other Lamellibranchia. The Swan Mussel has superficially a perfectly-developed bilateral symmetry. The left side of the animal is seen as when removed from its shell in fig. 124 (1). The valves of the shell have been removed by severing their adhesions to the muscular areæ *h*, *i*, *k*, *l*, *m*, *u*.

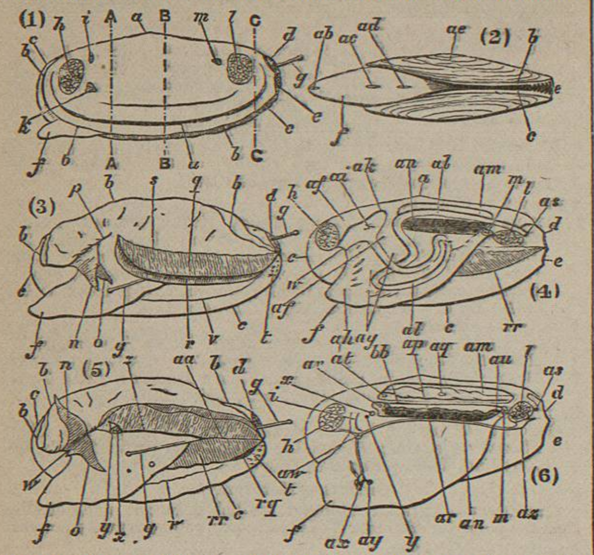

FIG. 124.—Diagrams of the external form and anatomy of *Anodonta cygnea*, the Pond-Mussel; in all the figures the animal is seen from the left side, the centro-dorsal region uppermost, as in the drawings of fig. 75, which compare. (1) Animal removed from its shell, a probe *g* passed into the sub-pallial chamber through the excurrent siphonal notch. (2) View from the ventral surface of an Anodon with its foot expanded and issuing from between the gaping shells. (3) The left mantle-flap reflected upwards so as to expose the sides of the body. (4) Diagrammatic section of Anodon to show the course of the alimentary canal. (5) The two gill-plates of the left side reflected upwards so as to expose the fissure between foot and gill where the probe *g* passes. (6) Diagram to show the positions of the nerve-ganglia, heart, and nephridia.

Letters in all the figures as follows:—*a*, centro-dorsal area; *b*, margin of the left mantle-flap; *c*, margin of the right mantle-flap; *d*, excurrent siphonal notch of the mantle margin; *e*, incurrent siphonal notch of the mantle margin; *f*, foot; *g*, probe passed into the superior division of the sub-pallial chamber through the excurrent siphonal notch, and issuing by the side of the foot into the inferior division of the sub-pallial chamber; *h*, anterior (pallial) adductor muscle of the shells; *i*, anterior retractor muscle of the foot; *k*, protractor muscle of the foot; *l*, posterior (pedal) adductor muscle of the shells; *m*, posterior retractor muscle of the foot; *n*, anterior labial tentacle; *o*, posterior labial tentacle; *p*, base-line of origin of the reflected mantle-flap from the side of the body; *q*, left external gill-plate; *r*, left internal gill-plate; *rr*, inner lamella of the right inner gill-plate; *rg*, right outer gill-plate; *s*, line of concrescence of the outer lamella of the left outer gill-plate with the left mantle-flap; *t*, pallial tentacles; *u*, the thickened muscular pallial margin which adheres to the shell and forms the pallial line of the left side; *v*, that of the right side; *w*, the mouth; *x*, aperture of the left organ of Bojanus (nephridium) exposed by cutting the attachment of the inner lamella of the inner gill-plate; *y*, aperture of the genital duct; *z*, fissure between the free edge of the inner lamella of the inner gill-plate and the side of the foot, through which the probe *g* passes into the upper division of the sub-pallial space; *aa*, line of concrescence of the inner lamella of the right inner gill-plate with the inner lamella of the left inner gill-plate; *ab*, *ac*, *ad*, three pit-like depressions in the median line of the foot supposed by some writers to be pores admitting water into the vascular system; *ae*, left shell valve; *af*, space occupied by liver; *ag*, space occupied by gonad; *ah*, muscular substance of the foot; *ai*, duct of the liver on the wall of the stomach; *ak*, stomach; *al*, rectum traversing the ventricle of the heart; *am*, pericardium; *an*, glandular portion of the left nephridium; *ap*, ventricle of the heart; *aq*, aperture by which the left auricle joined the ventricle; *ar*, non-glandular portion of the left nephridium; *as*, anus; *at*, pore leading from the pericardium into the glandular sac of the left nephridium; *au*, pore leading from the glandular into the non-glandular portion of the left nephridium; *av*, internal pore leading from the non-glandular portion of the left nephridium to the external pore *x*; *aw*, left cerebro-pleuro-visceral ganglion; *ax*, left pedal ganglion; *ay*, left otocyst; *az*, left olfactory ganglion (parieto-splanchnic); *bb*, floor of the pericardium separating that space from the non-glandular portion of the nephridia.

