THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[FIFTH SERIES.]

No. 40. APRIL 1881.

XXVII.—*Contributions to the Study of the British Palæozoic Crinoids.*—No. I. *On* Allagecrinus, *the Representative of a new Family from the Carboniferous Limestone Series of Scotland.* By P. Herbert Carpenter, M.A., Assistant Master at Eton College, and R. Etheridge, Jun., of the Museum of Natural History.

[Plates XV. & XVI.]

1. *Introduction.*

We have for many years been in the habit of meeting with a very small and peculiar Crinoid in almost every collection of Scotch Carboniferous-Limestone fossils examined by us, in which attention has been paid to the remains of the more minute organisms that inhabited the old Carboniferous seas.

The systematic position of our fossils will be best discussed at the conclusion of this paper, after we have described the remarkable combination of characters which they present. We believe them to represent the type of a new genus, for which we propose the name *Allagecrinus**, on account of its

* ἀλλαγή, change.

singularly protean nature. We cannot even refer it to any known family of Crinoidea, although in many respects it approaches the Haplocrinidæ very closely.

The sources from which our material is derived are two. The ample and fine collection of Dr. J. S. Hunter, of Braidwood by Carluke, has supplied us with two well-preserved examples of the calyx. In the second place, we have been permitted to use a very large series of specimens, showing all stages of growth, from the collection of the Geological Survey of Scotland. The examples in question were collected and washed from shale by Mr. James Bennie; and we are indebted to the kindness of Prof. A. Geikie, LL.D., F.R.S., for the loan of them.

In the descriptions which follow we have united under the one name a series of forms possessing up to a certain point in their organization the same general structure, but beyond this differing in minor degrees, which we were at first sight inclined to look upon as probably of specific value. The finding of a regular gradation, however, between the extreme forms of the series has led us to reconsider this view; and we now think the additional points of structure referred to may be looked upon simply as an advance from a less to a more complex condition in the same form.

2. *Description of the Genus and Species.*

Genus Allagecrinus, Ether. & Carp. (gen. nov.).

Gen. char. Calyx pyriform or cylindro-conical, composed of five basals and five unequal radials, one to four of which, or sometimes none, *may* be axillary. An oral pyramid of five closely fitting valves, and of very variable height, is present in the young, but is probably wanting in the adult. Arms composed of elongated joints, sometimes forking twice. Stem short and vermiform, of low rounded joints; canal circular; terminal faces slightly granular.

Obs. Although the various individuals figured on Plates XV. & XVI. differ from one another to a very considerable extent, both in size and form, we have been led to the conclusion that they are really all referable to one species and represent various stages in its development. The most advanced, and probably fully grown, stage is shown in Pl. XV. figs. 1, 2, and 6. These are the only three tolerably complete specimens of the adult that we have met with, and were all found at the same locality. Fig. 2 represents that which is most fully developed and also the best preserved of the three.

A projection of the calyx and the arm-bases in connexion with it is shown in fig. 3 of the same Plate.

There are only two rows of plates in the calyx, which is cylindro-conical in form, expanding slightly from below upwards. The basals form a complete ring and a very shallow pentagonal cup, but little higher at the angles than at the sides; the sutures are nearly if not quite invisible as a general rule. Fig. 4 (Pl. XV.) represents the interior of this cup as seen from above. The five radials which rest upon it are elongated pieces with subparallel lateral margins, increasing slightly from below upwards both in width and in convexity. They vary considerably in size, some of them being axillary and bearing two arms, while others are narrower and have only one articular facet on the upper surface (Pl. XV. figs. 2,*a*, 2,*b*). In two specimens (Pl. XV. figs. 1-3) four of the radial plates are wide and axillary, so that the number of (primary) arms must have been nine. In the third specimen, however (Pl. XV. fig. 6), only three of the radials are axillary, corresponding to eight primary arms; while the two adjacent ones, which bear but one arm each, are unequal in size (Pl. XV. fig. 6,*b*). The articular facets for the attachment of the arms are large and distinct (Pl. XV. fig. 6, *a* & *b*), and nearly horizontal in position, so as to give a projecting lip-like appearance to the upper and outer edges of the radials. They have the same general form in all three specimens, although a certain amount of variation is perceptible. The dorsal fossa for the elastic ligament is narrow and crescentic, and lacks the central pit, which is often so very distinct in other Crinoids. Above it is the transverse articular ridge expanding around the opening of the central canal, which is unusually large. On the upper side of the ridge are large fossæ for the articular ligaments, which vary somewhat in shape in the different specimens. The muscular fossæ, in the few cases in which they are discernible, are small and at a lower level than the ligamental fossæ, from which they are separated by ridges.

