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## XXV.—On the Chitonidæ. By WILLIAM CLARK, Esq.

*To the Editors of the Annals of Natural History.*

GENTLEMEN,

Norfolk Crescent, Bath, Feb. 1, 1853.

BEFORE I enter on matters, I beg to state, that a more extended experience of the Mollusca has compelled me to relieve myself, in part, of the assistance of conchological attributes, as I have found them singularly defective and fallacious in reference to the existing constitutions of divisions, families and genera; in support of this view, I refer to many proofs in the various papers of mine that have appeared in the 'Annals.' I therefore, as regards the past, and henceforth, shall only consider the shell coverings of the Mollusca as good and useful aids, in strict subservience to the malacology of the animal, and as specialties, consequential, and emanating from the vital organs; and that the meaning of whatever appellation may be attached to a division, family or genus, has with me no reference to the testaceology: for instance, speaking of the *Muricidæ*, or its synonym, the *Canalifera*, the shell is not in question, except as a corroborating incident, but the animalia canalifera, whose mantles form canals; and in like manner, in mentioning the *Holostomata*, the entire periphery of the aperture is not primarily intended, but, that the mantle lining it is entire.

The use of the word 'shell,' instead of 'animal,' in the construction of the subordinate divisions of a class, has doubtless arisen from the ignorance of naturalists of the inhabitants; but as this cause is in a great measure removed, it is time to abandon a system founded on fallacious bases, and have recourse to nature's imperishable land-marks.

In these observations, I do not mean to say that conchology is without its use: to palæontologists, collections of shells are the only resources to denote that their fossils present similarities to many existing forms; but how infinitely more valuable is an account of an existing animal, to inform them of the real character of the relics of former epochs! Beyond the restricted points, conchology is totally unworthy to be the succedaneum of the attributes of nature, and the true worshippers of the great book will rejoice at the decadence of a usurpation to its just limits.

The Chitons have long been a source of difference of opinion with naturalists, not only as to their position amongst the Mollusca, but it has been insisted on, that they are apocryphal members of that class. The greatest authorities are in collision: M. De Blainville considers that the motive power and other

apparatus of the circulation have a rectilinear dorsal arrangement, similar to that of the Annelida: Cuvier and Lamarck regard them as true Mollusca, ranging with the Patelloid group: Professor Forbes has doubts, and looks on the question as still within the limits of debateable ground, and terms the Chitons malacological "puzzles." Some observers contend, that the reproductive organs, unlike the asymmetrical ones of the Gasteropoda, exhibit a disposition of parities on a medial line, and like M. De Blainville refer them to the Annelida. Milne-Edwards demurs that they are Mollusca, and goes no further than to regard them as an aberrant tribe of Gasteropoda.

Having dissected many examples of three species, I think that my notes may assist zoologists in coming to sound conclusions with respect to natural position. As my investigations have induced a chain of reasoning which has convinced me that the Chitons are true Mollusca of the patelloid type, it may be as well at once to allude to that part of them which bears upon the objections that have just been stated.

Though doubts have lately sprung up as to the natural position of these curious animals, they have, until now, been placed by most authors in close connection with the Conchifera. If this is right, what then is there extraordinary and unusual in the disposition of the organs of the circulation? They have nearly the same dorsal rectilinear position as in the Acephala, from which they have long been considered, and I think it will be shown rightly, the point of transition to the Gasteropoda. Why not, therefore, contrast this peculiar arrangement which is the invariable consequence of the symmetry of the bivalve cone, with that which obtains in the Chitons from the same cause, and also in others of the Patelloid tribe that have the same position and a similar parity of their organs? I admit, that the strict *Patellæ*, though symmetrical in their testaceous cones, are exceptions with regard to the heart, auricle, and branchial plume: *Haliotis*, which with me is a patelloid animal, and also an exception, is the reverse, having the organs of the respiratory circulation symmetrical, but not the cone. These, and two or three other genera, may be regarded as the precursors of the Gasteropoda, and points of transition from the strict parities of the cone of the shell and organs of the Patelloida, to the asymmetrical division of the Gasteropoda.

The only differences, and they are not important, with respect to the position of the circulation in the bivalves and Chitons are, that in the latter the motive power is placed greatly more posteriorly than in the former; and the illustrious Cuvier has taught us to observe, that the auricles of the Chitons have a quadruple connection with the heart, of which he has seen no other example

in the animal kingdom : this is not stated in an objective sense, but as a curious fact, though he gives no reason for this aberration of the usual structure. Enough has now been said to demonstrate the little value of the much insisted on dorsal rectilinear position of the motive power of the circulation in *Chiton*, in comparison with the Annelida.

