Family 14.—*Olividæ.*
Genera: *Oliva*, Brug.; *Ancilla*, Lam.; *Harpa*, Lam.
Family 15.—*Volutidæ.*
Genera: *Voluta*, L.; *Cymbium*, Montf.; *Marginella*, Lam.; *Volvaria* Lam.

Further Remarks on the Reptant Azygobranchia.—The very large assemblage of forms coming under this order comprise the most highly developed predaceous sea-snails, numerous vegetarian species, a considerable number of

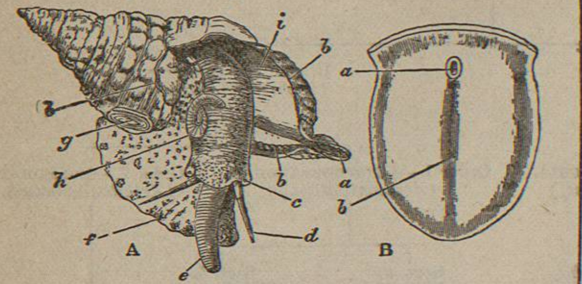

FIG. 37.—A. *Triton variegatum*, to show the proboscis or buccal introvert (*e*) in a state of eversion. *a*, siphonal notch of the shell occupied by the siphonal fold of the mantle-skirt (Siphonochlamyda); *b*, edge of the mantle-skirt resting on the shell; *c*, cephalic eye; *d*, cephalic tentacle; *e*, everted buccal introvert (proboscis); *f*, foot; *g*, operculum; *h*, penis; *i*, under surface of the mantle-skirt forming the roof of the sub-pallial chamber. B. Sole of the foot of *Pyrula tuba*, to show *a*, the pore usually said to be "aquiferous" but probably the orifice of a gland; *b*, median line of foot.

fresh-water, and some terrestrial forms. The partial dissection of a male specimen of the Common Periwinkle, *Littorina littoralis*, drawn in fig. 46, will serve to exhibit the disposition of viscera which prevails in the group.

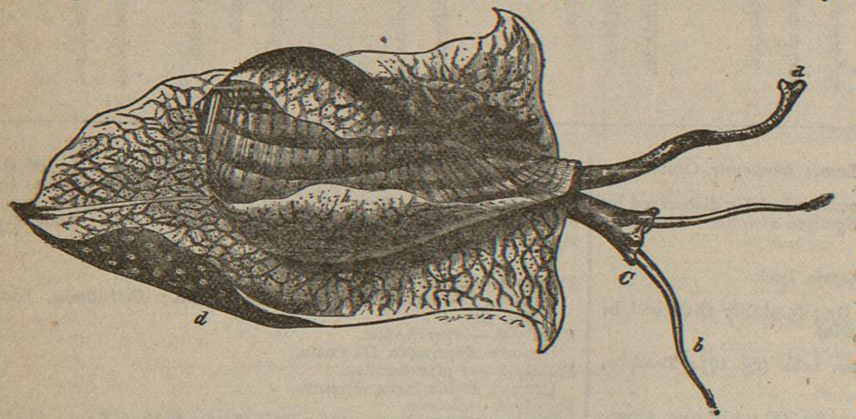

FIG 38.—Animal and shell of *Pyrula lævigata*. *a*, siphon; *b*, head-tentacles; *C*, head, the letter placed near the right eye; *d*, the foot, expanded as in crawling; *h*, the mantle-skirt reflected over the sides of the shell. (From Owen.

The branchial chamber formed by the mantle-skirt overhanging the head has been exposed by cutting along a line extending backward from the letters *vd* to the base of the columella muscle *mc*, and the whole roof of the chamber thus detached from the right side of the animal's neck has been thrown over to the left, showing the organs which lie upon the roof. No opening into the body-cavity has been made; the organs which lie in the coiled visceral hump show through its transparent walls. The head is seen in front resting on the foot and carrying a median non-retractile snout or rostrum, and a pair of cephalic tentacles at the base of each of which is an eye. In many Gastropoda the eyes are not thus sessile but raised upon special eye-tentacles (figs. 43, 69). To the right of the head is seen the muscular penis *p* close to the termination of the vas deferens (spermatic duct) *vd*. The testis *t* occupies a median position in the coiled visceral mass. Behind the penis on the same side is the hooklike columella muscle, a development of the retractor muscle of the foot, which clings to the spiral column or columella of the shell (see fig. 42). This columella muscle is the same thing as the muscular surface marked *c* in the figures of Patella, marked *k* in fig. 91 of Nautilus, and the posterior adductor of Lamellibranchs (fig. 131).

The surface of the neck is covered by integument forming the floor of the branchial cavity. It has not been cut into

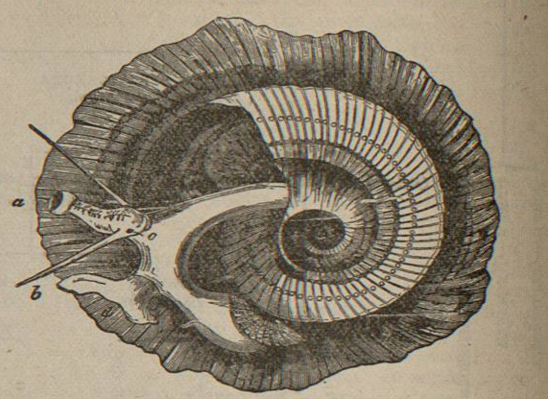

FIG. 39.—Animal and shell of *Phorus exutus*. *a*, snout (not introversible); *b*, cephalic tentacles; *c*, right eye; *d*, pro- and meso-podium,—to the right of this is seen the metapodium bearing the sculptured operculum.

