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XXII.—*On the Structure of the Echinoderms.*

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[Concluded from p. 123.]

CRINOIDEA.

NATURE has produced no transitional form between the Sea-urchins and the Starfish, which would be a flattened Sea-urchin with an ambulacral abdominal surface and an entirely antambulacral dorsal surface, but with only the double series of interambulacral plates of the Sea-urchins. The sole approximation to this form is the pentagon of the pentagonal kinds of Starfishes, whose interambulacral plates always form a triangular accumulation, of which only those plates which border upon the ambulacra are arranged in a similar order to these. Much nearer the Sea-urchins in form, but not in composition, are, among the Crinoids, the *Blastoidea* possessing a solid shell and no free arms, especially those *Pentremites** with rounded calyces, and the genus *Eleocrinus*, Rømer. The apex has enlarged into the antambulacral area of the calyx. However, the composition of the interambulacral area of the calyx departs far more widely from that in the Sea-urchins than these do from the Starfishes; in the *Blastoidea* these areas are formed partly by the five radialia which are disposed in the direction of the radii, partly by the interambulacral azygos deltoid pieces, a conformation which can be compared to nothing in the interambulacral areas of the Sea-urchins. The composition of the ambulacra is also aberrant in the *Pentremites*, as well from those of the *Asteridæ* as from those

* See, for an elaborate comparison of *Pentremites* with *Asteridæ* and *Ophiuridæ*, Prof. E. Forbes's Memoir on the British *Cystidæ*, Mem. Geol. Survey.—TRANSL.

of the Sea-urchins; this is evident from the analysis of the *Pentremites* given by Rømer. In *Pentacrinus* the antambulacral and ambulacral zones of the calyx (with ambulacral grooves) are equal, and both have become produced upon the moveable arms. The development of the antambulacral side of the radii in the Crinoids takes place either from the very base of the calyx, or from its circumference, or in the neighbourhood of the mouth, as in most *Cystidea*. In the latter case, the calyx presents no radial arrangement of plates from the base to the immediate neighbourhood of the mouth; it begins only at the mouth in the oral arms, whose ambulacral grooves however lead to the mouth, and, like the articulated antambulacral surface of the arms, present no traces of the general plan of the Echinoderms. Hence it is intelligible why, so long as the Cystideans were held to be armless, the radial arrangement of the Echinoderm was unrecognised.

The determination of the different structures which occur in the radii of the Crinoids is not always easy, but I have come to the following conclusions:—*Radii* are radial divisions of the Crinoid for the reception of the ambulacra, and they are either *calycine radii* or *arms*. *Calycine ambulacra* are grooves with suckers upon the ventral surface of the calyx in the direction of the arms when these exist. *Ambulacra of the arms* are the ventral surfaces of the arms and pinnulæ, provided with suckers. The *Blastoidea* have calycine ambulacra without arms. Many Crinoids, as *Actinocrinus*, *Platycrinus*, &c., have arms without calycine ambulacra or clefts of the calyx; the *Pentacrinites* and their allies possess both arms and calycine ambulacra. The arms are articulated in either one or two series, and are either simple or dichotomously divided. The divided arms arise from an undivided arm-basis, which is either articulated upon the calyx or is enclosed by its plates. The arms therefore are probably not originally double. The *pinnulæ*, on the other hand, are always in double rows and are never divided or branched. They are articulated processes either of the calycine ambulacra (*Blastoidea*) or of the ambulacra of the arms. Where arms are present the pinnulæ are absent on the calyx, and first appear as the arms become free from the calyx. They are articulated either in single or in double series, and are provided upon their ventral surface with suckers, like the arms and calycine ambulacra. Every single joint of the arm, or every segment of the ambulacrum (*Blastoidea*), has only one pinnula. The pinnulæ always alternate. Unquestionable examples of arms without articulated *pinnulæ* are afforded by *Cupressocrinites*; of *pinnulæ* without arms by *Pentremites*. *Pinnulæ* composed of a single piece, forming series upon a joint (of an arm) like the little plates on the

arms of *Cupressocrinites*, pass into marginal ambulacral plates, which are erect plates along the sides of the ambulacral grooves, and may occur as well along the ambulacral grooves of the calyx as of the arms and *pinnulæ* (*Pentacrinus*). They are set so closely upon the arms, that many occur upon a single joint. *Pentacrinus* possesses both marginal plates and *pinnulæ*. *Spines* or *bristles* are unarticulated appendages of the arms, and occur only in the division of *Crinoidea costata* (*Saccocoma*); they are arranged in pairs and opposite, upon each joint of the arms, thus differing from the *pinnulæ*, which are articulated and alternate. *Cirri* are articulated processes on the stem of the Crinoids and on the terminal knob of the *Comatulæ*.

