

the ambulacral, and like them set distinct from each other, which gives the surface of the test a nodulated air; a slight furrow passes down the centre of the interambulacral areæ, dividing them into two parts; the rows of tubercles diminish in number at the apex and base of the areæ, they are larger and more fully developed, however, in the latter region; the apical disc is small, ring-formed, and prominent; the poriferous avenues are deep and strongly defined, the pores are arranged in simple pairs above, but they form double ranges which fill up the wide space at the basis of the areæ; the base is concave, the mouth is large and pentagonal like the former species, the notches are closely approximated at the bases of the interambulacra, and the marginal arch over the ambulacra is straight and wide; the tubercles disposed at the bases of both areæ are larger and more fully developed than those occupying the sides.

*Affinities and differences.*—The size of the tubercles and their diminished numbers when compared with *A. Forbesii* serve as a sufficient diagnosis whereby *A. nodulosa* may be distinguished from the former Urchin; the slight median furrow down the centre of the interambulacral areæ is very different from the deep line separating the areæ in *A. Forbesii* into two equal nearly conical lobes.

*Locality and stratigraphical range.*—This species was collected by my friend the Rev. P. B. Brodie from the bed of clay resting on the Stonesfield slate at Sevenhampton Common, along with *Acrosalenia spinosa* and *Pecten varians*; this bed occupies the same relative position in other parts of Gloucestershire, and is probably the basal clay band on which the shelly freestone beds of the Great Oolite rest. I only know the solitary specimen before me; in Germany, Count Münster found it in the Jurakalk of Baireuth.

*History.*—First figured and described as an *Echinus* by Goldfuss. I am not aware of its having been noticed before as a British fossil.

My thanks are especially due to Mr. W. H. Baily for the pains he has taken with the beautiful figures which accompany this paper, the original specimens of which are in my cabinet.

XXII.—*Observations on the Connexion between the Crinoideæ and the Echinodermata generally.* By THOMAS AUSTIN, F.G.S., Fort Major, &c.

IN offering these observations and generalizations relative to the Crinoideæ, it is but an act of justice to acknowledge how deeply we are indebted to the laborious researches of those who have preceded us in this branch of inquiry. Among the writers on the Crinoideæ who have thrown considerable light on this im-



portant group of animals, the late Mr. J. S. Miller is entitled to a prominent place; and although the correctness of many of his inductions may be fairly doubted, we must nevertheless be sensible of his great assiduity, deep research, and persevering industry in raising the Crinoideæ from a miscellaneous state of confusion to a position of arrangement and order, which has caused them to be better understood and appreciated.

Subsequently, however, to Miller's investigation, so numerous have been the discoveries, that out of three or four hundred species of fossil Crinoids now known to science, he was only acquainted with twenty-four. The number of genera since established greatly outnumbers even the species discovered up to the period at which he wrote. Not only have new discoveries been made as regards numbers, but more perfect specimens have been obtained, so as to enable the naturalist to draw inductions and prove analogies between them and existing groups of animals, and thus in a manner compel him to re-arrange the whole tribe, to use a new nomenclature, and, in short, to raise it to a parallel position with the class to which it belongs, and which the advanced state of knowledge imperatively demands.

As we advance in our acquaintance with this very interesting class of animals, we are soon struck with the manner in which this remarkable tribe demonstrate the changes of organic life on our earth and the mutations it has undergone, and also the various physical changes that have taken place; the distribution of fossil zoological remains proving that these repeated changes in animal life have been in perfect accordance with the altered physical conditions of the planet.

The discoveries I have been fortunate enough to make of many new species, and nearly perfect in form, has thrown considerable light on the subject. Mr. Fletcher and Mr. Gray, of Dudley, have done good service to science in collecting many fine specimens of Crinoideæ, while the extensive addition of new forms made by Dr. Troost, of Tennessee, and other American geologists, reflects honour on their country. Dr. Troost has added between one and two hundred new genera and species, all of which he obtained from the American rocks. As far as my own observation yet extends, the species are without exception unknown to the rocks of Europe. Sir Charles Lyell found that the American marine shells agree with the European to the extent of 35 per cent. This is the more remarkable, as of the American fossil Crinoids which have come under my notice, consisting of upwards of twenty species, together with six new *Pentremites* and the allied *Olivanites*, and for which I am mostly indebted to the liberality of Dr. Yandell, I cannot recognise a single individual as being exactly identical with any European species.



