ON CRINOIDS AND BLASTOIDS.*

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The term *Crinoidea* was first used by Mr. J. S. Miller, a naturalized German resident in Bristol. In the year 1821 he published a work entitled 'A Natural History of the Crinoidea,' in which he introduced the name to designate certain animals resembling lilies in their general shape (*κρίνον*, a lily). The recent species upon which his studies were largely based was the well-known form which he called *Pentacrinus Caput-Medusæ* (= *Isis asteria*, L.), a creature found in deep water in the West Indies, which, both at that time and for long afterwards, was extremely rare. Our knowledge of the soft parts of the Crinoids has been vastly extended since Miller's time, owing to the large number of forms brought to light in recent years by deep-sea exploration. Miller's researches were also directed to various fossil forms, and he established several of the best known genera among the Palæozoic Crinoids, *e.g.*, *Actinocrinus*, *Cyathocrinus*, and *Platycrinus*. These, and others of Miller's genera, have since been more precisely defined, and his names, as he understood them, represent the "families" of modern palæontology.

In Miller's day the Crinoids, like the Sea-Urchins, were regarded as forming a zoological "family;" but this term then bore a higher meaning than it conveys at the present time. The Crinoids are now said to form a "class," belonging to the sub-kingdom of the *Echinodermata*. This group is one of the great sub-divisions of the animal kingdom, and also includes the sea-urchins, star-fishes, brittle-stars, and holothurians, with various extinct stalked forms more or less closely resembling the Crinoids.

As far back as the year 1848 Leuckart proposed the term *Pelmatozoa* (*πέλμα*, a stalk) for those Echinoderms which are fixed, either permanently or temporarily, by means of a stalk. The term, after having fallen into disuse, has been recently revived as a convenient designation for a primary group of Echinoderms. As it includes all the stalked types, it embraces not only the Crinoids,

* The substance of an address (illustrated by several photographs shown by the Sciopticon) from notes taken by F. W. Rudler, Esq., F.G.S., and revised by the lecturer.

but also the extinct Cystids and Blastoids. These groups, formerly regarded as families, and later on as "orders," now rank as "classes" in systematic zoology.

All the recent Pelmatozoa are fixed, either during the early part of their life or throughout the whole of it, to submerged objects, such as rock or seaweed, by means of a flexible stem, the back of the animal being directed downwards and the mouth upwards, so that it occupies an inverse position to that of the ordinary star-fishes. Crinoids, therefore, have no need of sucking feet, like those of star-fishes and sea-urchins; but although the water-vascular system of a Crinoid thus takes no part in effecting locomotion, its tentacles serve the same purposes of respiration as the sucking feet do in the other Echinoderms.

The Feather-stars at a certain period of development detach themselves from their fixed stem, and become free swimmers. When requiring to settle again the creature anchors itself, mouth upwards, by means of *cirri*, or clawed hooks, developed on the top stem-joint, which is retained in the body, and not discarded with the rest of the stem.

The Rosy Feather-star (*Comatula* [*Antedon*] *rosacea*) is abundant at Plymouth, Torquay, and generally round our southern and western coasts, as far north as the Clyde, but it is not common on the east coast of England. It is found again, however, on the east of Scotland. It occurs on the Atlantic coasts of France and Spain, throughout the Mediterranean, and perhaps, also, at the Canary Islands, and even as far south as the Equator.

In certain recent Feather-stars (*Actinometra*) the mouth is not in the centre of the disc, and may be placed even at its very margin. These forms, which have the mouth excentric in position, go back in time as far as the Lias, but it is notable that, so far as we yet know, all Palæozoic Crinoids have the mouth central.

Radiating over the disc from the mouth of a Crinoid are five grooves, known as the *ambulacral grooves*, and each corresponding to one of the five ambulacral areas in the test of an urchin, or to the median groove on the under side of the arm of a star-fish. The ambulacral grooves in the feather-stars fork one or more times, according to the number of arms, and give off branches to the pinnules at the sides of the latter. They are lined with cilia, which create a current of water setting along each groove in the direction of the mouth; so that minute organisms floating in the

water near the animal are swept by the currents down the grooves to the mouth, and thus serve as food. Indeed, the stomach of a feather-star is often a complete museum of microscopic organisms. When the mouth of a Crinoid is excentric, or near the margin of the disc, many of the hinder arms may be altogether destitute of ambulacral grooves and also of tentacles.

The stalked larva of a feather-star so closely resembles a *Pentacrinus* that it is known as a *Pentacrinoid*. It was discovered many years ago by Mr. J. V. Thompson that at a certain period of development the "head" of the young feather-star becomes detached from the stem; and Edward Forbes actually witnessed the separation. On the assumption that the *Pentacrinoid* larva was a mature form, it was originally described as a distinct species under the name of *Pentacrinus europæus*. The structure and development of the British *Comatula* were studied in great detail by the late Sir Wyville Thomson and Dr. W. B. Carpenter, and their results were published in the 'Philosophical Transactions' for 1865 and 1866.

