MOCO. [HYSTRICIDÆ.]

MOCKING BIRD. [MIMUS.]

MODIOLA. [MYTILIDÆ.]

MOEHRINGIA, a genus of Plants named after Paul Henry Gerard Moehring, a German physician, author of 'Hortus Proprius,' and other works. This genus belongs to the natural order *Caryophyllaceæ*, and has 5 sepals, 4 or 5 petals, either entire or slightly emarginate; 8 to 10 stamens, 2 or 3 styles, the capsule opening with 4 or 6 valves; the seeds numerous, with an appendage at the hilum. The species are alpine plants with the habit of *Arenaria*.

M. trinervia has ovate-acute stalked 3-5-nerved leaves, the upper ones sessile, the petals shorter than the calyx, the sepals lanceolate-acute, 3-ribbed; the intermediate rib strongest and rough. This plant was formerly referred to *Arenaria*, but it may be distinguished from that genus by the appendage to the hilum of the seed. This plant is found in damp shady places, and is a native of Great Britain. Four other species of this genus are described by Koch in his 'Flora Germanica;'—*M. muscosa*, *M. prona*, *M. polygonoides*, and *M. villosa*.

The species are alpine plants, and adapted for cultivation on rock-work or in small pots. They may be propagated by dividing them at the root. They are best grown in pots, in a mixture of sand, loam, and peat.

(Babington, *Manual of British Botany*; Don, *Dichlamydeous Plants*.)

MOENCHIA, a genus of Plants named after Conrad Moench, professor of botany at Marburg, who wrote several works on botany; amongst others, 'Enumeratio Plantarum Indigenarum Hessiæ, præsertim Inferioris,' Cassel, 1777, 8vo.; also a work on the cultivation of North American forest-trees in Germany.

The genus *Moenchia* belongs to the natural order *Caryophyllaceæ*, and has 4 erect sepals, 4 entire petals, 4 stamens, a many-seeded capsule opening at the end with 8 teeth.

M. erecta is the only British species. It is a small glaucous plant growing in dry gravelly and sandy places.

(Babington, *Manual of British Botany*.)

MOHOLI. [LEMURIDÆ.]

MOHR. [ANTILOPEÆ.]

MOHSITE, a Mineral, consisting of Titaniate of Iron. It occurs crystallised. The primary from is a rhomboid. The crystals occur attached and macled. The cleavage is not observable. The fracture is conchoidal. The hardness is sufficient to scratch glass. The colour and streak are black. The lustre metallic. It is opaque; not attracted by the magnet. It is found in Dauphiny.

MOLASSES. [SUGAR.]

MOLE. [TALPIDÆ.]

MOLE-BAT. [ORTHAGORISCUS.]

MOLE-CRICKET. [GRYLLIDÆ.]

MOLE-RAT. [TALPIDÆ.]

MOLENESIA, a genus of Fishes belonging to the family *Cyprinidæ*. The species are American.

MOLGE. [AMPHIBIA.]

MOLGULA. [TUNICATA.]

MOLI'NIA, a genus of Grasses belonging to the tribe *Festucineæ*. It has unequal glumes without lateral ribs, shorter than the lanceolate spikelet, of 2 or 3 semicylindrical flowers and a subulate rudiment of another; the paleæ hardening on the loose fruit, and the styles terminal. There is one species which is British—

M. cærulea, which has an erect elongate narrow panicle; spikelets from 1- to 3-flowered; the outer paleæ 3- rarely 5-nerved, downless; the upper part of the stem naked. The leaves are long, linear, and alternated. It grows on wet heaths in alpine situations. This species is the *M. depauperata* of Lindley.

(Babington, *Manual of British Botany*.)

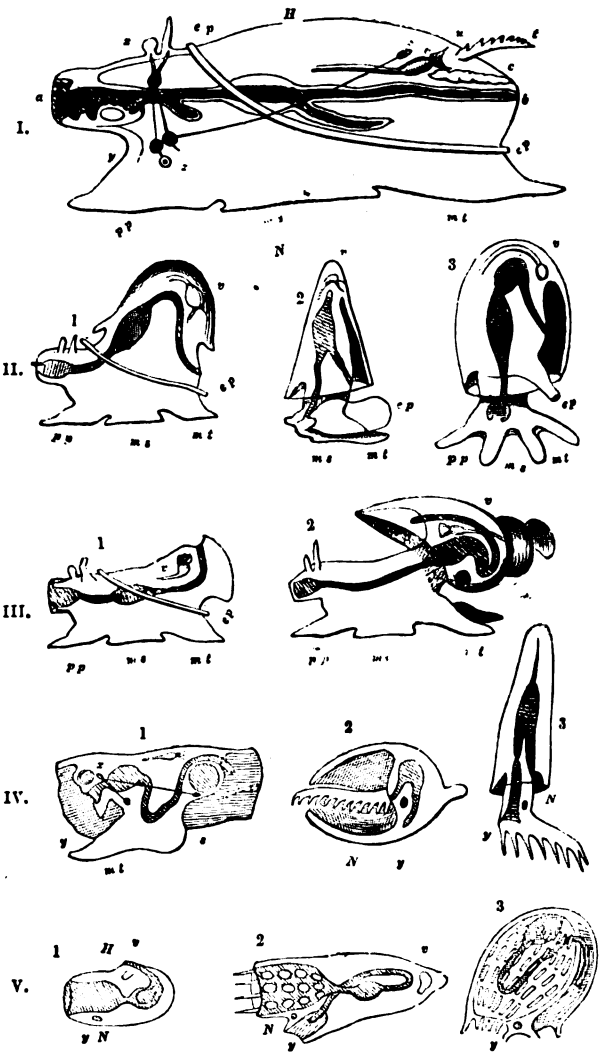
MOLLUSCA. Referring to the articles CONCHIFERA, GASTEROPODA, CEPHALOPODA, and MALACOLOGY, for information as to the zoological arrangement and subdivision of the various families of the *Mollusca*, we shall in the present article consider the animals which constitute this great group in a purely anatomical and morphological point of view; that is, we shall endeavour to show—firstly, what Common Plan or Archetype is discoverable among the varieties of Molluscan forms; secondly, in what way the Common Plan is more specially modified in the leading sub-typical groups of this great division of the animal kingdom; thirdly, the various modes in which the organs are arranged being thus comprehended—what peculiar characters are presented by these organs themselves; and fourthly, the development of the *Mollusca*, so far as it bears upon the idea of a Common Plan, will be discussed.

1. *The Common Plan or Archetype of the Mollusca.*—By the Common Plan or Archetype of a group of animals we understand nothing more than a diagram, embodying all the organs and parts which are found in the group, in such a relative position as they would have, if none had attained an excessive development. It is, in fact, simply a contrivance for rendering more distinctly comprehensible the most general propositions which can be enunciated with regard to the group, and has the same relation to such propositions as the diagrams of a work on mechanics have to actual machinery, or those of a geometrical work to actual lines and figures. We are particularly desirous to indicate the sense in which such phrases as Archetype and Common Plan are here used; as a very injurious realism—a sort of notion that an Archetype is itself an entity—appears to have made its way into more than one valuable anatomical work. It is for this reason that if the term Archetype had not so high authority for its use, we should prefer the phrase 'Common Plan' as less likely to mislead.

There are two modes in which the Archetype or Common Plan of any group of animals may be set forth. In the first, the community of plan among the members of each group would be demonstrated; and then, the minor plans thus obtained being compared together, the general Common Plan would be deducible. But this analytical method (which has been carried out to a certain extent for the *Mollusca* by the writer in a Memoir in the 'Philosophical Transactions' for 1852), would require more space and more illustration than can here be devoted to it; we must, therefore, take the opposite course, and, assuming a Common Plan, trace out its modifications in the subordinate plans, and explain the laws by whose operation they are effected.

This assumed Common Plan or Archetype of the *Mollusca* may be represented by *fig.* 1, I.:—

Fig. 1.



I. The Ideal Archetype or Common Plan of the *Mollusca*.

II. Its modifications in consequence of the development of an abdomen and consequent neural flexure of the intestine. 1, Hypothetical; 2, Pteropod; 3, Cephalopod.

III. Modifications resulting from the development of a post abdomen and consequent hæmal flexure. 1, Hypothetical; 2, Pectinibranchiate Gasteropod.

IV. Primarily neural flexure modified by subsequent changes. 1, Lamellibranchiate Mollusc; Neural *Molluscoida*. 2, Brachiopod; 3, Polyzoon.

V. Hæmal *Molluscoida* (Ascidians). 1, simple hæmal flexure, as in *Appendicularia*; 2, after hæmal flexure the intestine is bent back, and an atrium is formed; the branchial sac remains comparatively small; 3, the branchial sac comparatively large.

a, oral aperture; *b*, anal aperture, or extremity of the intestine; *c*, renal organ; *pp*, propodium; *ms*, mesopodium; *mt*, metapodium; *ep*, epipodium; *t*, branchiæ; *u*, auricle; *v*, ventricle; *x*, cerebral ganglia; *y*, pedal ganglia; *H*, hæmal region; *N*, neural region.

[The letters have the same signification in these and all the other figures, with the exception of figure 10.]

This figure is supposed to be bilaterally symmetrical, and the following parts and regions are to be distinguished in it :—(*H*). The Hæmal Region, or that upon which the heart is situated, and which corresponds with what is commonly termed the dorsal region. The word dorsal, however, is vague, being used in different senses in various divisions of the animal kingdom, and should therefore be, abandoned in philosophical anatomy. For the same reason, the opposite region (*N*) is termed, not ventral, but Neural, inasmuch as it is the region in which the great centres of the nervous system are placed. The termination (*a*) is the anterior or oral; the end (*b*), the posterior, or anal. Between these extremities the intestine takes a straight course. The neural surface is that upon which the majority of Molluscs move and by which they are supported; and it is commonly modified to subserve these purposes into a muscular expansion or disc called the Foot. Three regions again, often very distinctly divided from one another, may be distinguished in this foot :—an anterior, the Propodium (*pp*); a middle, the Mesopodium (*ms*); and a posterior, the Metapodium (*mt*). In addition to these, the upper part of the foot or middle portion of the body may be prolonged into a muscular enlargement on each side, just below the junction of the hæmal with the neural region—the Epipodium (*ep*). The mass of the body between the foot proper and the abdomen, or post-abdomen, which bears the Epipodium, and whose limits cannot very well be defined, though it would be very convenient to have a name for it, may be termed the Mesosoma (mid-body); and for what is loosely called the head the name Prosoma might advantageously be adopted. On the upper part of the sides of the head or Prosoma are two pairs of organs of sense: the Eyes (which may be supported on pedicles—Ommatophores), and the Tentacles. In the hæmal region the integument may be peculiarly modified and raised up at its edges into a free fold, either in front of or behind the anus, and when so modified it is called a Mantle (Pallium). In front of the anus again the Branchiæ (*t*) project as processes of the hæmal region. Among the internal organs we need only point out the position of the Heart (*u, v*), which lies in front of the branchiæ in the hæmal region; and the Nervous Ganglia (*x, y, z*), of which there are three principal pairs arranged around the alimentary canal, which they encircle by means of their commissures.

