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On the microscopic structure of urinary calculi of oxalate of lime.

BIBLIOTECA LANCISIANA S. SPIRITUS IN SAXIA

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(With Plates II—VI.)

Synopsis.—The chief macroscopic forms of urinary calculi composed of oxalate of lime.—The variations which oxalate of lime may present in the urine and under conditions outside the body.—The detailed microscopic description of the calculi, with remarks where indicated.—The general structure of the nucleus, and its comparison with natural and artificially produced elements.—The general structure of the body of the calculus, and its comparison with natural and artificially produced elements.—The structure of the calculi as a whole, and the relationship of the microscopic to the macroscopic forms.—The coloration of calculi of oxalate of lime.—Note of previous observations by others, and bibliography.

In this paper we devote our attention to calculi composed exclusively of oxalate of lime, or of oxalate of lime with as little admixture of other constituents as occurs in the purer calculi of the kind.

In the human subject calculi of oxalate of lime appear under four chief macroscopic forms.

In one (Fig. 1) they are remarkably smooth, and when dried present a highly glazed or polished surface.

Such calculi, indeed, are the smoothest of all urinary calculi met with in the human subject, whatever be their composition.

The best examples of this kind occur in the pelvis of the kidney and in cysts in the renal substance, and they vary from the size of hemp-seed or less up to that of haricot beans. They are commonly of flattened oval form or remarkably spherical, but at times present facets, arising from their having grown whilst in more or less immoveable apposition; in colour they are usually of a pale ashy grey, light yellow, or reddish brown.

It is seldom that calculi taken from the bladder exhibit the same

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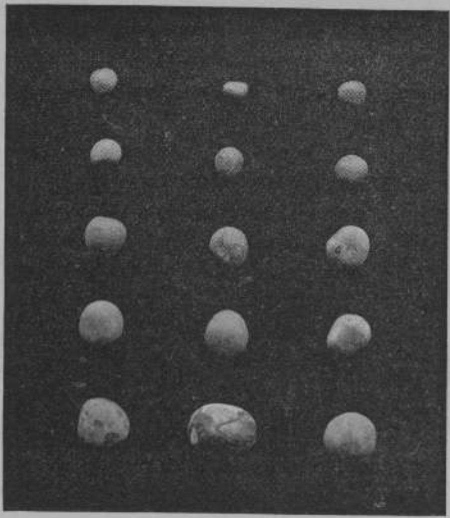
smoothness and regularity of form, although, of course, small calculi of such a kind formed in the renal pelvis would, imme-

FIG. 1.



Some of a small collection of smooth facetted calculi of nearly pure oxalate of lime, which were taken from the kidney after death. Their surfaces are highly polished.

diately after their descent into the bladder, present similar appearances.

Vesical calculi of this character are not of any magnitude (*e. g.* c. 84, c. 86, c. 124, Museum of the Royal College of Surgeons, London).

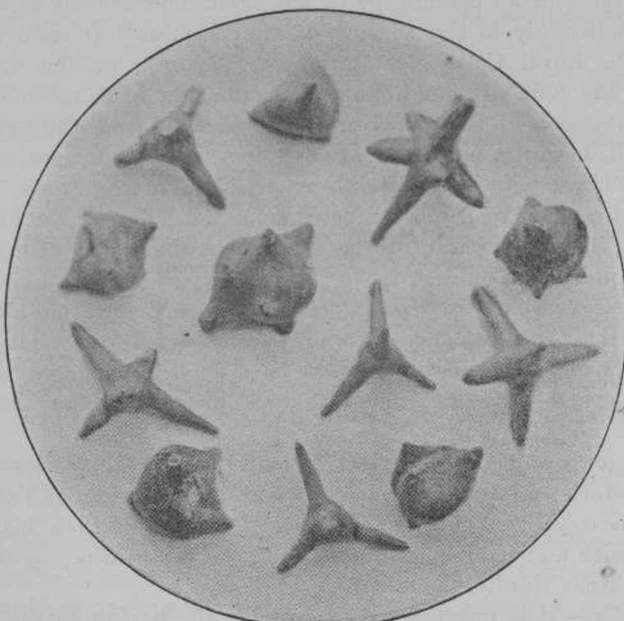
The second variety of oxalate calculus has, in its most pronounced form, a notably irregular tuberculated figure; and is, as contrasted with the foregoing, the roughest and the most irregular of all known kinds of urinary calculi. This is the most common met with in the urinary bladder.

But that small calculi of similar shape are formed in the pelvis and calyces of the kidney is shown by their being voided after renal colic. We have examined by microscopic section typical examples of this nature. When not encrusted with phosphates the calculus is commonly of a reddish-brown or sepia colour. The tuberculated surface and the deep colour of these have conferred on them the title of "mulberry calculus." But the colour varies, whether at the surface or in section, within wide limits, between deep blackish brown and the palest grey or even white. The degree of tuberculation varies; in the least pronounced degree the general contour is merely granulated.

The other two forms are of rarity but of interest.

In one (Fig. 2), from different parts of the surface of a calculus otherwise smooth, there project sharp thorny processes or spines in

FIG. 2.



A collection of twelve markedly spinous calculi (natural size) taken from the pelvis of the kidney of a woman who died of cancer of the uterus. (Jeremiah McCarthy, Esq., Mus. Coll. Surgeons.)

varying numbers of one and upwards. Calculi presenting this form are sometimes quite minute. Examples of such have been found in the renal pelvis, in cysts of the kidney, and in the bladder.

In the fourth and last form the surface is brilliantly crystalline, formed by large uncoloured octahedral crystals of oxalate of lime. Small calculi, of which we have examples passed after attacks of renal colic, are sometimes constructed solely of such an aggregation of brilliant flattened crystals, forming a peculiarly sharply pointed concretion.

Calculi presenting such a crystalline surface are not, however, always crystalline throughout. It is not rare to see typical mulberry calculi sparkling with small octahedra of oxalate of lime; and calculi of other composition (as urate of ammonia), when encrusted with oxalate of lime, may present a similar appearance. The deposit under such circumstances "sometimes presents the appearance of an assemblage of fine crystalline needles arranged perpendicularly to the surface of the calculus" (Catalogue of Calculi, Royal College of Surgeons, London); or the deposit takes the form of crystalline plates radiating from the nucleus, the outer ends of the plates projecting sharply from the surface. Calculi, however, composed exclusively of crystals do not, so far as our observation goes, attain any considerable magnitude. The largest we have seen was extracted from the pelvis of the kidney during life, and was of a flattened, somewhat triangular form, three quarters of an inch along its side; save for a small amount of amorphous white deposit (phosphate of lime) lying in the interstices, this calculus is wholly constructed of uncoloured crystals of oxalate of lime, which have an ill-pronounced radial arrangement. No ammonia-magnesia phosphate was present in it.

We propose in the next place to notice briefly the variations in form which oxalate of lime may present in the urine, and under various conditions outside the body. In the urine these may be dealt with under three headings: first, the octahedron; secondly, the sphere; thirdly, the tablet.

Firstly.—It is unnecessary to describe the perfect octahedron, but it is important in regard to future remarks to note some of its modifications.

The more important of these consist, first, in its flattening, either by a depression of the two pyramids composing it, the two apices being approximated; or, secondly, in a change in the proportion of the facets, some of which become relatively so large that the crystal as a whole is flattened, and suggests at first sight the rhombohedral form: the enlargement affects opposite faces in diagonally corresponding portions of the pyramids. Thirdly, the "macle" is a form in which the apposed bases are rotated so that the angles of one pyramid project across the sides of the base of the other, giving rise to an eight-pointed star; the apices of the pyramids are usually depressed.

Secondly.—The spherular form. The perfect sphere of oxalate of lime is certainly rare in urine. So far as we know, it is not found in urine unless the latter contain an abundance of colloid. The sphere under such circumstances is usually small, and presents slight indications of radial fibrillation. The more common variety of the spheroidal form is the well-known dumb-bell. This consists of two hemispheres, sometimes in complete apposition, at others joined by an isthmus, and not invariably equal. The minute structure of the dumb-bell offers slight variations. It may be homogeneous and highly refractive, or may present markings radiating from the centre of the flat face of the hemisphere, and others concentric in relation to the imaginary centre of the hemisphere.

It is important to note that whereas some dumb-bells truly comprise two hemispheres, others are only hemispherical when viewed in one position, and present when rotated an elongated oval form—they are hemispheres which may be described as though parallel portions had been shorn away symmetrically from opposite sides.

Again, while some dumb-bells have a perfectly smooth edge in optical section, others present a finely toothed border, as though composed of the short pyramidal ends of a series of fine tablets which by their collocation construct the dumb-bell.

Thirdly.—The tabular form. From the dumb-bell to the tablet we may trace many transitional forms. What we speak of as the tablet is a flattened, elongated, crystalline body, usually about four times as long as broad; its ends sometimes present each three sharp edges, a median and two lateral, the outline of the entire element being then octagonal. Sometimes the flattened ends are rounded along the border, and a sort of oval results. In good specimens three or four markings may be observed in each half of the tablet, conformed to the angular or rounded outline, and diminishing in size as the middle is approached, *i. e.* they are concentric in their disposition. Very often a distinct line runs across the middle of the tablet, and is bisected by lines diverging towards its narrow extremities. Such tablets, when viewed edgewise, refract light markedly, and are sometimes oval, though more frequently quadrangular, the angles projecting beyond the intermediate substance. When so viewed lines are again observed diverging from the centre towards the angles.

In a few instances a tablet of this kind, when viewed on edge, offers indications of the "wheatsheaf" form, one which may be best described by comparing it to what would be presented by a number of long pieces of card tied tightly together at the middle.

The key to the interpretation of these appearances is supplied by the well-known experiments of Mr. George Rainey. Mr. Rainey showed more than thirty years ago that carbonate of lime and other crystalline substances departed from the crystalline form when deposited in what he called viscous substances—in other words, in colloids. His first experiments were made with strong gum water in which chloride of calcium and carbonate of potassium were allowed to mix slowly, with the result that dumb-bells and spheres of calcium carbonate were formed when crystals might have been expected.

Subsequently Dr. Ord applied Mr. Rainey's observations to the elucidation of the changes presented by oxalate of lime in urine. Dr. Ord employed, in addition to solution of gum, gelatine and albumen. The experiments consisted in plugging open tubes at one end with a diaphragm of gelatine or albumen; the tube was filled above the diaphragm with solution of oxalic acid or of neutral oxalate of ammonium, the lower end of the tube being kept immersed in a solution of chloride of calcium. As diffusion took place into the diaphragm the two salts underwent double decomposition, and formed a dense stratum in the plug; sections of the gelatine plug were subsequently made and variously prepared; most were allowed to dry and subsequently mounted in Canada balsam.

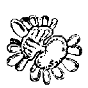
On microscopic examination such sections present a remarkable series of modified forms of oxalate of lime, ranging from octahedra to perfect spheres; the latter are obtained readily in albumen, rarely in gelatine.

The intermediate forms include tablets, dumb-bells, and wheatsheaves.

Of the spheres, some, usually of relatively small size, present an unbroken outline, and an internal fibrous crystalline structure radiating from the centre. This radiating structure is traversed by concentric lines, which are often very numerous, and darker than the rest of the sphere.

