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XXXV.—*Malacological Notes.*
By ROBERT GARNER, F.L.S. &c.

It seems to be a task neither easy nor free from doubt, to assign a proper place in the Animal Kingdom to the Mollusca, or, when their proper place is found, to fix their boundaries as a subkingdom. It is evident that animals, both as they exist now and as they have succeeded each other in past geological time, are marked by different degrees of elaboration; and this leaves room for the doctrine of derivation from simpler primordial forms of the higher. This increasing differentiation in the animal kingdom is also tacitly kept in view in taxonomy; hence Mammalia are placed highest in the whole animal series, and Mollusca in the non-vertebrate division of it.

But the above greater or less elaboration, though a primary consideration in general classification, is not by any means the sole one. Were it so, and were we assured that one of the higher forms is descended by an undeviating development from one of the simpler, we ought to have, tracing the former through the course of its formation, a summary of all organology, which we have not. Strong are the influences which the conditions of life (ethological as they are termed) exert on the course of development; or, in other words, great are the variations necessary to modify an organism for change of habitat, food, or climate, or for its protection. Along with the general plan and its greater or less elaboration upon which animals are formed, there are therefore revealed secondary types of formation, which, whether realities or abstractions,

Ann. & Mag. N. Hist. Ser. 4. Vol. xix.

25

must be imported into classification. Thus, in animals nearest the boundaries of the vegetable kingdom, the special character of life-force of the latter seems not extinct, causing a rayed or ramose disposition and a tendency to budding in their mode of increase; or we may say that animal life presupposes the vegetable, being itself but the manifestation of the same endowment in a higher form—just as, according to some, psychological phenomena are superadded to, or developed from, the physiological*. Again, amongst the disturbing influences which affect whole series of animals, the nature of their locomotion must be reckoned; for to an adaptation for this and for aerial or aquatic life can probably be referred many aberrations, such as metamorphosis or alternation of generations; and hence it is that a more regular ascent from the simple to the complicated animal ought to be seen when we confine ourselves to one form of life, say the aquatic.

The same aberrations render it difficult to trace the phylogeny of an animal—that is, to show from what antecedent form, extinct or existent, it originated, and through what phases its species passed. We see enough in nature to recognize, as already alluded to, one general plan of formation; and at the origin of all animals, or in the embryo stage, there is, as the rule, much sameness—and first either a division or a budding of a pullulating plasm, or an origin from the union of a simple cell and microzooid; but remarkable differentiations and variations occur early, almost withdrawn from our observation, and their *rationale* not always understood. It is true that a more or less intimate segmentation of the yolk of the ovum in all Invertebrata produces the *morula* form, preceding all development; but there is no complete uniformity further, and the variations remain unsystematized. The *morula* or granulated sphere may become hollow, and then be invaginated, so as to form a sacciform *gastrula*, so called; and Haeckel considered this to be the animal stock-form; but even in the cases where it prevails the *morula* may be first changed into a flat *planula*, and the sacciform disposition be attained, somewhat differently, by its flexure†. The cavity may also form in the interior, without any flexure or invagination, or with the latter imperfect; and in the normal *gastrula* it does not follow that the primary opening becomes the mouth, or the primary cavity or *blastocoele* the permanent stomach; and before any cavity

* Mr. Spencer teaches that the processes of morphological differentiation conform to the same general laws in the one kingdom as in the other ('Biology,' vol. ii.).

† Salensky, "On Haeckel's *Gastræa* Theory," Ann. & Mag. Nat. Hist., Jan. 1875.

forms at all, or contemporaneously, or closely following it, the molluscos shell, foot, and ciliated velum may appear, either in the above forms of development or in another, where upon the segmented *morula* a *germ-lamella* makes its appearance, in which the formative cleavage process is very active, so that the lamella grows quickly and surrounds the other residuary part of the yelk, which in some cases, as in *Sepia*, but not in the Argonaut, constitutes a large fund of sustenance for the young embryo*. As we have above observed, many of these and other modifications cannot, with our present knowledge, be reduced to a consistent system, nor can the succeeding stages always be so. Thus, for ourselves, an ascidian is manifestly allied to a bivalve mollusk, as much as the latter is to a gastropod, and we hold that morphology suffices to prove this; yet, on the other hand, very different are the early forms of the two, though in this case appropriate enough—one qualified for preliminary locomotion, the other, it may be, to immediately fix itself; indeed the former larva is so tadpole-like that it has been considered by Schmidt and others, as is well known, to foreshadow the vertebrate animal, though it is probably truly included in the molluscos community, its appendage comparable, it may be, to the tail of the *Carinaria*, to the *flagellum* of some bivalves, or even to the foot of the developed animal†. The *veligerous* stage, pretty general in, though not peculiar to, gastropods, seems a form well adapted for their dispersion, and indeed, in certain species, may perhaps be said to continue through life. Here the embryo is furnished with a ciliated disk or *velum*, and an external spiral shell is formed with an *operculum* attached to the foot, a shell even existing in the larva of the ultimately naked species; but in such naked species as have an internal shell (the Pulmonata having also other peculiar modifications in their development‡) it is intradermal. With respect to the Cephalopoda, Owen says, “were growth superinduced at any arrested stage of cephalopodic development, no known inferior order of mollusk would result.” With oneness of the animal plan in general, purpose is only accomplished by much variation and adaptation, as well as suppression or development of the homologous organs, even

* “Developmental History of Mollusca,” by Prof. E. Ray Lankester, Phil. Trans. vol. clxv. There is a clear and succinct account of the embryology of the Gastropod by M. A. Giard, Ann. & Mag. Nat. Hist., April 1876.

† Mr. Huxley compares the posterior prolongation of *Carinaria* to that of *Strombus*, considering it to represent the *metapodium*.

‡ These peculiarities are observable in the eggs of *Helix aspersa*, easily procurable, or better in the West-Indian *Bulimi*. See also Woodward's 'Manual,' p. 287.

at the early stages of life; and with so many embryological irregularities, or what at present seem such, what can we do as regards classification but avail ourselves of plain morphological data? With others of the advanced school M. Giard is somewhat severe on the homologists, yet he dwells on the very strong action of the exterior, as, for instance, in "the convergence of types by pelagic life" *.