Such is the Common Plan of which all Molluscs whatsoever may be regarded as modifications; the next question is, to consider the laws according to which the plans of the great sub-classes of the *Mollusca* may be derived from it.

2. *Modifications of the Common Plan.*—The structural peculiarities of all known Molluscs may be very simply accounted for by the excessive or defective relative development of certain regions in the Archetype, more particularly of one or other parts of the Hæmal Region. Of this region the portion which lies in front of the anus may be conveniently termed the Abdomen, while to that which lies behind it the term Post-Abdomen may be applied. Now, if it be supposed that the Abdomen grows out of proportion to the rest of the body, constituting a kind of prominence, and that the intestine passes into the outgrowth so as to form a sort of loop (II.), it is clear that the open angle of this loop will be turned towards the Neural surface; and the intestine may be appropriately said to have a Neural flexure. On the other hand, if it be supposed that the Post-Abdomen grow out in the same way, and draws into itself a loop of the intestine, then the open angle of the loop will be in the opposite direction, that is, it will be directed towards the Hæmal surface; the intestine therefore may in this case be said to have a Hæmal flexure (III.). It will be readily understood that either Abdomen or Post-Abdomen may develop a mantle or not, and that the existence or absence of this mantle has nothing to do with the essence of the change in question, however much it may affect the external appearance of the resulting form.

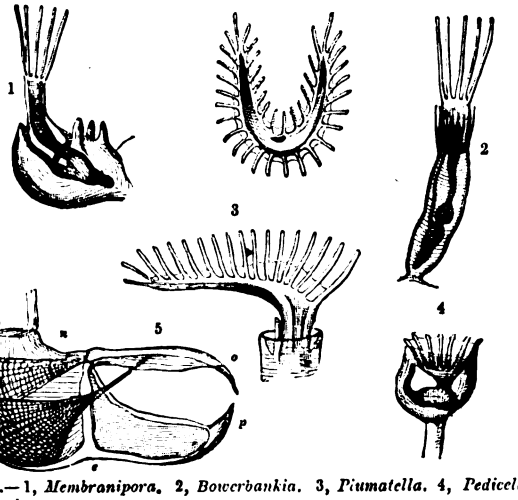
Again, the extent to which the Abdomen or Post-Abdomen is developed, may have a great influence on the relative position of certain organs of the Mollusc. Thus, in the first place, the position of the anus may become greatly altered. When there is a neural flexure it will acquire a direction towards the neural surface and backwards, the final approximation to the oral end depending on the amount of the development of the abdomen on the one hand, and that of the neural region on the other. Again, if the outgrowth of the abdomen take place, not symmetrically, but more or less on one side of the median line, the final position of the anus will be towards the opposite side and to the right or left, as the case may be.

It is even conceivable (this amount of modification indeed actually obtains in nature) that by an exceedingly one-sided development of the abdomen, the anus may be thrust quite round on to the hæmal side. Its final position therefore must not be regarded as certainly indicative of the direction of the flexure by which it obtained this position. Where there is a hæmal flexure again, the direction of the anus will be normally towards the hæmal (that is, dorsal) side, and forwards; its approximation to the head, its asymmetrical position, and the amount to which it may be thrust backwards and towards the neural side, depending upon conditions of the same order.

It is not merely the anus which is affected by these changes however; the branchiæ (and the heart which follows them) undergo similar transpositions, whose nature and origin it is very necessary to understand in order to appreciate their value as organic characters. M. Milne-Edwards long since pointed out the singular fact that, in certain Molluscs, the branchiæ are in front of the heart, while in others they are behind it. The latter he termed *Opisthobranchiata*, the former, *Prosobranchiata*. It will be seen that our Archetype is Opisthobranchiate. Now, it is easy to understand that if an Abdomen were developed in front of the heart, without involving the cardiac region, the Mollusc would remain opisthobranchiate; if however it were more extensively developed so as to involve the heart and branchiæ, the heart, from having been in front, would eventually take a position posterior to the branchiæ, and the Mollusc would thus become prosobranchiate. So with regard to the development of a Post-Abdomen; its effect on the position of the heart and branchiæ would depend wholly on the extent of hæmal surface which it involved. It follows, therefore, that Opisthobranchism may co-exist with either a hæmal or a neural flexure, or with none; while Prosobranchism indicates one or the other, but not which; and that these organic characters, however valuable, are secondary to and therefore of less importance than the neural and hæmal flexures (that is, development of an abdomen or post-abdomen), on which they depend. Dealing with the facts furnished by adult structure alone then, there are two primary modifications of the Molluscan Archetype, which may be shortly termed the Neural and Hæmal Plans. The *Cephalopoda, Pulmonata, Pteropoda, Lamellibranchiata, Brachiopoda,* and *Polyzoa*, are the molluscs which present madifications of the Neural Plan. The *Heteropoda, Gasteropoda, Tectibranchiata, Inferobranchiata, Cyclobranchiata, Tubulibranchiata, Nudibranchiata,* and *Ascidioida*, are those which present modifications of the Hæmal Plan.

3. *The Neural Plan and its Principal Modifications.*—Milne-Edwards has proposed a division of the *Mollusca* into the *Mollusca* proper, and the *Molluscoida* (*Molluscoides*), including under the latter class those Polype-like forms, the *Polyzoa* and the *Ascidioida*. Believing that the *Molluscoida* are as truly and wholly Molluscan as any other *Mollusca*, we nevertheless consider the distinction drawn by the eminent French naturalist to be very important, and that it should be retained as a primary subdivision of the great Hæmal and Neural Divisions. In the hæmal division the limits of the *Molluscoida* are the same for us, as for M. Milne-Edwards; but in the neural we include somewhat more. In fact, if the most fitting definition for this subdivision be those Molluscs which have the neural region comparatively little developed and the nervous system reduced to a single or at the most a pair of ganglia, while the mouth is usually surrounded by a more or less modified circlet of tentacles, then we shall find that, in the neural division, we must include the *Brachiopoda* with the *Polyzoa*. Commencing our study of the morphology of the special groups of the *Mollusca* with the Neural Division; and with the *Molluscoid* sub-division of the neural forms then, we have to consider first, the *Polyzoa* and the *Brachiopoda* :—

Fig. 2.



Polyzoa.—1, *Membranipora.* 2, *Bowerbankia.* 3, *Plumatella.* 4, *Pedicellina.* 5, *Avicularium.*

The *Polyzoa.*—Conceive the abdomen of the Archetype to be greatly prolonged, the neural region with its appendages, the organs of sense, and the heart, remaining undeveloped; so that the anus comes into close apposition with the oral extremity, while the edges of the latter are produced into long ciliated tentacles, and the result will be a Polyzoon, which needs only the power of gemmation to give rise to those composite aggregations which are so characteristic of the group.

The Polyzoic type itself presents five subordinate modifications in the five principal orders of the group :—the *Cyclostomata, Ctenostomata, Cheilostomata, Hippocrepia,* and *Pedicillinida.*

In the first three, the body of the Polyzoon when fully expanded is completely straightened, there being no permanent fold or inversion

of the integument. In the last two there is such a permanent inversion.

In the *Cyclostomata* the horny or calcareous deposit in the integument of the abdomen joins the soft parts by an even level edge, and there is nothing which serves as a cover or operculum, for the retracted Polyzoon.

In the *Ctenostomata* (*fig.* 2, 2) the margins of that portion of the abdomen which is inverted in the retracted state are produced into a toothed horny sheath, which can be retracted by special muscles, and which serves as an operculum.

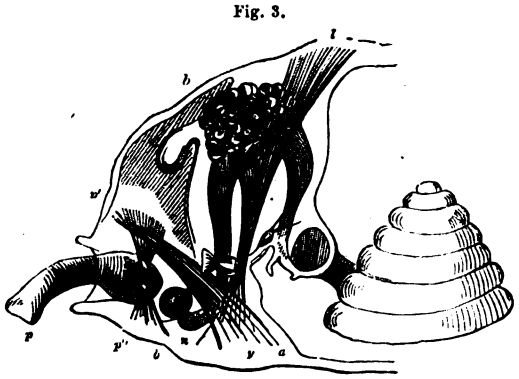
In the *Cheilostomata* (*fig.* 2, 1) the horny or calcareous deposit takes place in such a manner that the hardened integuments of the front portion of the hæmal region constitutes a sort of lid, regularly articulated upon the hinder portion, and provided with proper occlusor (and perhaps levator?) muscles. It should be noted that the anal aperture is directed away from this lid or operculum.

In each of the previous divisions the tentacles are arranged on a circular disc, or lophophore, of whose edges they are prolongations; but in the great majority of the *Hippocrepia* (*fig.* 2, 3), which are all fresh-water forms, the lophophore is so produced into two arms on the anal side as to assume a horse-shoe shape. It is important to consider this in connection with the peculiar features presented by the *Brachiopoda*.

Thirdly, we venture to regard the peculiar genus *Pedicellina* (*fig.* 2, 4) as constituting an order by itself. Essentially a Polyzoon, it is nevertheless distinguished from all other *Polyzoa* by the circumstance that its tentacles are united together by a membrane into a cup, which cup is never protruded far beyond the general boundary of the body.

The *Cheilostomata* are remarkable for possessing two kinds of moveable appendages—*Flabellaria*, whip-like processes, articulated to a bulb containing muscles by which they are moved; and *Avicularia* or bird's-head processes (*fig.* 2, 5). The structure of the latter is of great interest in a morphological point of view, and demands particular attention. They consist of a larger piece, or valve (*p*), shaped like a bird's head and produced into a longer or shorter process of attachment, to which a smaller valve (*o*), representing the bird's lower jaw, is articulated. Stalked or sessile, these avicularia present during life an incessant snapping action, produced by the alternate contraction of two sets of muscles, which arise from the concavity of the 'skull' of the bird's head by wide fan-shaped origins, and seem to be inserted by narrow tendons into the smaller articulated valve. The one tendon (*e*) is inserted into the smaller valve in front of the line of articulation, and the other (*n*) behind it, and therefore by their alternate action they raise and depress the lesser valve upon the larger.

Fig. 3.



Rhynchonella psittacea.

a, oral aperture; *b*, anal aperture, or extremity of the intestine; *l*, adductor muscles of *Brachiopoda*; *n*, cardinal muscles of *Brachiopoda*; *p*, pedicle; *p' p''*, pedicle muscles; *y*, pedal ganglion.

