, unquestionably do so; for these dumb-bells may form the nuclei of renal calculi. In cases, therefore, in which they are found, it is well to promote their expulsion from the kidney, and endeavour to prevent the formation of more by giving mild diuretics, with plenty of fluid. Two or three glasses of Vichy water daily for two or three days, will generally wash these crystals out of the tubes and prevent the formation of others.

Cystine ($C_6H_6NS_2O_4$) occurs occasionally as a crystalline sediment in urine, and also enters into the composition of a rare form of calculus, which has been termed the cystine calculus. Cystine was formerly spoken of under the name of cystic oxide, and the same term was applied to the calculus.

Cystine forms a whitish deposit, which is found, upon microscopical examination, to consist of characteristic *six-sided plates*, pl. XXXIV, figs. 188 to 192, which may be distinguished from uric acid crystals of the same form by dissolving a portion of the deposit in ammonia. Upon the spontaneous evaporation of this ammoniacal solution, the cystine is again deposited unchanged in its hexagonal crystals; while uric acid would have been converted into urate of ammonia, which, on evaporation, would have remained as an amorphous residue. Ammonia, it appears, merely dissolves the cystine, and does not enter into combination with it. Cystine is insoluble in boiling water, in strong acetic acid, and also in very weak hydrochloric acid; but it is readily dissolved by oxalic, and by the strong mineral acids. The most remarkable property of this substance is, that it contains as much as 26 per cent. of sulphur—a character in which it resembles taurine. Potash, like ammonia, readily dissolves cystine; but it is insoluble in carbonate of ammonia. The presence of sulphur in cystine may be proved by heating the substance in an alkaline solution of oxide of lead, when a black precipitate of sulphuret of lead occurs. This test cannot be regarded as characteristic of cystine, because all animal matters containing sulphur exhibit a similar reaction. Urine containing cystine is said to smell very much like sweet briar.

Dr. Golding Bird has observed that calculi composed of this substance undergo a change of colour by long keeping. From pale yellow or fawn coloured, they have been found to assume a greenish grey, and sometimes a fine greenish blue tint. Crystals of cystine may be obtained from a calculus by dissolving a portion in a solution of potash, and adding excess of acetic acid to the alkaline solution, when the cystine will be deposited in its well-marked six-sided plates. Virchow and Clöetta have proved that cystine is sometimes found in the liver, while taurine as well as cystine have been detected in the urine.

Of *the conditions of system* which give rise to the elimination of this substance by the kidneys, little is at present known. In the majority of cases in which it has been found, the general health and nutrition of the patient have been bad. Dr. Johnson found cystine once in the urine of a prisoner, and it is from time to time met with in the urine of ill-nourished persons.

When examining the urine of the insane for Dr. Sutherland (" Trans. Med.-Chir. Soc.," vol. XXXVIII, 1855, p. 26), I was surprised at the number of specimens which emitted large quantities of sulphuretted hydrogen, after standing a few days. It is not improbable that the sulphur resulted from the decomposition of cystine or some allied substance.

Analyses of Urine containing Cystine.—The notes of the following interesting case were kindly furnished by Dr. Milner Barry, of Tunbridge Wells, who also procured me some specimens of the urine for analysis.

Case.—" Mr. A., aged 23, dark complexion, well built and well nourished, of active habits, assiduously engaged in the duties of a laborious profession, suffers occasionally from sick head-ache, but is otherwise in the enjoyment of excellent health. The presence of cystine was ascertained microscopically at the beginning of October, 1857 ; but, as deposits supposed to be urates had often been previously noticed, the probability is that the cystine had been excreted in the urine for a long time. It seems now never to be absent from the urine. Debilitating agencies, and whatever promotes the metamorphosis of tissue, intellectual exertion, active bodily exercise, mental anxiety, and smoking, appear to cause an increase in the amount of cystine. You will observe the much larger relative proportion of the ingredient in the morning urine than in that passed in the evening a few hours after a meal. There is no lumbar pain, and no irritability of the bladder." ("Archives of Medicine," vol. I.)

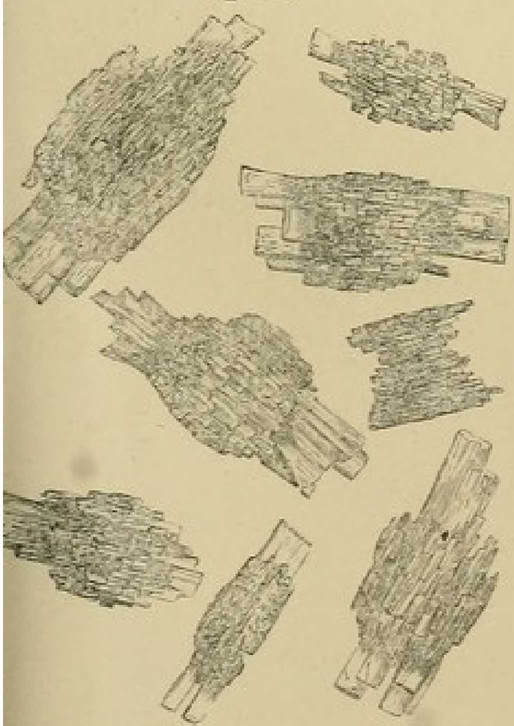
The first specimen of urine was received in October, 1857. It was of the natural colour, of acid reaction, and had a smell not unlike that of sweet briar. Specific gravity, 1,028.

URINARY DEPOSITS.

Fig. 133.

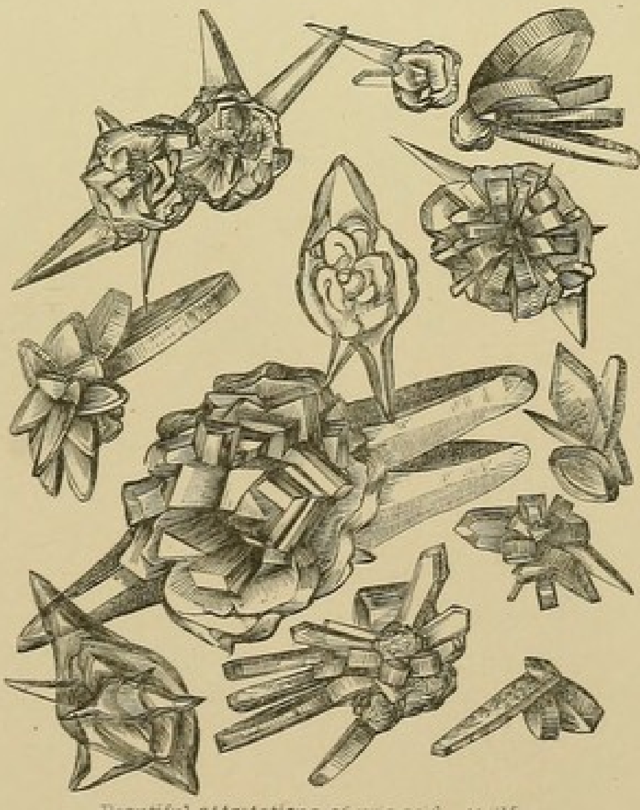
Groups of crystals of uric acid, often termed 'cayenne-pepper grains,' with octahedra of oxalate of lime. × 215.

Fig. 134.



Masses of small uric acid crystals. × 215.

Fig. 135.

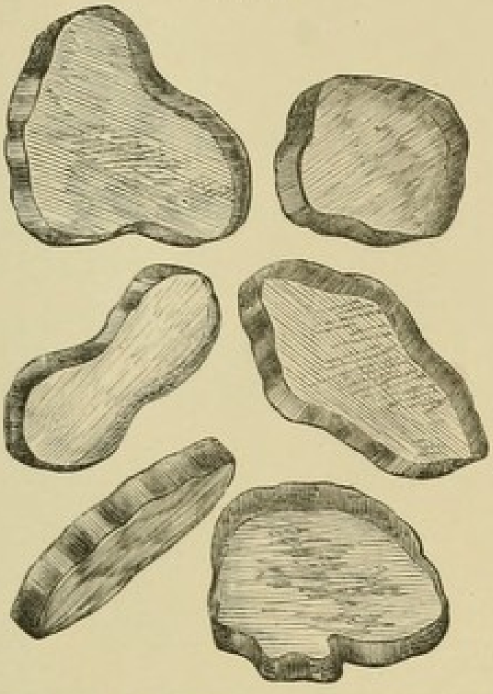


Beautiful aggregations of uric acid × 215.

$\frac{1}{1000}$ of an inch ⊢⊣ × 215.

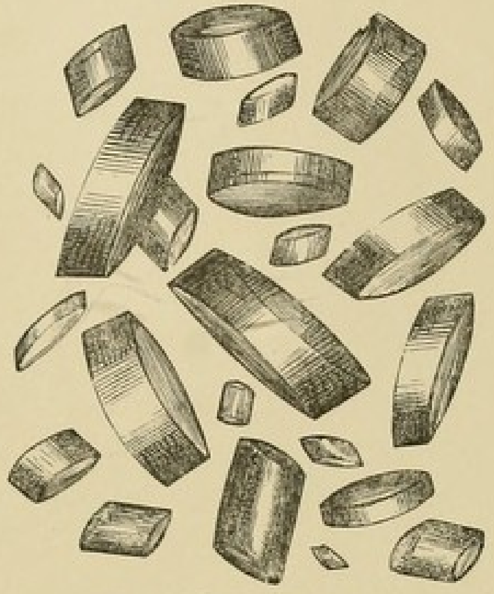
To face page 384.

Fig. 136.



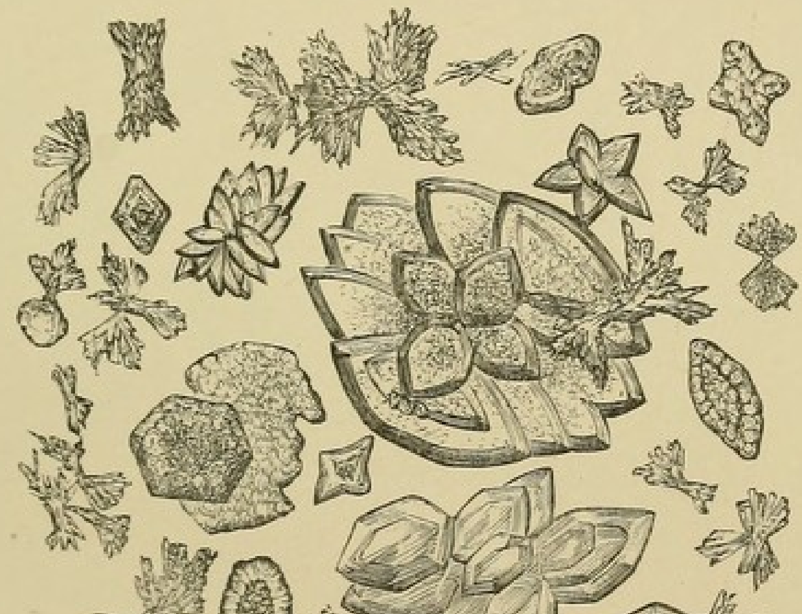
Large fiddle-shaped flattened crystals of uric acid. × 130.

Fig. 137.



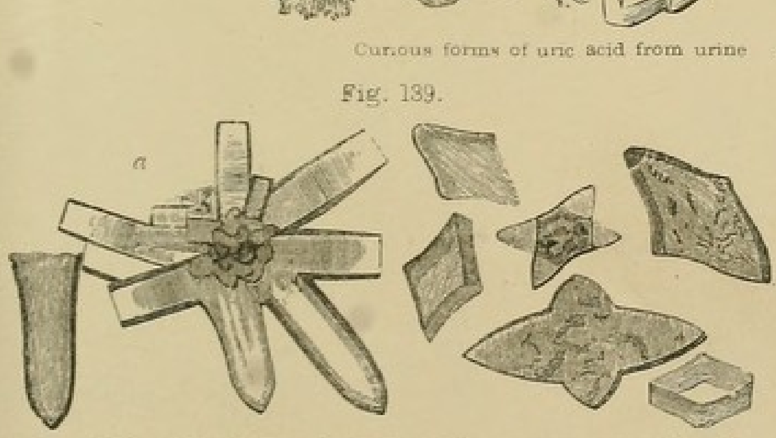
Uric acid from urine × 130.

Fig. 138.



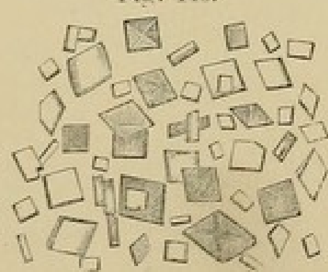
Curious forms of uric acid from urine × 215.

Fig. 139.



Large halbert-shaped crystals of uric acid *a*, 'cayenne-pepper' grain. × 215.

Fig. 140.

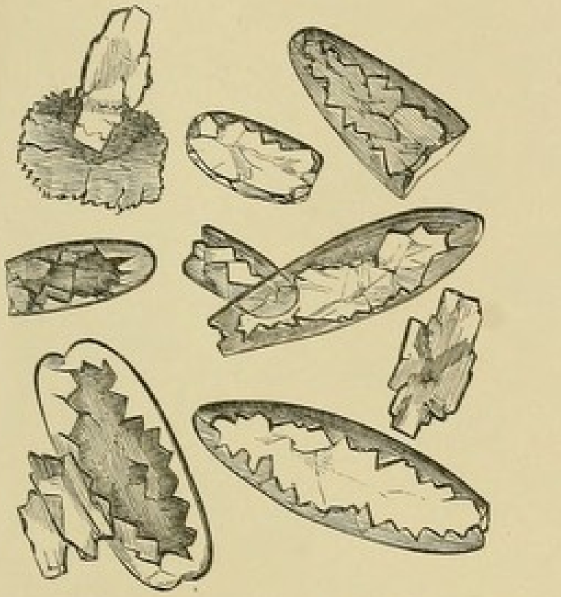


Minute crystals of uric acid. × 215.

$\frac{1}{1000}$ of an inch ⌴ 130.
" " ⌴ × 215.

[To follow PLATE XXIV.

Fig. 141.

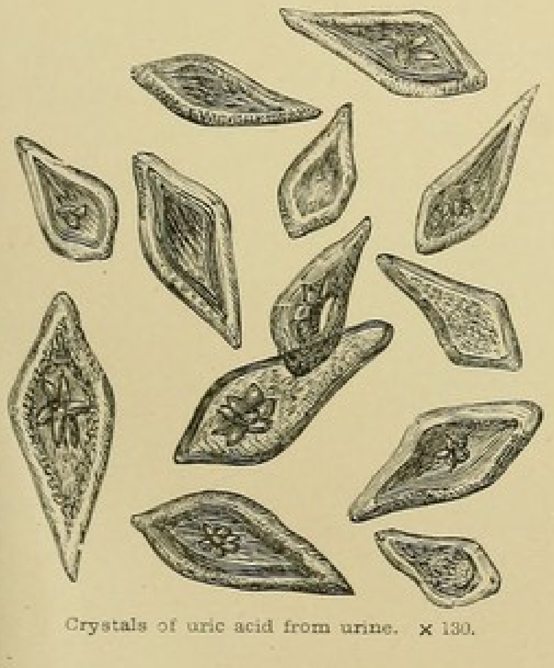


Curious lamellar crystals of uric acid, perfectly colourless. Sent by Mr. Lawrence. × 215.

Fig. 142.

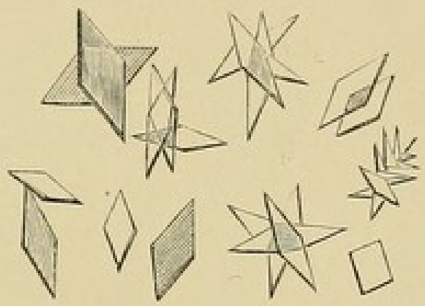
Lozenge-shaped crystals of uric acid, precipitated by the addition of acid to urine. × 215.

Fig. 143.



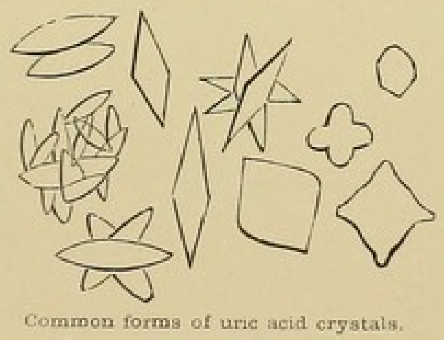
Crystals of uric acid from urine. × 130.

Fig. 144.



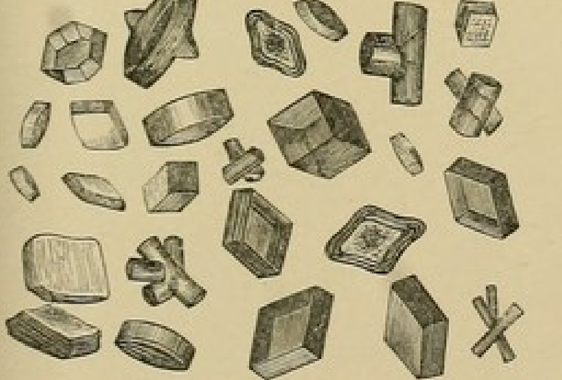
Lozenge-shaped crystals of uric acid obtained by adding acid to urine. × 215.

Fig. 145.



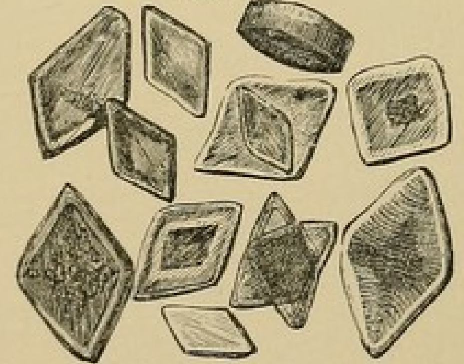
Common forms of uric acid crystals.

Fig. 146.



Common rhomboidal and cubical forms of uric acid from urine. × 215.

Fig. 147.



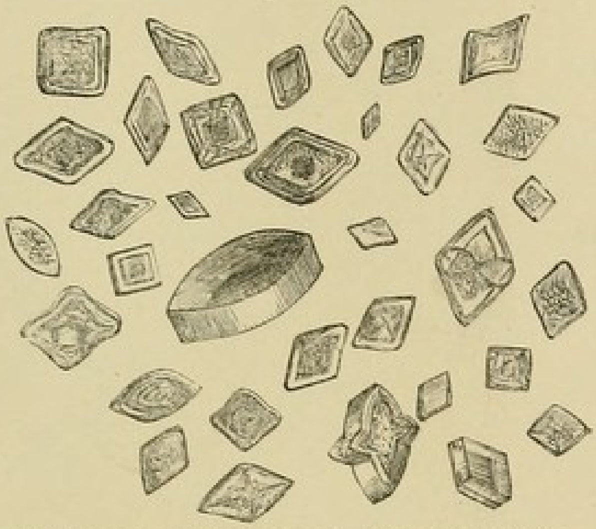
Large crystals of uric acid, deposited in urine after standing. × 130.

$\frac{1}{1000}$ of an inch |__| × 130.

,, ,, |___| × 215.

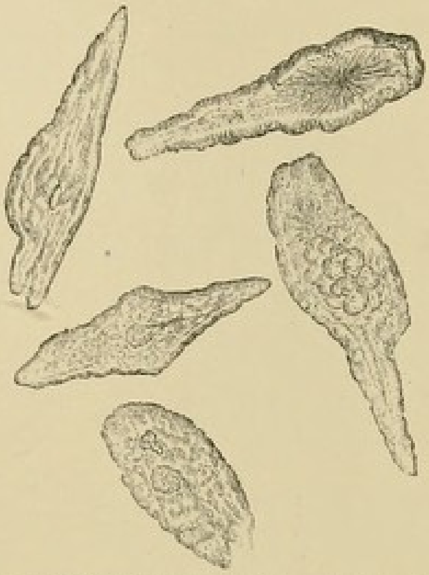
[To follow PLATE XXV.

Fig. 148.



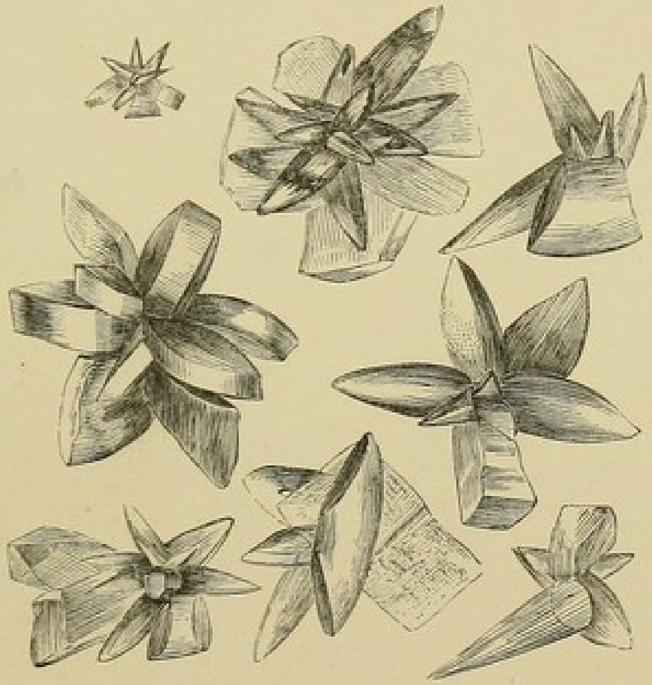
Rhomboidal crystals of uric acid. Very common form × 215

Fig. 149.



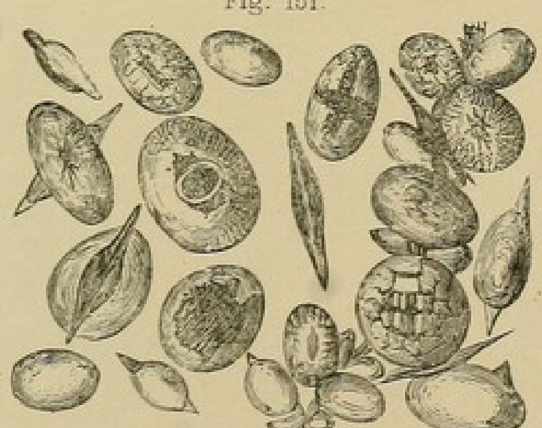
Curious forms of uric acid, deposited in the urine of a case of fatty degeneration of the kidneys. × 130.

Fig. 150



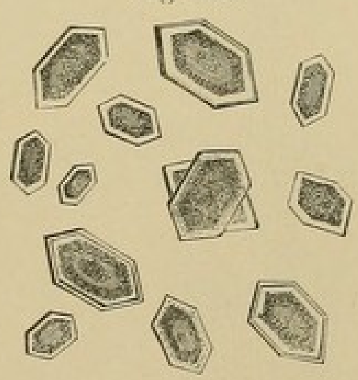
Large, very transparent glomeruli of uric acid, from urine. × 130.

Fig. 151.



Round, oval, and spear-headed masses of uric acid. Deposited from urine. × 215

Fig. 152.



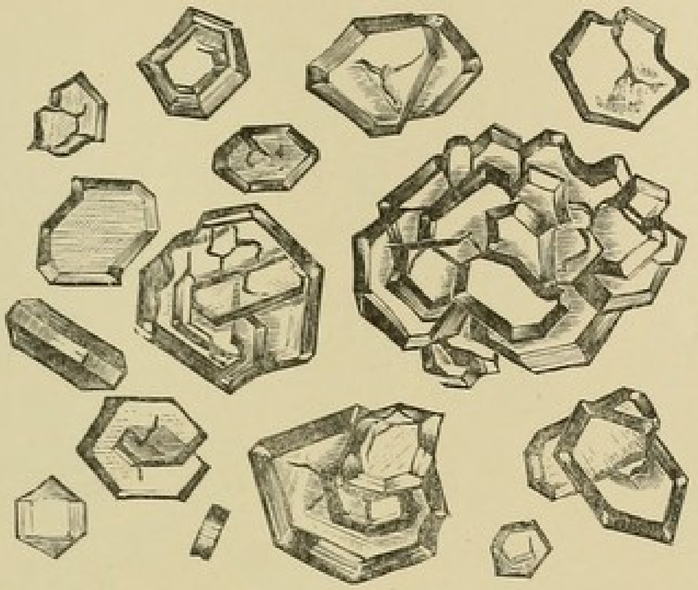
Hexagonal crystals of uric acid. This form occurs in urine very rarely × 130.

$\frac{1}{1000}$ of an inch ⌴ × 130.
" " ⌴ × 215.

[To follow PLATE XXVI.

URINARY DEPOSITS.

Fig. 153.

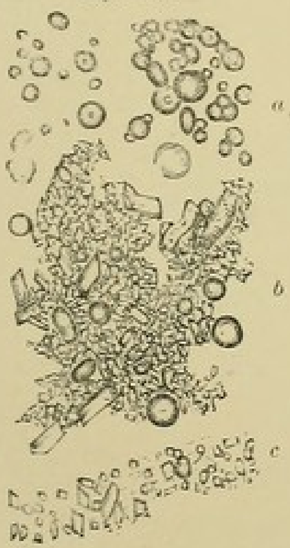


Perfectly colourless crystals of uric acid, resembling cystine. From the urine of an epileptic patient. Sent by Dr. Head. × 215.

Fig. 154.

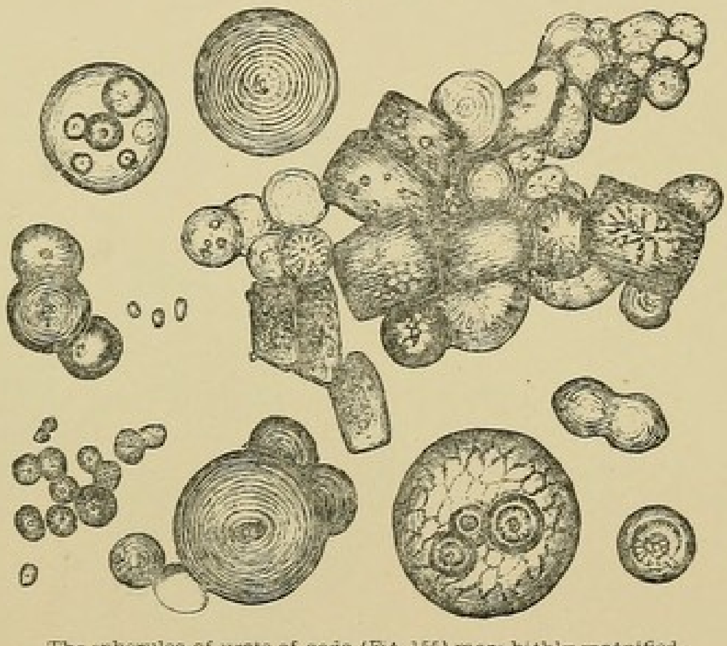
Small crystals of uric acid of a rhomboidal form; many of them resemble sections of small cylinders.

Fig. 155.



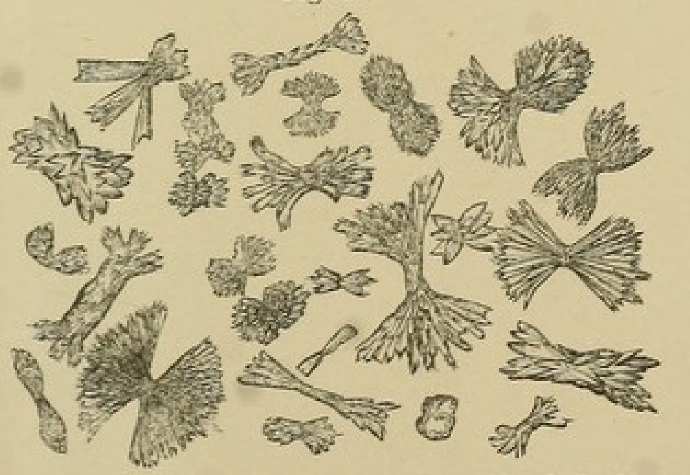
a, large spherules of urate of soda. *b*, film composed partly of urate of soda and partly of uric acid. *c*, uric acid. From the urine of a case of long-continued bilious and remittent fever. Sent by Dr. Kennion. × 42.

Fig. 156.



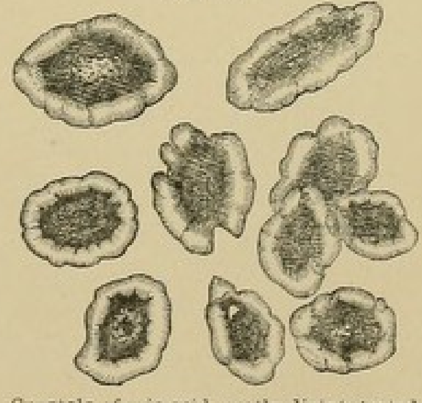
The spherules of urate of soda (Fig. 155) more highly magnified × 215.

Fig. 157.



Dumb-bell-like crystals of uric acid, obtained by adding hydrochloric acid to urine. Sent by T. W. Roper, Esq. × 215.

Fig. 158.



Crystals of uric acid, partly disintegrated. From a specimen which had been preserved for many years in the naphtha and creosote fluid. × 215.

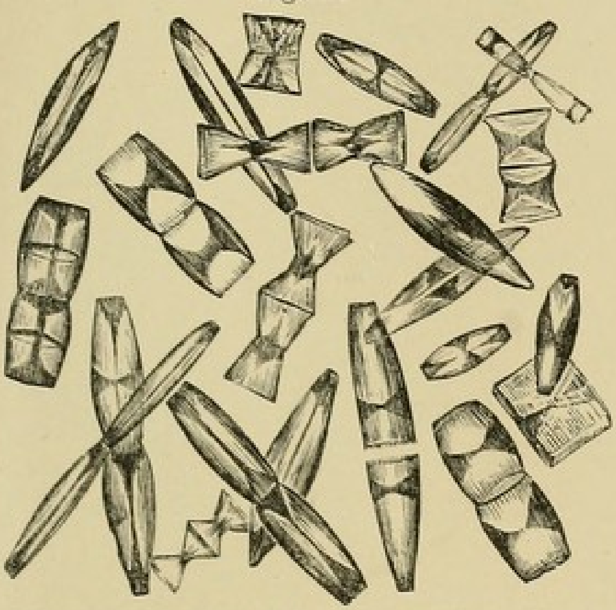
$\frac{1}{1000}$ of an inch ⌴ × 42.

" " ⌴ × 215.

[To follow PLATE XXVII.

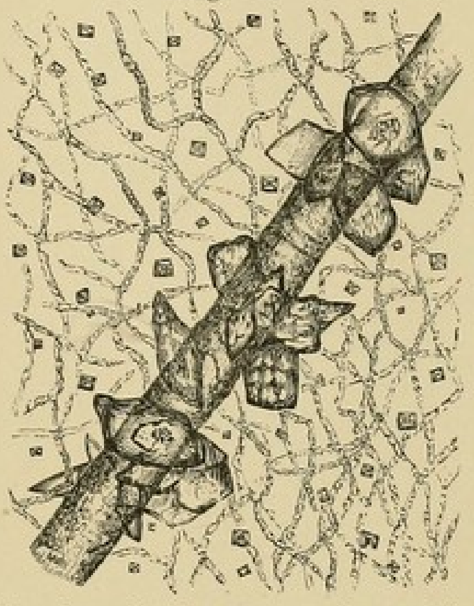
URINARY DEPOSITS.