The free edge of the left half of the mantle-skirt *b* is represented as a little contracted in order to show the exactly similar free edge of the right half of the mantle-skirt *c*. These edges are not attached to, although they touch, one another; each flap (right or left) can be freely thrown back in the way which has been carried out in fig. 124, (3) for that of the left side. This is not always the case with Lamellibranchs; there is in the group a tendency for the corresponding edges of the mantle-skirt to fuse together by concrescence, and so to form a more or less completely closed bag, as in the Scaphopoda (Dentalium). In this way the notches *d*, *e* of the hinder part of the mantle-skirt of Anodon are in the Siphonate forms converted into two separate holes, the edges of the mantle being elsewhere fused together along this hinder margin. Further than this, the part of the mantle-skirt bounding the two holes is frequently drawn out so as to form a pair of tubes which project from the shell (figs. 130, 141). In such Lamellibranchs as the oysters, scallops, and many others which have the edges of the mantle-skirt quite free, there are numerous tentacles upon those edges. In Anodon these pallial tentacles are confined to a small area surrounding the inferior siphonal notch (fig. 124, (3), *t*).

The centro-dorsal point *a* of the animal of Anodonta (fig. 124, (1)) is called the umbonal area; the great anterior muscular surface *h* is that of the anterior adductor muscle, the posterior similar surface *i* is that of the posterior adductor muscle; the long line of attachment *u* is the simple "pallial muscle,"—a thickened ridge which is seen to run parallel to the margin of the mantle-skirt in this Lamellibranch. In some of the Siphonate Isomya, which are hence termed "Sinupallia," the pallial muscle is not simple but deeply incurved at the posterior region so as to allow of the large pallial siphons being retracted within the shell or expanded at will (fig. 127, and figs. 140, 141).

It is the approximate equality in the size of the anterior and posterior adductor muscles which has led to the name Isoyma for the group to which Anodon belongs. The hinder adductor muscle may be considered as representing morphologically the transverse fibres of the root of the foot of Nautilus by which it adheres to its shell (fig. 91, *k*), the annular muscular area of Patella (fig. 27, *c*), and the columella muscle of the Gastropods generally. It is always large in Lamellibranchs, but the anterior adductor may be very small (Heteromya), or absent altogether (Monomya). The anterior adductor muscle is in front of the mouth and alimentary tract altogether, and must be regarded as a special and peculiar development of the median anterior part of the mantle-flap

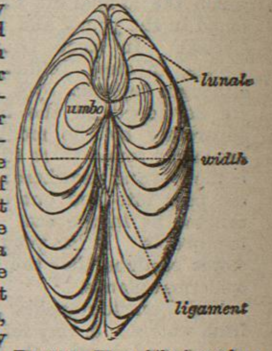

FIG. 125.—View of the two valves of the shell of Cytherea (one of the Sinupalliate Isomya), from the dorsal aspect.