Of the organs lying on the reflected mantle-skirt, that which in the natural state lay nearest to the vas deferens on the right side of the median line of the roof of the branchial chamber is the rectum *i'*, ending in the anus *a*. It can be traced back to the intestine *i* near the surface of the visceral hump, and it is found that the apex of the coil formed by the hump is occupied by the liver *h* and the stomach *v*. Pharynx and œsophagus are concealed in the head. The enlarged glandular structure of the walls of the rectum is frequent in the Azygobranchia, as is also though not universally the gland marked *y*, next to the rectum. It is the adrectal gland, and in the genera Murex and Purpura secretes a colourless liquid which turns purple upon exposure to the atmosphere, and was used by the ancients as a dye. Near this, and less advanced into the branchial chamber, is the single renal organ or nephridium *r* with its opening to the exterior *r'*. Internally this glandular sac presents a second slit or aperture which leads into the pericardium (as is now found to be the case in all Mollusca). The heart *c* lying in the pericardium is seen in close proximity to

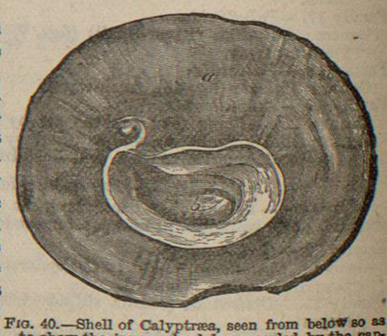

FIG. 40.—Shell of Calyptræa, seen from below so as to show the inner whorl *b*, concealed by the cap-like outer whorl *a*.

the renal organ, and consists of a single auricle receiving blood from the gill, and of a single ventricle which pumps it through the body by an anterior and posterior aorta (see fig. 105). The surface *x* of the mantle between the rectum and the gill-plume is thrown into folds which in many sea-snails (Whelks, &c.) are very strongly developed. The whole of this surface appears to be active in the secretion of a mucous-like substance. The single gill-plume *br* lies to the left of the median line in natural position. It corresponds to the right of the two primitive ctenidia in the untwisted archaic condition of the Molluscan body, and does not project freely into the branchial cavity, but its axis is attached (by concrescence) to the mantle-skirt (roof of the branchial chamber). It is rare for the gill-plume of an Anisopleurous Gastropod to stand out freely as a plume, but occasionally this more archaic condition is exhibited, as in Valvata (fig. 45). Next beyond (to the left of) the gill-plume we find the so-called parabranchia, which is here simple, but sometimes lamellated as in Purpura (fig. 47). This organ has, without reason, been supposed to represent the second ctenidium of the typical Mollusc, which it cannot do on account of its position. It should be to the right of the anus were this the case. Recently Spengel has shown that the parabranchia of Gastropods is the typical olfactory organ or osphradium in a highly-developed condition The minute structure of the epithelium which clothes it, as well as the origin of

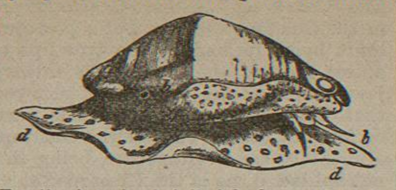

FIG 41.—Animal and shell of Ovulum. *b*, cephalic tentacles, *d*, foot; *h*, mantle-skirt, which is naturally carried in a reflected condition so as to cover in the sides of the shell.

FIG. 42.—Section of the shell of Tritonium, Cuv. *a*, apex; *ac*, siphonal notch of the mouth of the shell; *ac* to *pc*, mouth of the shell; *w*, *w*, whorls of the shell; *s*, *s*, sutures. Occupying the axis, and exposed by the section, is seen the "columella" or spiral pillar. The upper whorls of the shell are seen to be divided into separate chambers by the formation of successively formed "septa." (From Owen.)

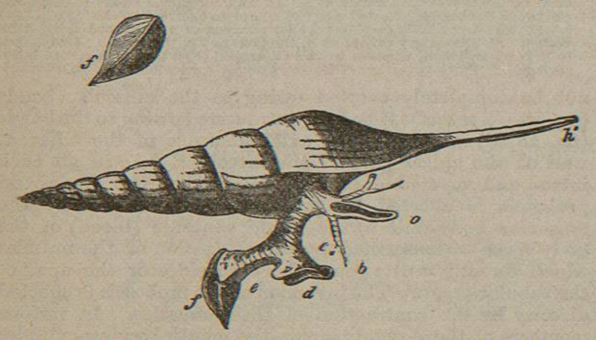

FIG. 43.—Animal and shell of *Rostellaria rectirostris*. *a*, snout or rostrum; *b*, cephalic tentacle; *c*, eye; *d*, propodium and mesopodium; *e*, metapodium; *f*, operculum; *h'*, prolonged siphonal notch of the shell occupied by the siphon, or trough-like process of the mantle-skirt. (From Owen.)

the nerve which is distributed to the parabranchia, proves it to be the same organ which is found universally in Molluscs at the base of each gill-plume, and tests the indrawn current of water by the sense of smell. The nerve to this

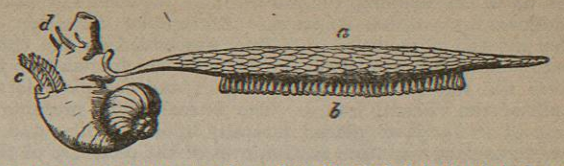

FIG. 44.—Female Janthina, with egg-float (*a*) attached to the foot; *b*, egg-capsules; *c*, ctenidium (gill-plume); *d*, cephalic tentacles.

organ is given off from the superior (original right, see fig. 19) visceral ganglion.