Fig. 159.



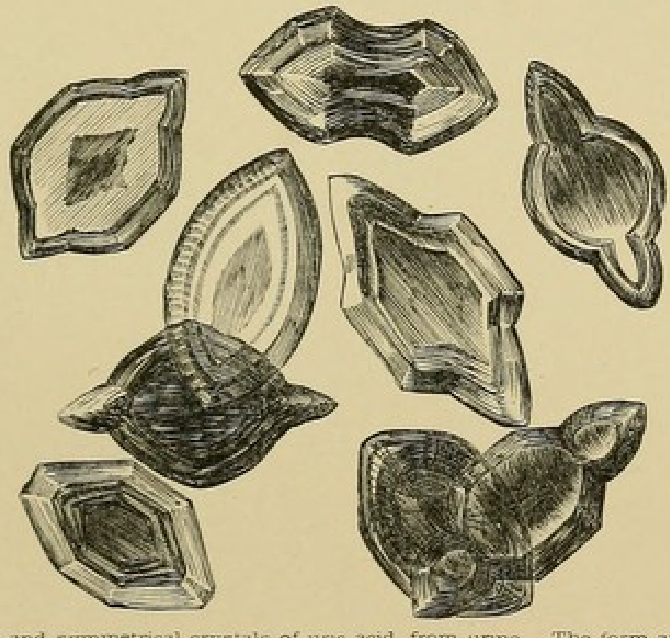
Curious crystals of uric acid. From a specimen of urine sent by Mr. Atchley. × 215.

Fig. 160.



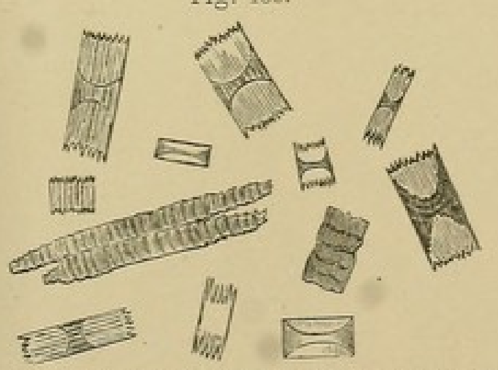
Uric acid crystallized round a hair; also octahedra of oxalate of lime, and penicillium glaucum. From the urine of a patient suffering from chronic bronchitis and emphysema. × 215.

Fig. 161.



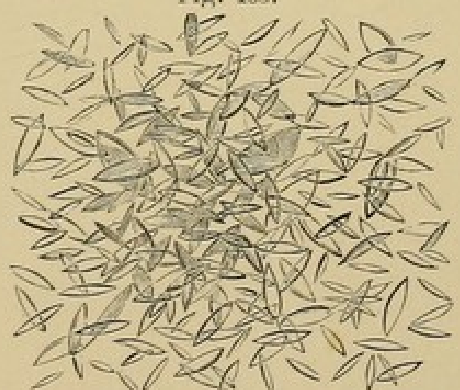
Very large and symmetrical crystals of uric acid, from urine. The form and peculiar markings of the crystals are well seen. × 215.

Fig. 162.



Forms of uric acid produced by rapid crystallization after the addition of nitric or hydrochloric acid to urine. × 215.

Fig. 163.



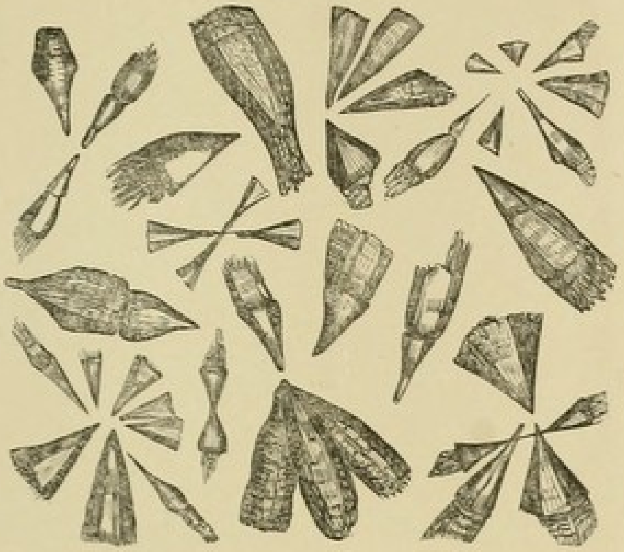
Small crystals of uric acid massed together so as to form a plate. × 215.

p. 372.

$\frac{1}{1000}$ of an inch ⌊___⌋ × 215.

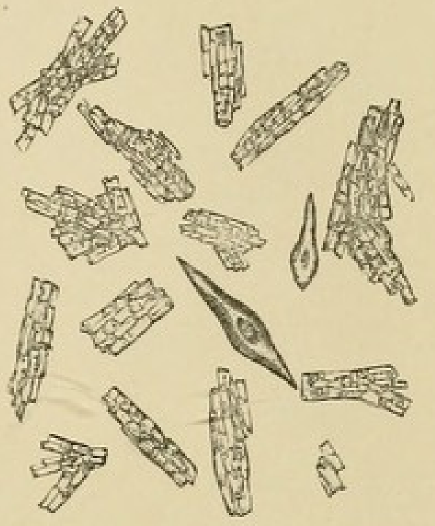
[To follow PLATE XXVIII.

Fig. 164.



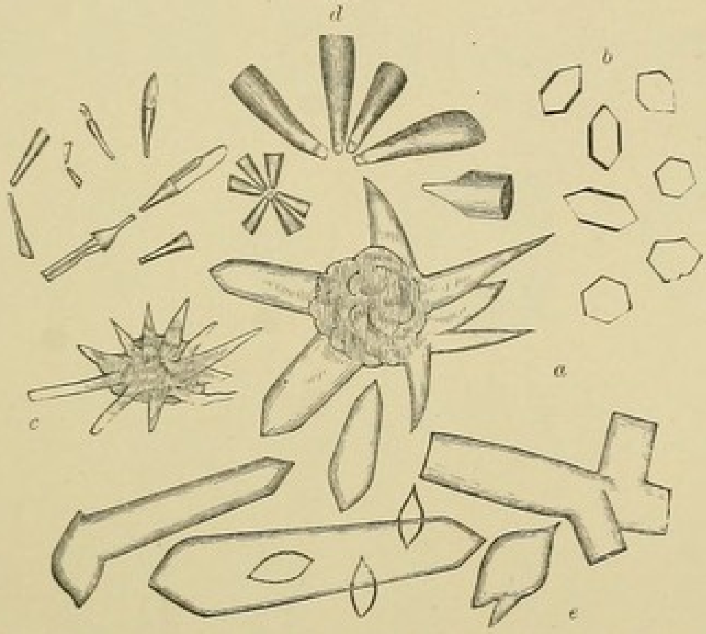
Quadrilateral pyramidal crystals of uric acid. Precipitated from urine by nitric acid. × 215. p. 371,

Fig. 165.



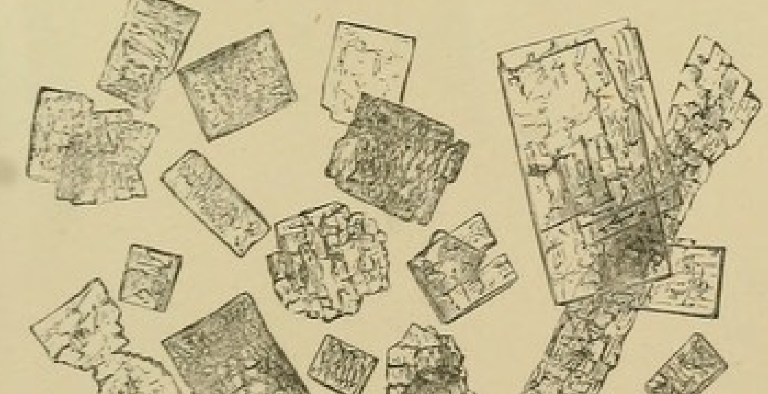
Uric acid from the urine of a case of fatty degeneration of the kidneys. × 45.

Fig. 166.



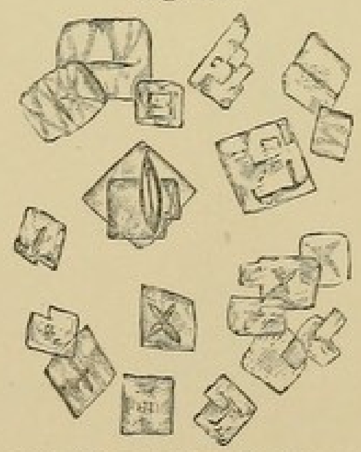
Less common forms of uric acid crystals. *a*, crystal like cayenne-pepper grain. *b*, six-sided crystals. *c*, mass with small uric acid crystals projecting from it. *d*, small pyramidal crystals of uric acid: very uncommon. *e*, peculiar forms of uric acid.

Fig. 167.



Irregularly shaped crystalline plates, consisting of uric acid. From urine. × 215.

Fig. 168.



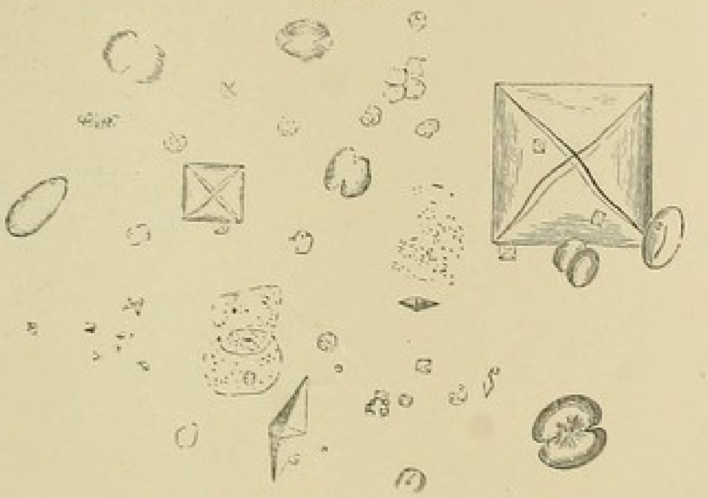
Two forms of uric acid. From a specimen of urine sent by Mr. Atchley × 45

$\frac{1}{1000}$ of an inch = × 42.

" " |___| × 215.

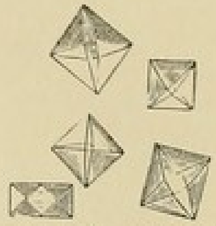
URINARY DEPOSITS.

Fig. 169.



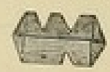
Dumb-bell and octahedral crystals of oxalate of lime. One very large octahedron is seen at the right-hand side of the figure. × 215. p. 378.

Fig. 170.



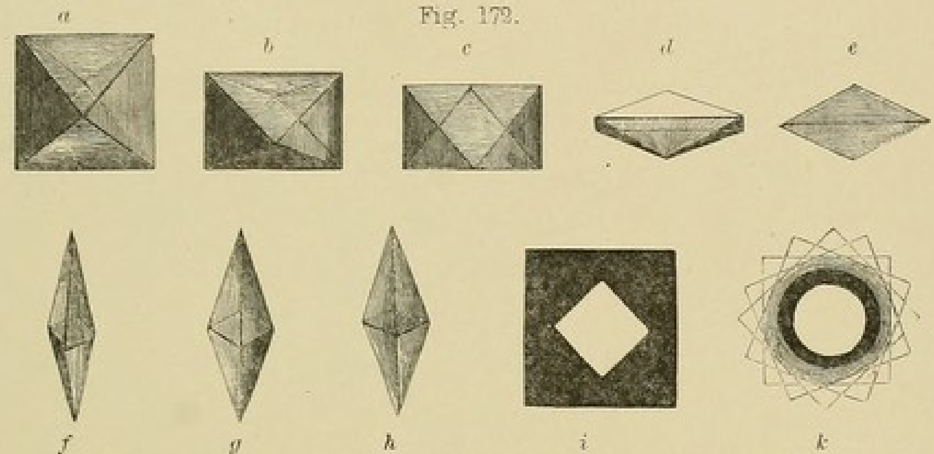
Octahedral crystals of oxalate of lime. × 215.

Fig. 171.



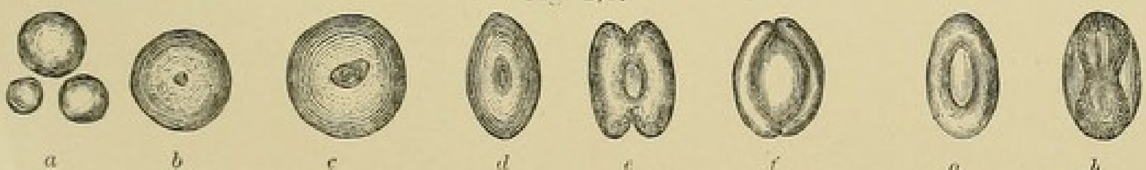
Curious prismatic crystal of oxalate of lime. p. 375.

Fig. 172.



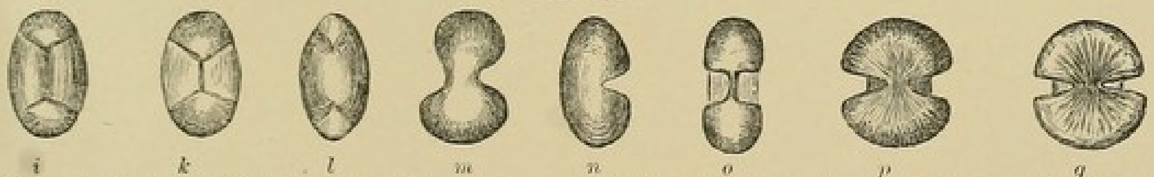
a, b, c, d, e, to illustrate the appearance of the same octahedron of oxalate of lime viewed in different positions. The crystal is supposed to be seen first lying upon one of its broad surfaces, and then gradually rotated FROM the observer until one edge is opposite the eye. *f, g, h*, the same crystal seen sideways, one of the lateral angles being towards the eye. *i*, the appearance of an octahedron when mounted as a dry object. *k*, unusual form of compound crystal of oxalate of lime. p. 375.

Fig. 173.



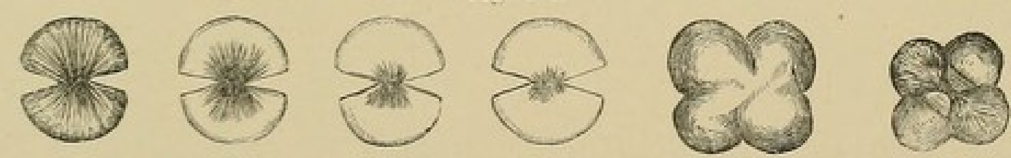
Circular and oval forms. p. 377. Dumb bell crystals and allied forms of oxalate of lime. p. 377.

Fig. 174.



Dumb-bell crystals and allied forms of oxalate of lime. Crystals approximating in form to the perfect dumb-bell.

Fig. 175.



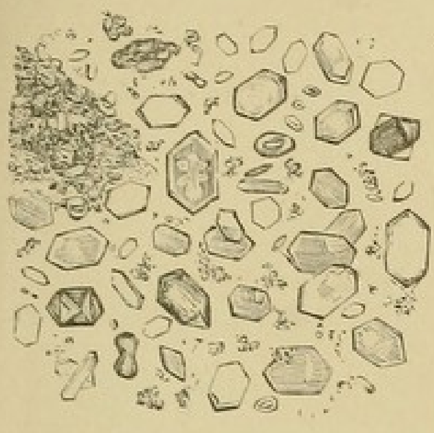
Perfect dumb-bell crystals of oxalate of lime which have been subjected to the prolonged action of weak acetic acid, by which much of the salt has been dissolved out from the organic matrix, which exhibits the appearance of a cell wall. p. 376.

Masses consisting of two dumb-bell crystals joined together.

$\frac{1}{1000}$ of an inch |____| × 215.

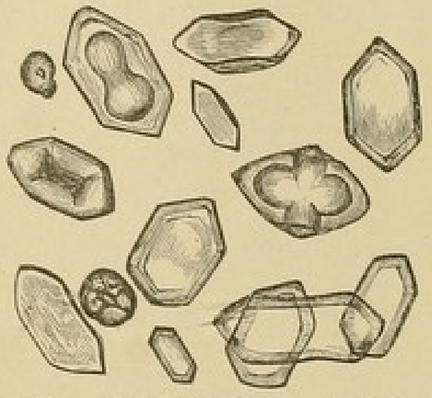
URINARY DEPOSITS.

Fig. 176.



Modified forms of oxalate of lime. From the urine of a man who was poisoned by oxalic acid. p. 382. × 215.

Fig. 177.

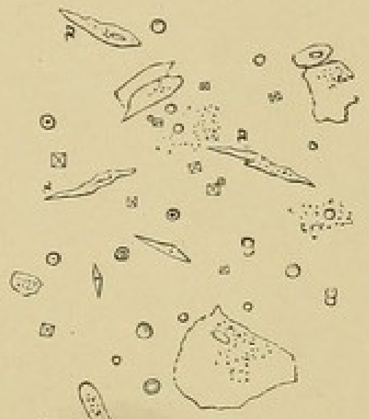


Some of the crystals in Fig. 176 magnified 550. p. 382.

Fig. 178.

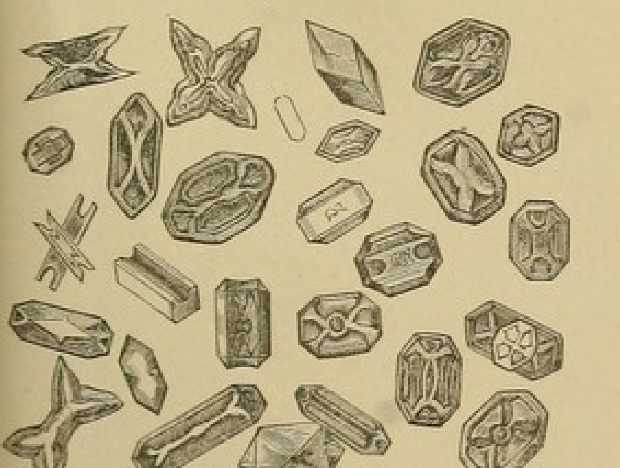
Beautiful feathery crystals of phosphates of lime and magnesia, with collections of octahedra of oxalate of lime, the angles of which are rounded. p. 380. × 215.

Fig. 179.



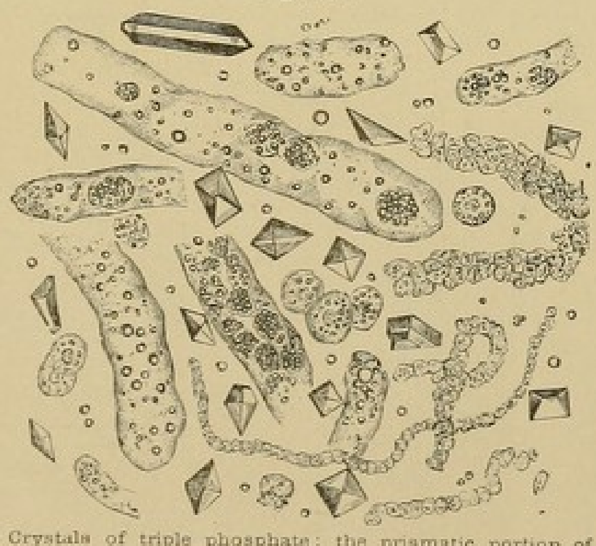
Small globules and octahedra of oxalate of lime.

Fig. 179*.



Beautiful crystals of triple phosphate, exhibiting peculiar markings resulting from partial solution. × 215.

Fig. 180.



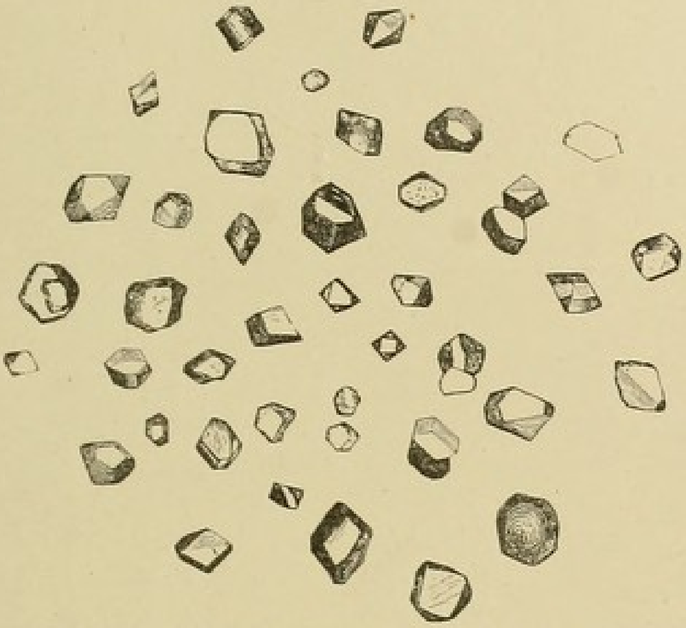
Crystals of triple phosphate; the prismatic portion of which is defective, and casts containing oil from the urine of a patient suffering from chronic nephritis, with partial fatty degeneration. p. 380.

$\frac{1}{1000}$ of an inch ⌊____⌋, × 215.

[To follow PLATE XXXI.

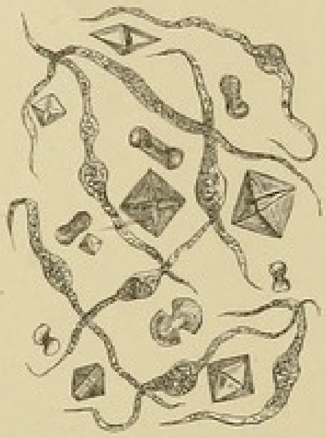
URINARY DEPOSITS.

Fig. 181.



Modified form of triple phosphate or phosphate of lime and triple phosphate. × 150. Sent by Mr. Richardson, of Dublin.

Fig. 181*.

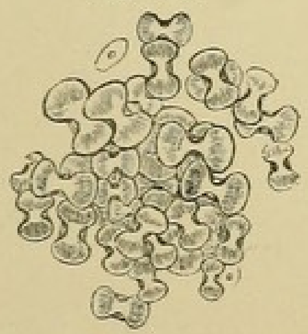


Octahedra and dumb-bells of oxalate of lime, and curious forms of fungi found in the urine of a young man passing much oxalate of lime. × 215.

Fig. 184.

Dumb-bells subjected to the prolonged action of acetic acid, showing the crystalline material nearly dissolved away. p. 377.

Fig. 182.

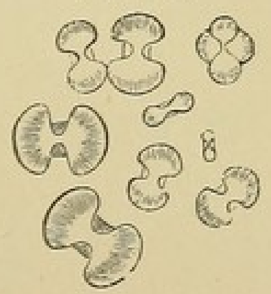


Collection of dumb-bells firmly adherent to each other. Such a mass might very easily become converted into a small calculus by deposition of material of a similar compo-ition in the intervals. p. 379 × 215.

Fig. 183.

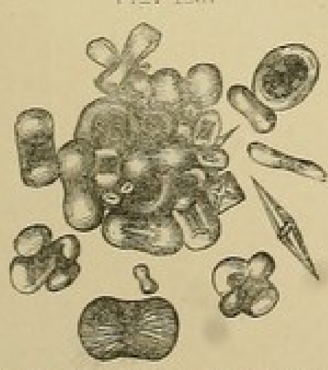
Minute crystals of oxalate of lime, with sporules of fungi resembling blood corpuscles. × 215.

Fig. 185.



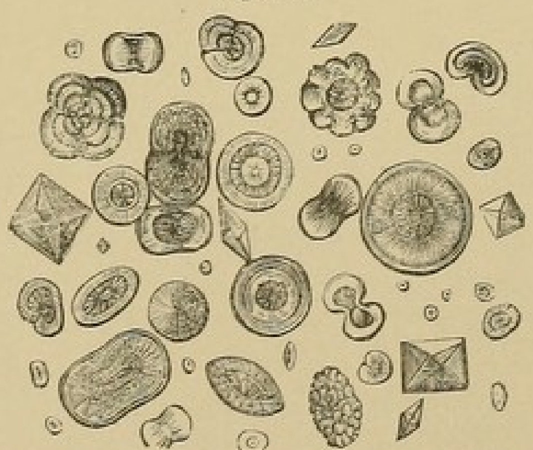
Perfect dumb-bell crystals from the urine of a child, two years old, suffering from jaundice. p. 379. × 215.

Fig. 186.



Dumb-bell crystals of oxalate of lime aggregated together, and forming a minute calculus. p 379. × 215.

Fig. 187.



Spherical, oval, and dumb-bell crystals of oxalate of lime, with larger spherules, which may be regarded as microscopic calculi. × 215.

$\frac{1}{1000}$ of an inch ⊢⊣ × 215.

[To follow PLATE XXXII.

ANALYSIS 87.

			In 100 grs. of solid matter.
	Water...	937·60	
	Solid matter ...	62·40	
	Urea	32·80	51·28
	Uric acid ...	·50	·80
	Extractive matter ...	12·90	20·67
Fixed salts, 16·00	Sulphuric acid	1·70	2·72
	Chloride of sodium	12·00	19·23
	Earthy phosphates	1·00	1·602
	Alkaline phosphates	2·50	4·00

The next specimens were received on January 28, 1858. No. 88 was passed on the morning of the 27th, at eight o'clock (before breakfast). Its specific gravity was 1,034.

ANALYSIS 88.

			In 100 grs. of solid matter.
	Water...	916·00	
	Solid matter ...	84·00	
	Cystine	·906	1·08
	Urea	49·00	58·33
	Extractives	16·94	19·52
Fixed salts, 17·6*	Chloride of sodium	9·30	11·07
	Sulphuric acid	4·50	5·35
	Earthy phosphates	·60	·71
	Alkaline phosphates	4·20	5·00

No. 89 was passed at 9 P.M. on the 26th, three hours after dinner. Specific gravity, 1,027.

ANALYSIS 89.

			In 100 grs. of solid matter.
	Water...	949·30	
	Solid matter ...	50·70	
	Cystine	Too little to estimate.	
	Urea	28·40	56·01
	Extractives...	1·30	2·76
Fixed salts, 19·6	Chloride of sodium	11·20	22·09
	Sulphuric acid	1·90	3·74
	Earthy phosphates	·60	1·18
	Alkaline phosphates	2·30	4·53

In these analyses it is interesting to notice that the sulphuric acid is by no means deficient; indeed, in the second, the amount present is considerably above the average quantity met with in healthy urine.

* In these analyses the fixed salts were estimated by incineration, while the sulphuric acid, phosphoric acid, and chloride of sodium, were estimated volumetrically. The slight discrepancy in the numbers arises partly from the volatilisation of some of the saline constituents during incineration, and partly from slight errors in the analyses, unavoidable when only small quantities are operated on.

The proportion of cystine was really very small, although it occupied a considerable bulk; so that the opinion commonly entertained with reference to cystine being a compound in which the sulphur is removed from the organism in an unoxidised state, in consequence of the oxidising processes being in a low condition, will not, therefore, explain its formation in the present instance, as the analyses prove that a much larger quantity of sulphur passed off as sulphuric acid than in a state of combination in the form of cystine. It is interesting to notice the large proportion of sulphuric acid present when the cystine existed in sufficient amount to be determined quantitatively (Analysis 88).

Of Cystine clinically, and of the Treatment of Cases in which Deposits occur.—Cystine has been met with in several different conditions of the system, but in most of the recorded cases the patients have been in a low weak state of health. Little is known with reference to the origin of this substance. It has been supposed to result from hepatic derangement, and Scherer and Virchow have detected cystine in the liver in disease. It is curious that cystine deposits occur in families, and even appear to be hereditary. Dr. Golding Bird speaks of an instance of its occurrence in three successive generations.

My friend, Mr. T. Pridgin Teale, of Leeds, sent me in April, 1868, some cystine crystals from the urine of a boy, age 17, who had also passed some cystine gravel. Mr. Teale gives the following very remarkable facts concerning this case:—

"One older brother, when a child, was cut for stone by my father, and a cystic oxide calculus was removed, the only one we possess in Leeds. Two or three years later the same boy was cut again, and a uric acid stone was removed. This boy died a year or two afterwards. Three years ago another brother, aged about 20, began to be ailing, being low in nervous power and energy, with headaches, and unfit for work. I found cystine crystals in his urine over a space of two or three months. He is now in good health; but I have not recently examined his urine.

"The present patient, aged 17, after a chill suffered frequent acute pain over the left kidney for several weeks, which ceased eventually after the passage of cystic oxide gravel. He was excessively prostrate, and very pale during this time, but had a good appetite. He is now well, free from pain, less pale; in the urine no gravel, but cystine crystals."

There are no special indications for the treatment of patients passing cystine, and I have nothing to add to the remarks made by Dr. Prout and Dr. Golding Bird. Iron and the dilute mineral acids should be given, and every effort made to improve the general health. The importance of good air, freedom from mental anxiety and fatigue, must be impressed upon the patient.

Carbonate of Lime occurs occasionally in the crystalline form in human urine; its microscopical characters are somewhat similar to those of the carbonate of lime which is constantly present in the urine of horses and other herbivora; but the spherules are smaller and more delicate. From the drawings given, it would seem that the slender crystals of which the globular mass is composed are not arranged so compactly together as in the case of the salt so common in horses' urine. In highly alkaline urine, in which the alkalescence is caused by carbonate of ammonia set free by decomposition of urea, carbonate of lime occurs in small quantity, but in an amorphous form. This is the only form in which I have yet seen carbonate of lime in human urine. Carbonate of lime may be recognised by the effervescence produced upon the addition of a drop of acetic acid to the deposit suspected to contain it, care being taken that the sediment be well washed with distilled water before adding the acid, in order to remove any soluble carbonate that may be present.

Urinary calculi containing carbonate of lime have been met with, but they are not common. Mr. Hitchings, of Oxford, has removed two or three, which are deposited in the Oxford Museum.

Chalk or marble is occasionally added to urine for the purpose of deceiving us. The presence of these substances is easily recognised by the action of acid, and by their being insoluble in water.

Silica, or Silicic Acid ($Si\ O_3$)—Sand.—It is asserted that silica sometimes forms a constituent of calculi. Berzelius long ago showed its presence in minute quantity in the ash of human urine; but it has never been met with as a deposit in this secretion, unless placed there in the form of sand, for the purpose of imposing upon us. I have received the urine of a hysterical girl for examination, containing nearly a fourth of its bulk of common house sand. In this quantity we could hardly fail to detect its composition; but the presence of a few grains might possibly give rise to some little difficulty in urine. Their nature, however, would be determined by treating them with boiling nitric acid, in which they are quite insoluble. Under the microscope they appear as crystalline particles of a very irregular form. Their hardness and insolubility distinguish them from uric acid.