As to the objection to the allocation of these animals with the Mollusca on account of the symmetry of the reproductive organs, we think they are of small importance, even if double : and who can say that the symmetrical Patelloida have not in this respect a similar structure ? but these points are doubtful. M. Deshayes says, " Quoique nous ayons fait des anatomies minutieuses d'Os-cabrions, il nous a été impossible de trouver la seconde issue des organes de la génération ;" and M. Cuvier observes, they became so attenuated that he confessed he could not trace them. Our own researches lead to doubts of these appendages being oviducts ; at the same time we admit, they may prove to exercise those functions : they are situate in the immediate vicinity of the heart and auricles, and may be glands to secrete a liquor for those organs, or the fecundating pouches of the peculiar hermaphroditism of this tribe, in which latter case, the true issue for the ova will probably be found between the rectum and the posterior part of the ovarian sac.

It has been said that the body is subannulate : in a hundred dissections we could not see much trace of such configuration, or breaks in it to correspond with the segmental arrangement of the valves ; only slight marks, the effect of pressure, were observed. The connection of the Chitons with the Crustacea is, as I think, so very slight and remote as to require no further notice.

Having cursorily disposed of certain objections, we will proceed to state our own views, and in their course, allude to other objections and discrepancies. Though the Chitons are in closer alliance with the Bivalves, anatomically, by the arrangement of the circulatory apparatus, symmetry of the branchiæ, and in the absence of tentacula and eyes, than by the external hard parts, still in them there are points of coherence which are not without their value ; for instance, in *Pholas dactylus*, its immediate predecessor, in our method, though the bivalve portion is not broken into regular segments, there are certain testaceous pieces, commonly, though perhaps incorrectly, called accessories, in number six, including the principal valves. We also find in the Chitons a subsymmetrical division into eight segments of what I consider essentially an integral patelloid cone, and as much accessorial as those of *Pholas* ; indeed both in one and the other, these component parts are equally necessary and essential. I admit that no great stress ought to be laid on the contrasted

points ; nevertheless, in conjunction with other decided anatomical analogies, they have their weight in the balance. Our view of the natural position of *Chiton* is after *Dentalium*, with which it has marked affinities, and in immediate contact with the Patelloid group, in which we regard, in almost every respect, *Fissurella* as the point of comparison, as in it is seen the same form of the cone, though entire instead of broken, the same parity of the branchiæ, a similar posterior anal debouchure, and the attenuated mantle, gradually thickening, in both genera, to a tumid coriaceous margin, which in *Fissurella* can scarcely be withdrawn within the shell, studded alike in both with papillæ and rugosities, and the same marginal fringes. The nervous masses in the two accord closely : the only exception is the striking, but really unimportant, division of the cone of the Chitons into segments ; but this incident may be accounted for on very simple grounds. We consider the fracture of the shell not a character denoting an affinity with the Annelida, as the body of the animal has no corresponding articulations, but simply an aid to facilitate locomotion. The foot of the strict symmetrical testaceous Gasteropoda is generally nearly concurrent with the length of the body, and forms its base, from which, by a gradually increasing cone, the animal becomes at maturity fixed to the summit of the shell by a powerful muscle : this structure united to an entire cone, and combined, as in the Bivalves, with the depressing effects of a complete hermaphroditism, that of *Venus sine concubitu*, almost extinguishes the locomotive functions ; and we see throughout the patelloid tribe, all of which have a foot co-extensive with the body, an almost entire fixation to the same spot ; indeed we believe that some of the *Patellæ* pass their existence in the depressions of the rock on which they are cast as embryos, and the same apathy exists in *Puleopsis* and *Calyptræa*. But nature has judged fit to give the Chitons additional motive powers, for when fixed on the area of a smooth pebble, they will travel off it, whilst the *Patellæ* are immoveable : this is owing to the integrity of the cone, and the enormous muscle which fixes the animal to its apex : this structure does not permit the body sufficient flexibility for much progression, and almost confines it to a vertical elevation and depression ; but the Chitons, by the segmental condition of their shells, have accorded to them sufficient flexibility to obtain a vermicular motion, and its consequence, a greater facility of march. The Trachelipoda have infinitely superior attributes for motion, by the foot being fixed to a small portion of the body by an elastic cylindrical pedicle that affords a perfect pliability, and the acquisition of the necessary undulatory quality to effect a comparatively facile progression.