Certain of the larger spheres have a nodular surface. The nodules are rounded transparent projections, and correspond to wedges of crystalline material running towards the centre of the sphere. In such spheres the nodules and the wedges often vary considerably in size; sometimes a sphere will present one or two large hemispherical projections, and the corresponding wedges frequently fail to reach the centre of the sphere. It would seem here as if a process of coalescence of two spheres was in progress but not completed. In fact, the whole appearance of these nodular spheres suggests the possibility that they may be the result of the coalescence of a number of smaller ones. There is another spherical form of great interest in relation to urinary calculi composed of oxalate of lime. The kind of sphere referred to presents strongly marked radial lines separating fine crystalline wedges; these, however, instead of terminating in rounded ends project as jagged crystals. Mixed forms are also to be found in which radiating crystals of some size are seen in the interior of the sphere, while the outer portion presents the radiating and concentric markings described in the sphere first referred to, the margin being sharp and uninterrupted. Finally we append a drawing of much interest in relation to the construction of calculi. It represents a dumb-

Fig. 3.



bell of oxalate of lime deposited in gelatine, having attached to its outer surface several elements, set radially or at right angles to its surface; these are somewhat elongated in the radial direction, vary in size, and, although of no regular crystalline figure, are nevertheless crystalline in appearance; they are evidently crystals modified by the circumstances under which they have been produced. The dumb-bell itself presents shallow indentations corresponding with the points of attachment of these subcrystalline bodies.

Numerous experiments were made with other salts. In the case of carbonate of lime and oxalate of copper perfect spheres were obtained; in the case of sulphate of calcium larger agglomerations of spheres were produced, curiously resembling certain forms of the urinary calculi.

As the structure of such artificially produced spheres has an important bearing on that of the calculi to be described, we may recount what this is in typical cases, selecting for examples oxalate of copper and carbonate of lime.

Oxalate of copper deposited in gelatine.—This salt assumes the spherical form much more readily than oxalate of lime.

A very large proportion of the forms deposited in the gelatine are perfect spheres, having a sharp unbroken outline. They exhibit a fine radial striation extending from the centre to the surface, the dark lines marking the striæ being so numerous as to render the central part of the sphere actually opaque, except in certain cases when a brilliant centre of transparent green colour is found in the midst of the striated substance.

Besides these are found numerous lobulated spheroids, which would appear to be composed of lesser spheres in process of aggregation, like those depicted in Mr. Rainey's work (loc. cit., fig. 4, p. 12) as met with in carbonate of lime. In the larger spheroids may be clearly seen a compound nucleus, composed of considerably smaller spheres. There occur also numerous small but singularly perfect dumb-bells. It is impossible, on examining a series as they increase in size, to fail to perceive that the dumb-bells pass by transitions to spheres; indeed, in some of the perfect spheres there may be seen an incomplete partition of dark striæ bisecting the sphere, and corresponding to the original interval between the hemispheres of the dumb-bells. These spheroidal elements entirely replace all angular crystalline forms.

Carbonate of lime deposited in gelatine.—These preparations confirm Mr. Rainey's observations on the same salt. The spheres show at comparatively wide intervals delicate concentric striæ, in addition to the radial markings noticeable in these and the foregoing. In some of the spheres the centre consists of a perfectly homogeneous spherule, defined from the surrounding substance by a sharper line than exists elsewhere. In others the centre is markedly striated, presents a subdivided border, and is evidently composed of a closely coherent mass of elements.

In addition to the spheroids there occur spherules, aggregates of minute crystals, comparable to the crystalline centre of certain of the spheres just described. There are, moreover, several flattened oval elements resembling the spheres in general structure.

Although there are no perfect dumb-bells, there is an approach to these forms, *i. e.* there occur bilobed spheres, or large spheres constricted across the middle, or marked by a strong diaphragmatic line, and having two distinct centres. There occur also dumb-bells without other structure than that of minute granules, which have in consequence a granulated surface, as have some dumb-bells of oxalate of lime met with in gelatine.

Spherular forms have been obtained in addition from barium sulphate, calcium sulphate, barium chromate, nitrate of urea. It is possible to obtain them from the last-named on so large a scale as to be visible to the naked eye, by adding strong nitric acid in excess to albuminous urine of a specific gravity of 1028 and upwards; in proportion as the quantity of albumen is increased the size of the spheres is diminished, and when examined under the microscope they are found to be composed of crystalline spicules arranged radially from a centre, and forming a dense spherical tuft, somewhat resembling but coarser than the tufts in which urate of soda is deposited from an aqueous solution.

From these observations we may conclude that the modifications of the octahedron of oxalate of lime observed in the urine depend upon the admixture of colloids. Of these colloids the one which exercises most influence is undoubtedly albumen. After albumen, mucus; if in considerable amount, as Dr. Beale has noticed, casts of urinary tubules sometimes contain the dumb-bell form of oxalate of lime. Of other abnormal constituents of urine, sugar, so far as can be made out, has no modifying influence on the form of crystalline oxalate of lime.

Of the possible modifications occurring in peptonuria we have no observations, although from the ease with which peptone passes through the dialyser its influence as a colloid is probably small.

Mr. Rainey's opinion was that the formation of spheres arose from some kind of combination between the crystalline material and the viscous substance. He also believed it could be demonstrated that if two spheres were brought into apposition, they gradually coalesced to produce a single one. The other remarkable phenomenon observed by Mr. Rainey, and termed by him molecular disintegration, has also to be kept well before us in endeavouring to interpret the constitution of larger calculi. He found that the spheres formed in one solution of gum became rapidly altered when placed in another, even of approximately the same strength; the spheres lost their perfect outline, became more and more striated, and gradually fell to pieces.

After this preliminary consideration we may proceed to the immediate subject of the paper, viz. the microscopic structure of calculi composed in the main of oxalate of lime.[1]

Description of the microscopic appearances presented by illustrative sections of calculi of oxalate of lime.

The arrangement of the following specimens is in order of simplicity. The letters are those originally used in the preparation of the sections; references to the calculi are made not by these, but according to the number of the section.

Section 1. *Calculus Nc* 29, Royal College of Surgeons.—From a very large collection of hemp-seed calculi taken from a hydronephrotic kidney. The nucleus is not differentiated in structure from the rest of the calculus. The whole is constructed of transparent radially and concentrically striated cones. It is double—*i. e.* the cones diverge from two centres, and as they abut laterally remain for some distance uncoalesced: it may be compared to a gigantic dumb-bell. Towards the surface, however, the radial striation of the doubly striated substance becomes abruptly more pronounced, so as to differentiate a kind of crust. In this crust the elements arise in diverging tufts in three or more tiers at different distances from the centre of the calculus: in some situations the tufts arise on narrow zones of molecular substance. Minute reddish-brown granules are distributed through all the parts of the calculus in concentric but ill-defined lines.

[1] The preparations were made in the following way:—The calculus was first rubbed down on a file or glass-paper and then on a hone with water until the centre was reached; the ground surface was then well washed beneath a gentle stream of water, and allowed to dry under a shade: it was then cemented to a glass slide with solid Canada balsam liquefied by heat. The calculus was subsequently ground from the opposite aspect by the same process, and when sufficiently thin, washed and allowed to dry. A drop of ordinary mounting fluid was then placed on the section and a cover-glass applied.

Chemical composition.—No carbonate, no phosphate, a trace of iron, no murexide reaction. Notwithstanding the last-mentioned fact the granules distributed through the calculus may be regarded as urate, the quantity of which is too minute to give signs of murexide reaction: this may be assumed, since when murexide reaction is obtained such granules occur in considerable bulk.

Section 2. *Calculus O.*—From the same collection of hemp-seed calculi. Shows the same structure as the preceding. Nucleus of massive cones; these are made up of comparatively coarse crystals individually more evident than usual, so that where divided obliquely or transversely the section appears much as a huge crystal in which coarse parallel cleavage has occurred.

Section 3. *Oa* (Plate V, fig. 1).—From the same collection. Nucleus of crystalline cones, starting from two centres as a gigantic dumb-bell.

Section 4. *Ob.*—From the same collection. Shows nothing new.

Section 5. *Oc.*—From the same collection. Shows in the nucleus asymmetrical rosettes, fan-shaped elements passing into cones, as well as ill-formed flat elongated crystals which also merge into cones. These elements are described in detail in certain of the calculi noticed further on. The "body" beyond the nucleus is constructed as in the rest of the same group.

Section 6. *Od.*—From the same collection. Shows nothing new.

Section 7. *Calculus C* (Plate II, figs. 1, 2, 3).—A small hemp-seed calculus, smooth, facetted; one of several taken from a cyst in the substance of the kidney (St. Thomas's Hospital Museum). Oxalate of lime and a small amount of urate or uric acid, as told by the murexide test. Dr. Bernays, on testing three of the group for iron, reports, "The coloured areas visible on the calculi remained visible in the ash as separate from the carbonate of lime resulting from the combustion: they appeared as reddish spots, therefore consisted of a ferric compound; very dilute HCl dissolved the carbonate before the reddish-brown material, which is shown to be a ferric salt. A considerable precipitate was obtained with ferrocyanide of potassium, *i. e.* Prussian blue."

Nucleus.—No foreign body. Coarsely crystalline, and composed of large variously misshapen crystals, in some places suggesting octahedra, in others tablets. These massive crystals show a secondary cleavage leading to a highly complex condition. In most instances it is clear that the cleavage runs in parallel planes, but whether across the long axis or parallel with one of the faces it is impossible to say. Towards the periphery there are irregular collections of small crystals closely and irregularly packed without intervening substance, and of short prismatic or tabellar forms. To this succeeds the proper "body" of the calculus.

The body is constructed, firstly, of a broad belt of transparent colourless crystalline material, marked by radiating interrupted lines. In several spots the points of departure of this crystalline substance appear as conoidal collections of long slender crystals, the apices of the cones being directed towards the centre of the calculus, *i. e.* they are set on the surface of the crystalline nucleus; the substance is crossed by extremely fine and very close-set concentric striæ. Moreover there are sparsely embedded in it minute dark reddish-brown granules of the kind so usual in calculi of oxalate of lime.

These granules are in places arranged in concentric lines, and are continued into the other striæ in which no such granules are discernible and which appear to be due to differences in refraction only. The coarser lines of granules occur in the deeper parts of the zone.

There occur concentrically, intersecting the crystalline material, yellow zones of a finely molecular, faintly brown substance, with or without dark embedded granules, through which zones the radial striæ of the crystalline substance pass without break.

To this succeeds a zone of nearly the same breadth, of molecular, faintly brown, not apparently crystalline substance, marked by fine concentric and remarkably regular lines of reddish-brown granules.

Again comes a crystalline zone like that next the nucleus, but considerably narrower, and in this zone there occur long rows of granules between the crystals, *i. e.* having a radial direction, and like those that are arranged concentrically in the non-crystalline material on the inner side of the zone: the granules present in this crystalline zone are most numerous in its inner fifth.

In a few situations the concentrically marked non-crystalline zone on the inner aspect of the outermost crystalline belt is radially intersected by long wedges of crystalline substance in which few or no granules are present, and in which the lines of the crystalline material converge to the apex of the wedge. These wedges or cones are continued from the midst of the non-crystalline into the crystalline zone on the outer side, the concentric lines of the granules being interrupted in these situations. The calculus is completed by a zone of non-crystalline material like those before described.

Chemical examination.—No carbonate; no phosphate; a trace of iron; a small amount of urate as told by the murexide test. From one of the sections of the same group of calculi which had been mounted in Canada balsam and showed microscopically the same kind of nucleus, the latter was isolated by removing the cover-glass, and scraping away the body of the calculus till no microscopic remains of anything except the nucleus were left. The balsam was then dissolved with xylol, absolute alcohol, and finally ether. On submitting the solid particles to the murexide test no trace of uric acid was obtained.