The ambulacra of the recent Crinoids are treated of in the memoir upon *Pentacrinus*; they are grooves which are continued from the mouth upon the perisoma of the calyx towards the arms and *pinnulæ*, covered by a soft membrane, and in *Pentacrinus* supported upon each side by perpendicular calcified marginal plates. Within the grooves there are two series of fine apertures upon which the minute suckers are seated. Upon the arms and *pinnulæ* the calcareous formations are limited on the ventral surface to the marginal plates of the ambulacral grooves. On the calyx, on the other hand, the ambulacral grooves are supported by calcareous deposits in addition to the marginal plates. Those plates which form the edges of the ambulacral grooves have a wall-like elevation, and serve not only to embrace the ambulacra but to support the erect marginal plates; they may be called the lateral ambulacral plates; they are distinguished, like the marginal plates, from the other ventral plates by the absence of the problematical calycine pores which characterize the latter. Beneath the soft covering of the groove little plates also lie, which were indicated in the memoir upon *Pentacrinus*. For the sake of comparison with the ambulacral plates of the Sea-urchins and Starfishes, I thought it important to subject these subambulacral plates to a closer examination. They form a single and therefore azygos series under the membrane of the groove, and are united to the lateral ambulacral plates by a firm membrane, in which lie the ambulacral pores. These pores are usually situated between the lateral series of plates and the median series. A semicanal is excavated upon the upper surface of the median series of plates, which appears destined to receive the ambulacral vessel. The ambulacral vessel would therefore, as in the *Asteridæ*, lie upon the outer surface of the ambulacral skeleton, and, as in them, be covered by the soft skin of the ambulacral cleft, while the ambulacral pores which are connected with the feet should perhaps be interpreted as passages leading to ampullæ. The presence of calcareous plates renders microscopical

investigation impossible, and allows only of dissection under the simple lens, by which the constitution of the plates and the ambulacral pores may be very well detected, but the relation of the feet to the ambulacral vessels is not directly observable. The entire inner surface of the calyx is loosely lined by a membrane, which also contains very minute microscopic calcareous plates. In making a general comparison of the ambulacra in the different orders, it is important to remember that *Pentacrinus* possesses not only median azygos but also lateral conjugate ambulacral plates, and that the ambulacral pores lie between the two. The ambulacra of *Pentremites* so far agree with this, that, according to Rømer's exact analysis, they possess besides the conjugate plates, a median azygos plate, which however runs under the whole ambulacrum. The ambulacral vessel and its lateral branches towards the pinnulæ, discovered by Rømer and Yandell, most likely lay above the plates, not under them, and the ambulacra were probably covered by a soft membrane, as in *Pentacrinus*.

The general arrangement of the ambulacral vessels follows one plan in all Echinoderms, but the composition of the ambulacral skeleton and the position of the ambulacral vessels in relation to it are subject to very great variations in the different organs. The ambulacral plates of the Sea-urchins, Starfishes and Crinoids differ essentially from one another, as much as the system of dorsal and interambulacral plating.

There exist however certain azygos median pieces in different divisions, which, when they are present, lie upon the dorsal side of the ambulacral vessel; to this series belong the subambulacral plates of *Pentacrinus*, the great subambulacral plate of the *Pentremites*, the rotulæ in the oral skeleton of the Sea-urchins, and those portions of the oral skeleton of the *Holothuriadæ* above which the ambulacral canals pass to the walls of the body.

Cystidææ.—Among the Crinoids the *Cystidææ* of L. von Buch form a group which is distinguished by the inclusion of the genital organs, together with the other organs, in the calyx. In the *Pentacrinites* and *Comatulæ* on the other hand, the sexual organs are attached to the pinnulæ of the arms; in those Crinoids which have only one calycine opening (mouth), as *Actinocrinus*, *Platycrinus*, &c., the exclusion of the sexual organs from the calyx is at once rendered probable by the absence of any aperture corresponding with them. The *Cystidææ*, on the other hand, have at least two and sometimes three apertures to their calyx, one of which, distinguished by its valvular closure, is found in no other Crinoids than the *Cystidææ*. L. von Buch has determined that this valvular pyramid is the genital aperture. We owe to him the recognition of the close alliance of these forms