Two of the specimens have the lowest joints of the arms preserved. They are small and irregularly cuboidal, with nearly circular distal faces (Pl. XV. figs. 2 & 6). In the best specimen the second and third brachials of three arms are also preserved (Pl. XV. figs. 2, 3). Each joint has an almost cylindrical shaft, with slightly expanded ends. Where the first radial is axillary, the second brachial is not much longer than wide; but in the second brachial of the azygos arm the length is more than twice the width. This may, however, be merely an accidental difference; for the three

third brachials vary considerably in size. Neither of these is an axillary; but their terminal faces are almost transverse to their longer axes, and seem to have been syzygial rather than articular. No traces either of vertical or transverse ridges are visible.

In none of the specimens is there any indication of an anal aperture.

The interior of the calyx between the radials is occupied by matrix; but there are no signs of its having been roofed over by a closed dome or vault of any kind. Had such a structure existed within the circle of radial plates, it would assuredly have been preserved in the original of fig. 2, together with the ring of first brachials. It is possible, however, as we shall point out later on, that the mouth was surrounded by a circle of oral plates, disconnected from the calyx like those of the recent *Rhizocrinus* and *Hyocrinus*.

The column is short, and when tolerably entire has a vermiform appearance (Pl. XV. figs. 2, *a*, *b*, & 7, *a*). It is composed of small, low, rounded joints fitting closely together. Each segment is biconcave, with a thickened margin, and the centre a little raised around the small circular canal, where the surface is also minutely frosted or granulated (Pl. XV. fig. 5).

The surface of the plates is minutely pitted.

The three specimens we have now described are from one locality, together with another in a much broken condition, and several fragments of other individuals. None similar have been met with elsewhere.

Other localities, on the contrary, have yielded a very large number of small specimens, the general appearance of which is so like that of the preceding examples that we have been led to regard them as the younger stages of the same, or of a closely allied species. They are all characterized by the presence of an oral pyramid, the relative size of which is greater the smaller the specimen. The various figures on Pl. XVI. and figs. 7, *a*, *b* of Pl. XV. represent a number of these specimens of various sizes and at various stages of development. Great as is the contrast between the originals of figs. 1 and 2 (Pl. XVI.) and those of the corresponding figures on Pl. XV., there are so many intermediate stages which pass gradually into one another that we are unable to regard the series as comprising more than one species.

We may commence the study of this interesting developmental series with the smallest and least advanced forms, such as are shown in figs. 1–3 (Pl. XVI.). The youngest

condition we have met with is shown in fig. 2 (Pl. XVI.). The calyx is covered by a round dome of oral plates, the height of which relatively to that of the radial plates is greater than in any other specimen we have seen. Its base is very nearly as wide as the summit of the radial pentagon, which is thus almost entirely concealed. At the centre of the upper edge of each radial is a minute opening, which penetrates beneath the dome; but no arm-facet corresponding to this opening is visible. The oral plates are so closely united that there is no trace of the sutures between them, though there are five faint grooves on the upper surface of the dome, which indicate their median lines. In older specimens, figs. 4, 7, 8, 10 (Pl. XVI.), these grooves are sometimes very marked. In this youngest individual the calyx is tolerably symmetrical, no one part being further developed than another. The same is the case in some older individuals, as is shown in figs. 5 and 7 (Pl. XVI.). On the other hand, specimens are not uncommon with some of the radials more developed than others. The youngest stage in this condition that we have met with is shown in fig. 1 (Pl. XVI.). The oral plates in this specimen are relatively lower, but cover the radials more completely than in the original of fig. 2, and their median grooves are much more distinct. Three of the radials have rudimentary arm-facets; but on the other two there is scarcely any more indication of these structures than in the specimen represented by fig. 2 (Pl. XVI.).

A larger and more advanced individual in the same condition is shown in fig. 3 (Pl. XVI.). The dome of oral plates is remarkably flat; and three of the radials have minute semicircular arm-facets, which are much less distinctly visible in the two remaining radials.

The next stage, in which the arm-facets are equally developed on all the radial plates, is exhibited in figs. 4–7 (Pl. XVI.). The calyx, which varies considerably in form, is surmounted by a low rosette-like dome, composed of the five very closely ankylosed orals. Each of these plates is triangular in shape and excavated rather deeply along its median line. At the centre of the dome they are in close contact laterally, so that no opening is visible; but their basal angles are more or less truncated, leaving a superficial gap between every pair of plates, which corresponds in position with the articular facet on the subjacent radial. The interior of this gap, however, is filled up by the deeper portions of the oral plates, which thus bridge over the semicircular notch on the upper surface of the facet. The latter consists of nothing

more than a thickened semicircular rim, which is thus converted into the opening of a tunnel that leads inwards beneath the dome.

