	H. cristata.	*H. galeata.*	*H. africæ-australis.*
Basal length	138	138	151
Zygomatic breadth	86	84	91
Length (round curve) of nasals	100	99	91
" " " of frontal	31	33	47*
Length of parietal (to extreme back of crest)	31	33	33*
Breadth of nasals at anterior end of naso-premaxillary suture	37·5	41	32
Breadth of nasals at posterior end	69·5	55	61
Interorbital breadth at edge of lacrymals	73	62·3	76
Interorbital breadth at rudimentary postorbital processes	68·5	66·5	70·6
Height of skull from palate between $\frac{\text{m. 1}}{}$	70	76	73·5
Least vertical diameter of lower anterior zygoma-root	5	5·5	1·7
Palate length	77	80	87
Mesial length of premaxillæ	29	25·7	28

These measurements show clearly the conspicuous differences between *H. galeata* and its allies in the relative proportions of the two interorbital breadths, anterior and posterior, in the shape of the nasals, and in the height of the skull, this last being the character from which is derived the name selected for the species.

Hab. Lamu, East Africa.

It is much to be hoped that more specimens of this interesting addition to the fauna of our East-African possessions will soon be brought to Europe, and it may be noted, as a hint to collectors, that a good series of skulls of different ages would be of especial value for the proper comparison of the species with its allies.

XXXIX.—*The Formation of the Skeletal Parts in Echinoderms.* By Carl Chun, of Breslau †.

The share of the mesoderm cells of Echinoderms in the building-up of the elements of the calcareous skeleton is altogether imperfectly understood. After it had already been shown by the older observers that the calcareous bodies are formed by the connective-tissue cells of the gelatinous central

* Fronto-parietal suture closed and its position not quite certain.

† Translated from the 'Zoologischer Anzeiger,' xv. Jahrg., no. 408, December 26, 1892, pp. 470–474.

substance of the larvæ (it was scarcely likely that Selenka and Hérouard should still retain the ideas they formerly expressed as to an ectodermal origin of the calcareous bodies of the integument), it was recently sought by Selenka and Semon to determine the finer processes which take place in the secretion of the calcareous matter. According to Semon's account there arises within the skeletogenous mesoderm cell a tetrahedron, which subsequently develops into the triradiate body already observed by Selenka and passes out of the cell enveloped in a delicate membrane. The triradiate body is then approached by other mesoderm cells, which enlarge it, and by means of complicated furcations transform it into the definitive calcareous structure. Semon's observations have been confirmed by a careful memoir by H. Théel, which has just appeared ("Development of *Echinocyamus pusillus*," R. S. Upsala), in so far as Théel also claims the tetrahedron developing into a triradiate body as the foundation for the building-up of the skeletal parts of the *Pluteus*. It is true that there are material discrepancies in the observations as to the earliest origin of the tetrahedron. For [according to Théel] it is formed between at least three cells in a clear organic basal substance, and therefore from the outset proves itself to be an intercellular skeletal element, in the enlargement of which a large number of amœboid cells subsequently take part.

Now Semon is inclined to regard the tetrahedron, which develops into a body with three or four rays as the case may be, as the universal starting-point of the whole of the skeletal structures of Echinoderms. This view, then, would also sanction the converse inference, that the individual calcareous structures represent the product of a larger number of mesoderm cells. Nevertheless this assumption does not hold for all skeletal elements, inasmuch as, *e. g.*, the wheels of the *Auriculariæ* and the anchors and anchor-plates of the Synaptidæ, according to the statements of older investigators, which in essential points were recently confirmed by Semon and Ludwig, do not exhibit a tetrahedron and body with three or four rays as a starting-point. Semon therefore believes that the original condition became obliterated in these instances, and that the appearance of a star with six rays, which he gives as the basis of many calcareous wheels, implies a curtailment of the primitive arrangement. It would lead us too far, should we wish to discuss this conception here; against it the objection may always be advanced that the calcareous wheels clearly represent quite primitive structures, which not only furnish the distinctive character of the *Auricu-*

laria-larva and in the case of many Synaptidæ persist throughout life, but also, according to the discovery of Joh. Müller, which was confirmed by Ludwig for the Asteriadæ, by Semon for Ophiuridæ, and by Théel for Echinidæ, form the basis for the construction of the spines. Nevertheless it may appear to be open to question whether we are justified in homologizing with the wheels of the *Auricularia* the basal wheels of the spines, which are stated by Ludwig to arise from a triradiate body, and according to Théel's latest result again exhibit a tetrahedron as their starting-point. For, according to my own observations, the mode of formation of the larval calcareous wheels is so peculiar that it by no means allows itself to be forced into the scheme, which was constructed on the basis of our previous knowledge of the building-up of the calcareous skeletal parts from mesoderm cells.

As material for investigation I made use of the splendid *Auriculariæ* which I caught in different stages of development at the Canary Islands in the winter of 1888. As I shall describe the larvæ, which attained a length of 7 millim., in another place, I here dispense with an account of the complicated course of their ciliated bands and of their internal structure. Let it merely be remarked that the calcareous wheels appear relatively very late, but then accumulate in unusual abundance in the aboral tuft-shaped outgrowths of the lateral regions, further on along the entire dorsal surface, and much more scantily upon the ventral side. In order to check my observations the Mediterranean *Auriculariæ* were also examined, which, so far as regards the formation of the calcareous wheels, exhibit almost identical conditions.