with the Crinoids, and at the same time of their peculiarities, the exact analysis of their calyces and the exposition of their genera. That they are not armless, as had hitherto been generally supposed, was first observed by A. von Volborth, who discovered the arms in *Echino-encrinus angulosus* and *striatus*, subsequently in *Echinosphærites aurantium*, where they proceed from the mouth. The figures of the Duke of Leuchtenberg, and those of Volborth of *Sphæronites Leuchtenbergii* and *Protocrinites oviformis* would indicate the presence of arms in these also, although they have not been actually obtained. In fact, branched grooves run from the mouth over a great part of the calyx; the branches of the grooves however end in papillæ of the calyx, which must be regarded as points of origin of arms—a circumstance so much the more remarkable, as it would follow that the arms of these *Cystideæ* must have had a position far removed from the mouth (Verhandl. d. Königl. Mineralog. Gesellschaft zu Petersburg, 1845–46, Petersb. 1849). A specimen of *Sphæronites Leuchtenbergii* in Von Buch's collection agrees exactly with these figures. When, in his second essay, L. von Buch founded the order *Cystideæ* (1844), the oral arms of *Echino-encrinus* were already known. He did not regard them as Crinoid arms, but called them feelers. With a correct foresight he even then arranged the *Pseudocrinites* and *Agelocrinus*, with long arms passing from the oral part of the calyx, among the *Cystideæ*, but was not inclined to consider these processes as true arms. He had even in 1840 termed the remains of the three arm-like processes in *Hemicosmites* arms or proboscides, but was led away from a just comprehension of their nature by comparing them with oral tubes.

In his beautiful monograph on the British Cystideans (Mem. Geol. Survey, t. ii. Lond. 1848) Forbes has increased the number of forms with oral arms. He divides the *Cystideæ* into,—1st, those with arms: *Pseudocrinites*, *Apiocystites*, *Agelocrinites*; 2nd, those with oral pinnulæ: *Prunocystites*; and 3rd, armless forms: *Caryocystites* and *Sphæronites*; to which latter the British form *Echino-encrinus* is added. Forbes considers that the arms observed by Volborth in the Russian species of *Echino-encrinus* are oral pinnulæ. The oral arms of *Echino-encrinus* and *Prunocystites* are articulated in two series. Volborth observed that in the former they are beset with small plates upon their ambulacral surfaces, which he calls tentacles, remarking that pinnulæ are absent. These plates have the characters of marginal plates, which in the Crinoids (*Pentacrinus*) occur on the arms as well as on the pinnulæ. In *Echino-encrinus angulosus* the remains of six arms were present. That this number does not agree with the five depressions which usually surround the mouth is explained by the fact, that the number of these facets

varies; Von Buch states that there are five or six; and I possess a specimen with eight round depressions about the mouth, which are united with the mouth by grooves. *Echino-encrinus striatus* possesses, according to Volborth, together with a very much narrower pointed oral extremity of the calyx, only two much larger opposed oral arms, which have the same structure as in *Echino-encrinus angulosus*. From their relations, however, it is probable that these are not pinnulæ, but arms; for it is not usual for pinnulæ to be isolated. If they both belong to a single ambulacrum, how are we to imagine a single ambulacrum in this locality in the immediate neighbourhood of the mouth? If, however, they belong to two different ambulacra, they can, as solitary structures, be only arms.

The arms of *Echinosphærites aurantium*, Wahlenb. (*Sphæronites aurantium*, His.) have essentially exactly the same relations as Volborth has described and figured. In such well-preserved specimens as now lie before me, the origins of three articulated arms at the oral region of the calyx are recognizable. The five uppermost calycine plates are raised into a three-sided pyramid transversely truncated above, whose obtuse edges are prolonged into the arms. Two sides of the pyramid are broader than the third. The sutures between the five pieces are so disposed that two of them are situated upon the broader side of the pyramid, the three others in the obtuse edges. Two supplementary pieces, however, are added to the five principal portions of the pyramid, and extend from the calyx into two of the angular sutures. The pore-grooves of the plates of the calyx extend only on to the lower portion of the circumference of all the seven pieces. The arms immediately subdivide again. From the oral aperture grooves, beset with marginal plates, pass on to the arms. For the rest, the division of the arms shows that they are arms, and not pinnulæ. Whether these arms, like those of a few other Cystideans, as *Pseudocrinites*, were provided with articulated pinnulæ, cannot be decided, since they are broken short off. Whether the *Caryocystites* possessed arms is not as yet known, but it can hardly be doubted, since they are not certainly distinguishable from *Echinosphærites*.