In the following paper the Bryozoa or ciliated polypes are, with some reserve, included with the mollusks, nor is much said respecting the lowest class of true mollusks, the Ascidia; it is the less needful, therefore, to dwell, as a prelude, on the manifestation of the composite, branched and rayed vegetative tendency in these two classes, trenching upon the confines of the molluscan subkingdom. In the latter (in *Salpa*, for instance), though, for us, mollusks, we have remnants of all these tendencies, as well as of alternation of generations—tendencies all predominant in still lower animals, as, for instance, in the plant-like infusorial *Vorticella*, or in the more minute but proliferous and branched *Dinobryon*—almost equally common in our pools, but less easy to detect or examine, as it swims freely about, mimicking the oceanic creature last named, the *Salpa*; in fact, it may be observed, *en passant*, that the Infusoria, so called, in a *broad sense*, stand alone within the animal cosmos. Their minute size, depending perhaps on a unicellular origin, and answering to that of the Desmids in the vegetable kingdom, constitutes almost a primary characteristic; and they present faint resemblances to other animals of several orders: they have the vibratile organs, or *cilia*, so common in mollusks, capable of effecting locomotion through the water in their own minute bodies, but bringing the water to the animal for respiration and for the conveyance of nutrient particles in the mature mollusk; some also (the Foraminifera) form shelly coverings, which simulate those of the same animals.

Animals have been arranged† into those which are centrally and those axially developed—that is, either in a radiate or a longitudinal fashion: with the former the Mollusca, as already intimated, cannot be well made to agree; with the latter they correspond no better. They have little of the axial arrangement of an annelid, and not always, though generally, bilateral symmetry, confining ourselves to the animal in contradistinction to the vital organs. Upon the whole, flexure *superse*, rather than any other plan, predominates, and prevails upwards in a great degree from the bryozoon to the cuttlefish,

* 'Revue des Sciences Naturelles,' March 1875.

† 'Principles of Biology,' Spencer, vol. ii.

due perhaps to the necessary arrangement of the inlets and outlets of the body in such animals as are encased and protected by a shell or in other ways. Mr. Spencer attributes the jointed form in the great subkingdom Articulata to repetition or budding, yet of a less mechanical origin than the jointed but adaptive disposition of the Vertebrata. Notwithstanding this low vegetative characteristic of the Articulata, if it hold good, they and Mollusca are commonly considered to form two parallel zoological divisions, rather than one concatenated series. Upon the whole, the Mollusca approach nearer to the Vertebrata, as will become evident hereafter; but the Articulata are highly developed for locomotion, which ensures perfect mechanical structure and symmetry; they are less generally aquatic, and often adapted for aerial movement, to which last the Mollusca cannot fairly be said to attain; they also evince wonderful powers of what looks like observation and purpose. At the same time the Mollusca present varied means of locomotion and of domiciling themselves; and their intelligence may be greater than our means of observation enable us to ascertain; the locomotion, however, with the exception of that of the pelagic swimmers, is generally of a simple kind, mere gliding or creeping rather than walking, the organs being formed with greater reference to hydraulics than mechanics. They are anchorites accommodated to their cells, sensitive rather than locomotive unities, seldom having any repetition of parts of an analogous kind, but commonly possessing, as already observed, more or less of that lateral duplicity present in all animals above the Radiata—though, indeed, in the Gastropoda this is liable to be interfered with by an atrophy of one side. Altogether a mollusk is a typical reality, showing either an origin from some primary molluscan root, or a uniformity of special plan throughout their own subkingdom. As a rule there may be said to be seen in them, as we have them at present, an ascent from their lowest to their highest forms, without any great *hiatus*—in this, more than in their geological sequence, agreeing with the theory of the derivation of one kind from another.

If we are to trace up the Mollusca to their origin, their biological pedigree, we shall, it is commonly held, arrive at the Bryozoa, or rather, to our mind, at the lowest Ascidæ. It seems far-fetched to form an alliance, as Cuvier did, between the *Teredo* and the articulate *Lepas*, though there is an obvious analogy between the valves and adductor muscles of the last and those of a bivalve mollusk—one of those curious resemblances often occurring in nature between animals far removed from each other, evincing, on the one hand, relation-

ship to the environment, and on the other unity of plan throughout. What is a little remarkable in this last example, instancing a kind of duplex structure, is that in the development of the cirripede the articulated disposition is primary and internal, the molluscan (if such it may be termed) the reverse. Darwin considers that the cirripedes present no real affinity with any other non-crustaceous animals; but some have seen in their pedunculated and sessile genera an affinity, on the one side, to the Brachiopoda and the Rudista respectively, and in these last to certain ordinary mollusks on the other. The first conclusion we scarcely admit; the last we do.

The ciliated tentacular crown or *lophophore* of the Bryozoa much more resembles that of some tubicolous annelids than the branchial cavity of the Ascidia, though the young bryozoon (*Plumatella*) is somewhat like the bivalve in the early stage, the egg-covering separating into two oval plates or valves. There are other external resemblances of Mollusca to lower or higher animals, analogous rather than homologous or homogenetic, but brought about purely to meet peculiarities of the circumstances of life (that is, special excess of those externals which nevertheless are set down as determining, in a gradual way, all animal development whatever), either by an adaptation to, or a modification by the same. Such are the resemblances of some aberrant mollusks to tubicolous annelids, or of a *Chiton* to an *Oniscus*—resemblances totally disregarded, but whether philosophically so some might doubt.

The mollusk, notwithstanding its frequent tendency to a flexure *super se*, is at other times, when unfurnished with a shell, of the more normal animal form, oval or elongate, with an undivided foot or muscular disk below abdominally, a protective mantle above dorsally, and the viscera enclosed between. The form, however, is generally much modified to accord with the shelly valves of the conchifer or bivalve, or the spiral shell of the univalve. It is only as we ascend that a head is developed (Cephalophores).

The Ascidia, then, we are disposed to consider as the lowest of the Mollusca and the progenitor of them, though not of the Brachiopoda; these are Acephala closely allied to the others, the bivalves. The tentacles, at the orifice of the respiratory sac, are, when they exist, but secondary to the sac, which has the true branchial structure of the higher Acephala, frequently with branchial or labial folds, like the pallial sac of the bivalve. This differs from the views of several living biologists, but has the support of Mr. A. Hancock*. The

* Journ. of Linn. Soc. vol. ix. (1868) p. 343.

tentacles just mentioned are analogous to those surrounding the orifices of the respiratory tubes in bivalves ; and that enigmatical part, the endostyle, may represent the crystalline style applied to its use (mechanical support), or at least so much of it as is retained after the loss of the larval appendage. The larval Ascidian, or the Appendicularia, constitutes a very indifferent vertebrate—the tail in the latter bent forwards at an acute angle to the body or towards the mouth, and its nervous cords (if such they be) seeming scarcely continuous with the cephalic ganglion, and having alternate instead of opposite ganglia, more unlike the vertebrate or articulate type in this respect than are the nerves in the arms of the Sepia or Argonaut*.

Bivalves would differ little from the Ascidia, provided the test and mantle of the latter were slit ; but in the former the branchia are more differentiated and the circulatory organ more perfect, shelly valves and muscles to close them are superadded—also a foot in most species, developed according to the amount and kind of locomotion required. There is in bivalves no true head ; but the mouth is furnished with lips and two laminated and ciliated palps on each side, distinct from the branchia but of similar structure, the lips proper sometimes specialized (as in *Pecten*).