At the time of the appearance of the first calcareous wheels the cellular elements of the gelatinous substance are sharply differentiated into skeletogenous and connective-tissue cells. The latter possess several long processes, which are much ramified and are interwoven almost after the manner of felt; the skeletogenous cells, on the contrary, are spherical and surrounded by a distinct membrane, in consequence of which they emit no pseudopodia. The sharp histological differentiation of the mesoderm cells, which was certainly preceded by an indifferent stage, may be essentially due to the fact that the calcareous bodies originate at a remarkably late period in comparison with what is found to be the case in other Echinoderm larvæ. The skeletogenous cells accumulate around the stone-canal and close beneath the ectodermal pavement epithelium. The latter with its nuclei is always distinctly discernible, even in *Auriculariæ* of the largest size, and there is no reason to suppose that it degenerates and is subsequently replaced (Semon) by means of the cells of the ciliated band or of the peripheral connective tissue.

A richly vacuolate plasma at once distinguishes the skeletogenous cells, the average size of which is ·01 millim. They rapidly grow to twice and thrice this bulk, while simultaneously the number of the cell-nuclei increases. In the same *Auricularia* we meet with all intermediate stages between uni- and multinucleate cells, which at first still retain a rounded contour, but subsequently flatten out on one side and become cup-shaped. The nuclei measure from ·003 to ·004 millim in length, and originally (so long as only from two to four are present) occupy a peripheral position; they afterwards increase to from six to eight in the case of the Mediterranean *Auricularia*, and to from twelve to eighteen in that of those from the Canary Islands, and form a central nuclear cluster.

When the cells have attained a size of ·03 millim. there appears within the old cell-membrane a new one, which has an undulating outline towards the circular margin and speedily assumes a star-shaped form. The tubular rays of the star which grow out are equal in calibre and meet the external membrane, arching forward somewhat at the points of contact. The longitudinal extension of the radially arranged outgrowths keeps pace with the increase in the size of the cell, and finally, when the cell attains a size of from ·06 to ·07 millim., the rays become united by a peripheral membranous ring. It is now impossible to mistake the mould of the subsequent calcareous wheel, prepared as it is by the complex folds of an internal membrane: the central portion with the cluster of nuclei corresponds to the nave, the tubes running out like the rays of a star represent the spokes, and the peripheral ring takes the place of the circumference (the felly) of the future calcareous wheel. Moreover the calx is actually secreted into this organic matrix formed by the skeletogenous cell, as into a mould, and in such a way that (as the older accounts already teach us) calcification takes place first in the nave, then in the spokes, and finally in the felly of the wheel. It is likewise in accordance with the theories which have recently been formulated as to the share of the nuclei in the vital processes of the cell that, corresponding with this centrifugal progress of the calcification, the majority of the cell-nuclei also separate from one another in a centrifugal direction, and in the case of the *Auricularia* from the Canary Islands come to lie in the acute angles between the spokes.

In rare instances they advance as far as the middle of the spokes or even to the periphery.

No secondary multiplication of the spokes of the wheel takes place; their number corresponds exactly with that of the undulating evaginations of the newly formed internal membrane, which develop into radiating tubes. As is well known, the number of the spokes varies; in the case of the *Auricularia* from the Canaries we find from thirteen to eighteen.

Since the diameter of the fully formed calcareous wheels is found to be from ·09 to ·1 millim., it follows that a tenfold enlargement of the diameter of the skeletogenous cells takes place, since the latter in the stage with a single nucleus only measure ·01 millim. Nevertheless after the secretion of the calcareous wheels they expand still further; for if we examine the wheels in alcohol preparations (the delicate points referred to can scarcely be demonstrated in glycerine and Canada balsam), we can distinguish a distant periphery formed by a delicate membrane, from which, alternating with the spokes and almost equalling them in length, membranous tubes arranged in the shape of a star run to the periphery of the wheel, where they usually exhibit flask-shaped expansions.

On careful decalcification of the wheels by means of weak chromic acid it is easy to show the nuclei and the contour of the wheel in the shape of a delicate membranous envelope within the skeletogenous cell.

The above statements as to the formation of the wheels in the *Auricularia* reveal a mode of development which at present appears to be unique. While the skeletal pieces of Echinoderms were hitherto essentially regarded as intercellular structures, the formation of which was due to several mobile amœboid cells (I am well aware that more recent observers are inclined to attribute the shape of the skeletal elements without hesitation to directly mechanical influences), we now find that **the form of the calcareous wheel is traced out within a multinucleate cell by means of an organic membrane which assumes complex folds, and that in this definitely circumscribed mould the casting of the hard parts ensues.**

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Chun, Carl. 1893. "XXXIX.—The formation of the skeletal parts in Echinoderms." *The Annals and magazine of natural history; zoology, botany, and geology* 11, 231–235. https://doi.org/10.1080/00222939308677507.

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