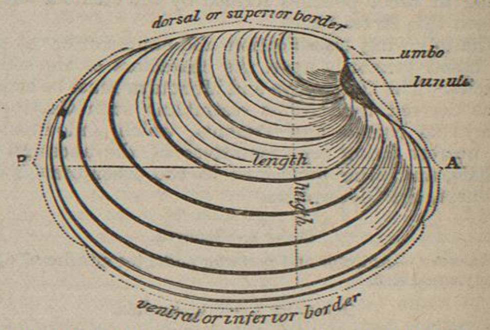

FIG. 126.—Right valve of the same shell from the outer face.

in Heteromya and Isomya. Amongst those Lamellibranchs which have only a posterior adductor (Monomya), it is remarkable that the oyster has been found (by Huxley) to possess, when the young shells and muscles first develop, a well-marked anterior adductor as well as a posterior one. Accordingly there is ground for supposing

that the Monomya have been developed from Isomya-like ancestors, and have lost by atrophy their anterior adductor. The single adductor muscle of the Monomya is separated by a difference of fibre into two portions, but neither of these can be regarded as possibly representing the anterior adductor of the other Lamellibranchs. One of these portions is more ligamentous, and serves to keep the two shells constantly attached to one another, whilst the more fleshy portion serves to close the shell rapidly when it has been gaping.

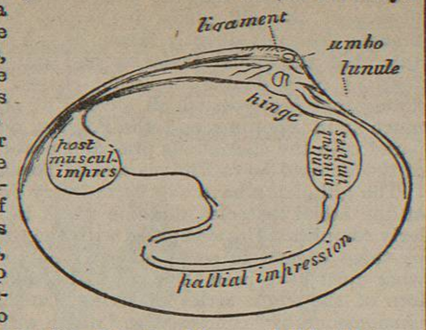

FIG. 127.—Left valve of the same shell from the inner face. (Figs. 125, 126, 127 from Owen.)

In removing the valves of the shell from an Anodon, it is necessary not only to cut through the muscular attachments of the body-wall to the shell but to sever also a strong elastic ligament, or spring resembling india-rubber, joining the two shells about the umbonal area. The shell of Anodon does not present these parts in the most strongly marked condition, and accordingly our figures (figs. 125, 126, 127) represent the valves of the Sinupalliate genus Cytherea. The corresponding parts are recognizable in Anodon. Referring to the figures (125, 126) for an explanation of terms applicable to the parts of the valve and the markings on its inner surface—corresponding to the muscular area which we have already noted on the surface of the animal's body—we must specially note here the position of that denticulated thickening of the dorsal margin of the valve which is called the hinge (fig. 127). By this hinge one valve is closely fitted to the other. Below this hinge each shell becomes concave, above it each shell rises a little to form the umbo, and it is into this ridge-like upgrowth of each valve that the elastic ligament or spring is fixed (fig. 127). As shown in the diagram (fig. 127*) representing a transverse section of the two valves of a Lamellibranch, the two shells form a double lever, of which the toothed-hinged is the fulcrum. The adductor muscles placed in the concavity of the shells act upon the long arms of the lever at a mechanical advantage; their contraction keeps the shells shut, and stretches the ligament or spring *h*. On the other hand, the ligament *h* acts upon the short arm formed by the umbonal ridge of the shells; whenever the adductors relax, the elastic substance of the ligament contracts, and the shells gape. It is on this account that the valves of a dead Lamellibranch always gape; the elastic ligament is no longer counteracted by the effort of the adductors. The state of closure of the valves of the shell is not, therefore, one of rest; when it is at rest—that is, when there is no muscular effort—the valves of a Lamellibranch are slightly gaping, and are closed by the action of the adductors when the animal is disturbed. The ligament is simple in Anodon; in many Lamellibranchs it is separated into two layers, an outer and an inner (thicker and denser). That the condition

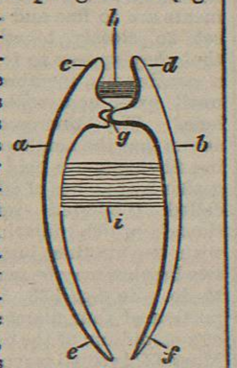

FIG. 127*.—Diagram of a section of a Lamellibranch's shells, ligament, and adductor muscle. *a*, *b*, right and left valves of the shell; *c*, *d*, the umbones or short arms of the lever; *e*, *f*, the long arms of the lever; *g*, the hinge; *h*, the ligament; *i*, the adductor muscle.