One or two detached pieces, it is true, appear to belong to well-known European species, but till more perfect specimens are obtained the identification cannot be complete.

Dr. Troost claims to have added two hundred new forms to the long catalogue of these fossils already known. After making considerable allowance for the zeal of a first discoverer in bestowing a name on every fossil new to him, by deducting a fair percentage from the gross amount, a very considerable number of new genera and species (probably all the latter) still remain to make Dr. Troost's discoveries of great value and interest to science in various ways, not the least of which is that of enabling us to compare the forms inhabiting the seas of our own latitude in remote epochs with those which existed three thousand miles distant in the West. On making this comparison we find that each portion of the globe had in those earlier periods its own peculiar animals, each equally distinct and strongly marked in character as at the present day. Few genera and species being common to such distant localities as Europe and America, yet when we take a casual view of the fossils found on the two continents, we are instantly impressed with the idea of their general resemblance to each other; but when we come to examine them more closely, the resemblance is no longer maintained. Genera that at first appear identical with long known forms, prove perfectly distinct, and species which seem to a casual observer as one and the same, under the eye of the scientific inquirer are found to be wholly dissimilar in the arrangement of the calcareous framework. Thus the *Agaricocrinus* of America closely approaches our *Amphoracrinus*, but it is in reality intermediate between that genus and *Actinocrinus*, and so on of many others.

Many distinguished naturalists have published detailed descriptions of various Crinoids; among these may be mentioned M. d'Orbigny, Count Munster, and M. Römer. The researches of these and other observers have greatly enlarged the limits of fossil zoology by increasing our acquaintance with those ancient and extinct genera and species of Crinoideæ which supply many important links which were before wanting to complete the chain in the scale of organic life, from the period when the world was first inhabited to the present time. In this manner as our information increases we find a perfect and unbroken succession of organic beings gradually developed in accordance with the physical changes that have taken place on the earth; changes so manifest, that the stratified rocks may be distinguished from each other not only by mechanical structure, mineral condition, chemical composition, arrangement and position, but above all by their fossil contents.

The manner in which these fossil bodies or organic remains



are distributed through the strata greatly aids the geologist in his inquiries. They enable him to identify at distant points rocks which may perhaps present different appearances of mineral composition and whose geological position is but obscurely indicated, but which, when the imbedded fossils are carefully examined, prove them to be of contemporaneous age; for we know by experience that certain genera and species of animal remains occur in regular and beautiful sequence in the different groups of rocks, and that in many cases certain species are peculiar to a single formation, by which it can be distinguished even amidst the greatest confusion; that is, when the original arrangement of the strata has been so disturbed as to reverse the order of their superposition, or their complications by faults so great that every relation to distant masses is rendered obscure and doubtful.

In the Crinoideæ, Mollusca, and other remains of ancient and by-gone periods, we find so many beacon-lights, or directing points, that, by an accurate knowledge of genera and species, we can arrive at results and conclusions, that under other circumstances we could never hope for, and but for such knowledge could never be attained. With a view of contributing to this desirable end, we have undertaken the task of describing the Crinoideæ in a monograph, not only because their remains are found so abundantly in the older formations, but also on account of the many new forms which have been discovered, and which have thrown so much additional light on a subject formerly so obscure and complicated.

Since those early periods in the earth's history when the Crinoideæ existed in countless myriads, they have gradually diminished in numbers during subsequent ages, until only a few species are found amongst the living creation; and these, with the exception of one, the *Pentacrinus Caput Medusæ*, are so unlike ancient forms, that few persons, except the scientific, would identify them as allied to this once abounding tribe.