The figures which are here given of various Azygobranchia are in most cases sufficiently explained by the references attached to them. As an excellent general type of the nervous system, attention may be directed to that of Paludina drawn in fig. 21. On the whole, the ganglia are strongly individualized in the Azygobranchia, nerve-cell tissue being concentrated in the ganglia and absent from the cords (contrast with Zygobranchia and Isopleura). At the same time, the junction of the visceral loop above the intestine prevents in all Streptoneura the shortening of the visceral loop, and it is rare to find a fusion of the visceral ganglia with either pleural, pedal, or cerebral—a fusion which can and does take place where the visceral loop is not above but below the intestine, *e.g.*, in the Euthyneura (fig. 67), Cephalopoda (fig. 112), and Lamellibranchia (fig. 144). As contrasted with the Zygobranchia and the Isopleura, we find that in the Azygobranchia the pedal nerves are distinctly nerves given off from the pedal ganglia, rather than cord-like nerve-tracts containing both nerve-cells or ganglionic elements and nerve-fibres. Yet in some Azygobranchia (Paludina) a ladder-like arrangement of the two pedal nerves and their lateral branches has been detected (30). The histology of the nervous system of Mollusca has yet to be seriously inquired into.

FIG. 45.—*Valvata cristata*, Müll. *o*, mouth; *op*, operculum; *br*, ctenidium (branchial plume); *x*, filiform appendage (? rudimentary ctenidium). The freely projecting ctenidium of typical form not having its axis fused to the roof of the branchial chamber is the notable character of this genus

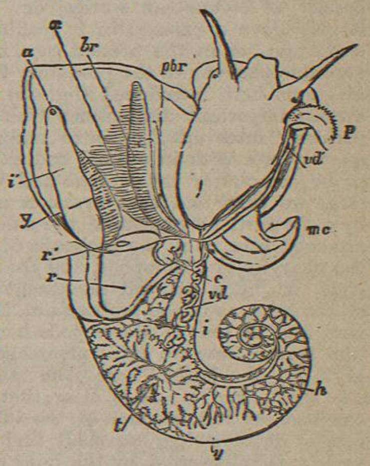

FIG. 46.—Male of *Littorina littoralis*, Lin., removed from its shell; the mantle-skirt cut along its right line of attachment and thrown over to the left side of the animal so as to expose the organs on its inner face. *a*, anus; *i*, intestine; *r*, nephridium (kidney); *r'*, aperture of the nephridium; *c*, heart; *br*, ctenidium (gill-plume); *pbr*, parabranchia (—the osphradium or olfactory patch); *x*, glandular lamellæ of the inner face of the mantle-skirt; *y*, adrectal (purpuriparous) gland; *t*, testis; *vd*, vas deferens; *p*, penis; *mc*, columella muscle (muscular process grasping the shell); *v*, stomach; *h*, liver. *N.B.* Note the simple snout or rostrum not introverted as a "proboscis."

The alimentary canal of the Azygobranchia presents little diversity of character, except in so far as the buccal region is concerned. Salivary glands are present, and in some carnivorous forms (Dolium) these secrete free sulphuric acid (as much as two per cent is present in the secretion), which assists the animal in boring holes by means of its rasping tongue through the shells of other Molluscs upon which it preys. A crop-like dilatation of the gut and a recurved intestine, embedded in the compact yellowish-brown liver, the ducts of which open into it, form the rest of the digestive tract and occupy a large bulk of the visceral hump. The buccal region presents a pair of shelly jaws placed laterally upon the lips, and a wide range of variation in the form of the denticles of the lingual ribbon or radula, the nature of which will be understood by a reference to fig. 9, whilst the systematic list of families given above shows the particular form of dentition characteristic of each division of the order.

The modification in the form of the snout upon which the mouth is placed, leading to the distinction of "proboscidiferous" and "rostriferous" Gastropods, requires further notice. The condition usually spoken of as a "proboscis" appears to be derived from the condition of a simple rostrum (having the mouth at its extremity) by the process of *incomplete introversion* of that simple rostrum. There is no reason in the actual significance of the word why the term "proboscis" should be applied to an alternately introversible and eversible tube connected with an animal's body, and yet such is a very customary use of the term. The introversible tube may be completely closed, as in the "proboscis" of Nemertean worms, or it may have a passage in it leading into a non-eversible œsophagus, as in the present case, and in the case of the eversible pharynx of the predatory Chætopod worms. The diagrams here introduced (fig. 48) are intended to show certain important distinctions which obtain amongst the various "introverts," or intro- and e-versible tubes so frequently met with in animal bodies. Supposing the tube to be completely introverted and to commence its eversion, we then find that eversion may take place, either by a forward movement of the side of the tube near its attached base, as in the proboscis of the Nemertine worms, the pharynx of Chætopods, and the eye-tentacle of Gastropods, or, by a forward movement of the inverted apex of the tube, as in the proboscis of the Rhabdocœl Planarians, and in that of Gastropods here under consideration. The former case we call "pleurecbolic" (fig. 48, A, B, C, H, I, K), the latter "acrecbolic" tubes or introverts (fig. 48, D, E, F, G). It is clear that, if we start from the condition of full eversion of the tube and watch the process of introversion, we shall find that the pleurecbolic variety is introverted by the apex of the tube sinking inwards; it may be called acrembolic, whilst conversely the acrecbolic tubes are pleurembolic. Further, it is obvious enough that the process either of introversion or of eversion of the tube may be arrested at any point, by the development of fibres connecting the wall of the introverted tube with the wall of the body, or with an axial structure such as the œsophagus; on the other hand, the range of movement of the tubular introvert may be unlimited or complete. The acrembolic proboscis or frontal introvert of the Nemertine worms has a complete range. So has the acrembolic pharynx of Chætopods, if we consider the organ as terminating at that point where the jaws are placed and the œsophagus commences. So too the acrembolic eye-tentacle of the snail has a complete range of movement, and also the