In *Hemicosmites*, three of the six uppermost plates of the calyx are provided with an insetion, which arises from the triradiate median calycine opening. Each of the insetions is continued into a groove; the groove terminates after a slight expansion in an elevation of the calyx which served for the attachment of an arm. The elevation no longer lies on the plates of the uppermost, but upon three of the plates of the second series. The elevation exists only in specimens which are not worn down, and is beautifully obvious in a specimen which M. Ewald has sent

me. The triradiate clefts of the calyx, and the calycine grooves continued from them, are covered with minute plates which readily fall off. In the specimens figured by L. von Buch, they are still perfect, and form a fine series of plates from the mouth to the ventral surface of the three arms. In this series, again, three delicate grooves are distinguishable, as in *Echinosphærites aurantium*, which correspond with the subjacent clefts of the large plates of the calyx and their grooves. In the always much worn specimen of *Cryptocrinites cerasus*, no indications of arms have hitherto been observed.

Forbes regards the *Cystideæ*, like the *Blastoidea*, as sections of the Echinoderms different from the Crinoids. The *Sphæronites* were already arranged among the Crinoids by reason of their stalks before their arms were discovered, and we now have still more reason for considering this to be their true position. Volborth and Rømer consider the *Cystideæ* as a group of Crinoids, which is also my own view. The position of the arms, however, must not be regarded as one of their characters; for in *Sphæronites Leuchtenbergii* and *Protocrinites oviformis* the arms were situated far away from the mouth, as in the other Crinoids.

The suctorial feet of the Cystideans were unquestionably placed, as in *Pentacrinus*, on the ambulacral side of the arms and in the calycine grooves. In the introductory part of this essay, however, it has been demonstrated to be contrary to all analogy that suctorial feet should exist in any Echinoderm upon the antambulacral side of the perisoma from the apical end to the arms, or between the ambulacral radii. In the *Cystideæ*, therefore, the whole calyx, with the exception of the calycine grooves, is to be regarded as anambulacral.

The genera *Pentacrinus*, *Caryocrinus*, and most Cystideans are distinguished among the Crinoids by the existence of very peculiar pores in the anambulacral plates of the calyx. *Pentacrinus* alone has afforded the opportunity of an exact investigation of these pores. I have described and figured them in the essay upon *Pentacrinus*.

The interambulacral (interpalmar as well as intrapalmar) calycine pores of *Pentacrinus* pierce the ventral calycine plates, and lead beneath the inner membrane of the calyx. They possess no soft external prolongations. In contrast with the ambulacral calycine pores for feet, these may be called anambulacral calycine pores. Their signification is not understood, only it is certain that they are not passages for feet. A comparison with the respiratory pores of the *Asteridæ* suggests itself; soft tubes project from these, with regard to which Ehrenberg has shown (and I can confirm his statement by my own observation) that they

are cæca, which are indeed connected with the abdominal cavity, but are perfectly closed externally.

The calycine pores of *Caryocrinus* are equally without relation to the arms; and thence, though differently distributed, resemble the anambulacral calycine pores of *Pentacrinus*. They occupy the antambulacral part of the calyx behind the arms as far as its base.

Most Cystideans (*Cryptocrinites cerasus* excepted) possess calycine pores, which are distributed over a greater or smaller part of the calyx without radiation and in a very peculiar manner. In those forms with calycine grooves, as *Protocrinites* and *Sphaeronites Leuchtenbergii*, these pores again appear to be anambulacral, since, like the anambulacral pores of *Pentacrinus*, they are disposed in the area external to and between the ambulacral grooves; here, however, their distribution is far wider, since they extend as far as the base.

Two principal divisions have been made, according to the distribution and combination of these pores:—

I. Cystideans with pore-rhombs. The pores are disposed in rhomboidal figures, the one-half of which belongs to one plate, the other to its contiguous neighbour. Every two pores of these rhombs appear to be invariably united by canals or grooves, which are visible either upon the outer or on the inner side of the plates, in such a manner that the united pores belong to two different adjacent plates.

a. Pore-rhombs without external connexion of the pores. *Hemicosmites* and *Caryocrinus*; in *Hemicosmites* the combining grooves are, according to Volborth, upon the inner surface of the plates.

b. In *Echinosphærites granatum*, Wahlenb. (*Caryocystites granatum*, v. B.), the pores are united by bands projecting externally, which contain the connecting canal of the pores, and this canal is always a single one between each pair of pores, or even a series of pores*. The more importance is to be attached to this circumstance, as the number of the calycine plates, even of the basal plates in *Caryocystites granatum*, varies, so that some specimens possess more superimposed plates than others, and even specimens with five basal plates are not rare. According to the arrangement of the plates, I do not think that *Caryocystites* and *Echinosphærites* could be separated.