Section 6. *Calculus H.*—From a cyst of the renal tissue; the same group of calculi as C.

Nucleus.—This shows even more clearly than in C the massive irregular subcubical crystals composing it; they all present fine parallel striation, indicating the occurrence of secondary cleavage. At the peripheral part of the nucleus the crystalline material is set in coarse parallel columns, the lateral limits of which are very distinct and somewhat irregular; many of these present a horizontal parallel cleavage. This columnar arrangement obtains, however, only in places. The nucleus terminates quite abruptly, and the rest of the calculus is as described under C. This nucleus was subsequently used for the chemical test described at the close of Calculus C.

Section 8. *Calculus K* (Plate III, fig. 1).—A small dark brown typical mulberry calculus.

Nucleus.—This consists of gigantic uncoloured transparent crystals, some of which present delicate traces of parallel lines of secondary cleavage; some are square or rhombohedral in the section, and are apparently octahedra. Here and there are still larger polyhedral masses very like some of those described later under oxalate of lime gravel, but having somewhat sharper outlines. The nucleus is much like that in Section 7, except that in this the crystals are so cleft as to lead to opacity. This crystalline centre is traceable outwards as irregular radii into certain of the long crystalline nuclei of the prominent processes of the calculus.

In these extensions of the main nucleus the crystals are smaller, and mingled with forms such as occur in Section 12 and will be presently enumerated.

In some places the "body" arises directly upon the large crystals of the nucleus; in others on a zone of smaller elongated octahedra and other forms. It has the usual character of laterally sutured columns or cones, the entire structure being both radially and concentrically striated.

In the secondary or subordinate nuclei the crystals are not so massive, and they are confusedly mingled with other elements of the kind fully described under Section 10, viz. fan-shaped elements radially striated, and with coarse dentate edges indicating their composite structure; fan-shaped elements both radially and concentrically striated; and circular aggregates radially striated. There occur also crystalline rosettes, of which portions are finely striated both in the radial and circumferential directions.

There is, in fact, no sharp line of division between the fan-shaped crystalline aggregations and the doubly striated cones, the jagged edges of the latter being due to their having a compound crystalline structure.

The "body" around the secondary nuclei is structurally like that about the primary.

The growing surface of the calculus is formed for the most part by broad stunted cones closely packed, in places without much order, and striated radially and concentrically. In some spots it is plain that the original element was a rosette or crystalline sphere, the elements of which have grown inordinately on the outer or peripheral aspect. In other parts of the surface the columns terminate in a regular series of crystalline points, into some of which the fine radial striation of the subjacent substance is prolonged. In yet other places the growing surface is of diverging tufts of long crystals finely striated in the radial direction only; the lateral borders of the tufts abutting obliquely upon each other, so that the extent of the different aggregates is quite readily distinguishable. Where most regular the surface is not curvilinear, but crenate in correspondence with the coarser radial striæ of the columns forming it; these coarser striæ indicate the compound structure of the columnar substance, which is composed of diverging tufts of comparatively coarse crystals in which a finer secondary striation has occurred as well as a transverse.

Section 9. *Calculus G.*—A small calculus of deep brown colour, with a stout spine projecting at one spot; passed after renal colic accompanied with hæmaturia.

Nucleus of the spine.—Of beautiful massive crystalline structure. Its component crystals are angular, some showing the octahedral form; all are of large size.

Most of them exhibit a delicate parallel striation; in some there lie embedded in the crystals lines of dark brownish granules parallel with the finer striæ. In one place there occurs a fan-shaped group of long clear crystals with pointed free ends. On this nucleus is implanted the body of the calculus, which has the usual crystalline character, and is radially and concentrically striated—an aggregate of diverging cones.

The body has a general light brown coloration.

Section 10. *Calculus E* (Plate III, figs. 3 and 4).—A smooth-surfaced flattened oval calculus from the renal pelvis. Oxalate of lime with a trace of uric acid, as shown by the murexide reaction.

Nucleus.—No foreign body. It is entirely crystalline and tuberculated in outline. Its component crystals are mostly of large size, and with irregular wavy or jagged outlines in the form of tablets; some are octahedral, more or less perfect, homogeneous, colourless, transparent. Here and there the crystalline material is arranged as rosettes, which exhibit certain differences in their more intimate structure.

In the simplest of these a few of the crystals lie with one end set centralwise.

From such a simple arrangement may be traced the formation of finely radially striated spherular masses lying in the conglomerate of crystals.

Certain of the rosettes appear, for instance, as composed of slender crystalline plates pointed centralwise, *i. e.* to a centre, about which they converge, and abruptly truncated or bluntly pointed peripherally: the outer ends of the several crystals, or of the different elements resulting from the cleavage of such, do not so accurately correspond as to give to the whole the form of a perfect sphere. *These correspond closely with the aggregates of oxalate of lime crystals deposited in gelatine, as figured in pl. v, fig.* 3*h, and pl. vi, fig.* 2, of Dr. Ord's monograph, 'The Influence of Colloids upon Crystalline Form.'

There may be seen also in the crystalline conglomerate, besides the rosettes noticed, smaller fan-shaped arrangements of the crystals, that is segments of spheres, or incomplete rosettes.

The importance of such forms lies in the fact that the body of the calculus starts in similar but more perfectly formed elements. Such forms are to be seen at the outermost parts of the crystalline nucleus, and some are finely striated in a radial direction, and have the pale brown colour presented by the body of the calculus which follows immediately upon the nucleus.

The most remarkable structures in the nucleus, however, are what appear as still more perfectly developed spheres, but which are really cross-sections of processes arising from the nucleus. They are of considerable size, lie amid the two crystals of the nucleus, and offer to view not only a fine radial striation, but a very distinct slightly undulatory concentric marking in addition, precisely like that presented by the body of the calculus as is described later on. The crystalline character of these is very evident in the sharp dentate edges which in places they present, the divisions between the teeth of which correspond with the main radial striæ of the sphere.

Of some of the larger of such spheres the centre is truly crystalline like the main substance of the nucleus; the true crystalline elements, however, are smaller than the crystals of the conglomerate which form the proper nucleus of the calculus as a whole. These crystalline spheres, like the body of the calculus, have a pale brown colour, and they present a double radial striation,—a coarser corresponding with the divisions between the component crystals, and a finer within the latter.

To this nucleus succeeds the "body" of the calculus, and this is crystalline.

The crystalline substance takes its point of departure in the form of tufts of diverging crystals, the outer ends of the component elements being in places remarkably plain.

In most situations the fusion is more complete, the result being a radially striated structure in which a coarser striation exists indicative of the main lines of the crystalline fusions, and a finer radial striation, perhaps of secondary production.

The fusions are beautifully cross-striated with fine close-set wavy lines, in some of which granules of reddish-brown substance (urate) occur.

The crystalline cones are set with their long axes at right angles to the subjacent surface of the nucleus. Hence, as the latter is irregular, the growing or outer parts of the cones come to meet in places corresponding with the recesses between the projecting processes of the crystalline nucleus. This meeting is marked by zigzag or wavy lines continued far into the body of the calculus, the striæ proper to the cones abutting obliquely along this line, which is in reality a fissure; *i. e.* the crystalline material is here discontinuous.

The entire body of the calculus may be regarded as composed of a series of independent wedge-shaped or conoidal masses set upon the outer surface of the crystalline nucleus. As the distance from the centre increases, the width between the coarser radial striæ becomes correspondingly greater. So the structure continues to the surface. The exterior is not absolutely smooth, though the general contour is ovoidal without visible tubercles; the section offers to view the rounded ends of crystalline columns, the clefts between which are continued for some distance inwards as radial lines.

The radiating masses have much the appearance of striated muscle-fibres with their points of insertion directed towards the centre. In oblique or transverse section their outline is festooned, indicating that they are composed of aggregations of elongated closely-applied crystals. In such sections of the cones also there occur in certain places irregular collections of minute brownish granules, the explanation of this disposition being that such extended collections represent what in a section along the axis of the cones appears as one of the concentric coarser granular lines or striæ.

In one spot may be well observed the introduction of a new centre, some distance from the proper nucleus. This occurs as a spheroidal collection of moderately sized crystals, and from this secondary nucleus start a new series of crystalline fusions or cones, which at their commencement form in the section a considerable segment of a circle; the cones show a radial and transverse striation like the rest of the body of the calculus. For some distance the interposition of this new centre leads to disturbance in the concentric striation; moreover the radial striæ of this pertaining part of the body, owing to their more abrupt divergence, abut obliquely upon the radial striæ of the substance on either side.

The presence of the granules disposed concentrically in the substance of the crystalline fusion is to be explained thus:—the growth of the calculus proceeds by the deposition on to the free ends of the crystals of fresh oxalate of lime; during this process of growth the granules of urate come to be embedded in the crystalline material. This accounts for the undulatory character of the granular lines, the growing surface during the deposition being slightly undulatory from the projections of the crystalline columns.

Chemical composition.—Contains a trace of uric acid, as shown by the murexide reaction.

Section 11. *Calculus P.*—A miniature mulberry calculus.

Nucleus as described in Section 10; crystals and crystalline rosettes minutely striated radially, and jagged at the edge. Also fan-shaped, finely radially striated elements, and similar elements showing also cross-striation. There are, moreover, asymmetrical rosettes of which the larger part is cross-striated, and the rest only radially: here and there at the periphery occur collections of small crystals. On the nucleus start the typical crystalline fusions, striated in both directions. Secondary nuclei occasion the production of the typical mulberry form, though the whole calculus is not so big as a pea. Such secondary nuclei are of small crystals, as in Section 10. There occur frequent and irregular interpositions of new elements in the body in the form of striated cones. Most externally is a zone very finely striated in the radial direction, crystalline, but for the most part opaque in consequence of the mingling with it of blackish-brown granules; where in least abundance these are disposed in coarse concentric lines, and in finer radial lines corresponding with the finer radial crystalline markings.

Section 12. *Calculus F* (Plate III, fig. 2, and Plate VI, fig. 1).—A calculus of mahogany-brown colour, three quarters of an inch in diameter.

Nucleus.—Composed of colourless transparent closely aggregated crystalline material. Portion consists of the transverse and oblique sections of crystalline cones, other portions of what appear at first to be crystals of medium size. The former portion presents itself as closely arranged, large, highly irregular jagged areas, which towards the outer part of the nucleus, at one or two spots, where divided vertically, pass into fragmentary blocks of radially striated substance like that to be hereafter described in the "body" of the calculus, and like it crossed by lines concentric with the centre of such crystalline fusions. With such exceptions the crystalline cones are arranged with the utmost irregularity; and although individually they present both a longitudinal radiating and a transverse striation, they are so disorderly apposed that no continuously striated substance results.

The other portion of the nucleus, which appears at first to be a compact mass of crystals, consists of elements without any regular shape, more or less angular, and accurately adapted to one another by their edges. A higher power, however, shows that these elements are closely allied in their nature to those already described. Many are circular in section, and may be best described as rosettes; they are constructed of long crystals radiating from an imaginary centre; their inner ends tapering and pointed, the outer truncated and not terminating regularly, so that the outline of the aggregate is correspondingly notched or jagged: these present no concentric striation. Were they cross-sections of cones they would not offer the regular and perfect radial striation which they do. Such elements, however, do not appear always as completely circular; they may be fan-shaped, and except that they want a transverse striation, such resemble the broad doubly striated cones confusedly arranged in other parts of the nucleus,—indeed, they occur mingled with them.