These notches on the upper surface of the radial plates are the central ends of the grooves which are excavated in the upper surface of the arm-joints, and were called the arm-grooves by Müller. They are often, although incorrectly, spoken of as the ambulacral grooves. Above and partly contained in these grooves were the vascular and generative tubes of the arms, and above all these the true ambulacral or food-grooves, which may or may not have been protected by special plates, as in *Cyathocrinus* and many other fossil and recent Crinoids. All these structures entered the calyx on their way to join their respective circumoral centres through the openings at the edge of the vault between the radials and the orals. These openings are of course the representatives of the ambulacral openings round the edge of the vault of *Actinocrinus*; but there is no trace in *Allagecrinus* of any such separation of the soft parts by plates as we find in the former genus. In both cases the cœliac canal, which was lodged in the lowest portion of the arm-groove, is continued directly downwards into the visceral cavity. It was separated in *Actinocrinus* from the water-vessel and food-groove by the subambulacral plates, which form the floor of the ambulacral tunnels beneath the vault; but there is no trace of these in *Allagecrinus*.

In none of these small specimens is there any trace of an anal opening, either directly piercing an oral plate, or at the margin of the dome, between the orals and the radials. The central end of one or more of the former may be marked by faint tubercles (figs. 5 and 7, Pl. XVI.); but we cannot suggest any explanation of these. In the specimen shown in fig. 6 the central portion of the dome has been removed, and only the bases of the triangular oral plates are visible.

Except in the characters of the stem, and in the general aspect of the basals and radials, these small specimens differ so much from the larger ones previously described that it would seem only natural to place them in entirely different families, characterized respectively by the presence or absence of an oral pyramid. Fortunately, however, we have met with a few specimens that show us such a gradual transition between the two groups that we have been compelled to place them together under one specific name.

These intermediate forms, which are represented in Pl. XV. fig. 7, and Pl. XVI. figs. 8–10, while agreeing in certain general characters, seem to have developed along different

lines. The radial plates are better developed relatively to the orals than in the younger forms. Hence when the calices are viewed from above they are seen to be only very incompletely covered by the dome and project considerably beyond its circumference, while distinct facets for a true articulation with the first arm-joints begin to make their appearance (Pl. XVI. figs. 9, 10). These are least marked in the specimen shown in fig. 8 (Pl. XVI.). In one or two cases the facet is something more than a mere thickened rim to the arm-groove, and shows traces both of a central canal and of a dorsal fossa for the elastic ligament. The chief character indicating the advanced condition of this specimen is the inequality in the size of its radial plates, one of which is axillary and has two arm-facets, which are not yet completely developed. In the individual shown in fig. 10 (Pl. XVI.), on the other hand, all the radials have well-developed articular facets, which are pierced by the openings of the central canals; but though the radials are unequal in size, none of them is an axillary. The great reduction of the relative size of the orals in this specimen is especially noteworthy. In two other specimens, which also have much-reduced orals, there is a remarkable inequality in the development of the arm-facets. Thus, in the original of fig. 9 (Pl. XVI.) three of the radials have well-marked articular surfaces for the first arm-joints, while that of the fourth is very imperfect, and that of the fifth altogether undeveloped, no trace even of an arm-opening being visible. Fig. 7 (Pl. XV.) shows a similar irregularity. The orals are relatively very small, and two of the radials have distinct articular facets, whilst two others have small cuboidal brachials still in contact with them. The fifth radial, however, bears a very small and rudimentary brachial, which is shown on the right of fig. 7, *a*.

The originals of fig. 6, Pl. XV., and figs. 1 and 2, Pl. XVI., differ very considerably in size. Apart from that, the chief point of difference is the presence of oral plates in the latter and not in the former. It does not seem to us a very improbable supposition that during the growth of the smaller specimen to the size of the larger its orals would come to be of such small relative size (as they do in the development of *Comatula*) as to be altogether lost in the fossil state, even if they persisted during adult life.

The large and small forms agree in so many points, especially the inequality in size of the radials, and the fact that some of them may be axillary, that we do not see our way to separating them specifically. It must be remembered that these little fossils occur at various localities. Even the larger

and more fully developed forms are at a very low stage of organization* as compared with most other Crinoids; so that it is natural to suppose they would present a considerable amount of variability, both local and general.

Although it may be thought that the variations we have described exceed the widest limits allowable on these grounds, we prefer rather to ask for an extension in this direction than to multiply species in a manner which appears both artificial and unnecessary.

When all the above facts are taken into consideration, it seems to us hardly possible to doubt that the specimens we have described represent various stages in the development of a Palæozoic Crinoid. In the smallest examples there is a relatively large oral pyramid, and the uniformly sized radial plates were not perforated by a central canal. The axial cords lay at the bottom of grooves in their upper surfaces, just as in the young Pentacrinoid larva of *Comatula* (with closed oral pyramid) and in the mature stages of many Palæocrinoids. Next we find specimens in which there are distinct canals developed for the axial cords, and the articular facets of the radials gradually come to exhibit their characteristic markings. At the same time the sizes of the different radials become more or less unequal, and the orals relatively less prominent, though still resting directly on the radials.