A form nearly allied to *Caryocystites granatum*, observed by M. Beyrich (Drift [*Geschiebe*] near Berlin), the plates of whose calyx are more numerous, is distinguished by the bands which

* . . . und dieser Canal ist immer ein einziger zwischen je zwei Poren, oder selbst einer Porenreihe.

unite the pores belonging to an entire series of pores, which penetrate the entire thickness of the plates, so that the series of pores appear also upon the inner surface of the plates. Something similar may also be observed in many specimens of *Caryocystites granatum*, inasmuch as the canals of the bands not unfrequently also exhibit clefts here and there between the terminal pores. These clefts may indeed be readily explained by the grinding down of the canals; the occurrence of the regular rows of pores in the species above mentioned, however, leads us to question whether they always have this origin.

c. In *Echinosphærites aurantium* and *aranea* every two pores of two plates are not uncommonly connected by one, usually by two canals, which are recognizable upon the outer surface of the plates; *Echinosphærites testudinarius*, included by Von Buch in the ill-defined genus *Caryocystites*, is an elongated Echinosphærite. Its pore-rhombs agree more closely with the previously-named species than with *Caryocystites granatum*, though the number of the pore-canals between every pair of pores is in some localities still greater. In fact, we not unusually observe not only two, but three, or even four conjoined canals, which open at both ends into a pore, and are so connected.

d. The genera *Echino-encrinus*, *Pseudocrinites*, *Apiocystites*, *Prunocystites*, are distinguished by possessing only a few pore-rhombs—fragments of the system—which however are here justly termed pore-rhombs. In *Echino-encrinus angulosus* and *striatus* there can be no doubt that the elongated pores of these rhombs are clefts which penetrate the whole thickness of the plates. Forbes remained in doubt with regard to these pores, and was inclined to interpret the 'pectinated rhombs' as the situation of ciliary organs comparable with the ciliated epaulettes of the larvæ of *Echini*. Seeing the very problematical nature of all pore-rhombs, and of all non-ambulacral pores of the Crinoids, in fact, the supposition that the cilia are connected with the pores and pore-canals is not to be excluded.

The number of the pore-rhombs in the *Echino-encrinites* appears to vary, and *Echino-encrinus granatum*, Volb., would appear to be only such a variety of the *E. angulosus*.

II. Cystideans with double pores upon the calycine plates, which belong not to two different plates, but to the same. The plates are faceted, and each facet possesses two closely approximated pores. Here belongs a small group of Cystideans, which, since it consists of many genera, might be called *Diploporitida* (*Diploporiten*). The genera included in it are:—

1. *Sphæronites pomum*, His. Type of a peculiar genus, which may retain the name of *Sphæronites*, as opposed to the *Echinosphærites* with pore-rhombs.

2. *Protocrinites* (*P. oviformis*, Eichw.).

3. *Sphæronites Leuchtenbergii*, Volb. Type of a peculiar genus, which may be termed *Glyptosphærites*. That the Russian *Sphæronites pomum*, Leuchtenb., or *S. Leuchtenbergii*, Volb., is not the Swedish *S. pomum*, Volborth thought probable from Gyllenhal's account. The specimens of the Swedish form in the Mineralogical Museum of this place put this beyond doubt. There are no calycine grooves on the true *Sphæronites pomum*, His.; on the other hand, the five outermost calycine plates are elevated into a triangular pyramid truncated at the mouth, as in *Echinosphærites aurantium*; the edges of the pyramid are broken off in all the specimens, and leave a doubt as to the form of the arms which were probably present. The base of the calyx is transversely truncated, and very broad in relation to the diameter of the calyx; it consists of 6-7 pieces.

The relation of a few other *Diploporitidæ* to these genera is still unknown. Many of the Cystideans described by Forbes, and enumerated by him among the *Caryocystites*, viz. *C. Litchii* (F.), *C. pyriformis* (F.), *C. munitus* (F.), do not belong to the genus *Caryocystites* (Von Buch), being rather *Diploporitidæ* allied to *Sphæronites pomum*, which require further investigation.

Crinoids with reticulated hands.—A fossil Crinoid with reticulated hands from Gothland has long been recognized as such in Stockholm, but has not yet been figured and described. Many years ago Prof. A. Retzius transmitted fragments of the hands to me, at the same time pointing out the peculiarity of this Crinoid. Numerous dichotomously-ramifying series of joints are united into a petaloid form by lateral processes of the joints. I had never seen anything of the kind, and could hardly imagine them to be portions of a Crinoid.