Blood Corpuscles usually form a red or brownish-red granular deposit, which sinks to the bottom of the vessel; but a few corpuscles are usually diffused through the urine. If the urine be perfectly neutral, or slightly alkaline in its reaction, the colour of the globules will be bright red; but in those instances in which the reaction is decidedly acid, the globules will be found of a brown colour, imparting to the supernatant fluid a "smoky" hue. When the urine has a decidedly "*smoky appearance*," it will generally be found that the blood is derived from the kidney. If, however, the urine is decidedly alkaline, the blood will retain its florid red colour. In the majority of cases in which the mixture of blood and urine is bright red, it is probable that it has escaped from the mucous membrane of the bladder, or from the prostate, or urethra. If blood globules remain long in urine, they become much altered in form, the outline appearing irregular and ragged, and the surface granular. Sometimes, however, they appear swollen and very much enlarged. These changes are no doubt due to physical actions. The characters of blood corpuscles are represented in pl. XXXIV, fig. 194. The corpuscles represented at *a*, *b*, *c*, have been taken from the living body; those at *d*, *e*, *f*, from the urine; the corpuscles, *d*, are smaller than natural; at *e*, their circumference is serrate and ragged; and at *f*, a somewhat similar appearance is shown.

If blood remains for some time stagnant in the uriniferous tubes, or in the capillary vessels, before it passes into the urine, crystals of hæmatoidin are often found, pl. XXXV, figs. 201, 202. From five days to two weeks probably elapse before the crystals in question result.

Chemical Characters of Urine containing Blood.—Urine containing blood corpuscles must also contain serum; but the quantity of this fluid in many cases is very small, although numerous blood corpuscles are to be discovered by microscopical examination. If there be much blood, the albumen of the serum is readily detected by the ordinary reagents. *See* p. 221.

Of Blood in the Urine clinically.—Blood in the urine may be derived from any part of the genito-urinary mucous membrane. In the female, it often escapes from the vessels of the uterus or vagina. It is, of course, always met with in the urine of the female at the catamenial periods, pl. XXXIV, fig. 200.

Blood may come from the kidney, in consequence of recent inflammation or old-standing disease, leading to congestion and subsequent rupture of the vessels of the Malpighian body, or its escape may depend upon that peculiar condition of system in which there is a tendency to capillary hæmorrhage in all parts of the body.

When blood corpuscles are found entangled in casts, we may feel almost certain that they have escaped from capillary vessels in the cortical or secreting portion of the kidney, and generally from the vessels of the Malpighian body. In these cases, the urine is usually acid, and exhibits the well-known 'smoky' appearance. This remarkable change in colour is due to the action of the acid of the urine upon the hæmato-crystallin of the blood.

Hæmorrhage from the kidney also occurs in the course of many forms of chronic disease. In such instances it is a favourable sign if the albumen is not to be detected after we have failed upon microscopical examination, to find blood corpuscles. If the albumen, however, continues to be passed, we may feel sure that it has not been solely derived from the serum which escaped with the corpuscles through the ruptured capillary vessels, but its presence must be attributed to chronic renal disease.

When the kidney is injured by mechanical violence, hæmorrhage occurs, and sometimes a violent shake appears sufficient to cause the rupture of some of the small vessels of the kidney, and the escape of a considerable quantity of blood in the urine. A gentleman of my acquaintance fell against a step, and his side and back came violently in contact with the edge. Much blood soon made its appearance in his water, and for several days the hæmorrhage was severe. After the lapse of a fortnight the urine still contained an abundant brownish deposit, in which a few altered blood corpuscles with numerous crystals of hæmatoidin were found, pl. XXXV, fig. 202. The blood effused in some of the tubes had probably remained in them sufficient time for the crystals to be formed from the blood-colouring matter. I have seen similar crystals in sputum sometime after hæmoptysis; in the fluid outside hydatids of the liver, which sometimes escapes with the sputum; and oftentimes in clots in the brain two or three weeks after rupture of the vessel.

Hæmorrhage from the kidney and bladder always occurs sooner or later in the course of cancer of these organs. The diagnosis is often very difficult, as there may be no pain and a complete absence of any definite symptoms. The persistence of the hæmorrhage, its occasional increase in amount, the gradual emaciation of the patient, will lead the practitioner to suspect the real nature of the malady, and not unfrequently the detection of cancer cells in the urine proves beyond doubt the nature of the case. Fungus of the kidney or bladder is almost invariably accompanied by hæmorrhage which is sometimes very violent, and soon exhausts the patient.

Hæmorrhage from the prostate may be a very serious affection, and is one of the first symptoms of structural disease of that organ. Occasionally the veins of the gland become dilated and varicose, and at length rupture. The attack may last a few weeks and then pass off, or it may continue in spite of all treatment, until the patient's strength becomes exhausted.

Hæmaturia may depend upon a calculus being impacted in the kidney, in which case it may continue for a day or two, and then cease entirely for some time. In many cases it recurs constantly after unusual exertion.

Hæmorrhage from calculus in the bladder is often very considerable, and occasionally persists uninterruptedly for days or weeks, but more commonly it lasts only for a few days, and recurs after an interval. The patient should of course be carefully sounded.

Simple hæmorrhage, not dependent upon organic disease, sometimes takes place from the mucous membrane of the bladder, as well as from other mucous membranes, as that of the nose, throat, lungs, stomach, &c. ; but it must never be forgotten that slight hæmorrhage is often the very first symptom of that terrible malady, cancer of the bladder, and the practitioner should, therefore, in a doubtful case, always give a very guarded opinion.

Small quantities of blood are sometimes passed day after day by apparently healthy persons just as micturition ceases. It seems as if the effort to expel the last drop of urine had caused the rupture of a few capillaries about the membranous part of the urethra or neck of the bladder. The hæmorrhage usually ceases after a time if the patient rests. Usually no special treatment is necessary, but it may be desirable to give a saline purge. In some of the cases which have fallen under my notice, the bleeding was certainly caused by undue sexual indulgence.

Blood Clots assume various forms, and if they have been retained for many days in the bladder, undergo great changes in colour and form, so that there may be considerable difficulty in identifying them. They have been mistaken for portions of mucous membrane, entozoa, and other things, pl. XXXV, fig. 206.

Hæmaturia is occasionally due to entozoa in some part of the renal tract, but this is, perhaps, the rarest cause of hæmorrhage, in this country, although it is a common cause at the Cape and in Egypt. *See* p. 401.

Brown Deposit in Urine resembling Blood.—It not unfrequently happens that the urine contains a red-brown and bulky deposit much resembling blood in its general appearance, but upon microscopical examination not a blood corpuscle is to be found, and the deposit is seen to consist entirely of brown granular matter. The cases in which this deposit occurs have been regarded as examples of '*intermittent hæmaturia*,' but as there is neither blood nor blood corpuscles, the term is not suitable. The urine may contain a decided proportion or the merest trace of albumen. The older observers invariably called this deposit, blood, from its colour, and for the same reason it has been generally concluded that it was derived from the blood. Although this is its probable origin it has not been rendered certain that such is the case. The fact that the colouring matter has been detected in the cells of renal epithelium must not be lost sight of. The peculiar colouring matter in question may be actually found in the secreting organ and thus its ultimate relation with a large excess of urates would receive explanation. These cases are quite distinct from those in which the colouring matter of the red blood corpuscles is dissolved and excreted in a soluble form, as occurs at the course of exhaustive fevers, &c.

Of the Treatment of Hæmaturia.—If the blood present in the urine has escaped from the kidney in consequence of acute congestion or inflammation, as may generally be determined by the sudden accession of the symptoms—the small quantity of the urine, the presence of casts, a considerable quantity of albumen, associated with puffiness about the face, and perhaps lumbar pain—the case must be treated by rest, purgation, sweating, and, in bad cases, the patient should be cupped over the loins. *See* p. 81 *et seq.*

If the escape of the blood from the kidney is due to a low state of health, or to a condition of system allied to that which gives rise to purpura, the treatment must be directed to improving the general health and the action of the stomach; tonics, the tincture of perchloride of iron or gallic acid, may be given; quinine, dilute acids, and pepsin, also do good. If hæmaturia occurs in the course of a case of scurvy, the scurvy, not the hæmaturia, must so to say, be treated; lemon or lime juice, as generally given in this disease, will be of essential service.

In cases where the hæmorrhage depends upon renal calculus, rest in the recumbent posture must be enjoined, and the patient must take a warm bath, or warm fomentations may be applied. Small doses of opium by the mouth, and a suppository in the rectum often affords relief. *See* p. 431.

Hæmorrhage from the kidney is not uncommon in cases of continued fever. Sometimes it occurs in the course of pneumonia; and I have seen it in several cases of acute rheumatism. In all these conditions the vessels of the kidneys and internal organs generally are highly congested. The symptom generally passes off after a few days, but in one case of acute rheumatism it persisted for three weeks, producing an anæmic condition; cupping over the loins and several remedies were tried, but did not seem to produce any immediate effect upon the hæmorrhage, which, however, gradually subsided as the patient improved in health. Turpentine in this as well as in many other forms of hæmorrhage seems to do good in some cases. Acetate of lead in doses of three or four grains every three hours, for five or six doses, often checks hæmorrhage. This remedy was much employed by Dr. Golding Bird. It is of course very important not to continue giving lead for any length of time, and it should be borne in mind that some persons are more susceptible to its influence than others. If the blue line should appear near the free edge of the gums, the lead must be stopped and its elimination promoted by purgatives and sudorifics. *Gallic acid* is one of the most powerful remedies in hæmorrhage from the kidneys or bladder. It may be given in much larger doses than is usually recommended. I have given from ten grains to half a drachm five or six times in the twenty-four hours in many cases. Ergot of rye, alum, matico, and other styptics may be tried in obstinate cases.

In some very severe cases of hæmaturia depending on renal disease great advantage has resulted from the administration of the tincture of perchloride of iron. In this as in many other forms of disease, more relief may be afforded by improving the state of the blood than by giving remedies supposed to affect directly the particular action at fault. I have seen patients suffering from chronic renal disease completely blanched by renal hæmorrhage who have improved immediately after they had been put upon a more generous diet, and the digestive powers had been increased by the administration of hydrochloric acid, quinine, and pepsine.

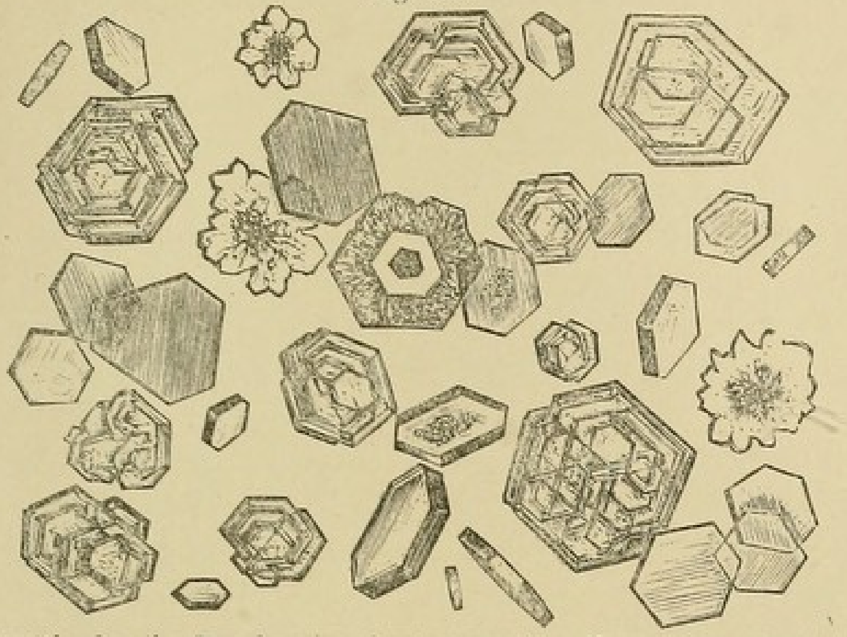
In hæmorrhage depending upon cancer of the kidney or bladder the treatment is necessarily only palliative. Gallic acid, opium, and complete rest sometimes afford great temporary relief. If in such a case the hæmorrhage is dangerous from its excessive amount, ice should be applied to the pubis, and styptics may be injected into the bladder.

Hæmorrhage from the kidney which results from a blow, fall, or other injury, often ceases if the patient remains perfectly quiet for a few days. It is doubtful if recovery can take place after very decided laceration of the kidney, but it is probable that in many instances some of the delicate capillaries may be ruptured without the secreting structure being actually torn through.

In that obstinate and distressing hæmorrhage from the prostate, the patient should remain in the recumbent posture with the pelvis raised on a pillow to favour the gravitation of blood from the gland, and kept as quiet as possible. Iron, gallic acid, turpentine, or other styptics may be tried, but they often fail to afford relief. Sometimes small pieces of ice placed in the rectum diminish the hæmorrhage. In such cases, if we are sure of the absence of stone, and there is no other positive indication for its use, it is desirable to avoid introducing the catheter, for the operation frequently increases the hæmorrhage and adds to the distress the patient already suffers. In cases in which the blood has coagulated within the bladder and especially if the hæmorrhage continues, the practice of introducing an instrument to break up the clot, and the injection of iced water has been recommended. Dr. Prout injected into the bladder a solution of alum (20 to 40 grains in a pint of water) and says that by this proceeding he succeeded in stopping violent hæmorrhage from the bladder which had resisted other methods.

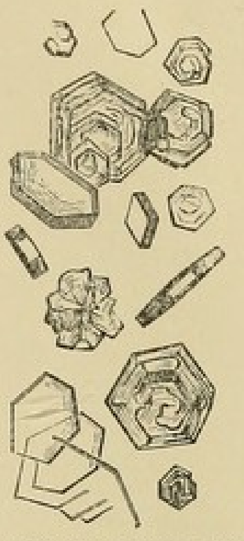
Intermittent Hæmaturia.—Cases of the so-called intermittent hæmaturia often improve under large doses of quinine, but some do not seem to derive advantage from any plan of treatment yet tried. The condition is probably often connected with gout, and sometimes with ague, and although it may last a year or two, it generally passes off. *See* a paper by me in No. 2 of the 'Practitioner,' p. 73, July 1868. I have

Fig. 188.



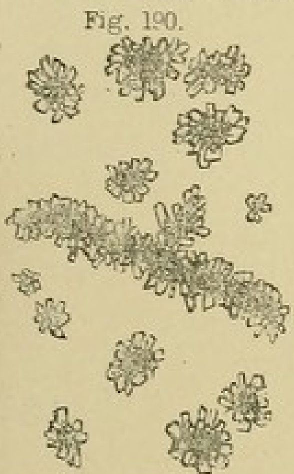
Crystals of cystine from the urine of an insane patient. Numerous crystals of uric acid were also present in the deposit. p. 383. × 215

Fig. 189.



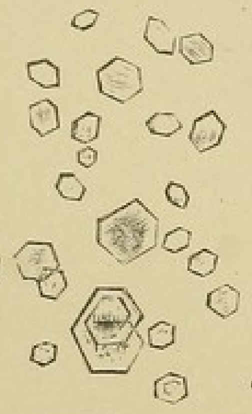
Crystals of cystine. p. 383. × 215.

Fig. 190.



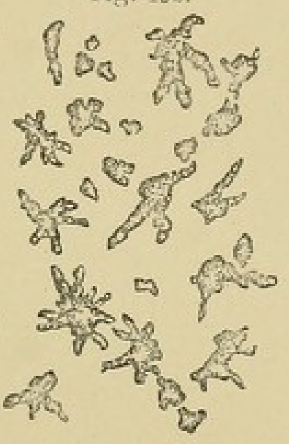
Clusters of crystals of cystine, formed by evaporating a solution of the crystals represented in Fig. 188 in ammonia. × 215.

Fig. 191.



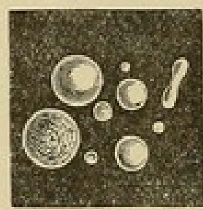
Six-sided crystals of cystine, formed from a solution of the crystals in ammonia.

Fig. 192.



Irregularly formed crystals of cystine, formed by allowing the ammoniacal solution (Figs. 190, 191) to evaporate to dryness. × 215.

Fig. 193.

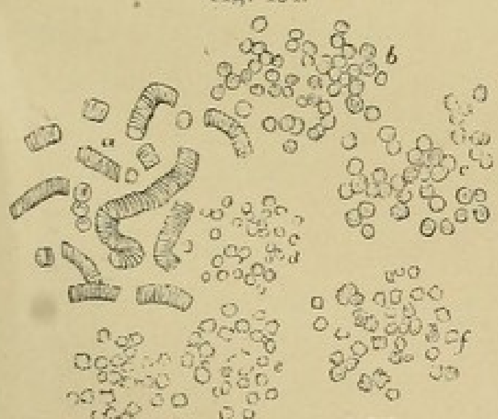


Crystals of carbonate of lime, seen by reflected light. p. 387.

Fig. 196.

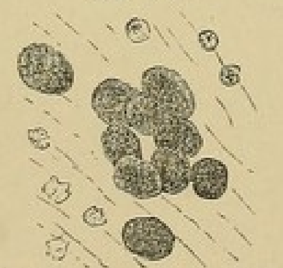
Crystals of carbonate of lime, in Canada balsam; seen by transmitted light. p. 387.

Fig. 194.



Blood corpuscles, *a*, *b*, *c*, taken from the living body; *d*, *e*, *f*, from the urine. *d*, corpuscles smaller than natural; at *e* their circumference is serrate and ragged; and at *f* a somewhat similar appearance is shown. p. 388.

Fig. 195.

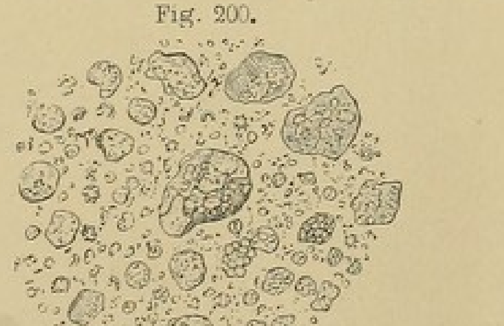


Large cells filled with granular matter; chronic bronchitis. p. 395.

Fig. 199.

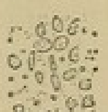
Epithelium from the uriniferous tubes and pelvis of the kidney, with granules of colouring matter embedded in them. p. 390. × 215.

Fig. 200.



Altered blood from retained menstrual secretion. p. 388.

Fig. 197.



Tubercle corpuscles from a tubercle in the lung. p. 394. × 215.

Fig. 198.

Cells found in the urine of a case of renal dropsy. p. 395.

never had an opportunity of examining the kidneys of a patient who died whilst suffering from this affection.

Circular Sporules closely resembling Blood Corpuscles.—Occasionally the sporules of fungi are found in urine which very closely resemble blood corpuscles in size, and also in their general appearance. ("Archives of Medicine," vol. II, p. 49.) Upon very careful examination, however, with a high power, a little eminence, which is the first commencement of the formation of a new sporule from the parent, may frequently be observed projecting from them. Not unfrequently two sporules may be seen together, one having grown from the other. Some round sporules, resembling blood corpuscles, are represented in pl. XXXIII, fig. 183. They vary in size more than blood corpuscles. Some time since I received a specimen of urine from a friend which contained numerous bodies of this kind; and the resemblance to blood corpuscles was so great that, had I examined the specimen carelessly, I should certainly have considered them to be of this nature. By using a power of seven hundred diameters, however, the true nature of the bodies was distinctly made out. In these cases albumen, due to the existence of kidney disease, may be found in small quantity, which would complicate the case, and increase the chance of our being led to form a wrong conclusion. When doubt exists, the deposit should be set aside for a few days, exposed to the air in a warm place. The spores will germinate, and all doubt as to their nature will be set at rest.

Bodies rarely met with in Urinary Deposits, and Substances the nature of which is doubtful.

Under this head I shall include tubercle and cancer, and a few bodies of the nature of which I am not perfectly certain. Some of these substances have been carefully examined by other observers, but the results have not been sufficiently satisfactory to justify positive statements as to their nature.

Cancer Cells.—In cases of cancer of the bladder it is not uncommon to meet with well-defined cancer cells in the urine. Some time since, Sir William Fergusson requested me to examine for him a small portion of gelatinous-looking matter, which had been passed by a patient suffering from disease of the bladder. Of the exact nature of this matter there had been some difference of opinion. Upon treating a fragment of it with a little glycerine and water, and subjecting it to examination with a power of two hundred diameters, I had no difficulty in making out loops of capillary vessels covered with a thick layer of cancer cells. The specimen presented the usual appearances which distinguish a cancerous tumour rapidly growing into a hollow viscus, and was evidently one of the tongue-like or villous processes, broken off from the mass. There could, therefore, be no further doubt as to the exact nature of the case.

The diagnosis was confirmed by subsequent examination of the parts after the patient's death.

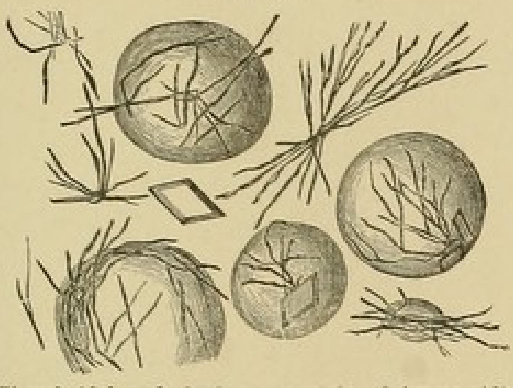
I have seen several cases of cancer of the bladder in which the disease was detected for the first time by the microscopical examination of the urine. In most of these there was an abundant deposit of a dark brown colour, much resembling blood in appearance when it occurs in acid urine. This brown deposit was found to consist principally of a vast number of cancer "cells," varying greatly in form and size, most of them being very large. Many were of considerable length, and contained "cells" in two or three different places. These so-called "cells" consist, in fact, of a soft material corresponding to the wall of a normal epithelial cell, in which masses of germinal matter are embedded in considerable number. A very good specimen of cancer cells from the bladder is represented in pl. XXXV, fig. 204; and in fig. 63, pl. VIII, a young cell of normal bladder epithelium is seen, which is undergoing division. The cancer cells multiply in the same way, but faster and much more irregularly, instead of succeeding one another in an orderly manner, layer after layer.

From time to time specimens of urine are sent for examination, containing numerous well-defined spindle-shaped cells, which, from their general resemblance to the cells of scirrhus, have been supposed to indicate the existence of this terrible malady in connection with the kidney or bladder. But it must be borne in mind that such cells may have been derived from the ureter, bladder, or urethra, and their presence may be therefore quite unconnected with disease. *See* "Illustrations of Structure of the Kidney," pl. III, figs. 9, 10, 11, "Illustrations of Urinary Deposits," pl. VIII, figs. 57, 58. Epithelium of the ureter, and some cells derived from certain parts of the mucous membrane of the bladder and urethra, very closely resemble in form and general appearance the drawings which are given of the cells of hard cancer.

Tubercle Corpuscles.—Tubercle is occasionally met with in urinary deposits. Dr. Thudichum ("The Pathology of the Urine," p. 265), alludes to a remarkable and undoubted case which he saw in the Brompton Hospital. It is often very difficult to identify tubercular matter in sputum; and in many cases where the deposit escaped in the urine the disintegration of the tubercular matter would be so great as to interfere with its detection, pl. XXXIV, fig. 197. For the characters of tubercle *see* "The Microscope in its Application to Practical Medicine," 3rd edition.

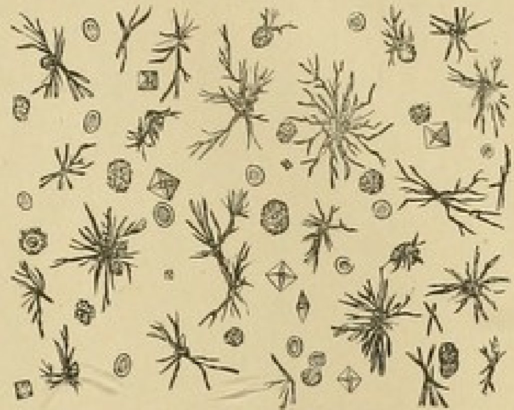
Of the Clinical Importance of Cancer and Tubercle in the Urine, and of the Treatment of these Cases.—The presence of cancer cells in the urine, it need scarcely be said, is positive evidence of cancer of the bladder. This disease must be fatal sooner or later, and we can never give much hope of a favourable termination. In my experience the

Fig. 201.



Rhomboidal and feathery crystals of hæmatoidin, from a softened clot. Human. p. 389. × 215.

Fig. 202.

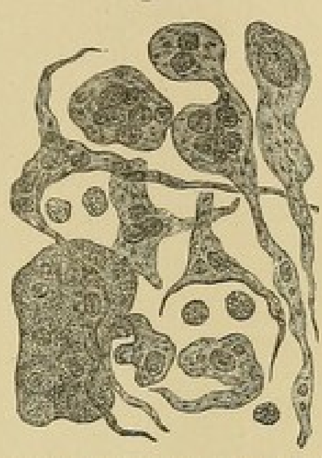


Feathery crystals of hæmatoidin, found in the urine a fortnight after slight rupture (?) of one kidney. Human subject. p. 389. × 215.

Fig. 203.

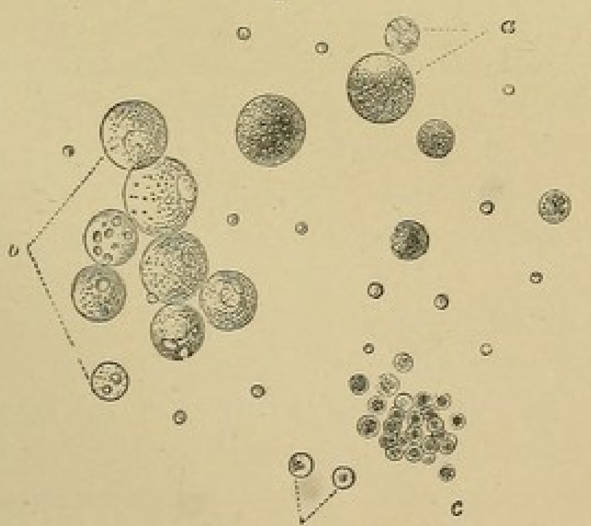
Cancer cells from the urine in a very bad case of cancer of the uterus. The deposit was very abundant. p. 394.

Fig. 204.



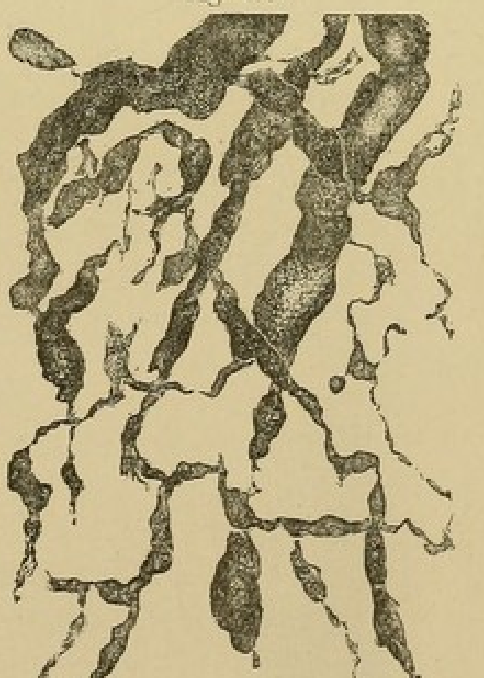
Cancer cells found in urine. From the bladder. p. 394.

Fig. 205.



Cells from the urine of a case of acute rheumatism. *a*, in the natural state. *b*, treated with acetic acid. *c*, resembling pus. *d*, the same treated with acetic acid. The small circular bodies are blood corpuscles. p. 395.

Fig. 206.



Blood clots in the form of irregularly shaped cords. From the vagina, found in urine. p. 390. × 215.

$\frac{1}{1000}$ of an inch |___| × 215.

All these figures × 215.

[To face page 391.

suffering is far less in those cases in which a large quantity of the cellular growth forms upon the surface of the mucous membrane, small masses becoming detached from time to time, than when the muscular coat of the bladder is the chief seat of disease. I have known cases of the former disease in which there was scarcely any suffering, the patients dying in from two to three years after the cells were first found in the urine, from the gradual exhaustion caused by the hæmorrhage which sometimes takes place daily and never entirely ceases. The object of treatment is simply palliative. Tincture of the perchloride of iron or gallic acid will sometimes alleviate the hæmorrhage when very bad. In treating these cases, we must endeavour to keep the urine in as healthy a condition as possible, for if it be either very acid or alkaline the patient's suffering will be increased. If the pain or irritability of the bladder should become excessive, opium should be cautiously given, sometimes by the mouth, and sometimes a suppository may be placed in the rectum.

Spherical Bodies containing Nuclei and Granular Matter.—Round cell-like bodies are sometimes met with in specimens of urine, the nature of which is obscure. I have not been able to determine with accuracy the portion of the mucous tract from which some of these bodies are derived, or their pathological importance. The cells represented in pl. XXXIV, fig. 205, were found in the urine of a patient suffering from rheumatic fever. *a*, in the natural state; *b*, treated with acetic acid; *c*, cells resembling pus; *d*, the same treated with acetic acid. The small circular bodies are no doubt altered blood corpuscles. × 215. The large cells contained several transparent bodies within them, which became very distinct upon the addition of acetic acid (nuclei?). The central bodies did not refract like oil globules, nor did they present the circular, dark, and well-defined outline so characteristic of these. They are probably altered cells from the bladder.

Cells presenting somewhat similar characters have come under my notice in several other cases; and from that portion of the mucous surface of the bladder known as the trigone, I have obtained cells agreeing with some of them in general characters. It is not unreasonable, therefore, to assume that many of these peculiar cells are accidental modifications of bladder epithelium.

In fig. 195, pl. XXXIV are represented specimens of large cells filled with dark granular matter, but not containing any oil particles, from the urine of a case of chronic bronchitis. There were also a few pus globules present in this specimen. Fig. 198 represents a curious cell found in the urine of a case of renal dropsy of seven weeks' duration. Casts of medium diameter, with a few small cells containing oil, were also present in the same specimen of urine. Of the nature of these bodies I am not certain, neither have I been able to ascertain from what part of the genito-urinary mucous membrane they have been derived. Every care was taken to prevent the presence of matters of extraneous origin; but it is very likely that some of the cells figured have been derived from sputum which had passed into the urine and had been altered by the action of the urine.

Small Organic Globules.—Under this name, Dr. Golding Bird has described some little bodies smaller than the pus or mucus corpuscles, with a perfectly smooth surface, and unaffected by acetic acid. Dr. Bird suggests that they may be nuclei which have been set free from a cell by the bursting of the investing membrane, but it is not probable that this view is correct.

In pl. XXXIII, fig. 183, the appearance of the deposit from the urine of a patient suffering from calculus is represented. The small round bodies seen in different parts of the figure were insoluble in strong acetic acid, and were unaltered on the addition of ether or potash. Many of them contained a central dark spot. They were accompanied with numerous small octahedral crystals of oxalate of lime. From their highly refractive properties and chemical characters just referred to, it is probable that they were composed of oxalate of lime.

Dr. Balfour, of Edinburgh ("Edinburgh Medical Journal," vol. I, 1856, p. 617, note), has shown that blood corpuscles correspond to Dr. Golding Bird's "small organic globules." After the crenated margins, so often seen in blood corpuscles in urine, have made their appearance, the globule undergoes further change, until at last it reassumes its spherical appearance, but becomes much smaller than before, and is not altered by hot or cold acetic acid. These so-called small organic globules may therefore consist of *little spherules of oxalate of lime*, *altered blood corpuscles*, or the *sporules of fungi*. I have demonstrated the last in a great number of cases; and sometimes they form a "visible white deposit," such as Dr. Bird described. It is a pity that the name "organic globule" has been employed at all, for certainly several bodies differing from one another answer to the descriptions given of it. The so-called "large organic globules," or "exudation or granular corpuscles," have been shown to consist of an aggregation of fat globules. I have, therefore, thought it better, in order to avoid confusion, not to employ the term in this work. *See* note on p. 313.