Amongst bivalves the above remarks only partially apply to the Brachiopoda, which, if we endeavour to trace their genetic affinities, present us with some difficulties. They have been considered to have the same relationship to, or descent from, the Bryozoa as the Lamellibranchiate bivalves ; but if so, it must be in a different line, and without the intervention of the Ascidia. It may be questioned what relation the upper and lower valves of Brachiopods bear to the right and left valves of the ordinary Lamellibranchiata. The crossing of the principal adductor muscles in the *Lingula*, and their median union in some *Terebratulæ*, the compression of the body and arms or tentacles in Brachiopoda generally, in the opposite direction to the arrangement of the body and corresponding parts in the Lamellibranchiata, the perfect lateral symmetry in the former, and a tendency to division, seen in *foramina*, notches, or *septa*, in several species (as in *T. diphyæ*), whilst there is often a difference, in some respect or other,

* "On the Genus *Appendicularia*," by E. L. Moss, Linn. Trans. vol. xxvii. part 2. See also USSOW'S Zool.-Embryol. Investigations (by Dallas), Ann. & Mag. Nat. Hist., Feb. and May 1875. The last writer is decidedly against the molluscos nature of the Ascidia ; and so are others ; but the validity of this opinion depends upon the accuracy of minute and difficult researches upon the nervous ganglion and other parts, and the opposite conclusions of Mr. Hancock are perhaps as reliable.

between the anterior and posterior portions of the valves in Lamellibranchiata, are facts which seem to favour the idea that the dorsal valve, for example, of a brachiopod is not analogous to the right or left valve of an ordinary bivalve, but rather to the anterior portions of the two valves united together, and so *vice versâ*.

The fossil Hippurites and Rudista, with such forms as *Dianchora* and *Podopsis*, appear to have had most affinity in form and structure, amongst bivalves, with the Chamadæ—branches of the same stock, one passed away, the other still flourishing, therefore the affinity rather collateral than derivative. One or both valves may have put on the spiral form, the former case in the Spherulite, and the latter in *Diceras*; or one of them may have become elongated and multilocular, as in the Hippurite and, indeed, in some oysters. Such a spiral form, or such an elongation, must be attended with a division of the connecting ligament or cartilage, just as we see in *Isocardia* or, in a different form, in *Gryphæa*. Further, if the shell-forming mantle becomes expanded at the circumference all round, as in *Chama*, there will be a tendency for both hinge-teeth and cartilage to become central, a circumstance which has apparently taken place in many of these curious fossils. They have other peculiarities of the valves difficult to account for.

But however explained, whether from descent, relationship, or modification for or by externals, the *Anomia* appears to be a transitional form between the attached brachiopod (*Crania*, *Orbicula*) and the ordinary bivalve; the oblique position of the mouth, the non-marginal situation of the shell-nucleus, the very short intestine, the lengthened, narrow, and loose palps or labial appendages (which are confluent with the branchiæ), the complex muscular system, the ovigerous mantle, and the notched valve would seem to show as much, as well as the structure of the shell in some allied species. The plug may be the homologue of the byssus or pedal plate of *Arca* on the one side, and of the brachiopodous pedicle and *deltidium* on the other. A very small foot exists; but there is a very long crystalline body, having apparently a mechanical use to support the unusually detached mantle-lobe. We see in these transitional bivalves a tendency to diverge from the symmetry which preponderates in the class throughout; for when certain other species show the same tendency, it is generally with some relation to the nature of the hinge. Though the brachiopod is very distinct in many ways from the bivalve, we are not convinced that the arms of the former do not perform the office of branchiæ.

The boring or burrowing Lamellibranchiates are often very aberrant—*Pholas* especially in its hinge, the valves and mantle being reflected at the *umbones*, and there being often a row of underlying cells here, with *fimbriae* of the mantle lodged in them; muscular fibres (the anterior adductor) cross from valve to valve at this part; and we should suppose that the valves are opened somewhat, as well as closed, by the voluntary efforts of the animal. *P. dactylus* has several shelly plates covering the reflected part of the mantle, *P. candidus* only one, but in addition a weak ligament. The valves have a tendency to become otherwise disintegrated in these boring bivalves; a calcareous enveloping tube is often formed, and the true valves are much diminished in proportion in *Xylophaga* or *Teredo*, or even become incorporated with the tube. The body is often strangely elongated, as in the last species. The *Teredo* or ship-worm is a remarkable example of how much ordinary type may be modified to meet external conditions. Notwithstanding its extreme elongation it is in every respect a true lamellibranchiate; thus the alimentary canal is reflected over the posterior adductor muscle as usual, though to be so it has to ascend within a few lines of the anterior extremity. It has, however, two new parts, *spatulæ* or palettes, guarding the posterior siphons, curiously imbricated and possibly a dismemberment of the valves, analogous to what we shall see in *Chiton*. In the mature *Teredo* the shelly enveloping tube has, in the neighbourhood of the palettes, imperfect partitions, and it becomes closed at the other extremity. The internal processes or spoons seen in the small valves support and protect the foot and viscera, help to keep together the valves, and give attachment to muscles; the heart is not perforated by the rectum, and, with its auricles, is of the shape of the inverted letter λ . *Xylophaga* has commonly no palettes; but the foot has a central *papilla* with an orifice, more developed, however, in *Pholas crispata*; and here the curved crystalline style is inserted, having itself a hard calcareous nucleus; this must support the foot; and it is possible that there may be a vent here, in the wood-borers, for some softening fluid from the stomach. Though the writer broached the idea that ciliary action, or rather the consequent currents of water, constitute especial agents in the burrowing powers of mollusks &c., and that the fleshy and ciliated foot, aided, it may be, by hard particles, has furthermore much to do with it, yet he was not blind to the existence of other adaptations to aid, at least, in the perforation of timber.

The anterior extremity of *Aspergillum* (watering-pot shell) is still more modified, the valves being curiously fused with

the tubular shell, which has also a perforated disk or rose in front, in which is a small central slit for the attenuated foot, and also having a ray of shelly tubules around the margin. These animals, compared with ordinary bivalves, and with tubicolous annelids, are another instance showing the difference between homology and analogy, the latter occurring, as observed already, in very different animals where the circumstances of life are similar. Like *Teredo*, *Aspergillum* is in every respect a bivalve conchifer, with the mantle, however, closed in front, but having there a thickened muscular disk with tentacular processes for the perforations above mentioned, and also giving exit to the foot, as does the corresponding shelly plate. We should suppose that the animal lives buried in fine sand or mud, in which its rayed fringe must secure it, as the expanded foot of some other bivalves does.