On mentioning these fragments to Von Buch, he recollected that similar equally problematical fragments from Gothland were in his own possession. We brought them upon the same day to the Gesellschaft Naturforsch. Freunde, and it was evident at once that they were identical. Von Buch, with the friendship which he has always shown, readily offered to share with me the specimens which he possessed. I was obliged however to renounce the attempt to elucidate the nature of the animal from such portions as I possessed without the calyx; and I entertain a thorough aversion for the practice of hastily naming, which inflicts upon science an encumbrance out of all proportion to the possible gain therefrom. I gave over the fragments which I had received to the Mineralogical Museum, as the most proper place for their reception. In this museum there were also additional fragments of this Crinoid from Gothland, sent to me by M. Beyrich.

When M. Peters visited Stockholm in the spring of the pre-

sent year, he inquired further for the remains of the animal from Gothland; and M. Lovén was so good as to send to me for description the beautiful fragments which he possessed of it. In one of these specimens, the greater portion of the calyx with a part of the hands is preserved; in another, a part of the calyx with the petaloid hands. A third specimen consists of the hands alone. Prof. A. Retzius also sent me besides a beautifully preserved specimen of the hands. Who can contemplate without joyful surprise these remains, in which the peculiar structure of one of the most remarkable forms of the Crinoids is clearly evident?

The base of the calyx, whose plates are perfectly smooth, is not quite perfect, but appears to consist of five *basalia*, on which follow a circle of five *parabasalia*; with these alternate five arm-bases, *radialia*, which are in contact, there is, however, a small intermediate piece between two of the five. This arrangement would thus agree with *Cyathocrinus*. The *parabasalia* are hexagonal; their breadth to their depth as 3:2. The *basalia* are exceedingly depressed, three times as broad as they are deep. On each of the *basalia* three joints are seated,—one, of a triangular form, upon the excavated centre of the anterior edge; two at its sides; the inner edges of the latter lie over the middle piece, and so come into contact. These two lateral pieces are the bases for all the series of joints of both halves of the hands. To each are first attached two joints, an internal, and a far broader external. The broader is the first of the longitudinal series of broad joints which runs along the outer edge of the commencement of the hand. At first very broad, they become successively narrower; their outer edges constitute the outer edge of the hand, while the inner edge is, as it were, cut into steps of two joints, sufficiently deep to allow of a new series of joints being articulated upon the notches thus formed.

The step-like notches therefore pass over one, and further on even many joints. The series of joints soon divides dichotomously again, and the dichotomy is continually repeated. Even at a small distance from the bases of the arms, we find more than thirty longitudinal series in the breadth of a hand; at the distance of an inch from the base of the hand there are as many as eighty series, and so they go on multiplying. The joints lie not merely in regular dichotomous longitudinal series, but in as exactly regular arched transverse series, and are articulated together laterally by opposed processes, so that all the joints of the hand taken together form a petal with innumerable minute gaps. These five hands have an extraordinary breadth at their periphery; in their expanded condition they would doubtless no

more cover one another than the expanded petals of a pentapetalous corolla; in the closed condition they mutually overlap, just like the folded petals of a closed corolla; in fact, their sides are quite rolled in. The joints of the coalesced fingers are in general as long as they are broad, or a little longer.

The dorsal surface of the joints is flat, the lateral processes lie in the middle of the length of the joints, but usually somewhat further forwards, so that the joints viewed from the dorsal surface have the form of a cross with very short arms. The union of these joints before and behind, in a longitudinal direction and by their lateral processes transversely, gives rise to a network with regular meshes. At the commencement of the arms the meshes are as yet undeveloped, and the joints not cruciform but four-sided.

Close above the calyx the joints measure in thickness, that is in the direction from the dorsal to the volar side, much more than in length. The lowest, which rest upon the radialia of the calyx, are the thickest. Thence onwards they decrease successively in thickness, so that soon it is only one-third of what it was close above the calyx. The great development of the first joints internally, produces, with the radiale of the calyx, a sort of arch over the periphery of the calycine cavity. A nutritive canal is observed upon the articular surfaces at the end of the joints. In a transverse section also we observe that the volar side of the joints is deeply excavated, the cavity being included by two ridges.

Further outwards the thickness of the joints rapidly diminishes; an inch from the base they are still twice as thick as they are long, but very soon their thickness is not greater than their breadth. They retain the excavation upon the volar side, which forms a deep canal on the volar side of the longitudinal series of joints, and is covered transversely by minute plates, which usually alternately interdigitate with one another. At the sides of the volar surfaces of the joints, including the ambulacra, stand exceedingly delicate pinnulæ or narrow marginal plates, many of which (three to four) occur in the length of a single joint. These pinnulæ are unarticulated; it is only at their base that a small portion appears to be divided off. The height of the pinnulæ on the broader portion of the hand equals the thickness of the joints. The volar surface of the hand was therefore, corresponding with the dichotomy of the series of joints, provided with hundreds of dichotomous ambulacral grooves, supported by delicate calcareous marginal plates.

