SCIENTIFIC RESULTS

OF

THE SECOND YARKAND MISSION;

BASED UPON THE COLLECTIONS AND NOTES

OF THE LATE

FERDINAND STOLICZKA, PH.D.

SYRINGOSPHÆRIDÆ.

BY

PROFESSOR P. MARTIN DUNCAN, M.B. LOND., F.R.S.,

VICE-PRESIDENT OF THE GEOLOGICAL SOCIETY, CORRESPONDENT OF THE ACADEMY OF NATURAL SCIENCE OF PHILADELPHIA.

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CONTENTS.

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I.—The history of the discovery of the *Syringosphæridæ* and the literature of the subject.

A number of spheroidal and of spherical stones, ornamented naturally on the surface, and which give no indications of ever having been attached to other bodies, could not but attract the attention of those geologists who years since travelled in Kashmir. Measuring in some instances two or three inches in diameter and in others not half an inch, and resembling stone balls in shape, these fossils, from the Karakoram range, became known to the curious as "Karakoram stones." But that they were not simple mineral productions was evident from the first to the educated collector; nevertheless, the nature of their external anatomy was singularly mistaken by those palæontologists into whose hands they first came. Dr. Verchère, when writing on the geology of Kashmir in the *Journal of the Asiatic Society of Bengal* in 1867, had the benefit of the palæontological skill of M. de Verneuil, and two plates of figures accompanied the descriptions of these remarkable forms.[1]

The description given of one species was that the bodies are "perfectly globular, covered with small rounded warts, sharply defined. The whole shell, between the warts, is pierced with minute pores. No traces of plates; no mouth nor stalk scar visible." The locality whence the specimens were derived was the rocky plains at the foot of the Masha Brum, Karakoram chain. The generic position was stated to be that of *Sphæronites*.

Another species had the name *Sphæronites ryallii*, Verch., given to it; and the diagnosis is as follows:—"Globular, large warts well set apart and not very sharply defined. The whole shell is covered with pores. No mouth. A stalk stem very conspicuous." A third specimen, also classed as a *Sphæronites*, is thus noticed:—"Depressed, no warts or spines: no plates or traces of plates, no stalk scar. The whole surface pierced by minute pores." These two specimens were derived from the same locality as the first.

[1] Journal, Asiatic Society of Bengal, 1867, Pt. 2, No. 3, Appendix p. 208, Plate VIII, Figs. 5 and 6, and Plate IX, Fig. 1.

The illustrations of this essay of Dr. Verchère do not assist the comprehension of the subject, and they were evidently drawn with a crinoidally disposed pencil. The so-called stalk stem is evidently an adventitious and accidentally adherent body.

The only other notice of the Karakoram stones previously to that of Stoliczka was attached to a specimen of one which was presented to the Geological Society by Major, now Colonel Godwin-Austen, and collected by him. This specimen closely resembles a *Parkeria*, and this did not escape the accomplished palæontologist, who, at the time of the reception of the fossil, had charge of the Museum of the Society. Professor Rupert Jones, F.R.S., wrote on the label of the specimen "*Parkeria.*"

The next and the most important notice of the Karakoram stones was the last effort of Stoliczka, whose lamented death occurred soon after he concluded his short description of their geological position.

The following extract from Stoliczka's last diary places the subject at the point whence the present attempt to explain the morphological characters and the classificatory position of the Karakoram stones may be said to commence:—[1]

Extract from Stoliczka's last diary.

"*June 15th, Karakoram-brángsa, 14 miles.*—Starting from Woabjilga, the grey triassic limestones were met with, afterwards the red limestones succeeded them, and continued to camp, often interrupted by patches of greenstone, which is greatly developed at the camp north of the pass.

"*16th, Daulatbeg Uldi* (crossing the Karakoram pass), *about 22 miles.*—Leaving camp, the green stones are underlain by black crumbling shale, in mineralogical character like the Spiti shales, but are very likely triassic, like that near Aktásh. Then follows an alternation of grey or whitish limestones and shales, and the triassic red limestones; and on these rest blackish and grey marly shales, which are overlain by almost horizontal strata of brown limestone, very much like the lower Taglang limestone, and which contains fragments of *Belemnites.* These *liassic rocks* form the Karakoram range proper, and extend far eastward. The hills to the west are much higher, and do not allow a distant view.

After crossing the pass, the road skirts the base of the centre ridge in a south-east direction; and here the liassic limestones come down several times, and about four miles from the pass grey marly shale, or almost marly limestone, crops out from under the brown limestones; both are evidently liassic. On the right bank of the stream more massive limestones occur, dipping to north-east, but very indistinctly. I should think that these are triassic limestones. They very readily crumble to pieces, being dolomitic; and these often contain reddish beds interstratified.

"*17th, Burtsi, 24 miles.*—First we crossed the Dipsang plain, with solitary low hills, probably still belonging to the Taglang series. Then we ascended towards the watershed. The low worn-down hills to the west were thickly strewed with round pieces of whitish or reddish compact limestone, intermingled with boulders, large and small, of fine-grained syenitic gneiss. This rock must be *in situ* somewhere near the head of the watershed. Further on were many greenstone boulders coming down from the west, and this rock must also be found in that direction. At last we descended into a narrow gorge, the sides of which for fully a mile consisted of a limestone conglomerate, the boulders of white, grey, or black limestone being well rounded and worn and cemented together by a stiff bright red clay. Upon this followed dolomitic limestone, rather indifferently bedded, massive and white, and this was overlain by bluish shales and well bedded limestone, extending from about six miles north of Burtsi to the camp. These limestones appear to be triassic; they are compact, with layers full of small gasteropods, among which I recognised a *Nerinæa.* The so-called Karakoram stones, *i.e.*, corals, occur in dark shales below the limestones, which are capped by a yellowish-brown limestone, well bedded, but of unascertained age. The whole series dips south-west at a moderate angle. [The last paragraph closes the diary.]"

[1] See the portion of the present work relating to Geology, by W. T. Blanford, page 45.

The late distinguished Palæontologist to the Geological Survey of India had traced these remarkable spheroids to their time and place in the succession of rocks, and he expressed an opinion regarding their zoological position. They were found in shales beneath limestones which were certainly lower than the Lias, and which were probably triassic in age. The term "coral" was singularly justified, for some of the superficial markings on the stones resemble, in their radiate appearance and regularity, the casts of the calices of minute *Madreporaria* of the genera *Astrocœnia* and *Stylocœnia*. But it is only necessary to remark that Stoliczka's great knowledge of the *Anthozoa* would have led him to the expression of a different opinion had his specimens been prepared for microscopic examination.

The so-called Karakoram stones collected during the second Yarkand Expedition by my lamented friend were placed in my hands by Mr. W. T. Blanford in 1878.

The specimens are numerous and in very perfect condition; the weathering to which some have been subjected rendering the outside details all the more visible. Their surfaces are free from other fossils, and a broken serpula tube is the only one to be recognised.

Fossilization has occurred by the introduction of calcite, and this is usually somewhat dark in colour, but is transparent in thin sections. The original structure of the body now consist of carbonate of lime of a different and lighter colour to the infiltrated calcite, and it appears that on the outside of the fossils the original structure has usually disappeared and the intermediate or infiltrated mineral has lasted.

Carefully made radial and tangential sections of the fossils, assisted by biting out with dilute acids, and the use of low and high powers of the microscope, assisted by the polarising apparatus, rendered their remarkable construction evident, and also that it was necessary to include all the Karakoram stones in a new order of *Rhizopoda* called the *Syringosphæridæ*. A notice of this new order was published in the Annals and Magazine of Natural History for October 1878, Ser. 5, Vol. II, page 297.