With the exception of *Aspergillum* and one or two allied genera with fused valves, adductor or *janitor* muscles are general in bivalves, and also peculiar to them—unless we hold Oken's theory that the operculum of Gastropods is in reality one of the altered valves of the bivalve, in which case the retractor muscles of the former may also include the adductors*. The muscles of attachment of *Patella*, *Fissurella*, *Hipponyx*, *Navicella*, *Sigaretus*, and *Haliotis* show the transition from the retractor pedal muscles of the bivalve to the more or less united and contorted muscle of the spiral gastropod. There is sufficient resemblance between an *acephalous* and a *cephalous* mollusk to proclaim them of the same division of the animal kingdom; but the latter, with its more or less marked head, has generally its nervous system more concentrated into a brain or cephalic ganglion, with defined auditory sacs, more developed eyes, and, in some, organs of smell. In *Acephala*, when mature, no eyes, except the *ocelli* at the margin of the mantle, exist. The lips and labial palps of bivalves are transmuted in Gastropods to subulate or flattened tentacles, or sometimes into supra- or infraoral disks or processes. Horny jaws of varied form, median or lateral, but the representatives of the beak of the cuttlefish, and a spiniferous tongue or *odontophore* (Huxley) may exist, the latter almost universally, though it does not appear to have been found in the *Pyramidellæ*. The hooks or teeth from this tongue do not lose their form when boiled in nitric acid or when calcined, but vitrify with potash, which is perhaps conclusive as to their siliceous nature. The branchiæ are so varied in position that they were chosen

* This theory is strongly advocated by Macdonald, Journ. Linn. Soc. vol. v. no. 18. He considers the operculum to be homologous with the right valve (see further on).

by Cuvier to distinguish the separate families. They are generally protected by a shell, and are of course *en liaison* with the heart, as the latter is, more or less, with the alimentary canal; indeed we should have before observed that in the Lamellibranchiates the ventricle is commonly traversed by the rectum, this arrangement being either an advance upon the disposition seen in still lower animal forms, where the intestine is enveloped by the general reservoir of the blood, or, as has been thought, due to the young bivalve being the result of the union of twin embryos. It is probable, as may be traced in their vascular arrangement, that the branchiæ in mollusks are normally four in number, as we see them in bivalves and again in *Nautilus*; the two of one side, however, are combined into a single one in most Gastropoda, and in some *Arceæ*, *Anatina*, *Solemya*, and other bivalves; or one only, altogether (homologically *duplex* however), may exist, as in other Gastropods, its fellow of the opposite side being more or less undeveloped. Are the pair of branchiæ found in the dibranchiate Cephalopoda the representatives of the four branchiæ of the tetrabranchiate *Nautilus*? or have we the rudiments of the wanting pair, or simply of the corresponding cardiac parts, in the anomalous appendages of the lateral hearts, which, however, are wanting or little developed in *Octopus*? The monobranchiate *Aplysia* has an aortal appendage. Some of the Gastropoda have pulmonary sacs instead of branchiæ, and others (*Ampullaria* and perhaps some littoral species) have both*.

The position of the branchiæ in *Patella* and *Chiton* (Cyclobranchiata) is analogous to that in the bivalves, to which mollusks these Gastropods form the natural transition; but the ventricle of the heart has not the intimate connexion with the rectum, though both heart and rectum are situated at the posterior extremity of the body in the latter genus. Not so in those allied genera where the branchiæ have ascended wholly or partially above the neck (Scutibranchiata)—*Fissurella*, *Emarginula*, and *Haliotis*; for here the ventricle and rectum are in union, as in the bivalve. In *Haliotis* and *Sigaretus* one branchial plume is commonly less than its fellow; and in *Haliotis* the inequilateral composition of the shell is indicated by the row of foramina. In *Calyptræa* and its congeners the smaller of the branchiæ has disappeared; and in this last case, probably, the shell is correspondingly the expanded representa-

* The circumpedal fringe of *Patella* has doubtless a branchial function; but we do not deny that the animal, when exposed by the receding tide, may take air into the supradorsal cavity, though this rather appears to be the renal organ.

tive of but one valve of the bivalve, and not of two, as we think is the case with *Patella* and *Fissurella*. In *Dolabella* one valve is developed, the other all but gone.

Perhaps the normal position of the vent in Gastropods, where there is no flexure *super se*, is, as in most other animals, towards the opposite extremity to the mouth; *Onchidium*, *Doris*, and *Chiton* (representatives of the pulmonate, naked-gilled, and cover-gilled Gastropods) are examples of this: but, as said before, the branchiæ and their accompanying heart are in especial relation with the shell; and as this develops, the tendency is for the concomitant removal of branchiæ and vent forwards and to the right (Pleurobranchiata), or especially forwards (Prosobranchiata). This transference may be seen to take place progressively, in the Pulmonata, in *Onchidium*, *Testacella*, *Limax*, and *Helix*, in the Nudibranchiata, in *Doris*, *Eolis*, and *Pleurobranchus*, in the Cyclobranchiata and Scutibranchiata, in *Chiton*, *Microschisma*, *Fissurella*, *Emarginula*, *Gadinia*, and *Natica*—a remarkable transposition of parts!

The shell, then, of the *Patella* corresponds to the two conjoined valves of a lamellibranchiate bivalve; they are less conjoined in *Fissurella*, *Emarginula*, and *Haliotis*, in which last is perhaps seen, as already observed, the division into right and left valves in the row of foramina and the long fissure of the mantle. The spiral form becomes progressively more pronounced in *Crepidula*, *Calyptrea*, and *Sigaretus*; and this is accompanied by a want of development on one side affecting heart, branchiæ, and other organs. Indeed, with respect to the spiral univalves the preceding paragraph requires some qualification; for in them the torsion of the body and the great development of one side (the right) causes the frequently single branchial tuft to be carried to the left, accompanied by the heart.

We have always felt disposed to receive the theory held by Adanson, Oken, Dr. Gray, and Macdonald, with respect to the normal spiral Gastropod. The latter writer shows the correspondence and resemblance between the operculum and the univalve shell. He looks upon the muscles connecting the operculum with the spiral shell as the adductors of the dimyary bivalve, and perhaps also combining the representatives of those fibres which serve to retract the foot. He supposes the body of the bivalve, now occupying the left valve, to revolve from left to right on its longitudinal and transverse axis, in both cases moving through a quarter of a circle. There is no violence done to fact here; the greatest requisition demanded appears to be the flexure or displacement forwards