of gaping of the shell-valves is essential to the life of the Lamellibranch appears from the fact that food to nourish it, water to aerate its blood, and spermatozoa to fertilize its eggs, are all introduced into this gaping chamber by currents of water, which are set going by the highly-developed ctenidia. The current of water enters into the sub-pallial space at the spot marked *e* in fig. 124, (1), and, after passing as far forward as the mouth *w* in fig. 124, (5), takes an outward course and leaves the sub-pallial space by the upper notch *d*. These notches are known in Anodon as the afferent and efferent siphonal notches respectively, and correspond to the long tube-like afferent inferior and efferent superior "siphons" formed by the mantle in many other Lamellibranchs (fig. 130).

Whilst the valves of the shell are equal in Anodon we find in many Lamellibranchs (Ostræa, Chama, Corbula, &c.) one valve larger, and the other smaller and sometimes flat, whilst the larger shell may be fixed to rock or to stones (Ostræa, &c.). A further variation consists in the development of additional shelly plates upon the dorsal line between the two large valves (Pholadidæ). In *Pholas dactylus* we find a pair of umbonal plates, a dors-umbonal plate and a dorsal plate. It is to be remembered that the whole of the cuticular hard product produced on the dorsal surface and on the mantle-flaps is to be regarded as the "shell," of which a median band-like area, the ligament, usually remains uncalcified, so as to result in the production of two valves united by the elastic ligament. But the shelly substance does not always in boring forms adhere to this form after its first growth. In Aspergillum the whole of the tubular mantle area secretes a continuous shelly tube, although in the young condition two valves were present. These are seen (fig. 129) set in the firm substance of the adult tubular shell, which has even replaced the ligament, so that the tube is complete. In Teredo a similar tube is formed as the animal elongates (boring in wood), the original shell-valves not adhering to it but remaining movable and provided with a special muscular apparatus in place of a ligament.

Let us now examine the organs which lie beneath the mantle-skirt of Anodon, and are bathed by the current of water which circulates through it. This can be done by lifting up and throwing back the left half of the mantle-skirt as is represented in fig. 124, (3). We thus expose the plough-like foot (*f*), the two left labial tentacles, and the two left gill-plates or left ctenidium. In fig. 124, (5), one of the labial tentacles *a* is also thrown back so as to show

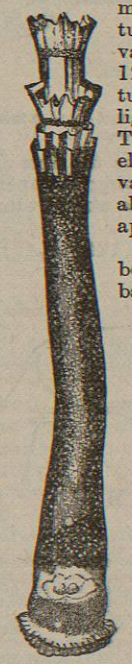

Fig. 128.

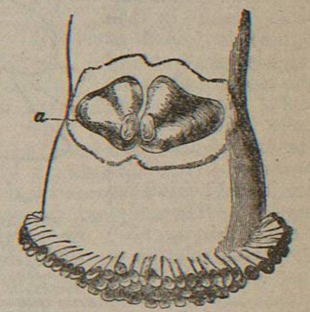

Fig. 129.

FIG. 128.—Shell of *Aspergillum vaginiferum* (from Owen).
FIG. 129.—Shell of *Aspergillum vaginiferum* to show the original valves *a*, now embedded in a continuous calcification of tubular form (from Owen).

the mouth *w*, and the two left gill-plates are reflected so as to show the gill-plates of the right side (*rr*, *rq*) projecting behind the foot, the inner or median plate of each side being united by concrescence to its fellow of the opposite side along a continuous line (*aa*). The left inner gill-plate is also snipped so as to show the subjacent orifices of the left nephridium *x*, and of the genital gland (testis or ovary) *y*. The foot thus exposed in Anodon is a simple muscular tongue-like organ. It can be protruded between the flaps of the mantle (fig. 124, (1), (2)) so as to issue from the shell, and by its action the Anodon can slowly crawl, or burrow in soft mud or sand. It has been supposed that water is taken into the blood-vessels of the Anodon through pores in the foot, and in spite of opposition this view is still maintained (Griesbach, 47). In fig. 124, (2) the letters *ab*, *ac*, *ad*, point to three pit-like depressions, supposed by Griesbach to be pores leading into the blood-system. According to Carrière (48) these pits are nothing but irregularities of the surface; in some cases they are the entrances to ramified glands. Other Lamellibranchs may have a larger foot relatively than has Anodon. In Arca it has a sole-like surface. In Arca too and many others it carries a byssus-forming gland and a byssus-cementing gland. In the Cockles, in Cardium, and in Trigonia, it is capable of a sudden stroke, which causes the animal to jump when out of the water, in the latter