II.—The general morphology of the Fossils, their histology, and their position in the classificatory scale.

The Karakoram stones are either nearly perfectly spherical, or more or less spheroidal or ellipsoidal in shape. They may be of small size, and some are more than three inches in their greatest diameter; but they are always symmetrical, and there is no trace of a stalk or of any former attachment by the surface to other bodies. Some forms are nearly smooth, others are minutely granular, each granule having a definite construction, and the most numerous types have tubercules, wart-like growths, and large eminences crowded, more or less, with papillæ and little warts upon them. There is one group of forms with a very verrucose surface, and, on the other hand, another type is covered with a finely granulate surface: nevertheless this external structure does not interfere with the general curvature of the mass, the tops of the highest and lowest eminences never exceeding their symmetrical position.

The more rugose and mammilated surfaces of the fossils have small circular or deformed shallow pits scattered here and there; they are very numerous in some of the types with rounded surface tubercles, and are but scantily distributed in others, and whilst they crowd the surface of one form with a granular surface, they do not exist on another. These pits become elongate on the equatorial part of some of the spheroidal fossils, and are found on the sides and on the edge of the bases of some of the papillæ, tubercles and warts of other types. Their resemblance to minute oscula of sponges is superficially evident; but it is to be shown that one great group of the fossils under consideration does not possess them, that they differ in their number in different parts of the same fossil and in different individuals of the same species. I have called them "pores," and their absence in one of the groups of the fossils has led me to divide these Karakoram *Syringosphæridæ* into two genera—one with pores on the outer surface is termed *Syringosphæria*, and that without pores I have dedicated to Stoliczka's memory, terming it *Stoliczkaria*.

The method of examination of the fossils is necessarily a simple one. Their surfaces are usually well preserved and not over-weathered, and the insides, in the majority of instances, yield good sections, both radial and tangential. Careful washing adds to the details of the surface, and biting with hydrochloric acid and water is necessary to distinguish tube structure from the intertubular calcite of fossilization which sometimes simulates it.

The sections, on account of the brilliant opacity and white or white-brown colour of the tubes, can be well studied by reflected light, and indeed it is advisable to do this preparatory to the examination by transmitted rays. The dilute acid is very useful in some confused sections, for it dissolves the infiltrated calcite which exists between the tubes, and leaves their granular wall to a certain extent untouched. The paths of tubes can then be seen by reflected light very well. If the acid is allowed to act too strongly, all structure disappears.

The tubes, both radial and interradial, are easy to see in the majority of instances, but in one particular case polarized light and the selenite plate determined the visibility of the structures, which were hidden amongst a confused mass of calcite. The calcite which was introduced during fossilization fills the tubes as well as their interspaces, and it has taken on definite or indefinite cleavage planes. These must be studied under polarized light, for the dark lines they produce to ordinary transmitted light, and which simulate cœnenchymal structure, can then be decided to be only divisions between crystals or parts of different polarizing influence on the ray.

Low powers of the microscope suffice for most of the examination, but a good $\frac{1}{8}$-inch object glass is required to distinguish the granules and granule-spiculate elements of the tubes.

No other form of fossilization but that by calcite has been noticed, and silica does not enter into the composition of the bodies.

On examining the surface of a rugged or tuberculate specimen of either of these genera with a hand lens, a reticulate appearance is seen between the projections. In very good specimens, on the ordinary level of the surface, after biting with dilute acid, or sometimes without this proceeding, this reticulation resolves itself into a gyrose tubulation; the tubes coming to the surface, running along it in close proximity, dipping down again suddenly and re-appearing, and sometimes bifurcating. Between the tubes is a more or less linear interspace filled with dark calcite. Weathering sometimes has destroyed the tubulation and left the thin interspace to look like a mesh, or the interspace has been left void, the tubules remaining.

Besides this reticulation, there are in some types numerous, and in others but a few minute openings from $\frac{1}{1000}$ to $\frac{1}{300}$ inch in diameter, and they have a margin or tube layer. They are sometimes separate, and at others they are clearly the outside opening of one of the superficial tubes just mentioned. Usually the caliber of the tubes is filled with brownish coloured calcite, or with granular carbonate of lime, but in some instances the presence of a very delicate tube wall, unattached by its outside to any structure, is evident.

On the projections, whether mammilated, wart-like, papillate, tuberculate or granular, there are markings to be seen which are of two kinds. On the top or centrally are circular markings, few or many, which on careful examination turn out to be the openings of tubes. They are often very minute, and their caliber is smaller than that of the tubes seen in the interspaces just alluded to. On the sides, and converging to the margins of the top of the eminences, are numerous close, straight lines, usually continuous, but sometimes wavy, broken and bifurcate. They are, according to the condition of the fossil, either the preserved calcite of converging tube interspaces, or they may be the walls of the tubes themselves, or both. These tubes may be traced on the surface to be continuous with some of those of the spaces between the projections, to appear from within the fossil and to run up outside the eminences. In many instances they open, finally, at the surface around those smaller ones which appear in the centre of the top.

In some forms, especially where the eminences are broad and low, these converging tubes open all over the projection.

It is evident that the projections, whether they are simple or compound, are made up of the outsides of tubes, tube openings, and of calcite which fills up the interspaces between them; there being much bifurcation and side inosculation of the tubes also. The projections, mammilation or granulate tube openings and convergings belong to a *radial tube series*, and the tubulation between these eminences to an *interradial series*. No cœnenchyma or skeleton exists.

The pores are spaces in the superficial interradial tubulations, but in rare instances they are found elsewhere. They are surrounded and limited at their margin by tubes bounded within by others, and their shallow floor has the outward openings of deeply-seated tubes on it. The distinction between the interradial tube reticulation and the radial tube series is best seen in the genus *Stoliczkaria*, on account of the definite intervals, without pores, which exist between the granules containing the end of the radial series. It is well seen in the pore bearing *Syringosphæriæ*, which have distinct eminences, and it is the least apparent in some spheroidal kinds, where there is as much space occupied by pores as by eminences.

The relative positions of the radial and interradial series of tubes, and the close and converging character of the one and the reticulate appearance of the other, must be kept in mind as this description proceeds, for they have the same definite relation within the fossil. In some species, moreover, the radial tubes are readily distinguished, because they are smaller than those of the interradial series.

This persistence of the radial series of tubes, and the environing interradial and reticulate tubulation, can be well seen in tangential sections of those types in which the structure is close; for instance, in *Stoliczkaria granulata*, especially if the thin slice is taken rather close to the surface of the body. Then a number of star-shaped masses are seen, separated from one another by a denser structure. The centre of the star contains small tubes cut across, and giving off small branches to the outside and separating structures, which consist of sections of larger tubes made in different directions, such as oblique, transverse, and longitudinal. The small tubes of the centre of the star are well separated from each other, except where they bifurcate, but the surrounding tube reticulation is close, the tubes being nearly in contact. Clear calcite fills the spaces between the small tube ends of the star, and there is less of it amongst the large tubes around. The opacity of the calcareous structure of the walls is evident, and they are usually brilliantly white or brown under reflected light. Here and there the lumen of a tube may be seen filled with calcite. (Plate III, Fig. 5.)

In other types the limitation and surrounding of the radial series of tubes by the larger and more extensive series of reticulating ones is readily seen in tangential sections close to the surface, but it becomes rather confused at some distance within, on account of the obliquity of the radial series in relation to the surface. For they start as it were from a central point in the fossil, and radiate in all directions, increasing in width and in their number of tubes. The distinction between the two series is readily made, however, for the interradial is usually the largest in extent and its tubes are eminently bifurcate and form close reticulations, bending often suddenly and showing geniculate outlines. Tangential sections further in, even although they are less distinct, show that the breadth of the radial and interradial series diminishes centrally.

