specimens from the Kentei and Ussuri, representing Schrenck's "*Lagomys hyperboreus*, var. *cinereo-fusca*," are without dates, but the present series enables me to determine them with confidence as being respectively summer and winter examples of one form.

This animal would appear to be not more than subspecifically distinguishable from *cinereo-fusca*, and as Schrenck considered that a variety of *hyperborea* I do the same for the present form; but the intergradation with the Tschuktschi Pika may hereafter prove to be broken, and the Amur and Mantchurian forms to be worthy of specific separation from the more northern species.

15. *Capreolus bedfordi*, Thos.

♀ and two young. Khingan Mts.

LXIII.—*On the Regular Hexactine Spicule of Hexactinellida.* By R. Kirkpatrick.

The regular hexactine spicule characteristic of Hexactinellid sponges has three axes crossing at right angles through a common centre and corresponding with the axes of the regular crystalline system; but the silica of which the spicule is composed is isotropic and amorphous. What is the meaning of the form of the regular hexactin * ? Is it due to purely organic causes, or is its shape influenced by its mineral characters; or do both of these factors contribute? Further, if its form is due to biological causes, how have they fashioned the regular hexactine shape? Before attempting to suggest an answer to these questions I will refer to theories already put forward by Schulze and Minchin.

The typical Hexactinellid sponge is a cup-shaped lamina with a central layer of thimble-shaped flagellated chambers suspended between an outer dermal and an inner gastral layer of delicate network. Schulze † was of opinion that the regular hexactine spicule came into existence because it was adapted to support the thimble-shaped flagellated chambers.

Minchin ‡ has stated his belief that the spicules arose before the flagellated chambers were formed, that the stauractin preceded the hexactin, and that the symmetry of these two

* I use the term actine as an adjective, and actin as a substantive.

† 'Challenger' Report. Hexactinellida, 1887, p. 504.

‡ "A Speculation on the Phylogeny of the Hexactinellid Sponges," Zool. Anzeiger, 1905, xxviii. p. 439.

forms resulted from the mineral properties of the silica. Later *, he thought it might be possible, by accepting a modification of Marshall's theory of silicification of circular and longitudinal strands of sarcode (Z. wiss. Zool. xxvii. p. 116), "to find a phylogenetic explanation for the origin of the rectangular symmetry without having recourse to supposed crystalline structure, for which there is no evidence, in the siliceous material."

My own view is that the shape of the regular hexactin is due to biological causes, that the form arose primarily to support strands of the network and not to uphold flagellated chambers, and that the coincidence of the axes with those of a regular crystalline system is, literally, a coincidence.

Schulze † thinks that there is not sufficient evidence to prove that purely stauractinophoran sponges existed; for the supposed stauractins may be reduced hexactins (apparently as in the autodermalia of the primitive thin-walled *Bathydorus fimbriatus*, F. E. Sch.), or distal rays of hexactins might have been broken off, or hexactins, though not hitherto observed, may be present. Again, the fact that autodermal stauractin megascleres are the first spicules to appear in the larva of *Vitrolulla*, may, as Ijima observes (Contrib. iv. p. 52), be entirely devoid of phylogenetic significance.

Minchin considered that a homocœlous condition must have preceded the heterocœlous, and that the inner ray of a hexactin, if present, would inconveniently penetrate an unfolded collar cell layer, that a square-meshed network would form convenient spaces for the first outfoldings of the choanosomal layer, and that, as the flagellated chambers arose, radial rays would be added on to the nodes of the tangential rays, just as quadriradiates arise from triradiates in Calcarea; but this hypothesis would not account for the existence of gastrosomal micro-hexactins.

In recent Hexactinellida the hexactins are found not only in the dermatosome, but also in the gastrosome, where there can be no question of supporting the convex ends of thimble-shaped flagellated chambers, but every need for keeping open the meshes of the trabecular network. Possibly the distinction between megascleres and microscleres first arose when the choanosome was thrown into folds; some of the micro-hexactins would become macrohexactins, and, later, flexible diactins; but, at first, in a well supported dermal reticulum the *membrana reticularis* possibly could take care of itself.

* "Sponge-Spicules," Ergeb. Fortschr. Zool. 1909, p. 268.
† 'Valdivia' Hexactinellida, 1904, p. 170.

The characteristic feature of the Hexactinellid sponge, which must have existed before stauractine or hexactine spicules arose, and which probably conditioned the shape of those spicules, is the dermal * syncytial network.

If purely stauractine sponges existed, it was because this network would be extremely thin at first, and Nature would have the problem of forming a practically—not, of course, mathematically—two-dimensional scaffolding (*i. e.* stauractine). When in course of time the network grew thicker, a three-dimensional scaffolding would become necessary.

It has been supposed that the biological conditions, which would account for the existence of the regular hexactine form, do not occur, because the meshes of the trabecular network are of all shapes. It seems to me that these conditions do actually exist. Nature has a very elusive material to deal with in the case of the fluent and contractile syncytium of the Hexactinellid sponge, and it would be impracticable to construct a scaffolding that would exactly follow the protean form of a syncytial network.