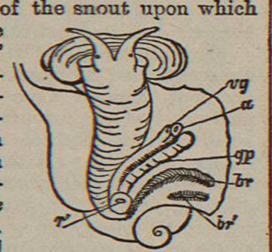

Fig. 47.—Female of *Purpura lapillus* removed from its shell; the mantle-skirt cut along its left line of attachment and thrown over to the right side of the animal so as to expose the organs on its inner face. *a*, anus; *vg*, vagina; *gp*, adrectal purpuriparous gland; *r'*, aperture of the nephridium (kidney); *br*, ctenidium (branchial plume); *br'*, parabranchia (= the comb-like osphradium or olfactory organ).

pleurembolic proboscis of the Rhabdocœl prostoma. The introverted rostrum of the Azygobranch Gastropods presents in contrast to these a limited range of movement. The "introvert" in these Gastropods is not the pharynx as in the Chætopod worms, but a præ-oral structure, its apical limit being formed by the true lips and jaws, whilst the apical limit of the Chætopod's introvert is formed by the jaws placed at the junction of pharynx and œsophagus, so that the Chætopod's introvert is part of the stomodæum or fore-gut, whilst that of the Gastropod is external to the alimentary canal altogether, being in front of the mouth, not behind it, as is the Chætopod's. Further, the Gastropod's introvert is pleurembolic (and therefore acrecbolic), and is limited both in eversion and in introversion; it can-

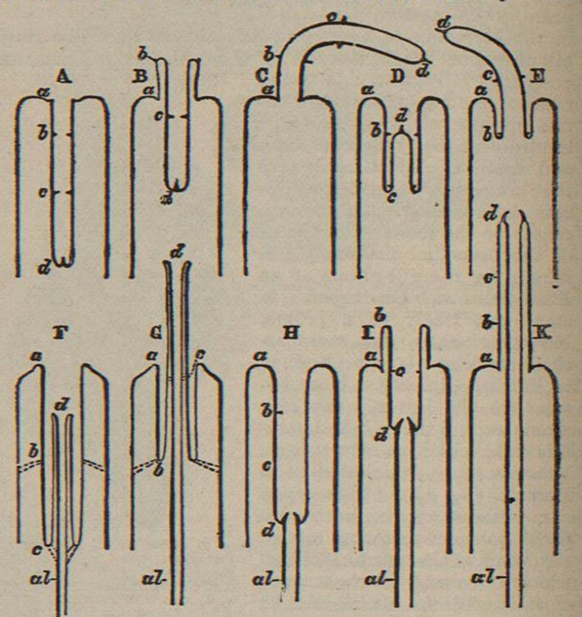

Fig. 48.—Diagrams explanatory of the nature of so-called proboscides or "introverts." A. Simple introvert completely introverted. B. The same, partially everted by eversion of the sides, as in the Nemertine proboscis and Gastropod eye-tentacle = pleurecbolic. C. The same, fully everted. D, E. A similar simple introvert in course of eversion by the forward movement, not of its sides, but of its apex, as in the proboscidean Rhabdocœls = acrecbolic. F. Acrecbolic (= pleurembolic) introvert, formed by the snout of the proboscidiferous Gastropod. *al*, alimentary canal; *d*, the true mouth. The introvert is not a simple one with complete range both in eversion and introversion, but is arrested in introversion by the fibrous bands at *c*, and similarly in eversion by the fibrous bands at *b*. G. The acrecbolic snout of a proboscidiferous Gastropod, arrested short of complete eversion by the fibrous band *b*. H. The acrembolic (= pleurecbolic) pharynx of a Chætopod fully introverted. *al*, alimentary canal; at *d*, the jaws; at *a*, the mouth; therefore *a* to *d* is stomodæum, whereas in the Gastropod (F) *a* to *d* is inverted body-surface. I. Partial eversion of H. K. Complete eversion of H. (Original.)

not be completely everted owing to the muscular bands (fig. 48, G), nor can it be fully introverted owing to the bands (fig. 48, F) which tie the axial pharynx to the adjacent wall of the apical part of the introvert. As in all such intro- and e-versible organs, eversion of the Gastropod proboscis is effected by pressure communicated by the muscular body-wall to the liquid contents (blood) of the body-space, accompanied by the relaxation of the muscles which directly pull upon either the sides or the apex of the tubular organ. The inversion of the proboscis is effected directly by the contraction of these muscles. In various members of the Azygobranchia the mouth-bearing cylinder is introversible (*i.e.*, is a *proboscis*)—with rare exceptions these forms have a siphonate mantle-skirt. On the other hand, many which have a siphonate mantle-skirt are not provided with an introversible mouth-bearing cylinder, but have a simple non-introversible rostrum, as it has been

termed, which is also the condition presented by the mouth-bearing region in nearly all other Gastropoda. One of the best examples of the introversible mouth-cylinder or proboscis which can be found is that of the Common Whelk and its immediate allies. In fig. 37 the proboscis is seen in an everted state; it is only so carried when feeding, being withdrawn when the animal is at rest. Probably its use is to enable the animal to introduce its rasping and licking apparatus into very narrow apertures for the purpose of feeding, *e.g.*, into a small hole bored in the shell of another Mollusc.