In one group of the fossils, forming the genus *Stoliczkaria,* no trace of the surface-pores exists and no vestige of any of them can be distinguished in sections. But in the other group forming the genus *Syringosphæria,* the pores can usually be distinguished in some parts of the fossil, besides the surface, especially in tangential sections, as circumscribed structureless spaces filled with clear or opaque calcite. It does not appear that the tubes which pass out of the pores, at the surface, are restricted to one particular series, and they may belong to the radial group, or more frequently to the reticulate or interradial set.

Radial sections of the fossils show structures which correspond to those seen in tangential sections, and the morphology of the forms is divisible into two categories. In one, the structures consist of numerous conical congeries of bifurcating radial tubes, the apex being central and the base at the surface of the body; and of a reticulate tubulation separating the cones, joining their external tubes and arising from them. The cones and the intermedial reticulation increase in size towards and at the surface of the body, on which are widely or closely-placed tubes passing radially, tangentially, and obliquely. Hence the surface of the body presents the ends of the radial tubes and those of the reticulation, and it is mainly composed of the tubes which are placed tangentially over the circumference.

In those types of the *Syringosphæridæ,* where there are eminences with radial tubes surrounded by much space occupied with tube-reticulation, the radial sections illustrate the structure of the whole admirably. One of these sections may be considered in three parts in order to explain the morphology. Near the centre fossilization confuses the structure, but it appears that a simple tubular structure arises from around a foreign body, such as a many-chambered Foraminifer, or that one tube branches suddenly in every direction. The tubes radiate in separate groups, each tube bifurcating frequently as it recedes outwards, and there are frequent lateral tubes connecting them together. Hence the mass of tubes increases in the number of its tubes, and forms in section a more or less triangular outline, the apex being towards the centre of the body. At the same time the tubes of the outside of the triangle or longitudinal section of the cone give off others which form in part the reticulation of the interradial part. This is small at first, but increases in section in the middle of the body.

In the middle of the body, in sections, the radial series is seen to be broader and the interradial to form large meshes. Close to the surface of the body, in sections, the radial series of tubes is seen to bifurcate to the last, and to open directly on an eminence so far as its central tubes are concerned, and many of the outer tubes pass obliquely on the flanks and open at the top. The interradial series also opens by its radial tubes at the surface and by its oblique tubes, but those parallel with the circumference pass over it. (Plate III, Figs. 1, 4, 6).

The relative size of the radial and interradial series is apparently of specific importance.

In the radial sections the pores are seen to be spaces surrounded by interradial tubes, some of which open on the floor.

But in the radial sections of those types which have a great number of radial series and a very scanty surrounding reticulate tubulation, the appearances under the microscope are not so striking as in the other instances. In these the radial cone is very long, and bifurcation occurs comparatively scantily, so that it is narrow, and the sides of the series often appear to be parallel. The tubes of the radial series, moreover, are smaller than the surrounding series; they are not so close together side by side, and their course is almost invariably straight. The interradial surrounding tubes are closer and larger than the others, and they bend so as to present oval or geniculate knots, the continuity of the tube being often lost to sight, a cross line denoting the upward or downward bend. They bend laterally also, and touch here and there and bifurcate. The size of this series is usually larger than the other, so that in these radial sections a radiating series of light lines is separated by broader dark ones.

This close structure is best seen in the group without pores, but it exists in the other, in some species. (Plate III, Fig. 6).

In one type of the *Syringosphæridæ* the pores are very developed, especially equatorially.[1] In radial sections their presence is evident in the body or from the surface. They extend in long rectangles one outside the other, and evidently bound radial series, but they are situated just within the interradial. On either side of them are elongate tubes, offshoots of the environing series, and separating one space from another; that is to say, from within outwards is a bridge of cross and reticulate tubes parallel with the circumference, like a tabula of a hydrocoral. Several of these bridges exist, and the last one is incomplete, often quite at the surface where a pore is about to be occluded.

In tangential sections, the circular outline of the pores may be seen surrounded with tubes.

In other specimens, this absence of tube-structure along definite lines, that is to say, the presence of pores, is not so visible, but they can be detected as vacant pits or circular spaces filled up with extraneous material.

No special tubes enter the pores.

The tubes forming both series are continuous, bifurcating, and inosculating; and, as has been already noticed, some are in the main straight and others are curved and form the edges or sides of greater or less meshes or vacant spaces.

The tubes are much larger in some types than in others, and they range from $\frac{1}{1000}$ inch to $\frac{1}{300}$ inch in diameter; they usually retain the same caliber for some distance or altogether, but frequently in some types they swell out, become varicose, flat, and again return to their original cylindrical condition. (Plate III, Figs. 6, 8.) The union of tubes is by small offshoots usually, but the bifurcation, often at an acute angle, gives origin to two tubes of equal size to the parent, or nearly so.

The tubes have a wall and a lumen, and the thickness of the wall varies; moreover, some of the constituents of it pass irregularly into the caliber, as well as occasionally surround the tubes like a furry investment.

[1] *Syringosphæria porosa*, Duncan. Plate III, Fig. 3.

There are no diaphragms in the tubes. In some types a part of the tube-wall is so homogeneous as to render the possibility of the former existence of a membrane well worthy of consideration; but in the majority of instances, the construction of the wall is evidently of close and semi-spiculate granules and of shapeless granules, and was probably not quite impervious. The tubes are filled with calcite. They are often perfectly transparent, and at other times impervious to light. Under high powers the structural element of the tube is shown to be mainly spiculo-granular and molecular; the grains usually being $\frac{1}{10000}$, $\frac{1}{15000}$ inch, or less in breadth. But in some instances there are elongate pieces with spiny processes on them, all being however excessively small. The structure of the tube-wall was organic in its origin, and not the result of simple adhesion of foreign or arenaceous particles.

The question whether there is an intertubular cœnenchyma of fibres, or a reticulate skeleton, which supports the tubes, separates them, and allows the symmetry and ornamentation of the surface to be kept up, is by no means readily answered. The examination of the forms of *Syringosphæridæ*, with the radial series of tubes separated by much tube reticulation, leaves this question not satisfactorily solved. The fossilization is by calcite, and the cleavage planes, commencing cleavage planes, irregular crystals, and cracks show dark lines by transmitted light, which in many instances resemble sponge structure, and even in one instance a hexactinellid spicule was suggested to the eye. Polarized light, with or without the selenite plate, resolves these markings into the limiting lines of different crystals, and, although one or two evidently extraneous organic bodies have been seen amongst the tubes, no continuous or partial interskeleton can be determined to exist now. In the centre of the masses, the confusion of tube radiations, cleavage planes, and the presence of some foreign body, which formed in some instances the nucleus, or rather the starting point of the *Syringosphæridæ*, renders it impossible to decide dogmatically whether there is a cœnenchyma or not. On the other hand, in those forms where the tubes are close, even in the interradial series, the absence of cœnenchyma is evident enough. Under correction, and relying on the specimens examined, I do not think that there ever was a structure in them external to the tubes and which supported and separated them after the manner of a cœnenchyma.

The position of these spherical and spheroidal masses of radiating and interradiating tubes in the classificatory scale must be low. The minute size of the tubes, their bifurcating so frequently, and inosculating, and giving off others from small offshoots, and the structure of the wall, do not render the *Syringosphæridæ* polyzoan in their nature. The analogy with the tubular or more or less globular masses of *Fascicularia* found in the English Crag is of the slightest in degree. It is tempting to theorize, so as to place a Gastrozooid in each pore, supplying it by the radial tubulation, and to decide that the tubes of the interradial series opening at the surface were those of Daclylozooids, the whole being a hydroid. But the absence of pores in some forms, the evidence that there are places where growth is not proceeding in others, and the deficiency of surrounding open tube mouths in most, prevents this idea from having any value. There are moreover no tabulæ in the tubes.