When the series of fingers have been broken out from the stone and the impressions of their volar sides left behind, these

impressions appear like rounded dikes with closely-set transverse or zigzag insections, which appear to correspond in position with the covering plates between the pinnulæ.

On making a transverse section of the hands, the involution of the sides of the arms is observable. In a longitudinal section perpendicular to the calyx, we observe not merely the interior of the calyx and the above-mentioned overarching of the peripheral portion of the cavity of the calyx, but also the ventral perisoma above the calyx, which, passing from the hands, lies above the overarching portion, and stretches like a line over the middle of the calyx. The delicate pinnulæ or marginal plates of the series of joints of the hands are continued on to the ventral surface of the calyx, and in sections may be traced to the middle, where in all probability the mouth was situated.

The composition of the stem is at present unknown.

Among the numerous Crinoids of Gothland described and figured by Hisinger in the 'Lethæa Suecica,' we look in vain for any figure of reticulated arms, though there are not a few among them whose arms have not been preserved. It is difficult to conceive that among the many remains of Crinoids which he saw, there should have been nothing appertaining to the reticulated Crinoid; and in fact there is a figure, not of the reticulated hands, but of the calyx and the first joints, which would appear to do so. It is his *Cyathocrinus pulcher*, "calycis articulis hexagonis margine striatis, manibus circiter 35, brevibus linearibus, puncto medio profundo, angulo recto infractis." Leth. Suec. Suppl. ii. tab. 39. fig. 5. It would be impossible to conclude that this is our Crinoid from the figure of the pieces of the calyx, which is probably imperfect; and the marginal striæ figured upon them are equally in disagreement with it. For in the Crinoid with reticulated arms, the margin of the pieces of the calyx at the edges by which they are in contact is in some parts excavated, and in some entire, without the external surface of the pieces of the calyx themselves being insected or striated. What however strongly suggests that this is our Crinoid, is the figure of the lowermost joints of the arms which are still attached to the calyx, and extend from without inwards as far as in the Crinoid with reticulated arms, and possess the canal in the same situation and the excavation upon the yolar side. Hisinger has taken these joints with their bare articular surfaces for short linear hands inflexed at a right angle. The median deep point, which he speaks of, is the nutritive canal which makes its appearance upon the articular surface of the joints. It is very difficult to make out Hisinger's figure, and it would be quite impossible without a knowledge of that internal structure of the joints peculiar to the Crinoid with reticulated arms. The object there figured is

assuredly allied with ours; but we should not be justified in identifying the two either from the description or the figure.

In the Royal Mineralogical Museum of this place there is a model in plaster of an English Crinoid from Dudley, the excessively delicate and numerous rays of whose arms, and the regular series of their articulations transversely and longitudinally, present a certain similarity with the network of the Swedish Crinoid. The calyx agrees with that of *Cyathocrinus rugosus*, Müll., *i. e.* *Crotalocrinus rugosus*, Austen, having the same sculpture of the calycine plates. At the first sight of this model, which came from M. Crantz, one is inclined to ascribe to this English Crinoid the same reticulated structure of the hands as in the Swedish form, and to regard them both as species of one and the same genus, or of two closely allied genera. On careful examination, however, no certain evidence of a transverse connexion of the joints in the English Crinoid can be obtained. In fact, the very numerous series of articulations are so given off from the calyx, that there are great difficulties in the way of the supposition that they are united into five hands. However, this point can only be decided by the examination of various original and well-preserved specimens.

Austen thus speaks of *Crotalocrinus* in the 'Annals of Natural History,' vol. xi. 1843, p. 198:—"Dorso-central plates five; first series of perisomic plates five; second series five; on the latter are a series of wedge-shaped plates which bear the rays: the exact number of these plates is unascertained. Column with a pentapetalous perforation.

"*C. rugosus*. The plates surrounding the body agree with the generic character. Rays numerous, probably amounting to one hundred. Column composed of thin joints articulating into each other by radiating striæ. The columnar canal is pentapetalous. The rays are remarkably small in proportion to the size of the animal."

The authors, who could compare with Miller's specimen, observe, that Miller has erred with regard to the plates, which he wrongly regards as scapulæ, with a single excavation for articulation with the arm-joints. These plates possessed no excavation at all, but a regular series of wedge-shaped plates rested upon them, from which the rays, amounting to about 100, proceed.