Should the practitioner meet with objects of the nature of which he is in doubt, he should at once make careful drawings, and take notes of the case in which they occurred. The importance of all microscopical observers being familiar with the appearance of all extraneous matters likely to be found in urine, has been dwelt upon in p. 293, *et seq.*

ENTOZOA.

Hydatids.—Small hydatids which have escaped from parent cysts in the kidneys, have been passed in the urine, and *echinococci* and their hooklets have been detected in the deposit in some cases. The hooklets of these creatures are very characteristic, and would be found in the urinary deposit. Several cases have occurred in which small cysts have been passed entire. In these rare cases, the symptoms of a tumour connected with the kidney are present. At length the cyst bursts; the fluid with echinococci is discharged in the urine; and perhaps some fragments of the cyst also escape. These and the hooklets of the echinococci are perfectly characteristic, and cannot be mistaken for anything else. An account of a recent case is given by Mr. Curling in the "Medical Times" of August 15, 1863. Mr. Curling gave me several of the hydatids passed by this patient. I could not find any echinococci or hooklets, but there could not be the smallest doubt as to the nature of the cysts. Echinococci are represented in pl. XXIII, fig. 121, and the hooklets in fig. 123. (Dr. Sieveking, "Lancet," 1853; Mr. Simon, "Lancet," 1853; "Glasgow Medical Journal," 1856; "Medical Times and Gazette," 1855.) In most of the cases the termination has been in recovery, and even if the hydatids make their way from the kidney through the lung, the probability is, that the patient will recover.

The occurrence of hydatid cysts are less common in the kidney than in the liver and lung. The parent cyst is usually surrounded by purulent fluid.

The wall of the renal hydatid cyst like the walls of cysts in other situations varies much in thickness. It is a tough, white, opalescent jelly-like membrane, not unlike boiled white of egg, and under the microscope is seen to consist of several layers of the same homogeneous material throughout. In transverse sections, or when the wall is doubled on itself, this characteristic laminated appearance is most distinctly visible, "Entozoa," pl. I, fig. 1. The structure of the wall appears homogeneous or slightly granular, as if it had been deposited by the outer surface of the inner germinal membrane from which new cysts and echinococci are formed. The majority of renal cysts contain a number of secondary or daughter cysts, which vary very much in size and number in different specimens; some may be more than half the size of the containing or mother cyst, while others of them may be so small as to be invisible to the unassisted eye. These secondary cysts float freely and unattached in the fluid with which the parent cyst is filled.

The granular appearance of the inner membrane arises from the presence of little elevations with which the surface is studded. By scraping these gently with a knife, not unfrequently many echinococci will be removed. The echinococci may also be obtained by allowing the fluid contents of the acephalo-cysts to flow into a conical glass. After a short time the echinococci sink, and may be removed with a pipette. They grow as buds or offsets from all parts of the internal surface of the vesicle, and are developed in groups of from six to ten. Many soon become detached from the wall of the cyst and die. Echinococci are represented in pl. I, fig. 2, p. 402.

The echinococcus is developed from some of the masses of germinal matter of which the inner wall of the cyst seems to be almost entirely composed. They may be seen at different stages of development in many cysts projecting like buds from the surface.

The echinococcus has been proved chiefly by the researches of Siebold and Van Beneden to be the immature condition of the *tænia echinococcus*, a minute tape worm found only in the dog and wolf. The tænia echinococcus is about $\frac{1}{4}$th of an inch long, and consists of only four joints, including the head, which has four suckers and a circle of hooks, pl. I, fig. 6. The eggs contain a six-hooked embryo which does not develope into a cysticercus, but into a spherical cyst containing a granular material. The echinococci are afterwards developed by budding from the inner wall of the vesicle. My friend and pupil, Mr. Nettleship has published some very interesting observations upon the development of this parasite in the "Proceedings of the Royal Society" for June 21, 1866, and I have to thank him for some beautiful specimens of the tænia in the dog's intestine which were developed from the echinococci taken from the liver of a sheep.

The entire adult worm of this species scarcely exceeds the size of a millet seed, and consists of three segments of which only the last one is fruitful. On the arrival of this segment at maturity, being then full of ova, it is thrown off from the creature, and a new segment is developed in its place. The ova thus set free in the intestines of the dog, are discharged by myriads in the excrements, and finding their way into the stomachs of men as well as of other animals, their embryos are soon set free. Then after burrowing through the mucous membrane, perhaps through the agency of the circulating blood, they become conveyed to and lodged in some distant organ, where, after the necessary interval, they reappear as hydatid vesicles in which echinococci are developed, as explained above.

Fig. 3 represents the appearance of echinococci magnified with an inch object-glass. The hooks are sometimes extruded, a condition which has been considered to result from the occurrence of endosmosis and commencing decomposition. They may be made to protrude their hooks by leaving the opened cyst for twenty-four hours in the fluid.

The echinococcus is about 1-200th of an inch long. It is nourished by imbibition only. The hooklets are thirty-four in number.

If a little of the fluid from the interior of an hydatid cyst be evaporated upon a glass slide, numerous crystals of chloride of sodium will be formed. Heintz gives the following plan for detecting *succinic acid* in the fluid of the hydatid cysts. The fluid concentrated by evaporation is to be treated with a little hydrochloric acid and agitated with water, and ether free from alcohol, until nothing more is taken up. The impure succinic acid obtained by evaporating the etherial solutions, is dissolved in water. The solution is to be filtered and evaporated to dryness. The residue is then treated with alcohol and completely recrystallised.*

The character of the claws, "Entozoa," pl. I, figs. 4, 5, should be particularly noticed, as their presence is characteristic of echinococci. Hydatids are occasionally expectorated; usually in consequence of a cyst in the liver opening into the base of one lung. The appearance of the cysts in the sputum will direct attention to the origin of the pulmonary mischief, but the observation should be always confirmed, if possible, by the microscopical examination of the claws or hooks. Echinococci may be preserved in the creosote solution or in the preservative gelatin. The hooks may be preserved moist in fluid, or dry in Canada balsam.

Diplosoma Crenata.—The most remarkable case on record in which worms were passed from the urinary bladder, is one which is reported by Dr. Arthur Farre, who has made some most careful dissections of the worm, and observations on the anatomy of the ova. ("Archives of Medicine," vol. I, p. 290.) This is the case recorded by Mr. Lawrence in vol. II of the "Med.-Chir. Trans.," in the year 1811. It is the only one on record. Dr. Farre describes the general characters of the worm in the article Worms, "Library of Medicine," vol. V, p. 241. Rudolphi, on insufficient evidence, declared that these worms were merely lymphatic concretions; and, in consequence, this interesting and authentic case has not yet been properly noticed by writers on parasites. In a recent re-investigation of the whole subject Dr. Farre has described the minute anatomy of the worm and the characters of the ova.

The patient was a woman twenty-four years of age; and, during the course of two or three months, she passed as many as from eight hundred to a thousand worms. The worms were of two different kinds. The first form, which varied from four to six inches in length, were passed in great number. The other kind was smaller, varying from half an inch to an inch in length. These worms were passed on one occasion only; they lived in the urine for three days, and moved very briskly. They

* Heintz, "Lehrbuch der Zoochemie," page 239.

belong to the genus spiroptera, and Rudolphi gives to them the name of spiroptera hominis. The larger worms have been named by Dr. Farre, from their body being double, diplosoma crenata. Fig. 7, pl. I, represents the general characters of the worm, one half the natural size. The drawing was taken from one of the largest and most perfect specimens of the entozoon. In the centre, at the upper part of the figure, is the sharp twist or kink, where the body is most contracted. From this point each half gradually enlarges to a certain distance, but tapers again towards either extremity; the right half terminating, in this specimen, in a point, the left furnished with a lateral membranous flap. This half of the body shows the abdominal groove, and double crenate border. The right half, being spirally twisted, exhibits successive portions of the dorsal, lateral, and abdominal surfaces. This twisting is observable in many specimens. Towards the extremity of this half, numerous fibrous cross-bands are shown. The minute structure of this creature is very peculiar, and has been accurately investigated by Dr. Farre, who has illustrated his remarks with numerous drawings. It appears therefore from these observations that, in this unique case, two new forms of living creatures, never seen before or since, were passed from the bladder in considerable number. For the details of the case, and for the account of the structure of the worms, I must refer to Dr. Farre's original paper in my "Archives."

Dr. Cobbold authoritatively condemns Dr. Farre's researches, and affirms that the bodies described by him are not entozoa at all.

Dactylius Aculeatus.—The only case on record in which this parasite has been found in connection with the urinary organs, is that of a girl, aged five years, who was under the care of Mr. Drake. Several worms were voided, and some of them were carefully examined by Mr. Curling, whose memoir, with drawings of the worm, is published in the twenty-second volume of the "Transactions" of the Medico-Chirurgical Society. The female was four fifths, and the male only two fifths of an inch in length. The tegument was armed with spines, occurring in clusters. The worms exhibited active movements; and, if left in the urine, they lived for two or three days. There were no symptoms in the case pointing to any derangement of the urinary organs. They were first noticed in the urine on May 26, 1839, and on several occasions between this date and June 11, after which no more worms were passed. These entozoa were, therefore, only found during a period of sixteen days, and they were not present each day.

Strongylus Gigas.—This parasite appears to have been found in the human kidney on one occasion, although Küchenmeister comes to the conclusion that it has never been met with. The specimen is preserved in the Museum of the College of Surgeons. It is occasionally found in the lower animals. A few years since, I found three beautiful specimens of the worm, two males and one female, coiled up in the kidney of a large dog. The female was about 15 inches in length, and rather less than half an inch in diameter. The skin was of a very bright blood-red colour, mottled with black. The males were about nine inches long, of a reddish brown colour, and about a quarter of an inch in diameter. The kidney was reduced to a mere fibrous cyst, rather larger than the organ on the opposite side; and the three entozoa were coiled up together, and occupied its entire cavity. The ureter was pervious throughout, and over its surface, and embedded in the mucus of the bladder, were multitudes of ova. Ova were passed in great number in the urine of this dog. The kidney and the female worm were preserved, and are still in my possession.

This large entozoon is almost peculiar to the kidney and urinary passages and is rarely found elsewhere. It is distinguishable from the common round worm by its greater size, its reddish colour, and by the possession of six papillæ round the mouth.

Distoma Hæmatobium has been found in the bladder, ureters, and pelvis of the kidney, as well as in the veins of the intestine, in the portal veins, small intestine, gall bladder, &c. Griesinger states that this parasite is very abundant in Egypt. The eggs of the worm were embedded in the mucous membrane of the bladder, which was much congested and ecchymosed in these situations. The worms themselves appear to have been found in the vessels. The eggs often form the nuclei of small deposits of uric acid. They have been found adhering to the mucous membrane of the bladder, kidneys, and ureter.

Bilharzia Hæmatobia.—Dr. John Harley has recently called attention to the existence of endemic hæmaturia in certain parts of the Cape of Good Hope, and in Natal, and has shown it to be due to a species of Bilharzia which, after careful comparison with Griesinger's figures of Bilharzia hæmatobia, he has been induced to refer to another species named by him, B. Capensis, "Medico-Chirurgical Transactions," vol. XLVII, p. 55. As no opportunity has yet been afforded of examining the adult animal, it is, however, probable that the species is identical with B. Hæmatobia.

Dr. Harley found in the urine of his three patients the eggs and ciliated embryos of the parasite, also part of its intestine, and a portion of ciliated integument. Drawings of the eggs embedded in mucus and free, are given in 'Entozoa,' pl. I, figs. 8, 9, 10. For the specimens from which these drawings were made, I have to thank my friend and colleague. This parasite is a non-hermaphrodite trematode worm. It has two suckers, and in the body of the male is a peculiar channel, the "gynæcophoric canal," which contains the female during copulation. *See* fig. 11. The parasite is chiefly found in the vesical, mesenteric, and portal veins, and by its presence in their minute branches gives rise to lesions of the mucous membrane of the intestines, bladder, ureters, and pelves of the kidneys. The principal symptoms are diarrhœa and hæmaturia, accompanied by great anæmia and prostration of strength. After a certain time the ova and embryos of the parasite are found in the urine. Dr. John Harley considers that the eggs often become, after the total disappearance of the hæmaturia, the nuclei of renal calculi. After death the mucous membranes affected are found studded with extravasations of blood, and more or less thickened and ulcerated.

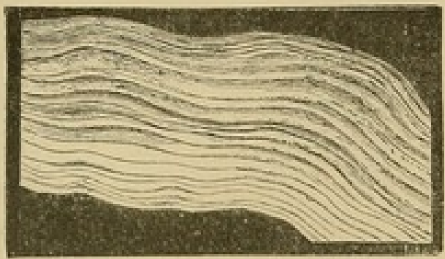
Pentastoma Denticulatum is a minute club-shaped encysted parasite having a double pair of hooks, but being destitute of sexual organs. Is frequently found on the surface of the liver in goats, oxen, rabbits, cats, and some other animals. There is but one known instance of its ever having been found in the human urinary organs, when Wagner discovered one of the species while making the autopsy of a painter 62 years of age, who died of Bright's disease.

Other Worms passed from the Urinary Organs.—A case is related by Raisin in which a worm three inches long was passed by a man fifty years old. Moublet alludes to the case of a boy aged 10, who voided four worms from four to five inches long, accompanied by pus. Other instances are recorded, but these do not seem to be well authenticated.

Parasites and other Animals of accidental presence in Urine.—Intestinal worms are sometimes passed into the vessel containing the urine, and the patient not unfrequently affirms that they came from the bladder. Various species of acari are frequently met with in urine. It need hardly be said they were not formed in the urinary organs. Insects and their larvæ are from time to time found in urine. Patients will positively assert that larvæ of the common flesh-fly have been passed through the urethra. I have on many occasions had specimens of the common maggot and cheese maggot forwarded to me, with the positive assurance they had been voided by the patient. The presence of the tracheæ in every part of the body prove the creature to be an insect, and it need scarcely be said that an air-breathing insect could not have been developed in any part of the urinary organs. These insect larvæ will pass through the entire tract of the intestinal canal in a living state. *See* "The Microscope in its Application to Practical Medicine," and papers by Dr. Brinton and Mr. Blood, in vol. III of my "Archives."

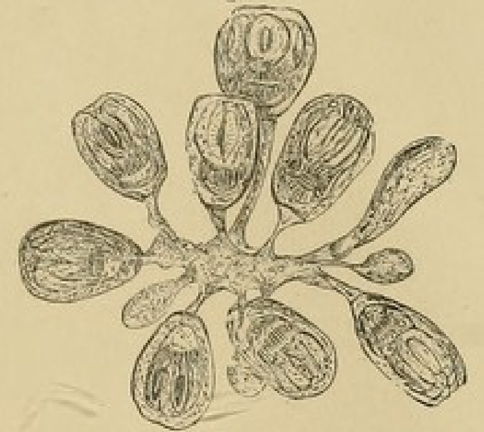
Elongated clots of Fibrin or of Blood are occasionally mistaken for intestinal worms. Microscopical examination will enable any one at once to distinguish them without difficulty, as the threads of fibrin cannot be mistaken for any texture of an entozoon. If, however, entozoa be altered by remaining for some time in the urine, their texture may become so disintegrated, as to present no special anatomical characters whatever.

Fig. 1.



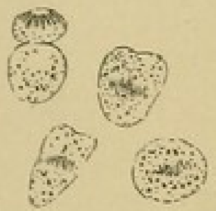
Layers of which the wall of an hydatid cyst is composed. p. 397. × 215.

Fig. 2.



Echinococci from hydatid. Liver of ox. p. 398. × 40.

Fig. 3.



Echinococci. p. 398. × 42.

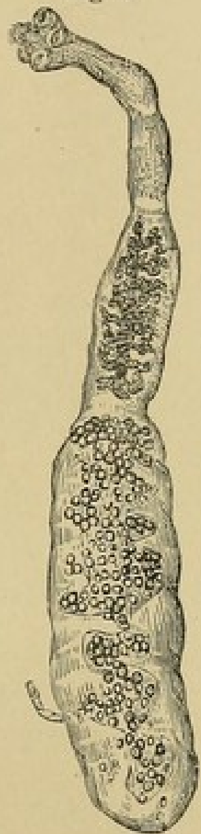
Fig. 4.

Free hooklets from echinococcus. p. 399. × 215.

Fig. 5.

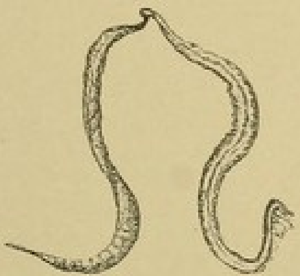
Hooklet of echinococcus. p. 399. × 100.

Fig. 6.



Tænia echinococcus. p. 398. × 15.

Fig. 7.

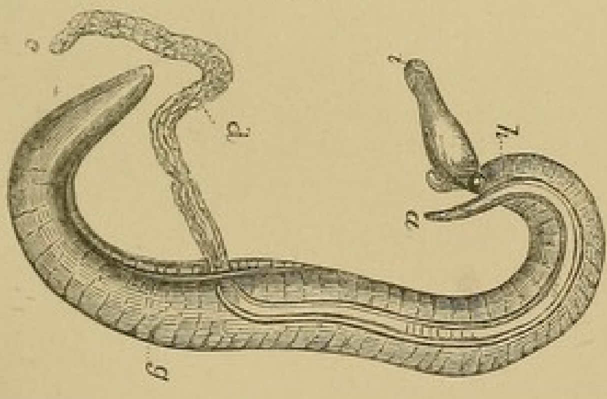


Diplosoma crenata; one-half the real size. After Dr. Farre. p. 399.

Fig. 8.

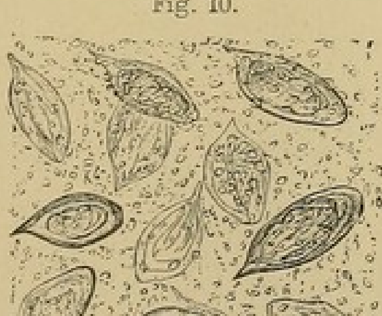
Ova of bilharzia hæmatobia in urinary deposit. Drawn from a preparation of Dr. Harley's. p. 401. × 15.

Fig. 11.



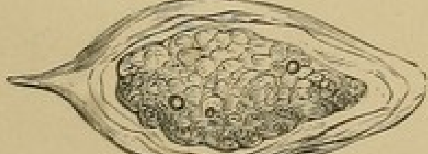
Bilharzia hæmatobia. *a, c, d,* the female lodged in the gynæcophoric canal of the male, *h, i, g.* After Bilharz.

Fig. 10.



Ova of bilharzia hæmatobia, from urine. Drawn from Dr. Harley's preparations. p. 401. × 130

Fig. 9.



Ovum of bilharzia hæmatobia, from a specimen of Dr. John Harley's. p. 401. × 215.

$\frac{1}{1000}$ of an inch |__| × 130.
,, ,, |___| × 215.

[To face page 402.

ON URINARY CALCULI.

General Considerations on the Formation of Calculi.—There are several substances in healthy urine which are only slightly soluble in water. In certain derangements of the physiological actions, some of these are produced in much larger proportion than in health, while other matters not present in healthy urine, and not readily soluble in water, are sometimes formed. It is not therefore surprising that, from time to time, we find that some of these matters are slowly deposited in the insoluble form from the urine while it yet remains in the bladder, or even before it reaches this organ. It is interesting to consider the various conditions which are likely to lead to this deposition of insoluble calculous material, and it is instructive to study the state of the system in relation to the particular form of insoluble matter deposited. If we were accurately acquainted with the mode of deposition of calculous matter, it is very possible that we might lay down such rules for the guidance of patients in whom the tendency existed as would prevent the formation of the stone, or retard its increase if already formed.

The deposition of a calculus does not always depend upon the state of the urine, for it is possible that the urine may be healthy while a stone is forming; the changes taking place on the surface of the stone itself causing the precipitation of more insoluble matter. Remedies which act on the kidney in many cases exert no influence upon the formation of a stone. It will often be found that the tendency to calculous disorder is explained by deranged chemical changes, which may perhaps be materially modified by attending to the action of the alimentary canal and skin, altering the mode of living, and administering the salts of the vegetable acids, alkalies, mineral acids, or mere diluents in large quantity, according to the nature of the case.

In those cases in which the deposition of the calculous matter mainly depends upon the urine being in a state unfavourable for holding certain slightly soluble matters in solution, it follows that the tendency to deposit may be averted, if the condition of the urine can be altered. It is possible that at one time an acid state of urine may favour the precipitation of uric acid; while, after a short interval, its characters may become so altered that it becomes alkaline. Not only does the precipitation of uric acid cease, but phosphates, which are insoluble in an alkali, are deposited. Phosphatic salts are soon precipitated on the uric acid, and the stone thus becomes most effectually protected from the further solvent action of an alkali.

Animal Matter in Calculi.—Calculi are usually composed of many different constituents; but one generally predominates greatly over the rest, and the calculus is named accordingly. Even the purest calculi composed of earthy salts contain, nevertheless, a certain proportion of organic matter; and those which seem to consist of organic material only, contain a small proportion of earthy salts. A certain amount of animal matter is deposited with the hard material, and in many cases serves to agglutinate the particles together.

It has been shown by Mr. Rainey that, when saline matter crystallises in a viscid substance like gum or mucus, it takes the form of a spherical mass instead of assuming its usual crystalline characters. (*See* Mr. Rainey's "Observations on the Formation of Shell," &c.) After the hard matter of a stone has been dissolved, this animal matter may be seen in the form of a translucent, granular, mucus-like mass. Upon microscopical examination, the remains of delicate fungi can often be detected in this matrix, and very frequently dumb-bells of oxalate of lime, or fragments of them, are found. The fungi were formed during the formation of the calculus; and it is probable that the reaction developed in the fluid in contact with them during their growth, occasioned the continued precipitation of the insoluble matter.

The hard calculous matter may consist of substances which exist in healthy urine, like *phosphates* and *uric acid*, slowly deposited from their weak solution in the secretion; or of materials which are not present in perfectly normal urine, such as *oxalate of lime*, *cystine*, &c.

Of the Concentric Layers of Calculi.—The insoluble material is deposited in distinct layers, which can often be readily detached and separately examined, 'Calculi,' pl. I, fig. 1. These layers are easily demonstrated by making a section of the calculus, which, except in the case of the hardest and most brittle calculi, may be readily effected as follows. The calculus is to be sawn through with a fine sharp saw. The cut surface is next to be ground smooth, by being rubbed down upon a smooth flat hone with water. When it is perfectly even, it may be washed and allowed to dry. Lastly, the cut surface is to be varnished; and now all the different layers will be seen most distinctly. If the calculus be very brittle and hard, unless it be sawn through with a diamond wheel, it is better to grind away one half without attempting to saw through it. Small calculi are very easily ground and polished, and often furnish very instructive specimens.

The concentric layers are often of different colours, of different degrees of hardness, containing varying proportions of organic base, and of different chemical composition. Each ring forms the section of a layer, and a portion of each may be detached and separately subjected to chemical examination. Some of these layers are deposited quickly, others more slowly; and they therefore vary considerably in hardness. In examining a calculus, it will be necessary to subject a small portion of several layers to examination.

Concentric layers may be demonstrated in the most minute calculi, even in those microscopic calculi which require to be examined under a power of 250 diameters, pl. II, figs. 12, 13, 14, 15.

Seldom can any definite crystalline form be made out, except upon the surface of the concretion; and upon examining small portions of a calculus in the microscope, nothing but a great number of fragments, exhibiting concentric layers, can usually be distinguished. Sometimes the material is at first deposited in separate little spherical masses, which become aggregated, and at length become incorporated together. Although distinct names are assigned to different forms of calculi, a concretion entirely composed of one substance is seldom met with.

Of the Classes of Urinary Calculi, and of the Chemical Examination of Calculi.

For convenience of description, calculi may be arranged in two classes, according to the relative proportion of the organic matter and inorganic salts present. The *combustible*, or *almost entirely combustible* calculi, are those which leave very little residue after exposure to the action of a red heat on platinum foil; while the *partially combustible* or *incombustible* calculi leave a considerable proportion of fixed residue.

I. The first class includes calculi composed of *uric acid*, *urates of ammonia*, *soda*, *lime*, *and magnesia*, and the rare forms of *uric* or *xanthic oxide calculi*, *fibrinous* and *blood calculi*, and those consisting of *cystine*.

II. The second class comprehends the *oxalate of lime* or *mulberry calculus;* calculi composed of various *phosphatic deposits;* that consisting of *carbonate of lime*, which is very rare in the human subject but not uncommon among the lower animals; and the *silicic acid* calculus.

The first preliminary test to which a portion of calculous matter of unknown composition is subjected, consists in exposing it to the action of a red heat. When reduced to a fine powder, a little is placed upon a piece of platinum foil, and heated in the flame of a spirit-lamp. If a carbonaceous mass remain, it is to be exposed for some time to a red heat, until it is entirely dissipated, or until nothing but a white ash remains.

If it be almost entirely dissipated, the original powder is to be tested for *uric acid*, *urates of soda*, *lime*, *ammonia*, *or cystine*, according to the method described for testing for these substances, when they occur as urinary deposits. *See* tables V, VII.

If the powder be incombustible, or only *partially combustible*, it is to be tested for *phosphate of lime*, *triple phosphate*, and *oxalate of lime*, by the methods indicated. *See* table VI.

Tests kept in Small Bottles with Capillary Orifices.—In p. 97 I have directed attention to a very convenient plan of keeping reagents, which is not only applicable to the subject now under consideration, but will be found of great advantage in all cases in which only a very small portion of matter is to be subjected to examination, particularly in ascertaining the chemical characters of substances which form the subject of microscopical enquiry. The plan of examining the chemical composition of a substance which I am about to describe, may be termed not inaptly *microscopical testing*. A chemist may carry his laboratory in his pocket; and the physician may take all the apparatus necessary for the most complete qualitative examination he is ever called upon to make, in a space much less than that now usually occupied by the urinometer, spirit-lamp, and acid-bottles.

These little test-bottles have been arranged in a case, with the urinometer and other apparatus required for the examination of urine. The mode of filling these test-bottles is described in p. 98. When we proceed to test a small portion of calculous matter, it is to be powdered and placed on a glass slide. The cap is removed from the test-bottle containing the appropriate reagent, which is then inverted, and its capillary extremity placed near to the matter or drop of solution to be tested. The warmth of the hand expands the air contained in the bottle, and a drop of the liquid is expelled. In this way, a drop of an unknown solution can be readily subjected to the action of several tests, and indications of the presence of certain substances may be obtained as clearly as if much larger quantities were operated on.

Testing for Carbonates.—In testing for carbonates, the powder or solution may be lightly covered with a piece of thin glass, and the acid subsequently added; the slightest effervescence becomes at once clearly perceptible; and, if necessary, the specimen may be subjected to microscopical examination, and thus the smallest disengagement of air-bubbles can be detected.

CLASS I.—*Calculi which leave only a Trace of Fixed Residue after Exposure to a Red Heat.*

Uric Acid Calculi.—Nearly two thirds of the calculi in the museums in this country consist in great part of uric acid. They vary very much in size. Small uric acid calculi are sometimes formed in considerable number in the kidney. For the most part, the deposition of the uric acid commences in the kidney itself; and not unfrequently the small concretion becomes impacted in the lower part of the uriniferous tubes or in the infundibula, and gives rise to great irritation, until it becomes released, and passes down the ureter into the bladder. It may now escape from the ureter or remain in the bladder, when layer after layer is added, and if it be not removed, it soon attains a considerable size.

The uric acid calculus is usually of an oval form, but somewhat flattened on two of its surfaces. A large uric acid calculus consisting of concentric layers of uric acid, deposited upon a smaller calculus composed of oxalate of lime, is represented in pl. I, fig. 1. It is sometimes quite smooth externally, sometimes rough, or covered with a number of rounded projections. It is generally of a brownish hue, varying from a pale fawn colour to a dark brownish red. Dr. Rees met with one specimen in which the nucleus was quite white, and was composed of pure uric acid destitute of colouring matter. The consistence of the uric acid calculus is usually hard, and its texture compact, but rarely it is soft, and can be broken down between the finger and thumb. It breaks up into small angular pieces.

I have examined many small uric acid calculi, and in several instances have found that the nucleus consisted of matter insoluble in potash, which polarised readily; and, in some specimens, well-defined dumb-bell crystals of oxalate of lime were discovered. In some few cases, the nucleus probably consisted originally of mucus or some soft matter, which after a time had shrunk and nearly dried up, leaving a space or cavity in the centre of the calculus; but, even in these instances, matter, insoluble in potash and acetic acid may generally be detected, and not unfrequently dumb-bells of oxalate of lime may be found in the nucleus of uric acid calculi.

The uric acid calculus is often coated with phosphates. The irritation of the calculus, according to Dr. G. O. Rees, excites the secretion of an abnormal quantity of alkaline fluid from the mucous membrane of the bladder, which causes the earthy phosphates to be precipitated from their solution in the urine. If ammonia were set free by the decomposition of the urine, it is possible that a little of the uric acid calculus might even be dissolved; but this would soon be prevented by the deposition of earthy phosphate upon the surface. The phosphates are not *secreted* in increased quantity by the mucous membrane of the bladder, as was formerly believed, but are merely precipitated from their solution in the urine.

Chemical Characters.—Insoluble in boiling water, soluble in potash. From the alkaline solution, crystals of uric acid may be obtained by adding excess of acid. The murexide test may be applied, p. 372. When heated on platinum foil, it evolves an odour of burnt horn. Carbonate of ammonia and hydrocyanic acid are among the products of decomposition. The small amount of residue which remains after the ash has been exposed to a red heat for some time, consists principally of phosphates and carbonates of soda and lime.

Calculi composed of Urates.—These calculi usually contain urates of soda, ammonia, and lime; and very commonly small quantities of oxalate of lime are deposited with the urates. This calculus is in great part soluble in boiling water, and gives off ammonia when heated with a strong solution of bicarbonate of potash. Dr. Prout states that it is principally met with in children, and is usually small in size, of a pale brown colour. Layers of urate are often found in uric acid calculi.

Chemical Examination.—After treating the calculus with boiling water, the insoluble matter is to be separated by filtration. This may consist of oxalate of lime and phosphates. If only a little boiling water has been added, the urate will be deposited as the solution cools. The solution is to be tested as follows. Acetic acid will precipitate the uric acid. The mixture is to be filtered, and the filtered solution evaporated to dryness. The residue is to be exposed to a red heat. Carbonate of soda and carbonate of lime remain. The last may be obtained by solution in acetic acid and precipitation as oxalate.

Uric Oxide, Xanthic Oxide, Xanthine.—These names have been given to a rare form of calculus, which has only been found in man on three occasions. It is not soluble in water; it is hard, of a yellowish brown colour, and the surface can be polished by friction. Scherer has found xanthine in the liver and spleen, in muscle and in blood. It is closely allied to uric acid, and also to hypoxanthine, which only differs from it in containing two atoms more of oxygen, p. 374.