The *Brachiopoda*.—Now, if we compare the relative positions and mode of articulation of the operculum and cell of a Cheilostomatous Polyzoon, or of the two valves of an avicularium, with those which obtain in the shells of the typical *Brachiopoda*, such as the *Terebratulidæ* and *Rhynchonellidæ*, the resemblance will be found to be very striking; and still more so, if in addition the arrangement of the muscles be taken into consideration. In such a Brachiopod, in fact (*fig.* 3), the shell is composed of two valves—one large, excavated, and produced into a canal or tube, through which a pedicle of attachment passes; while the other is smaller and more or less flattened. The two valves are articulated together by means of a socket in the smaller valve and a tooth in the larger, on each side, the intermediate space being free, just as the operculum of the Polyzoon is united with its cell, or as the lesser valve of an avicularium is articulated with the larger. So likewise the anal extremity of the Brachiopod is turned from the smaller valve. Then the arms of the Brachiopod are essentially comparable to those of the lophophore of a Hippocrepian Polyzoon, except that their direction is different; the calcified supports to which they are fixed in many *Brachiopoda*, are so variable in form and so extensively absent in others, that their existence can in nowise affect the homology of the parts. Again, if we leave out of consideration the pedicle-muscles (which are however, in all probability, as Mr. Hancock as shown, the homologues of the retractors of the *Polyzoa*), the arrangement of the other muscles is precisely what we have seen to obtain in the avicularium: the adductors which pass from the larger valve to be inserted into the smaller, in front of its point of support, corresponding precisely with the occlusor muscles of the avicularium; while the cardinal muscles, which arise from the larger valve, and pass to be inserted into the cardinal process of the smaller, behind the point of support, are identical with the divaricator muscles of the avicularium.

The existence of distinct muscles for the purpose of separating the valves of the shell is characteristic of the *Polyzoa* and *Brachiopoda*, the only approximation to such an arrangement at present known among the *Lamellibranchiata* being presented by the *Pholades*.

Finally, if the great proportional size of the *Brachiopoda*, their pedunculated attachment, their thick and solid shells, and their simple forms, be brought forward as arguments against the view we take of their essentially polyzoic nature, we would remind the objector of the like opposition in such features between *Boltenia* and *Botryllus*, or *Aplidium*, among the Ascidians.

Two principal modifications of the common Brachiopod plan are to be observed. In the *Terebratulidæ* and *Rhynchonellidæ*, and in all probability in their extinct allies the *Spiriferidæ*, *Orthidæ*, and *Productidæ*, the muscles are always arranged in three sets—Adductor, Cardinal, and Peduncular. At the same time the mantle (whose homology with the produced edges of the non-retractile part of the abdomen of a Polyzoon is at once appreciable), though divided into two distinct lobes in front, is continuous and entire behind, that is, towards the peduncle. A still more remarkable feature in their organisation is that, at least in *Waldheimia* and *Rhynchonella*, there is no anal aperture, the intestine terminating in a cœcum directed towards the middle of the large valve.

In the *Craniadæ*, *Discinidæ*, and *Lingulidæ* the muscles have a very different arrangement, which could only be rendered intelligible by detailed descriptions and illustrations, as the homologies of these muscles with those of the other division are not yet determined. The lobes of the mantle again are completely separated (*Discina*, *Lingula*, *Crania*?), and the intestine opens upon one side of the body between these lobes. There are no teeth, and the articulation of one valve with the other and the modes of attachment vary remarkably; *Lingula* having a long peduncle; *Crania* being attached by the surface of its lower valve; and *Discina* having an aperture in the corresponding valve through which a portion of the adductor passes, and spreading out at its extremity into a sort of plug, acts as a pedicle.

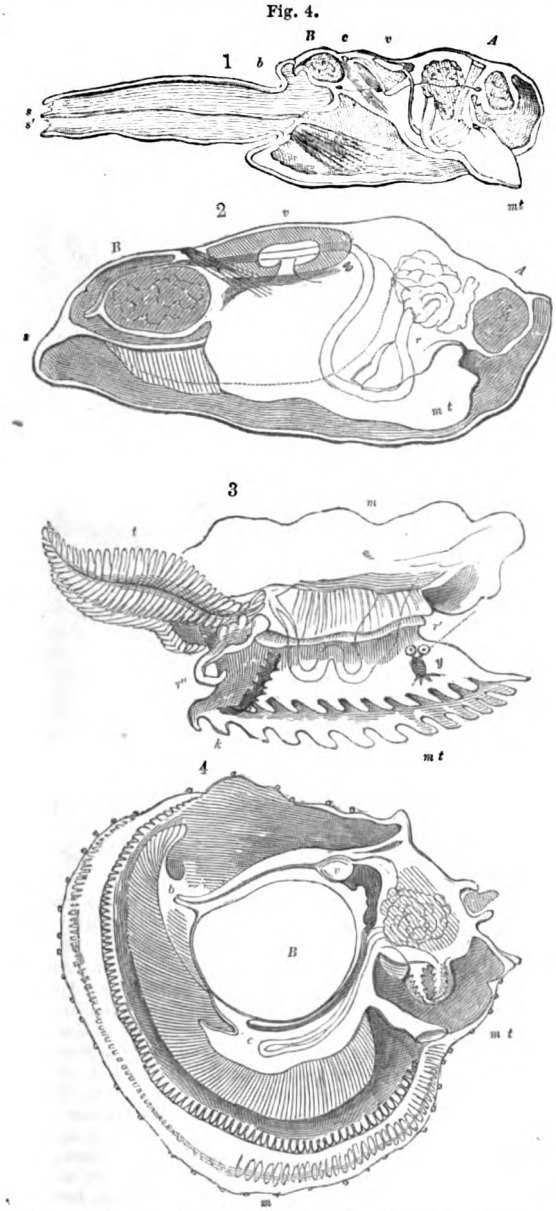
Neural Mollusca.—The *Lamellibranchiata*. In all *Mollusca* proper the neural region is developed to a much greater extent than in the *Molluscoida*, and there are always three pairs of ganglia, two Cerebral, two Pedal, and two Parieto-Splanchnic (or branchial). The especial characters of the *Lamellibranchiata*, as modifications of the Archetype, are the following:—The hæmal region is well developed in its abdominal portion, but forms no prominent sac-like abdomen, into which the viscera enter in the adult condition. Its edges are produced into extensive pallial lobes, which are arranged on each side of a longitudinal plane, and not above and below a horizontal one (or more properly before and behind a transverse one), as in the *Brachiopoda*. The mouth is surrounded by a fringe, representing the tentacles in the *Molluscoida* (as may be well seen in *Pecten*, *fig.* 4, 4) which is produced laterally into elongated 'palps,' but is totally unprovided with any manducatory apparatus. The intestine passing from the stomach either forms a simple loop with a second open angle directed hæmally, or this loop may be much coiled and convoluted: the intestine finally passing over the great posterior adductor and terminating between the lobes of the mantle behind it.

The foot may be more or less largely developed, but never presents any clear distinction into pro- meso- and meta-podium, unless indeed, as we are inclined to suspect, the whole free portion of the foot of the *Lamellibranchiata* ought to be regarded as a modified metapodium. Besides the pedal muscles, the Lamellibranchs possess one or two characteristic muscles—the adductors, which approximate the valves of the shell, and whose greater or less development seriously affects the ultimate form of the animal.

The gills deviate but little from their archetypal form and position in some Lamellibranchs, such as *Trigonia* and *Pecten*, being merely thrown downwards by the development of the mantle. In *Nucula* (*fig.* 4, 3), their inner edges are united posteriorly, but they remain comparatively small. In the majority of Lamellibranchs however, the gills are exceedingly large in proportion to the rest of the body, and consist of two double plates, which are united with the mantle and with one another, in such a manner as to divide the pallial cavity into two chambers, a supra- and infra-branchial, which communicate only by the passage between the anterior edge of the branchiæ and the foot, and by the multitudinous perforations in the branchial plates themselves.

It is in the absence of external organs of sense or of any buccal masticatory apparatus, and in the peculiar arrangement of the gills, that the main difference between the *Lamellibranchiata* and the *Gasteropoda* lies; and hence the great resemblance which the ideal section of

Fig. 4.



Lamellibranchiata.—1, *Lutraria*. 2, *Unio*. 3, *Nucula*. 4, *Pecten*.

a, oral aperture; *b*, anal aperture, or extremity of the intestine; *c*, renal organ; *m*, mantle; *r*, labial palpi; *s s'*, anal and branchial siphons; *t*, branchiæ; *v*, ventricle; *y*, pedal ganglion; *A*, anterior adductor; *B*, posterior adductor.

a typical Lamellibranch bears to a typical Gasteropod. Compare (*fig.* 4) 4 with with 1, 3, and 2.

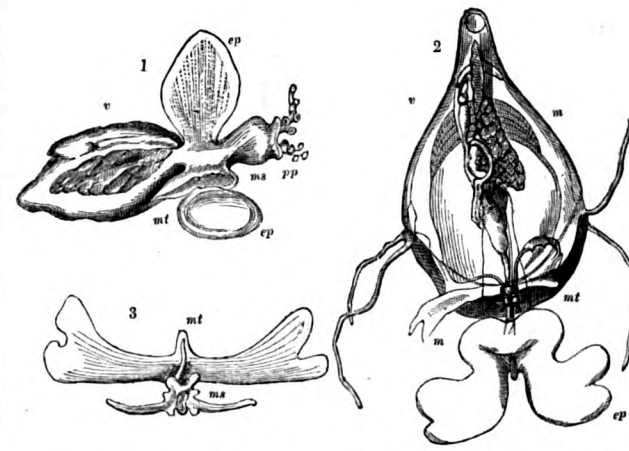
It may seem at first sight inconsistent with our own principles to consider as neural molluscs these Lamellibranchs, which confessedly have the principal loop in the intestine open to the hæmal side. But the position of the largely-developed mantle, completely in front of the anal aperture, and the direction of the aortic end of the heart, unchanged from what is observable in the Archetype, are sufficient, apart from developmental considerations, which will be adduced by and bye, to prove that the second flexure of the intestine in this case is to be considered accidental, the result of the great development of the mesosoma, to serve as a chamber for the viscera, and of the enlargement of the great posterior adductor, thrusting up the rectum which passes over it.

As for the leading varieties of form of the Lamellibranchs, there are none which, in reality, depart very widely from the Common Plan. Perhaps *Teredo* or *Pholas*, on the one hand, and *Ostræa*, on the other, may be regarded as the extreme forms, the former being as much as possible elongated longitudinally, the latter attaining the extreme of concentration about a centre. At the same time there is a reduction of parts to a minimum, as shown in the absence of a second adductor, and of any foot in the adult state. The differences between these forms are however decidedly less than those which may be observed between the extreme forms among the *Cephalopoda* or *Gasteropoda*.