Lastly, in the best-developed examples the radials have strongly marked articular facets—some of them (never all) being axillary and bearing two arms, while the orals have entirely disappeared as an integral part of the calyx. In fact, one would scarcely expect to find them retaining their embryonic condition of a closed pyramid on the top of a calyx, the radials of which had reached such a high state of development.

The very complete fusion of the orals in the specimens represented in figs. 8–10 (Pl. XVI.) appears to show that they remained united until a comparatively late stage, and so closed in the tentacular vestibule, in the floor of which was the opening of the mouth.

* Beyrich has pointed out (Crinoideen des Muschelkalks, pp. 43, 44) that in young individuals of *Encrinus* the sutures between the basals are invisible, though those between the radials are distinct enough. This is the case in nearly all our specimens of *Allagecrinus*, both young and old. It may also happen in the young *Encrinus* that one of two arms on the same axillary may remain rudimentary, while the other develops first. The inequality in size of the radials in *Allagecrinus* and of the arms which they bear is even a lower condition than that noticed by Beyrich in the young *Encrinus*. There is no similar stage in the young of recent Crinoids, in which all the radial plates are equal from the first.

The entire absence of orals from the three largest specimens does not necessarily prove that they were not present during life. We imagine that in the subsequent stages to those represented in fig. 7 on Pl. XV. and figs. 8–10 on Pl. XVI., the orals were relatively carried inwards, away from the radials, and separated from them by perisome (just as they are in the Pentacrinoid larva of *Comatula*) when the arms began to appear above the radials. Whether the orals ever separated so as to open the mouth to the exterior, and whether the ring of perisome forming the ventral disk between them and the radials was naked, as in *Rhizocrinus*, or plated, as in *Hyocrinus*, must of course remain undecided. The absence of any distinct anal system in the calyx of the large specimens indicates that the anus was situated in a ventral disk, which, if plated at all, can only have been but lightly so, as in the Ichthyocrinidæ. It is true we have no proof that there were any orals at all in the older specimens; but, judging from the relative sizes and development of the largest examples with oral plates, and the smallest without, we think it scarcely likely that they were entirely unrepresented in the adult. It is obvious that, if they were united to the radials by perisome, whether plated or bare, they would be readily lost under conditions that would have had no destructive effect on younger specimens, in which there was a closer union between the two rings of plates.

Lastly, we may say a few words about the ornament and size of the specimens. In the larger individuals, although visible, the pitted structure is not so decidedly apparent as in many of the smaller and younger ones. For instance take figs. 3 *a* and 10 *a* (Pl. XVI.), as compared with figs. 1 *a*, 2 *a*, and 2 *b* (Pl. XV.). In the former it absolutely amounts to ornamentation.

The diameter of the full-grown calyx varies from about 3 millims. to 5 millims.

3. *On the Relations of the Species.*

Three or four years ago, when our acquaintance with *Allagecrinus* was in a much less advanced state than at present, specimens were forwarded to Prof. L. G. de Koninck of Liége, for his opinion as to their identity. He very kindly referred one of the present writers to the description and figure of the *Poteriocrinus isacobus*, T. and T. Austin *, as coming nearest in general appearance to the specimens in question. The identity of our little Scotch fossils with this

* Mon. Recent and Foss. Crinoidea, p. 74, t. 8. f. 4, *a* & *b*.

species not being so clear as could be desired, Major Austin, F.G.S., was communicated with for further details of *P. isacobus* than are contained in the description given by himself and his son. Major Austin very kindly replied that his specimens had unfortunately been mislaid. We are therefore unable to institute a close and detailed comparison between *P. isacobus* and our *Allagecrinus*. We propose to call the latter *A. Austinii*, Ether. & Carp., as a slight tribute of respect to Major Austin in connexion with his work on the Carboniferous Crinoidea.

According to Messrs. Austin, "the dorso-central and perisomic plates (of *P. isacobus*) appear to agree in number with the typical species" of *Poteriocrinus*. If this be the case, *P. isacobus* is not in the least related to *Allagecrinus*. But in the figure of it given by the Messrs. Austin there is no indication whatever of the presence of two rows of plates below the radials*. We believe the plates which are represented as forming the greater part of the calyx to be the radials, and the ring upon which they rest to consist of five closely united basals, as in our specimens. Above these radials the Messrs. Austin's figure is incomplete: but one portion of it appears to represent the end of a short first brachial which has been displaced; and upon this there seems to have been an elongated axillary brachial, each face of which bore a similarly elongated axillary that supported two arms. Hence there were probably twenty arms.