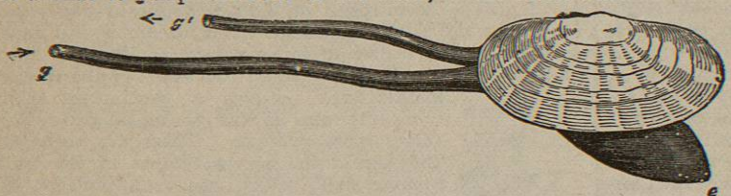

FIG. 130.—*Psammobia florida*, right side, showing expanded foot *e*, and *g* incurrent and *g′* excurrent siphons (from Owen).

genus to a height of four feet. In Mytilus the foot is reduced to little more than a tubercle carrying the apertures of these glands. In the Oyster it is absent altogether.

The labial tentacles of Anodon (*n*, *o* in fig. 124, (3), (5)) are highly vascular flat processes richly supplied with nerves. The left anterior tentacle (seen in the figure) is joined at its base in front of the mouth (*w*) to the right anterior tentacle, and similarly the left (*o*) and right posterior tentacles are joined behind the mouth. Those of Arca (*i*, *k* in fig. 132) show this relation to the mouth (*a*). These organs are characteristic of all Lamellibranchs; they do not vary except in size, being sometimes drawn out to streamer-like dimensions. Their appearance and position suggest that they are in some way related morphologically to the gill-plates, the anterior labial tentacle being a continuation of the outer gill-plate,

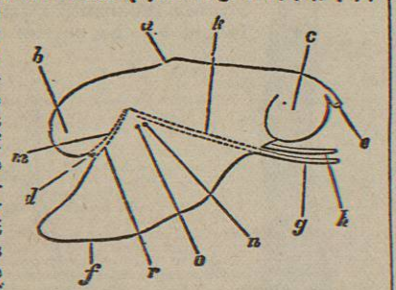

FIG. 131.—Diagram of a view from the left side of the animal of *Anodonta cygnæa*, from which the mantle-skirt, the labial tentacles, and the gill-filaments have been entirely removed so as to show the relations of the axis of the gill-plumes or ctenidia *g*, *h*. *a*, centro-dorsal area; *b*, anterior adductor muscle; *c*, posterior adductor muscle; *d*, mouth; *e*, anus; *f*, foot; *g*, free portion of the axis of left ctenidium: *h*, axis of right ctenidium; *k*, portion of the axis of the left ctenidium which is fused with the base of the foot, the two dotted lines indicating the origins of the two rows of gill-filaments; *m*, line of origin of the anterior labial tentacle; *n*, nephridial aperture; *o*, genital aperture; *r*, line of origin of the posterior labial tentacle. (Original.)

and the posterior a continuation of the inner gill-plate. There is no embryological evidence to support this suggested connexion, and, as will appear immediately, the history of the gill-plates in various forms of Lamellibranchs does not directly favour it. Yet it is very probable that the labial tentacles and gill-plates are modifications of a double horseshoe-shaped area of ciliated filamentous processes which existed in ancestral Mollusca much as in Phoronis and the Polyzoa, and is to be compared with the continuous præ- and post-oral ciliated band of the Echinid larva Pluteus and of Tornaria (49).