The above remarks perhaps furnish us with the proper value

of the arguments of malacologists in favour of the Chitons being, by the peculiar disposition of the testaceous covering, allied to the Articulata.

It is scarcely necessary to observe, that the usual single powerful muscle of attachment of the animal to the shell in the patelloid tribe, is in *Chiton*, from a necessity arising from the disunited structure of the cone, converted into a minuter series of coordinate muscles to attach it and each section of the shell in its proper position.

It will now be convenient to look at the anatomy of these animals, of which the most important feature are the medullary masses, and for an account of them we refer to the descriptive notes on *Chiton fascicularis*, in which will be seen the unmistakable œsophageal collar of the Mollusca, without a trace of the longitudinal knotted, or ganglionic cordon of the Annelida, or any of that division of the Articulata termed Crustacea, including the Cirripoda. This point alone is, perhaps, decisive of the question at issue. The next consideration are the organs of the circulation; these, by being disposed on a mesial line, dorsally, and more externally than in the strict Gasteropoda, have a greater alliance with the conchiferous type, and as they exhibit some unusual variations in their composition, it will be necessary to examine with detail the extraordinary, I believe unique, structure of these organs, and we hope to arrive at such probable conclusions as will account for the rationale of this abnormal disposition.

The posterior position of the motive power of the circulation will, I think, assist in solving this problem, and must always be kept in view.

If we divide the longitudinal area of the animal into eight equal sections, the heart will be found near the hinder extremity, and may be considered as composed of two inflations connected by an intermediate marked strangulation; but between them, there is an isochronal systole and diastole action; the anterior inflation is of an elongated oval shape, and the largest, the posterior, is considerably smaller and more subrotund. The auricles receiving blood from the branchial veins communicate in the usual lateral manner with the greater division of the heart, and at this point present their largest calibre; they then form an attenuated arcuation on each side the constricted portion, and effect a second contact at the sides of the lesser inflation, which may be regarded as an aortic ventricle receiving the blood by a special auricular apparatus. From the anterior axis of the major part of the heart, a long and large aorta or arterial vein ascends medially to the front, distributing by diverging arteries the aerated fluid to the greater portion of

the body, whilst the minor and posterior ventricle, after receiving from the arcuated ducts of the auricles its quota of blood, serves the remaining area; but I could not detect a descending arterial vein, which however must exist to convey the blood; unless one of the arteries of the ascending aorta doubles back and supplies the part. But this conjecture is scarcely tenable, as we must then suppose, that the blood conveyed by the arcuation of the auricles to the lower inflation is thrown back again on them and the larger ventricle, thus producing a useless periodic action and counter-action.

We will now endeavour to explain the probable causes and effects of this unusual construction. It has been shown that the principal ventricle of the heart is the propelling power of the blood to the major part of the body, and the smaller one by its separate auricular contact supplies the remainder; we also have observed on the connection of both parts of the heart by the strangulated and without doubt valvular intervening portion, so that no blood can pass between the two; and it is clear that none is intended to pass, as the auricles by distinct ducts supply each with its proportion of the vital fluid; consequently the mitral valves of the ventricles are closed at their axes abutting on the strangulation, at each simultaneous dilatation, and thus this constriction acts as a *point d'appui* and departure, and enables them to exercise a full power of propulsion.

We shall now perceive the reason for these separate inflations. If one only had existed, with an ascending and descending aortic vein of similar calibre, as much blood would be sent to a very small area as to one seven times more extensive, and so great an inconvenience would have resulted, that nature has created this peculiar mode to effect a just distribution. I hope I have almost proved that this anomalous structure is a consequence of the posterior position of the heart.

I have extended these remarks somewhat beyond what is necessary, but I am anxious to show that this curious contrivance to effect a particular object has nothing in it essentially contrary to the molluscan type; in other respects, as in it, the circulation is aortic, venous, and particular, the blood being brought from the body by the *venæ cavæ* to the great arterial vein of the respiratory organ, from whence it is distributed to its minor arteries, and after aëration reverts by the branchial vein to the auricles and heart, to repeat, as long as life lasts, the same course; consequently it is completely molluscan, and appears more advanced in composition than that of the Annelida, by the presence of a much more effective motive power of the heart and auricles, which in the Articulata are comparatively obsolete, or mere continuous fluctuating cylinders or inflations. A short œsophagus



conducts to the stomach, which is an irregular subcylindrical cavity about double the diameter of the pyloric extremity; it traverses the body, forming a sudden curvature like the doubling of a horse-shoe, and returns across the body with the posterior portion parallel to the anterior one, commencing at the pyloric orifice a very long intestine of five or six transverse or oblique folds, supported by the liver, and dissemboguing as rectum, at the centre of the posterior extremity between the branchiæ.