The young feather-star leaves the egg as a free swimming larva, somewhat barrel-shaped and surrounded by four bands of cilia. It then gradually becomes club-shaped, and a skeletal system of calcareous plates is developed. The ciliated bands disappear, and the creature attaches itself to some solid support; the head becomes five-lobed, tentacles appear, and then the arms and cirri, until the *Pentacrinoid* larva finally passes into its fully developed condition.

The development of the skeletal plates deserves some consideration. A series of delicate calcareous rings, representing the stem-joints, appears very early; and the stem terminates distally in a small limestone plate, supporting the flattened disc by means of which the larva attaches itself. Around the alimentary canal appear ten plates in two rows; the lower circle of five plates which rest on the top stem-joint being called the *basals*, and the upper ring the *oral* plates of the calyx. These basal and oral plates come to be separated by skin, in which, alternating with them in position, are afterwards developed the five *radial* plates. These radials are of great morphological importance, as they represent the ocular plates of an Urchin, while its genital plates correspond to the basals of the Crinoid. A second series of radials appears above the first, and a third above the second. The oral plates are eventually carried away from the rest of the

skeleton, and stand up as five triangular valves around the mouth, every two of them being separated by an ambulacral groove, which extends on to the growing arm.

The stem of a *Pentacrinus* is composed of a number of more or less pentagonal joints, some of which bear whorls of *cirri*, like those on the top stem-joint of *Comatula*, and are, therefore, known as *nodal joints*, while the others are distinguished as *internodal joints*. The inferior surface of each nodal-joint is attached to the top joint of the internode below (*infra-nodal*) by that mode of union which is known as a *syzygy*. This term was introduced by Johannes Müller, to indicate an immovable sutural union between the arm-joints, but was also applied by Sir Wyville Thomson to a similar union between two stem-joints. The stem of *Pentacrinus* is more readily broken across at a syzygial union than at any other part. If a living *Pentacrinus* happens, when swimming, to catch its stem in any object, it can easily snap it off at a syzygy, and anchor itself by means of the cirri on the lowest remaining nodal joint. Fossil stems of the *Pentacrinidæ* are often found in fragments, naturally severed along the lines of the syzygies; and one end, or both, of each fragment then exhibits the smooth syzygial face.

At the summit of the stem of *Pentacrinus* are five basal plates (b),* which are interradian in position, and rest on the angles of the upper stem-joints. In some species they form a closed ring at the base of the calyx; but in a few Crinoids, as in most *Comatulæ*, no basals are visible on the exterior of the calyx. In some of the Palæozoic Crinoids (*e.g.*, *Cyathocrinus*), and in a few Mesozoic species (*e.g.*, *Encrinus*), the basals are separated from the uppermost stem-joint by a ring of radially situated plates, the *under-basals* (u). Above, and alternating with, the five basals of *Pentacrinus*, are five radials, forming a closed ring. These, which are the primary or first radials (r^1), are succeeded in turn by a row of second radials (r^2), and these by the third, or axillary radials (ra). Each of the latter bears two arms, which may either remain single or divide more or less frequently. In the latter case the joints up to, and including, the next axillary (da) are termed *distichals*. The distichals are thus the joints of the primary arms, which may divide and subdivide until the total number of arms becomes very considerable. For purposes of description the joints of the secondary arms are conveniently distinguished as *palmars*, while the joints above the last axillary are the *brachials*.

* See the diagram on p. 27.

The genus *Pentacrinus* was established by Miller, who recognized five species. Of these the only recent species was the West Indian *P. Caput-Medusæ*, originally described by Linnæus as *Isis asteria*. Of late years the old specific name has been revived in place of Lamarck's *Caput-Medusæ*, and hence the species is now properly known as *Pentacrinus asterius*.

Some interesting new species of *Pentacrinus* have been obtained by recent deep-sea exploration. The name *Pentacrinus Wyville-Thomsoni* was given by the late Dr. Gwyn Jeffreys to a Crinoid first obtained by the "Porcupine" in 1870, at a depth of 1,095 fathoms off the coast of Portugal, and since dredged at a smaller depth by a French expedition. In this species, short, stout cirri occur at regular and rather long intervals along the stem, which, in many cases, was in a semi-free condition, having been broken at a syzygy in the manner already described.