To the geologist, the zoologist, and those who desire information, the fossil genera present a wide field for inquiry and contemplation:—their symmetry of form, and the beautiful arrangement seen in the elaborate contrivance by which hundreds of thousands of separate indurated pieces are so placed that each piece is so nicely fitted to the adjacent pieces, that a skeleton seemingly so complicated in its mechanism becomes obviously, as we study the uses of the various parts, as simple in action as it is delicately articulated and geometrically constructed.

In the *Extracrinus Briareus* I have counted upwards of 741,710 joints or separate pieces, exclusive of the small plates which stud the membrane that covers the inside of each ray, and which



if taken into the calculation would swell the number to upwards of a million. And if we consider the number of muscles requisite to put this million of parts in motion, we are lost in admiration at the apparent complexity, but in reality simplicity of structure in the indurated skeleton of this animal.

For the better comprehension of this important and interesting group of animals it is desirable to enter into some detail respecting the whole tribe of Echinoderms, a term applied by Bruguière to those animals whose skin is generally furnished with calcareous spines. Accordingly the Star-fishes or *Asteriadae* are first noticed. These animals are enveloped in a coriaceous integument studded in various degrees with granules of calcareous matter. They present different modifications of form, and according to that form depend in a great degree the characters which have enabled naturalists to divide them into various genera and species.

The genus *Goniaster* may be described as an animal of a pentangular form; on the inferior surface and on a line with the angles run five furrows or depressions, on the margins of which are numerous foramina, through which protrude the tubuliform tentacula, which are furnished with cup-like appendages. These may be considered as the feet, as they are the only locomotive organs possessed by animals of this genus.

The true *Asterias* are known by their simple flattened rays, which are generally five in number, but some species have as many as ten or twelve. All these have the mouth placed beneath, around which are several perforated plates; these perforations are known to be the ovarial passages. There are other openings which probably aid in the purposes of respiration, as well as in the water circulation, as they lead to the canals known as the aquiferous system. The term 'oviducal plates' has been applied to the pieces through which the ovarial apertures pass.

Next, the *Ophiura* may be known by a small orbicular disc-like body, from which emanate five circular attenuated rays. These are in many instances furnished with spines which aid them in locomotion.

The *Euryale*, or *Gorgonocephalus* of Leach, bears some resemblance to the *Ophiura*; but in place of the five simple rays, each of its rays branches off into so many subdivisions, that 512 have been counted as given off by each ray, which multiplied by 5, the number of the parent rays, gives 2560 lesser subdivisions or filaments capable of forming a net for the capture of food, and also by its undulatory motion of producing progression through the water. By means of these filaments the *Euryale* can attach itself to extraneous bodies, such as *Gorgoniæ*, and thus moor itself in order to repose, or as a protection against the violence of an agitated sea.



Before passing from the *Stelleridæ*, it will be well to bear in mind that among their essential characters that of being free locomotive animals must not be lost sight of; also, that their natural position is with the mouth downwards; that the cavity containing the digestive organs is a pouch-like sac giving off cæca, the refuse of their food in all the *Ophiuridæ*, and in many true Star-fishes, being rejected by the mouth; likewise, that they possess distinct, well-defined oviducts, and are supposed by many naturalists to possess the power of self-impregnation.

In connecting the Star-fishes with the Crinoideæ it will be well to notice two genera, one now extinct, and the other an inhabitant of the seas of our own times. These in a very decided manner unite the more ancient Crinoids with the recent Echinoderms.

First the *Marsupite*, whose body, that is, the dorsal portion of it, is covered by sixteen pentagonal plates. Fifteen of these plates are arranged in three tiers or series of five each; the upper row, being the ray-bearing plates, has in each piece a horseshoe-shaped concavity in its centre for the insertion of the rays, while the lower series rest on the dorso-central pentagonal plate.

The *Marsupite* has only been discovered in a fossil state in the chalk beds of Sussex, and has no doubt been long extinct; and consequently although it furnishes us with but few indications of its habits and mode of life, yet it directs our attention to a genus which is found in a living state in our own seas, and which may be considered as the representative of the extinct *Marsupite*, namely the *Comatula*, which at once leads us back again to the Crinoids.