The *Pteropoda* and *Pulmonata*.—The Lamellibranchs are, as we have said, curiously exceptional in presenting the general features of the *Mollusca* proper, without that singular buccal apparatus which we meet with in all other members of the subdivision, whether neural or hæmal, and whose peculiar nature is described below. Again, they are exceptional in the vast development and symmetrical longitudinal division of their mantle, and in the corresponding division of their pallial shell into two pieces or valves—characters we shall not meet with again in any modification of the Common Plan.

In the *Pteropoda* and *Pulmonata* the mantle is never developed into such lateral lobes, and the shell to which it gives rise never consists of two pieces, but is constituted by a single mass, which either has the form of a flat plate or presents some modification of a cone. Again, the foot (or some part of it) is always well developed, presenting no obvious distinction into regions in the *Pulmonata;* but in the *Pteropoda* often exhibiting a well-marked meso- and meta-podium, and always presenting a characteristically large epipodium—an organ which in these Molluscs constitutes the so-called 'wings,' from which their name is derived.

Fig. 5.



Pteropoda.—1, *Pneumodermon*. 2, *Cleodora*. 3, *Psyche* (foot and head only). Letters as in figure 1.

There is usually a well-developed mantle in the *Pteropoda* and *Pulmonata*, and its walls act as a branchial surface without being produced into true gills—(*Hyalæa*?)—the sea-water in the marine *Pteropoda* and the air in the terrestrial and aquatic *Pulmonata* being inspired and expired into its cavity.

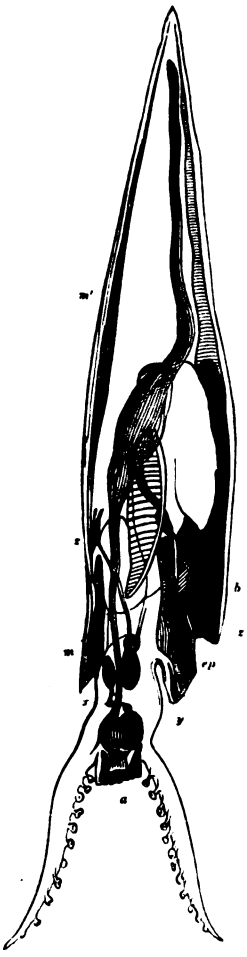
In the *Pteropoda* in general, the aperture of the pallial cavity and that of the anus, are situated upon the posterior surface of the body, in accordance with the neural flexure of the intestine. The anal aperture however is usually thrust to one side of this surface, and, in *Limacina* and *Spirialis*, this lateral thrust has taken place to such an extent, that not only the anal aperture, but that of the mantle cavity, is thrown up completely on to the dorsal surface. This latero-dorsal, or dorsal position of the anal and respiratory apertures, is as regular in the *Pulmonata* as it is exceptional in the *Pteropoda*.

In the *Pteropoda* and *Pulmonata* some most important modifications of form are produced by the greater or less development of the mesosoma on the one hand and of the mantle on the other. The predominance of the latter is to be observed in such forms as *Criseis*, *Cleodora*, *Hyalæa*, and *Helix;* while the former may be seen in *Pneumodermon* and in *Limax*. In the latter the mantle is very small, and in the former it is almost if not entirely absent; what is ordinarily considered as the mantle in this mollusc being in fact nothing more than the mesosoma. The like confounding together of parts so essentially different has taken place, we shall find, in the *Nudibranchiata* and in the *Heteropoda*.

The *Cephalopoda*.—In the Pteropod forms, *Pneumodermon* and *Clio*, a hood, giving off long processes covered with suckers from its inner surface, surrounds the oral aperture, and there is every reason to believe corresponds with the propodium, whose lateral halves have united over the mouth. If the like process were to take place in a *Criseis*, but to a greater extent, so that the mouth were thrust back between the halves of the mesopodium, and the propodium and mesopodium formed one continuous tentaculigerous sheath around the oral aperture; and if at the same time the two halves of the epipodium united posteriorly into a funnel-shaped tube, the *Criseis*, so far as its external organisation goes, would no longer be a Pteropod, but would have become a Cephalopod. In fact, the Cephalopod may be derived from the Archetype by supposing these modifications. The mantle is always well developed, and its cavity incloses one or two pair of gills. The two halves of the epipodium are united behind into what is called the funnel, a peculiar apparatus, of great importance in the economy of many Cephalopods; and in the majority of the group the sides of the foot, having united in front of, and forming a

complete sheath for the head, are produced into eight or ten processes, the so-called arms, on which are set the acetabula, or suckers.

Fig. 6.



Vertical Section of *Loligo media*.

a, oral aperture; *b*, anal aperture, or extremity of the intestine; *m*, mantle; *m'*, shell; *t*, branchiæ; *x*, cerebral ganglia; *y*, pedal ganglia; *z*, parieto-splanchnic ganglia; *ep*, funnel.

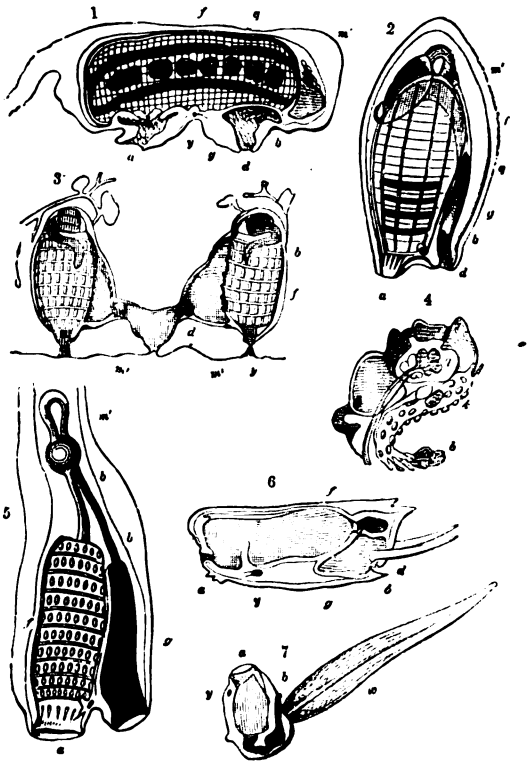
Beyond this peculiar arrangement and development of the external organs, we are not aware that any characters exist by which the *Cephalopoda*, as a class, can be distinguished from the other *Mollusca*. Among themselves they present a remarkable harmony, differing chiefly in the number of their branchiæ, in the internal or external position of their shell, and in the nature of the appendages into which the edges of the foot are modified—characters which do not attain to ordinal importance in other divisions of the *Mollusca*.

Having thus glanced at all the leading modifications of the Neural Plan, we may next turn to the Hæmal Plan, commencing with its Molluscoid modification constituted by the *Ascidioida* alone.

The *Ascidioida*.—As a Molluscoid group, the Ascidians are characterised, in the first place, by the rudimentary condition of their whole neural region, and by the reduction of their nervous system to a single infra-œsophageal ganglion. Besides these however, their organisation presents certain characters which appear at first sight very remote from such a Common Plan as has been described, and hardly deducible from it. An Ascidian, in fact, is usually fixed by one extremity of its body, and presents at the other two apertures. One of these leads into a wide cavity, whose entrance is fringed with a circlet of tentacles, and whose walls (except along the middle line anteriorly and posteriorly) are perforated by innumerable ciliated apertures, and often thrown into folds, by which their surface is greatly increased. At the bottom of this cavity—the branchial sac—a second wide aperture leads into the alimentary canal, which invariably presents a hæmal flexure, and then almost always bends backwards neurally to terminate in a second wide cavity. This, the *atrium*, whose more external portion is usually termed the *cloaca*, opens externally by the second or cloacal aperture, and extends along each side of the branchial sac up to its median line of attachment—communicating freely with its cavity by means of the small ciliated

apertures which have been mentioned. The single ganglion lies between the oral and cloacal apertures.

Fig. 7.



Ascidioida.—1, *Boltenia*. 2, *Cynthia*. 3, *Botryllus*. 4, Intestine of *Perophora*. 5, *Clavelina*. 6, *Salpa*. 7, *Appendicularia*.

a, oral aperture; *b*, anal aperture, or the extremity of the intestine; *d*, cloacal aperture and atrium; *f*, branchial sac; *g*, hypo-pharyngeal band; *m'*, test; *q*, genitalia; *y*, pedal ganglia.

Now, in what manner is this form derivable from the Archetype? It is to be remarked, in the first place, that the pharynx, large in the *Polyzoa*, becomes comparatively enormous in the Ascidians; while the tentacles, which were very large in the *Polyzoa*, are in the Ascidians comparatively small. Next, with the development of a post-abdomen, the intestine acquires a hæmal flexure; but instead of the anal aperture remaining on the hæmal side, it is bent round, by the same process as in *Spirialis* and *Limacina*, but in the inverse direction. Suppose with all this that a mantle has been developed, and that its free margin remaining small and narrow, has followed the anus to the neural side, while its cavity has extended up on each side of the pharynx to the middle line of the hæmal surface of the latter, carrying to a great extent a process of which the outline may be seen in *Cymbulia*, and giving rise to the atrium;—imagine also that the sac thus constituted externally by the inner surface of the mantle (third tunic), and internally by the pharynx, becomes perforated by minute apertures—and the result would be an Ascidian.

Such is the manner in which the Ascidian type is derivable from the Common Plan. Of this type the group presents three subordinate modifications. The first is that presented by the extraordinary and instructive genus *Appendicularia* (*fig.* 7, 7), which in a manner represents permanently the larval state of the more perfect members of the group—swimming by means of a long rapidly-vibrating tail, like that of a tadpole. In *Appendicularia* there is no cloacal aperture or atrium. The mouth opens into a wide pharynx representing the branchial sac of other Ascidians; from this a gullet leads into the stomach. The narrower intestine passes from the stomach, forwards and to the hæmal surface, where it terminates without bending downwards, and without being surrounded by any special cavity. *Appendicularia* therefore might be said to be a form in which the process of modification of the Molluscan Archetype into the Ascidian Type is arrested half way.