Cystic Oxide—Cystine.—This form of calculus is of a pale greenish colour; its surface is smooth, and there are no indications of concentric layers. The fracture is glistening, and the structure is semi-transparent. The chemical characters of this calculus are the same as those of cystine, p. 383.

Fibrinous Calculus.—This form was first noticed by Dr. Marcet, and it appears to consist entirely of an elastic organic substance closely allied to fibrine. It is said to resemble yellow wax in its appearance. It dissolved in potash, but was precipitated by excess of acid. It was insoluble in water, alcohol and ether; but was dissolved by acetic acid, with the aid of heat. In this solution, ferrocyanide of potassium produced a precipitate. It left very little fixed residue after exposure to a red heat.

Blood-Calculi.—Dr. Scott Alison furnishes the following interesting remarks with reference to a case in which he discovered some blood-calculi in the kidney. ("Archives of Medicine," vol. I, p. 245.) Upon examining the body of a man named William Solly, who was admitted into the Consumption Hospital, Brompton, under the care of Dr. Cursham, on August 23, and who died on the 30th of the same month, the left kidney was found by Dr. Alison to be greatly wasted and changed in structure. The infundibula and pelvis were stuffed with hard bodies, most of which were of a coal-black colour, pl. I, figs. 7 and 8. "The black calculi occupied the pelvis, while the infundibula were tenanted with a few calculi of a whitish-grey colour, with one exception small in size, about the magnitude of pear-seeds, and wanting the ordinary physical characters of phosphate of lime. One calculus, which occupied an infundibulum, is the size of a horse-bean, looks somewhat worn and disintegrated, and at one point resembles a piece of decayed wood. At one side it is black, from the presence of altered blood. It is very light in weight, and is composed of blood and phosphate of lime. The black calculi, which form the chief point of interest in the case, were about six in number, and ranged from the size of a coriander-seed to that of a small horse-bean. When found, these black calculi were tolerably hard; but, being friable, they partly broke asunder in handling. The fractured surface varied a little in colour, in some parts presenting a dark rusty tint." Liquor ammoniæ dissolved them; they were capable of partial combustion. The microscope revealed only amorphous particles; but Dr. Owen Rees, with the assistance of a neutral saline solution, discovered forms which he considered to be the remains of blood corpuscles.

The kidney was remarkably altered. It was very small, but retained somewhat of the normal shape. It weighed only an ounce and a half, and was only two inches in length. Its colour was drab; its consistence was firm and fibrous. At one extremity only could any natural cortical or tubular structure be found. The organ resembled a sac with thin irregular walls. The lining membrane appeared healthy. The renal artery was small, thickened, and scarcely admitted a common probe. The ureter was small, but less out of proportion than the artery. The investing membrane could not be separated from the other parts with which it was connected.

The atrophy of the kidney in this case was probably brought about by the production of inflammatory action, set up, perhaps, by the presence of small calculi of phosphate of lime. Blood was probably effused in consequence, and, from suppression of urine, remained in the infundibula and pelvis, and failed to be washed down the ureter. This blood, hardening, would form the calculi which were discovered. After the abatement of the supposed inflammatory action, degenerative processes would supervene, and lead to the remarkable atrophy and change which the kidney presented. The duties of this altered kidney would be thrown upon the other; but, as the system was much wasted by disease, no increase of size would result.

"Only a very imperfect history of the patient could be obtained, he being very exhausted when he came into hospital. Since his death, inquiries have been made for information, but with little success. He was fifty-two years old, and by trade a painter. He had been ill with cough two years, and his feet and legs became œdematous only two weeks previous to his decease. No information could be obtained respecting his having suffered from calculi in the bladder, or from hæmaturia; but it is right to mention that no member of the family of the deceased could be found."

Fatty Concretions.—These have been already alluded to under *Urostealith.* Specimens of urine which contain large lumps of hard fatty matter will sometimes be brought for examination. Quite lately I have seen two such specimens, which were said to be cases in which concrete fatty matter had been passed in the urine. In these, however, the fat was ordinary suet, as was proved by the presence of the fat-vesicle, white and yellow fibrous tissue, and fragments of vessels.

CLASS II.—*Calculi which leave a considerable quantity of fixed residue after exposure to a red heat.*

Oxalate of Lime Calculi.—I have seen an oxalate of lime calculus not larger than the 1-500th of an inch, and have traced the formation of these stones through their several stages. I believe that the dumb-bell crystals formed in the kidney, in the first place become aggregated together, forming small collections, as represented in pl. XXXIII, figs. 182, 186; crystalline matter is then deposited in the interstices, and gradually a microscopic calculus results. Two beautiful specimens of microscopic oxalate of lime calculi are represented in figs. 12 and 13, pl. II, 'Calculi.' At *a*, fig. 12, a much smaller microscopic calculus is seen, consisting of only two dumb-bells. In figs. 14 and 15, microscopic calculi of oxalate of lime are also represented.

These minute calculi remain probably for some time in the kidney, and slowly increase until they form the concretions known as the hemp-seed calculi. Not unfrequently a number of them are formed in the kidney, and pass down the ureter one after the other at various intervals of time. Sometimes one becomes impacted, and gives rise to the most serious and distressing symptoms. Having arrived at the bladder, the slow deposition of the oxalate may continue, or layers of uric acid or phosphate may be deposited, according to the state of the urine.

In cases where the oxalate increases, the surface becomes tuberculated, in consequence of the irregular deposition of the salt; the colour varies from a pale brown to a dark brown purple. They are commonly called mulberry calculi. Such stones often attain a large size. They are very heavy and hard. On section, the laminæ are well seen, and it is often noticed that the calculous matter has been deposited most unequally.

Occasionally the oxalate of lime is deposited almost colourless and crystalline. Dr. Prout figures one of these calculi. I have a beautiful specimen, which was given me by Dr. Gibb, and was obtained from the horse. Large octahedral crystals of oxalate of lime can be seen all over the surface. The small hempseed calculi, which are white on the surface, also exhibit numerous beautiful crystals, although they are smaller than those referred to in the last specimen.

A beautiful example of another form of oxalate of lime calculus, the surface of which is of a pale brown colour, and the tubercles small and delicate compared with the mulberry calculus, is represented in fig. 2, pl. I, 'Urinary Calculi.'

Occasionally, however, in *post-mortem* examinations, we are somewhat surprised to find these calculi in the kidney, although the patient never suffered from the slightest symptom during life. I have a calculus the size of an almond, which I found fixed very firmly in one of the ureters of a man who died of another malady. Although its surface is rough, and it is half-an-inch in diameter, it caused scarcely any uneasiness, and there was no suspicion of its existence before the patient died.

The large mulberry calculus represented in fig. 5, was removed from a man aged 45, by Mr. James H. Ceely, of Aylesbury. The drawing is from a photograph, and represents the calculus two thirds of its real size. Mr. McCormick sent me the following history of the case. It is not a little remarkable that a rough calculus like this, weighing twelve drachms, should have been present without causing great pain and uneasiness:—

"At the age of 15 years the patient (now 45) suffered from pain in the hypogastric region, extending along the urethra to the glans penis. At intervals during the succeeding twelve months the pain was very violent, and was at each attack followed by the evacuation of bloody urine. Occasionally since then he experienced pain in these situations, while taking horse exercise, or during unusual exertion, but *never to any great extent, and he was never compelled to seek advice.*

"With these exceptions his general health, although delicate, had been good till last June (1858), when he had an accession of symptoms resembling those mentioned, but greatly aggravated. The urine, in addition to blood, contained 'gravel.' At this time he consulted Mr. Reynolds, of Thame, who detected a vesical calculus, and on the 20th September, Mr. J. H. Ceely, performed the lateral operation and removed a rough, irregular, mulberry calculus, weighing twelve drachms.

"During the first ten days subsequent to the operation, the urine contained considerable quantities of pus and blood, after which time all abnormal characters disappeared, and the patient was discharged from the Bucks Infirmary perfectly well on the 8th of October, and had suffered little pain or inconvenience. This patient had enjoyed excellent general health during a period of twenty-nine years, notwithstanding the presence of a calculus probably during the whole period."

Another mulberry calculus, which was of a beautiful plum colour, is represented in pl. I, fig. 3.

A calculus of very curious shape, the nucleus of which consisted of oxalate of lime, is described by Mr. Price in the eleventh volume of the "Transactions of the Pathological Society." Mr. Price removed fourteen calculi from the bladder of an old man by the lateral operation of lithotomy. Two of the calculi were peculiar in possessing several spine-like projections. The largest of these was about the size of a chestnut, and from its surface projected from eight to ten spines, two of which were upwards of half-an-inch in length. Surrounding the oxalate of lime nucleus were several layers of uric acid and urates, with some earthy phosphate. The spines were formed of the latter salts alone, and there was no projection of the oxalate of lime nucleus into them.

The cause of their peculiar shape could not be ascertained. The stone was not in any pouch in the bladder, but was free in its cavity, and the absence of any spines projecting from the nucleus militates against the idea of the peculiar form having been given to it while in the kidney. No *post mortem* was allowed. It seems possible that the formation of the spines might have depended upon the more rapid deposition of calculous matter on those parts opposite to the intervals between the smaller calculi, than over the part of the surface in immediate contact with them. Only the two largest calculi exhibited this peculiarity.

Chemical Characters.—The powdered calculus is soluble in the mineral acids, and the oxalate of lime is precipitated as a white powder by ammonia. Acetic acid will not dissolve oxalate of lime. After the powder has been exposed on platinum foil to a dull red heat for some time, a white ash consisting of carbonate of lime remains. This gives off bubbles of carbonic acid when it is treated with an acid. If the temperature be much higher than a dull red heat, a certain quantity of the carbonate of lime undergoes conversion into quick lime, which does not effervesce on the addition of an acid.

Calculi in Patients who have had Cholera.—The circumstances under which oxalate of lime is deposited in the form of the dumb-bell crystals have been already alluded to. It is interesting to find that both Dr. Prout and Kletzinsky have noticed deposits of oxalate of lime in patients who had had cholera, in which disease the fluids are in a high state of concentration. In *two* cases of this disease dumb-bells of oxalate of lime were found in the urine by myself. Dr. Prout also alludes to the frequency of cases of *calculous disease* in those who had suffered from cholera. These are important facts in favour of the view I entertain with reference to the formation of the nucleus of the calculus, which I have, in fact, shown to be in many cases a microscopic calculus. The remarkable concentration of the fluids which occurs in cholera is favourable to the deposition of the least soluble substances in a solid form.

Passage of Oxalate of Lime Calculi from the Kidney.—Oxalate of lime calculi often give rise to extreme pain when impacted in the kidney, and while passing down the ureter, or lodged in the bladder. In the kidney the pain is often of the most violent character, and frequently the patient suffers from many attacks before the stone is dislodged. Very frequently hæmorrhage occurs, and sometimes inflammation is excited, which terminates in the suppuration of the tissues contiguous to the stone.

On the other hand calculi may pass without giving rise to the least inconvenience; indeed, I have known many instances where a calculus has been for years impacted in the kidney, and has at last passed down the ureter without the patient having been conscious of it.

Calculi composed of Earthy Phosphate.—Both phosphate of lime and ammoniaco-magnesian phosphate enter into the composition of calculi. Dr. Prout showed that the phosphates were very often deposited upon other calculi, while there were very few instances in which uric acid, urates, or oxalate of lime, were deposited upon the phosphate. These two earthy salts enter into the composition of the *fusible calculus;* its degree of fusibility varying according to the proportion of triple phosphate present. The latter substance is easily fused in the blowpipe flame, while the phosphate of lime is quite infusible.

When the calculus contains but a mere trace of triple phosphate its structure is dense and even, it is heavy, and its surface is smooth and polished; but large calculi of this kind are exceedingly rare. A small quantity of triple phosphate is almost always present in the large calculi. Portions of the laminæ of these calculi are easily broken off. Phosphatic calculi are represented in figs. 6 and 9, pl. I. In both specimens the composition of the nucleus is different to that of the body of the calculus. In fig. 9 a small uric acid calculus, with some oxalate of lime, is seen in the centre of the phosphatic mass. Phosphate of lime calculi are often found in the kidney. In some cases the whole of the pelvis is filled with them, varying in size and shape, and mixed with a considerable quantity of pulverulent matter like fine sand. Each particle of this is found, upon microscopical examination, to consist of a minute calculus, containing a certain quantity of organic matter, probably mucus and disintegrated epithelium, for its nucleus. Several of these calculi are represented in pl. I, fig. 10. Occasionally a phosphatic calculus, lodged in the pelvis of the kidney, gradually increases until a large calculous mass is formed by the deposition of earthy salts, layer after layer, until the whole pelvis of the kidney is occupied by it, and its prolongations extend into the infundibula and calyces.

The calculus, which consists almost entirely of triple phosphate, has a very porous structure; it is light, easily broken down by pressure, and perfectly white. Its surface is rough, and large crystals of triple phosphate can often be discerned upon the surface with an ordinary lens.

In the deposition of phosphatic calculi, the alkali which causes the precipitation of the phosphates is secreted, according to Dr. G. O. Rees, by the mucous membrane of the bladder. The earthy salts are precipitated from the urine, not *secreted* from the mucous membrane, as was formerly supposed.

Mr. Charles Hawkins sent me several small calculi which had been passed by a patient, to the very large number of 600, in a fortnight or three weeks. They were all about the size of a small pea. The surface exhibited several flattened sides, evidently caused by so many being formed together. They looked very like small biliary calculi which had been packed together in the gall bladder. The matter of which they were composed consisted of phosphate of lime and ammoniaco-magnesian phosphate, with a considerable quantity of organic matter. Although these calculi were, in many respects, like prostatic calculi, it is almost certain that they came from the pelvis of one kidney.

Chemical Characters.—The phosphate of lime calculus is infusible. It contains, like other calculi, a little animal matter, but this is often so small that laminæ, which have been exposed to a red heat, retain their general characters after ignition. It is soluble in the mineral acids, and slowly in acetic acid. Phosphate of lime is precipitated in an amorphous form when the acid solution is neutralised with ammonia. When oxalate of ammonia is added to the acetic acid solution, a precipitate of oxalate of lime is formed.

The calculus composed of triple phosphate and phosphate of lime is fusible. The solution in acids, when neutralised by ammonia, gives a precipitate of ammoniaco-magnesian phosphate in stellate crystals, and a little phosphate of lime in an amorphous form. The quantity of phosphate of lime present is sometimes so small, that the solution in acetic acid does not give a precipitate when oxalate of ammonia is added. Calculi, composed of triple phosphate, generally contain more mucus and organic matter than the other phosphatic calculi.

Carbonate of Lime Calculi, though common among herbivorous animals, have rarely been met with in man. They are friable, and sometimes perfectly white. Mr. Smith has described some which are very like the mulberry calculi ("Med.-Chir. Trans.," vol. IX, p. 14). There are specimens of this form in the Oxford Museum, among Mr. Hitchings' collection, but, unfortunately, no history is attached to them. Dr. Thudichum states that he has examined prostatic concretions which consisted almost entirely of carbonate of lime. A small quantity of carbonate of lime is usually deposited with the earthy phosphates.

This calculus effervesces freely when exposed to the action of acids previous to incineration; white oxalate of lime yields carbonate only after having been exposed to a red heat.

Mr. Wagstaffe showed at the Pathological Society, December 17, 1867, a specimen of renal calculus, almost solely carbonate of lime, removed from a patient aged 42, who was admitted into St. Thomas's Hospital with heart-disease, and died thirteen days after admission. The urine was slightly albuminous, but otherwise healthy. At the *post-mortem* examination, besides the atheroma of the aortic valves and aorta, with hypertrophy and dilatation of the left side of the heart, the upper half of the right kidney was greatly dilated; and the pelvis contained a large calculus, which branched very freely into the calyces. There were also several loose rounded calculi, and a quantity of fine calculus grit. The minute structure of the kidney appeared healthy under the microscope. The main part of the calculus was lying in the pelvis, and appeared exactly like uric acid. The small loose rounded calculi were of about the size of peas, white, laminated, smooth, and hard. A fine dry, soft, opaque white powder, very much resembling phosphate of lime was also present. The small calculous grit resembled diminutive uric acid calculi. On examining each of these separately and with great care, it was found that *carbonate of lime formed the almost sole constituent*, a small trace of triple phosphate being discernible. Mr. Wagstaffe did not know of any specimen in which carbonate of lime was proved to be the constituent of a renal calculus, but he was inclined to think it not so uncommon a form of deposit as represented.

Silicic Acid Calculi.—I have never met with calculi which contained silica; but Berzelius, Vauquelin, Fourcroy, and Mr. Venables and others have detected it. It exists usually in very small quantity only, and in order to obtain it a considerable quantity of the calculus must be operated upon.

Prostatic Calculi.—These calculi vary very much in size. The small ones are roundish, but often the sides are more or less flattened when many have been lying in apposition. Small prostatic calculi are represented in pl. I, fig. 4. They are generally hard and white, like porcelain or alabaster, but occasionally have a soft porous structure. The surface is generally perfectly smooth. They consist of organic material, with phosphate of lime and a trace of carbonate; but it is seldom that triple phosphate is to be detected. The earthy matter may vary from 50 to 90 per cent.

These calculi are formed in the follicles of the prostate gland, and commence as minute very transparent concretions, which contain scarcely any hard calcareous material, and at this early period of their formation, therefore, are not entitled to the name of calculi. The microscopic concretions have been detected in the follicles during the periods of youth and early manhood by Sir H. Thompson, who states that he found them in every one of a series of fifty prostates which he subjected to examination. In old age, as is well known, they are often found of considerable size. When small, they do not give rise to any symptoms, but they may increase in size and number, and cause the greatest inconvenience and distress.

In sections of the prostate which I have made from a man of about forty years of age, who died from pneumonia, the various stages of growth of these concretions were well observed. The specimen has been preserved in glycerine, in order to increase its transparency. Each follicle of the gland is seen to be occupied by many small roundish bodies, and a considerable number of epithelial particles. Many of the follicles are distended by a number of transparent microscopic concretions, varying from a pale yellow colour to a dark reddish brown. Some of the smallest are not more than the one two-thousandth of an inch in diameter, and yet these are seen to be composed of *several concentric layers*. In the centre of almost all the concretions no one can fail to notice a quantity of minute globules, and in some, one or more roundish cells may be seen distinctly. These, in fact, constitute the "nucleus" of the concretion. The concretions under consideration consist almost entirely of organic matter, which resists the action of moderately strong solution of potash and acetic acid. It is an albuminous material, which, in its chemical characters, agrees with the substance of which the cell wall is composed. The walls of hydatid cysts, and some of the elastic albuminoid concretions occasionally found in the peritonial cavity, and in other situations, are composed of a substance closely allied to this. These bodies, I believe, are formed by the slow deposition of albuminous matter round a nucleus consisting of epithelial cells or *débris*. The material which is deposited in successive layers has probably been formed by the cells of the gland, and is of nearly the same composition as the matter of which the outer part of the cells themselves consists. It is sometimes colourless, but more commonly of a yellowish colour, and sometimes reddish. A small concretion having been once formed, new matter is deposited upon it, and gradually becomes hardened by the absorption of its fluid constituents.

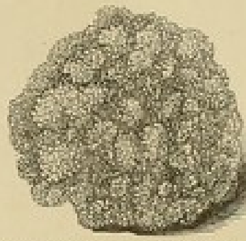
Up to this period of its formation there is very little earthy matter in the concretion, but gradually a change takes place, and granules of phosphate of lime are precipitated in the substance of the transparent organic matter. This change having commenced, the further separation of calcareous matter goes on. The particles already formed increase

URINARY CALCULI.

Fig. 1.

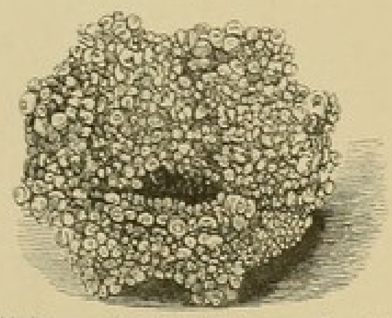
Large uric acid calculus, consisting of concentric layers of uric acid, deposited upon a smaller calculus composed of oxalate of lime. p. 407.

Fig. 2.



A beautiful example of oxalate of lime calculus, the surface of which is of a pale brown colour, and the tubercles small and delicate. p. 411.

Fig. 3.

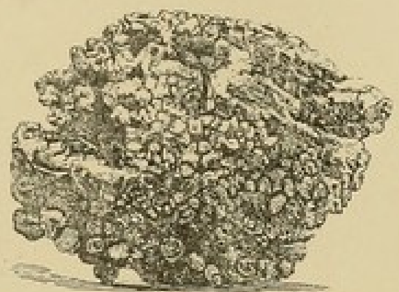


Mulberry calculus which was of a rich plum colour. p. 411.

Fig. 4.

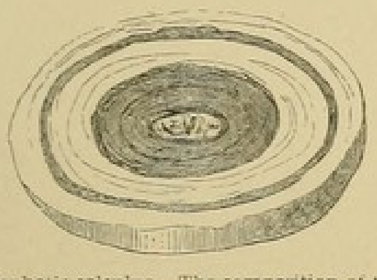
Small prostatic calculi. p. 415.

Fig. 5.



Large mulberry calculus, two-thirds the real size. p. 411.

Fig. 6.

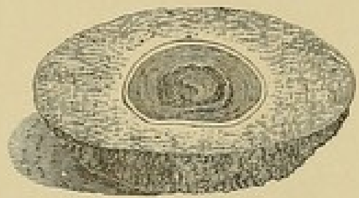


Phosphatic calculus. The composition of the central portion is different to that of the body of the nucleus. p. 413.

Fig. 7.

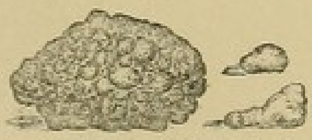
Blood calculus from one of the infundibula of the kidney. p. 409.

Fig. 9.



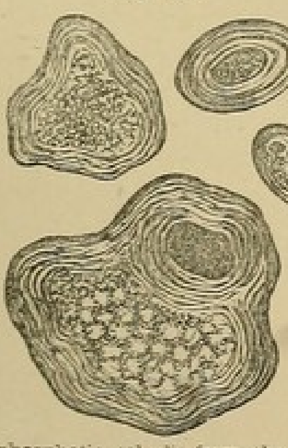
Phosphatic calculus. The nucleus being composed of a small uric acid calculus p. 413.

Fig. 8.



One large and two small black blood calculi, found in the pelvis of the kidney. p. 409.

Fig. 10.



Small phosphatic calculi, from the kidney. The nuclei are composed of a soft granular material, probably consisting of disintegrated epithelium. p. 413. × 130.

Fig. 11.

Very small calculi, from the follicles of the prostate gland of a man, aged 40, who died of pneumonia of three weeks' duration. The structure of the bladder and prostate seemed perfectly healthy. *a*, calculi composed of a number of smaller ones; *b*, very small calculus containing a single granular cell in the interior; *c*, calculi composed of a collection of cells around which the hard material has been deposited; *d*, calculus in which the nucleus seems to be crystalline; *e*, epithelium from the ducts of the prostate. p. 417. × 215.

$\frac{1}{1000}$ of an inch ⌊___⌋ × 215.

[To face page 416.

by attracting more phosphate from the surrounding fluid, which holds it in solution. As the concretion enlarges, the proportion of phosphatic salts to the organic matter becomes greater, and a *prostatic calculus* at last results. The calculus may attain a very large size, and may even extend forwards, into the urethra, and backwards, into the bladder.

The characters of these concretions are well described by Sir Henry Thompson, whose remarks are illustrated by careful drawings ("The Enlarged Prostate," pls. IV and V, p. 265). The account above given does not differ materially from the conclusions arrived at by this author, who thinks that the concretions are first formed by the coalescence of the small yellow bodies or granules, which afterwards coalesce and form a larger mass. Professor Quekett considers that they commence by a deposit of earthy matter in the secreting cells of the gland, while Dr. Handfield Jones believes that the concretions originate in a vesicle, which increases by endogenous growth. In various parts of my sections of the prostate gland, concretions, the nucleus of which appears to consist of granular matter, may be observed. There are others in which concentric layers may be traced quite to a central point or granule. Some have a perfectly transparent centre. And not a few exist, in which the nucleus is composed of small granular cells, varying in number from one to twenty, or more, pl. I, fig. 11, *b*, *c*, pl. II, figs. 14 and 15.

Summary of the Chemical Characters of Urinary Calculi.

1.—Calculi which leave only a slight residue after ignition.

Uric Acid.—Murexide formed when a solution in nitric acid is evaporated and exposed to the vapour of ammonia. A mere trace of residue left after ignition. Ammonia not given off when heated with a solution of caustic potash.

Urate of Ammonia.—Reaction of murexide. Ammonia evolved when heated with potash.

Urate of Soda.—Reaction of murexide. Fuses and gives a yellow tint to the flame. Leaves a decided residue after ignition.

Urate of Lime.—Reaction of murexide. Infusible. After ignition, carbonate of lime remains.

Urate of Magnesia.—Reaction of murexide. Infusible. The residue after ignition dissolves, with slight effervescence, in dilute sulphuric acid. The magnesia is precipitated from this solution, in the form of triple phosphate, upon the addition of phosphate of soda and ammonia.

Xanthine does not exhibit the murexide reaction. The solution in nitric acid turns yellow on evaporation. It is not soluble in carbonate of potash.

Cystine is soluble in caustic ammonia, and in carbonate of ammonia. It crystallises from an ammoniacal solution in six-sided plates.

Fibrine emits an odour of burnt feathers on ignition. Solution in caustic potash precipitated by acetic acid, and also by ferrocyanide of potassium after the addition of a little acetic acid.

2.—Calculi which leave a considerable residue after ignition.

Triple or Ammoniaco-Magnesian Phosphate fuses in the blow-pipe flame, and gives off an ammoniacal odour. It dissolves in acetic acid without effervescence. Ammonia gives in this solution a crystalline precipitate of triple phosphate.

Phosphate of Lime does not fuse. Soluble in hydrochloric acid. Precipitated by ammonia in amorphous granules. From a solution in acetic acid, the lime may be precipitated as oxalate when oxalate of ammonia is added.

Oxalate of Lime.—Soluble in mineral acids, without effervescence. Precipitated from acid solution by ammonia. Insoluble in acetic acid. After ignition, residue effervesces freely on the addition of acids.

Carbonate of Lime.—Soluble in acids, with effervescence. Lime precipitated from an acetic acid solution by oxalate of ammonia.

On the Origin and Formation of Urinary Calculi, and of the Nature of the Nucleus.

The Nature of the Nucleus of a Calculus.—This subject has been already referred to incidentally. Whenever there is a tendency to the precipitation of any of the slightly soluble constituents of the urine in an insoluble form before the urine has left the organism, one of the conditions most essential to the formation of calculus is present; or, if an unusual quantity of any such substance should be formed, so that the urine contains a stronger solution of it than in health, very slight circumstances will lead to its deposition before the urine has left the bladder, and thus insoluble deposits result. Each little mass of deposit may form a nucleus, around which new matter collects; but, as a general rule, the deposit escapes with the urine. Often it would appear that on the surface, and in the interstices, of rough stones more especially, small quantities of urine are retained, and prevented from mixing with the general mass. Chemical changes soon occur, the immediate result of which is the further precipitation of insoluble material. If the urine alters in its character from time to time, different substances may be deposited; thus oxalate of lime may form the nucleus of the calculus; and, after this has reached a certain size, the deposition of the oxalate may give place to that of uric acid. Again, the precipitation of this substance may cease, and several successive layers of phosphate may afterwards be formed. In some calculi, these layers alternate in a very remarkable manner.

The most interesting part of the whole process is the formation of the nucleus, and it is most important that we should study this matter very carefully. If we could ascertain the existence of calculi at a very early period of their formation, we could in many cases, doubtless, promote their expulsion before they attained any size, and thus distressing suffering would often be prevented, and sometimes the necessity for a severe operation removed, and all contingent accidents avoided.

Any solid matter may form the nucleus of a calculous concretion. Inspissated mucus from any part of the urinary organs—crystals which have been deposited—cells of epithelium—ova of entozoa—pieces of fibrine and small clots of blood—foreign bodies which have been introduced from without, such as peas, portions of slate pencil, or tobacco-pipe, pins and needles, and other substances which have been occasionally passed into the urethra by silly persons. A piece of a catheter and bougie have also been found in the centre of a stone. *See* preparations in the Museum of the Royal College of Surgeons.

My friend, Mr. Charles Hawkins, gave me, a short time ago, some very curious concretions. They were about half-an-inch in length, and about the tenth of an inch in diameter. The surface was rough. They were of a whitish colour, and the calcareous matter of which they consisted was composed of triple phosphate and phosphate of lime. Upon breaking several with care a hair was found in the centre. The patient from whom they were obtained suffered from an ovarian cyst, which had opened into the bladder. These concretions were, in fact, composed of earthy phosphates, which had been deposited from the urine upon the hairs, which had doubtless been formed in the ovarian tumour, and had passed into the bladder. Hair and teeth, as is well known, are not unfrequently developed in ovarian tumours.

Large Calculi formed by the Aggregation of Smaller ones.—Large calculi are sometimes formed by the aggregation of very small ones, just as a microscopic calculus may be formed by the aggregation of dumb-bells. Mr. Haynes Walton showed me a calculus of an oval form and whitish colour, with a very smooth external surface, about an inch and a half long by an inch wide, which he had removed from the urethra, directly behind the scrotum, of a gentleman of eighty years of age. It had been impacted in this situation for years. There was distinct evidence of the presence of this calculus fifty years before it was removed! On making a section of this calculus, no concretic layers nor central nucleus were seen, but, upon examination with a low power, sections of very small calculi were observed in every part of the surface. In each of these a central nucleus and several concentric lines were clearly distinguishable. These small calculi were connected together by a certain quantity of whitish matter, probably consisting of phosphate of lime and triple phosphate.

The Formation of Microscopic Calculi.—For some time I have had my attention very forcibly directed to the formation of urinary calculi, in consequence of having met with many specimens of *microscopic calculi* in urine. It is not at all uncommon to find microscopic uric acid calculi —aggregations consisting of uric acid crystals, which, if retained, might receive deposits of fresh material on the outside, until the small calculi, varying in size from a mustard-seed to that of a pea, or larger, are formed.

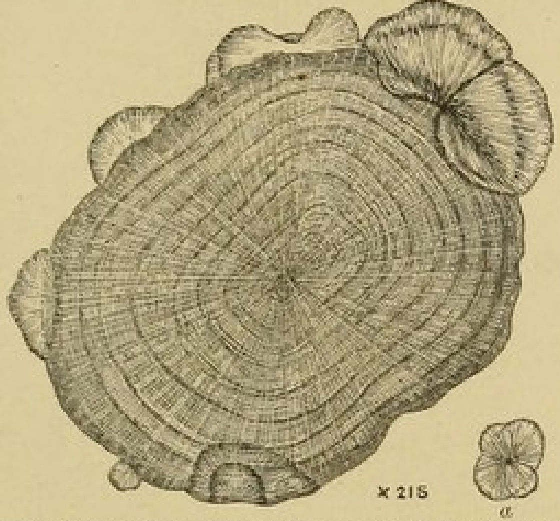
Microscopic calculi of phosphate of lime are by no means uncommon, and I have found them in the kidney in several instances. In some cases, as is well known, renal phosphatic calculi grow to a very large size, and occupy the entire pelvis, leading in some instances to the destruction of the secreting structure.