of the *termini* of the intestine and excretory organs, which circumstance we see to have evidently taken place in *Fissurella*, *Haliotis*, *Gadinia*, &c. But no account is taken of the effect of the transposition on the size &c. of the organs in the above theory; and, judging from the character of the torsion which has taken place, we are disposed to think that it is the *right* valve which preponderates, and not the *left*, although the tendency to the spiral form which we see in some bivalves, as *Isocardium*, tallies best with the dextral direction of the spire in ordinary Gastropods. Mr. Owen expresses himself as adverse to this view, principally from the existence of the operculum from the first in the embryo. In a few cases the operculum, or *clausium*, may be a dismemberment of the columella or, tantamount, of the posterior portion of a patelli-form shell. The operculum of *Navicella*, for instance, is formed by the posterior reflection of the afterpart of the shell-mantle; and it answers to the shell of *Crepidula*, or the columellar portion of the univalve *Calyptrea*; in *C. Dillwynii* there is the same part, but curved, and free at its margins, though attached to the apex of the shell; in *C. rudis* this has become a complete cup, whence the name *cup-and-saucer limpet*; whilst in the pretty little *C. sinensis*, or *Chinese bonnet*, the lamina goes to form the inner part and *columella* of a spiral shell. In *C. rudis* it is puzzling to understand how the inner cup is formed; it perhaps answers to an open columella; the formation of the other species is more intelligible. In ordinary cases the operculum is formed on a distinct pallial *lamina* at the back of the foot, occasionally connected above with the shell-pallium, as in some Turbinidæ. If we reject Oken's view altogether, we are driven to suppose that the curiously modified operculum is the homologue of the byssus of bivalves. In *Phasianella* there is an equal development of both branchiæ, separated by a septum, as in many Cephalopoda; and yet here, with little internal derangement, we have an operculum—this being somewhat adverse to the above theories, though it might be accounted for in the modern mechanical way, the further from the centre of rotation the greater the tendency to divide.

Two patelli-form shells, then, very similar in form, may belong to animals of quite different families: one may cover a dioecious and carnivorous mollusk with only a single branchial process, and a heart with simple auricle and ventricle, with the intestine opening on the right side (*Calyptrea*, *Crepidula*, and *Hipponyx*); another a monœcious and phytophagous animal, with two symmetrical branchial organs, and heart with double auricles and perforated ventricle (*Fissurella*). In the first case one of the branchial laminæ and the corresponding

side of the body appear to have become atrophied; and here we are to suppose that the shell, as seen from above, is homologically univalve, with a strong tendency to become spiral, in fact so strongly centrifugal in *Calyptræa* as to have carried the heart into an unusual position, and almost to have disintegrated the shell; whilst in the second case the whole conformation of heart, branchiæ, foot, muscles, and organs of generation agrees so certainly with that of bivalves, that we must have in one of these molluscous shells the two shells of the bivalve in union. In *Patella* the branchiæ continue situated at the sides of the foot, though the heart is to the left, whilst the rectum opens on the right side of the neck; in *Emarginula* the pedal fringe is but rudimentary, and the true branchiæ are seen above the neck—a disposition (in the last respect) normal in most univalves; but in this case the ventricle is perforated by the rectum. *Calyptræa* and, more markedly, *Hipponyx*, being often fixed on very irregular surfaces, have the power of levelling for themselves a foundation by the secretion of a shelly pedestal. It is puzzling to say how this is formed, or with what part in other mollusks it is homologous. It must either be the representative of the byssus, or, more probably, what appears to be the foot-disk is in reality an opercular surface secreting the support, which is consequently marked with muscular impressions. There are lappets in front of the disk in these genera; correspondingly the anterior dorsal disk in *Sigaretus* is not homologous with the similar anterior dorsal surface of *Bullæa*; the situation of the mouth shows this.

The form of the univalve shell, due primarily to original plan, or, in other words, to an adaptation of ways to ends, depends, secondarily and immediately, on the form of the mantle-opening, on its inclination from the action of the foot, and on the relative activity of its circumference with respect to the secretion of the shelly matter. An increasing tube would be prolonged in a straight line or nearly so, if the mantle at the circumference were equally active and not unequally inclined, as, for example, in *Dentalium*, which is in all respects near to the Gastropods lately dwelt upon, *Fissurella*, &c.; but, on the contrary, it would be more curved if one side were more active or more extensile. *Vermetus*, *Siliquaria*, and *Magilus* have an unequal deposit at first, and are then spiral; afterwards the shells become disjoined and approach the straight line. In *Patella* the whole circumference of the mantle secretes and grows almost equally and rapidly, hence the depressed conical form; whilst *Capulus* is at first less rapidly expanded, with the axis of increase changing somewhat, whence it attains its peculiar form and is named “Hungarian

bonnet." A similar formation, but less gradual and more anterior, produces such shells as *Navicella*, already dwelt upon; whilst, if the mantle expands laterally instead of totally in front, we have the corresponding form of the river and lake *Ancylus*, or of the internal shells of *Aplysia*, *Limax*, and *Bullæa*. If the lower or inner part of the mantle does not secrete at all, the spiral shell can have no *labium* or inner lip, and no inward pillar or columella, the axis of rotation. In *Scalaria*, but for the opposite reason, the shell has no material axis, there being an approach to the disjointed *Vermetus*. The shape of a transverse section of the spiral tube of a shell (that of the angular-edged *Trochus* for instance, or of the rounded *Turbo*) is due to the shape of the bend in the edge of the mantle. The oblique direction of the mouth of a shell, and consequently the produced spire, are owing, as alluded to before, to the extra development of the component right valve. A rotation on the same plane (as seen in the *Nautilus* and sometimes in *Planorbis*) and the slow or rapid increase in the diameter of the whorls occasion the preceding ones to be apparent (*Ammonites*) or covered-in (*Bellerophon*). In *Conus* the mantle-opening is disposed in the opposite direction to what is most usual, and still more so in *Ovula* or *Cypræa*, being in the same line as the foot, and not transverse or diagonal to it; and the consequence is, that the last whorl more or less covers up the spire of the shell, which, however, in some cases, appears to become absorbed. In *Chiton* the valves, except the last, answer to the anterior part of the shell of a *Patella* or *Hipponyx*, in some species of which there is a tendency for the successive laminae to separate. The shell-umbo appears to be the middle of the last valve in *Chiton*. There is also in *Chiton* as in *Nerita* some tendency of the pedal nerves to put on the disposition seen in *Articulata*; and the auricles communicate with the elongated ventricle by two or three openings on each side (*Chitonellus*). The intestine has been described to go in a straight line from head to vent, but is in reality, in some species, more convoluted than in any other mollusk*.

The shell of the *Nautilus* and also of the Argonaut appear to correspond in external form, and excepting the multilocular character of the former, to those of the spiral *Gastropods*, though, from the symmetrical disposition of the animals, and the restoration of the branchiæ to their original bilateral and

* Perhaps the truest approach in a molluscan to the *Articulata* is in several tectibranchiate species, as *Akera bullata*, where the posterior *somite* of the body is so distinct as to have its separate pair of ganglia, irrespective of those for the supply of the vital organs.

abdominal situation, these shells may be considered abdominal rather than dorsal, and revolute or reversed as to the direction of the spire. The siphon here is not situated dorsally but ventrally; and the back of the head is directed towards the spire—the reverse of what it is in Gastropods, *Planorbis* for instance. But the shell or bone (so called) of the *Sepia* rather answers to the dorsal plate of the pteropodous shell, as also the fossil *Beloteuthis*; and what is the expanded portion of the Nautilus-shell is scarcely developed at all in the *Sepia*, though more so in *Belosepia*. No doubt the light spongy laminated part of the *os sepiae* represents the hydrostatic cells of a Nautilus and Ammonite and the phragmacone of the Belemnite or of *Spirulirostra*; the wavy lines seen by the lens on the *septa* of the *os sepiae* answer somewhat to the wavy sutures of Ammonites, showing at least similarity of construction histogenetically. In *Spirulirostra* we have a form connecting *Sepia* with *Spirula* and *Nautilus*, as *Conoteuthis* appears to do the Belemnite with *Loligo*. *Turritiles* must have had an unequal lateral development, like Gastropods*.