In yet other cases a doubly striated rosette is prolonged on one aspect into a broad cone, in the distal part of which the concentric striation is incomplete, in correspondence with the fact that here the structure represents a section only of the circle.

To the nucleus succeeds a well-defined compact zone of fine elongated crystals inextricably intermixed (compare the first crystalline zone beyond the nucleus in Calculus A). Next, a zone striated both radially and concentrically; in this there occur minute dark brownish granules (urates), both concentrically and, in less numbers, radially disposed. The points of departure of this striated zone are obvious in places as cones of various sizes, the pointed inner ends of which abut on the finely crystalline zone immediately surrounding the nucleus; in other places, however, fine long crystals, such as compose the cones, arise without any such aggregation.

Next comes a belt of discrete or non-confluent crystals of moderate size, of no regular form though tabellar, and without order: at its periphery, however, the crystals are more minute, elongated, and like those which immediately succeed the nucleus as before described. The most internally placed, unlike the rest, are arranged with considerable regularity, and like a palisade lie directly upon the ends of the radially and horizontally striated columns beneath them, in series with which they are and which they, as it were, cap.

To this succeeds a zone of doubly striated crystalline substance, and this, with little variation, continues for a considerable distance, the general contour of the calculus so far being oval, the only variation in the structure consisting in the interposition of zones of intermixed fine acicular crystals which interrupt the continuity of the doubly striated substance, which latter again arises on these zones as described around the nucleus.

But now the typical mulberry form arises. As seen under an ordinary lens, there project about ten processes like the tentacles of a polyp, bluntly conical, some presenting constrictions in their course: in some there is visible a less transparent centre, like that composing the nucleus of the main calculus. The irregularities thus produced in the contour are in this particular calculus subsequently filled in with opaque crystalline deposit and the oval contour restored, the concretion in its final condition wanting a typical mulberry form.

To describe the microscopic structure of one such process in which the section has traversed its middle:—The projection shows a distinct nucleus of precisely the same structure as that of the main calculus, already fully described, and consists of radially striated rosettes, and broad, stunted, doubly striated crystalline cones, the whole being quite devoid of any orderly arrangement. On this secondary nucleus there are set doubly striated cones of crystalline substance, which coalesce, or, more correctly, are sutured by their sides, to form a continuous structure like that of the rest of the body of the calculus.

In the outer parts of the protuberances there occur two or more incomplete zones at different levels, which break the general monotony of structure: these zones extend in places for considerable distances, following the contour of the calculus as at this level existing, or they occur only in short disconnected fragments. They are constructed of large perfectly colourless and transparent crystals, which in the main affect the character of prisms; some such have a fan-like or even stellar disposition: in some of the collections, however, these crystals present the form of very irregular plates or tablets of considerable area. That these plates are not phosphates is shown in a negative way by there being a complete absence of the chemical reactions of phosphates in the calculus, which should have been obtainable, since the substance in question occurs in considerable amount; but in a positive way their nature is shown by the fact that in some places the prismatic forms are continuous with the radiating columns of the doubly striated substance immediately to their inner side, the elements in such circumstances having a corresponding radial arrangement: certain of the irregular tablets, moreover, have a fan-like form, allying them with the stunted cones which lie in certain situations on the outer aspect of the fragmentary zones in question, and with some of which they are directly continuous. They correspond closely with certain of the forms of oxalate of lime in gelatine figured by Dr. Ord (loc. cit.) in pl. vi, figs. 1, 5, 7.

At a certain level the recesses between the protuberances are all filled up with another substance, with the result that the irregular contour is replaced by one that is regularly oval.

The substance occupying the recesses is, to the naked eye, quite obvious by its whiteness and want of complete transparency even in the section as it is mounted in Canada balsam. It consists mainly of radially disposed prismatic crystals, though the regularity of such an arrangement is not very well pronounced. Here and there the elongated crystals take their point of departure as diverging tufts; and here and there a well-marked rosette is to be encountered.

Where the elongated crystals are most parallel they produce a columnar structure, but one in which no regular cross-striation is present as in the transparent parts of the calculus, though the elements are irregularly and somewhat minutely fissured from secondary cleavage: it is this cleavage, combined with the presence between the prisms of closely packed minute crystals of similar nature (for all gradations of size are traceable), that produces the relative opacity of these areas even in the microscopic section after its treatment with Canada balsam solution.

In these parts there occur, moreover, very ill-defined zones of shorter irregular crystals, but of similar nature, and exhibiting the same kind of secondary cleavage. As a whole this deposit has a pale yellow colour, and since the calculus contains urate of soda, and the crystalline prisms resemble such as this salt may present (compare Dr. Ord, loc. cit., pl. iv, figs. 1, 8), and because the general structure is to be observed in microscopic sections of calculi of the uric acid series, it must be concluded that the substance in question consists of urate, and not—as the first impression would be—of phosphate.

From the outer surface of the urate deposits the clearer substance of the oxalate of lime beyond takes its point of departure in crystalline cones radially and concentrically striated, and with such the rest of the calculus is made up.

Chemical examination.—No carbonate; the murexide test shows the presence of uric acid, combined as urate of soda; a minute trace of iron; no phosphate. The opaque zone is urate of soda.

Section 13. *Calculus V* (Bb. 6, St. Thomas's Hospital Museum), —Nucleus of opaque, drab-coloured urate of ammonia, succeeded by oxalate of lime, and thin laminæ of similar urate interposed between the wavy layers of more transparent, pale brown oxalate. Surface granulated; patches of similar urate, in places, fill the bottom of the hollows between the hemispherical eminences at the surface. The laminæ of oxalate are individually continuous, *i.e.* the granulations are not due to the formation of discrete calculous spheres.

The structure of the uratic zones we reserve for a subsequent communication. We may mention, however, that in large part they consist of coarsely laminated spheres, presenting also a remarkably fine radial striation; they are characterised, moreover, by a certain degree of opacity and a distinct yellow coloration.

As to the general structure of the oxalate portions, there is nothing special; the section was made in order to study the *origin of the eminences,* which are not confined to the exterior, but are equally marked in the deeper laminæ, showing the granular character to have persisted during the growth of the calculus.

The eminences result from the formation of secondary nuclei constructed of different elements, such as coarsely crystalline rosettes; fan-shaped aggregates of similar coarse and elongated crystals without transverse striation; discrete crystals, of which some are elongated like those composing the rosettes, and others are larger transparent blocks suggestive of ill-shaped octahedra. The whole of these forms are such as are described in detail under

Sections 10 and 11. These secondary nuclei, however, are connected by a more or less continuous zone of similar elements, *i. e.* they arise as irregularities in the deposit of coarsely crystalline layers of oxalate interposed between the usual doubly striated substance.

It is also of interest to note that the section shows a more or less complete zone of small, colourless, glassy-looking spherules in process of fusion, the whole corresponding precisely with the nucleus of Section 18, Calculus D, and that of Section 19, Calculus L. In certain situations this zone takes the form of an undulatory glassy line, as described in the body of Calculus D. The line bounds what in its deeper part is a finely granular or nebulous uncoloured material, composed apparently of very minute crystals, seeing that this material merges further outwards into irregular blocks of crystalline substance which still more outwardly pass into the regular doubly striated general material of the calculus. On the outer aspect of the wavy line the substance of the calculus takes the form of cones of small size irregularly disposed, or fusing into an orderly layer.

Section 14. *Calculus A* (Plate IV, figs. 1 and 2).—A smooth calculus, one of many; oxalate of lime with small quantities of urate and phosphate and much organic matter (Dr. Bernays). The calculus was from the renal pelvis in a case of malignant disease of the kidney.

Nucleus.—No foreign body, or space indicative of such. In outline it is irregularly oval. Structurally it consists of an aggregation of minute perfectly colourless closely packed crystals, with exceptions to be immediately noticed.

The other structures in the nucleus appear as discrete circular areas transmitting light more readily than the rest of the nucleus, and constituted by similar slender, uncoloured crystals, but arranged radially from a centre with great regularity.

These are of precisely the same nature as the crystalline spheres of nitrate of urea producible in albuminous urine by the addition of nitric acid, or as the crystalline spheres of oxalate of lime which may artificially be formed in gelatine. The close relation of such to the perfect sphere is proved by the transitions between the two in a single experiment; the radial striation presented by the sphere is the indication of its crystalline nature. In the case of carbonate of lime deposited in gelatine, *e. g.*, there may be observed both perfect spheres and rosettes of fine acicular crystals with intermediate forms. The crystalline spheres in the nucleus are distinguishable from spherules of urate by their absence of coloration, their transparency, and absence of coarse concentric striation. Such spherules of urate are alluded to under the description of Section 13, Calculus V.

Beyond this, the very centre of the nucleus, is an incomplete narrow zone devoid of crystalline elements, in which lie embedded minute brownish granules. To this succeeds a zone of closely packed slender colourless prismatic crystals of small size, though considerably larger than those described as comprising the nucleus. They are inextricably interlaced, and packed either without intervening material, or in a substance thickly beset with small dark granules. Some of the crystals are shorter and broader than others, with ends cut sharply at right angles.

These elements may be compared with certain of the slender tablet forms of oxalate of lime met with under rare circumstances in urine, but producible in abundance when this salt is deposited in gelatine.

At one part the crystals are set radially, or at right angles to the subjacent surface, and here can be beautifully traced the fusion of the apposed crystals to form a radially striated, clear, crystalline substance such as will be presently noticed as constructing the chief part of the body of the calculus. Here, too, the reddish-brown granules lie in irregular groups, and have a radial direction in correspondence with the spaces between the crystals.

More outwardly the structure again becomes non-crystalline, a homogeneous basis-substance reappearing, interspersed with brown granules; but nearly everywhere fine acicular crystals are embedded in it exactly as in the nucleus itself, and this zone, like the nucleus, is limited on the outer aspect by a non-crystalline layer of varying thickness—a basis or ground-substance with embedded granules.

To this succeeds a zone of closely interlaced prismatic crystals short and somewhat broad; this merges into a remarkable zone of similar crystals, but of which the crystalline aggregate is parted out by the brown granules into large diamond-shaped areas, which apparently represent octahedra in which secondary cleavage has taken place. The crystals occupying the octahedral spaces are tabular, and not arranged in any definite order. Here and there are irregular masses of crystals with radial arrangement and in process of fusion; they are not strictly radial in every spot, but set sometimes in such a manner that they converge bipinnately, *i. e.* meet on a median line directed towards the centre of the calculus.

These structures are succeeded by the main body of the calculus.

Firstly comes a broad, not obviously crystalline belt of a nebulous transparent pale brown substance, with minute brown granules sparsely distributed in it. This is marked out into concentric laminæ by closer collections of the same granules; the laminæ are three or so in number, and not sharply defined.

Close examination reveals delicate indications of crystalline structure in the ground-substance; it appears as if composed of interwoven fine crystals of the same kind as those described in the nucleus.

This zone probably consists of the organic matrix of the calculus with oxalate of lime in a fine state of division, the embedded granules being probably urate, of which this calculus contains a marked quantity.

The next zone is one of very uniform thickness, colourless, transparent, and although no crystals can be discerned individually, clearly crystalline and due to fusion.

The transparent substance is marked by interrupted lines, which have in general a radial direction with respect to the centre of the calculus, but themselves deviate so far from a precise radial course that if prolonged they would intersect at acute angles.