For further particulars we refer to the description of the type, as well as for the liver, ovary, and foot, all which present no essential variation from the molluscan type, except the double oviduct, if such be the case.

The Chitons are best illustrated by the patelloid section of the class, from which they are inseparable, but there is scarcely a group of Mollusca to which they are not allied. The posterior termination of the rectum is not without example; it is essentially the same in *Fissurella*, and more or less so in many of the *Bullidæ* and *Pleurobranchidæ*. M. Deshayes observes, that the want of eyes and tentacula has been adduced as denoting affinity with the Annelida; but, as we have already observed, why not compare these deficiencies with the Conchifera, their immediate predecessors? And as regards the Gasteropoda, the absence of eyes and tentacula is not unusual: for instance, *Bulla cylindracea* has not a trace of these organs; the *Velutina otis* of authors, Mr. Gray's *Otina*, has no tentacula; some of the *Bullidæ* are without eyes, and others without tentacula; there are examples of the *Naticæ* without eyes, and in the *Dentalia* both eyes and tentacula are absent. *Dentalium*, in my method, is placed in the van of the Gasteropoda, and *Chiton* follows; both are closely allied, and, we think, appropriately succeed the Conchifera.

I do not say that with the latter, the characters of alliance are very decided; still on examination there will be found analogies: for instance, in *Chiton* and *Dentalium* the branchiæ are placed symmetrically, though varying in particular position. In *Chiton*, though not in *Dentalium*, the anus has the same posterior site as in the Conchifera and in some of the patelloid forms. The strict sexual order of hermaphroditism appears to obtain in both, and throughout the Patelloida to the Pleurobranchidæ and Bullidæ, in which a more influential plan of reproduction commences. These notes, in conjunction with the special typical ones, only call for a very brief summary, and we think a calm review of all the circumstances that are adduced will go far to convince zoologists that there is not a *locus standi* for any one organ in *Chiton* contrary to molluscan-essential characters;—all are confirmatory of the *Chitonidæ* belonging to that class, and the only return we can make *per contra* is—*nil*.

It has been suggested by Professor Forbes in the 'British Mollusca,' vol. ii. p. 390, that an examination of the foetal metamorphoses of the Chitons would throw light on their natural position; I propose, if practicable, to carry out this idea, though the attempt will be attended with difficulties and uncertainties, which need not now be alluded to.

We are not sure that much will be gained by the investigation; it may possibly give us an idea of the affinities of remoter lineages with the present conditions of a particular genus or species; but we think the arrival of the animal, after its embryonic phases, at an adult state, will not only give a knowledge of what it is not, but of what it actually is, and more will be gained by a comparative view of the mature organs with those of its allies.

We apply these remarks to the present case, and think that the cesophageal nervous collar, the buccal mass, the long spinous tongue, the system of the circulation, and the true Gasteropodan foot, will inform us that such an animal cannot be either one of the Annelida or Cruripoda, or belong to any other group of the Articulata, and we believe that the comparative examination of the above-mentioned organs with those of the Conchifera and Patelloida will irresistibly lead us to acknowledge their true molluscan composition.

#### CHITONIDÆ.

The British Chitons are a group of about ten species; we have given notes of three, selecting the *C. fascicularis* as the type. They inhabit all the zones according to their respective special habits. As regards British geographical distribution, they appear to arrive at larger growth in the northern latitudes.

*Chiton*, Linnæus.

*C. fascicularis*, Linnæus et Auct.