The *Comatula* in its mature state is an unattached animal having a depressed orbicular body covered with calcareous plates which inclose the digestive organs. The mouth is central and somewhat protrusive, and is surrounded by tentaculated jointed rays or arms. On the dorsal side of the body below the rays are several claspers terminating in a hooked point. These bear a striking analogy to the auxiliary side-arms so common to many species of true Crinoids.

The *Comatula* possesses both an oral and anal opening. In its early state it is attached to extraneous substances by a flexible column, and when first discovered was described as the *Pentacrinus Europæus*.

When examining these two genera, we see in a very remarkable manner the connection between the free swimming and the permanently attached *Asteriadæ*, or between the Star-fishes and the Crinoids.

So perfect are all the arrangements in the organized world, and so complete the gradations from genera to genera and species to species, that in studying any one class of animals we



find that no connecting link is wanting in the chain which seems to run through animated nature from an early period of time to the present day. Thus again the Lansdown Encrinite, discovered some years since by Mr. Baretti, of Bath, in the Oolite at Lansdown, is another connecting link between the fixed and free Echinoderms. This Crinoid has heretofore been placed in the genus *Apiocrinus*, but the impropriety of arranging a free locomotive animal in the same genus with those which were permanently attached by a massive base, and from which it so essentially differs, is too apparent to require a moment's hesitation in elevating it into a new genus, for which the name of *Gnathocrinus* has been proposed.

The column of this fossil consists of a series of annular pieces, more or less numerous in different individuals; each joint gradually decreases in size as it recedes from the body, until the terminal joint ends in a small obtuse point without the slightest indication of root, or other appendage for permanent attachment. It would seem from this, that the animal possessed the power of free locomotion, and it may also be inferred that by twining its tapering column round extraneous objects, such as coral branches, sea weed, &c., it could moor itself securely to watch for its prey, or in order to remain at rest.

The genus *Apiocrinus* affords considerable insight into the anatomy of the whole tribe. In this genus, I have examined specimens ranging from the embryonic monad to the mature and perfect animal, which at its first dawn of existence seems to have borne some resemblance to a minute *Actinea* encased in a calcareous integument. In the fossilized embryonic roots and stems the form of the parent Crinoid had not yet become fully developed, therefore proving that these animals were oviparous, since from the smallness of these rudimentary specimens, it is evident they were in their earliest state of existence mere monads, and yet are found attached, not to the parent's body, but to a plate that had been separated from its original place, and had lain for some time exposed at the bottom of the sea. Whereas the offspring produced by gemmiferous generation never become detached from the body of the parent until they have attained a considerable size and more perfect form.

Some well-preserved specimens show the oviducts in different stages of advancement towards ejecting the ova. In others we see, through the displacement of the pieces, the internal opening for the passage of the oviduct, and in others the oviducts appear as if turgid with ova. These specimens prove that the animals possessed ovaries with five ducts as in *Echini*.

If we make a horizontal section of an *Actinocrinus* where the rays divide the body into the dorsal and ventral parts, the figure



approaches that of a *Goniaster*; and if the ovarian pores in *Actinocrinus* are situated at the base of the rays, as is generally believed, then the resemblance becomes more complete; the difference in this respect being that in *Goniaster* the ovarian pores are marginal and situated between the rays, and in *Actinocrinus* at the points from whence the rays emanate. The *Actinocrinus* section also closely resembles in outline an impregnated *Apio-crinus*, making the connecting links still more perfect.

In the American *Agaricocrinus* of Dr. Troost, the ovarian ducts are clearly seen at the base of the rays. This newly discovered genus, forming as it does a connecting link between the genera *Actinocrinus* and *Amphoracrinus*, again shows the gradations by analogy that exist between the different genera in the whole group.

Passing from the Encrinites proper, another very singular extinct family presents itself to our notice, of which we have no exact type in the living creation, namely the *Blastoidea*, established by Say. This family contains but one genus, named *Pentremites*. The genus may be defined thus:—Perisomic plates so united and fitted to each other as to completely inclose the digestive organs and generative system; the mouth and ovarian pores placed on and around the apex; branchiæ arranged in five ambulacral rows; column cylindrical, perforated in the centre and composed of numerous articulating joints; arms none.