An elegant species, dredged by the "Challenger," at a depth of 350 fathoms, off Pernambuco, on the coast of South America, is represented at present by only a single specimen. It was named by Sir Wyville Thomson *Pentacrinus maclearanus*, and is of interest to geologists, inasmuch as it presents certain characters recalling the Liassic *Extracrinus briareus*. The stem is pentagonal, with rounded angles; the nodal joints are closely approximated; each ray generally bears six arms, and the cirri have a slight downward curvature.

Miller was acquainted with two Liassic species of *Pentacrinus*, namely, *P. briareus* and *P. subangularis*. These forms were transferred by Messrs. Austin to their genus *Extracrinus*. In *E. briareus* the stem is not especially long, but in *E. subangularis* it may exceed 50 or even 70 feet in length. *E. briareus* has the nodal joints closely approximated, and is provided with a great number of subsidiary arms, or armolets, branching off from the inner sides of the principal arm-trunks. Enormous colonies of *Extracrinus* must have flourished on the floors of the Liassic seas; but although most numerous in the Lower Lias, its remains are also found in Britain in the Great Oolite, Forest Marble, and Cornbrash.

The *Apiocrinidæ*, or Pear Encrinites, are characterized by the absence of cirrus-whorls on the stem. There may be a few radiicular cirri, but there is no division of the stem-joints into nodal and internodal. The summit of the column expands, and there are five large basal plates at the bottom of the calyx. In most

members of the group the number of arms is ten, as in the well-known Pear Encrinite of the Bradford Clay (*Apiocrinus Parkinsoni*), but this number may sometimes be exceeded.

The *Apiocrinidæ* of the Oolitic seas are represented in the Chalk by the *Bourgueticrinidæ*, a group comprising smaller and apparently degenerate types. The genus *Bourgueticrinus* seems to be confined to Cretaceous rocks;* for the stem-joints from Eocene deposits, which have been referred to this genus, are in all likelihood those of the still more degenerate *Rhizocrinus*, which is found in various parts of the Atlantic, and is the modern representative of the Secondary *Bourgueticrinidæ* and *Apiocrinidæ*. The genus *Rhizocrinus* was established by the late Michael Sars, in 1864, for the reception of a new Crinoid dredged off the Lofoten Islands by Prof. G. O. Sars. Special interest attaches to this Crinoid, since it may be regarded as representing the starting point of recent British deep-sea exploration, inasmuch as it was mainly due to the interest of Sars's discovery that the late Dr. W. B. Carpenter and Sir Wyville Thomson were led to take action in the matter, and to secure official aid for the cruises of the "Lightning" (1868) and the "Porcupine" (1869-70), which ultimately led to the expedition of the "Challenger." In *Rhizocrinus*, and in the allied genus *Bathocrinus*, the joints of the stem are of dice-box shape; and there may be a number of radicular cirri, branching irregularly from its base. The calyx of *Rhizocrinus* is composed of five long basals and five radials, which bear single arms. The arm-joints are united in pairs by syzygies, and the pinnules are limited to the upper or "epizygal" joint of each pair.†

The deepest dredging (2,435 fathoms) of the "Porcupine" in the Bay of Biscay in 1869 yielded a small Crinoid, to which Sir Wyville Thomson gave the name of *Bathocrinus*. The work of the "Challenger" brought to light larger specimens of new species of the same genus, all obtained from deep water. *Bathocrinus* stands close to *Rhizocrinus* in its structural relations, but has smaller basals, and ten arms instead of five only; but it has not yet been discovered in the fossil state.

The remarkable genus *Holopus* was first described by D'Orbigny as far back as 1837. His specimen, obtained from Martinique,

* *Bourgueticrinus ooliticus*, McCoy, may perhaps be a *Thiolliericrinus*.

† The lower or "hypozygal" joint (h) of a syzygial pair never bears a pinnule.

was for a long time unique, and was notable for having only four rays instead of five, as in most Crinoids. Sir Rawson Rawson, when Governor of Barbadoes, obtained some specimens which were normally pentamerous; and other examples of the type have since been dredged in the Caribbean Sea. The basals and radials are fused together into a tubular calyx, which is fixed to the sea-bottom by an expanded base. There are ten massive arms closely curled inwards over the disc, which is chiefly occupied by five large oral plates. *Holopus* shows affinities with many ancient types. It is clearly related to the fossil form from the Faxoe Chalk, described by Steenstrup in 1847 as *Cyathidium*. Close relationship may also be traced with the Liassic genus *Cotylecrinus*, and with the Palæozoic *Edriocrinus*, described by James Hall, from the Upper Silurian rocks of New York, all these genera being sessile, and unprovided with a stem.

Marsupites, the well-known "Tortoise Encrinite" of the Chalk, is a curious type of apparently sessile Crinoid, with large under-basals. In *Agassizocrinus*, an American Palæozoic Crinoid, we possibly have the forerunner of *Marsupites*. It was probably a free form, like *Comatula*, with its under-basals anchylosed into a solid piece, closing the bottom of the cup.