Mr. Percy Sladen has proposed to establish a new genus, *Dactylocrinus*†, for the fossils described by Miller and the Messrs. Austin respectively under the name *Poteriocrinus tenuis*. He takes that figured by Messrs. Austin as the type of his new genus, and calls it *D. loreus*; while the *Poteriocrinus tenuis*, Miller, becomes the *Dactylocrinus tenuis* of Sladen, who thus continues:—"The *P. isacobus* of Messrs. Austin seems identical with the present species. In any case it is very much nearer than the fossil figured by them as *P. tenuis*." We regret that we are unable to accept this view of

* The "first series of perisomic plates" of Messrs. Austin are those which one of us has proposed to call "under-basals." This name has been adopted by Messrs. Wachsmuth and Springer and by Prof. Zittel. The "second series of perisomic plates" are the "parabasals" or "subradials" of the old nomenclature, and the "basals" of the more rational modern one. The dorso-central plate described in *Poteriocrinus* by Messrs. Austin is not recognized by other authors as occurring in this genus at all.

† "On the genus *Poteriocrinus* and Allied Forms," Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire, 1877, pp. 245–247.

Mr. Sladen's. Whether the *P. tenuis*, Austin, is identical with *P. tenuis*, Miller, does not concern us now; but underbasals are represented in the type-figures of both authors; while in the Messrs. Austin's figure of *P. isacobus* there is no trace of these plates, and the statement as to their presence is a very guarded one. For the same reason we cannot follow Messrs. Wachsmuth and Springer* in referring *P. isacobus*, Austin, to the sectional group *Scaphiocrinus*, Hall. We believe its calyx to be a simple one, consisting of a monocyclic base supporting five large radials, just as in our own fossil (*Allagecrinus*); and we are disposed to regard the two types as congeneric, but as specifically distinct from one another. In *A. Austinii* some (1 to 4) of the radials may be axillary, bearing arms directly without the intervention of any second or third radials. These arms may have divided (but there is no evidence of their having done so) before the fourth joint above the radials. In *A. isacobus*, on the other hand, there seem to have been but five primary arms, which forked on the third and then again on the fourth joints above the radials. Without a personal examination of the Messrs. Austin's original specimen we are naturally unable to say much about it; but we venture to think we are correct in referring it to a type which is much more closely allied to *Allagecrinus* than to *Poteriocrinus*, *Dactylocrinus*, or *Scaphiocrinus*.

4. *Position of* Allagecrinus *with respect to other Families of Crinoidea.*

If we are right in believing that the various forms figured in Pls. XV. and XVI. are merely different stages in the development of one singularly protean species, *Allagecrinus* must be regarded as a type of singular interest; for although it is a Palæozoic Crinoid, the most advanced individuals are entirely devoid of those characters which are supposed to be specially distinctive of the Tessellata. According to Müller's definition of the "Crinoidea articulata," *Allagecrinus* is as much an articulate Crinoid as *Pentacrinus*. On the other hand, the younger specimens are truly "tessellate," and they retain the peculiarities which are supposed to be eminently characteristic of the Tessellata until they are considerably larger and more strongly built than the largest *Comatula*-larvæ in the "tessellate" stage.

Were we dealing with these specimens only, *Allagecrinus*

* Revision of the Palæocrinoidea, part i. p. 113, extracted from the 'Proceedings of the Philadelphia Academy of Natural Sciences,' Nov. 4, 1879.

would find its place without difficulty in the family of the Haplocrinidæ, the special character of which is the presence of a dome of oral plates. But we can find no family, either in the Tessellate or in the Articulate division of the excellent classification of Prof. Zittel*, to which we can refer the larger specimens of *Allagecrinus*. We therefore propose to institute for its reception the family Allagecrinidæ, with a definition essentially the same as that already given for the genus. The inequality of size of the radials, owing to some of them being axillary, is a character which sharply distinguishes *Allagecrinus* from the Encrinidæ, Apiocrinidæ, and Pentacrinidæ, and, in fact, from all the "Articulata," to which division of the Müllerian classification it clearly belongs. It is, however, one of the Palæozoic Crinoids, and, like most members of that group, retains several embryonic features. Hence it adds one more to the many proofs which we have already of the unsatisfactory nature of Müller's definitions of the Articulata and Tessellata.

5. *Locality and Horizon.*

Allagecrinus Austinii appears to be dispersed generally throughout the shales and some of the limestones of the Scotch Carboniferous system. We are acquainted with its distribution in the east of Scotland much better than in the west. The following may be taken as typical localities:—

No. 16 Mine, Addiewell, near Bathgate, in the decomposed No. 1 main, or Hurlet Limestone; Howood, near Johnston, in shale above the Hurlet Limestone; Catcraig Shore, near Dunbar, and Burlage Quarry, near Dunbar, in shale above the Skateraw Limestone; Carlops Quarry, near Carlops, in shale above the Carlops Limestone; Roscobie, near Dunfermline, in shale above the limestone developed there. The foregoing horizons are all in the Lower Carboniferous Limestone group.