That these great and small spherical and spheroidal masses are corals is, of course, out of the question, and the evidence of their sponge nature is small.

Had there been a cœnenchyma between the tubes, the bodies would have resembled foraminifera, with gigantic canal systems, but its absence and the peculiar nature of the tube-wall remove these forms from that polymorphic group. The absence of labyrinthic spaces, and the fact that the tubes are not formed by arenaceous particles, separate the *Syringosphæridæ* from the arenaceous foraminifera of the *Parkeria* group.

It is evident that the calcareous granules and spicules were not collected by these tube-makers mechanically, and their occasional presence in the tubes themselves, and their extending beyond them, but still clinging to the furry outside in other instances, show that the tube structure is organic in origin and that it resembles that of some *Rhizopoda*. The symmetry of the bodies could only have been maintained by a common sarcode, enveloping the whole; food could only have been obtained by pseudopodia from the tubes, and these soft external substances would not be unfavourable to the shape of the mass, and to its never being found worn by resting or attrition.

That these fossils are rhizopodous is almost a necessary belief, but it is evident that they cannot be brought within the order *Radiolaria* any more than they can within any group of the foraminifera. It remains, therefore, to establish a new order, the *Syringosphæridæ*, amongst the class *Rhizopoda*, and to include these triassic or lower liassic fossils within it.

Class: RHIZOPODA.

Order: *SYRINGOSPHÆRIDÆ.*

Genus: **SYRINGOSPHÆRIA.**

Species SYRINGOSPHÆRIA VERRUCOSA.
" S. MONTICULARIA.
" S. TUBERCULATA.
" S. POROSA.
" S. PLANA.
Variety S. MONTICULARIA var. ASPERA.

Genus: **STOLICZKARIA.**

Species STOLICZKARIA GRANULATA.

III.—A DESCRIPTION OF THE GENERA *SYRINGOSPHÆRIA* AND *STOLICZKARIA* OF THE ORDER *SYRINGOSPHÆRIDÆ.*

Order: SYRINGOSPHÆRIDÆ.

Body free, spherical or spheroidal in shape, consisting of numbers of limited, more or less conical, radiating congeries of minute, continuous, long, bifurcating and inosculating tubes; also of an interradial close or open tube reticulation arising from and surrounding the radial congeries. Tubes opening at the surface on eminences and in pores, and ramifying over it. Tubes minute, consisting of a wall of granular and granulospiculate carbonate of lime. Cœnenchyma absent.

The presence of pores on the surface of some forms of the order, and their absence in others, and the very close nature of the interradial reticulation in the poreless kinds, necessitates its division into two genera.

Genus: SYRINGOSPHÆRIA.

Body large, symmetrical, nearly spherical or oblately spheroidal, covered with large compound wart-like prominences with intermediate verrucosities, or with compound monticules having rounded summits, with solitary eminences between them, or with close broadly rounded tubercles, or with minute granulations. Rounded, or oblique, or linear depressions occur on the surface usually between the eminences, but sometimes upon them; they are shallow and are bounded by tubes, some of which open on their floor. The surface has tubes opening on it from the internal radial series, and also from the interradial tube reticulation; also masses of tubes running over it, converging on the eminences, and more or less reticulate elsewhere.

Radial congeries of tubes numerous and defined, and the interradial tubulation is open or close and varicose.

Genus: **STOLICZKARIA.**

Body very large, symmetrical, oblately spheroidal, covered with a great number of minute distinct granulations, which are circular at the base, short and rather flat where free, and which are separated by an amount of surface about equal to their breadth. No pores exist. Tube openings occur on the granulations, and tubes, with or without openings, converge to their base and cover the intermediate surface. The tubes opening on to the granulations are terminations of the very numerous radial series, and are small; and the others, which are larger, belong to the closely-packed varicose and much contorted interradial series. The body within consists of a vast number of small, not very conical, but rather straight, radial series, whose rather distant tubes give off minute offshoots to the surrounding large tubes of the close interradial series. No cœnenchyma can be discovered.

I have named the most remarkable of all these fossils, those which belong to the poreless division of the order, after the distinguished Palæontologist, whose loss, whilst in the performance of his duty and whilst studying these very forms, is greatly and justly regretted.

IV.—A DESCRIPTION OF THE SPECIES OF THE GENUS *SYRINGOSPHÆRIA*.

There is nothing more unsatisfactory than the endeavour to separate and define rhizopodal forms into species, and the attempt would not have been made in this instance were there not five well-characterised types of the first, and one of the second genus.

As the presence and absence of pores have been held to be of generic value in classifying the order, so the paucity or abundance of them can enter into the specific diagnosis; moreover, the surface ornamentation, although of doubtful value, becomes more important to the specialist when it is accompanied, or not, by an open or close condition of the interradial tube series.

There is one group of the genus *Syringosphæria* in which the pores are in excess, and occupy as much of the surface as the eminences do. This forms a specific distinction and is all the more important, because the presence of former pores can be detected within the body, and the interradial tube reticulation is rather close. These, then, are the specific characters of *Syringosphæria porosa*. Plate II, Figs. 3 and 4.

The kinds with compound verrucose elevations have a moderate number of pores and a very open tube reticulation in the interradial series; they form, with the group possessing compound and simple monticules, a tolerably well-defined set, divisible into two species by the surface growths. They are *Syringosphæria verrucosa* and *Syringosphæria monticularia;* Plate I, Figs. 1 to 12; Plate III, Figs. 1 to 4, 8 and 9. The species *Syringosphæria monticularia* is, however, subject to variation, and the monticules may be very flat, the whole surface being nearly level, or the eminences may be sharply defined. The forms classified under the last head constitute the variety *aspera;* Plate II, Figs. 6 and 7. A form with granular and minute processes with pores leads to the next genus. It is *Syringosphæria plana.* All these are well defined and readily recognised species.

There is but one species of the genus *Stoliczkaria*, the granulate, poreless surface of which distinguishes it from all other forms of the order.

SYRINGOSPHÆRIA VERRUCOSA, Duncan. Plate I, Figs. 1 to 3.

The body is spheroidal in shape, and the surface has numerous large compound wart-like or rounded or conical mammiliform eminences on it, and also solitary mammiliform projections, as well as small, distant, sharp granules. Numerous minute, shallow, circular pores exist, especially on the bases of the verrucose and mammiliform projections, and there are some on the surface between them. The largest of these eminences are on the equatorial region. The surface between the great and small verrucosities and mammiliform eminences supports the majority of the small granulations, and is covered with closely-packed tubes and many tube openings. The tubes run short courses, bend and dip down, and are from $\frac{1}{200}$ to $\frac{1}{300}$ inch in diameter. They are separated by linear, low projections of dark coloured calcite, and very frequently the tube has disappeared and left these limiting products of fossilization only. The openings of the tubes at the surface are surrounded by circular rims of the dark calcite.

The top of every mammiliform, conical or verruciform eminence is smooth, and many tubes open on the summit and resemble circular patches of a slightly different colour to the brownish calcite which environs them. On the sides of the eminences, and reaching around and more or less on to the summit (Plate I, Fig. 3), are converging, wavy, linear projections of calcite, separated by long broad spaces. The spaces are the remains of tubes, and amongst them are wavy tube openings, limited by calcite rims. The pores have tubes around them and opening on their shallow floor, and they appear to be parts where the upward growth of some radial systems has not been as rapid as the interradial. The height of the body is $1\frac{1}{3}$ inch, and the breadth is $1\frac{2}{3}$ inch. The diameter of the base of a large compound verrucose prominence is $\frac{3}{10}$ inch. In the fossilization of this form the tube-wall is light brown and the calcite, which has been infiltrated, is darker brown and smooth.