This remarkable genus bears so little affinity to any other yet discovered, excepting Dr. Troost's recent discovery of the *Olivanites*, to which it is allied, that it cannot with propriety be referred to any natural family hitherto instituted, for to those which most nearly approach it, it is but remotely and obscurely allied. Its columnar attachment seems to connect it with the true Crinoids, but the absence of projecting rays altogether excludes it from that group; while the body in which are situated the ambulacral cilia, circularly placed openings and the central generally angulated one, proves its affinity to the *Echinidæ*, but the columnar support and attachment prove that it cannot be properly grouped with them.

Considerable analogy also exists between some species of *Pentremites*, the *P. inflatus* and *P. pentangularis* for example, and the Star-fishes. Likewise, if the internal sac of a small *Goniaster* be filled or inflated to turgidity, the body assumes a conoid form, and then the general resemblance becomes strikingly obvious, while the ovarian apertures bear considerable analogy to each other. The *Pentremites astraformis* even more nearly approaches the *Goniaster Templetoni* (Thompson) than the *P. inflatus* or *P. pentangularis*. It also presents on its ventral surface some characters common to both *Asterias* and *Ophiura*. The



genital openings however differ in position. Those of the *Pentremites* encircle the mouth, whilst those of the former are marginal; yet here we have links which connect the *Pentremites* with *Asterias* and *Ophiura*.

By investigating the family of *Pentremites* we are led progressively, as before indicated, to the *Echinidæ*, when, taking *Cidaris* for the type, we find the skeleton formed of five tumid or blunt rays, each composed of a double series of hexagonal plates, these rays being separated by a similar number of ambulacra, sinuous and perforated by minute foramina or ambulacral pores. The ambulacra radiating from the mouth, which is beneath, and taking an upward course, terminate near the apex, which is composed of five plates, each of which has a central opening or ovarian aperture. These pieces united may be considered as the dorso-central plate, in the centre of which the vent is situated.

From this genus we pass by natural gradations to others; but we may pause for an instant to remark on the resemblance which exists between the genus *Conulus* and some species of *Pentremites*, in which the ovarian openings exhibit considerable similitude to each other.

As previously observed, in *Cidaris* and *Echinus* the mouth is found beneath, and the anal opening above or opposite; but in *Spatangus* and other allied forms the anal pore occupies a lateral position, and as we extend our observations we find it, by gradual modifications in different genera or species, becoming more remote from the dorsal plane, and consequently by degrees approaching the oral aperture. Thus in *Chlypeaster* its position is in the extreme margin, in *Echinoneus* it is seen on the same plane as the mouth, and finally its approximation becomes so close, that at length in some instances it is merged in the oral opening as in *Echinocyamus*, thus returning through various and beautiful modifications of form and structure to the starting-point, or until it becomes typical with the Star-fishes.

If a common Star-fish of five rays or lobes be examined, we find it to have a well-defined ambulacrum on the inner surface, sunk as it were in a deep furrow, which diverges from the central disc in the direction of the rays. Numerous foramina and small spines will also be observed. By flattening out the rays, the perforated ambulacra will be found ranged along the sides; and if we bring up the points of the Star-fish to meet in a centre above, a spherical body is at once produced closely resembling an *Echinus*, the now curved ambulacra meeting and forming the double lines as seen most clearly in *Cidaris*; and further, if the extreme points of the star are turned inwards, an apophysis is formed capable of supporting the muscles which in *Echinus* move and sustain the maxillary process or jaws.



Again, if we take an *Echinus* and separate the plates down the middle of the interambulacral spaces and fold them back so as to meet above, and then turn down the separated bands, we have a complete Star-fish with the ambulacra and mouth beneath as in the *Asteriadeæ* generally. Likewise, if an *Echinus* is placed with the mouth upwards, we find the central plate beneath the proper axis. This not inaptly represents the upper joint of the column to which it bears considerable analogy. The five oviducal plates may be considered as corresponding to the quinquepartite dorso-central plate of the *Apiocrinus*, in which are seen the openings of the oviducts. Above these pieces are the double range of hexagonal plates which indifferently represent the perisomic plates, rays, &c., of the Crinoid.