The gill-plates have a structure very different from that of the labial tentacles, and one which in Anodon is singularly complicated as compared with the condition presented by these organs in some other Lamellibranchs, and with what must have been their original condition in the ancestors of the whole series of living Lamellibranchia. The phenomenon of "concrescence" which we have already had to note as showing itself so importantly in regard to the free edges of the mantle-skirt and the formation of the siphons, is what, above all things, has complicated the structure of the Lamellibranch ctenidium. Our present knowledge of the interesting series of modifications through which the Lamellibranch gill-plates have developed to their most complicated form is due to R. Holman Peck (50) and to Mitsukuri (51). The Molluscan ctenidium is typically, as shown in fig. 2, a plume-like structure, consisting of a vascular axis, on each side of which is set a row of numerous lamelliform or filamentous processes. These processes are hollow, and receive the venous blood from, and return it again aerated into, the hollow axis, in which an afferent and an efferent blood-vessel may be differentiated. In the genus Nucula (fig. 134), one of the Arcaceæ, we have an example of a Lamellibranch retaining this plume-like form of gill. In other Arcaceæ (*e.g.*, Arca and Pectunculus) the lateral processes which are set on the axis of the ctenidium are not lamellæ, but are slightly-flattened, very long tubes or hollow filaments. These filaments are so fine and are set so closely together that they appear to form a continuous membrane until examined with a lens. The microscope shows that the neighbouring filaments are held together by patches of cilia, called "ciliated junctions," which interlock with one another just as two brushes may be made to do. In fig. 133, A a portion of four filaments of a ctenidium of the Sea-Mussel (Mytilus) is represented, having precisely the same structure as those of Arca. The filaments of the gill (ctenidium) of Mytilus and Arca thus form two closely set rows which depend from the axis of the gill like two parallel plates. Further, their structure is profoundly modified by the curious condition of the free ends of the depending filaments. These are actually reflected at a sharp angle—

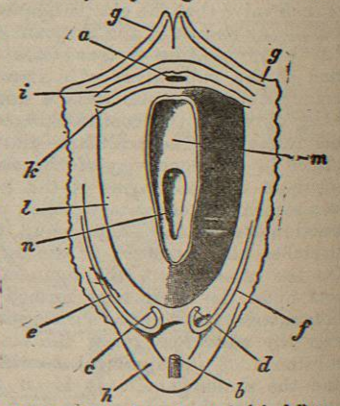

FIG. 132.—View from the ventral (pedal) aspect of the animal of *Arca Noæ*, the mantle-flap and gill-filaments having been cut away. *a*, mouth; *b*, anus; *c*, free spirally turned extremity of the gill-axis or ctenidial axis of the right side; *d*, do. of the left side; *e*, *f*, anterior portions of these axes fused by concrescence to the wall of the body; *g*, anterior adductor muscle; *h*, posterior adductor; *i*, anterior labial tentacle; *k*, posterior labial tentacle; *l*, base line of the foot; *m*, sole of the foot; *n*, callosity. (Original.)

doubled on themselves in fact—and thus form an additional row of filaments (see fig. 133, B). Consequently, each primitive filament has a descending and an ascending ramus, and instead of each row forming a simple plate, the plate is double, consisting of a descending and an ascending lamella. As the axis of the ctenidium lies by the side of the body, and is very frequently connate with the body, as so often happens in Gastropods also, we find it convenient to speak of the two plate-like structures formed on each ctenidial axis as the outer and the inner gill-plate; each of these is