The foot of the Azygobranchia, unlike the simple muscular disc of the Isopleura and Zygobranchia, is very often divided into lobes, a fore, middle, and hind lobe (pro-, meso-, and meta-podium, see figs. 39 and 43). Very usually, but not universally, the meta-podium carries an operculum. The division of the foot into lobes is a simple case of that much greater elaboration or breaking up into processes and regions which it undergoes in the class Cephalopoda. Even among some Gastropoda (viz., the Opisthobranchia), we find the lobation of the foot still further carried out by the development of lateral lobes, the epipodia, whilst there are many Azygobranchia, on the other hand, in which the foot has a simple oblong form without any trace of lobes.

The development of the Azygobranchia from the egg has been followed in several examples, *e.g.*, Paludina, Purpura, Nassa, Vermetus, Neritina. As in other Molluscan groups, we find a wide variation in the early process of the formation of the first embryonic cells, and their arrangement as a Diblastula dependent on the greater or less amount of food-yelk which is present in the egg-cell when it commences its embryonic changes. In fig. 7, the early stages of *Paludina vivipara* are represented. There is but very little food-material in the egg of this Azygobranch, and consequently the Diblastula forms by invagination; the blastopore or orifice of invagination coincides with the anus, and never closes entirely. A well-marked Trochosphere is formed by the development of an equatorial ciliated band; and subsequently, by the disproportionate growth of the lower hemisphere, the Trochosphere becomes a Veliger. The primitive shell-sac or shell-gland is well marked at this stage, and the pharynx is seen as a new ingrowth (the stomodæum), about to fuse with and open into the primitively invaginated arch-enteron (fig. 7, F).

In other Azygobranchs (and such variations are representative for all Mollusca, and not characteristic only of Azygobranchia), we find that there is a very unequal division of the egg-cell at the commencement of embryonic development, as in Nassa (fig. 5). Consequently there is strictly speaking no invagination (emboly), but an overgrowth (epiboly) of the smaller cells to enclose the larger. The general features of this process and of the relation of the blastopore to mouth and anus have been explained above in treating of the development of Mollusca generally. In such cases the blastopore may entirely close, and both mouth and anus develop as new ingrowths (stomodæum and proctodæum), whilst, according to the observations of Bobretzky, the closed blastopore may coincide in position with the mouth in some instances (Nassa, &c.), instead of with the anus. But in these epibolic forms, just as in the embolic Paludina, the embryo proceeds to develop its ciliated band and shell-gland, passing through the earlier condition of a Trochosphere to that of the Veliger. In the veliger stage many Azygobranchia (Purpura, Nassa, &c.) exhibit, in the dorsal region behind the head, a contractile area of the body-wall. This acts as a larval heart, but ceases to pulsate after a time. Similar rhythmically contractile areas are found on the foot of the embryo Pulmonate Limax and on the yelk-sac (distended foot-surface) of the Cephalopod Loligo (see fig. 72**).

The history of the shell in the development of Azygobranchia (and other Gastropods) is important. Just as the primitive shell-sac aborts and gives place to a cap-like or boat-like shell, so in some cases (Marsenia, Krohn) has this first shell been observed to be shed, and a second shell of different shape is formed beneath it.

A detailed treatment of what is known of the histogenesis in relation to the cell-layers in these Mollusca would take us far beyond the limits of this article, which aims at exposing only the well-ascertained characteristic features of the Mollusca and the various subordinate groups. There is still a great deficiency in our knowledge of the development of the Gastropoda, as indeed of all classes of animals. The development of the gill (ctenidium) as well as of the renal organ, and details as to the process of torsion of the visceral hump, are still quite insufficiently known.

One further feature of the development of the Azygobranchia deserves special mention. Many Gastropoda deposit their eggs, after fertilization, enclosed in capsules; others, as Paludina, are viviparous, others, again, as the Zygobranchia, agree with the Lamellibranch Conchifera (the Bivalves) in having simple exits for the ova without glandular walls, and therefore discharge their eggs unenclosed in capsules freely into the sea-water; such unencapsuled eggs are merely enclosed each in its own delicate chorion. When egg-capsules are formed they are often of large size, have tough walls, and in each capsule are several eggs floating in a viscid fluid. In some cases all the eggs in a capsule develop; in other cases one egg only in a capsule (Neritina), or a small proportion (Purpura, Buccinum), advance in development; the rest are arrested either after the first process of cell-division (cleavage) or before that process. The arrested embryos or eggs are then swallowed and digested by those in the same capsule which have advanced in development. The details of this history require renewed study, our present knowledge of it being derived from the works of Koren and Danielssen, Carpenter and Claparède. In any case it is clearly the same process in essence as that of the formation of a vitellogenous gland from part of the primitive ovary, or of the feeding of an ovarian egg by the absorption of neighbouring potential eggs; but here the period at which the sacrifice of one egg to another takes place is somewhat late. What it is that determines the arrest of some eggs and the progressive development of others in the same capsule is at present unknown.