In the deeper part of this zone are scattered considerable numbers of the brown granules before so frequently referred to, and such occur also in the rest of its extent in fair numbers though widely apart, and without interfering with the general transparency.

This accumulation of what are doubtless urate granules is to be noticed generally under similar circumstances, and is comparable to the disproportionate amount of pigment met with at and about the centre of biliary calculi. Theoretically this result may be viewed as due to the attraction of the granules, whilst still embedded in the viscid matrix, towards the centre of the calculus. The same force acting upon the crystalline material determines its radial arrangement.

To this succeeds a zone like that preceding the last, viz. a nebulous or faintly granular substance with admixed reddish-brown granules arranged on its inner and outer borders, as well as in incomplete and not sharply defined concentric lines in its mid-substance.

With alternations of such structure and the radially striated crystalline fusions the rest of the calculus is made up.

As previously noticed, brown granules occur in the radially striated crystalline zones; and in certain of those zones the granules are arranged in linear series, not singly, but in collections which form narrow concentric lines crossing the radial striæ of the zone: other groups of the granules occur between the coarser radial striæ themselves.

Most outwardly of all and for a wide extent the calculus consists solely of a faint brown nebulous basis-substance, in which lie the coloured granules in concentric lines of variable thickness: the most peripheral layer of all consists of the ground-substance only.

Chemical composition.—Oxalate of lime with small quantities of urate and phosphate, and much organic matter.

Section 15. *Calculus M.*—From a collection of smooth oval calculi, a few of them spiked: Museum of St. Thomas's Hospital. They were taken after death from the pelvis of the kidney, and consist of oxalate of lime with urate.

The general microscopic structure is much as that of Section 7, Calculus C. There is, however, in all the zones of radially striated crystalline material a remarkable want of perfect transparency, such as in the case of Calculus C is confined to the large crystals composing the nucleus. This is due to irregular secondary cleavage of the crystals. The nucleus is throughout crystalline, composed of much elongated octahedra, confusedly intercrossing at the centre, where there exists an intervening ground-substance of minute crystals in which they lie, but radially arranged at the periphery, where the outer ends of the crystals can be seen embedded in the next, pale brown, concentrically laminated zone. All the larger crystals are wanting in perfect transparency by reason of irregular secondary cleavage.

The nucleus is succeeded by a fairly broad zone of homogeneous or molecular basis-substance, marked into concentric zones by somewhat coarse lines of reddish-brown granules (urate). To this succeeds a broad coarsely crystalline zone, constructed like the peripheral portion of the nucleus.

The rest of the calculus is composed of alternating narrow zones of these two kinds: in some of the outer crystalline zones the crystals are not elongated and radial, but minute and devoid of arrangement.

Of this section the nucleus was subsequently isolated, and washed in a watch-glass first with xylol, then with absolute alcohol, and finally with ether: its elements became dissociated, but were not otherwise altered. The murexide test subsequently showed no uric acid.

Next, the rest of the section was tested in the same way: it included concentrically striated reddish-brown zones and zones of crystals similar to those comprising the nucleus.

Here the murexide test gave a very obvious and marked evidence of uric acid. From this it is evident that the urate is contained in the brown zones, and, so far as can be judged, is limited to the granules, for were the whole zone of urate the reaction would have been more pronounced.

Section 16. *Calculus Mc* (Plate VI, fig. 4).—From the same collection.

In the centre of the crystalline nucleus are remarkably long octahedra, the spaces between which are filled with a groundwork of small uncoloured crystals.

At the periphery the long crystals are arranged radially; but all are wanting in perfect homogeneity and transparency, owing to secondary cleavage.

The body of the calculus precisely resembles that in the preceding specimens from the same case (q. v.).

Section 17. *Calculus Mf* (Plate V, fig. 2).—From the same collection.

This calculus shows a double nucleolus of two perfect spheres joined by an isthmus of coarsely crystalline uncoloured substance, wanting in transparency from secondary cleavage of its component crystals. The connecting isthmus is of the same construction as the crystalline aggregate of the nucleus in which the nucleoli are embedded; it is, however, separated from it by means of a narrow line of pale brown non-crystalline material, in which lie reddish-brown granules, and which is continuous with similar material forming the most external parts of the nucleoli.

Each of the nucleoli is constructed of beautifully transparent cones radially and concentrically striated.

There are scattered, moreover, in the coarsely crystalline nucleus small rosettes finely striated in the radial direction.

Beyond the nucleus the calculus in all ways resembles the others of the same group.

Section 18. *Calculus D* (Plate VI, fig. 2).—One of a small group of smoothly polished facetted calculi, averaging about 8 mm. in diameter.

Nucleus.—This consists of small homogeneous closely-packed spherules, which at the periphery fuse into a glassy homogeneous substance (a similar construction is shown also in Section 19, Calculus L, and in Section 13, Calculus V). This is a rare form for oxalate of lime to assume. Such spheres may be produced, however, in gelatine, and are figured in pl. v, fig. 3, of Dr. Ord's work before cited.

To the nucleus,[1] which is abruptly defined, there succeeds a pale brown zone of nebulous substance, in which lie concentric lines of fine reddish-brown granules.

In part of its circumference this zone presents in addition the fine radial striation indicative of crystalline fusion. Then follows a broader belt of radially striated crystalline substance finely cross-striated.

In the deeper part of the zone there are present dark brownish granules in considerable collections between the radially set crystals, these collections having thus a radial direction.

In parts of its circumference the crystalline substance is interrupted by non-crystalline areas of pale brown substance traversed by coarse concentric lines of dark brownish granules; but both crystalline and non-crystalline parts merge into one another by all gradations. In this zone, towards the outer part, is an incomplete line of minute crystals, packed closely without fusion or order, and where this is present the radial striation is interrupted.

This striated part is followed by a complete zone of minute crystals traversed by a thin wavy or zigzag interrupted line, of singular homogeneity and transparency, and due evidently to crystalline fusion (compare the similar substance produced by the fusion of spherules in the nucleus of the same calculus).

Next, not sharply demarcated from the foregoing, a pale brown zone in which are discernible minute interlaced crystals.

Then follows a zone like that preceding the latter, minutely

[1] The structures hereafter described do not always uniformly encircle the calculus, so that the description in certain cases is drawn up from a particular section only.

crystalline, and containing fragments of a narrow homogeneous wavy line. This is followed by a nebulous zone of the palest brown colour, finely striated in the concentric direction, and broken through in places by tufts or brushes of long crystals. The component elements of these tufts present a fine transverse striation, and this deviates in course from the concentric striation of the non-crystalline substance between, in correspondence with the direction of the long axis of the crystals, which long axes are crossed at right angles by the striæ. The striæ of this nebulous zone itself are in certain spots distinctly granular and of finely crystalline texture.

To this succeeds another zone of small intermixed crystals, in places traversed near its middle by a narrow slightly wavy line of bright structureless uncoloured material; then a broad zone of the non-crystalline pale brown material, concentrically marked by granules and finer nebulous striæ. There comes next a final belt of discrete crystals, of short prisms or flattened forms, some ill-shapen octahedra, and of larger size than those in the preceding zone; and finally a crust thicker than the rest of the calculus together, of the usual concentrically striated non-crystalline material.

On the deep aspect of that one of the confusedly crystalline belts which is nearest the nucleus it is instructive to notice the mode of termination of the subjacent crystalline columns of the radially striated zone which lies on its inner aspect; in some situations the outer ends of these columns are very distinct and produce a crenate edge, the divisions of which correspond with the radial markings in the zone: the edge represents what at one stage was the free surface of the calculus, the mode of formation having after this period ceased and been changed for another.

Chemical composition.—No phosphate; the murexide test shows no urate.

Section 19. *Calculus L* (Plate VI, fig. 3).—A minute spherical calculus, chiefly white in section, composed of oxalate of lime; passed after severe renal colic of several days' duration.

Nucleus.—Composed of beautiful bright spherules, homogeneous, without visible structure; towards the periphery these have fused into a glassy homogeneous substance, in which there occur short winding fissures where the coalescence has failed to take place. (A similar structure is previously described in Section 18, Calculus D, and it occurs in the body of Section 13, Calculus V.)

To this succeeds a doubly striated narrow zone composed of stunted cones of the usual character; or in places of fan-like tufts of comparatively coarse crystals, in which a finer secondary divergent and a transverse striation are present. This zone is incomplete, and here and there are isolated cones which lie in the midst of the spherular aggregate, the incomplete zone being succeeded by material similar to that composing the nucleus.

The outer parts of the calculus are wanting.

The sections were subsequently examined chemically. Acetic acid produced no result on the spherules: pure hydric chloride led to solution of the inorganic substance without effervescence, an animal matrix being left.

Uric acid had been noticed in the urine before the passage of the small calculus.

Section 20. *Calculus I.*—A crystalline calculus with sharp crystalline surface, and about the size of a small pea.

Pickings from the surface mounted in a cell of Canada balsam show in places perfect octahedra though flattened; some are of comparatively small size, others very large; the smallest are considerably larger than the forms common in urine. In most of the crystals lie multitudes of minute deep reddish-brown granules: these granules are for the most part arranged in planes parallel with those of the crystal, in which they seem to mark out coarse but accurately parallel laminæ. Some of the crystals are distinctly tabular with six sides. They cohere into irregular groups without intervening material.

Chemical composition.—No carbonate; a trace of iron; the murexide test shows no uric acid.

Section 21. *Calculus Q.*—A small dumb-bell shaped calculus not more than 3 mm. in greatest diameter.

Nucleus.—Crystalline.

Body.—Of the usual character, viz. doubly striated crystalline substance.

The specimen, though showing nothing new in other respects, is valuable in this, that in addition to the faint general brown coloration of the general substance of the body there occur groups of distinct crystals of brilliant orange pigment, derived doubtless from blood. This pigment lies in the nucleus as well as in the crystalline fusion of the adjoining portion of the body. The pigment takes chiefly the form of long fine needles in groups of different numbers. In places these are parallel with and contained in the radiating crystalline fusion, probably between its component elements, and due to crystallisation having occurred from effused blood. In other places in the crystalline nucleus, in addition to such bunches of slender orange crystals, there occur associated with them comparatively large similarly coloured crystals of rhombohedral form, singly and in clusters. The crystalline substance of the body generally is of a pale reddish-brown colour. Oxalate of lime "gravel" passed from the bladder.

FIG. 4.

A crystal of oxalate of lime passed with others in the urine, and of sufficient size to be visible to the naked eye, "oxalate gravel." The figure is magnified 40 times.

Except that the crystals are not sharply angular, they are much like those artificially detached in Section 20, Calculus I.

Many of the masses are compound; a polyhedral pattern is discernible, the exterior presenting angular elevations, or being highly undulatory.

The forms presented by the nuclei of calculi composed of oxalate of lime.

The nucleus may be classed under the following chief forms, upon each of which we may make general observations.

1. Large transparent crystals of oxalate of lime (Section 8, Calculus K).

2. Similar crystals rendered more or less opaque by secondary cleavage (Section 7, Calculus C).

3. Minute crystals not of octahedral form (Section 14, Calculus A).

4. Rosettes or striated conoidal or fan-shaped elements like those which more outwardly construct by their regular juxtaposition the body of the calculus (Section 12, Calculus F).