6. *On the Divisions of the Crinoidea. Articulata and Tessellata; Palæocrinoidea and Stomatocrinoidea; Regularia and Irregularia.*

Although Müller's terms Articulata and Tessellata are practically meaningless as regards the Crinoids, they have nevertheless come to be looked upon as representing two very distinct sections of the order, viz. the Mesozoic, Tertiary, and Recent types on the one hand, and the Palæozoic types on the other. We think, however, that the time has come

* Handb. d. Paläontol. Bd. i. pp. 342–346.

when they may be fitly replaced by other names which are less misleading in their character.

According to Müller's original definition *, the articulate Crinoids are those in which the radii are free down to the base of the calyx. They do not meet laterally; but the intervals between them are filled by perisome continuous with that of the ventral surface of the disk, and either bare or plated. Lütken has pointed out † that, according to this definition, the Mesozoic *Apiocrinus* and *Guettardicrinus* cannot be included among the Articulata. In the former the second and third radials are united with their fellows all round the calyx by interradial plates, while in the latter the rays are united as far as the second arm-joints, either directly or by interradial plates. The same is the case in many recent *Comatulæ*. On the other hand the rays of the Palæozoic *Taxocrinus* were just as free as those of *Pentacrinus*; and this genus entirely corresponds to Müller's definition of the Articulata. The same may be said of other so-called "tessellate Palæocrinoids."

An attempt has also been made to separate the Mesozoic Articulata from the Palæozoic Tessellata on the ground that the successive radial plates of the latter are only suturally united, while in the former group they articulate upon one another. Here again, however, *Guettardicrinus* and *Apiocrinus* are tessellate though not Palæozoic Crinoids. Further, in many of the Palæocrinoids the distal faces of the first or second radials are true articular surfaces in which the fossæ for the insertion of muscles and ligaments are much more distinctly marked than in the corresponding joints of many Apiocrinidæ, or even of recent Pentacrinidæ.

In spite of Lütken's well-grounded attack upon the Müllerian classification, it has recently been entirely adopted by Prof. Zittel ‡ on the ground that it "liefert vortrefflich abgegrentzte natürliche Gruppen." We cannot understand, however, how *Cyathocrinus*, *Poteriocrinus*, *Platycrinus*, and *Myrtillocrinus* can find places in a group a leading characteristic of which is that the plates of the calyx are "unbeweglich durch einfache Nähte verbunden." It is obvious from the context that vertical and not horizontal union is meant. The latter occurs in all Crinoids as far as the first radials,

* "Ueber den Bau des *Pentacrinus caput-Medusæ*," Abhandl. d. Berlin. Akad. 1843, p. 25 (of separate copy).

† "Om Vestindiens Pentacriner med nogle Bemaerkninger om Pentacriner og Sölilier i Almindelighed," Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjöbenhavn, 1864, no. 13–16, pp. 220 *seq.*

‡ *Op. cit.* pp. 342 and 345.

and a good deal further in many types; while sutural union in a vertical direction is not exclusively confined to the Palæozoic Crinoids, though it is certainly more common among them than among the younger forms. But at the same time there were several genera (and those by no means the least common) in which the second radials were not only free from their fellows, but articulated to the first radials, in precisely the same manner as the corresponding joints of a *Pentacrinus* or *Comatula*.

Other genera, however, are characterized by a peculiarity which is only met with among the Palæocrinoidea, viz. the absence of any distinct articular surface on the distal faces of the first radials, which are not perforated by canals for the axial cords of the rays. The presence of these canals is mentioned by Zittel among the characters of the Mesozoic and younger Crinoids; but their absence is not distinctive of the Palæocrinoids, as they exist in *Platycrinus* and in all the forms with true articular facets on the first radials.

There are several Palæozoic types, however, in which the second radials were in contact with the first by semicircular or horseshoe-shaped surfaces, with or without notches for the reception of the axial cords at the bottom of the concavity. This, though a permanent condition in some Palæocrinoids, is a transitory one in the young *Comatula*, and, as seen above, in the young *Allagecrinus*; and as none of the Neocrinoidea (if we may so call them), with the doubtful exception of *Comaster*, Goldfuss *, retains this peculiarity when mature, it is, as far as it goes, a good general character for separating the younger from the older Crinoids.

Another and a better distinction between them is one on which considerable stress has been recently laid by Messrs. Wachsmuth and Springer †, who believe that the mouth was internal in most Palæozoic Crinoids, if not in all of them; while it is external and suprategminal in the recent forms, for which they propose the general term Stomatocrinoidea.