Section *b* (of the Azygobranchia).—*NATANTIA.*

Characters.—Azygobranchiate Streptoneura which have the form and texture of the body adapted to a free-swimming pelagic habit. They appear to be derived from holochlamydic forms of Reptant Azygobranchia. The foot takes the form of a swimming organ. The nervous system and sense-organs (eyes, otocysts, and osphradium) are highly developed. The odontophore also is remarkably developed, its admedian teeth being mobile, and it serves as an efficient organ for attacking other pelagic forms upon which the Natantia prey. The sexes are distinct as in all Streptoneura; and genital ducts and accessory glands and pouches are present as in all Azygobranchia. The Natantia exhibit a series of modifications of the form and proportions of the visceral mass and foot, leading from a condition readily comparable with that of a typical Azygobranch such as Rostellaria, with the three regions of the foot (pro-, meso-, and meta-podium) strongly marked, and a coiled visceral hump of the usual proportions, up to a condition in which the whole body is of a tapering cylindrical shape, the foot a plate-like vertical fin, and the visceral hump almost completely atrophied. Three steps of this modification may be distinguished as three sub-orders, the *Atlantacea*, the *Carinariacea*, and the *Pterotracheacea*.

Sub-order 1.—*Atlantacea.*

Characters.—Natantia with a large spirally-wound visceral hump, covered by a hyaline spiral shell; mantle-skirt large, overhanging a well-developed sub-pallial branchial chamber as in Azygobranchia, to the wall of which is attached the branchial ctenidium; foot well developed, divisible into a mobile propodium, a mesopodium on which is formed a sucker, and a metapodium which, when the animal is expanded, extends backwards beyond the shell and visceral hump; upon the upper surface of the metapodium is developed an operculum.

Genera: *Atlanta, Oxygurus*. Probably here belong the Palæozoic fossils *Bellerophon*.

Sub-order 2.—*Carinariacea*.

Characters.—Visceral hump greatly reduced in relative size; shell small, cap-like, hyaline; ctenidium (branchial plume) projecting from the small sub-pallial chamber; body cylindrical; of the foot-lobes only the mesopodium is prominent, provided with a sucker, and compressed laterally so as to form a vertical plate-like fin projecting from the ventral surface; the propodium forms simply the ventral surface of the anterior region of the cylindrical body whilst the metapodium forms its posterior region.

Genera. *Carinaria, Cardiopoda.*

Sub-order 3.—*Pterotracheacea.*

Characters—Visceral hump still further reduced, forming a mere oval sac embedded in the posterior dorsal region of the cylindrical body; no shell; foot as in Carinariacea, except that the sucker is absent from the mesopodium in the females.

Genera: *Pterotrachea, Firuloides.*

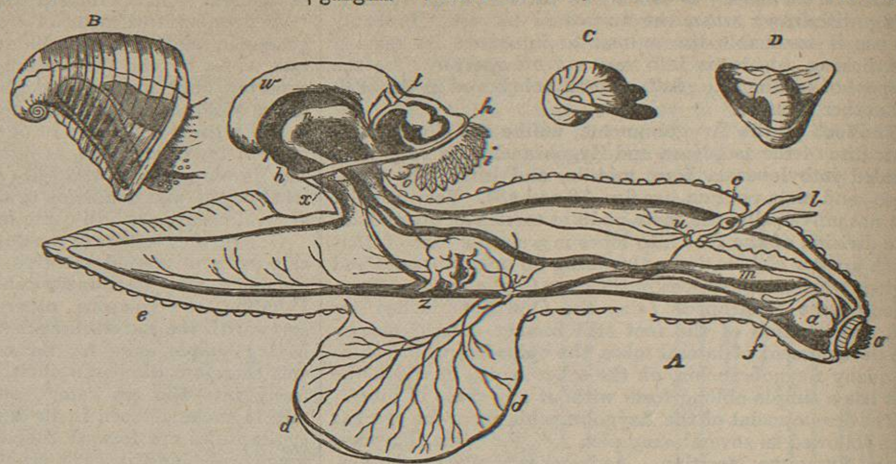

FIG. 50.—*Carinaria mediterranea.* A. The animal. B. The shell removed. C, D. Two views of the shell of Cardiopoda. *a*, mouth and odontophore; *b*, cephalic tentacles; *c*, eye; *d*, the fin-like mesopodium; *d'*, its sucker; *e*, metapodium; *f*, salivary glands; *h*, border of the mantle-flap; *i*, ctenidium (gill-plume); *m*, stomach; *n*, intestine; *o*, anus; *p*, liver; *t*, aorta, springing from the ventricle; *u*, cerebral ganglion; *v*, pleural and pedal ganglion; *w*. testis; *x*, visceral ganglion; *y*, vesicula seminalis; *z*. penis. (From Owen.)

Further Remarks on the Natantia Azygobranchia.—Logically the Natantia should stand as we have placed them, viz., as a special branch or section of the Azygobranchia, related to them somewhat as are the Birds to the Reptiles. They are true Azygobranchia which have taken to a pelagic life, and the peculiarities of structure which they exhibit

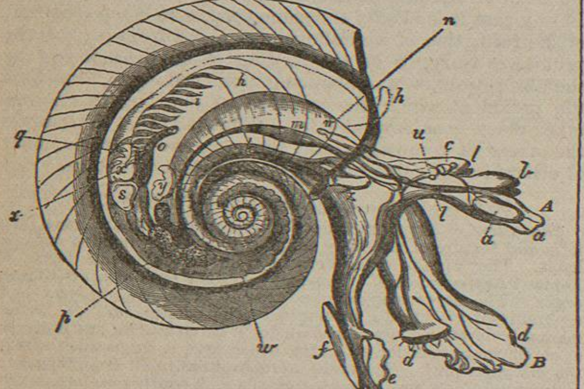

FIG. 49.—*Atlanta (Oxygura) Keraudrenii* (magnified 20 diameters). *a*, mouth and odontophore; *b*, cephalic tentacles; *c*, eye; *d*, propodium (*B*) and mesopodium; *e*, metapodium; *f*, operculum; *h*, mantle-chamber; *i*, ctenidium (gill-plume); *k*, retractor muscle of foot; *l*, optic tentacle; *m*, stomach; *n*, dorsal surface overhung by the mantle-skirt, the letter is close to the salivary gland; *o*, rectum and anus; *p*, liver; *q*, renal organ (nephridium); *s*, ventricle; *u*, the otocyst attached to the cerebral ganglion; *w*, testis; *x*, auricle of the heart; *y*, vesicle on genital duct; *z*, penis. (From Owen.)