5. Spherules in process of coalescence (Sections 18, 19, Calculi D, L).

These forms may occur in various combinations. Most commonly rosettes[1] are mingled with the crystals. The former are of different degrees of fineness in regard to their component elements, and vary considerably in size; the larger of them may be concentrically striated. Or fan-shaped elements presenting fine radial striation, and, it may be, concentric as well, may occur in conjunction with crystals of medium or larger size, and with or without rosettes, to make up the nucleus.

1. The nucleus of large transparent crystals of oxalate of lime.

It is of interest in regard to this form to note that similar large octahedral crystals are met with in the urine in rare cases, constituting one of the forms of "gravel." In such gravel either single crystals or groups of such may be found, as in the parallel case of uric acid. Such a nucleus appears to be a chance aggregation of crystals cohering without colloid. We know of no specimen showing that this simple construction ever obtains for any long period. We have never seen any calculus thus constituted larger than a bean. Such a nucleus is succeeded by the modified forms of oxalate noticed in the general remarks on the structure of the body as distinguished from the nucleus of the calculus.

This is due doubtless to the fact that the presence of such a calculus leads to the admixture of colloid with the urine by reason of the inflammation in the urinary passages which it excites; there occurs an increased secretion of mucus, and an inflammatory exudation from the vessels of the inflamed mucous membrane of that portion of the urinary passage in which the calculus lodges.

2. A nucleus of large crystals rendered more or less opaque by secondary cleavage.

This secondary cleavage indicates probably the action of colloid in an early stage and slight degree.

3, 4. The nucleus of minute crystals.

The crystals in such nuclei are to be regarded as tablets. This, although not traceable in the particular nucleus described (A), is plain in certain similarly constructed zones in the body of oxalate calculi, where minute tabellar forms are visible amongst others which are probably minute tablets viewed edgewise so as to appear more or less needle-shaped. Such forms are producible in large numbers experimentally when oxalate of lime is deposited in

[1] By a rosette we imply a compound form resulting from a radial disposition of elements, but flattened or discoid, and not spheroidal in figure.

gelatine. And in such experiments, together with these minute tablets, there may occur spherular aggregates of similar crystals of various degrees of coarseness, some small and comparable to the crystalline spherules present in the nucleus of calculi constructed of a conglomerate of similar minute crystals.

The crystalline spheres, in short, which occur in conjunction with the minute tablets, are comparatively small, and of similarly fine crystals. The coarser rosettes, or spheres of oxalate of lime produced artificially in colloids, are precisely like those often met with in conjunction with the crystalline forms of larger size, such as constitute the elements of nuclei 1 and 2.

The various elements of such a mixed nucleus as that last mentioned may be found in a single experiment made with a colloid; associated with octahedra (normal, elongated, and gigantic), with tablets, unfissured and in process of fission, there may be found coarsely crystalline spheres and rosettes of various degrees of complexity.

In the simplest phase the rosette, artificially produced, consists of four elements, somewhat like a Maltese cross. From such simple forms gradations are traceable to the more highly complex, which result from further fission directed from the margin to the centre.

The rosettes or flattened forms are related to fissure of tablets; the crystalline sphere, or the spherical aggregate of crystals, to the regular octahedral crystal.

The rosette may be imperfect, *i. e.* wanting in part of its circumference, so as to produce a fan-like aggregate.

The transition between rosettes and the fan-shaped aggregates appears in the asymmetrical forms of the first, of which the elements on one side may be prolonged far in excess of those around the rest of the circumference.

5. The presence of proper spherules of calcium oxalate in the nucleus is exceptional; we have observed it only twice out of a large number of preparations.

The spheres alluded to are, as observed in our preparations, homogeneous, glassy, and without the radial (or concentric) striæ which occur in the two forms already alluded to as "rosettes" and "crystalline spheres."

The structure of the body of calculi of oxalate of lime.

In considering this it will be most natural to proceed from within outwards. In all cases the body arises in cones of crystalline substance sharply pointed at their inner ends, and diverging from the outer surface of the nucleus. These cones as traced outwards present no interspaces, and they can nowhere be followed individually for any great distance. This is evidently due to the fact that their sides, which are deeply fluted, lie in perfect apposition, or are sutured together. The general contour of the cones may be deduced from the appearances presented by oblique or transverse sections. When seen in these ways they are of extremely irregular outline, deeply sinuous or jagged. In all cases they present in longitudinal section a double striation—radial, and transverse or circumferential, although one marking only may be present at and about the apex, viz. the divergent or radial.

The radial striation appears as delicate interrupted or incomplete lines which diverge in correspondence with the increasing width of the cone; they cannot be traced continuously from apex to base, but are comparatively short, and terminate at various distances; neither do they diverge with mathematical exactness, but are so directed that if prolonged they would intersect at acute angles in various directions. These lines indicate that the cone is constructed of a series of somewhat narrow closely apposed rod-like elements, and the irregularity of the sides of the cones as studied in oblique or transverse section results from the same construction.

In some calculi such a doubly striated crystalline substance resulting from the lateral apposition and suturing of such structures is traceable to the very surface which may present a series of blunt or rounded points coinciding with its different elements.

The fact that the cones can never be traced individually for a long distance suggests that their axis is not straight; they appear rather to take a twisted or spiral path. Such an idea is suggested by the construction of large dumb-bells of oxalate of lime both natural and artificial: in these the leaflets or tabellæ are constantly found twisted, somewhat as the petals in the contorted æstivation of a flower, the direction of the rotation being, of course, reversed on each side of the centre; the crystalline fibres partake in the contortion like the strands of a partially twisted rope. It is obvious that if such a dumb-bell were cut longitudinally none of its fibres would be traceable continuously from its centre to the surface.

The radially striated cones present a second striation, viz. a transverse, or one concentric with the centre of the calculus. In its typical form this is exceedingly delicate, and the appearance may aptly be compared with that of striped muscle-fibre. The lines are close, devoid of visible granules, sharply defined, and remarkably parallel. They are of the same nature as the concentric striæ seen in certain of the artificially produced spheres; but in neither case can we offer any satisfactory explanation of their production. It need scarcely be stated that in cross-sections of the cones this concentric striation is not to be seen. Sometimes the whole of the body of the calculus is composed of such cones so closely applied by their sides as to form in sections a continuous zone of clear crystalline substance, striated both radially and concentrically with respect to the nucleus of the calculus. In many cases, however, there occur in addition zones of another substance alternating with those just described.

Sometimes, and very commonly in the smooth variety of calculus, the second substance constitutes the chief portion of the outer part of the concretion. In its typical form this substance is non-crystalline, and consists of a molecular basis in which lie concentrically arranged lines of distinct granules, dark reddish brown in colour. These lines vary in thickness and density; and individually are not always of uniform thickness.

We regard the nebulous basis-substance as oxalate of lime combined with the colloid which forms the organic matrix of the calculus, the power of the colloid having obliterated all crystalline structure. The brownish granules we regard as urates embedded in the matrix during the growth of the calculus.[1]

That this view of the essential nature of the basis-substance is correct is supported by the fact that such zones present no sharp line of demarcation from the radially striated crystalline substance first described; every degree of radial striation is to be observed in such zones, sometimes faintly indicated, sometimes distinctly pronounced.

Such zones are probably, moreover, closely related to another or second variety, in which a very minute crystalline structure is discernible.

The minute size of the crystals, when visible in such substance, indicates the action of colloid added to the urine, but colloid acting

[1] When the calculus is at all largely composed of such substance the murexide test shows the presence of urate. That the test does not in all cases do the same when the calculus contains such material microscopically, depends probably on the minute quantity present.

with less power than in the case where such a structure is merely molecular, although even in the latter case the molecular appearance may be, theoretically, due not to the presence of minute spherical elements, but of crystals.[1]

In zones which show a transition between the crystalline and non-crystalline forms it may commonly be observed that the coloured granules (urate) are present in chief amount at the deeper, *i. e.* the inner parts, or those on the aspect of the zone proximal to the centre of the calculus.

This is possibly indicative of the attraction of the urate granules towards the centre whilst in the colloidal basis. A corresponding arrangement exists in those zones of biliary calculi which inter-

[1] It is interesting to observe that a substance of similar characters may be artificially produced, in which it is clear that crystallisation is concerned. If a saturated solution of sodium phosphate is added to a saturated solution of urate of ammonium, potassium, or sodium, both being previously heated to a temperature of over 100° F., the fluid becomes on cooling quite gelatinous, like freshly precipitated silica, so that the test-tube may be completely inverted without any escape of its contents. If the substance in this stage is examined under the microscope it presents no visible crystalline elements, but consists of a very delicately molecular ground-substance with embedded masses of spherical form, in some cases not very perfect in outline, in others perfect, where the forms are relatively small. In the same preparation, after a short space of time, the same ground-substance is found to be gradually replaced by crystalline elements which take the shape of fine curved needles, irregularly and sparsely scattered. At the same time the spheres undergo change; in their outer portion fine spicules make their appearance, and increase in number until the whole sphere bristles with needle points, rarely straight, but rather matted together, though always with their free ends directed more or less radially. It is apparent that in this case the urate of soda is at first precipitated in a colloidal form, and that this colloid acts upon its own crystalline material so as to determine its deposit in spherular form, the whole being ultimately broken up into crystals when the period of colloidal existence comes to an end.

It has long appeared to me probable that every chemical substance in passing from solution to the solid form, or in being born afresh, passes through a stage comparable to the colloid. I venture to propose the hypothesis that what is called the "nascent stage" of various substances when set free from combinations is really a colloidal one, in which they offer a readiness to combine with other substances which they do not present when they have passed into a further *quasi*-crystalline stage. This may be seen in precipitated oxide of iron and in silica, to name two very different substances. I venture to think it would apply to ozone and to many gaseous and liquid substances which at the moment of chemical dissociation from other substances are known to have remarkable readiness for fresh combination. (W. M. Ord.)

vene between the homogeneous peripheral laminæ and the strongly crystalline centre: two substances of different crystalline tendency, viz. the cholesterine and biliary pigment, separate after a time, though precipitated together, and during this process of separation the pigment is attracted towards the centre, whilst the crystalline material coheres at the periphery.

The structure of the calculi as a whole, and the relationship of the microscopic to the macroscopic forms.

One of the most interesting of the results offered by the structure of the calculi above discussed is its likeness to the microscopic spheres and crystalline aggregations which may be artificially produced, or occur as natural formations. Among natural products the urinary granules of the snail offer perhaps the most parallel examples.

Each form of calculus, however, is represented amongst the microscopic forms; besides the perfect sphere, with smooth surface, there are met with forms constructed of crystalline elements disposed radially about a centre, and of which the outer free ends give a sharply spinous character to the whole. The essentially crystalline nature of the most perfect sphere is shown in its radial striation; and no sharp line of division can be drawn between the spherical crystalline aggregates and perfect spheres.

The smooth hemp-seed calculus, then, is in its simplest form (in which it is devoid of a differentiated nucleus) comparable to the simple typical smooth-surfaced microscopic sphere. We do not meet, however, with calculi which present in microscopic section no concentric striation in conjunction with the radial, whereas in the microscopic sphere the concentric striæ may be wanting, or if present may be numerically few.

The smooth variety of calculus in which there are present zones of crystalline and non-crystalline substance is closely represented in certain of the microscopical spheres.

In the urinary granules of the snail several varieties of internal structure are to be observed. Some are striated only radially, though of as large a size as others; some are striated both radially and concentrically, the concentric striæ being less close than the radial which they cross, and terminating short of the centre: the concentric lines often cease abruptly, so as to define a nucleus of less transparency and striated only in the radial manner; but others, resembling the form of calculus under notice, present a more transparent and structureless peripheral zone or crust, sharply separated from the radially striated more central part. We have observed almost similar forms to the last in urate deposited in the mucus of the renal pelvis of a child.