Having traced the gradual transition from the *Asteriadeæ* to the *Crinoideæ*, from the *Crinoideæ* to the *Blastoidea*, and from these again to the *Echinidae*, and these last into the Star-fishes, it now only remains to notice the *Cystideæ* or *Sphæronidae*, in which analogies and gradations may be traced connecting them with the *Pentremites* and *Crinoideæ*, as well as with the *Asteriadeæ* and *Echinidae*, in a similar manner to those links which I have endeavoured to indicate in the preceding observations as existing between the different groups of Echinoderms, but which will however form the subject of further investigation.

The *Cystideæ* is an order of radiated animals which has long been known to naturalists, but until recently no attempt was made to place them in a position which their geological and zoological importance seemed to demand. Mr. Gray of the British Museum was the first, I believe, to see the necessity of establishing a family for the grouping together of those ancient forms of Radiata which closely resemble true Crinoids, but which are devoid of arms, properly so called. With this view Mr. Gray appears to have proposed the name of *Sphæronidae* for the group. Subsequently Baron von Buch, in his essay "Ueber Cystideen," published at Berlin in 1845, grouped them together under the above title. But I reserve further observations on this portion of the subject to another opportunity, remarking however that Prof. E. Forbes, at p. 531, part 2. vol. ii. of the 'Geological Memoirs,' seems to doubt the occurrence of Cystideans in our Mountain Limestone, and asserts that the bodies I have described as such he has "inspected through the kindness of Mr. Morris, and they appear rather to belong to a group along with *Pentremites* rather than to true *Cystideæ*."

In reply to this observation I can only remark, that the specimens in my possession were not seen either by Prof. Forbes or Mr. Morris, and that I ventured to group them with the *Cystideæ* on the authority of Von Buch himself, who founded the family, as



the following extract from the translation of his paper on the *Cystidea*\* will prove:—

“Mr. Austin states that *Sycocrinites* exhibits three dorso-central plates,” &c. (see *Annals of Nat. Hist.* vol. xi. p. 206). “This is manifestly the description of a *Cryptocrinite* (so named in 1840); but this author does not state the locality of his specimen,” &c.

I will only add, that *Cryptocrinus* is a genus arranged with Von Buch’s family of *Cystidea*, and that it does not appear to belong to a group along with *Pentremites*.

August 9th, 1851.

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XXIII.—*Descriptions of two new species of Nudibranchiate Mollusca, one of them forming the type of a new Genus.* By JOSHUA ALDER and ALBANY HANCOCK. *With the Anatomy of the Genus,* by ALBANY HANCOCK.

[With two Plates.]

THE Nudibranchiate Mollusks, which we have now the pleasure of introducing for the first time to the notice of naturalists, we owe to the persevering researches of our friend Mr. W. P. Cocks of Falmouth, by whom they have been communicated to us, with kind permission to publish descriptions of them. The first species we shall notice we refer to the *Thecacera* of Fleming, a genus at present so imperfectly understood that any addition to our knowledge of its characters may be considered as furnishing a desideratum in this family of the Mollusca. We propose to characterize it as follows:—

*Thecacera virescens.* Body rather convex, smooth, of a light peach-blossom tint, blotched with green anteriorly and posteriorly. Head with a plain subvelar margin in front. Tentacles broadly laminated, the laminated portion green, the lower or smooth portion of the same colour as the body; they are retractile within moderately-sized sheaths with smooth margins. Branchial plumes five, green, margined with white. A single row of obsolete tubercles encircles the branchial region. Foot of a dull yellowish white. Length  $\frac{5}{10}$ ths of an inch.

This beautiful little animal differs in several respects from the *Doris pennigera* of Montagu, which is the type of the genus *Thecacera*, and might by some naturalists be thought entitled to rank as a new genus; we prefer, however, to consider it an ab-

\* A translation of this paper appeared in the *Journal of the Geological Society*, Feb. 1st, 1846.





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