Until a few years since, I had never had an opportunity of watching the formation of calculi composed of oxalate of lime. The nucleus of these calculi does not consist of mucus or epithelium, as in the phosphatic calculus, but is of the same composition as the exterior. Figs. 12, 13, pl. II, represents a mass of dumb-bell crystals, many of which collections were passed in the urine. Although the mass is seen to consist of a number of distinct crystals, these are firmly attached, so that the whole may be rolled over and over without the individual crystals being separated from one another.

Such collections I have many times seen in the uriniferous tubes in kidneys obtained from *post-mortem* examinations, which leaves no doubt as to the precise seat of formation of these bodies. *See* plate X, 'Diseases of the Kidney,' fig. 53*. I have seen them in the kidney of the fœtus, and have detected dumb-bells in the urine of children under two years of age. Gradually the interstices between the individual crystals become filled up, and at the same time a few of the larger crystals increase in size at the expense of the smaller ones. At length a small crystalline mass, of an oval form, is developed, which clearly consists of a microscopic mulberry calculus. If retained, the calculus will gradually increase in size, pl. II, figs. 14, 15. When such calculi reach the pelvis of the kidney, a few sometimes increase gradually by the deposition of oxalate of lime upon their exterior; while no doubt, the greater number escape with the urine, and give no trouble. Such small bodies would easily become entangled in the mucus of the mucous membrane, and might remain in the pelvis of the kidney without exciting any disturbance until they had grown so large as to cause great inconvenience. If some of them passed down the ureter into

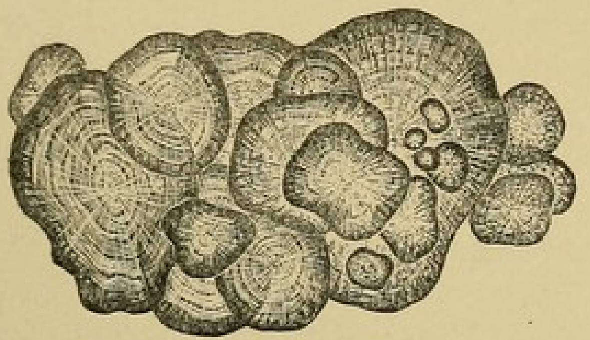
URINARY CALCULI.

Fig. 12.



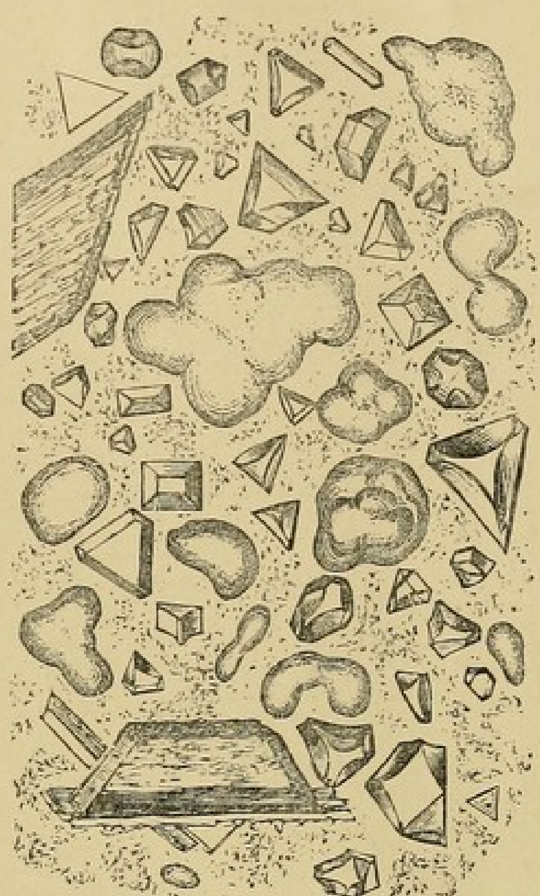
Small compound oxalate of lime calculus, found in the urine of a young man who was passing numerous dumb-bells of oxalate of lime and crystals of uric acid. Around the surface numerous large dumb-bells of oxalate of lime are seen partly incorporated with the mass. pp. 410, 420. × 215.

Fig. 13.



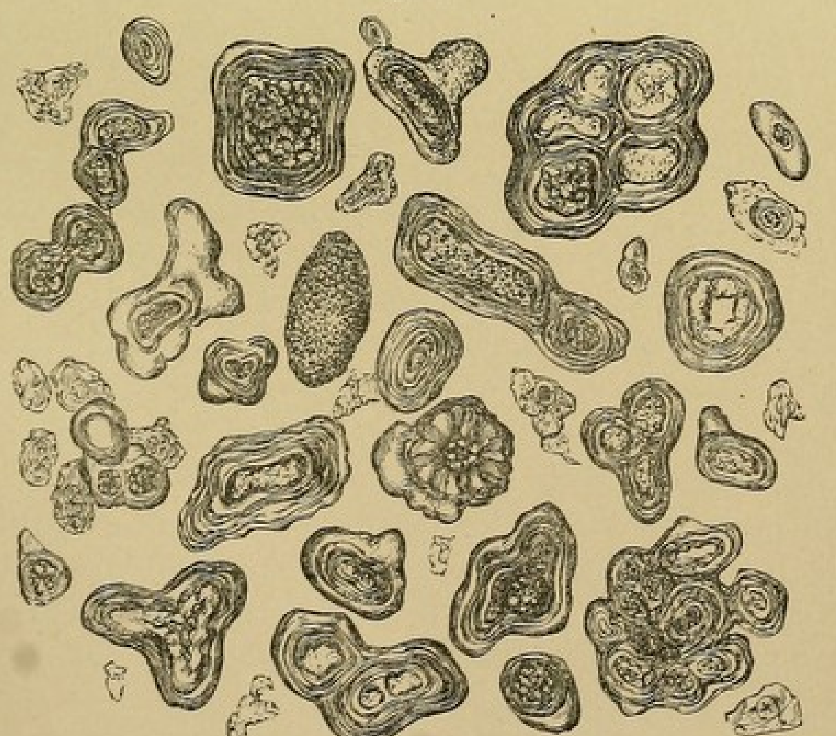
Compound oxalate of lime calculus, from the same case as that shown in Fig 12. pp. 410, 420. × 130.

Fig. 14.



Urinary deposit, consisting of crystals of triple phosphate and numerous smooth and irregularly shaped microscopic oxalate of lime calculi. From a patient suffering from symptoms of renal calculus. Sent by Dr. Cotton. p 420. × 215.

Fig. 15.



The same calculi as shown in Fig. 14, after being treated with acetic acid, dried and mounted in Canada balsam. The nuclei and concentric layers of each individual calculus have been rendered beautifully distinct. p. 420. × 215.

$\frac{1}{1000}$ of an inch ⊢——⊣ × 215.

[To face page 420.

the bladder, and happened to be retained for some time in this viscus, in a case where the urine contained much oxalate, they might increase in size until too large to escape by the urethra. It is, therefore, of great importance that cases in which these dumb-bell crystals are deposited should be very carefully watched. This observation is of some interest also as showing the chemical composition of the dumb-bells, which has long been a disputed point.

As I have before stated, many small uric acid calculi, which appear to be composed entirely of this substance, will be found upon careful examination to possess a nucleus consisting of oxalate of lime, and not unfrequently well-defined dumb-bell crystals may be obtained after the uric acid has been dissolved by liquor potassæ. These are insoluble in potash, and also in acetic acid. I have obtained from several specimens fragments of a mass larger than that represented in pl. II, fig. 12, and no doubt formed in the same manner. From recent analyses I have made, I have been led to the conclusion that the dumb-bell crystals almost invariably form the nucleus, around which the uric acid is deposited. I have not detected oxalate of lime in the centre of the small renal calculi composed of phosphate of lime. The phosphate is probably more usually deposited around masses of epithelium or in and upon pieces of mucus.

Frequency of Occurrence of different kinds of Calculi.—It is often very difficult to ascertain why certain varieties of calculi should be found in greater proportion in some parts of the country than in others. The question is one of great interest in connection with the consideration of conditions under which the formation of urinary calculi occurs.

In the collection of calculi at Guy's Hospital the proportion composed of phosphate of lime is as 1·29; at Bartholomew's as $1{\cdot}32\frac{1}{4}$; while in Norwich it is as $1{\cdot}132\frac{3}{5}$; and in Bristol as 1·155. Of 230 pure uric acid calculi in different hospitals in England and on the continent, as many as 164 are contained in the Norwich collection. (*See* the tables in the appendix to Dr. Prout's work on "Stomach and Urinary Diseases.") In the collection of urinary calculi in the museum of Guy's Hospital, it appears, from the statement of Dr. Golding Bird, that out of 208 calculi the *nucleus* consisted of uric acid in 127, of oxalate of lime in 47, of phosphates in 22, and of cystine in 11; or, of uric acid in 60 per cent., of oxalate of lime in 22 per cent., of phosphates in 10 per cent., and of cystine in 5 per cent. These figures are somewhat different to those given by Dr. Golding Bird, because I have thought it more correct to reckon in this calculation 142 calculi, which were obtained from one individual, as one.

Dr. Carter's observations on the composition of the calculi in the Grant Medical College, Bombay, prove that very few *nuclei* are composed of uric acid, while a large number consist of oxalate of lime. The following table from Dr. Carter's paper, shows the percentage of calculi in India and in England entirely composed of uric acid, urate of ammonia, and oxalate of lime:

	Grant Med. College. Per Cent.	College of Surgeons. Per Cent.	Guy's Hospital. Per Cent.	Norwich Hospital. Per Cent.
Uric acid	3·3	32·92	15·38	24·73
Urate of ammonia	5·0	2·15	3·84	8·29
Oxalate of lime	14·0	5·12	9·13	3·16

The following are the conclusions to which Dr. Carter has been led :—" 1. That, in the Bombay Presidency, the proportion of calculi having oxalate of lime for their nucleus, or wholly composed of it, is about twice as great as in England, taking for comparison certain standard collections there. 2. That the proportion of calculi having uric acid or a urate for their nucleus or entire substance, is considerably less in India than in England; in the former, urate of ammonia calculi are somewhat more frequent than uric acid calculi; the opposite is the case in England. 3. That the number of calculi wholly composed of earthy phosphates, or having them for a nucleus, is proportionately much fewer in India than in England, the difference being chiefly owing to the rarity of the mixed phosphate in the former." ("An Account of the Calculi contained in the Grant Medical College Museum, with some General Remarks on Calculi in India." By H. V. Carter, M.D., Lond., Assistant-Surgeon, Acting Curator of the Museum, August, 1859.)

Formation of a Calculus composed of Phosphate, Uric Acid, and Oxalate of Lime.—It is important to bear in mind that the central part of the calculus which is visible to the unaided eye is spoken of as the nucleus, but the real nucleus may be microscopic, and of a different composition to the material which immediately surrounds it. The nucleus of many calculi, which apparently consists of uric acid, is composed entirely of oxalate of lime. The phosphatic calculus which is represented in pl. I, fig. 1, seems to have a nucleus of uric acid about the size of an almond, but the latter contains in its centre a small nucleus, consisting of oxalate, which can only be demonstrated by the microscope. Now the history of the formation of this is, probably, as follows :—A number of dumb-bell crystals of oxalate of lime, formed in the uriniferous tubes, pl. X, fig. 53*, *opp.* p. 48, became aggregated together, and around this small mass uric acid was deposited as it lay in the tubes and pelvis of the kidney; then it passed down the ureter into the bladder, where the phosphate was deposited, and where the calculus attained its present size. Now, the deposition of the phosphatic salts on the uric acid is not more dependent on the presence of the latter than the precipitation of the uric acid was consequent upon the presence of the oxalate. In all probability neither the phosphate nor the uric acid would have been precipitated had not the oxalate been present in the first instance. It is not too much to say that, if the latter had not remained for some time in the uriniferous tubes, and gradually increased in size, no calculus would have been formed in the present case; if, therefore, the collection of dumb-bell crystals had been washed out of the kidney by diluents, soon after its formation, the further precipitation of calculous matter would have been entirely prevented.

It is important that we should make numerous observations on the nuclei of various calculi, and endeavour to determine their exact nature by microscopic investigation, and by the application of chemical tests. In this enquiry it will be found advantageous to take the smallest calculi and examine them as soon as possible after they have been passed. After they have become dry, it is in most cases quite useless to attempt investigations upon the nature of the nucleus.

ON THE TREATMENT OF CALCULOUS DISORDERS.

On the Importance of the Administration of increased Quantities of Fluid in certain Calculous Affections.—I have already adverted to the importance of increasing the quantity of fluid taken by persons who suffer from certain varieties of urinary deposits. This principle has been fully recognised by Prout and many practical physicians who have had experience in treating cases of this class; but the remedy, perhaps from its very simplicity, has certainly not received the attention at the hands of many practitioners that it deserves. There are conditions of the system which are very much influenced by the dilution of the blood, and many of the chemical decompositions going on are promoted by an increase in the quantity of fluid. Some changes will not take place unless the solutions of the substances be very dilute. Many comparatively insoluble matters are slowly dissolved away by the frequent renewal of the fluid in contact with them. Even silica is capable of being dissolved in water; and it is from a solution containing so slight a trace that the substance can only be detected at all by operating upon very large quantities, that the whole of the silicious matter contributing in so important a degree to give firmness to the stems of grasses, is deposited. The amount of water that must pass through the tissues of the plant during its growth and give up its silicious matter, must be enormous, since the quantity dissolved in each pint of fluid taken up by the roots is so very small.

On the same principle, by causing much liquid to traverse the tissues of a living animal, comparatively insoluble substances will be washed out; while, on the other hand, if little fluid permeates the tissues, and that contains a considerable proportion of solid matter dissolved in it, the state of things will be favourable rather to increased deposition than to the solution and removal of matters already deposited. It is doubtful if that abundant deposition of urate of soda which is from time to time met with in almost all parts of the body, in certain cases, would have occurred at all, if the fluids had been constantly maintained in a proper state of dilution. When such crystals have been formed, we may endeavour to remove them, and to prevent further deposition by maintaining the fluids of the body for some time in a state of dilution, and by increasing the solvent properties of the serum for the urate by giving frequently repeated small doses of alkali.

We are, perhaps, too apt, in many chronic cases, to put invalids upon a plan of treatment for only a few days or weeks; and our patients are often unreasonable enough to expect that remedies will remove, in a week, matter which has been slowly accumulating, perhaps, for years. It is chronic cases of this kind, which receive such real benefit from the comparatively prolonged course to which they are subjected in a German bath or hydropathic establishment; and it too often happens that, in endeavouring to perform quickly, by remedies, that which it is only possible to effect by giving large quantities of fluid during a considerable period of time, we disappoint ourselves and our patients. Perhaps in the end they attribute to some quack remedy or system, to which they have subsequently had recourse, the favourable result,—but this is obviously due to the water they have drank, and the hygienic rules to which they have been subjected. In certain cases of gout, in chronic rheumatism, and in many cases where uric acid and urates are constantly deposited in the urine or in the tissues of the body, the most important of all things is to ensure the thorough washing out of the system. Exercise, when it can be taken, is of the utmost importance. Hot baths, Turkish baths, &c., are beneficial, because they promote sweating and excite thirst. Thus more fluid is ingested. which is soon got rid of by various emunctories and carries out with it insoluble substances. The fluid which is removed is soon replaced by a fresh quantity. In the frequent repetition of these processes from time to time a vast quantity of fluid is made to pass through the body, with the most beneficial results. It is surprising how very little water some persons take habitually; and this little is often saturated with soluble substances. The fluid thus introduced is barely sufficient to hold the various compounds in solution while undergoing chemical change, and this is particularly the case in those who habitually live well. Many dislike to drink water, and not a few have a very strong prejudice against it; and these are not unfrequently the very individuals who suffer from gout, rheumatic pains in the muscular and fibrous tissues, and various forms of urinary deposits. Such persons usually receive great benefit from moderate sweating, and taking alkalies dissolved in a large quantity of water.

We seldom find difficulty in prevailing on patients to take Seltzer, Vichy, or other alkaline waters daily, or a few doses of the effervescing citrate of magnesia now sold so largely, although it would be useless to recommend them to take *pure water*. They can take these waters with their wine at dinner, the last thing at night, and in some cases it is desirable that the patient should take the water the first thing in the morning. People who live well every day, or rather too well, will find great advantage from continuing this plan, and now and then taking small doses of alkalies. It is quite superfluous for me to enter into the minute details applicable to individual cases; but I cannot too strongly recommend a careful enquiry into the general mode of life of patients of this class; for permanent relief may be afforded if we can but convince them of the importance of constantly attending to simple rules based on the principles to which I have adverted.

It seems to me unnecessary to give formulæ for prescriptions which have been advocated, and I shall abstain even from enumerating the many drugs that have been recommended in calculous disorders, for I am convinced that we shall practise our profession with greater advantage to our patients, and advance its interests more, by studying carefully the nature of the actual processes going on in disease, and considering how these processes are to be modified by simple means and a few remedies whose action is certain and well understood, than by employing new specific medicines, or combining together a great number of compounds, many of which are completely modified as soon as they enter the stomach, and are certainly destroyed long ere they reach the part of the organism where we imagine they will exert their specific influence.

Catheterism.*—The performance of the simple operation of passing a catheter, sound, or bougie into the bladder may be rendered both difficult and painful by many circumstances. A want of skill or of the proper delicacy of touch in manipulating the instrument, or a want of attention to the natural curves of the urethra, and to the position of the triangular ligament and neck of the bladder will often cause much inconvenience and delay. A silver catheter of the proper curve is usually more easily passed than an elastic or straight one. If an elastic catheter is used it should have the proper curve impressed upon its stilette, which should be so far stiff and resisting as to retain its

* For the practical remarks upon this important subject I am indebted to my friend Mr. Wood.

curve under some degree of pressure. The instrument should be well cleaned, both inside and outside, and its channel carefully examined for and freed from obstructions of hardened mucus or blood. It should then be rubbed briskly with a soft cloth or silk handkerchief to warm it to the temperature of the urethra and well oiled. In introducing it the operator should always have the umbilicus exposed to his view, as a guide and indication of the median line of the body in which the urethra lies. The ring end of the catheter should be kept strictly in this median line; any deviation of the instrument when held with its point in the direction of the bladder indicates a departure from the proper line of the urethra. A similar twist of the point of the instrument out of its course is shown by a want of level in the rings on each side of the open end of a silver catheter. During introduction it is better to stand on the left side of the patient. The penis should be held between the finger and thumb of the left hand and the meatus opened by pressure above and below it. If a bougie or straight catheter be used a firm yet gentle traction upon the penis should be made so as to bring the front and more moveable curve of the urethra in a straight line. In using the silver catheter while the patient is standing up, a dexterous manipulator will often employ the "tour de maître," which is thus performed. The instrument is held with its concavity directed down and backwards, and the penis is left to hang in its normal curve. The end of the catheter being placed in the meatus, it is then slided gently along the lower wall of the curve until the point reaches the front layer of the triangular ligament at the sinus of the bulb. A half turn round to the patient's left groin is then given to the end of the instrument with a sweeping and at the same time onward motion. This brings the point of the instrument into the upward curve of the vesical end of the urethra, pressing gently against the upper wall, and places it in the position for entering the bladder, at right angles to the level of the perineum. The shaft being kept strictly in the median line, its own weight will then be sufficient to urge the end into the cavity of the bladder. The advantage of the "tour de maître," when cleverly performed, is a greater ease of the passage and much less pain to the patient. In the healthy urethra there are several points which may form a difficulty by obstructing the point of the catheter or bougie. Normally, the narrowest parts of the urethra, and pathologically, the most common strictures are at the external orifice, and at the anterior layer of the triangular ligament—where the inner or upper curve of the *ʃ* meets the outer or lower bend; any instrument which passes these easily should pass through the whole canal. Below the size of No. 4, the point may become entangled in the "lacuna magna," a "cul de sac" or follicle which is placed in the upper wall of the urethra about 1½ inches from the meatus. Next it may be arrested in the sinus of the bulb by pressing against the triangular ligament below and behind the orifice of the membranous portion. It is here that the major part of false passages are made by urging the catheter too much backwards towards the rectum instead of upwards into the bladder. Next the point of a small catheter may be entangled in the "sinus pocularis" of the "verumontanum" or in one of the prostatic sinuses on each side. All these are to be avoided by keeping the point of the catheter against the upper or front wall of the urethra in the median line. But even this direction must not be carried to excess. In cases of difficulty from stricture in the membranous urethra, a false passage is sometimes made through the upper or anterior wall, bringing the point of the catheter either between or behind the layers of the triangular ligament and in front of, or into the anterior part of the prostate. Such false passages are liable to a greater danger of urinary infiltration into the pelvic fascia, and of subsequent peritonitis which is frequently fatal.

It cannot be too much impressed upon the mind of the operator that forcible catheterism is under almost any circumstances of difficulty a very dangerous proceeding. A great many cases of death from the shock of such a proceeding have happened both in healthy and debilitated constitutions. It is much better to try again and again with patience and gentleness than to endanger the patient in this manner. If retention of urine be pressing and the bladder much distended the comparatively safe operation of tapping the bladder from the rectum should be performed in case of failure of the catheter. Afterwards, when the congestion and spasm of the urethra have ceased and the abnormal traction upon the urethra by a distended bladder has been removed, persevering efforts to pass a catheter and subsequent slow dilatation can in a great majority of cases be safely accomplished.

On the Methods of Dissolving Urinary Calculi.—I can only offer a very few remarks on this important and interesting subject. Many of the observations which I have made with reference to the prevention or removal of urinary deposits are also applicable to calculi of allied composition. When a uric acid or urate of ammonia calculus, for instance, has been deposited, it may be dissolved, or its increase may be prevented, by producing alterations in the chemical composition of the urine. This may be effected partly by diet, and partly by the administration of various remedies, especially alkalies and the salts of the vegetable acids.

Mere dilution of the urine will sometimes exert a considerable influence upon a calculus; and it is possible that some calculi may have been entirely dissolved in this manner. An acid state of urine would tend gradually to dissolve a phosphatic calculus; and it is very possible that, if a feebly alkaline condition of the urine could be maintained for a considerable time, an impression might be made upon calculi composed of different forms of urates or even upon an uric acid calculus. The irregularities often seen upon the surfaces of such calculi have been very properly termed "water-worn," and clearly indicate that the urine has exerted, for a time at least, a solvent action. Although in certain cases it would undoubtedly be right to adopt for a time treatment of this kind, we must not look forward to the result with any great degree of confidence; at best, such changes are tedious and very uncertain.

Many attempts have been made to dissolve the calculus by injecting fluids, which exert a solvent power upon the stone, into the bladder. The most convenient plan is to inject the fluid through a double catheter for half an hour every two or three days or more frequently. Dr. Willis has recommended that the fluid should be placed in a reservoir at a sufficient height above the patient, and connected with the catheter by a tube provided with a stop-cock, by which means the flow of the solvent may be carefully regulated. In carrying out this plan, it is very important that the solution should be so weak as to prevent all chance of the mucous membrane of the bladder being injured. Sir Benjamin Brodie showed that phosphatic calculi might be greatly reduced in size, or entirely dissolved, by injecting a weak solution of nitric acid (2 to 2½ minims of strong nitric acid to an ounce of distilled water). Such a solution would also act very favourably in removing the sharp edges of fragments remaining in the bladder after the operation of lithotrity.

The objection to the use of alkalies in attempting to effect the solution of uric acid or urates is, that the phosphates are precipitated from the urine, and the calculus protected from the further action of the solvent.

The most ingenious plan for dissolving calculi was that proposed some years since by Dr. Hoskins, who employed a weak solution of acetate of lead (one grain to the ounce) with a mere trace of free acetic acid. With a phosphatic stone, double decomposition occurs. Phosphate of lead, in the form of a fine granular precipitate, and an acetate of lime and magnesia, are formed. The solution, it need hardly be said, does not produce any irritation or unfavourable action upon the bladder.

It is possible also, in certain instances, to dissolve the stone by injecting solvents into the bladder. In many cases, however, all our attempts to remove the stone by effecting its solution will be ineffectual, and we shall have to call in the assistance of the surgeon, who may remove the stone entirely by lithotomy, or may crush it with the lithotrite into several small pieces, which escape by the ordinary channel.

Experiments on the Solvent Action of Alkaline Carbonates.—Dr. Roberts found "that very weak solutions of the alkaline carbonates dissolved uric acid calculi with considerable rapidity, while stronger ones altogether failed. In order to decide what strength of solution had the most solvent power, fragments of uric acid, weighing from 40 to 112 grains, were placed in 10-oz. phials, and solutions of carbonate of potash and soda of various strength were passed over them at blood heat. The experiments were continued day and night; and the daily flow of solvent varied from 6 to 15 pints.

"Operating in this way, it was found that above a strength of 120 grains to the pint no solvent action was exerted; and even with 80 grains to the pint there was only a little; but solutions of 50 and 60 grains to the pint dissolved the fragments freely. A coat or crust of white matter invariably invested the stone in the stronger solutions, and prevented further action. At and above 120 grains to the pint this coat was dense and tough, and could not be wholly detached from the subjacent surface. With 80 grains to the pint it was brittle, and easily detached like a layer of whitewash. With 60 grains to the pint, and under, either no crust formed at all and the stone dissolved clean with a water-worn appearance, or it was only represented by a few loose flakes, scattered here and there over the surface, and offering no impediment to dissolution. This coating or crust was found essentially to consist of bi-urate of potash or soda, and its formation depended on the fact that the alkaline bi-urates are almost insoluble in any but very weak solutions of the alkaline carbonates. In the strong solutions the bi-urate remains undissolved and encases the stone in an insoluble investment; while in weaker ones it is dissolved as fast as it is formed, the surface of the stone remains clean, and dissolution proceeds without impediment." *

The following table is the result of an experiment continued for forty-eight days.

* "Archives of Medicine," vol. III.

TABLE II.—*Uric Acid and Carbonate of Potash.*

Strength of Solution.	Flow per 24 Hours.	No. of Obs.	Daily Average Loss of Weight Per Cent.	REMARKS.
Grs. per Pint.	Pints.			
240	6	1	0	Covered with a tenacious white coat, as if of paint.
120	6	3	0	Covered with a less dense coating. After detaching this and wiping, there was a mean loss of weight of 7·1 per cent.
80	6	2	9·8	Covered with a loose detachable white crust.
60	14	2	19·0 … } 22·2	Surface clean.
60	6	5	21·4 …	Loose flakes in spots.
40	6	3	15·6	Sometimes a few loose flakes where the fragment rested.
30	15	4	13·0 } 11·9	Dissolved clean; occasionally a few loose flakes.
30	8	2	15·0	
30	4	2	9·5	
30	6	4	10·2	
20	6	3	11·0	Dissolved clean.
10	6	3	6·5	Ditto.

On Dissolving Calculi by Electrolysis.—Attempts have been made to disintegrate and effect the solution of calculi in the living body by aid of galvanism. MM. Prevost and Dumas ("Annales de Chimie," vol. XXIII, p. 202, 1823) employed electricity for the purpose of disintegrating phosphatic calculi, by the mechanical action of the gases set free in the electrolysis of water; but only a grain per hour was thus removed. The *solution* of the calculus was not attempted in those experiments. Dr. Ludwig Melicher ("Oesterreich. Medicin. Jahrbuch," 1848, vol. I, p. 154) tried to dissolve a calculus by the aid of electricity. It is said that two experiments on the living body were successful. (Quoted by Dr. Bence Jones.)

The latest efforts have been made by Dr. Bence Jones, who employed a solution of nitrate of potash, and decomposed this by the aid of a powerful galvanic battery. The nitric acid set free at the positive electrode would decompose the uric acid exposed to its influence, and the potassa evolved at the negative electrode would dissolve it, so that an uric acid calculus placed between them would be disintegrated at both points. The battery employed was from five to twenty pairs of

Grove's plates. From 2 to 9 grains of uric acid calculus were dissolved per hour at the temperature of the body. Of oxalate of lime ½ grain to 2 grains per hour only were dissolved. The action was four times as slow as upon uric acid calculi. Of oxalate of lime and uric acid, in alternating layers, 4½ to 5 grains were dissolved per hour. Of phosphatic calculi upwards of 25 grains were dissolved per hour.

Treatment during the passage of a Calculus along the Ureter.—The violent pain which often, but not invariably, results from the passage of a calculus down the ureter, is generally relieved by hot fomentations or a warm bath. Diluents and sudorifics should be given internally. In one case, referred to by Dr. Prout, the intolerable burning sensation was relieved by the application of pounded ice to the region of the kidney. If there is violent hæmorrhage, the patient must be kept lying down; and if the pain is constant, an opium or henbane suppository in the rectum often affords temporary relief. Moderate exercise, or even the violent jolting of riding, when the suffering is not very great, will often promote the descent of a calculus from the kidney. I know of several cases in which a calculus has passed down the ureter without causing any pain whatever, and the patient was not conscious of its existence until he had passed it. Purgatives, cupping over the loins, and alkaline diuretics, with small doses of opium or henbane, are required, if the descent of the calculus is very slow, or if the stone is impacted in the kidney; often there is violent sickness, but this is of short duration. In some cases the calculus may be washed out by giving the patient a large quantity of fluid during six or eight hours.

Sometimes a stone will remain impacted in the lower part of the ureter obstructing or entirely preventing the entrance of urine into the bladder on that side, and finally making its way by ulceration into the cavity of the bladder. Such cases are usually attended with atrophy and cystic degeneration of the corresponding kidney. The presence of pus in the urine, succeeding to pains in the loins and the usual signs of the passage of a calculus by the ureter, and accompanied by many of the signs of stone in the bladder characterise these cases. The sound passed into the bladder fails to recognise the stone or to give the metallic chink which the surgeon likes to hear before proceeding to an operation for the removal of a stone from the bladder. Patience and palliative treatment for the relief of suffering are the only remedies for such a state of things; after a time the stone makes its way into the bladder and then its more evident signs are distinctly manifested.

Lithotomy and Lithotrity.—This is a part of the subject which I am quite incompetent to discuss, but there are one or two recent modifications in these operations to which I may be permitted to advert very briefly. The operation of lithotomy, which is usually performed by most surgeons in the present day, is the lateral one. For a discussion of the various important points connected with this operation, I must refer to Sir William Fergusson's treatise on "Practical Surgery."

Some time since, the median operation was performed with considerable success by Mr. Allarton. Its principal advantages seem to be, that the levator ani and prostatic capsule and plexus escape injury, while the course into the bladder is most direct. There is also the advantage that the knife is not used either to knotch the prostate or to open the bladder. On the other hand, there seems to be considerable chance of injuring the ejaculatory ducts, and a surgical friend tells me that there is a want of space in manipulating with the forceps, and in seizing and extracting the stone, and that there is also some risk, especially in children, of injuring the bulb of the urethra or the rectum. The operation is described in the "Lancet," 1859, vol. I, p. 122. (*See* also Mr. Allarton's work on "Lithotomy Simplified." London: Ash and Flint. 1854.)