In the case of biliary calculi this double form of a single substance is particularly well marked; towards the centre of the calculus the substance will present a distinct radial striation, and peripherally a uniformly granular character where the cholesterine is intimately mixed with biliary pigment.

Again, the less tuberculated form of mulberry calculus, or that which may arise without the interposition of secondary crystalline nuclei, is accurately represented in certain of the microscopic forms of spherular oxalate of lime. Such spheres may, in short, be compound or composite in structure, and present a nodular surface, with a corresponding series of coarser radial striæ which mark out the sphere into closely applied conical processes. The dumb-bell itself is a closely allied form, two elements being here concerned in the production of the composite structure; in the next simplest, four; and so on with increasing complexity.

Further, the microscopic calculus composed of distinct crystals is represented in artificially produced forms by collections of crystals commonly arranged with perfect regularity about a centre, and so of more regular construction than the pathological concretion: in calculi of other composition encrusted with crystalline oxalate of lime, however, the crystals of the latter substance may be arranged with complete radial precision on the more central part of the calculus.

Finally, in the microscopic forms artificially produced may be seen the first stages in the formation of a distinct "body," such as occurs in the calculi.

Upon the exterior of dumb-bells or more complex compound forms there may be regularly arranged smaller elements of spheroidal figure with rounded angles, but separated by distinct intervals from one another. Such represent the crystalline cones so frequently referred to as composing the body of the most perfect forms of calculi of oxalate of lime (see Fig. 3, p. 7).

The coloration of calculi of oxalate of lime.

By Wollaston and Marcet the brown colour which such calculi present was supposed to be due to blood. That blood occurs admixed is undoubted. In one of the sections (Q) described in this communication brilliant crystals of hæmatoidin (an iron-free product of hæmatin) are present in the nucleus and the body of the calculus.

The presence of iron, demonstrable in many of the specimens, can in fact be explained by common hæmorrhage; but as normal urine contains small quantities of iron in as yet an unknown state of combination, this does not exhaust the question.

As observed in urine, crystals of oxalate of lime are invariably devoid of colour. The same is true of the calculi, *i. e.* the proper crystals, whether in the primary or secondary nuclei, are uncoloured, and so are the large crystals of oxalate of lime that are sometimes easily recognisable on the surface of calculi of other chemical composition.

It is important to observe that the coloration is not limited to such non-crystalline zones as contain embedded granules of urate, and is certainly not due to the presence of the latter. It may be diffused through the doubly striated substance of the body even where this is most typical; and the molecular basis of the "non-crystalline" zones, in which the concentric lines of brown granules lie, is also itself of a pale brown colour. It varies in degree in different cases, and in different zones of the same calculus: sometimes it is, in thin sections, hardly recognisable.

The typical coloration is present in the intestinal calculi of oxalate of lime met with in herbivora. The usual macroscopic structure of these (of which there are excellent examples in the Royal College of Surgeons, London) is like that of the smooth variety of urinary calculus: they are composed of a compact substance both radially and concentrically striated; and they exhibit the characteristic dull brown colour, varying in depth in different zones, that is observed in the smoother varieties of the urinary forms. One of these specimens (W 4, 'Catalogue of Calculi,' Coll. Surg.), in composition nearly pure oxalate of lime, has a periphery of crystals which project at the surface, as in certain examples of urinary calculus described.

These considerations lead to the conclusion that the coloration of the urinary forms is due not to urinary pigment, but probably to hæmoglobin; and this coloration obtains not in connection with the perfect crystals, but the crystalline fusions constructing the body of the calculus and the molecular zones, in some of which a minute crystalline structure is discernible,—indeed, there is no sharp line of division between the two.

As to the organic matrix present in all calculi of oxalate of lime, its existence has been long known; and its nature has, most recently, been treated by W. Ebstein in his work on urinary calculi.

Notice of observations by other authors.—BEALE ('Urinary Deposits,' 3rd edit., 1869) has observed cohering dumb-bells in the urine, and similar collections in the kidneys in the urinary tubules.

In pl. xi, figs. 12, 13, op. cit., he represents minute concretions of oxalate of lime from the case of a man who was passing dumb-bells of oxalate of lime and crystals of uric acid. One of them is a minute compound calculus formed by an aggregation of spheroidal elements which are doubly striated.

In fig. 12 he represents a microscopic calculus, doubly striated, without differentiated nucleus: to the exterior there adhere a few dumb-bells.

Dr. VANDYKE CARTER ('Urinary Calculi,' 1873) studied urinary calculi by examining fragments of the nucleus and surrounding layers with the aid of chemical reagents. He describes in oxalate of lime calculi (1) granules (so appearing under comparatively low magnification); (2) crystals; (3) rounded, ovoid, and dumb-bell forms (the simplest form, a minute, clear, rounded or oval crystal;[1] (4) spheroids (doubly striated).

When of large size the last named "with their *débris*" may, he states, wholly compose the pale, loose, gritty deposits of oxalate of lime which are sometimes found in calculi.

He imagines that the spheres arise in the "clustering and blending of the dumb-bell crystals, attended with deposition on the surface of the aggregated particles." The tuberculated character he supposes due to the arched or wavy course of incipient laminæ corresponding to the contour of subjacent and enclosed spheroids.

He describes crystals occurring in the form of rhomboid plates or rhomboid prisms, in scattered groups, or disposed in one or more layers, which he regards as oxalate of lime from the fact that

[1] In regard to group 3 the author states that such forms are especially associated with uric acid laminæ and layers of urates.

Dr. Ord had obtained such crystals in his experiments made with gelatine.

W. Ebstein ('Die Natur und Behandlung der Harnsteine,' 1884) figures (Taf. iii) a thin section of a small portion of the body of a calculus of oxalate of lime, showing its radial and concentric striation.

He represents a certain number of more or less spheroidal bodies, yellowish in colour, embedded in its substance; these he suggests are calcified epithelial cells from the urinary tract. We have not ourselves met with similar bodies in any of our sections, and can offer no opinion on their nature, though we may observe that both Beale and Carter have described the presence of dumb-bells of oxalate of lime embedded in calculi of uric acid.

W. Ebstein ('Experimentelle Erzeugung von Harnsteinen,' 1889) has experimentally produced urinary calculi in dogs and rabbits by the administration of oxamide.

The excretion appeared as sand in all parts of the urinary track; in the renal pelvis the concretions attained a size of 2 cm. in length and 7 mm. in thickness. Like calculi of oxalate of lime, they had a warty surface, and were in section doubly striated.

The presence of an organic matrix, giving the reaction of albumen, was demonstrated by digesting the calculus in distilled water at 80°—90° C.

Dr. George Harley ('Proceedings of the Royal Society,' 1889), in regard to the structure of crystalline pearls, describes them as showing basalt-like prisms radiating from the centre to the circumference, and as presenting concentric markings as well: the prisms he describes as striated, and as branched and interlacing; but he imagines that the striation resides in the animal matter which he conceives to surround each individual prism.

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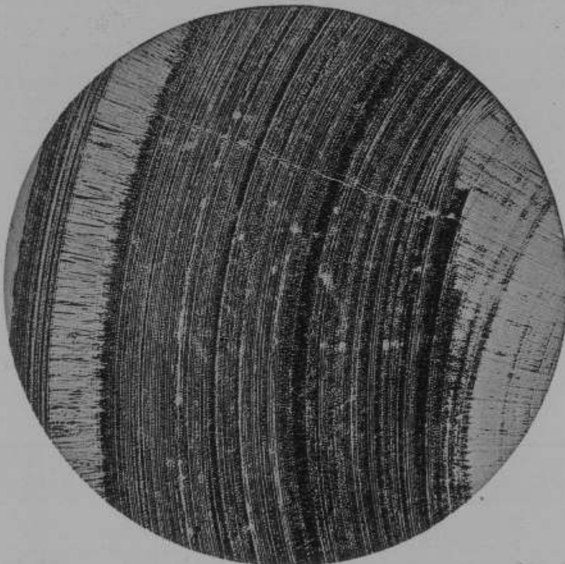
DESCRIPTION OF PLATE II,

Illustrating Dr. W. M. Ord's and Mr. S. G. Shattock's paper on the Microscopic Structure of Calculi of Oxalate of Lime.

FIG. 1.—*Section* 7. *Calculus C.* × 40. Showing the nucleus of coarse crystals suggesting octahedra; and the body of the calculus consisting of zones of radially striated crystalline substance and non-crystalline zones marked into concentric layers by lines of brown granules.

FIG. 2.—*Section* 7. *Calculus C.* × 140. Showing the more peripheral portion of the body of the calculus. The growing surface is constituted by non-crystalline substance marked into concentric layers by lines of brown granules. The body is made up of radially striated crystalline substances and non-crystalline zones marked into concentric layers by lines of brown granules (urate).

FIG. 3.—*Section* 7. *Calculus C.* × 140. Showing the nucleus of coarse crystals in places suggesting octahedra, and which exhibit a secondary cleavage. Towards its periphery are irregular collections of small crystals. To this succeeds the body of the calculus, which is made up, as seen in figs. 1 and 2, of radially striated crystalline substance and non-crystalline zones marked into concentric layers by lines of brown granules. In many places the points of departure of the crystalline material can be seen in the form of cones or diverging brushes of long crystals. The two kinds of structures first mentioned are variously intermingled, or cross one another.



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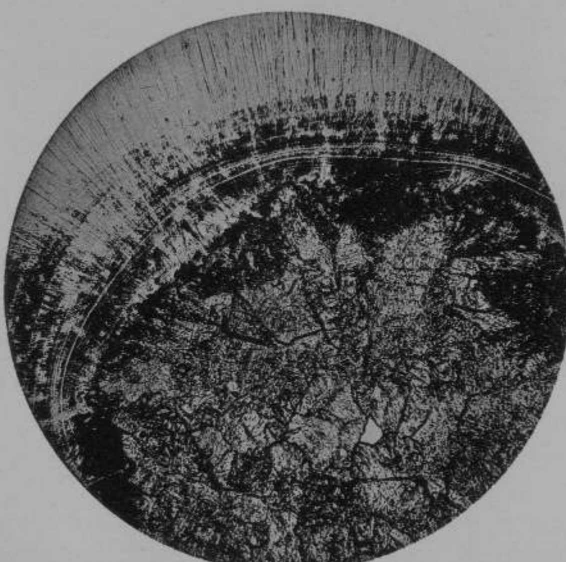

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DESCRIPTION OF PLATE III,

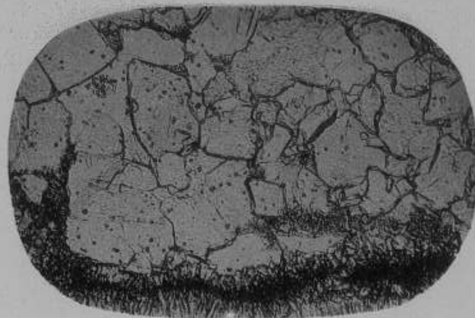
Illustrating Dr. W. M. Ord's and Mr. S. G. Shattock's paper on the Microscopic Structure of Calculi of Oxalate of Lime.