are strictly adaptations of the structure common to them and the Azygobranchia consequent upon their changed mode of life. Such adaptations are the transparency and colourlessness of the tissues, and the modifications of the foot, which still shows in Atlanta the form common in Azygobranchia (compare fig. 49 and fig. 39).

The cylindrical body of Pterotracheacea is paralleled by the slug-like forms of Euthyneura. Spengel has shown that the visceral loop of the Natantia is Streptoneurous. Special to the Natantia is the high elaboration of the lingual ribbon, and, as an agreement with some of the Opisthobranchiate Euthyneura but as a difference from the Azygobranchia, we find the otocysts closely attached to the cerebral ganglia. This is however, less of a difference than it was at one time supposed to be, for it has been shown by Lacaze Duthiers, and also by Leydig, that the otocysts of Azygobranchia even when lying close upon the pedal ganglion (as in fig. 21) yet receive their special nerve (which can sometimes be readily isolated) from the cerebral ganglion (see fig. 36). Accordingly the difference is one of position of the otocyst and not of its nerve-supply. The Natantia are further remarkable for the high development of their cephalic eyes, and for the typical character of their osphradium (Spengel's olfactory organ). This is a groove, the edges of which are raised and ciliated, lying near the branchial plume in the genera which possess that organ, whilst in Firuloides, which has no branchial plume, the osphradium occupies a corresponding position. Beneath the ciliated groove is

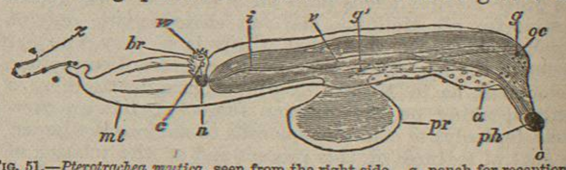

FIG. 51.—*Pterotrachea mutica.* seen from the right side. *a*, pouch for reception of the snout when retracted; *c*, pericardium; *ph*, pharynx; *oc*, cephalic eye; *g*, cerebral ganglion; *g'*, pleuro-pedal ganglion; *pr*, foot (mesopodium); *v*, stomach; *i*, intestine; *n*, so-called nucleus; *br*, branchial plume (ctenidium); *w*, osphradium; *mt*, foot (metapodium); *z*, caudal appendage. (After Keferstein.)

placed an elongated ganglion (olfactory ganglion) connected by a nerve to the supra-intestinal (therefore the primitively dextral) ganglion of the long visceral nerve-loop, the strands of which cross one another,—this being characteristic of Streptoneura (Spengel).

The Natantia belong to the "pelagic fauna" occurring near the surface in the Mediterranean and great oceans in company with the Pteropoda, the Siphonophorous Hydrozoa, Salpæ, Leptocephali, and other specially-modified transparent swimming representatives of various groups of the animal kingdom. In development they pass through the typical trochosphere and veliger stages provided with boat-like shell.

Branch *b*.—*EUTHYNEURA* (Spengel, 1881).

Characters.—Gastropoda Anisopleura in which the visceral loop (the conterminous visceral nerves) does not share in the torsion of the visceral hump, but, being placed entirely below the intestine, remains straight and untwisted, the junction of the visceral cords being below, and not

FIG. 52.—*Bulla vexillum* (Chemnitz), as seen crawling. *d*, oral hood (compare with Tethys, fig. 62, B), possibly a continuation of the epipodia; *b*, *b'*, cephalic tentacles. (From Owen.)

above, the intestine as it is in Streptoneura. Although the anus is not brought so far forward by the visceral torsion as in the Streptoneura, and may even by *secondary* growth assume a posterior median position, yet, as fully developed, an asymmetry has resulted as in the Azygobranchia, only the original right renal organ, right ctenidium (if any), right osphradium, right side of the heart, and right genital ducts being retained. All the Euthyneura are hermaphrodite. The lingual ribbon has very usually numerous fine denticles undifferentiated into series in each row. The shell is light and little calcified; often it is not developed in the adult, though present in the embryo. An operculum, often found in the embryo, is never present in the adult (except in Tornatella, fig. 53). Many Euthyneura show a tendency to, or a complete accomplishment of, the suppression of the mantle-skirt as well as of the shell, also of the ctenidium, and acquire at the same time a more or less cylindrical (slug-like) form of body.

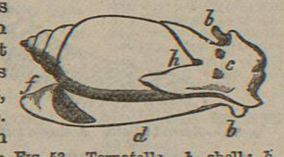

FIG. 53.—Tornatella. *h*, shell; *b*, oral hood; *d*, foot; *f*, operculum.

The Euthyneura comprise two orders, the Opisthobranchia and the Pulmonata.