The description which M'Coy gives of the genus *Crotalocrinus* and of *C. rugosus* in his 'Synopsis of the Classification of the British Palæozoic Rocks,' pt. 2. p. 55, strengthens my belief that the model of the English Crinoid is referable to *C. rugosus*. The description of the calycine plates agrees exactly. It is stated with regard to the five scapulæ that a series of small pentagonal plates rests upon each, which for the whole breadth of each

plate support a great number (? 15 or 16) of very delicate rays. None of the English writers mention any reticulated connexion of the rays; I must therefore leave it unsettled, whether this English Crinoid stands in any relation, either close or distant, with our present subject.

Under these circumstances it will be necessary to found a peculiar genus for the Crinoid from Gothland with reticulated arms, for which I propose the name of *Anthocrinus*—species *Anthocrinus Loveni*, Müll. It is obvious that these Crinoids with reticulated arms stand alone and constitute a peculiar small section, of which at the present time only one form, from the Silurian formation of Gothland, is known. I shall hereafter, when I am more fully acquainted with the Crinoids of this formation, be able to speak of its relations with the other Crinoids of the transition limestone.

The continuation of this memoir is concerned with the *Holothuriadae*, and reports of its contents have been already given. The numerous figures appertaining to the memoir are reserved for the Transactions of the Academy. In conclusion, I offer my hearty thanks to the friends who have so generously assisted my labours.

Supplementary Notice.

It should be added to the remarks upon the interambulacral plates of the *Asterida*, that in *Astropecten* the different series of interambulacral plates are simultaneously applied to the ambulacral plates; the outer being the lateral plates of the grooves, the inner only visible in the abdominal cavity uniting the ambulacral plates with the inferior marginal plates. The intermediate plates between the lateral and marginal plates have already been referred to.

Note by the Translator.

Without wishing in the slightest degree to detract from the originality of the views with regard to the homologies of the Crinoid skeleton expressed by Prof. Müller in the preceding pages, we nevertheless feel bound, in justice to our distinguished countryman Prof. E. Forbes, to state that he has long taught in his public lectures an essentially similar doctrine, viz. that the 'head' of a Crinoid may be compared to an Echinid placed mouth upwards, and having its vent brought into proximity with the mouth (as in *Echinocyamus*): that the arms are freed ambulacra; that the cup or 'pelvis' is formed, partly by the oculars, partly, in many genera, by accessory plates (like those in the disc of *Salenia*), and partly by the interambulacral plates,—the genital

plates being probably suppressed; finally, that the basal or stem-bearing plate is the homologue of the madreporiform body.

It was our intention to have added some illustrations to the present memoir, but on consideration we think it better to run no risk of misrepresenting Prof. Müller.

XXIII.—*Description of a new species of Closterium (Closterium Griffithii)*. By the Rev. M. J. BERKELEY, M.A., F.L.S.

[With a Plate.]

A PRETTY but rather puzzling little Alga has been nursed for two years or more by Dr. J. W. Griffith in bog water, in which it has multiplied, without however giving any opportunity of ascertaining its mode of propagation. I have lately had occasion to examine mounted specimens, accompanied by a magnified representation of the plant in a living state, and from these and notes communicated by Dr. Griffith, who is preparing a work on the microscope, to the appearance of which I am looking forward with much interest, it is quite clear that it belongs to the genus *Closterium*, notwithstanding its comparatively minute size, the absence of curvature, and the hitherto unobserved copulation of the filaments. The circulation, which can only be seen under a power of from 1000 to 1500 diameters, is precisely that of *Closterium*, and the green colour and absence of lateral marking forbid the notion of its being a *Synedra*, though there are one or two species figured by Kützing to which it has some resemblance in point of form. The species may be characterized as follows:—

Closterium Griffithii. Minutum rectum fusiforme medio turgidulum, utrinque fortiter attenuatum apicibus acutissimis setaceis hyalinis. Long. .033–.025 unc., centro lat. .0002–.0016.

At first the frond is green, but a hyaline band is at length formed in the centre, where division ultimately takes place. *Closterium setaceum* resembles it somewhat in form, but that is more swollen in the centre, much longer, striated, and the tips of the fronds are curved. The var. β . of *C. cornu* approaches it in size, but the whole outline is extremely different. There can be no doubt of its being a very distinct species. The figure (Pl. XIV. fig. 2) represents three individuals in different stages of growth magnified 450 diameters. The species belongs to the genus *Stauroceras*, Kütz., which is very properly considered as part of *Closterium* by Mr. Ralfs.