Fossil *Comatulæ* occur in the Jurassic, Cretaceous, and Tertiary formations. The genera *Antedon* and *Actinometra* are found in the Lias of France, but are not known in this country from rocks older than the Inferior Oolite. In *Antedon* the mouth is central; in *Actinometra*, excentric, as already described.

The genus *Woodocrinus*, named after the late Edward Wood, of Richmond, in Yorkshire, is characteristic of the Carboniferous Limestone of Richmond. In this genus the basals are separated from the stem by a ring of under-basals (u), which were called basals by Johannes Müller; while he gave the name "parabasals" to the true basals (b) which lie immediately beneath, and alternate with the radials, and were termed "sub-radials" by de Koninck. *Woodocrinus* has about twenty rather massive arms, and the lower part of the stem tapers towards the base; so that this Crinoid would seem to have been partially or entirely free, and not fixed, as is usually the case.

The *Blastoidea* constitute a peculiar group of stalked but armless Echinoderms which were separated from the brachiate forms, or *Crinoidea* proper, in 1825, by Thomas Say, of Philadelphia; but

the foundation of all our exact knowledge of the group was laid by Ferdinand Roemer some years later.

The calyx of a Blastoid contains only three basals, which are followed by a cycle of five radials. These are more or less deeply notched for the reception of the ambulacra, and support five inter-radials,* which reach up to the mouth, and are sometimes known from their shape as *deltoid* plates. Radiating outwards from the mouth, which is at the centre of the summit, are five linear or petaloid zones, forming the ambulacra; and it is the symmetrical appearance of these petaloid areas that gives to the typical Blastoid (*Pentremites*) its bud-like form, and consequently the name of the class (*βλαστός*, a bud). The Blastoids were destitute of arms, and probably also of ambulacral tentacles, while but little is known about the stem, though it seems to have been generally similar to that of a Crinoid.

The group of Blastoids is exclusively Palæozoic, ranging from the Upper Silurian to the Carboniferous. The earliest known forms occur in the Niagara group of North America, the equivalent of our Wenlock Limestone. In Britain they make their first appearance, very scantily, in the Middle Devonian rocks. They are more abundant in our Carboniferous Limestone, no fewer than ten genera being known. *Pentremites*, the typical genus of Blastoids, does not occur in Britain, for most of the British forms hitherto referred to this genus are now placed in the genera *Granatocrinus* and *Mesoblastus*—the former having been established by Troost in 1849; the latter quite recently by Etheridge and Carpenter.

The oldest known form of the Pelmatozoa in Britain, and probably even in the world, is *Protocystites menevensis*, described by Dr. Hicks, from the Menevian Beds of St. Davids. Then there is the obscure form, known as *Dendrocrinus cambrensis*, from the Lower Tremadoc at St. Davids; and at a somewhat higher horizon occurs *Macrocystella Mariae*, described by Dr. Callaway, from the Shineton shales (Tremadoc) of Shropshire. As our knowledge stands at present, these are the three most ancient forms of Pelmatozoa from the rocks of Britain. The oldest American Pelmatozoa are some obscure forms in the St. John's Group and Potsdam Sandstone, which represent the Lingula Flags and Tremadoc Slates of Britain.

* In many Crinoids, especially the palæozoic ones, there are interrarial plates (I) in the calyx, which sometimes rest on the first radials, but sometimes on the basals, as shown in the diagram.

DIAGRAM SHOWING THE VARIOUS PARTS IN THE CALYX AND ARMS
OF A CRINOID.

A, B, C, D, E, the five rays.

u. Under-basals, with the impression of the top stem-joint.

b. Basals.

$r^1, r^2, \dots$ ra. First, second, . . . and axillary radials.

$d^1, d^2, \dots$ da. First, second, . . . and axillary distichals.

$p^1, p^2, \dots$ pa. First, second, . . . and axillary palmars.

$b^1, b^2, \dots$ &c. First, second, . . . brachials.

I. Primary interradials.

i. Higher interradials.

An. Primary anal plate.

- a. Higher anal plates.
- id. Interdistichals.
- p. Pinnule.
- s. Syzygy. h, hypozygal. e, epizygal.
- b.a. Biserial arm.
- u.a. Uniserial arm.

The figures 1, 2, 3, are placed in the angle of each pair of primary, secondary, and tertiary arms, respectively.

The Basals and First Radials correspond to the Genital and Ocular Plates of an Urchin. All the plates which are above the First Radials, and lie in the direction of the rays, are in reality arm-joints; but the various series between the successive axillaries are called radial, distichal, palmar, &c., for convenience in description. They are sometimes spoken of as the various orders of radials.