In connection with the subject of lithotomy, I may remark that, in a recent improvement in the manner of carrying out the lateral operation, by Mr. Wood, the injurious effects which sometimes result from a free division of the prostate, pelvic fascia, and levator ani with the knife are altogether avoided. Mr. Wood employs a staff composed of two blades, which can be separated from each other while the instrument is held in position. Dilatation of the urethra is readily effected by allowing the finger to slide in between the blades. In the single case in which this operation has been performed in the living subject, it certainly succeeded admirably. ("Medical Times and Gazette," December 22, 1860.)

The principal advantages of this over the ordinary lateral and median operations respectively are that, as the knife does not enter the bladder at all, neither the prostatic veins nor the fascial capsule are injured, nor can the ejaculatory ducts be cut. The levator ani cannot be divided, and all chance of the extravasation of urine into the pelvic areolar tissue is avoided. The form of the external incision is such that more room is given than in the ordinary operation, while injury to all important vessels and other structures is avoided. By this proceeding the dilatation necessary for the extraction of the stone is much more easily effected than in the median operation.

Of late years lithotrity appears to have been carried out very successfully in numerous cases in which the operation of lithotomy would have been practised formerly. The number of fatal cases resulting from lithotomy is considerably greater than that obtained from an analysis of the cases of lithotrity to which I have been able to refer. And it appears that stones of very large size may be crushed with safety. So far as I can learn, setting aside a few exceptional cases, it would seem that lithotomy afforded but a poor chance of safety where lithotrity could not be confidently recommended. These remarks, I need hardly say, apply only to adults. In children, lithotomy is so safe an operation, while the small size of the urethra and other circumstances are unfavourable to lithotrity, that it is not likely that surgeons will have recourse to any other proceeding.

The experience especially of Sir Benjamin Brodie, Mr. Charles Hawkins, Mr. Prescott Hewett, and Sir Henry Thompson, has proved that, when performed with care, lithotrity is a most successful operation. Mr. Hawkins tells me that he has operated with success even in cases of stricture and irritable bladder, and has performed lithotrity where lithotomy could not have been undertaken. (*See* a case reported in the "Transactions" of the Royal Medical and Chirurgical Society for 1859.) On the subject of lithotrity, I must refer to Sir B. Brodie's paper in the twentieth volume of the "Transactions" of the Royal Medical and Chirurgical Society, in the concluding paragraph of which are these words :—" My own experience has certainly led me to the conclusion that lithotrity, if prudently and carefully performed, with a due attention to minute circumstances, is liable to a smaller objection than almost any other of the capital operations of surgery."

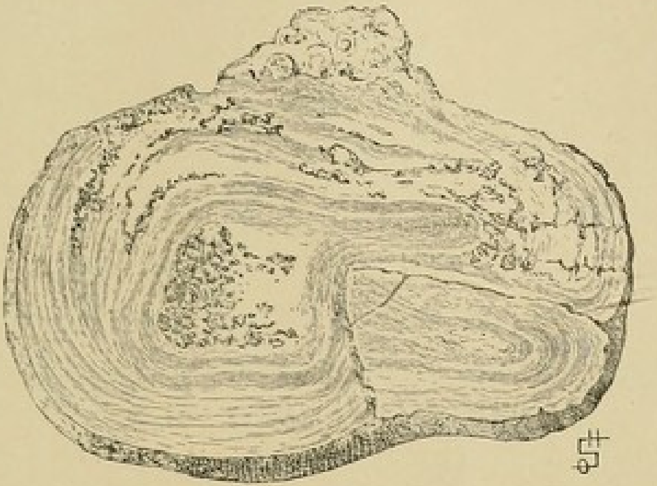
In some cases a stone becomes encysted or impacted in some part of the bladder. This may occur in two ways. First, by the previous presence of sacculi of the mucous membrane protruding between the separated meshes of the dilated muscular coat. Into one of these a calculus has been known to pass occasionally or to remain permanently. 2ndly, by a totally different process, viz., that of ulceration by pressure, a stone may make its way through some part of the wall of the bladder usually the neck. In an interesting case of this kind in a male adult recorded in the "Transactions of the Pathological Society," 1867, vol. XVIII, p. 171, by Mr. Wood, an uric acid stone, weighing upwards of 4 oz., had lodged for many years in the neck of the bladder, —bridging across the orifice of the urethra. Much difficulty h as experienced in dislodging the stone during the operation of lithotomy which Mr. Wood performed for its removal. It was afterwards found to have formed for each of its ends a pouch in the walls of the bladder, which on the right side had obliterated the orifice of the ureter, and completely perforated the proper vesical wall, and was closed in by a thickened dense deposit in the connective tissues around. An enormous distension and hypertrophy of both ureters and dilatation of the right kidney into a mere sac with corresponding hypertrophy of the left kidney had been the result of this abnormal position of the stone.

Sometimes a small stone will either form or become impacted in the prostatic portion of the urethra. When formed here it is usually composed of phosphate of lime. If it affords an obstacle to micturition it should, if possible, be extracted by the urethral forceps. If this fail, it may be pushed back into the bladder by the use of a full-sized bougie, and may then be crushed by a lithotrite. If this cannot be done, the surgeon must cut down to it from the perineum by a median operation, as if it were in the bladder. In such a case Mr. Wood removed a small stone by means of a long-handled small scoop manipulated upon the finger introduced into the rectum, and used to steady and press forward the prostate against the point of the instrument.

On the Spontaneous Fracture of Urinary Calculi in the Bladder. —But few cases of this uncommon accident have been recorded. When three or four phosphatic calculi exist in the bladder, it sometimes happens that one or two are broken. The fragments may be discharged by the urethra. Concretions of phosphate around portions of mucus which are not unfrequently found in the urine of persons suffering from phosphatic deposits, have been mistaken for fragments of calculi. A stone has been fractured in the bladder by direct violence. Mr. Southam has recently brought forward three interesting cases in which single calculi had undergone fracture in the bladder. *See* a paper read before the British Medical Association at Dublin, 1867, and printed in the "British Medical Journal," January 4, 1868. In two of the cases, the calculus consisted of uric acid and oxalate of lime. Mr. Southam thinks that the fracture must have resulted from the development of gas within the calculus itself, possibly in consequence of the decomposition of the animal matter of the calculus. This view is supported by specimens in the Dupuytren Museum, in which the fracture is limited to the *internal* portion of the stones, the outer layers being intact. Mr. Southam has kindly allowed me to have copies taken of his drawings, and to publish them in this work. *See* 'Calculi,' pl. III, figs. 16 to 20.

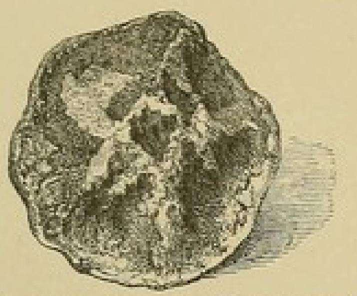
URINARY CALCULI.

Fig. 16.



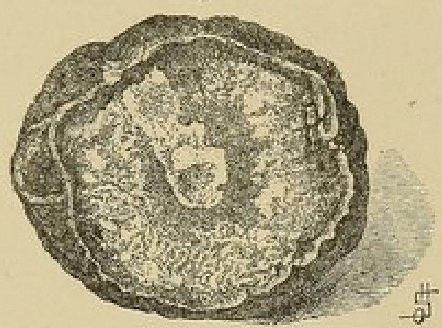
A calculus in which spontaneous fracture has occurred in the internal layers only, the separated portion appears to have become again cemented, and encrusted with a subsequent deposit. After Mr. Southam. p. 434.

Fig. 17.



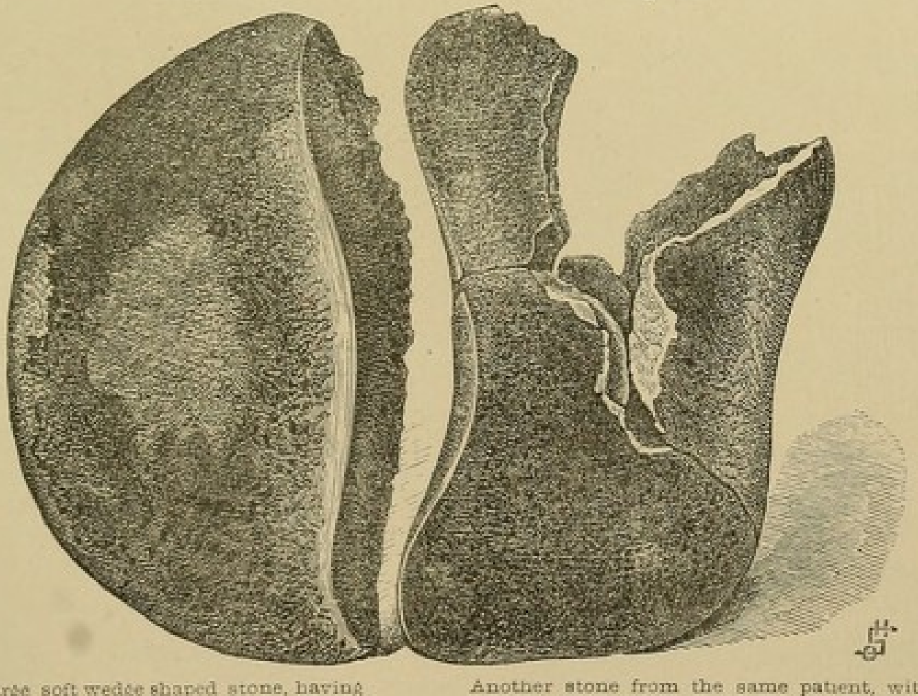
Urethral portion of a calculus, removed by Mr. Southam, from a boy, aged 15. p. 434.

Fig. 18.



Larger fragment of the same stone, which was in the bladder. The separation was not of recent date. p. 434

Fig. 19. Fig. 20.



Large soft wedge shaped stone, having one rounded surface and two facets, removed by lithotomy, by Mr. Luke. After Mr. Southam. p. 434.

Another stone from the same patient, with corresponding facets to those upon the stone represented in Fig. 19.

TABLES FOR THE EXAMINATION OF URINE.

BRIEF SUMMARY OF THE PRINCIPAL CONSTITUENTS OF URINE, AND THEIR MICROSCOPICAL AND CHEMICAL CHARACTERS.

Healthy Urine. Quantity.—A healthy man usually passes from 40 to 60 oz. (17,500 to 26,250 grains) during twenty-four hours.

Quantity of Water.—Average, about 20,000 grs. in twenty-four hours, or 940 grains per 1,000 grains of urine. Varies much even in health, and at different periods of the day.

Quantity of Solid Matter varies inversely as the water—600 to 1,200 grains excreted in twenty-four hours.

Specific Gravity of the urine in health varies from 1,015 to 1,025; depends not only upon the quantity of solid matter in the urine, but also upon the specific gravity of the constituents, p. 116.

Reaction.—Acid. Varies at different parts of the day, p. 118.

On the quantities of the various constituents in the urine in health, *see* p. 121, and the tables on pp. 123, 127.

Examination of Urine.—When endeavouring to ascertain if there be any abnormal condition of the urine, note its *reaction*, *the quantity* passed in twenty-four hours, its *specific gravity*, and the *amount of solid matter*. Also apply certain chemical tests, and resort to microscopical examination, if there be any deposit, pp. 218, 282.

Chemical Analysis alone will show the presence of urea, uric acid, extractive matters, salts, sugar, albumen, bile; and is employed for ascertaining the composition of certain deposits, pp. 219, 285.

The Microscope discovers various substances which are either not recognised at all, or are with great difficulty proved to be present by other means, p. 285.

DIRECTIONS FOR INSTITUTING A ROUGH GENERAL EXAMINATION OF A SPECIMEN OF URINE.

The most necessary tests may be arranged under six heads; and, by having recourse to one or more of these, we are enabled to determine roughly the most common morbid states of the urine.

1. **Reaction** (p. 117).
2. **Specific Gravity** (p. 116).—When very high, we may suspect an increased quantity of urea (excess); or the presence of sugar. Apply tests mentioned on p. 243. Hysterical urine, and urine

of cases where much water has been taken, is of very low specific gravity, p. 179.

3. **Heat.**—Urate of soda, distinguished from pus or phosphate, p. 350. Albumen. Precipitation of phosphate, &c., pp. 221, 222.

4. **Nitric Acid** dissolves phosphates, p. 157; decomposes urate of soda (if strong, rapidly); precipitates albumen in urine, even when in very small quantity and due to the presence of pus. Used also to test the presence of uric acid, p. 140. Excess of urea, p. 185. Bile, p. 233.

5. **Potash.**—Urates, distinguished from pus or phosphate, p. 350. Uric acid, from blood, p. 390. Sugar indicated by a brown colour, after prolonged boiling, p. 243.

6. **Nitrate of Silver.**—Precipitate of chloride of silver, insoluble in nitric acid, p. 167. In certain cases, the urine does not contain a trace of chloride of sodium, p. 202.

CHEMICAL EXAMINATION OF URINE.

1. *Chemical Examination with reference to Detecting the Nature of the Deposit.*

a. **Light and Flocculent Deposits** (pp. 116, 317).—Deposits of this class are generally too light, and the quantity is too small, for the application of chemical tests. *See* "Microscopical Examination of Deposits," p. 282.

b. **Dense and Opaque Deposits** (p. 350), usually present in considerable quantity, are of three kinds, which much resemble each other in appearance.

1. **Urate of Soda** (p. 351).—Lateritious, nut-brown sediment. Varies much in colour. Urine acid. *Tests.*—Soluble by heat, in potash, ammonia, water. Decomposed by acid; uric acid set free.

2. **Phosphates** (p. 355).—Urine usually alkaline or neutral. When triple phosphate alone is present, the urine is sometimes feebly acid. *Tests.*—Insoluble by heat or in alkalies; soluble in acids, and afterwards precipitated by ammonia.

3. **Pus** (p. 362).—Diffused through the urine, rendering it turbid, or forming a bulky creamy deposit, with clear or turbid supernatant fluid. *Tests.*—Rendered glairy by potash. Albumen in urine precipitated by heat and by nitric acid. *Caution.*—Albumen *may* be independent of the pus.

c. **Crystalline or Granular Deposits are usually in small quantity, forming a sediment which may either be coloured or transparent and colourless** (p. 350).

1. **Uric Acid** (p. 371).—Colour characteristic, usually of a dark mahogany brown, sometimes paler, very seldom quite colourless.

Large separate clusters of crystals. It rarely forms a granular deposit. *Tests*, p. 372.—Soluble in potash and nitric acid. After evaporation with nitric acid, ammonia gives the dark violet colour of murexide or purpurate of ammonia. Often mixed with blood, smoky urine. Albumen detected in the fluid, p. 347.

2. **Blood-corpuscles** (p. 387).—*See* "Microscopical Examination of Urinary Deposits," on p. 438.

3. **Oxalate of Lime** (p. 374).—Seldom in sufficient quantity to form a deposit visible to the unaided eye. *Tests*, p. 380.—Insoluble in water, potash, and acetic acid, even when boiled; soluble in mineral acids; and again thrown down amorphous, but unchanged in composition, by ammonia. By incineration, an odour like that of burnt feathers is evolved. Black ash becomes white by decarbonisation; this ash is soluble in acetic acid, with copious effervescence. Oxalate of ammonia added to acetic acid solution precipitates oxalate of lime.

4. **Silica** (p. 387) is said to have been found in very minute quantities in urine; rarely met with as a deposit, except in the form of grains of sand in the urine of hysterical patients and impostors. Easily known by its great density, general appearance, and insolubility in strong mineral acids.

2. *Chemical Examination with reference to the Discovery of an Abnormal Condition of the Soluble Constituents of the Urine, or of the existence of Substances of a Soluble Form not met with in Health*. Part III, p. 175.

1. **Albumen** (p. 220 *et seq.*).—Urine pale; often of very low specific gravity, 1,005 to 1,012 or 1,014. *Tests*, p. 220.—Heat or nitric acid, if urine be acid; nitric acid, if the urine be alkaline. Reason: solubility of albumen in alkalies. *Fallacies.*—A *trace of nitric acid* prevents the precipitation of albumen by heat, p. 223. Precipitation of phosphates by simply boiling the urine, p. 222. Precipitation of minute crystals of uric acid upon the addition of dilute nitric acid to some specimens of urine: hence necessity for employing both tests, p. 222. New substance allied to albumen, p. 226.

2. **Excess of Urea** (p. 185).—Urine frequently high coloured; specific gravity, 1,030 to 1,040. Upon the addition of an equal volume of strong nitric acid, crystals of nitrate of urea occur within half-an-hour, if there be much excess. Oxalic acid is often employed when the urea is to be determined quantitatively.

3. **Sugar** (p. 238).—Urine pale, of high specific gravity, from 1,030 to 1,050. Trommer's test, p. 243. Potash tests, p. 243. Fermentation test, p. 249. Tartrate of copper, p. 244. Brücke's test, p. 249. Bismuth test, p. 250.

4. **Sulphates** (pp. 165, 166, 206).—Nitrate of barytes or chloride of barium, after the addition of a few drops of nitric acid.
5. **Chloride of Sodium** (pp. 167, 200).—Nitrate of silver, after the addition of a few drops of nitric acid.
6. **Bile** (pp. 232—237).—Urine of a dark yellow colour. Nitric acid; play of colours. Pettenkofer's test, p. 234.

MICROSCOPICAL EXAMINATION OF URINARY DEPOSITS.

Part IV.

Great caution required in every step, p. 282. A large quantity of urine (at least four ounces) should be allowed to subside in a *conical glass*, figs. 1, 13, plates I, II, "Chemical and Microscopical Apparatus," for some (two or three) hours, or the greater portion of the urine may be poured off from the deposit, which may then be submitted to examination. In the last case, small bottles only need be taken to collect specimens; but, of course, no idea can be formed as to the relative amount of deposit present, p. 283. *Pipettes*, 'Apparatus,' fig. 7, pl. I. *Examination in cells or cages*, figs. 17, 18, 23, pls. II and III.

Insoluble matter may be—

1. Diffused through the urine, or it may form a visible deposit. When the insoluble matter has subsided, the deposit may assume one of three characters, p. 317.
2. It may occupy a large bulk, and present a flocculent appearance, p. 318; or—
3. It may form a dense, opaque, and abundant or scanty stratum, p. 350; or—
4. The deposit may be small in quantity, crystalline, consisting of sparkling colourless points, or of more or less coloured granules, p. 370.

All these characters may coexist in one deposit, in which case we observe three distinct strata, each of which must be *separately* submitted to microscopical examination. In many cases there are two distinct strata.

1. *Substances floating on the Surface of the Urine, or diffused through it, but not forming a visible Deposit*, pp. 297, 317.

"*Illustrations of Urinary Deposits*," pl. V.

a. Opalescence produced by urates, pp. 297, 350.
b. Opalescence produced by vibriones, p. 322.
c. Milk in urine, p. 298.
d. Chylous urine, p. 299.

2. *Deposit light and flocculent, occupying a considerable bulk*, p. 317.

"*Illustrations of Urinary Deposits*," pls. V to XVIII.

Always take specimens from the bottom of the glass for examination, as well as from the bulk of the deposit.

a. Simple mucus-corpuscles, p. 318, or with bladder or renal epithelium, p. 326. Cells sometimes tinged yellow with bile, p. 233.

b. Simple mucus, or epithelium with numerous small crystals of oxalate of lime entangled in it, p. 320.

c. *Casts.* Various forms of casts, pp. 339 *et seq.* *a.* Casts of medium diameter. *β.* Casts of considerable diameter. *γ.* Casts of small diameter, p. 341.

d. Spermatozoa, p. 329. Vibriones, p. 322. Torulæ, p. 323. Sarcinæ, p. 324.

e. Matters of extraneous origin, p. 293. Bed-flock: hair: feathers: dust. Fibres of deal; distinction from casts, &c., p. 295, pls. I to IV.

3. *Deposit dense, opaque, and abundant*, p. 317.

"*Illustrations of Urinary Deposits*," pls. XVIII to XXIII.

a. Urates. Amorphous deposit, p. 350.

b. Phosphates, p. 355. Phosphate of lime (amorphous), p. 356. Triple or ammoniaco-magnesian phosphate (crystalline), p. 355. Mixed with carbonate or oxalates.

c. Pus, p. 362. Characters. Potash. Acetic acid.

d. Matters of extraneous origin, pp. 293—296. Sand. Starch: potato: rice: bread-crumbs: arrowroot.

4. *Granular or Crystalline Deposits, small in Quantity, sinking to the Bottom, or adhering to the Sides of the Vessel*, p. 317.

"*Illustrations of Urinary Deposits*," pls. XXIV to XXXV.

a. Uric acid, p. 370. Forms of. Amorphous. Varies much in colour. Polarisation.

b. Oxalate of lime, p. 374. Forms of. Dumb-bells, p. 376. Distinction of oxalate of lime from triple phosphate.

c. Phosphate of lime, p. 356. Phosphate of lime, radiating crystals, p. 357.

d. Blood-globules, p. 387.

e. Cystine, p. 383. Carbonate of lime, p. 386.

f. Matters of extraneous origin, pp. 293—296.

TABLES

FOR

THE SYSTEMATIC QUALITATIVE EXAMINATION OF URINE.

*** ALL who desire to become practically familiar with the most important characters of the urine, are strongly recommended to submit to the routine which a conscientious practice of the experiments given in the following tables necessarily entails. The author is fully persuaded that the patient prosecution of the course recommended, for two hours on eight or ten occasions, will enable the practitioner to obtain a practical familiarity with the subject, which it is impossible he can acquire by reading only.

TABLE I.

GENERAL CHARACTERS OF URINE, p. 115.

Place about 100 grains of urine in a basin to evaporate over the water-bath.

1. COLOUR, SMELL, CLEARNESS OR TURBIDITY, DEPOSIT, FILM ON SURFACE.—Pour about four ounces of urine into a test-glass; take notice of its **colour** (p. 115), and **smell** (p. 115). Observe whether the specimen be **clear** or **turbid**, and notice the faint **mucous cloud** which collects on standing, p. 115. Observe whether there be any **deposit** which sinks to the bottom of the vessel, or **film** floating upon the surface of the fluid, pp. 116, 297.
2. SPECIFIC GRAVITY.—Take the **specific gravity** of the urine, p. 116.
   a. Using the *urinometer*, p. 93, figs. 13 and 14, pl. II, "Microscopical and Chemical Apparatus."
   β. Using the *specific gravity bottle*, p. 93, fig. 15, pl. II.
3. REACTION.—Test the urine with *blue litmus* paper, p. 117. If the specimen exhibit no **acid reaction**, test it with *reddened litmus*, and observe whether the colour be restored upon gently warming the paper upon a strip of glass, **volatile alkali** (p. 120), or not, **fixed alkali** (p. 121).
4. CRYSTALLINE SUBSTANCES IN URINE.—Place a drop of urine which has been *concentrated by evaporation* upon a glass slide, and cover it with thin glass. When cool, examine it under the microscope; note the form of crystals present, **urate of soda** (p. 195); **acid phosphate of soda** (p. 158); **basic phosphate of soda** (p. 159); **sulphate of soda** (p. 165); **chloride of sodium and urea** (pp. 133, 167); **ammoniaco-magnesian** or **triple phosphate** (p. 162); **granules of phosphate of lime** (p. 162). "*Illustrations of Urine*," pl. I, p. 130.
5. DECOMPOSITION BY HEAT.—Place a small portion of the *solid*

residue (about the size of a pin's head) in a hard glass tube, and expose it to the flame of a spirit-lamp, gradually raising the temperature to redness. Test the *reaction* of the vapour emitted from the tube with reddened litmus paper, which has been moistened. Ammonia evolved, p. 155.

6. SALINE CONSTITUENTS.—Remove the *carbonaceous residue* from the tube, and expose it upon platinum foil to a dull red heat, until nothing but a **white ash** remains, p. 155, "*Illustrations of Urine*," pl. I, fig. 2.

7. ALKALINE SALTS.—Place the ash upon a glass slide, and treat it with one drop of *distilled water*, applying warmth. Concentrate the aqueous solution by evaporation, and allow crystals to form. These should be covered with thin glass, and subjected to microscopical examination. **Chloride of sodium** (p. 167), **phosphate of soda** (p. 158), **sulphate of soda and potash** (p. 165), "*Illustrations of Urine*," pl. I, fig. 1.

8. EARTHY SALTS.—If the saline residue is not entirely dissolved by water, add a drop of nitric acid, and observe whether effervescence occurs, **carbonate of lime**, or if the *insoluble matter* is dissolved without the escape of any *bubbles of gas*, **phosphate of lime.**

9. URIC ACID.—Place about four ounces of urine in a beaker, add about a drachm of *hydrochloric acid*, and allow the mixture to stand for twelve hours. **Crystals of uric or lithic acid** (pp. 140, 371).

10. URIC ACID.—To a small quantity of the urine, concentrated by evaporation, and placed in a watch-glass, add a few drops of *acetic acid*, and insert in the mixture a few *filaments of tow or silk*. Allow the whole to stand for twenty-four hours, covered with a glass shade, in order to prevent the entrance of dust (p. 140). **Crystals of uric or lithic acid.**

*** The deposits from the urine examined in §§9 and 10 are to be examined in Table II.

TABLE II.

SYSTEMATIC QUALITATIVE EXAMINATION, p. 171.

THE ORGANIC CONSTITUENTS, p. 171.

11. REACTION.—SPECIFIC GRAVITY.—Ascertain the **reaction** and **specific gravity** of the specimen of urine, and take note of any general characters you may observe, p. 116.
12. PLACE two portions, A and B, of about 300 grains each, in basins, to evaporate over the water-bath, "Chemical and Microscopical Apparatus," figs. 4 and 9, pl. I.
13. IN PORTION A.—UREA, MUCUS, URIC ACID, EXTRACTIVE MATTERS, EARTHY PHOSPHATE, AND SILICA, p. 171.
14. IN PORTION B.—FIXED SALTS, p. 172.

B is to be placed in a *platinum capsule* and incinerated, "Chemical and Microscopical Apparatus," pl. I, fig. 3. The saline residue is to be maintained at a red heat, and, when decarbonised is to be preserved for examination in Table III.

Proceed with Portion A.

15. UREA $C_2H_4N_2O_2$—Extract A is to be treated with three successive portions of *alcohol*, about the *sp. gr.* ·825, which are to be boiled upon the residue for a few minutes over the *water-bath*. The alcoholic solutions are to be mixed together and concentrated by evaporation, p. 172. The extract is to be treated with a little *water*, in order that it may be reduced to the consistence of *syrup*, pp. 131, 185.

a. A little of the syrupy extract, when cold, is to be placed in a small basin, and treated with a few drops of strong *nitric acid*, **nitrate of urea** $C_2H_4N_2O_2,HO,NO_5$. Examine the crystals thus formed in the microscope, p. 132, "*Illustrations of Urine*," pl. III.

b. The remainder of the concentrated extract, C, is to be placed over a *water-bath*, conveniently arranged, and treated with *crystals of oxalic acid* until no more are dissolved at a temperature of 200°. The mixture is then permitted to cool; and, after the crystals have been slightly washed with a little distilled water, they may be placed between folds of filtering paper, **oxalate of urea** $C_2H_4N_2O_2,HO,C_2O_3$. Examine a few of the crystals in the microscope, "*Illustrations of Urine*," pl. IV, fig. 1. After having been well pressed, to absorb **extractive matters**, &c., the crystals are to be dissolved in *warm water*, and excess of **carbonate of lime** added to the solution, to decompose the **oxalate of urea** (p. 171). When the mixture becomes *neutral* to *test-paper*, it is to be filtered, and the clear solution, which consists of **urea,** with a little colouring matter, concentrated by evaporation. **Urea and colouring matter** remain. The latter may be removed by dissolving the urea in water, and boiling the solution with animal charcoal, and subsequent filtration, p. 171.

The process of filtering is seen in "Chemical and Microscopical Apparatus," pl. II, fig. 12; the manner in which the paper is folded, in pl. I, fig. 6. The wash-bottle for washing precipitates is represented in fig. 5.

16. MUCUS, URIC ACID, EARTHY PHOSPHATE, AND SILICA.—*The matter insoluble in alcohol*, D, p. 172, is to be treated with hot water, to dissolve extractive matter, and filtered.

The residue on the filter is to be dried and incinerated on platinum foil. The **mucus** and **uric acid** are destroyed.

When the residue, consisting of **phosphate of lime** and **silica** is decarbonised, it is to be treated with a drop of *nitric acid*. Observe whether effervescence occurs, **carbonate of lime** CaO,CO_2. A trace of **silica** remains undissolved, p. 172.

To the acid solution add a drop of *ammonia*, and note the result. Examine the precipitate in the microscope, and notice the crystals of **ammoniaco-magnesian** or **triple phosphate,** and the amorphous granules of **phosphate of lime** (p. 162), "*Illustrations of Urine*," pl. X, figs. 3 and 4.

17. URIC ACID, $C_{10}H_4N_4O_6$.—Examine with the microscope, the crystals deposited upon the sides of the vessel, and upon the filaments of *tow* or *silk* which were set aside in Table I, and note the form of the crystals, "*Illustrations of Urine*," pl. V, figs. 4, 5; "*Illustrations of Urinary Deposits*," pls. XXIV to XXXI. Then collect them upon a *glass slide*, and divide them into three portions.

a. To the **first** add a little *solution of potash*, which dissolves the crystals, forming **urate of potash,** and afterwards excess of *acetic* $C_4H_3O_3,HO$, or *hydrochloric acid* HCl. After a few minutes have elapsed, subject the deposit to microscopical examination. *Crystals of* **lithic or uric acid** $C_{10}H_4N_4O_6$, p. 140.

b. To the **second** portion add a drop of *nitric acid* HO,NO_5, evaporate the mass to dryness over the lamp, then allow it to cool, and add a little *ammonia* NH_3, or expose the acid residue to the vapour of ammonia. A beautiful purple colour, owing to the formation of **murexide** $C_{12}N_5H_6O_8$ results, p. 140, 1; p. 372.

c. To the **third** portion add solution of *carbonate of potash* KO,CO_2+2Aq, which will dissolve the uric acid $C_{10}H_4N_4O_6$, but more slowly.

TABLE III.

SYSTEMATIC QUALITATIVE EXAMINATION, p. 172.
THE SALINE CONSTITUENTS.

18. Alkaline and earthy salts.—Treat the residue resulting from the incineration of portion B with boiling distilled water and filter, p. 172; reserve the residue for subsequent operations (No. 23, below). Proceed with the *clear solution*, which is to be divided into two parts, one consisting of *three fourths* and the other of *one fourth*.

The *fourth part* of the solution is to be divided into three *equal portions* (No. 21.)

ALKALINE SALTS.

19. Sulphuric Acid.—To about three fourths of the clear solution add a few drops of *nitric acid* HO,NO_5, and observe if *effervescence* occurs, **carbonate of soda** $NaO,CO_2 + 10Aq$. Next add to the solution, placed in a flask and heated over a lamp, a small quantity of a solution of *chloride of barium*, $BaCl + 2Aq$. Boil the mixture and separate the precipitate by filtration. **Sulphate of Baryta** BaO,SO_3, p. 165.

While filtration is proceeding, pass on to No. 21.

a. A small quantity of the white precipitate of **sulphate of baryta** is to be boiled in *caustic potash*, and another portion in strong *nitric acid*. It is insoluble in both.