In certain tectibranchiate mollusks, as *Gastropteron*, *Aplysia*, *Bullæa*, *Aceras*, and *Ianthina*, we have a transition from the Gastropods to the Pteropods, either the foot or mantle being developed more or less into swimming-organs, whence they might be arranged as natatory gastropods. The Pteropoda proper, though perhaps at present not at their zenith of development, at least as regards size, appear in type to constitute a characteristic class, and upon the whole a transition between the two whose morphology has been dwelt upon, though their likeness to the young veliferous Gastropod may induce others to think differently. With *Sepia*, for instance, *Hyalea* may be compared in respect of shell, also as regards the abdominal situation of the branchiæ. *Limacina* scarcely differs from *Hyalea* except in having a spiral shell and the pedal lamina a little more specialized. The tentacles of *Clio* and *Pneumodermon* are apparently transitional in structure to the arms or feelers of Cephalopods. Pteropoda correspond with Gastropods as to the dextral position of the rectum; but the heart is also dextral or rather abdominal, and they vary somewhat as to the openings of their androgynous generative organs†. Four of the six cephalic ganglia lie in

* The Ammonite appears to have been furnished with an operculum. The Argonaut-shell has been compared to the ovigerous float of *Ianthina*: perhaps it has not been conclusively shown by Madame Power what part mainly secretes it, the veliferous arms or the mantle; if the former, we might consider it to answer to a developed operculum.

† The above we believe to be correct; but there is some confusion in descriptions.

Clio above the œsophagus, but the reverse in *Hyalæa*, *Cleodora*, and *Pneumodermon*. Fins are especially developed, but only the rudiment of a foot; they swim rather than creep. The high position here accorded them systematically rather depends, it will be seen, upon type or external morphology than upon structure. Eyes are to be seen in *Hyalæa*; and Eschricht showed them to exist in *Clio*; there are also dark points on the cerebral ganglion of *Cleodora*, which must be corresponding organs. *Carinaria*, though not considered to be a pteropodous animal, can scarcely be better placed as a Gastropod. In it the greatly developed vital or vegetative organs of the mollusks generally are dwindled in bulk. The pretty shell covering the viscera is curiously carried above the elongated cylindrical body of the animal, which has caudal and abdominal fins developed, the latter being the transmuted foot, with a little sucker and pore at its posterior part. It has very developed eyes; and we may observe little reddish ear-sacs with their nerves floating internally behind and below these eyes.

As far as we have yet described, *form* rather than structure has, in a few instances, faintly assimilated the Mollusca to the Vertebrata; but apparently we see a true structural approach to them in the *Sepia*. If there is any thing in the lower mollusks which is a shadow of vertebrate structure or of a notochord, we might fix upon the crystalline style, acting as a *fulcrum* of locomotion, though its connexion with the stomach and its gastric lamina remind us, on the other hand, of the lingual plate and ribbon of the higher mollusks. Strange modifications of an organ these, if they are such! but organs *are* curiously modified in many cases to perform different functions.

There are in some carnivorous Gastropods, as well as in *Chiton* &c., cartilaginous pieces supporting the lingual apparatus; and the cephalic ganglia of other species are enveloped in an almost cartilaginous tissue. In Cephalopoda, besides the shell, there are internal cartilages answerable to the internal skeleton of the Vertebrata; the *Sepia*, for instance, has a cartilaginous expansion, holding and supporting the brain, eyes, and organs of hearing, besides giving passage to many nerves and vessels, and having in front a *trochlea* for the mediate tendon of a binocular muscle, the orbits still further completed by supplementary laminae. There is another cartilaginous lamina in front at the root of the arms, others in the neck, and cartilaginous *acetabula* at the base of the siphon, into which prominences of the mantle fit—a curious arrangement to give the parts fixity during the respiratory movements. There are also two lengthened sword-like cartilages at the

side, where the semicartilaginous rays of the long fins begin, reminding us much of the similar parts in a skate. *Octopus* has not the cups at the base of the siphon; but it has two cartilaginous styles in the sides of the mantle; these last are absent in the argonaut. The siphon in the Octopodidæ has not the valve which is present in the Sepiadæ. This siphon may be seen in the Gastropoda to arise from the body rather than the mantle, and so in the Cephalopoda.

Besides the internal skeleton the Cephalopods are furnished with other new or more developed organs—their curious beak, for instance, reminding us of birds or of some reptiles or fishes, but, in fact, a further development of parts of other mollusks similarly situated, as already alluded to. In these, too, the molluscan foot is broken up or differentiated and resolved into arms or tentacles, which are furnished with peculiar suckers or hooks. We see this disintegration in some Gastropods and Pteropods, and at the same time its transference to the head, forming a *mentum* or *propodium* (*Ampullaria*, *Sigaretus*, *Natica*), or fin-like side lobes or *epipodia* (*Bullea*). *Bullea* also presents us with a tentacular lobe or supercephalic disk. With the above transposition the arms and tentacles in Cephalopods are very specially developed, whether as the cupuliferous arms and tentacles of ordinary species, or as the less formidable sheathed tentacles of the Nautilus.

The circulation in mollusks undergoes a progressive complication, much as it does in the Vertebrata. They have been described as being destitute of true veins; but this is far from the case, though these veins may communicate with sinuses to which even the external element may have access, and such cavities may be the media of absorption or nutrition rather than the veins primarily. The circulation is already well provided for in the Lamellibranchiates, as much so in Gastropods; and it is very remarkable for its perfection in the highest mollusks. These circulatory, like the other vital organs, are probably originally double or bilateral, and become single by development, somewhat the reverse of what is the case in Vertebrata; thus in bivalves the auricles, and less frequently the ventricle, continue more or less parted, or the ventricle envelops a length of the rectum, as already observed. Some *Arcae* and *Pectunculi* have two hearts; *A. auriculifera* but one, of the shape of an inverted M. The blood is returned from the system in part directly to the heart, in part through the medium of the branchiæ, the latter portion also appearing to have previously circulated through the renal organ; but the dibranchiate Cephalopoda are peculiar in having two auxiliary branchial hearts between the system and the branchiæ.