SYRINGOSPHÆRIA MONTICULARIA, Duncan. Plate I, Figs. 4 to 12; Plate III, Figs. 1, 2, 3, 4, 8 and 9.

The body is oblately spheroidal in shape, and the surface has wide-apart, low, rounded, compound mammillæ on it, consisting of one large rounded eminence surrounded by many smaller; also solitary, short, flatly rounded mammillæ, and very small blunt granules of two or three sizes may exist. The pores are very numerous and are small, being found everywhere on the surface, and opening directly or obliquely.

The intermammillate surface is marked mainly with the openings of tubes, and by a few sides of tubes passing for a short distance on the surface and converging on the eminences. Most of the tubes are $\frac{1}{300}$ inch in diameter. The mammillæ are crowded with tube openings which are circular, and often the lighter colour of the substance within the tube is seen surrounded by infiltrated calcite. In some specimens the tubes are excessively bent and geniculate, and they dip down or end suddenly. They surround the pores and open into them. The tubes are crowded, close, and the linear dark calcite often alone remains, ndicating the lateral limits of former tubulation.

Radial sections show the radial series of tubes to bifurcate or inosculate frequently, and to increase in size in varicosities. These tubes mainly go to the surface and open there directly; and some of them give off branches on all sides to form the interradial tube reticulation. As much of this reticulation consists of radiating tubes, the last series of them opens at the surface. The tubes of the outer meshes are also represented at the surface by flat or bent tubes. The interradial series thus formed separates, very distinctly, the wide conical radial congeries from each other. Almost every mammilla has its radial congeries of tubes. The diameter of the smallest lateral tubes given off is $\frac{1}{1000}$ inch, but the average size of the tubes is $\frac{1}{300}$ inch in diameter. Near the surface there are occasionally great differences in the size of the tubes, many of which become flat, and the same spreading out is seen further in, where the granular element of the tube-wall has been formed in excess.

The typical specimen is $\frac{7}{10}$ inch high and 1 inch broad. The diameter of the pores is $\frac{1}{80}$ inch to $\frac{1}{90}$ inch. (Plate I, Figs. 4, 5, 6).

A young specimen has the compound mammillæ hardly formed, but the single ones and the pores are abundant. It is more spheroidal than the type (Plate I, Figs. 7, 8, 9). The magnified radial sections (Plate III, Figs. 1, 8, 9) were taken from this form.

A variety of the species has a larger body than the type (Plate I, Figs. 10, 11, 12), but the mammillæ are low and insignificant. The magnified oblique section, showing the divergence of the very open tube series (Plate III, Fig. 4), is from this form, as is also the top of a monticule showing tubes and tube openings (Plate III, Fig. 3).

SYRINGOSPHÆRIA MONTICULARIA, variety ASPERA, Duncan. Plate II, Figs. 6, 7.

This transitional variety has very few compound mammillæ, but a great number of single ones and pores. It is a large form, and is oblately spheroidal, about 1 inch in height and 2 inches in breadth. It was collected by Colonel Godwin-Austen, and is introduced here in exemplification of the series.

The radial section shows that the radial congeries are very widely separated by reticulate tubulation; that the tubes are large, usually $\frac{1}{300}$ inch, that they have a very delicate wall, are often varicose, and that they pass in great multitudes to the surface close together. Farther in, the intertubular space equals the diameter or the tubes, and gives rise to much confusion, and it is difficult to know, except by reflected light, which is tube and what is calcite infiltration.

In some parts the tube reticulation is close, and the tubes crowded together, and in this there is an approximation to the next species.

SYRINGOSPHÆRIA TUBERCULATA, Duncan. Plate II, Figs. 1, 2.

The body is spherical and symmetrical in shape, and is covered with numerous low, rounded, broad elevations, separated by indistinct interspaces. There are minute pores scattered over the whole surface. The eminences about $\frac{1}{10}$ inch across at their base, are not $\frac{1}{3}$ of that measurement in height; they are sometimes irregularly shaped. In some parts the interspaces are as broad as the bases of the eminences, but usually the slope of one eminence merges into that of another, the interspaces being confined to the concavity. The interspaces are covered with a very crowded and close arrangement of the tubes; many tubes pass out radially on them, and the orifices are only seen; others come up to the surface and bend down again suddenly, leaving a geniculate swelling visible; and others enlarge and diminish in their caliber. Some of these pass along the surface for a very short distance, and all very close together laterally, and others pass up the flanks of the eminences converging close to the summit and opening on them with their orifices, or more frequently on the centre of the tubercular elevations.

The pores are numerous, small, shallow, and universal; they are limited by lateral tubes, and some open on their floor. The fossilization is by calcite, and in many places the interspace between the surface tubes infiltrated with calcite has been preserved, the tubes having weathered away. The tubes are so close together that the infiltrated calcite is difficult to distinguish from tube; but its breadth is usually much the smaller.

In radial sections the radial series of tubes are numerous and large, but the interradial systems are not very distinct from them, there being no wide tube reticulation.

The tubes of the radial series are rather close, large, bifurcate, varicose, geniculate often, suddenly diminishing in size where joining others; they join much with each other, side by side, are usually distinctly radial in their direction, which, however, is locally irregular, and they have thin walls and a large caliber.

The interradial tubes, very radial in their course, however, are often seen passing for short distances, parallel with the circumference, in all parts of the body. They are more varied in their courses than the radial series, and are usually close together and crowded, the distance between them being small. They unite with the radial systems by offshoots of tubes, and it is evident that at the surface of the body most of the interradial tubes open directly outwards.

There is no very definite relation between the outward opening of the tubes within and the eminences and interspaces; moreover, the pores are situated without order.

The majority of the tubes are nearly $\frac{1}{300}$ inch in diameter, some being $\frac{1}{500}$ inch, but very small tubes are rare.

The fossilization of the interior of the body has led to radiating portions being infiltrated with a denser semi-granular calcite which hides much structure, and especially centrally. In some places the tubes are filled with opaque matter, and the intertubular spaces are readily distinguished, whilst in others the intertubular spaces are large, and the tube has either disappeared or remains in very transparent calcite. Under this condition, it is difficult to distinguish tube from continuous infiltrated calcite in section. Relics of the pores, as clear spaces, are to be seen in radial sections. The height of the body is $2\frac{2}{10}$ inches, and the whole resembles a *Parkeria*.

Syringosphæria plana, Duncan.

The body is oblately spheroidal, almost smooth on the surface, with many minute granules on it, and numerous small shallow scattered pores. The granules are flat, with rounded, or elongate, or irregular bases, and are about the same size as the pores. Many tubes open on them, forming circles on their periphery, and also into the pores, and there is considerable variation in their caliber. No tube reticulation exists on the surface, but the massing of the tubes is closer in some places than in others.

In radial sections of the body a very marked tube arrangement is to be seen. A very considerable number of long, narrow, radial series pass on all sides to the surface, bounded and environed by broader interradial series, with slightly larger, closer, and very bent tubes. The tubes of the radial series are wider apart than the others, although their course is usually radial and straight; they often bend much here and there, are irregular, and are often geniculate at the sides. They unite by means of very small offshoots, and bifurcate, but rarely increase in number sufficiently to present the aspect of a cone in the mass. They rather form linear radial lines.

The larger and closer interradial series bend, unite, bifurcate, and are singularly gyrose, varicose, and irregular in their course in many places. They are often so close together that they resemble knots of tubes, and then the section having cut across many, exhibits the more or less circular incision in the tube-wall and the lumen.