Animal forming an elongated oval, the body being convex on the upper surface, and enveloped in a mantle, thin above, but gradually resolving into a thick, strong, broad, granular margin, clothed with a rigid setose white fringe, and on each side is furnished with eight packets of yellowish white bristles, 12-15 in each, and two of the same number at the anterior end; above these are imbedded, in the margin and longitudinal area of the animal, eight transverse, convex, saddle-shaped, beaked, imbricated, strongly shagreened, dark gray testaceous plates, whereof the anterior one has five emarginations, the six behind in succession one on each side and two on the terminal margin of the eighth. The head is a membranous puckered frill, under which is the rugosely-rayed buccal disk with its round orifice in the

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centre: there are neither eyes nor tentacula: the buccal apparatus consists of two elliptical white, or pale yellow corneous plates, between which a rather long, black, strap-shaped tongue passes, armed with a double line of tubercles, the inner edges being tricuspid; at the base of the corneous plates is a nervous collar of five minute subrotund yellow ganglions; these are followed by the œsophagus, which leads into a complicated stomach doubled on itself, and is continued as an intestine of four or five folds supported by the liver, which from their complexity can scarcely be described, as they lie in a space of little more than  $\frac{1}{8}$ th of an inch; the last fold passes into a moderately long rectum that discharges in the centre of the branchial cordon; the convolutions can be easily drawn out, and with the stomach, œsophageal canal and rectum produce an extent of nearly two inches in moderate-sized examples. The pale yellow, minutely granular, sinuated ovarium is immediately under the mantle, nearly coextensive with the length of the body, and under it are the stomach and other organs, including the large liver of many granular dusky greenish brown lobes. The foot is suboval, very little angular in front, slightly tapering to an obtuse termination. The under part of the mantle is of a red-brown colour. Between the foot and mantle is the branchial cordon, composed of fifteen oblique cord-like, short, close-set, pale brown fillets, on each side the body, commencing at the right and left of the immediate posterior extremity, leaving between the series only room for the depuratory duct; the cordon does not quite extend half the length of the body; the fillets gradually diminish in volume from the posterior end, and at the antecal termination are not more than half the length or size of the hindmost ones. There are no traces of male reproductive organs; and of the other sex, we only meet with the doubtful oviducts, and a conspicuous well-filled ovarium in the genial epoch; it may therefore be inferred that these animals depend on their own individual generative influences, on which we shall perhaps, at a future time, make some observations in a paper on the *Patellæ*; indeed the present matter would be incomplete without introducing that group, now omitted, to bring this communication within reasonable limits.

*Chiton asellus*, Chernnitz.

*Chiton cinereus*, Auct.

The anatomy of this species is nearly the same as the preceding, which we have considered the type of the genus, and as the external organs do not vary greatly, I shall only mention the deviations; the principal, and I believe the only one of the least consequence, is, that there are only ten branchial fillets, on each

side the body, which do not nearly occupy half the extent of its circumference. The inner surface of the mantle in different individuals exhibits the various hues of flesh-colour: the foot is a dull muddy purple. The margin of the mantle is powdered with minute, granular, dark, sand-like points, and fringed with very short, fine, close-set, pale yellow filaments. This species, at Exmouth, is rarely met with in the littoral or laminarian districts; its habitat is within the coralline limits, and it is scarce.

*Chiton cinereus*, Linnæus.

*Chiton marginatus*, Auctorum.

The same remarks apply to this as to the preceding species, from which the only decided variation is the greater number of branchial leaflets, being seventeen on each side, of a dull flesh-colour, and occupying considerably more than half the circumference of the mantle, which on its inner surface is also flesh-colour. A fine, setose, short, thick, pale rufous fringe clothes the margin of the mantle, which is minutely granulated, as if aspersed with dark sand-points. This very common species is strictly, at Exmouth, a littoral one, and rarely found beyond its limits.

The other British Chitons are—the *C. discrepans* of Brown, *C. Hanleyi*, *C. ruber*, *C. levis*, *C. cancellatus*, *C. albus*, *C. marmoreus*, which latter is the *C. lævigatus* of authors, and the ‘*latus*’ of the Rev. R. T. Lowe. The *C. discrepans* of Brown is not strictly one of our indigena, being confined to the Guernsey and Channel Islands: it is not improbable that this and the *C. fascicularis* are identical, and only exhibit the specialty-differences of locality.

I am, Gentlemen,

Your most obedient servant,

WILLIAM CLARK.

XXVI.—*Additional Character of the Shell of the Cyclostomatous genus Alycæus of Gray, with descriptions of its Animal Inhabitant,—of a fourth species,—and of other new Indian Cyclostomata; also, Remarks on an unrecorded Character in Diplomatina.* By W. H. BENSON, Esq.

THE existence of a sutural callus in a third species of Gray's genus *Alycæus*, described below as *A. Urnula*, induced a conjecture that the feature might be generic, and that it had been overlooked in the single remaining Cochin Chinese species *A. gibbus*, as well as in *A. strangulatus* and *constrictus*, the first