In all other Ascidians this process is complete, and there is a distinct cloacal aperture and atrium; but these forms again may be arranged under two great sub-typical modifications, according to the development of the branchial sac relatively to that of the post-abdomen. In such forms as *Cynthia*, *Boltenia*, *Perophora*, *Botryllus*, the branchial sac attains so great a proportional size as to occupy the whole, or nearly the whole, length of the body, the intestine lying on one side of it: these might therefore be well denominated *Ascidiæ Branchiales*, Branchial Ascidians. On the other hand, in *Clavelina*, *Aplidium*, *Polyclinum*, *Salpa*, the alimentary canal lies completely behind the

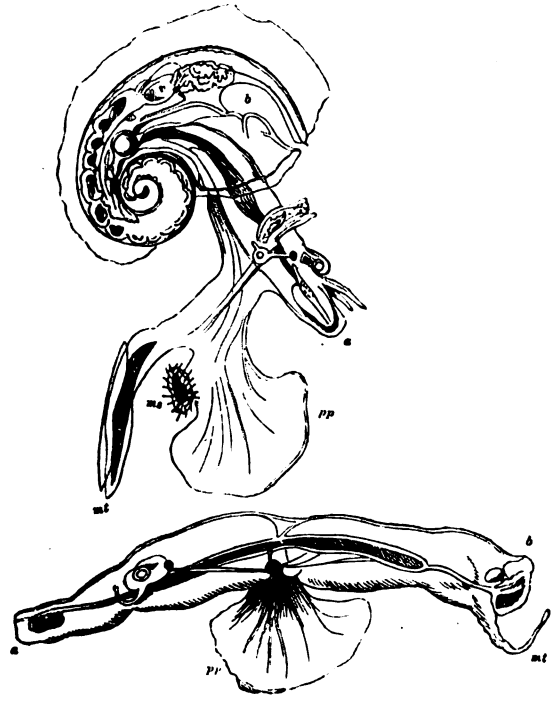
branchial sac, which is proportionally small, and these might therefore be termed *Ascidiæ Intestinales*, Intestinal Ascidians. A very complete mutual representation will be found to obtain between the members of these two groups.

Hæmal Mollusca.—In passing from the Hæmal *Molluscoida* to the Hæmal *Mollusca*, we find the same new features presenting themselves as in the Neural Division, the transition being even more abrupt, from the absence of any representative of the *Lamellibranchiata*. In all these *Mollusca*, in fact, there is a more or less well-developed foot; a distinct head, with its organs of sense and buccal armature; and three pairs of ganglia—cerebral, pedal, and parieto-splanchnic.

The modification of the Common Plan is carried to a less extent in this than in the Neural Division, the chief varieties of its forms depending on the changes in the shape of the shell with which the majority are provided; on the greater or less development of the different regions of the foot; but most of all in the relative proportions of the mesosoma and mantle.

If we divide the Hæmal *Mollusca* into two great groups—the one consisting of the *Heteropoda*, *Scutibranchiata*, *Tubulibranchiata*, *Pectinibranchiata*, and *Cyclobranchiata*, families which are most intimately allied, and which are connected as a group by the dicœcious arrangement of their reproductive organs; and the other of the *Nudibranchiata*, *Inferobranchiata*, and *Tectibranchiata*, families in like manner united, among other characters, by their common hermaphrodism, then we shall find in each such group two extremes of form—the one resulting from the great development of the pallial region, the other from that of the mesosoma. In the Dicœcious Division, *Dentalium*, *Vermetus*, *Atlanta*, and the ordinary *Pectinibranchiata* may be regarded as examples of the former case; and in the Monœcious Division the *Inferobranchiata* and *Tectibranchiata;* while the mantle becomes rudimentary or absent altogether in the Dicœcious *Firoloides*, in the Monœcious *Phyllirhoë*, and the *Nudibranchiata* in general, where the region from which the so-called branchial processes arise, and which is commonly called the mantle, is not the homologue of the mantle of *Atlanta* for example, but of its mesosoma, which here, as in *Firoloides*, constitutes the main portion of the body.

Fig. 8.



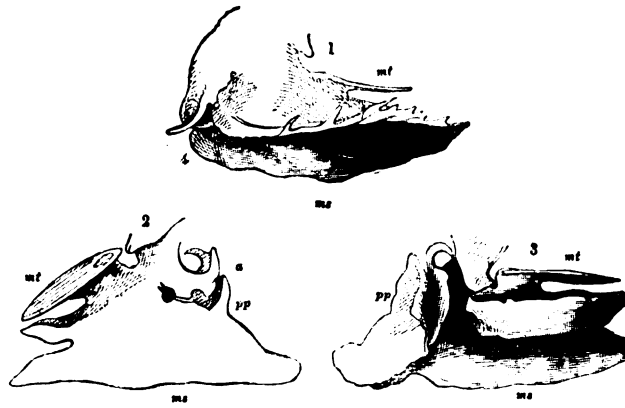
Heteropoda.—8, *Atlanta;* 9, *Firoloides.*

a, oral aperture; *b*, anal aperture, or the extremity of the intestine; *mt*, mantle; *ms*, mesopodium; *pp*, propodium; *v*, ventricle.

The foot in the Monœcious Hæmal *Mollusca* rarely presents any special development of its different regions, except that in certain forms—namely, *Aplysia* and *Gasteropteron*—the epipodium is as well marked as in the *Pteropoda*, and serves the same end in locomotion. This is well known in *Gasteropteron*, and we have seen a tropical *Aplysia* 'fly' through the water in precisely the same way as a Pteropod would do. These epipodial lobes have been frequently called mantle, although the true mantle is a most distinct and obvious structure.

In the Dicœcious group the epipodium is never well developed, presenting itself at most under the form of little lobes and processes —at least it would seem probable that the neck-lappets and head-lappets of the *Trochidæ* are rudiments of the epipodium. On the other hand, it is in this group that the propodium, mesopodium, and metapodium attain their most complete and distinct form; as in *Atlanta*, where the propodium constitutes the anterior flattened fin, the mesopodium the rounded sucking disc, and the metapodium extends backwards, as the tail-like lobe which carries the operculum. In *Firoloides* we find that the mesopodium has vanished, and the metapodium has taken the form of a mere filament, while the propodium constitutes the great swimming fin.

Fig. 9.



Foot of *Pectinibranchiata.*—1, *Trochus*; 2, 3, *Natica.*

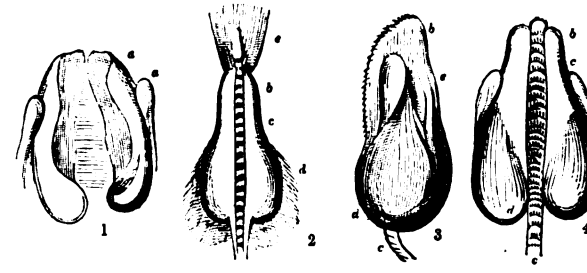
a, oral aperture; *mt*, metapodium; *ms*, mesopodium; *pp*, propodium.

In the ordinary *Pectinibranchiata*, on the other hand, the foot may not be differentiated into its subdivisions at all, the metapodium being marked only by the position of the operculum, when this exists, as in *Buccinum*. In other cases, as in *Oliva* and *Sigaretus*, a deep cleft marks off a very distinct propodium from the conjoined mesopodium and metapodium; in others, as in *Pteroceras*, the metapodium is as specialised as in *Atlanta;* while again, in such forms as *Natica*, the three constituent parts are distinguishable—the propodium constituting the hood in front of the head; the mesopodium the creeping disc; and the metapodium the operculigerous lobe. (*Fig.* 9, 2 and 3.)

Having thus passed in review those modes of arrangement of the various organs of the *Mollusca* which constitute the Common Plan of the group and the subordinate plans of its leading subdivisions, we have next to consider the peculiarities presented by these organs themselves, or, in other words, those more striking features in which the organs of the *Mollusca* differ from those of the *Vertebrata*, *Annulosa*, and *Radiata*. The most important organs, in this point of view, are those of—1, the Alimentary; 2, the Circulatory; 3, the Respiratory; 4, the Renal; and 5, the Nervous System.*

1. The Alimentary Organs, in certain *Mollusca*, present two kinds of apparatus which are met with in no other division of the Animal Kingdom. The first of these is that peculiar manducatory instrument usually called the 'tongue,' which is possessed by all the *Mollusca* proper, except the *Lamellibranchiata;* and for the first description of whose true structure and mode of action we are, we believe, indebted to Mr. Thompson (see article 'Tongue,' in the 'Cyclopædia of Anatomy and Physiology'), although the organ itself had been more or less an object of attention ever since the time of Cuvier.

Fig. 10.



Tongue of *Patella.*

1. *a a*, the cartilaginous plates which constitute the pulley over which the elastic plate 2, *b*, supporting the series of teeth *c*, plays; *d* and *e* are the anterior and posterior insertions of the intrinsic muscles of the tongue. 3 is a side view, and 4 a view from above, of the entire apparatus.

The tongue is essentially composed of a cartilaginous mass, with a pulley-shaped upper and anterior surface, which projects from the bottom of the oral cavity. An elastic plate plays over the pulley, and is attached at each end to muscles which arise from the upper and

* Our limits preclude the consideration of the tegumentary and genital systems, whose peculiarities however are less exclusively Molluscan.

lower surfaces of the cartilaginous mass. Along the middle line of this elastic plate successive transverse series of strong recurved teeth are set—new ones being continually formed behind as the old are worn away—in a sort of persistent dental sac.

When the tongue is brought into play it is protruded by appropriate muscles from the cavity of the mouth, and its extremity is firmly applied against the body to be rasped. The superior and inferior sets of muscles, which are inserted into the corresponding ends of the elastic plate, now contract alternately, and the resulting action is precisely that of a circular saw. It is by means of this apparatus that the Carnivorous *Mollusca* bore through the shells of the animals upon which they prey; and perforated shells which have been thus emptied abound on every coast.

The other appendage of the alimentary canal peculiar, so far as we at present know, to the *Mollusca*, is what is termed the Crystalline Style, a transparent, usually elongated body, which projects by one end into the stomach, and is lodged for the rest of its extent in a sac formed by a diverticulum of that organ. The Crystalline Style is found in a great number of Lamellibranchs (to which group it has erroneously been supposed to be confined), but has hitherto been observed in only a few Pectinibranch *Mollusca*, such as *Pteroceras*, *Strombus*, *Trochus*, and *Murex*. Its function is wholly unknown.

Among the alimentary appendages, the Liver in one group, the Ascidians, departs sufficiently from the ordinary plan to deserve particular notice. In these animals (*fig.* 7, No. 4, *k*) it always consists of a series of narrower or wider anastomosing tubules, commencing in cœca upon the outer surface of the intestine, which they envelope in a close network, and terminating by a narrow duct in the stomach. In the *Botryllidæ* the hepatic tubules are remarkably wide.

2. The nature of the Circulatory System in the *Mollusca* is at present in some respects a vexed question, more especially as regards the important point whether they possess a true closed system of vessels or not. Without entering into any discussion of the various arguments used on both sides of a dispute which is in some respects verbal, we may be permitted shortly to state our own conclusions on the subject.