The tubes are usually $\frac{1}{300}$ inch in diameter, those of the interradial series being the largest. Throughout the number of tubes in the interradial series is very great.

In some spots calcite has filled up a vacant space which was evidently once a surface pore, and in one or two places the tubes end at one of these places. New tubes were formed distally to the space by the arching over of side ones, and the branches taking a radial direction. In some parts the radial tubes are smaller than in others, and then there is manifest difference between them and those of the adjoining interradial series, which branch give off offshoots from one side, and twist in a close and remarkable manner.

The interspaces between the radial tubes are the largest, and those of the interradials are very minute.

Towards the centre of the section a confused mass of convoluted tubes exists, and the radial and interradial series appear to start from it. The tubes are thin at the wall, and the structural element, granular, molecular and thinly set, is minute in the extreme.

At the surface of the body every granule with its circlet of pores is the outlet of a radial series, and the space between the granules, pores included, represents the interradial structure within.

The greatest breadth of the spheroidal body is one and a half inch.

SYRINGOSPHÆRIA POROSA, Duncan. Plate II, Figs 3, 4.

The body is very oblately spheroidal in shape and symmetrical. The surface is covered with minute low, rounded granules. The granules vary much in size, the pores are exceedingly numerous and unequally distributed, and the space between many of them is in ridges, giving a boldly reticulate appearance, especially equatorially. No large amount of tube reticulation is visible on the surface; on the contrary, it appears, except at the pores, to be made up of tubes opening directly with circular or oblique outlines, and of wide intertubular interspaces filled with dark calcite. Where there is much space between the pores, the irregularity of this calcite indicates the former existence of peripheral tubes which have weathered out; but where the granules show any structure, it is that of tubes on their sides, converging upwards and opening at the top, and of tubes opening on the centre of the top. The pores are clearly spaces where tube-growth has not progressed equally with that of the surrounding parts. The sides of the pores present tubes passing radially, and tubes open on their floor.

Tangential sections, under low powers, exhibit localised and more or less circular groups of tubes which correspond to granules. In some the tubulation is reticulate, and in others, so radial that only the cut ends of tubes are seen. There are spots where the reticulation is very diffused, the tubes being very irregular in size, shape, and position in the section. In some places the tubes are very close, bifurcate, as in the other instances, and are more or less around the circular groups. There is not much difference in the size of the tubes, which vary from $\frac{1}{300}$ to $\frac{1}{500}$ inch. There are spots without any tube structure, and these are circumscribed and are the relics of old pores, passed by during the radial growth of the body.

In radial sections there is in many places such an exact relation in shape between the tube-structure, whether reticulate or radial, and the interspaces, that it is very difficult to distinguish interspaces filled with clear calcite from very transparent tubes. So many circular spaces exist, $\frac{1}{300}$ inch in diameter, in these parts of the section, that they may be taken for tube sections, surrounded by a whitish and rather opaque calcite. But they are really interspaces, the true tubes having the translucent walls. The radial series is not, on the whole, very distinguishable from the interradial, but the pores exist as vacant elongate spaces bounded by tubes all around, and bridged over tangentially by tube reticulation. They are not lined by any special structure.

The minute structure of the tubes is a finely granular substance (carbonate of lime), lightish red to transmitted light, and there are dark granules like minute dendrites. There is no trace of a cœnenchyma, and the fossilization simulates many structures, which are, however, readily resolved by even low powers of the microscope.

The height of the body is $1\frac{2}{10}$ inch, and the breadth 2 inches.

V.—The species of *Stoliczkaria*.

One species of this genus is amongst the collection, and its forms are readily known by their great size, minutely, but not sharply, granular appearance, and the absence of pores.

Stoliczkaria granulata, Duncan. Plate II, Fig. 5; Plate III, Figs. 5, 6, 7.

The body is large, spheroidal, and symmetrical; it is covered with a vast number of minute eminences and interspaces. The eminences are separated by about their own breadth, or they may be closer, touching at their bases; they are usually circular in outline, low, flat or rounded at the free extremity, and are about as tall as their base is broad. There are usually five, and the corresponding interspaces, in $\frac{1}{10}$ inch. In some places the bases are continuous so as to form long narrow gyrose ridges, and in others they are absent, the circular base existing only. Here and there are some larger ones, and minute granules are interspersed.

Rather large tubes are on the outside and flanks of the eminences, and they open around and close within the circular top edge. They pass on to the spaces between the eminences, and are closely crowded, very bent, and form a dense reticulation, some opening there outwards.

The inner or central part of the upper surface of the eminences has a few, rather wide-apart tubes opening there; they are radial and small, and are readily distinguished from the interradial series around. Where an eminence is rudimentary, the central radial tubes may be seen separated by a little interspace from the dense reticulation of larger and closer interradial tubes.

Sections of the body tangentially show a vast number of small circular radial systems, surrounded by encircling interradial tube-structures (Plate III, Fig. 5). The tubes are for the most part seen cut across, and the radial are very small, few in number, and are wide apart. The surrounding mass of tubes consists of those of large caliber, often with minute offshoots to the radial series, and usually very varied in shape and size on account of their gyrose, varicose, rapidly bending course, of their inosculating and bifurcating, and of the necessary obliquity of their section. They are close and crowded. Both series have the tube-wall developed and thin, and the radial tubes are usually $\frac{1}{500}$ inch in diameter, the others measuring usually not much less than $\frac{1}{300}$ inch. The section gives the appearance of a multitude of stars by transmitted light, the centre of each being most distinct and occupied by the radial tubes. These combined series do not increase much in their size from within outwards, and they are $\frac{1}{50}$ inch across. The interradial tubes of one system communicate with those of the neighbours, and with the surrounding radial series sometimes. The sections of some of the interradial tubes present a flask-shaped outline, and this arises from the radial tubes or the interradial now and then giving off very delicate tubes of connection.

The sections made radially present a totally different appearance to those just described.

A little way below the surface a series of nearly equal parallel systems of tubes is seen; one set of tubes is closely crowded, and they are close, large, swell out here and there, bend, bifurcate, and give off minute offshoots. The other consists of a few wide-apart, narrow, not over-straight, tubes which give off tubes of their own size or a little smaller to each other and to the larger tubes of the set at their side. The larger set is the interradial system, seen, longitudinally or radially, and the smaller by its side is a radial system. Next comes another interradial system, about as broad as the radial one thus included, or perhaps a little broader; (Plate III, Fig. 6).

When the radial section is examined, close below and at the surface, the large tubes of the interradial systems are seen in lines, with the smaller radial ones parallel with them.

The height of the body is $2\frac{3}{10}$ inches, and the breadth nearly 3 inches.

VI.—DESCRIPTION OF THE PLATES.

PLATE I.

Fig. 1. The body of *Syringosphæria verrucosa*, Duncan. Natural size.

" 2. A portion of the surface of the same specimen magnified to show the superficial projections, pores, and tubulation.

" 3. The top of a large eminence, with pores on its sides; the tubes are seen crowding the surface, and many round markings at the apex denote the openings of internal tubes. The specimen is the same as the last, and is more highly magnified.

" 4. The body of *Syringosphæria monticularia*, Duncan. Natural size.

" 5. The same specimen magnified in part to show the monticules, pores and openings of tubes, with many ramifying and superficial tubes on the surface.

" 6. A monticule more highly magnified to show canal openings, canals and spaces between them, also some small monticules.

" 7. The body of a smaller and less mature specimen of *Syringosphæria monticularia*.

" 8. A portion magnified, the radiating canals and the canal openings being shown on the monticules.

" 9. A portion more highly magnified, showing a large monticule and smaller ones, with superficial tubulation and the exit of internal tubes. Pores are also shown.