That the mouth was internal in the Actinocrinidæ we have, of course, not the smallest doubt; but we would point out that the "vault" of this family, closing in the mouth and all the covered ambulacra of the body, is a very different structure from the six "apical dome-plates" of the Cyathocrinidæ and Ichthyocrinidæ, which merely close the peristome and leave the plated ambulacra as much external as those of any

* Linnean Society's Journal, Zoology, vol. xiii. pp. 454–456.

† *Op. cit.* pp. 6, 30. See also "Notes on the Internal and External Structure of Palæozoic Crinoids," by Charles Wachsmuth ('American Journal of Science and Arts,' 1877, vol. xiv. pp. 117–127 and 181–190).

recent Crinoid. We see no reason to believe that the plates bordering these ambulacra were not movable during life, like the similar ones on the ambulacra of the arms, so that the food-grooves were completely open to the exterior. In fact Wachsmuth * admits that "this might possibly have been the case in *Cyathocrinus iowensis*; but I even doubt it here, as the corresponding plates in other closely-related species, though arranged upon the same fundamental plan, present rather an aspect of true vault-pieces." Whatever may have been the case in the Cyathocrinidæ, we believe that the ventral disk of the Ichthyocrinidæ, which was composed of "a more or less soft or scaly integument yielding to motion in the body and arms," was essentially like that of a recent Crinoid with movable plates bordering the ambulacra and an irregular pavement in the interradial areas. We cannot therefore regard *all* the Palæocrinoids as having been without external food-grooves, as is supposed by Wachsmuth and Springer; and we think it also quite possible that the apical dome-plates of the Cyathocrinidæ and Ichthyocrinidæ were movable during life, so that the mouth was open to the exterior. Hence we do not attach quite so much importance to these two characters as do Wachsmuth and Springer. But we regard the *presence* of the apical dome-plates or of a true vault, and not the condition of the mouth and food-grooves, as an important distinction between the older and the younger Crinoids. It is certainly a more constant one than the absence of axial canals in the radials, though not altogether universal.

Probably the most constant difference between the Palæozoic and the younger Crinoids is one to which we do not think attention has yet been drawn. In almost all the Mesozoic and recent Crinoids the calyx is perfectly regular and symmetrical all round †. There are five equal and similar basals, upon which rest five equal and similar radials; and each of these is in close lateral union with its immediate neighbours without the intervention of any interradial pieces at all ‡. Should there be any interradials in the calyx, as between adjacent second or third radials, they are not limited to any special side of the calyx, but are equally distributed all round it, as in *Guettardicrinus* and *Apiocrinus*. Lastly, if the rays divide, it is always the third radial that is the axillary joint.

* Palæozoic Crinoids, p. 184.

† The distortion of the calyx in the Eugeniacrinidæ may be left out of consideration for the present.

‡ The partial freedom of the first radials from one another in *Bathycrinus* and *Pentacrinus subangularis* does not affect the question under discussion, owing to the absence of interradials in these genera.

Now in the Palæozoic Crinoids the symmetry of the calyx is always disturbed by the presence of an anal or azygos side. This may be indicated simply by the presence of an anal opening, which notches one of the oral plates, as in *Phimocrinus*, *Haplocrinus*, &c., or by the presence of a single anal plate, as in *Belemnocrinus*, which in other respects has such a close resemblance to the recent *Rhizocrinus*, or more commonly by the fact that one of the basals and two of the radials differ from their fellows in size and shape so as to give room for the system of anal plates which separates two of the rays, or in some similar manner.

Even in cases where the radials are closely united all round and the general contour of the calyx is perfectly regular, a want of symmetry is indicated by the inequality in the numbers of basal and radial plates. This is the case, for example, in *Eucalyptocrinus*, which has five radials but only four basals.

Lastly, in those Palæozoic Crinoids which have divided rays the position of the axillary joint is by no means so fixed as in the younger types. The rays may fork on the first radial, as in *Allagecrinus*; or the axillary may be as many as six joints beyond it, as in *Poteriocrinus radiatus*, or in any intermediate position.

Taking all the above facts into consideration, we are inclined to think that the Palæocrinoids do constitute a group that is distinguished from the more modern types by an assemblage of very definite characters, perhaps the most constant of which is the distinction between the perfectly symmetrical calyx of the Mesozoic and recent forms, and the more or less irregular one of the Palæocrinoids. We suggest therefore that the two groups should be distinguished as the Palæocrinoidea (Wachsmuth) and Neocrinoidea (nob.), or as Irregularia and Regularia. The old terms Articulata and Tessellata are meaningless, as we have shown above, while the name "Stomatocrinoidea," proposed by Wachsmuth, is long and cumbersome; and we are by no means sure that some of the Palæocrinoids did not have an external oral opening.