In the *Polyzoa* there are no special circulating organs, if we except the cilia with which the perivisceral cavity is often lined, and which keep up a continual current in the perivisceral fluid; nor do we imagine that any one will insist that in them the perivisceral cavity is not a sinus, but has a truly venous lining membrane.

In the *Ascidians* there is a heart, but it is a simple muscular sac, open at each end, and possessing the extraordinary power of reversing the direction of its contractions, and thus circulating its blood first in one way and then in the opposite. The blood thus poured out is driven through channels in which assuredly no separate lining membrane is demonstrable. Indeed it is difficult to comprehend how any one with a living Ascidian under his microscope can question that here, at any rate, the circulation takes place through lacunæ, and not through vessels with distinct walls.

In the *Brachiopoda* a very remarkable vascular system has been said to exist, consisting of two hearts (in *Rhynchonella* of four), each composed of an auricle and a ventricle; the former being in free communication with the perivisceral venous sinuses (perivisceral cavity, *nobis*), while the latter ends in an aorta, whose branches undergo a regular distribution. Such is the circulatory system in the *Brachiopoda* according to Professor Owen; but our own inquiries have tended to strengthen very greatly the doubts first raised by Mr. Hancock as to the true nature of this so-called circulatory system. In fact these inquiries lead us to doubt whether the so-called 'hearts' of the *Brachiopoda* have anything at all to do with the circulating system; inasmuch as, in the first place, we are pretty confident that no 'arteries' are given off from the apices of the 'ventricles,' as has been said, and think it more than probable that they open externally. Secondly, there is no evidence at present, either indirectly from structure or directly from observation during life, that the so-called 'hearts' of any Brachiopod are contractile. Thirdly, the multiplication of these hearts to four in *Rhynchonella* seems not a little to militate against their cardiac nature.

We may fairly conclude then that, for the present, the nature of the circulatory system in the *Brachiopoda* must be regarded as an open question.

Mollusca Proper.—The doctrine first advocated by M. Milne-Edwards that in these Molluscs the circulating system is always more or less incomplete, has met with a wide acceptance, but also with no small opposition. So far as the minute transparent Molluscs, which can be submitted to direct microscopical observation during life, are concerned, we do not understand how the truth of M. Milne-Edwards's doctrine can be questioned. If the term 'venous lining' is to have any meaning but a non-natural one, assuredly it cannot be said with truth that anything of the kind exists in the sinuses of *Firoloides*, or of *Atlanta*, or in those of the *Pteropoda*.

In the larger *Mollusca*, on the other hand, much depends on the verbal question—what is the definition of a 'vein,' or 'venous membrane?' If a lamina of connective tissue separable from the surrounding parts be a venous wall, then doubtless the venous blood-channels of many Lamellibranchs and Gasteropods, and perhaps of all Cephalopods, are veins. If on the other hand a greater histological differentiation corresponding to that which exists in the *Vertebrata* be required to constitute a vein, evidence of the existence of anything of the kind in the greater proportion of the venous blood-channels of these creatures is at present wanting.

As regards the grosser structure of the circulatory apparatus in the *Mollusca* proper, it may be observed that, in the *Lamellibranchiata* there is either a single auricle and a single ventricle (*Ostræa*), a single ventricle and a double auricle (most Lamellibranchs), or two auricles and two ventricles (*Arca*). In all other *Mollusca*, except the *Cephalopoda*, there is a single auricle and a single ventricle. In the *Cephalopoda* the heart is essentially similar to that of the Lamellibranchs, inasmuch as it consists (in the *Dibranchiata*) of a single ventricle and of two contractile, so-called 'Branchio-Cardiac Veins,' which represent the two auricles of the Lamellibranchs. The circulation in these creatures is assisted (at least in *Loligo media*, in which we lately had opportunities of convincing ourselves of the fact), not only by the regular contraction of the so-called 'branchial hearts,' which are dilatations of the afferent branchial veins, but by that of the gills themselves.

The nature of the so-called Pericardium in the *Mollusca* has been much misunderstood. It is most important to recollect that in no case is there evidence of its being a closed serous sac comparable to the pericardium of the higher animals. On the contrary, wherever it has been examined with sufficient care (*Lamellibranchiata*, *Pteropoda*, *Heteropoda*, *Nudibranchiata*, and *Cephalopoda*), it has been found to be a blood-sinus, which in some cases (*Pteropoda*, *Cephalopoda* (?), *Lamellibranchiata* (?), and *Heteropoda*) communicates with the exterior by the mediation of the renal organ.

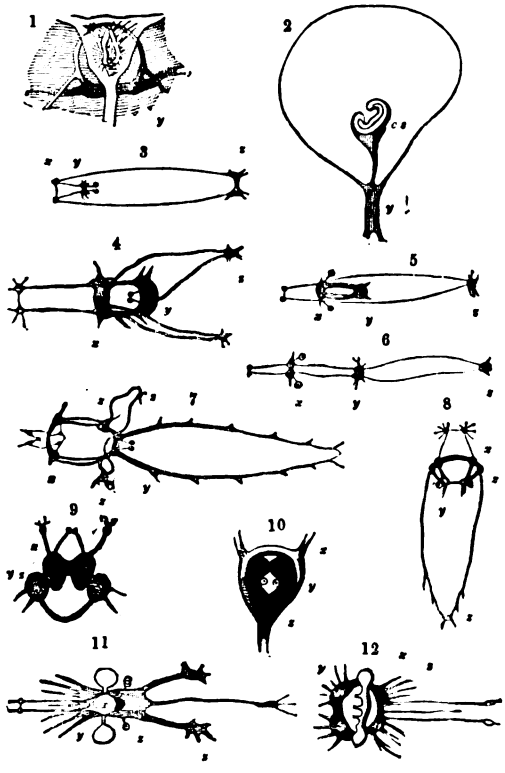
3. The Respiratory Function is performed by modifications of several distinct parts in the *Mollusca*.—1. By the general surface of the pallial cavity, which may be more or less adaptively modified: this kind of respiratory organ is to be found in the *Brachiopoda*, *Pteropoda*, and *Pulmonata*. 2. By specially modified parts of the walls of the pallial cavity into true gills: the whole tendency of the modification of form which these gills undergo is to increase their surface, and this end, generally speaking, is effected in one of three ways:—*a.* By the development of simple processes, as in *Patella* or *Atlanta*. *b.* The simple processes become ramified, so that the gill eventually consists of a stem with lateral branches, and these again may be subdivided into smaller and smaller branchlets—*Pectinibranchiata* and *Cephalopoda*. *c.* In the *Lamellibranchiata* each gill essentially consists of a stem with lateral undivided branches, and in such forms as *Trigonia* and *Nucula* (*fig.* 4, No. 3, *t*.); the branchiæ have precisely this structure. In *Nucula* the lateral branches are comparatively short, but in *Trigonia* they are much longer. In *Pecten* they turn up at their free ends upon themselves and form a close loop, so that the free end takes a position near the fixed extremity; at the same time lateral processes are given off from the branches which unite and connect them together by a very loose and open vascular network. Each gill has thus become a flattened pouch, completely open, both laterally and superiorly; the sides of the pouches are very open, and are constituted superficially by the parallel produced and reflected portions of the gill-branches, and more deeply by the very loose network formed by the anastomosing lateral processes. Now, if we suppose that the reflected portion of the outer gill-pouch adheres to the mantle, while the reflected portion of the inner gill-pouch remains free on each side of the foot, but adheres to its fellow behind the foot, thus forming a complete partition across the pallial cavity, the deep vascular network becoming very close, and giving off vertical septa, by which the pouch becomes divided into successive antero-posterior chambers; then the result will be such a gill as we meet with in the Oyster, the *Unio*, and the great majority of *Lamellibranchiata*. The minute structure of these branchiæ strikingly resembles that of the branchial sac of the Ascidians, as has been long since pointed out by Siebold and others, and has given rise to the prevalent idea that the two organs are homologous. Structural resemblance, however, is in itself no true basis for the establishment of homologies, and here there are abundant means of demonstrating the resemblance to be simply analogical. 3. The 'branchiæ' of the *Nudibranchiata* again doubtless subserve respiration, but they are developed from the mesosoma, and contain the gastro-hepatic processes of the alimentary canal—features by which they are essentially distinguished from true gills. 4. The branchial sac of the Ascidians is, as we have shown, a modification of their pharyngeal sac, resembling the gills of fishes (especially *Amphioxus*) more than any structure to be found in other *Invertebrata* (the nearest approximation perhaps is in the cloacal branchiæ of Neuropterous Larvæ and of some Annelids). Like the wall of the gill-pouch of *Lamellibranchiata*, that of the branchial sac of the Ascidians is fundamentally composed of two elements—a superficial strong framework of branchial bars corresponding with the 'gill-branches,' and a deeper vascular network connecting these. The more obvious peculiarities in the structure of the branchial sac of Ascidians are produced by the plaiting of its wall into the so-called branchial folds, which may vary in number from four (*Cynthia*) to a number so great that the wall of the sac appears crimped (*Phallusia*).

4. The Renal Organs.—The existence of a special organ for the urinary secretion has now been demonstrated in all the great divisions of the *Mollusca* except the *Polyzoa* and *Brachiopoda*. The essential feature

of the molluscan kidney is the deposition of a quantity of urinary excretion beneath a free surface, which in all aquatic *Mollusca* is, by some means or other, freely bathed with water. In *Phallusia*, for instance, minute rounded sacs, each clothed with a delicate epithelium, and containing one or many concretions, are scattered over the intestine immediately beneath the lining of the atrial cavity. It is probable that the constant current setting through this cavity carries away some portion of the secretion; but the greater part seems to remain, and eventually coats the whole parietal surface of the atrium. Here the secreting part of the apparatus appears to be out of proportion to the excretory. In the *Pteropoda* and *Heteropoda* the reverse relation would appear to obtain. In these animals in fact the concretions have not yet been detected; but the excretory apparatus is an elongated sac which opens at one end by the side of the anus, and at the other communicates with the pericardial blood-sinus. The sac contracts rhythmically and with great rapidity, so that the blood in contact with its delicate walls must be very effectually washed. How far the internal communication with the blood-sinuses is available for the same end, is not at present understood. In the *Lamellibranchiata* (at least in *Unio*) the pericardial sinus is connected anteriorly with the internal cavities of two spongy bodies—the glands of Bojanus—in which a great quantity of concretionary matter may be detected; on the other hand, the outer surfaces of these glands lie in a cavity which admits the water freely by an opening placed anteriorly close to the genital aperture. This cavity clearly corresponds with the contractile sac of the *Pteropoda* and *Heteropoda*, but no evidence of contractility has yet been observed in it or in the renal organ itself. Keber also denies that any direct communication exists between the interior of the kidneys and pericardial sinus and the outer sac, but it is somewhat difficult to make sure of this. However this may be, the arrangement of the kidney in *Unio* is very interesting from its close analogy with what obtains in the *Cephalopoda*, where the 'serous cavities,' which open at the base of the gills and contain the peculiar spongy venous appendages attached to one of their walls, correspond exactly with the excretory sacs of the *Lamellibranchiata*, while the spongy appendages themselves are but the glands of Bojanus in another form. Our limits will not permit of the description of the structure of the renal organ in *Nudibranchiata* and *Pectinibranchiata*, but it might readily be shown to resemble in all essential points that of the *Lamellibranchiata* and *Cephalopoda*.