10. A part of the body of a large specimen of a mature *Syringosphæria monticularia*.

11. A portion considerably magnified, showing a minute monticule and two pores. The tubulation is between the dark lines, and the dots on the monticule and elsewhere are the openings of internal radiating tubes.

12. A portion less highly magnified, showing numerous minute pores and larger monticules.

Plate I.

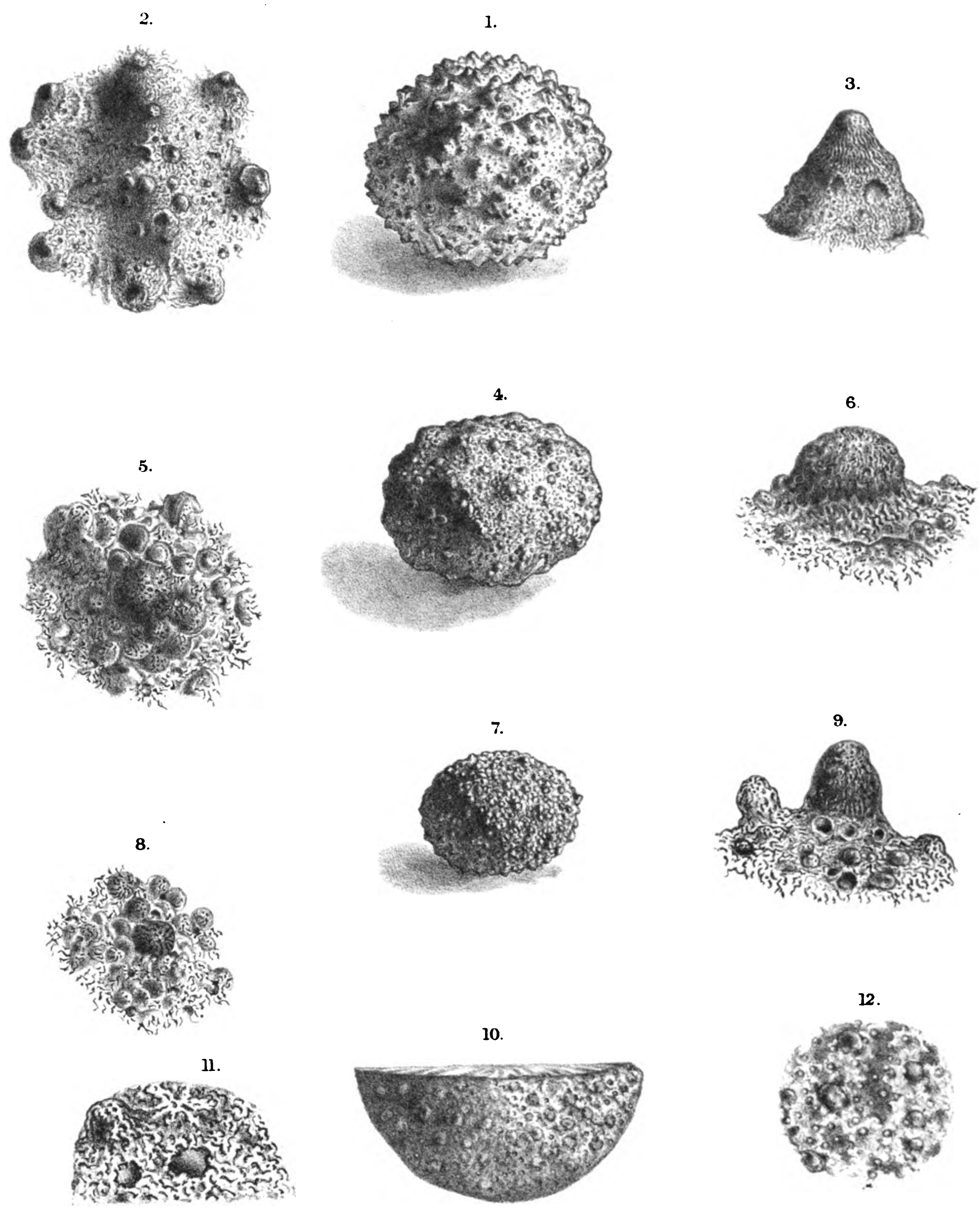

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PLATE II.

Fig. 1. The body of *Syringosphæria tuberculata,* Duncan. Natural size.

„ 2. A portion magnified, showing the tubulation on the surface of the body and monticules, and a few pores.

„ 3. The body of *Syringosphæria porosa,* Duncan, shown in outline, with a portion indicating the numerous pores. Natural size.

„ 4. A portion magnified, showing numerous round pores with canal openings and the intermediate surface with indistinct tubulation.

„ 5. The body of *Stoliczkaria granulata,* Duncan, shown in outline. The upper portion of details is of the size of nature, and indicates the numerous irregularly disposed granulations. The lower portion is in part magnified to show the numerous granulations, the tube openings on their top and their radiating tubulation on their sides and in the intervening space.

„ 6. The body of *Syringosphæria monticularia,* Duncan, variety *aspera.* Natural size.

„ 7. A portion magnified, showing the openings of tubes on the monticules and the other tubulation, the black lines being interspaces between stout, crooked tubes.

Plate II.