Order 1.—**Opisthobranchia.**

Marine Euthyneura the more archaic forms of which have a relatively large foot and a small visceral hump, from the base of which projects on the right side a short mantle-skirt. The anus is placed in such forms far back

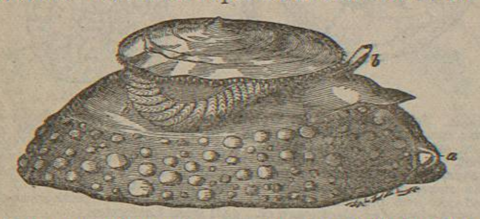

FIG. 54.—*Umbrella mediterranea.* *a*, mouth; *b*, cephalic tentacle; *h*, gill (ctenidium). The free edge of the mantle is seen just below the margin of the shell (compare with Aplysia, fig. 63). (From Owen.)

beyond the mantle-skirt. In front of the anus, and only partially covered by the mantle-skirt, is the ctenidium with its free end turned backwards. The heart lies in front of, instead of to the side of, the attachment of the ctenidium,—hence Opisthobranchia as opposed to "Prosobranchia," which correspond to the Streptoneura. A shell is possessed in the adult state by but few Opisthobranchia, but all pass through a veliger larval stage with a nautiloid shell (fig. 60). Many Opisthobranchia have by a process of atrophy lost the typical ctenidium and the mantle-skirt, and have developed other organs in their place. As in some Azygobranchia, the free margin of the mantle-skirt is frequently reflected over the shell when a shell exists; and, as in some Azygobranchia, broad lateral outgrowths of the foot (epipodia) are often developed, which, as does *not* occur in Azygobranchia, may be thrown over the shell or naked dorsal surface of the body.

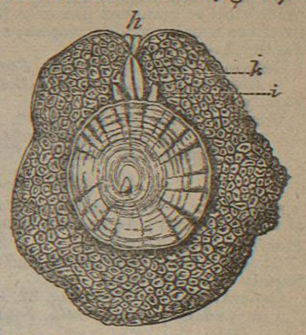

FIG. 55.—*Umbrella mediterranea*, seen from above. *h*, mouth; *i*, cephalic tentacles; *k*, penis-sheath. (After Keferstein.)

The variety of special developments of structure accompanying the atrophy of typical organs in the Opisthobranchia and general degeneration of organization is very great, and renders their classification difficult. Two sections of the order may be distinguished, according as the typical Molluscan mantle-skirt (limbus pallialis) is or is not atrophied, and within each section certain sub-orders.

Section *a*.—*PALLIATA* (= *Tectibranchiata*, Woodward)—the typical Molluscan mantle-skirt or pallium retained.

Sub-order 1.—*Ctenidiobranchia.*

Characters.—Palliata in which the ctenidium is retained as the branchial organ; with rare exceptions a delicate shell, which may be very small or completely enclosed by the reflected margin of the mantle; epipodia (lateral outgrowths of the foot) frequently present.

Family 1.—*Tornatellidæ.*

Genera: *Tornatella*, Lam. (fig. 53); *Cinulia*, Gray, &c.

Family 2.—*Bullidæ.*

Genera: *Bulla*, Lam. (fig. 52); *Acera*, Müller; *Scaphander*, Montf.; *Bullæa*, Lam.; *Doridium*, Meckel; *Gastropteron*, Meckel, &c.

Family 3.—*Aplysiidæ*

Genera: *Aplysia*, Gmelin (the Sea-Hare) (figs. 20, 56, &c.); *Dolobella*, Lam.; *Lobiger*, Krohn, &c.

Family 4.—*Pleurobranchidæ.*

Genera: *Pleurobranchus*, Cuvier; *Umbrella*, Chemnitz (figs. 54, 55); *Runcina*, Forbes, &c.

Sub-order 2.—*Phyllidiobranchia.*

Characters.—Palliata in which the ctenidia have atrophied; much as in Patellidæ among the Zygobranchiate Streptoneura their place is taken by laterally-placed lamellæ, developed from the inner surface of the bilaterally-disposed mantle-skirt in two lateral rows.

Family 5.—*Phyllidiadæ.*

Genera: *Phyllidia*, Cuiver; *Pleurophyllidia*, Meck. (fig. 57).

Section *b*.—*NON-PALLIATA.*

Characters.—The typical Molluscan mantle-skirt is atrophied in the adult. No shell is present in the adult, though the dorsal integument may be strengthened by calcareous spicules (Doris). The otocysts are not sessile on the pedal ganglia as in other Gastropods, but, as in the Natantia Azygobranchia, lie close to the cerebral ganglia. In one sub-order (Pygobranchia) the typical ctenidium appears to be retained in a modified form; in the others special developments of the body-wall take its place, or no special respiratory processes exist at all. The general form of the body is slug-like, the foot and visceral hump being coextensive, and a secondary bilateral symmetry is asserted by the usually median (sometimes right-sided) dorsal position of the anus on the hinder part of the body.

Sub-order 1.—*Pygobranchia.*

Characters.—The ctenidium assumes the form of a circlet of pinnate processes surrounding the median dorsal anus; a strongly marked epipodial fold may occur all round the foot and simulate a mantle-skirt (see fig. 62, C, Doris); papillæ or "cerata" of the dorsal integument may occur as well as the true ctenidium (fig. 61).

Family 6.—*Dorididæ.*

Genera: *Doris*, L.; *Gonicdoris*, Forbes; *Triopa*, Johnst.; *Ægirus* Loven; *Thecacera*, Fleming; *Polycera*, Cuvier; *Idalia*, Leuckart; *Ancula*, Loven; *Ceratosoma*, Adams; *Onchidoris*, Blainv.