FIG 1.—*Section* 8. *Calculus K.* × 80. Showing large clear crystals constructing the nucleus. At the periphery of the nucleus the crystals are smaller, and on the left are set vertically as a palisade. On the crystalline nucleus the substance of the body of the calculus arises in the form of crystalline cones. The lower portion of the calculus is arranged round another nucleus, the zigzag fissure marking the apposition of the two different series of aggregated cones.

FIG. 2.—*Section* 12. *Calculus F.* × 260. Showing the outer part of the nucleus. There are shown clusters of fan-shaped elements and rosettes, to which succeeds a zone of minute crystals, and to this the doubly striated substance of the body.

FIG.3. —*Section* 10. *Calculus E.* × 120. Nucleus, showing the large crystals that mostly compose it; portion of the body of the calculus is shown arising upon the nucleus in cones of diverging crystals which form a radially striated general mass crossed at right angles by a second series of lines concentric with the nucleus.

FIG. 4.—*Section* 10. *Calculus E.* × 120. Showing the general structure of the body of the calculus, which is composed of a fusion of long crystals arranged in diverging tufts or cones, and crossed by fine striæ at right angles to their long axes. The preparation shows one of the clefts which correspond with the situation of recesses in the contour of the nucleus, the growing ends of the divergent cones coming to abut, without being strictly continuous, in planes which correspond with the recesses mentioned.



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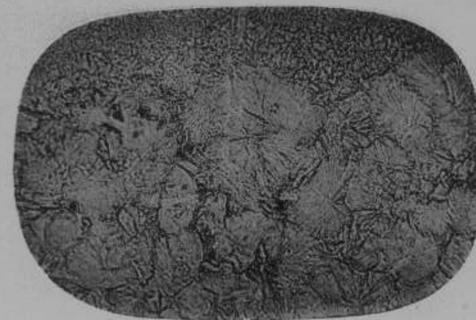

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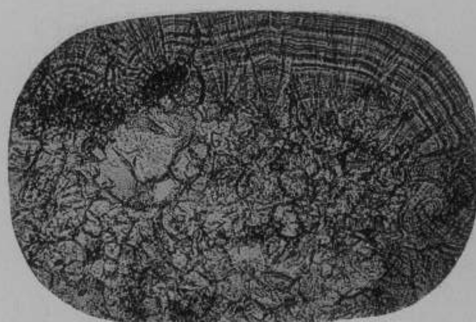


Fig. 3.

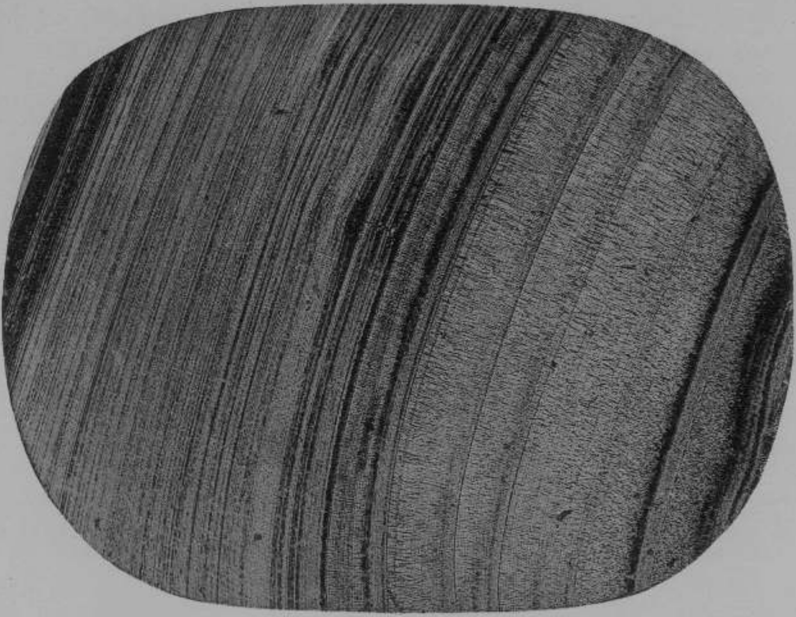
Fig. 4.

DESCRIPTION OF PLATE IV,

Illustrating Dr. W. M. Ord's and Mr. S. G. Shattock's paper on the Microscopic Structure of Calculi of Oxalate of Lime.

FIG. 1.—*Section* 14. *Calculus A.* × 70. Showing the nucleus. In the darker centre may be distinguished certain of the spherules described in the text; then succeed a zone of non-crystalline substance, one of finely packed crystals, and on this another of non-crystalline material: there follows a zone of interlaced crystals, and next one in which large diamond-shaped collections of small crystals occur,—octahedra of oxalate of lime in which secondary cleavage has taken place. Beyond this is the body, which is firstly constituted by a broad non-crystalline belt marked into three or more concentric laminæ by brown granules of urate; to this succeeds the radially striated crystalline substance.

FIG. 2.—*Section* 14. *Calculus A.* × 40. Showing the body of the calculus beyond the diamond-spaced area. There comes firstly a broad non-crystalline nebulous zone divided into three or more concentric strata by coarse lines of brown granules; then a crystalline one marked by interrupted radial lines, in the deeper part of which are scattered considerable numbers of brown granules of urate; next, another nebulous zone, then a broad radially striated crystalline one incompletely intersected in the concentric direction by others that are non-crystalline and nebulous. For its outward half the structure of the calculus is finely laminated or striated in the concentric direction.



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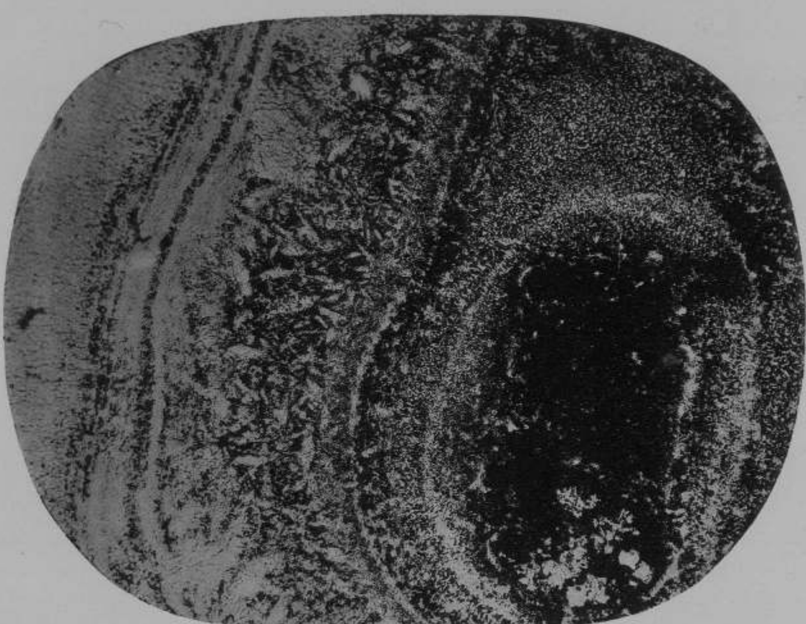

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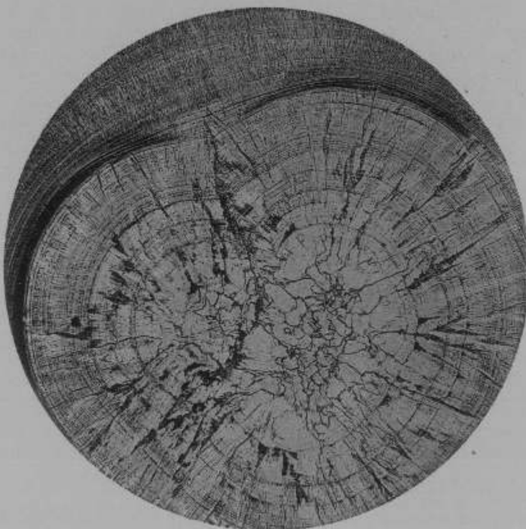
DESCRIPTION OF PLATE V,

Illustrating Dr. W. M. Ord's and Mr. S. G. Shattock's paper on the Microscopic Structure of Calculi of Oxalate of Lime.

FIG. 1.—*Section* 3. *Calculus O (a)*. × 36. A small spherical oxalate of lime calculus (one of many hundreds) from the pelvis of a hydronephrotic kidney. There is no differentiated nucleus, but the more central part consists of divergent cones of doubly striated substance starting from two centres somewhat as a gigantic dumb-bell. At the centre some of the cones are divided transversely, and are so discontinuous with the rest in the section.

FIG. 2.—*Section* 17. *Calculus M.f.* × 40. Showing a double nucleolus of doubly striated substance. The rest of the nucleus is made up of crystals in which secondary fission has occurred. Peripherally the crystals are of considerable size, and set more or less radially.

The body of the calculus, of which part is shown to the north, is non-crystalline and concentrically striated.



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DESCRIPTION OF PLATE VI,

Illustrating Dr. W. M. Ord's and Mr. S. G. Shattock's paper on the Microscopic Structure of Calculi of Oxalate of Lime.

FIG. 1.—*Section* 12. *Calculus F.* × 127. Showing a collection of large crystals of oxalate of lime, some in stellar aggregations, in the body of the calculus, which on either side consists of the usual doubly striated substance. The transition between the crystals and the wedge-shaped aggregate forming the body of the calculus to the north of the figure is readily traceable.

FIG. 2.—*Section* 18. *Calculus D.* × 40. The nucleus consists of small homogeneous spheres in process of coalescence. The most external part of the body is formed of concentrically striated non-crystalline substance, and zones of the same occur in the more internal portions of the body, in different degrees intersected by radiating tufts of crystals. The other parts consist of minutely crystalline material traversed by fine wavy lines (clearly discernible on areful inspection of the photograph). The most peripheral zone of such material consists of somewhat larger crystals.

FIG. 3.—*Section* 19. *Calculus L.* × 220. Showing a zone of oxalate of lime in the form of doubly striated cones in the midst of spherules of the same substance; the spherules are in process of coalescence, and form the nucleus and much of the body of the calculus. No effervescence ensued in the spherules on the action of acetic acid, and with hydric chloride they cleared up without effervescence, leaving an organic matrix.

FIG. 4.—*Section* 16. *Calculus Mc.* × 40. Showing portion of the nucleus in which are long octahedra of oxalate of lime in which secondary fission has taken place. At the periphery the crystals are set radially, but the secondary fissuring destroys their proper transparency. The body of the calculus consists of non-crystalline substance in concentric layers darkened by deposit of urate, especially around the crystalline structure of the nucleus.

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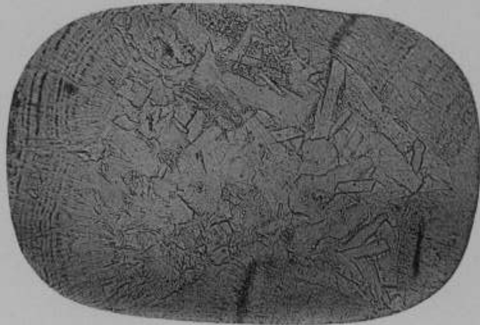

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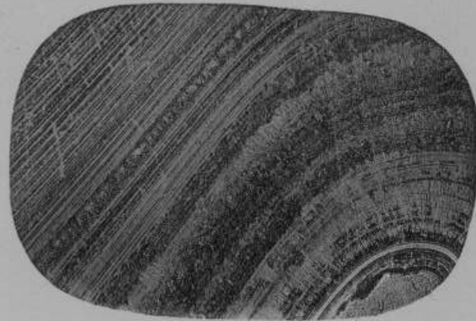

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