In the Hexactinellid sponge, it is not necessary to look for a perfectly regular network of protoplasmic strands to account for a similarly regular network of supporting scaffolding; the protoplasmic strands of syncytium need only loosely drape the supporting rods; they may fill in the sharp corners, form subsidiary meshes in the cubical compartments, and lastly prod out the walls of the cubicle with spandrils or end rays. For the support of three-dimensional spaces of a network, the most economical and efficient scaffolding is the cubical one. The selected sclerite has been one with six rays at right angles, giving support in the direction of length, breadth, and depth.

Nature, having selected the hexactin, has certainly stereotyped her pattern in a wonderful manner. It is always a surprise to see the axis-cross persisting in long slender diactine and even in monactine spicules, such as the distal pronged knob of root-tuft spicules of *Hyalonema*. No wonder we are led to account for such phenomena by calling in the mysterious molecular forces of crystallisation in place of, or in aid of organic forces acting *en masse*.

We find, however, that Nature readily adapts her methods to the changing requirements. As I have already endeavoured to prove †, when it becomes a question of supporting concentric laminæ of reticulum, the two tangential axes essential in a

* Dermal, as contrasted with gastral, and including dermatosome and gastrosome.

† Ann. Mag. N. H. 1909, (viii.) vol. iv. p. 479.

three-dimensioned structure are dispensed with, and the one-dimensioned prop or standard (amphidisk) is brought into requisition. Although the amphidisk is probably a reduced hexadisk, the axis-cross representing the aborted rays is not in evidence, so completely has the triaxial character been suppressed.

If the coincidence of the primary axes of the spicule with those of the regular system can be accounted for on grounds of selection of a form adapted to maintain the patency of a meshwork, certain cases of coincidence with secondary planes of symmetry are easily explained.

The true microhexactin of *Hyalonema divergens*, F. E. Sch., and the monoxyhexaster of *Bathydorus uncifer* are both of approximately the same shape, *i. e.* with rays meeting at right angles in a common centre, and with curved ends lying in secondary planes of symmetry. In the case of *Hyalonema*, the spicule is a true microhexactin with axial canals running to the very points of the rays; in the monoxyhexaster, the axial canals only extend a short distance from the centre. Along with the monoxyhexasters are hemi-oxyhexasters with some main rays ending in more than one end ray; and there is no reason to doubt that the monoxy-hexasters are reduced from such forms, and that the curved ends are merely deflected spines or end rays. Whatever theory one may adopt concerning the micro-hexactins of *Hyalonema*, it is difficult, in view of the probable history of the spicules, to believe that the incidence of the ends of the rays of the mon-oxyhexaster of *B. uncifer* in secondary planes of symmetry is anything more than the result of the stresses and strains of the strands of contractile meshwork. Similarly, as Schulze has shown, the pointing of the rays of the discoctaster to the angles of a cube simply results from centripetal pressure suppressing the main rays of a hexaster and pressing back the sclero-blastic end rays (2, 3, 4 or many) till they fuse with neighbouring rays into secondary main rays; this incidence of axes in lines pointing to angles of a cube is a pure coincidence; frequently "supernumerary thorns" fail to become fused and do not point to the angles of the cube.

Summary. Reasons are given for the belief:

(1) That the regular hexactine spicule was primarily formed in Hexactinellid sponges as being the most economical and efficient* means for supporting the strands of a syncytial network; for, in the gastrosome at any rate, the microscleres would be useless for upholding the body or

* The human architect, also, has found that the regular hexactin is the most convenient form of spicule for constructing his dictyonine

flagellated chambers, but most efficient for the vitally important function of keeping open the meshes of the dermal network :

(2) That the geometrical forms of cubes, squares, or lines (hexactins, stauractins, amphidisks) arise in correspondence with the requirements for supporting cubical spaces, surfaces, or concentric laminæ :

(3) That the support of flagellated chambers and of the body as a whole was a later need, and was effected by the development of microscleres into parenchymal and auxiliary surface macroscleres :

(4) That the identity of axes of the regular hexactin with those of the regular crystalline system is a coincidence, the real determining factor of the shape being a biological one : the axes of a geometrical system are pure abstractions. The concrete organic filament of the regular hexactin round which alternating layers of spiculin and silex are formed is nothing more than a model of those abstractions. (It is not implied, however, that the cylindrical shape of the axial tubes is to be regarded as an argument against the crystal theory ; for crystals may have curved surfaces.)

LXIV.—*Descriptions of Oriental* Capsidæ. By W. L. Distant.

[Continued from p. 454.]

Hyalopeplus clavatus, sp. n.

Head, pronotum, scutellum, and corium bronzy ochraceous ; head with three longitudinal black lines, the lateral ones converging anteriorly ; antennæ with the basal joint bronzy ochraceous, with a more or less distinct piceous line beneath, second joint black, with its base ochraceous (remaining joints mutilated in typical specimens) ; pronotal collar with the margins and three longitudinal lines black, the central line more prominent, posterior pronotal margin and the posterior angles black ; clavus with the inner and outer margins and the suture black ; corium with the costal marginal area paler and bordered on each side with black, veins piceous ; mem-

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scaffoldings. He resorts to the method of splicing with rope his radial and tangential axes (standards, putlogs, and ledgers), because, when separated, they are easier to transport in bundles.