Near the branchiæ, most commonly, are located the organs

of excretion. The lamellar mucous gland, seen in *Buccinum* in the branchial chamber, is probably homologous with those of the female *Sepia*; there are also glandular parts for the secretion of the purple or other colouring-matter, sometimes simply a diffused gland in the mantle, whilst sometimes the colouring liquid is received into a vesica as in *Sepia*, *Doris*, or some *Purpuræ*; also renal organs, the latter opening, in the branchiated Gastropods, at the far recess of the branchial cavity, but by a long duct in the pulmonate animal. They are near the mouth in *Bullæa*, and open between the branchial processes in *Chiton*, near the double ovaries, but variously in bivalves*—sometimes in them into an aquiferous chamber or double pleural sac, which also, according to Prof. Rolleston, often communicates with the pericardium. These renal organs commonly secrete little round concretions. The organs themselves are less concentrated in Cephalopods; but the tufts on the veins and bile-ducts are, we think, their homologues, excreting and not absorbing (at least entirely and solely), the excretion being sometimes seen in the form of yellowish glittering particles in the sac in which the tufts float, and which sac communicates with the circumambient fluid by two orifices, and also, in the opposite direction, with other membranous cavities containing the viscera, or which are in apposition to the spongy laminae of the shell in the *Sepia*. Water no doubt has access to these cavities, and perhaps to others situated about the head in Cephalopoda (*Tremoctopus* or male *Argonaut*)†, though the subocular pores in *Sepia* seem to be excretory, and to lead down to glands situated beneath the eye. Water has access likewise to the dorsal sinuses mentioned as existing in bivalves, and into their foot by means of the median pedal pore in some species, or the lateral pseudo-oviducts in others; or into the laminae of the mantle, as seen in opening a common *Anodon*.

From the lowest mollusk to the highest there is the same plan of nervous system, very different from that of the vertebrate or articulate animal. The first nervous centre that appears is the respiratory or branchial‡, presiding over the respiratory inlet and outlet in the *Ascidia*, and situated between the two orifices. Then the labial ganglia appear, in the oyster for instance, and give off cords, which communicate with the last, and, with their own uniting one, form a ring round the mouth. In such bivalves as possess a foot another ganglion or ganglionic pair supplies it, also communicating with the labial ganglia, so that the ring becomes two-corded

* Linn. Trans. 1836.

† The species examined was perhaps *Tremoctopus*.

‡ A disputed point, however.

below. The organs of sight and smell, when they exist, are supplied by the labial or oral ganglia, which unite above in the higher forms into what may be called, in this case, the cerebrum or cerebral ganglion, whilst the acoustic sacs are connected with the lower ganglia. As we ascend, other ganglia, or centres of nervous action, are formed; thus a sympathetic system appears, of which the principal centre is a large ganglion (*Sepia*), or several smaller ones (*Doris*), on or near the stomach (gastric), connected through nerves running along the alimentary canal with two or more (six in *Doris*) small pharyngeal ganglia, situated on the buccal mass, and through them with the cerebral ganglia, and also having branches connected with internal respiratory nerves, these last forming one or more branchial ganglia at the root of the branchiæ, and descending from the respiratory or lower and hindmost part of the cerebral ring. Probably the small pharyngeal or buccal ganglia exist in all Gastropods and Cephalopods. Pallial or external respiratory nerves also originate a little outside the internal ones, superadded to them, and especially belonging to the mantle, the inhalant and expelling sac, and forming the remarkable star-like ganglia so plainly seen on each side within the mantle in all dibranchiate Cephalopods. This pallial nerve in the *Sepia* thus reminds one somewhat of a spinal nerve, as it has ganglionic branches for the sac and non-ganglionic ones for the fin. There are special nerves from the same part of the cerebral centre for the siphon. In the Cephalopoda these nerves, which supply the branchiæ and respiratory sac or mantle, internal and external respiratory, descend symmetrically from the cephalic ganglion on either side the vent in front, and at an equal distance from the middle line. Bivalves, as well as *Chiton* and *Doris*, agree in this symmetrical arrangement; but in the ordinary spiral Gastropods (*Natica* or *Neritina* for instance), owing to the torsion of the mantle, the vent has risen to the right side above the neck, the left pallial or external respiratory nerve has followed in the same direction under the œsophagus, and the pallial ganglion, which it forms, is on the right side, whilst the right nerve crosses over the digestive canal to the left side preceding the right branchial appendage, the left (often atrophied) remaining in position, as in *Nerita*, or dwindled away. The pallial opening and also the siphon are correspondingly displaced. Two branchial nerves and ganglia (internal respiratory) exist, as already mentioned, in the dibranchiate argonaut and cuttlefish, with two ganglia in the course of each nerve in the first; but there is but a single nerve for the single gill in many Gastro-

Pods. *Aplysia* has sometimes only one ganglion, in other species two, to supply its duplicate but conjoined branchial process and the protective mantle; and the nerve crosses, as just described. In *Bullæa aperta* there is but one ganglion in the posterior or respiratory section of the body; in *Akera bullata* there are three. Thus as the animal ascends there are specific cerebral ganglia immediately connected with the above functional nerves and ganglia. The posterior respiratory part of the lower portion of the cerebral ring is always divided from the anterior part, presiding over locomotion, by the transit of the aorta; or, rather, it is divided from the more anterior part of the posterior centre, which supplies the siphonic nerves in the *Sepia*, by the entry inwards of the vessel through the cerebral ring, whilst that anterior respiratory part is separated from the still more anterior locomotive centre by its exit. The pharyngeal ganglia are seen in the higher mollusks to be connected both with the sub- and supracæsoophageal centres; in *Patella* they send forward little nerves, going to the lips and mouth, where they form two other little ganglia (olfactory); or the latter may occur as a large ganglion (*Sepia*) intermediately between these pharyngeal ganglia and the brain. Taste and smell appear to be connected with the last two pairs of ganglia, hearing with the lower part of the cerebral ganglion, sight with its upper part. The smell in the snail (*Arion*) may be located in the whitish surface under the mouth, though some think it resides in the tentacles. In some Cephalopoda, as in *Sepia*, the membranes (olfactory?) surrounding the beak are much developed. The organs of sight often appear as mere specks on the brain itself, when the skin is pervious to light (*Scyllæa*, *Doris*).

To facilitate a boundless production appears to be the first object followed out in the structure of the reproductive organs of Mollusca. A second is evoked by the necessity which there is for at least an occasional union between different individuals of the same species, even when each contains in itself the essential organs of both sexes (monœcious).