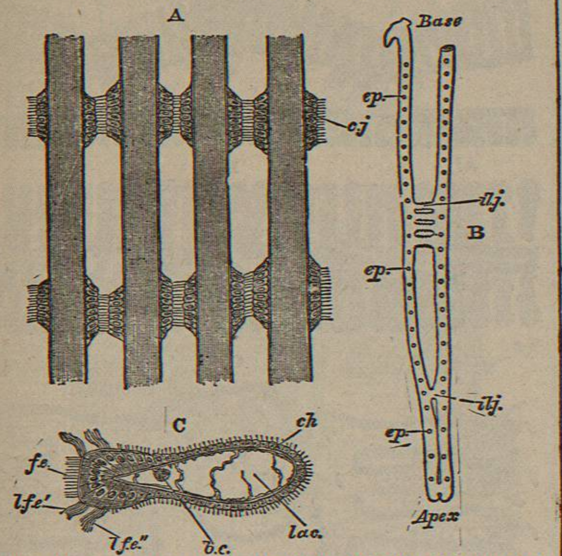

FIG. 133.—Filaments of the ctenidium of *Mytilus edulis* (after Holman Peck). A. Part of four filaments seen from the outer face in order to show the ciliated junctions *c.j.* B. Diagram of the posterior face of a single complete filament with descending ramus and ascending ramus ending in a hook-like process. *ep.*, *ep.*, the ciliated junctions; *il.j.*, inter-lamellar junction. C. Transverse section of a filament taken so as to cut neither a ciliated junction nor an inter-lamellar junction. *f.e.*, frontal epithelium; *l.f.e′.*, *l.f.e″.*, the two rows of latero-frontal epithelial cells with long cilia; *ch*, chitonous tubular lining of the filament; *lac.*, blood lacuna traversed by a few processes of connective tissue cells; *b.c.*, blood-corpuscle.

composed of two lamellæ, an outer (the reflected) and an adaxial in the case of the outer gill-plate, and an adaxial and an inner (the reflected) in the case of the inner gill-plate. This is the condition seen in Arca and Mytilus, the so-called plates dividing upon the slightest touch into their constituent filaments, which are but loosely conjoined by their "ciliated junctions." Complications follow upon this in other forms. Even in Mytilus and Arca a connexion is here and there formed between the ascending and descending rami of a filament by hollow extensible outgrowths called "interlamellar junctions" (*il.j* in B, fig. 133). Nevertheless the filament is a complete tube formed of chitonous substance and clothed externally by ciliated epithelium, internally by endothelium and lacunar tissue—a form of connective tissue—as shown in fig. 133, C. Now let us suppose, as happens in the genus Dreissena—a genus not far removed from Mytilus—that the ciliated inter-filamentar junctions (fig. 136) give place to solid permanent inter-filamentar junctions, so that the filaments are converted, as it were, into a trellis-work. Then let us suppose that the inter-lamellar junctions which we have already noted in Mytilus become very numerous, large, and irregular; by them the two trellis-works of filaments would be united so as to leave only a sponge-like set of spaces between them. Within the trabeculæ of the sponge-work blood circulates, and between the trabeculæ the water passes, having entered by the apertures left in the trellis-work formed by the united gill-filaments (fig. 138, A, B). The larger the intra-lamellar spongy