5. The Nervous System of the *Mollusca*.—The *Molluscoida* and the *Mollusca* respectively present a remarkable agreement in the general arrangement of their nervous apparatus, which consists in the *Polyzoa* and *Ascidioida* of a single ganglion placed in the midst of the neural region of the body; in the former case between the oral and anal apertures, in the latter between the oral and cloacal apertures. In the *Brachiopoda* the nature of the nervous system is only known with certainty in the *Terebratulidæ*, where it consists of a single elongated ganglion having the same position as in the *Polyzoa*, sending on each side a commissural branch to surround the mouth, and giving off numerous branches to the mantle. In the *Brachiopoda* no distinct organs of sense have yet been observed, but in the Hippocrepian *Polyzoa* a little tongue-shaped organ projecting from the lophophore close to the ganglion, probably represents the 'languet' of the Ascidians, an organ whose function is not known, but which probably performs, in conjunction with the ciliated sac, the part of an organ of sense. The 'ciliated sac' is, as its name implies, essentially a small ciliated pouch placed between the oral end of the hypopharyngeal band and the circlet of tentacles. In the *Cynthiæ*, *Phallusiæ*, &c., it becomes enlarged and twisted upon itself, so that its margin frequently presents a very elegantly convoluted pattern, *fig.* 11, 2, *cs*. In this form it was described by Savigny as the 'Tubercule Antérieure.' In *Appendicularia* and in the *Salpæ* an otolithic sac is also attached to the ganglion.

Fig. 11.



Diagrams of the Central Nervous System—1, *Waldheimia*; 2, *Phallusia*; 3, *Lamellibranchiata*; 4, *Pteroceras*; 5, *Atlanta*; 6, *Firola*; 7, *Patella*; 8, *Bullæa*; 9, Eolis (after Alder and Hancock); 10, *Criseis*; 11, *Ommastrephes* (Hancock); 12, *Nautilus* (Owen). The circles with central dots represent the auditory vesicles.

cs, ciliated sac; *x*, cerebral ganglia; *y*, pedal ganglia; *z*, parieto-splanchnic ganglia.

In all the *Mollusca* proper the nervous system presents a remarkable uniformity as to its central elements, and remarkable differences in their arrangement. There are essentially three pair of ganglia:—

1. The Cerebral, which supply the eyes and olfactory organ, and give off the nerves to the buccal ganglia where they exist.

2. The Pedal Ganglia, which supply the foot with nerves, and always, save in *Heteropoda* and perhaps some Nudibranchs (where the exception is very possibly only apparent), give off the nerves to the auditory vesicles.

3. The Parieto-Splanchnic Ganglia, which supply the hæmal region of the body and many of the viscera.

There are never more than two pedal and two cerebral ganglia, but the parieto-splanchnic centres would seem to be capable of almost indefinite multiplication. These multiplied centres however may be reduced to two classes—Parietal Ganglia, which give nerves to the sides of the body, and Visceral Ganglia, which supply the heart, branchiæ, &c.

The accompanying diagramatic figures of the nervous systems of Molluscs of all classes, in which the Cerebral Ganglia are marked *x*, the Pedal *y*, and the Parieto-Splanchnic *z*, will render the great changes of position, while the essential parts remain the same, obvious without further description.

For the organs of sense of the *Mollusca* proper we must refer to the articles Conchifera, Gasteropoda, &c.

4. *The Development of the Mollusca*.—Those conceptions which the philosophical anatomist comprehends under the name of Archetypes, or Common Plans of Animal Forms, must always present a certain value and interest to all who regard anatomy as something more than an exercise of the memory; but the amount of the value of such conceptions, and of their beneficial influence on the forward progress of science, depends entirely on the extent to which they embrace the whole anatomical peculiarities of a group of animals. Now animals, like all living beings, not only are, but become; and their anatomy, in the widest sense of the term, is to be obtained, not merely by the study of their structure (which is their final anatomy), but also by that of their development, which is the anatomy of the successive states through which they pass in attaining their final condition. Now the Archetype or Common Plan professing to be the embodiment of the most general propositions which can be enunciated with regard to the anatomy of the group, its validity will depend upon its embracing both structural and developmental facts. If it neglect either of these, it will be theoretically imperfect, and will run the risk, at any rate, of being practically erroneous. Before the publication of Von Bär's great work, and unfortunately too often since then, the extant notions of archetypes, unity of organisation, &c., were open to precisely this objection, their authors having contented themselves with devising hypotheses to fit the facts of adult structure, without concerning themselves whether their hypotheses would or would not also fit the facts of development. Hence the infinite variety of baseless speculations of the 'Nature-philosophie' school; in botany, the unlimited and quite gratuitous demands upon 'abortion and fusion' of parts which Schleiden has so justly ridiculed; in zoology, such notions as that a Cephalopod is a vertebrate animal doubled upon itself, that an Insect is a vertebrate animal with free ribs, &c.

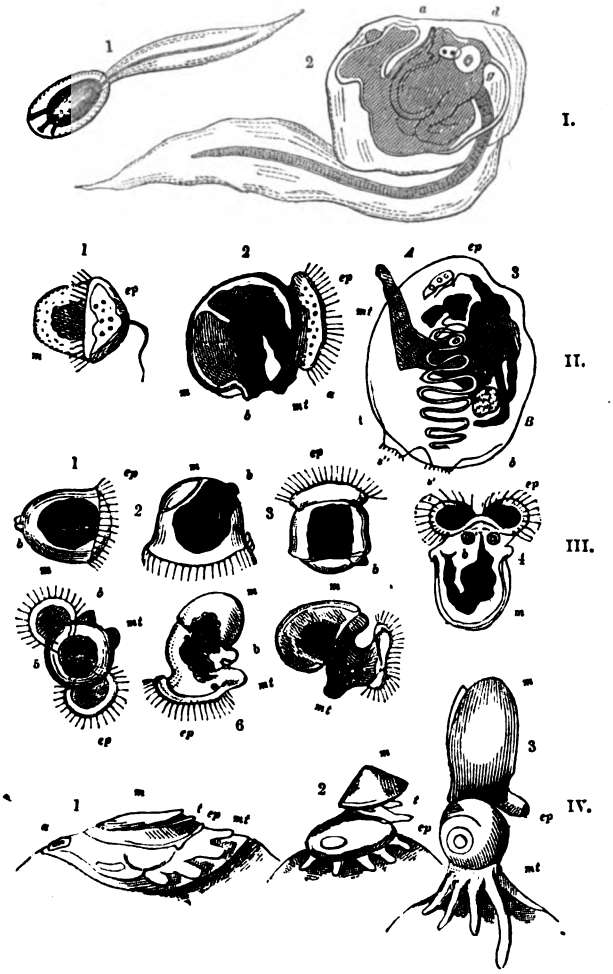
It is precisely on this footing however that at present our Common Plan or Archetype of the *Mollusca* stands. We have before us the evidence which might perhaps have satisfied Geoffroy and Oken. Given our plan and certain laws of modification, and all known molluscan forms may be derived from it; but it remains to be seen how far the evidence which would alone have satisfied Von Bär, the evidence of development, justifies the view which has been taken; how far in fact our hypothesis is capable of being elevated to the dignity of a theory.

To this end it is by no means requisite to show that every Mollusc has at one time the archetypal form, and is subsequently modified into its persistent condition; to maintain such a proposition it would be necessary greatly to simplify (though not essentially to alter) the

archetype, and thus to do away with a great part of its utility in exhibiting the tendencies of every Mollusc. All that appears to be really necessary is to show:—first, that no molluscan form presents features in its development which cannot be reconciled with the archetype; and secondly, that the kind of modifications which have been supposed to take place in the conversion of the archetype into the special types are such as actually occur.

The first stage of development of the *Mollusca* resembles that of other animals. The yelk, at first a homogeneous mass, undergoes the process of division to a greater or less extent, its outermost layers eventually becoming converted into a blastodermic layer, the plastic material out of which the future animal is modelled.

Fig. 12.



Development of—I. *Clavelina*. II. *Lamellibranch* (Lovèn). III. *Antiopa*. IV. *Sepia* (Kölliker).

a, oral aperture; *b*, anal aperture, or extremity of the intestine; *d*, cloacal aperture and atrium (Ascidians); *ep*, epipodium; *mt*, metapodium; *g*, hypopharyngeal band (Ascidians); *m*, mantle; *s'*, *s''*, anal and branchial siphons (*Lamellibranchiata*); *t*, branchiæ; *A*, anterior adductor (*Lamellibranchiata*); *B*, posterior adductor.

In the *Molluscoida* the rounded or oval embryo thus formed either becomes covered with cilia and swims away as a free form (*Polyzoa, Brachiopoda?*), or it gives rise from one portion of its surface to a long fin-like muscular process (*fig.* 12, I. 1.), by whose rapid vibration it is propelled (*Ascidioida*, in great part). With what organ of the *Mollusca* is this 'tail' or 'fin' of the Ascidian larva homologous? This is a very difficult point to ascertain, as the tail arises before the regions of the animal are differentiated. At first sight one might be tempted to consider it as a modification of the velum of the embryos of the *Mollusca* proper; but its relation to the middle of the neural surface, and its insertion close behind the ganglion, which may be readily observed in later stages, appear rather to indicate that it is the homologue of the foot proper, and probably of the metapodium, as this is the portion of the foot which in the *Mollusca* appears first.

In the further development of the *Molluscoida* there can be no question that, as regards the *Polyzoa*, the neural region soon almost ceases to grow, the further increase of the body taking place by the disproportionate development of the hæmal region, which constitutes almost the whole of the body of the adult animal, and presents the surface by which it becomes fixed. Again, simple inspection is sufficient to show that the intestine extends into the great abdomen thus developed; that it acquires herewith a neural flexure; that the tentacles are produced from the margins of its oral aperture; and that the pharynx acquires a large proportionate size.

In the *Ascidioida* the neural region remains in a like rudimentary condition, the hæmal region undergoing a similar disproportionate growth; but it is next to impossible to ascertain from the study of development whether this hæmal outgrowth is formed behind the anus or before it, inasmuch as the intestine has acquired its complete hæmal flexure when its parts are first distinguishable.