A third object is but a part of the first, an arrangement for the dispersion or safety of the young individuals till they attain a suitable *habitat*. The simple form of multiplication, budding, or, more simple still, self-division, is, as said before, a mode of increase only seen in the lowest mollusks, or rather molluscoids; and in them only can we find any trace of what has been called *alternate generation*, and which perhaps depends upon the provision made to attain the third object above mentioned. In some bivalves (in the fixed oyster, the scallop, and in some freshwater mussels) the essential male and

female glands appear without doubt to be combined in the same individual (hermaphrodite); yet we suppose that, from the antipathy of Nature to self-impregnation and from the difference of the period when the two glands mature and discharge their secretions, the ova are commonly fertilized from a foreign source, and that it takes place after they are discharged, commonly in the pallial cavity. Such species are perhaps at one time functionally male, at another female. The embryo has sometimes means of transport, as the cercariform larva of Tunicata or the ciliated young of Gastropoda, by which it seeks a suitable habitat; whilst the sedentary species, on the contrary, are often fixed for safety by a byssus, formed by an especial gland, the trace of which may be found, even in the adult *Anodon*, between the surface of the foot and the pedal ganglion, in the form of a brown, waxy, concentric, globular body. In all the above and in *Patella* or *Chiton* the essential glands of reproduction are very simple; but in other species, though still hermaphrodite or monœcious, as *Helix* or *Lymnæus*, they have many and very curious accessories; yet here the sexual union of two individuals is necessary, or at least most common.

The more locomotive bivalves, as *Cardium edule*, or the sea-mussel, have sexes distinct (diœcious), also a great number of Gastropods and Cephalopods; and union of these takes place either immediately or, in some Cephalopods, as is now well known, by means of a *hectocotylus*. There has been question respecting the little gland situated at the ending, or rather beginning, of the double set of organs of the monœcious Pulmonifera (*Helix* and *Lymnæus*), whether it is an ovary or testis, or the two combined, and whether the corresponding extremity of the shorter set of the duplicate organs is an ovary or simply an albuminiparous organ*. The first gland, imbedded in the liver at the end of the spire, was considered to be the ovary by Cuvier; but, according to Meckel, it includes both ovary and testis, with distinct though combined oviduct and *vas deferens*; and of this opinion we have now no doubt. The fact may be easily verified by pressing the gland and duct between two glasses, and submitting the object to the lens; and, from the movement of the spermatozoa, it is a truly wonderful object. In *Onchidium* this gland visibly consists of two others, quite disjoined; and in all mollusks it is connected with the external male organ, but never, we think, without first communicating with the semitransparent organ, now sup-

* The substance of which it is composed, however, is not coagulable by heat, but swells up and is very viscid in water. Bichloride of mercury and alcohol coagulate it.

posed to combine the *matrix* and albuminiparous gland, called testis by Cuvier. This double communication, with the imperfect separation of the vas deferens from the matrix (*Helix*), may effect the transference of both ova and spermatozoa to the matrix in default of impregnation from without. Perhaps, in the sluggish nature of the animals, and in their liability to be isolated, we may see a reason for this arrangement; and we think that there is no longer much special mystery in their generative economy. The *vesicle* is a reservoir or spermatheca, as is the *long companion tube* present in some *Helices*, and in which *post coitum* the *ligula* is found also. This just mentioned ligula or chitinous strap, being a *spermatophore* or carrier of the spermatozoa, is formed in the long appendix or *flagellum* attached to the male organ, whilst the *dart* (or two darts, *H. virgata*), so curious in itself, and still more so from the way in which it is used*, is formed by the fimbriated glands at the base of the muscular sac, in which it is contained when not in use. Other branchiate univalves (*Onchidium*) have the same organ, but less developed. Equally curious with the above, or more so, is the arrangement in respect of this function in the Cephalopoda, though in some of them the fertilizing material seems to be transmitted directly, through the medium, however, of spermatophores (corpora Needhami), tantamount perhaps to the curious spermatophores of *Paludina* amongst Gastropods. It may be mentioned, as an instance how much allied species may differ with respect to this function, that the genus *Bythinia*, so near to *Paludina*, has only the ordinary spermatozoa. Endosmosis has a remarkable effect on these last bodies†. In some of the Cephalopoda one of the arms is, as now well made out, transformed into the spermatophore or *hectocotylus*, becoming detached and left within the mantle or sac of the female, and maintaining its position by means of its suckers, the filiform extremity insinuating itself into the orifice of the oviduct. In a small *Loligo* we think we traced a duct leading from the male gland to the modified arm or *hectocotylus*‡; and we have several times found the

* It is commonly found in the recipient animal near the insertion of the narrower or upper conjoined oviduct and vas deferens—that is, near the termination of the companion tube of the vesicula. The author principally follows his own observations here as elsewhere, but may refer to two excellent papers:—Saunders, Quart. Journ. Micr. Science, Oct. 1866; and Newton, ib. Jan. 1868.

† Report of Brit. Assoc. Aberdeen.

‡ In some species the duct is seen to run up on the outside of the arm in a superficial cutaneous fold; in most species it is one of the right arms, in a few one of the left, which is *hectocotylized* (Woodward).

filiform processes amongst the discharged ova of Argonaut, at first, indeed, mistaking them for parasites; and in two specimens of *A. hians*, and in another species, we have taken the hectocotylus from the mantle-sac, in which they lay crossways, overhung by the imperfect septum of that cavity. *Sepiola*, *Sepia*, and *Loligo*, discharging their ova enveloped in albuminous matter, moulded into different forms, have large albuminiparous glands, answering to those of Gastropods, though more externally situated. The Argonaut has two genital outlets in the female and also in a supposed male specimen, whilst *Octopus* in the male, and the Decapoda in both sexes, have only one.

In the separation of the male gland from its corresponding external organ in some Gastropods to distant parts or extremities of the body (the latter being frequently connected with the right tentacle), in the connexion between the two by means of an internal vas deferens or by an external groove, so often seen, and in the formation of the spermatophore (*Helix*), we are led to conclude that the curious hectocotylus is not quite so isolated and unique a phenomenon as at first appears, but that a synthetical comparison might be made, with more or less success, in this particular, as in others in the Mollusca generally—a comparison which we have endeavoured to make, and such as may be traced, taking other vital organs and functions for comparison (the digestive system for instance, already well described by Cuvier), through the whole of the Invertebrata, and indeed through all animals—enough to show us that no animal has been produced having no relations to the others, or, in other words, upon a different plan to that of its fellows.

XXXVI.—*On the Final Stage in the Development of the Organs of Flight in the Homomorphic Insecta.* By Prof. J. WOOD-MASON, Deputy Superintendent of the Imperial Museum, Calcutta.

“La dernière mue développe subitement les organes du vol dans toute leur étendue par une transformation vraiment merveilleuse et encore inexpliquée, car on ne comprend pas comment des organes aussi volumineux peuvent être renfermés dans les petites gaines où ils se forment pendant la période de nymphe.”—H. DE SAUSSURE, *Mission scientifique au Mexique et dans l'Amérique Centrale, Recherches zoologiques*, vi^e partie, 1^{re} sect., *Études sur les Orthoptères*, 1872, p. 224.

WHEN an insect quits the egg it has no wings, nor the slightest rudiments of such, these making their first appear-