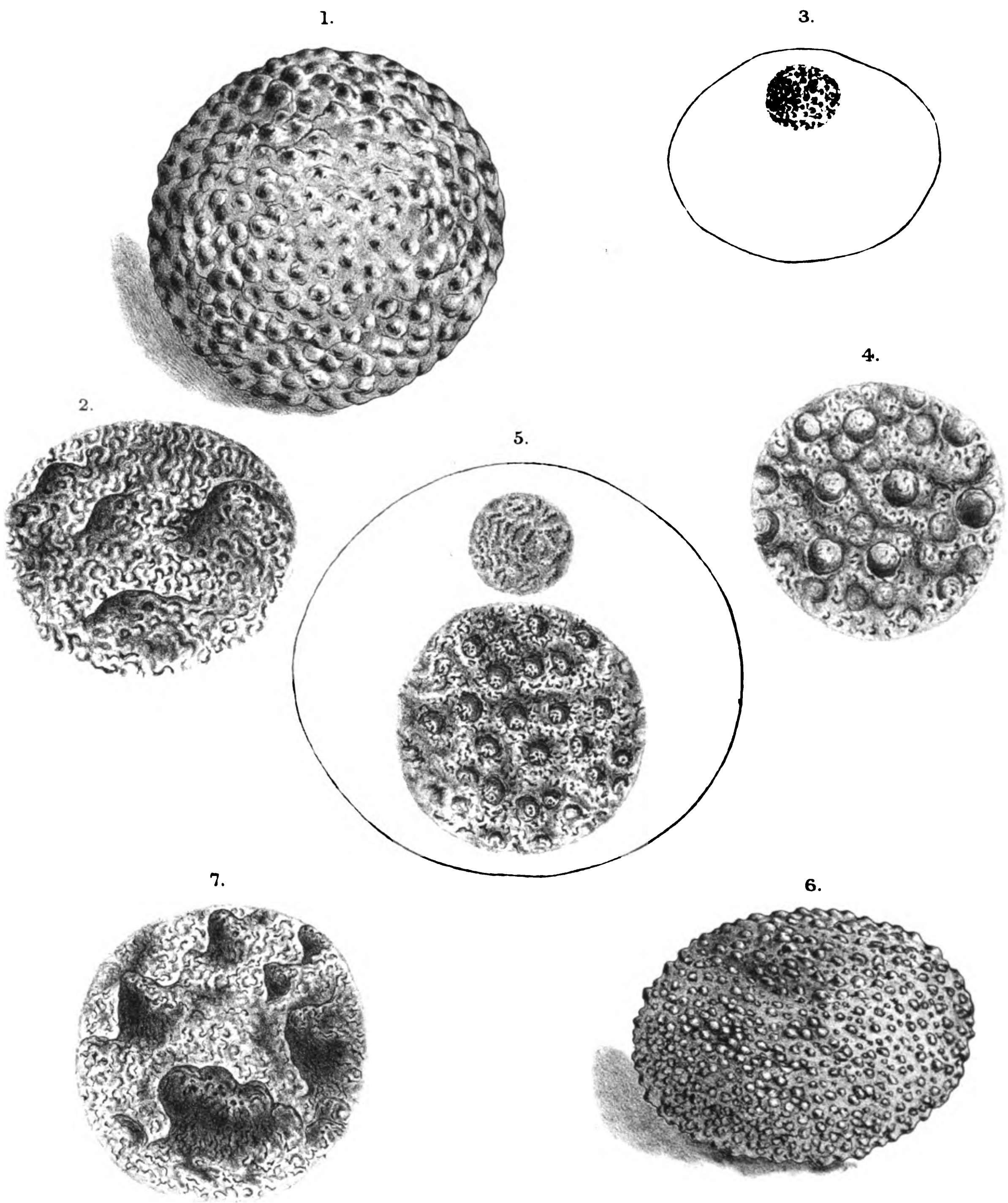

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PLATE III.

Fig. 1. A section taken from *Syringosphæria monticularia*, Duncan, the specimen being figured on Plate I in figure 7. The section is radial, and the top represents a small monticule at the surface; the lower part is towards the centre of the body. Many tubes are seen reaching to the surface and opening, some on the faintly rounded monticule, and others in the depressed part. The tubes in the centre of the section are essentially part of a radial congeries. At the sides there is tube reticulation and some of the endings of these tubes are seen at the surface. Swellings of the tubes are seen in some places. Magnified, half-inch object glass.

" 2. The surface of a specimen of *Syringosphæria monticularia* magnified, showing on the right a small pore with one large tube opening and two smaller. The dark, straight, bent, and branching dark lines elsewhere are the calcite intertubular infiltration, and the white or shaded spaces between them are tubes, some running, as on the left, a short course and opening on the surface, others bounding the pore, and some only showing geniculate portions of their track.

" 3. The top and sides of a small monticule of the same specimen, less highly magnified. There are tube openings of the radial series in the centre, and portions of tubes, partly of the radial and partly of the interradial series, covering the sides of the monticule, and opening externally around the top.

" 4. An oblique section near the centre of a specimen of *Syringosphæria monticularia* magnified. In the centre is what may be called a parent tube which gives off others that in turn bifurcate and radiate. Those on the sides of the section are becoming interradial reticulations, and are here and there irregularly swollen. Many small tubes cut across are seen disconnected. The central tubes are two radial sets, and the bifurcating is very characteristic.

" 5. A tangential section of one of the granules of *Stoliczkaria granulata* magnified. The small radial tubes open in the midst directly, and the large interradial tubes, most irregular in their outline of section, are, some of them, provided with neck-like prolongations. These are connected with the small radial series.

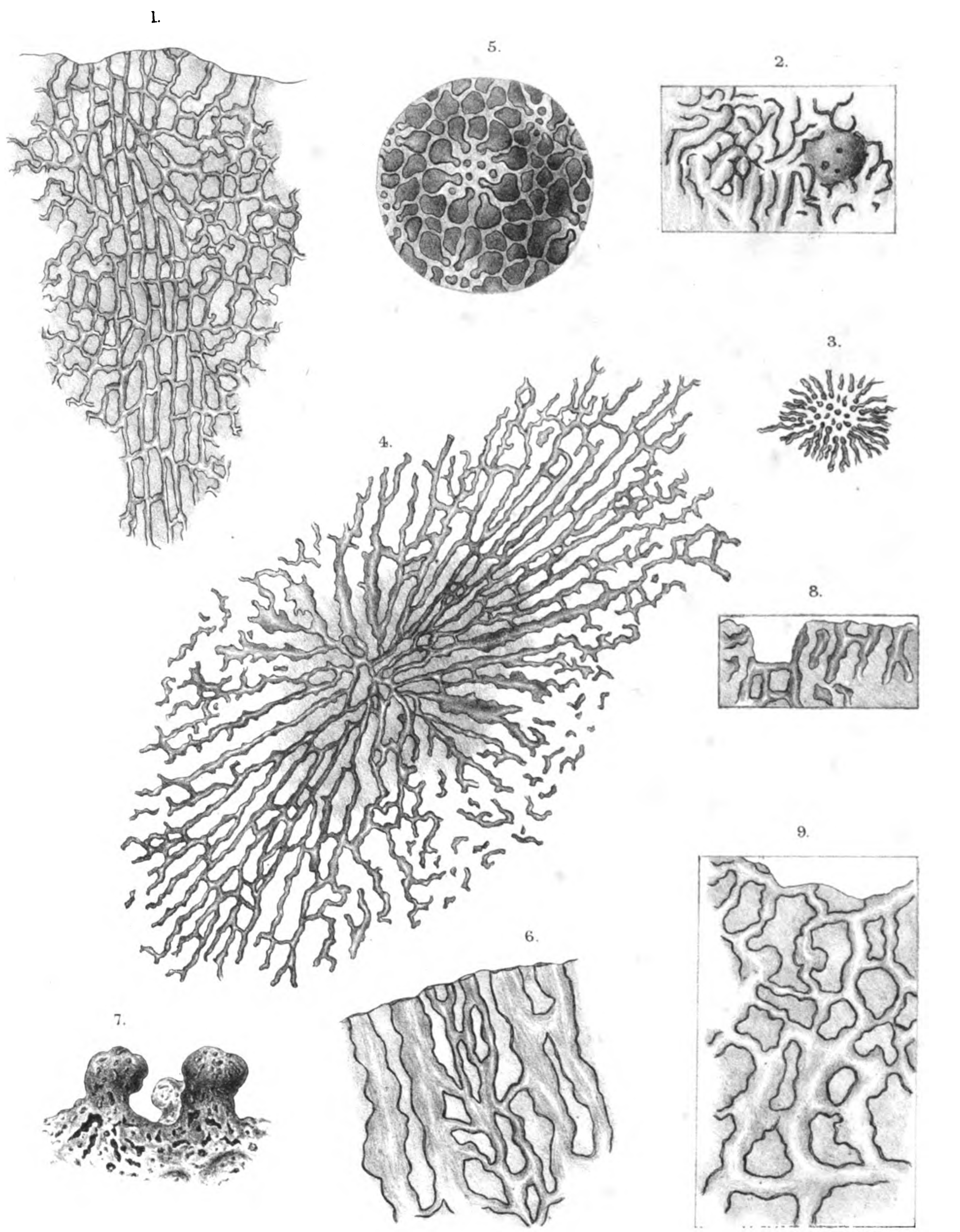
" 6. A longitudinal section of the same specimen and through a granule. In the centre are a few inosculating and bifurcating small tubes, and three of them open at the surface on the top of a granule, being equivalent to the central openings in figure 5. On either side are large interradial tubes, two uniting with the radial series by small short neck-like tubes. Magnified under quarter-inch object glass.

" 7. The surface of a rugged part of the same *Stoliczkaria* slightly magnified. The granules show tube openings on them and some large tube reticulation, the dark lines being intertubular weathering.

" 8. A longitudinal or radial section of *Syringosphæria monticularia* magnified. The depression is a pore, and the relation of some tubes to it is shown. Other tubes are opening out at the surface close by.

" 9. A radial section of the same specimen showing an interradial tube reticulation opening at the surface and running over it, forming there a tubular series. Elsewhere the irregular size of the tubes is shown and their general reticulation.

Plate III



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