Whatever name be adopted for the Palæozoic Crinoids, they are of the highest interest morphologically, owing to their presenting so many embryonic characters. These may be briefly summarized as follows:—

1. The great development of the orals, which sometimes form a closed pyramid.

2. The frequent presence of a more or less perfect vault

(in the absence of a closed oral pyramid), which covers in either the whole of the ventral side or only the peristome.

3. The want of symmetry, indicated by the presence between two rays of one or more special "anal plates."

4. The great development of the calyx as compared with that of the arms.

5. The frequent absence of a distinct articulation between the first and second radials, and of axial canals within the joints of the rays and arms.

EXPLANATION OF THE PLATES.

Plate XV.

Adult specimens.

Fig. 1. Nine-armed calyx with two brachials. Carlops Quarry, near Peebles. *a*, side view, showing the small radial, which bears one arm only; *b*, view of the calyx from above, showing the articular faces of the radials.

Fig. 2. Calyx and lower brachials of another nine-armed example, the most complete yet found. Carlops Quarry. *a* and *b*, side views, the former showing the single one-armed radial plate; *c*, ventral aspect of the same specimen, showing the second and third brachials or arm-joints of three arms.

Fig. 3. Projection of the calyx and lower brachials of the original of fig. 2.

Fig. 4. The basal cup as seen from above; the sutures are quite obliterated. Carlops Quarry.

Fig. 5. Terminal face of a stem-joint, showing rim-like margin, small canal, and central granulation. Carlops Quarry.

Fig. 6. Calyx with only three axillary radials and one of the first brachials still preserved. Carlops Quarry. *a*, ventral aspect of the calyx; *b*, side view, showing the two adjacent simple radials and one first brachial.

Intermediate specimen.

Fig. 7. Calyx and upper stem-joints of an irregular example, with small orals and unequally-developed radials. Near Carluke. *a*, from the side; *b*, from above; the radial on the right bears a very rudimentary brachial.

N.B.—The figures represent the specimens as magnified nine times.

Plate XVI.

Young specimens.

Fig. 1. Calyx of a very young individual, with unequally-developed radials and depressed oral pyramid. Catcraig, near Dunbar. × 25. *a*, from the side; *b*, from above.

Fig. 2. Calyx of another very young specimen, with a large dome of oral plates and very small arm-openings. Whitebaulks, near Linlithgow. × 25. *a*, from the side; *b*, from above.

Fig. 3. Calyx of a somewhat older example, with a depressed oral pyramid; three of the radials have distinct arm-facets. No. 16 Mine, Addiewell. × 25. *a*, from the side; *b*, from above.

Fig. 4. Calyx of a more advanced individual, with a higher and deeply-grooved oral pyramid and more marked arm-facets. Catcraig, near Dunbar. × 23.

Fig. 5. Calyx of a similar specimen, with equally developed radials and a single oral tubercle; the five grooves separating the orals are well shown. Burlage Quarry, near Dunbar. × 23.

Fig. 6. Calyx of a similar example, in which the centre of the oral pyramid has been broken away, leaving a rounded hiatus; portions of the grooves again visible.

Fig. 7. Calyx of a larger specimen, with a low deeply-grooved oral pyramid and large arm-openings. Catcraig, near Dunbar. × 24. *a*, from the side; *b*, from above.

Fig. 8. Three views of the calyx of a still more advanced individual, with unequally developed radials and a relatively small oral pyramid. Burlage Quarry, near Dunbar. × 26. *a*, from the side, showing a small radial; *b*, from the side, showing the large axillary radial; *c*, from above, showing the reduced condition of the orals.

Fig. 9. Calyx of a specimen in which three radials have distinct articular facets, whilst another has no facet, even of the simplest kind, and there is only an imperfect one on the fifth. Howood, near Johnstone. × 24. *a*, from the side; *b*, from above.

Fig. 10. Calyx of a much pitted specimen, with a small and low oral pyramid and well-marked articular facets on all the radials. Carlops Quarry, near Carlops. × 25. *a*, from the side; *b*, from above.

XXVIII.—*Description of a new Longicorn Beetle from Java.*

By W. L. Distant.

This fine Coleopteron was represented by a single example only in an entomological collection made by my friend Baron A. von Hügel in the neighbourhood of Kederi, Java. Mr. C. O. Waterhouse of the British Museum, to whom I exhibited it, and who kindly took some trouble with me in ascertaining it be an undescribed form, is desirous of figuring the same in his illustrated work, 'Aid to the Identification of Insects,' and has requested me to describe it forthwith.

Pachyteria Hügeli, n. sp.

Glabrate; cyaneous; head, first to seventh joints of antennæ, a little less than basal half of elytra, and legs ochraceous; four apical joints of antennæ dull black; eyes cyaneous and glabrate. Lateral margins of body beneath faintly clothed with greyish pubescence.

The head has a distinct, central, longitudinal incision on the