20. Phosphoric Acid.—The solution filtered from the precipitate produced by *chloride of barium* is to be treated with excess of *ammonia* NH_3 and the mixture rapidly filtered, *avoiding exposure to air* as much as possible. **Phosphate of baryta** $2BaO,HO,PO_5$, pp. 164, 172. *Concentrate* the clear solution by evaporation, and when reduced to a small bulk continue its further examination (No. 22).

21. Chlorine, Phosphoric Acid.—To the *first portion* add a few drops of *nitric acid* and excess of a solution of *nitrate of silver* AgO,NO_5, **chloride of silver** $AgCl$, p. 167. Filter. To the solution carefully add *ammonia*, avoiding an excess, **phosphate of silver** $3AgO,PO_5$. Then add more *ammonia*, and afterwards *nitric acid*, p. 173.

Phosphate of silver is soluble in *ammonia* and also in *nitric acid*.

Chloride of silver is soluble in *ammonia*, but insoluble in *nitric acid*.

a. PHOSPHORIC ACID *of the alkaline phosphates precipitated as* **ammoniaco-magnesian** or **triple phosphate.** To the *second* portion add a little of a solution of *muriate of ammonia* NH_4Cl, *ammonia* NH_3, and *sulphate of magnesia* MgO,SO_3. A precipitate of **phosphate of ammonia and magnesia** will take place, $2MgO,NH_4O,PO_5$. This is nearly insoluble in *ammoniacal salts*, p. 162.

b. PHOSPHORIC ACID *of the alkaline phosphate precipitated as* **phosphate of lime.** To the *third* portion of the clear solution add a little of a solution of *chloride of calcium* CaCl, and *ammonia* NH_3. **Phosphate of lime** $2CaO,HO,PO_5$ is precipitated.

Allow the two precipitates to subside, and then remove a little with the pipette and subject them to microscopical examination. **Phosphate of lime** prepared in this manner is amorphous, but the **ammoniaco-magnesian phosphate** is crystalline (p. 163), "*Illustrations of Urine*," pl. X, figs. 2, 3, 4.

22. POTASH, SODA.—Return to the examination of the solution obtained in No. 20, in which the presence of **potash** KO and **soda** NaO is to be demonstrated. Add it to an excess of *ammonia* NH_3, and carbonate of ammonia $2NH_4O,3CO_2$, in order to precipitate the excess of *baryta* BaO. Filter. Evaporate the solution to *dryness* and gently ignite the residue in a *platinum capsule.* Dissolve what remains in water, and add a few drops of solution of *bichloride of platinum* $PtCl_2$. Evaporate the mixture to dryness over the water bath, p. 173.

The *dry residue* is to be treated with successive portions of *alcohol.* **Potassio-chloride of platinum** $KCl,PtCl_2$ remains undissolved, p. 173.

The *alcoholic solution* is to be concentrated that crystals may form, **sodio-chloride of platinum** $NaCl,PtCl_2$. Examine both the crystalline deposits in the *microscope* under the influence of polarised light.

The crystals of **potassio-chloride of platinum** are *octahedral* and *do not* polarise, while the crystals of **sodio-chloride of platinum** are *acicular*, and *do* polarise.

EARTHY SALTS.

23. PHOSPHATE OF LIME, PHOSPHATE OF AMMONIA AND MAGNESIA.—Return to the examination of that portion of the saline residue insoluble in water (No. 18).

Add a few drops of *nitric acid* NO_5 to the residue, and notice if *effervescence* takes place, **carbonate of lime** CaO,CO_2. Dilute the solution and filter. Reserve any insoluble matter for further operations (No. 24).

a. To one portion of the clear solution add excess of *ammonia* NH_3, and examine the precipitate in the microscope. **Phosphate of lime** $8CaO, 3PO_5$, and **phosphate of ammonia and magnesia** $2MgO,NH_4O,PO_5+12Aq$, p. 162.

b. LIME, MAGNESIA.—To another portion of the acid solution add *ammonia* NH_4O, and afterwards excess of acetic acid $C_4H_3O_3$ HO, and then *oxalate of ammonia* NH_4O,C_2O_3+Aq, **oxalate of lime** CaO,C_2O_3. Boil and filter, pp. 169, 172.

Concentrate the clear solution by evaporation. When cold, add a little solution of *chloride of ammonium* NH_4Cl, and phosphate of soda $2NaO,HO,PO_5+24Aq$. Well stir the mixture, and examine the crystalline deposit in the microscope. **Triple** or **ammoniaco-magnesian phosphate** $2MgO,NH_4O,PO_5+12Aq$. "*Illustrations of Urine*," pl. X, figs. 2, 3, 4. "*Illustrations of Urinary Deposits*," pls. XIX to XXII.

24. SILICA.—That portion of the *earthy salts* insoluble in water is to be boiled with a few drops of strong *nitric acid* HO,NO_5, silica SiO_2 remains undissolved, p. 172.

IN THE SYSTEMATIC QUALITATIVE EXAMINATION OF HEALTHY URINE, commenced in Table II, the presence of the following substances has been demonstrated :—

In portion A,

Urea	**Mucus**	**Earthy Phosphates**
Uric acid	**Extractive matters**	**Silica**

In portion B,

Chlorine	**Potash**	**Magnesia**
Sulphuric acid	**Soda**	**Silica**
Phosphoric acid	**Lime**	

See also forms in p. 174.

TABLE IV.

SUBSTANCES HELD IN SOLUTION IN MORBID URINE.

Part III, p. 219.

EXCESS OF UREA, ALBUMEN, BILE.

25. ASCERTAIN the *reaction* and *specific gravity* of the specimens of urine marked A, B, C, D.

26. ALBUMEN.—Boil a portion of the urine in a test-tube over a *spirit-lamp* and observe the character of the precipitate, if one is formed, p. 221.

a. Treat a **second** portion with about ten drops of nitric acid, p. 221.

If no precipitate is produced upon the addition of nitric acid, or upon the application of heat, pass on to No. 27.

b. A **third** portion to be treated with half its bulk of *strong nitric acid*, and boiled.

c. To a **fourth** portion add two drops of very *dilute nitric acid*, and afterwards boil.

A very dilute solution of nitric acid prevents the precipitation of albumen by heat, p. 223.

d. A **fifth** portion is to be treated with a little *acetic acid* $HO,C_4H_3O_3$, and afterwards a solution of *ferrocyanide of potassium* $K_2,FeCy_3+3Aq$ is to be added.

e. To a **sixth** portion add a solution of *bichloride of mercury* $HgCl_2$, p. 225.

27. EXCESS OF UREA $C_2H_4N_2O_2$.—Add to the specimen of urine suspected to contain excess of *urea* from its deep colour and high specific gravity, about half its bulk of *nitric acid* HO,NO_5. Allow it to stand for a few minutes, and examine in the microscope the crystalline deposit which forms **nitrate of urea** $C_2H_4N_2O_2,HO,NO_5$, p. 185.

28. SUGAR.—*a.* A **portion** of the urine suspected to contain sugar is to be boiled in a test tube with half its bulk of solution of *potash* KO,HO [*Moore's test*]. If it becomes of a dark reddish brown colour from the formation of *melassic* or *sacchulmic acid*, it is to be treated with excess of *nitric acid*, when the peculiar odour resembling that of *molasses* will be produced, and the dark brown solution will become perfectly clear, p. 243.

b. A **second portion** is to be treated with one or two drops of a solution of *sulphate of copper* CuO,SO_3+5Aq, and afterwards a considerable excess of *potash* KO,HO is to be added. The *dark blue solution* is then to be heated over the spirit-lamp and boiled for a moment, when a yellowish brown **precipitate** of *suboxide of copper* Cu_2O, will be produced [*Trommer's test*], p. 243.

c. A **third portion** is to be heated with about an equal bulk of the solution of *tartrate of copper* in *potash*, **Barreswil's solution**, p. 245.

d. **Fermentation.**—Fill one of the tubes placed on the table with urine, and the other with water, to each add six drops of *yeast*, and then add a little more urine and water, in order that the fluids may rise above the brim of the tubes. Apply the *india-rubber pad*, and invert them in the small beakers. Pour in some mercury, and remove the india-rubber. Place the whole in a temperature of 80°, and, after the lapse of two hours, compare the size of the bubbles of gas in the respective tubes, pp. 249 and 251.

e. **Crystals.**—Allow a few drops of diabetic urine to evaporate spontaneously on a glass slide, and examine the residue on the next day to see if crystals have formed, "*Illustrations of Urine*," p. 242, pl. XII, figs. 1 and 2.

29. **Bile.**—*a.* One portion of the urine is to be placed in a test-tube, and after the addition of one drop of *syrup*, two thirds of the bulk of strong *sulphuric acid* SO_3HO are to be added *cautiously by drops.* Shake the mixture, and allow it to stand for a few minutes. If sufficient heat is not produced by the addition of the acid, warm the tube slightly over the lamp. The mixture becomes of a *dark violet colour*, which, however, is destroyed by a temperature little above 140° [*Pettenkofer's test*], p. 234.

b. Pour a few drops upon a *clean white plate*, and after spreading it over the surface, allow a drop of *nitric acid* to fall in the centre. Observe the **play of colours** (p. 233, *a*).

c. To another portion add a few drops of *serum*, and, after agitation, a little *nitric acid* NO_5, HO. Observe the colour of the coagulated albumen [*Heller's test*], p. 233.

TABLE V.

CHEMICAL EXAMINATION OF URINARY DEPOSITS.
II.—SECOND CLASS OF URINARY DEPOSITS, p. 350.
PUS, URATES, PHOSPHATES, pls. XVIII to XXIII.

30. OBSERVE the character of the urinary deposits in the glasses A, B, C, and note the *colour*, *reaction*, and *specific gravity* of each specimen.

31. AFTER having poured off the *supernatant fluid*, take about *one fourth* of the *deposit* from each glass, and pour it into a test-tube. Add to it about half its bulk of *solution of potash* KO,HO.

Pus is rendered *transparent*, *viscid*, and *glairy* by *potash*, p. 350.
Urates dissolved by *potash*. Solution *clear* and *limpid*.
Phosphates are not affected by *potash*.

32. URATES OR LITHATES.—If the deposit be soluble in *potash* KO, and is not rendered *glairy*, take another portion and heat it in a clean test-tube with a little water, p. 350. It will be *dissolved* upon the application of a *gentle heat*, and will be *precipitated* again when the solution becomes *cool*. Another portion may be dissolved in *potash* KO, and then excess of hydrochloric acid HCl, or acetic acid $C_4H_3O_3$,HO, added. After the lapse of *ten* or *twelve hours* the deposit, consisting of **uric acid** $C_{10}H_4N_4O_6$, may be subjected to *microscopical examination*, or tested in the manner described in No. 17, *a*, *b*, p. 443.

33. PUS.—If the deposit be rendered *glairy* by *potash* KO, note carefully its *microscopical characters* under the quarter of an inch object glass, and then add a drop of *acetic acid* $C_4H_3O_3$HO, and observe the change which takes place in the appearance of the corpuscles. Notice if any crystals of *triple phosphate* 2MgO,NH_4O, PO_5 + 18Aq are present in the deposit, and observe the character of any *epithelium* that may be met with, p. 363.

A small portion of the supernatant fluid is to be treated with *nitric acid* HO,NO_5, and another portion boiled in a test-tube. The precipitates consist of **albumen**, p. 363.

34. EARTHY PHOSPHATES.—If the deposit consists of earthy phosphates, it will not be altered by *potash* KO, nor by the *application of heat*. A portion of it is to be treated with *nitric acid* HO,NO_5, in which it is soluble without effervescence.* Observe its microscopical characters, p. 356. If there are no well-defined crystals dissolve a portion in dilute *nitric acid*, and then add excess of *ammonia*. Upon microscopical examination the precipitate will be found to consist of feathery crystals of **triple phosphate** and granules of **phosphate of lime**, pp. 161, 162. *See* pls. XIX to XXII, pl. XXXII, figs. 178, 179,* 180, 181.

* If effervescence occurs upon the addition of nitric acid, it probably depends upon

III.—THIRD CLASS OF URINARY DEPOSITS,

p. 370, pls. XXIV to XXXV.

URIC OR LITHIC ACID, OXALATE OF LIME, SAND.

35. OBSERVE the character of the *deposits* in the glasses D, E, F, and note the *colour*, *reaction*, and *specific gravity* of the fluid in each case.

36. IF THE DEPOSIT is very small in quantity, remove it in the manner described in p. 284, and place it in a small watch-glass or in the cell, pp. 283, 284, 'Apparatus,' pl. II, fig. 18.

Uric or **lithic acid** is dissolved by *potash*, while **oxalate of lime** and **sand** are not affected by this reagent. **Oxalate of lime** is insoluble in *acetic acid* and *potash*, but is dissolved by *nitric acid.* **Sand** is not affected by *potash*, nor by strong *nitric acid.*

37. URIC OR LITHIC ACID $C_{10}H_4N_4O_6$.—If the deposit is soluble in potash KO, treat a portion of it with nitric acid HO,NO_5, upon a glass slide, and carefully evaporate it to dryness over the *spirit-lamp.* When cool, expose the residue to the vapour of ammonia, or add to it a drop of that reagent. The beautiful purple colour which results depends upon the formation of murexide $C_{12}N_5H_6O_8$, pp. 140, 372. "*Illustrations of Urine*," pl. V, figs. 4, 5 ; "*Urinary Deposits*," pls. XXIV to XXX.

38. OXALATE OF LIME CaO,C_2O_3+2Aq.—If the deposit is insoluble in *potash* KO, and also in acetic acid $C_4H_3O_3,HO$, but is dissolved by nitric acid HO,NO_5, collect a portion of it upon a filter, and after having been well washed, let it be *dried* and carefully incinerated on *platinum foil.* To the *white ash* add a drop of *acetic acid*, and note the result. Examine a portion of the *original deposit* in the microscope, p. 375. "*Illustrations of Urinary Deposits*," pls. XXXI to XXXIII.

Oxalate of lime is decomposed, at a dull red heat, into **carbonate of lime** CaO,CO_2.

39. SAND.—If the deposit is insoluble in *potash* KO,HO, *acetic acid* $C_4H_3O_3,HO$, *nitric acid* HO,NO_5, boil it in strong *nitric acid* and examine it under the microscope.

the presence of carbonate of ammonia, resulting from the decomposition of urea, a change very liable to occur in disease of the bladder, in which case the mucus appears to act the part of a *ferment.*

TABLE VI.

THE EXAMINATION OF SMALL QUANTITIES OF DEPOSITS.

URINARY CALCULI.

1. *Calculi which are not destroyed by a red heat.*

Incombustible Calculi.

Phosphate of lime $8CaO,3PO_5$; **phosphate of ammonia and magnesia** or **triple phosphate** $2MgO,NH_4O,PO_5$; **fusible calculus consisting of a mixture of phosphate of lime and triple phosphate.**

2. *Calculi which are partially decomposed, or entirely destroyed by a red heat.*

Combustible or partially Combustible Calculi.

Uric or lithic acid $C_{10}H_4N_4O_6$; **urate or lithate of ammonia** $NH_4O,C_{10}H_4N_4O_6$; **urate of lime** $CaO,C_{10}H_4N_4O_6$; **oxalate of lime** $CaOC_2O_3$; **cystine** $C_6NH_6O_4S_2$.

If the calculus consists of several different layers, a portion from each layer should be finely powdered and examined separately.

MICROSCOPIC CALCULI.—*Calculi*, pls. II, III.

40. URINARY CALCULI.—Heat a portion of the calculus, about the size of a pin's head, on *platinum foil*, over the spirit-lamp. Expose the *black ash* thus obtained for some time to a *dull red heat* until the residue becomes *white*. If there should be *no fixed residue* pass on to No. 44.

Calculi which leave a Fixed Residue.

41. FUSIBLE CALCULUS.—The white ash is to be exposed to the heat of the blow-pipe flame. Observe if it be fusible or infusible.

42. PHOSPHATE OF LIME, AMMONIACO-MAGNESIAN PHOSPHATE.—The ash is to be dissolved in dilute *hydrochloric acid* HCl,HO. If *effervescence* occurs upon the addition of the acid pass on to No. 43. Neutralise with *ammonia* NH_3. Examine the precipitate in the microscope, p. 413.

a. *Carbonate of lime* results from the decomposition of *oxalate of lime*, **mulberry calculus**, at a red heat.

43. OXALATE OF LIME.—If effervescence occurred upon the addition of the *acid*, the solution is to be neutralised with *ammonia*, and afterwards excess of *acetic acid* added. To the solution add oxalate of ammonia NH_4O,C_2O_3+Aq, **oxalate of lime** Ca,OCO is thrown down. This is insoluble in *potash* KO,HO, and in acetic acid $HO,C_4H_3O_3$, p. 410.

Calculi which leave scarcely a trace of Fixed Residue.

44. URATE CALCULUS.—A small portion of the calculus finely powdered is to be treated with hot water. If soluble in that fluid a strong solution of *carbonate potash* is to be added, and the tube heated over the lamp. Ascertain the reaction of the fumes which are given off. Notice their smell, and hold a glass rod which has been dipped in hydrochloric acid over the mouth of the tube, p. 408.

45. URIC ACID CALCULUS.—If *insoluble in water* also add a little *potash*. If soluble in the last reagent, treat another portion of the calculus with *nitric acid and ammonia*, as described in No. 17, *b*. This test may also be applied in the case of a calculus supposed to consist of urate of ammonia, p. 406.

METHOD OF TESTING VERY SMALL QUANTITIES OF MATTER WITH REAGENTS KEPT IN SMALL BOTTLES WITH CAPILLARY ORIFICES, pl. II, figs. 16, 19.

46. PHOSPHATE OF LIME, CHLORIDE OF SODIUM, PHOSPHATE OF SODA, SULPHATE OF POTASH.—What is the nature of the substance upon the glass slides marked A, B? Test it with such reagents as you think requisite.

What substances are dissolved in the drops of water marked C, D, E?

TABLE VII.

MICROSCOPICAL EXAMINATION OF URINARY DEPOSITS, p. 282.

Insoluble matters and urinary deposits (p. 282 to p. 396).

INSOLUBLE MATTERS may be divided into four classes, p. 290 :—

1. INSOLUBLE MATTER FLOATING UPON THE SURFACE OF URINE, OR DIFFUSED THROUGH THE FLUID, p. 297.

2. LIGHT AND FLOCCULENT DEPOSITS, TRANSPARENT AND OCCUPYING CONSIDERABLE BULK, p. 318.

3. DENSE AND OPAQUE DEPOSITS, OCCUPYING CONSIDERABLE VOLUME, p. 350.

4. GRANULAR OR CRYSTALLINE DEPOSITS SINKING TO THE BOTTOM OR DEPOSITED UPON THE SIDES OF THE VESSEL, p. 370.

Many of the most important urinary deposits are scarcely visible to the unaided eye, and can only be detected by careful microscopical examination.

For collecting urine for microscopical examination, *see* p. 282.

In examining a specimen of urine the microscopical characters of the *pellicle* upon the surface of any *insoluble matter* diffused through the fluid, as well as those of the *deposit*, should be noticed. In many instances also it is necessary to examine the *deposit* in its *upper* part as well as that portion which sinks to the bottom of the vessel.

It is most important to be acquainted with the characters of those *extraneous matters* which are liable to fall into the urine accidentally, or which may have been placed there for the purpose of deceiving the practitioner. These are enumerated in pp. 293—297.

The *chemical reagents* required for examination are contained in the small *bottles with capillary necks.* "Chemical and Microscopical Apparatus," pl. II, figs. 16, 19.

47. With the *pipette*, p. 93, remove a portion of deposit from the urine in the different conical glasses, "*Chemical and Microscopical Apparatus*," pl. I, fig. 1, pl. II, fig. 13, and place it upon a glass slide or in a thin glass cell or in the animalcule cage, pl. II, figs. 17, 18, pl. III, fig. 23, and when carefully covered with thin glass, subject it to examination with the quarter of an inch object glass, p. 284.

What is the nature of the **urinary deposits** in the glasses numbered from 1 to 6, and the **extraneous matters** in glasses 7 to 12 ?*

* The nature of the substances placed in the glasses is seen by reference to the following sections. They must be prepared beforehand by the teacher.

1. *Diffused through the urine, and not forming a distinct deposit; or, forming a thin stratum or pellicle upon the surface of the urine.*

48. **Urates** (p. 351). "*Illustrations of Urinary Deposits,*" pl. V, figs. 25, 27, pls. XVIII, XIX.

Fatty matter in a state of *extremely minute division,* as it occurs in *chylous urine,* p. 299. "*Illustrations of Urinary Deposits,*" pl. V, fig. 26.

Vibriones, usually present only in urine which has been kept for some time, but occasionally found soon after the urine has been passed, p. 322. "*Illustrations of Urinary Deposits,*" pl. VI, figs. 32 to 38.

49. **Film** composed of **phosphate of lime** and **ammoniaco-magnesian** or **triple phosphate,** not unfrequently containing **oil-globules** (pp. 297, 313).

Torulæ occurring in *diabetic urine,* pp. 243, 323.

2. *First Class of Urinary Deposits,* p. 318.

50. **Mucus.** "*Illustrations of Urinary Deposits,*" pl. VI, fig. 31.

Epithelium—from the *convoluted portion* of the uriniferous tubes; from the *straight portion;* from the *pelvis of the kidney;* from the *ureters;* from the *bladder;* from the *urethra,* p. 327; from the *vagina,* p. 328; epithelium containing *oil,* "*Illustrations of Urinary Deposits,*" pl. VIII.

Spermatozoa. "*Illustrations of Urinary Deposits,*" pls. X and XI, figs. 69 to 76, p. 329.

Vibriones. "*Illustrations of Urinary Deposits,*" p. VI, figs. 32—38.

Torulæ—*sugar torula; penicillium glaucum,* p. 323. "*Illustrations of Urinary Deposits,*" pl. VI, figs. 39—42. "*Illustrations of Urine,*" pl. XI, figs. 1, 2, and 3, p. 323.

Sarcina (pl. 324), "*Urinary Deposits,*" pl. VII, figs. 53, 54.

Casts of the uriniferous tubes (p. 339) *of medium diameter, about the* 1-700*th of an inch,* p. 342.

Epithelial casts. Pale and slightly *granular* casts. *Granular* casts. Casts containing *pus, blood, crystals of oxalate of lime,* or *lithic acid.* Casts containing *oil,* p. 343. "*Illustrations of Urinary Deposits,*" pl. XI, fig. 78; pl. XIII, fig. 86; pl. XVI, fig. 90.

Casts of considerable diameter, about 1-500*th of an inch.*

Large and perfectly *transparent* casts. *Darkly granular* casts. Casts containing numerous *cells,* often enclosed, as it were, in a perfectly transparent tube, p. 344. "*Illustrations of Urinary Deposits,*" pl. XI, figs. 77, 79; pl. XII, fig. 83; pls. XIII, XIV, XV.

Casts of small diameter, about the 1-1000*th of an inch.*

Small waxy casts, perfectly clear in every part, or slightly granular in some places, p. 345. "*Illustrations of Urinary Deposits,*" pl. XI, fig. 78A; pl. XII, fig. 83; pl. XV.

3. *Second Class of Urinary Deposits*, p. 350.

Urate of soda with various colouring matters, red, pink, nut-brown, &c., with small quantities of **urates of ammonia, lime, and magnesia** (p. 351). "*Illustrations of Urinary Deposits*," pl. V, figs. 25, 27, pls. XVIII, XIX.

Pus (p. 362). "*Urinary Deposits*," pl. XXIII.

Phosphates, consisting of **phosphate of lime** and **phosphate of ammonia and magnesia** or **triple phosphate** (pp. 355 and 356). "*Illustrations of Urinary Deposits*," pl. XIX, figs. 106, 107, 108; pls. XX, XXI, XXII.

4. *Third Class of Urinary Deposits*, p. 370.

Uric or **lithic acid** in various forms, p. 371. "*Illustrations of Urinary Deposits*," pls. XXIV to XXX. "*Illustrations of Urine*," pl. V, figs. 4, 5.

Oxalate of lime occurring in the form of *octahedra*, p. 374, or of *dumb-bells*, p. 376. "*Urinary Deposits*," pls. XXXI to XXXIII.

Cystine (p. 383). "*Illustrations of Urine*," pl. XII, fig. 6. "*Urinary Deposits*," pl. XXXIV.

Carbonate of lime (p. 386).

Blood corpuscles (p. 387), "*Urinary Deposits*," pl. XXXIV.

51. The most Important Extraneous Matters accidentally present in the urine, or which are sometimes added for the purposes of deceiving the practitioner, are the following, p. 293, "*Illustrations of Urinary Deposits*," pls. I to IV.

Human hair (p. 294). "*Urinary Deposits*," fig. 2, pl. I.

Cat's hair. "*Urinary Deposits*," fig. 3, pl. I.

Blanket hair. "*Urinary Deposits*," fig. 1, pl. I.

Worsted.

Wool.

Cotton and flax fibres. "*Urinary Deposits*," figs. 6, 7, pl. II.

Splinters of coniferous wood swept from the floor. "*Urinary Deposits*," fig. 9, pl. II.

Portions of feathers, fig. 8, pl. II.

Fibres of silk. "*Urinary Deposits*," fig. 4, pl. I.

Milk and certain colouring matters. "*Urinary Deposits*," fig. 19, pl. IV.

Oily matter. "*Urinary Deposits*," fig. 20, pl. IV.

Potato-starch. "*Urinary Deposits*," fig. 11, pl. III.

Wheat-starch. "*Urinary Deposits*," fig. 12, pl. III.

Rice-starch. "*Urinary Deposits*," fig. 13, pl. III.

Tea-leaves. "*Urinary Deposits*," fig. 17, pl. IV.

Bread-crumbs. "*Urinary Deposits*," fig. 15, pl. III.

Chalk or **whiting.**

Sand.

Peroxide of iron (p. 293).

BRITISH WEIGHTS AND MEASURES.

TROY OR APOTHECARIES' WEIGHT.

Pound.		Ounces.		Drachms.		Scruples.		Grains		French Grammes.
1	=	12	=	96	=	288	=	5760	=	372·96
		1	=	8	=	24	=	480	=	31·08
				1	=	3	=	60	=	3·885
						1	=	20	=	1·295
								1	=	0·0647

AVOIRDUPOIS WEIGHT.

Pound.		Ounces.		Drachms.		Grains.		French Grammes.
1	=	16	=	256	=	7000	=	453·25
		1	=	16	=	437·5	=	28·328
				1	=	27·343	=	1·77

IMPERIAL MEASURE.

Gal.		Pints.		Fl. ounces.		Fl. drms.		Minims.
1	=	8	=	160	=	1280	=	76800
		1	=	20	=	160	=	9600
				1	=	8	=	480
						1	=	60

WEIGHT OF WATER AT 62°, CONTAINED IN THE IMPERIAL GALLON, &c.

		Grains.
1 Imperial Gallon	=	70000
1 ,, Pint	=	8750
1 ,, Fluid ounce	=	437·5
1 ,, Fluid Drachm	=	54·7
1 ,, Minim	=	0·91

CUBIC INCHES CONTAINED IN THE IMPERIAL GALLON, &c.

		Cubic Inches.
1 Imperial Gallon	=	277·276
1 ,, Pint	=	34·659
1 ,, Fluid Ounce	=	1·732
1 ,, Fluid Drachm	=	0·2166
1 ,, Minim	=	0·0036

FRENCH WEIGHTS AND MEASURES.

MEASURES OF LENGTH.

		English Inches.		Mil.	Fur.	Yds.	Feet.	In.
Millimetre	=	·03937						
Centimetre	=	·39370						
Decimetre	=	3·93707						
Metre*	=	39·37079						
Decametre	=	393·70790	=	0	0	10	2	9·7
Hectometre	=	3937·07900	=	0	0	109	1	1
Kilometre	=	39370·79000	=	0	4	213	1	10·2
Myriametre	=	393707·90000	=	6	1	156	0	6

* The metre is a ten-millionth part of a quadrant of a meridian circle of the earth.

MEASURES OF CAPACITY.

		Cubic Inches.		English Imperial Measure. Gal.	Pts.	F. oz.	F. drm.	Min.
Millilitre		·06102	=	0	0	0	0	16·3
Centilitre	=	·61024	=	0	0	0	2	42
Decilitre	=	6·10240	=	0	0	3	3	2
Litre*	=	61·02400	=	0	1	15	1	43
Decalitre	=	610·24000	=	2	1	12	1	16
Hectolitre	=	6102·40000	=	22	2	1	4	48
Kilolitre	=	61024·00000	=	220	0	12	6	24
Myrialitre	=	610240·00000	=	2200	7	13	4	48

MEASURES OF WEIGHT.

		English Grains.		*Avoirdupois.* Pound.	Ounce.	Drachms.
Milligramme	=	·0154				
Centigramme	=	·1543				
Decigramme	=	1·5432				
Gramme†	=	15·4323				
Decagramme	=	154·3234	=	0	0	5·65
Hectogramme	=	1543·2348	=	0	3	8·5
Kilogramme	=	15432·3480	=	2	3	5
Myriagramme	=	154323·4800	=	22	1	2

COMPARISON OF FRENCH OR ENGLISH WEIGHTS.

1 Gramme	= 15·432348	grains.
2 Grammes	= 30·864696	,,
3 ,,	= 46·297044	,,
4 ,,	= 61·729392	,,
5 ,,	= 77·161740	,,
6 Grammes	= 92·594088	grains.
7 ,,	= 108·026436	,,
8 ,,	= 123·458784	,,
9 ,,	= 138·891132	,,
10 ,,	= 154·323480	,,

To reduce Grammes to Grains.
Log. Grammes + 1·188432 = log. Grains.

To reduce cubic Centimetres to cubic Inches.
Log. cubic Centimetres + (—2·7855007) = log. cubic Inches.

To reduce Millimetres to Inches.
Log. Millimetres + (—2·5951663) = log. Inches.

To convert Grains into Grammes.
Log. Grains + (— 2·8115680) = log. Grammes.

To convert cubic Inches into cubic Centimetres.
Log. cubic Inches + 1·2144993 = log. cubic Centimetres.

To convert Inches into Millimetres.
Log. Inches + 1·4048337 = log. Millimetres.‡

* The capacity of a litre is that of a cube of a decimetre in the side.

† The weight of a gramme is that of a cubic centimetre of distilled water at 39·2 Fahr.

‡ From Miller's "Elements of Chemistry," vol. III.

INDEX.

CORRECTIONS.

On page 70 it is stated that Dr. Dickinson considers that amyloid deposit affects the small arteries before other parts, but since this was written he has told me that he agrees with Dr. Grainger Stewart in considering that the thickening of the capillaries of the Malpighian bodies precedes that of the small arteries. In the specimens I have examined I was led to conclude that the intertubular capillaries as well as the loops of the Malpighian body underwent the change in question before any alterations commenced in the coats of the small arteries.

Page 330, line 8, for *preparation* read *preservation*.

Page 335 In addition to the remarks made by the Rev. E. Thring, the following should have been introduced:—"I perfectly well knew of the existence of a sensual immoral set at Eton, but that innocent boys got on well enough, and were not exposed to corrupting influences unless they liked."

Page 378, line 9, for pl. *XXXIII*, fig. 181, read pl. *XVII*, fig. 96.

HARRISON AND SONS, PRINTERS IN ORDINARY TO HER MAJESTY, ST. MARTIN'S LANE.