In the youngest state in which the different organs are distinguishable, the intestine is almost entirely bent up on to the hæmal side of the body; the pharynx is a wide cavity (not wider proportionally however than that of a Polyzoon); the tentacles spring from its margin in exactly the same relative position as in a Polyzoon, and there is no atrial cavity. By degrees the pharyngeal cavity enlarges still more, the tentacles remaining comparatively rudimentary (*fig.* 12, I. 2). Contemporaneously with these changes, the end of the intestine becomes more and more bent down towards the neural surface, and a cavity, which in another Mollusc would be the mantle-cavity, appears around its extremity; a single or two lateral apertures (subsequently uniting into one) are soon formed, and allow this cloacal portion of the atrial cavity to communicate with the exterior. At the same time the atrium extends on each side of the enlarged pharynx, detaching it from the side of the body, and enveloping it just as a serous sac invests the surface of a viscus. Ciliated apertures (at first one or two only on each side) now pierce the wall of the enlarged pharynx, and increase in number until it assumes the structure of the perfect branchial sac. Finally, it depends upon the proportional development of the branchial sac, and of the post-abdomen, whether the adult Ascidian shall belong to the Branchial or to the Intestinal subtype.

We unfortunately know hardly anything of the development of the *Brachiopoda;* but so far as the *Polyzoa* and *Ascidioida* are concerned, it is obvious that the hypothetical modifications of the Archetype do in fact faithfully represent the actual course of development. (See however the remarks, further on, as to the nature of the post-abdominal outgrowth in hæmal *Molluscoida* and *Mollusca*.)

Development of the Neural Mollusca.—The *Lamellibranchiata*.—The first step towards the production of the organs from the blastodermic layer in this group is the development of one portion of its surface into a disc with mixed edges provided with very long cilia (*fig.* 12, II. 1). Next in the inner substance of the germ the intestine appears as a solid mass, bent upon itself, towards what the eventual development of the foot proves to be the neural surface; its oral portion being placed immediately behind the ciliated disc (2). Finally, the hæmal surface behind the ciliated disc gradually gives rise to the two lobes of the mantle, upon each of which a thin transparent pellicle, the first rudiment of one valve of the shell, eventually appears. As development goes on (3), the neural surface between the primarily approximated oral and anal apertures becomes converted into the large foot and mesosoma of the Lamellibranchs, which serve to lodge the principal mass of the viscera, the abdomen never becoming developed into a great process as in Gasteropods. The great posterior adductor makes its appearance on the neural side of the intestine, and by its development the latter is thrown up so as almost to appear to have a hæmal flexure. The gills next appear as processes of the body within the mantle-cavity, and therefore have not the remotest homology with the pharyngeal branchial sac of Ascidians, any more than the two siphonal apertures which are essentially dependent upon the union of the two lobes of the mantle with the gills and with one another have anything to do with the oral and cloacal apertures of the Ascidians.

Finally, it is said that the ciliated disc becomes metamorphosed into the labial palpi. This is a point well worthy of further investigation; for the arrangement and form of the appendages in *Pecten* lead us strongly to believe, as we have said, that they are the homologues of the tentacles in the *Ascidioida* and *Polyzoa*. On the other hand, there can be no doubt that the ciliated disc of Lamellibranchs is homologous with the ciliated lobes of the Gasteropod embryos; and these, there is every reason to believe, are nothing but the specially modified anterior portion of the epipodium. The tentacles of the *Polyzoa* would thus come to be the homologues of the epipodium; but the validity of the whole chain of reasoning obviously depends upon whether the ciliated disc does or does not become metamorphosed into the palpi—a position which the more requires confirmation as in the *Gasteropoda* the ciliated lobes are now known entirely to disappear. However this may be, what has been stated with regard to the main steps in the development of the *Lamellibranchiata* fully confirms the hypothetical derivation of the type from the Common Plan.

Pteropoda and *Pulmonata*.—In the primary stages of their development no important distinction is to be drawn between the members of this division and those of the last, except that in the *Pteropoda* the ciliated disc is replaced by two ciliated lobes, one on each side; and in the Pulmonate embryos by a contractile expansion—their so-called 'yelk-sac.' The primarily neural flexure of the intestine in the *Pulmonata*, and the development of their mantle in front of the anus (that is, the development of an abdomen), are fully demonstrated by late observations upon their embryogeny. It is important to remark, that in the *Pteropoda* the ciliated lobes of the embryo do not

become the lateral alæ of the adult form, but are a production of the anterior part of the epipodium, which usually disappears in the adult.

Cephalopoda.—In this group the embryo attains a much higher development before leaving the egg, and the modifications which its primary form undergoes are extremely instructive. The first organs of the Cephalopod which appear on the germ-disc are (*fig.* 12, IV. 1) the mantle, which is simply a thickening in the middle of the hæmal surface with somewhat raised edges; around this is a surface representing the mesosoma and foot, at one end of which is the mouth, and at the other or anal extremity are placed two little processes, the rudiments of the gills. Again, on each side of the mantle the mesosoma is produced into a longitudinal ridge occupying the precise position of the epipodium. As development goes on, the hæmal surface occupied by the mantle grows out, and becomes a prominent sac, whose free edges detaching themselves more and more for only a short distance anteriorly, but for almost the whole length of the sac posteriorly, give rise to the mantle cavity (IV. 2). The intestine passing into the abdomen thus formed becomes more and more bent upon itself, until at last it makes a complete loop, open towards the neural side. With all this the epipodium, remaining rudimentary in its anterior region, becomes a free process on each side posteriorly (representing for a time the alæ of a Pteropod), but after a while these processes unite, and form a hollow canal, the Funnel. The changes undergone by the margins of the foot are not less remarkable; they are produced from behind forwards into four or five digitations on each side, the anterior pair of which stretch in front of the mouth and unite over it; the digitations elongate more and more, and the mouth is in consequence at last placed in the centre of a sort of inverted cone, formed by the foot and its prolongations—the acetabuliferous arms (IV. 3).

Such may be taken as a very short abstract of Professor Kölliker's most valuable 'Entwickelungs-Geschichte der Cephalopoden,' and it is needless to point out that it is our hypothetical process of modification of the Archetype into the Cephalopod type, in other words.

The Hæmal Mollusca.—It is unnecessary to consider the development of the separate families of these Molluscs, as the process, as far as we know, is the same in all. We will take that of a Nudibranch (*Antiopa cristata*) as a type, having recently had occasion to go over it with especial reference to the points here under consideration.

The end of the process of yelk-division (which, we may remark in passing, results, not in the formation of 'nucleated cells,' but simply in that of smaller and smaller packets of yelk-granules) in this Mollusc, is the formation of a blastodermic layer investing the remainder of the yelk. The whole embryo next becomes more or less bell-shaped, a sort of rim, with very long cilia, appearing at the broader end, while a minute prominence is seen at the opposite extremity (III. 1). A straight line drawn from this prominence to the centre of the surface, surrounded by the rim, would have the body of the creature symmetrically disposed around it. On the one surface is a deep pit, formed by the edges of the blastodermic layer; on the opposite a delicate transparent cup, the rudiment of the future shell, and the indicator of the position of the hæmal surface and mantle, appears (III. 3). By degrees the hæmal surface becomes more and more prominent and the shell larger. With this the prominence above referred to is thrust more and more towards the right side, so that its position becomes quite asymmetrical (II. 3, 5). At the same time the ciliated rim from being circular is produced laterally into a lobe on each side—the ciliated lobes; the metapodium makes its appearance behind these as a small prominence; and a delicate operculum is formed upon the metapodium. The aperture of the mouth may now be observed behind the ciliated lobes and between them and the metapodium; and the internal substance of the germ is seen to present the outlines of an alimentary canal, consisting of a rounded gastro-hepatic mass and a narrower intestine, which turns abruptly forwards and upwards, to end on the right side more or less hæmally in the before-mentioned prominence, whose position has become thus extensively altered. The mantle cavity has begun to appear as a sort of pushing-in of the integument around the anal prominence.

Two things are obvious in this series of developmental changes. In the first place, the primary symmetricality of the embryo; secondly, the gradual asymmetry brought about by the development of that portion of the body which bears the shell, and which is a portion of the hæmal surface.

Now this is perfectly in accordance with our hypothetical derivation of the Hæmal *Mollusca* from the Archetype, and the only point which remains to be proved is, that this over-developed hæmal surface is to be considered as a post-abdomen, that is, as a post-anal portion of the hæmal surface.

This view has been taken in deriving these forms from the Archetype, because it is much the more readily comprehensible, and has many structural facts in its favour; but we are by no means prepared to assert that the post-anal position of the hæmal outgrowth in the Hæmal *Mollusca* may not be a secondary production, the result of a gradual twisting to one side and backwards of a primarily pre-anal outgrowth of the hæmal surface. The facts just detailed with regard to the development of *Antiopa* would favour this view; but, on the other hand, sufficient attention has not been paid to the process of development of other *Gasteropoda* to decide whether it is in these respects identical with that of the Nudibranchs or not. The anatomy of adult Pectinibranchs and Pteropods would lead one to believe that in these forms, at any rate, the hæmal flexure has been direct and primary; and it may be that a careful comparative study of development of the Pectinibranchs and Nudibranchs will lead to the translation of the Nudibranchs to the Neural division, the final hæmal flexure turning out to be a secondary modification. In the absence of sufficiently conclusive studies of this kind, however, we prefer to be guided by structural considerations, and thence to retain the Nudibranchs provisionally among the Molluscs with a hæmal flexure. It will probably be granted that the doctrine of a Common Plan among the *Mollusca*, which has been advanced, will have its value as a guide through the mazes of their varying organisation—even although the details of this first sketch should turn out to be even in many points erroneous.

MOLOCH. [DRACONINA.]

MOLOSSUS. [CHEIROPTERA.]

MO'LOTHRUS (Swainson), a genus of Birds placed in the subfamily *Icterinæ*, under the family *Sturnidæ*, with the following generic character:—Bill very short, thick, finch-like, conic, entire; the culmen not flattened, but slightly arched from the base, which is rather elevated. Wings lengthened, pointed; the first quill longest. Tail slightly rounded. Middle toe as long as the tarsus; lateral toes of equal length; hind toe shorter than the tarsus. All the claws rather small, and fully curved.

M. Pecoris, Sw., the Cow-Pen-Bird, Cow-Blackbird, Cow-Troopial, and Cow-Bunting (*Icterus Pecoris*, Temm.; *Emberiza Pecoris*, Wils.; *Fringilla Pecoris*, Gm.).

Male: Head and neck brown, inclining to black; the rest of the plumage shining black, glossy with violet reflections on the breast and shot with greenish above; irides hazel; legs and claws black.

Cow-Bird (*Molothrus Pecoris*).
a, male; *b*, female; *c*, young. Wilson.