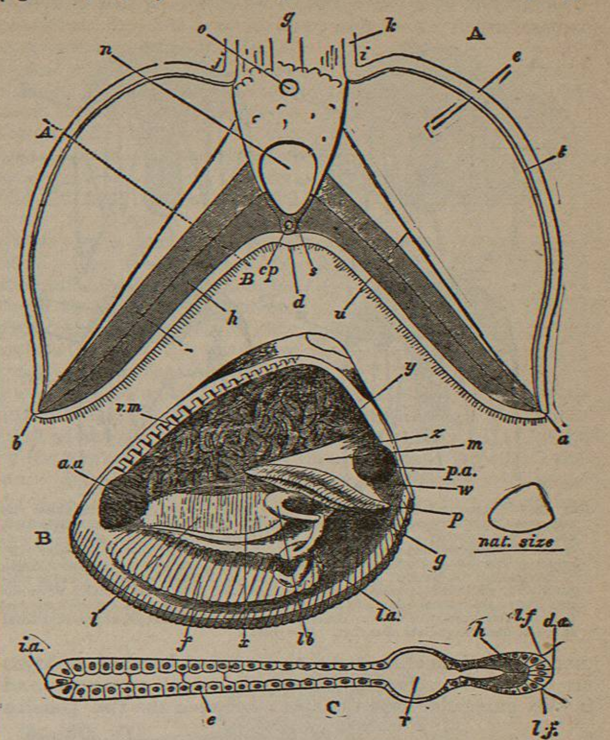

FIG. 134.—Structure of the ctenidia of Nucula (after Mitsukuri); see also fig 2. A. Section across the axis of a ctenidium with a pair of plates—flattened and shortened filaments—attached. *i*, *j*, *k*, *g* are placed on or near the membrane which attaches the axis of the ctenidium to the side of the body; *a*, *b*, free extremities of the plates (filaments); *d*, mid-line of the inferior border; *e*, surface of the plate; *t*, its upper border; *h*, chitonous lining of the plate; *r*, dilated blood-space; *u*, fibrous tract; *o*, upper blood-vessel of the axis; *n*, lower blood-vessel of the axis; *s*, chitonous framework of the axis; *cp*, canal in the same; *A*, *B*, line along which the cross-section C of the plate is taken. B. Animal of a male *Nucula proxima*, Say, as seen when the left valve of the shell and the left half of the mantle-skirt are removed. *a.a.*, anterior adductor muscle; *p.a.*, posterior adductor muscle; *v.m*, visceral mass; *f*, foot; *g*, gill; *l*, labial tentacle; *l.a.*, filamentous appendage of the labial tentacle; *lb*, hood-like appendage of the labial tentacle; *m*, membrane suspending the gill and attached to the body along the line *x*, *y*, *z*, *w*; *p*, posterior end of the gill (ctenidium). C. Section across one of the gill-plates (*A*, *B*, in A) comparable with fig. 133, C. *i.a.*, outer border; *d.a.*, axial border; *l.f.*, latero-frontal epithelium; *e*, epithelium of general surface; *r*, dilated blood-space; *h*, chitonous lining (compare A).

growth becomes, the more do the original gill-filaments lose the character of blood-holding tubes and tend to become dense elastic rods for the simple purpose of supporting the spongy growth. This is seen both in the section of Dreissena gill (fig. 136) and in those of Anodon (fig. 137, A, B, C). In the drawing of Dreissena the individual filaments *f*, *f*, *f* are cut across in one lamella at the horizon of an inter-filamentar junction, in the other (lower in the figure) at a point where they are free. The chitonous substance *ch* is observed to be greatly thickened as compared with what it is in fig. 133, C, tending in fact to obliterate altogether the lumen of the filament. And in Anodon (fig. 137, C) this obliteration is effected. In Anodon, besides being thickened, the skeletal substance of the filament develops a specially dense rod-like body on each side of each filament. Although the structure of the ctenidium is thus highly complicated in Anodon, it is yet more so in some of the Siphonate genera of Lamellibranchs. The filaments take on a secondary grouping, the surface of the lamella being thrown into a series of half-cylindrical ridges, each consisting of ten or twenty filaments; a filament of much greater strength and thickness than the others may be placed between each pair of groups. In Anodon, as in

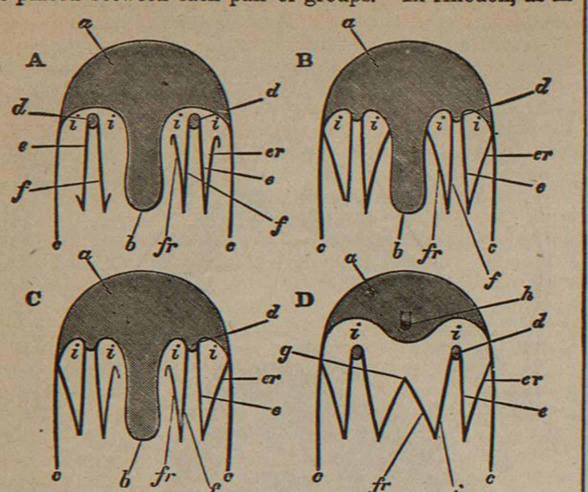

FIG. 135.—Diagrams of transverse sections of a Lamellibranch to show the adhesion, by concrescence, of the gill-lamellæ to the mantle-flaps, to the foot, and to one another. A shows two conditions with free gill-axis; B, condition at foremost region in Anodon; C, hind region of foot in Anodon; D, region altogether posterior to the foot in Anodon. *a*, visceral mass; *b*, foot; *c*, mantle flap; *d*, axis of gill or ctenidium; *e*, adaxial lamella of outer gill-plate; *er*, reflected lamella of outer gill-plate; *f*, adaxial lamella of inner gill-plate; *fr*, reflected lamella of inner gill-plate; *g*, line of concrescence of the reflected lamellæ of the two inner gill-plates; *h*, rectum; *i*, supra-branchial space of the sub-pallial chamber. (Original.)

many other Lamellibranchs, the ova and hatched embryos are carried for a time in the ctenidia or gill apparatus, and in this particular case the space between the two lamellæ

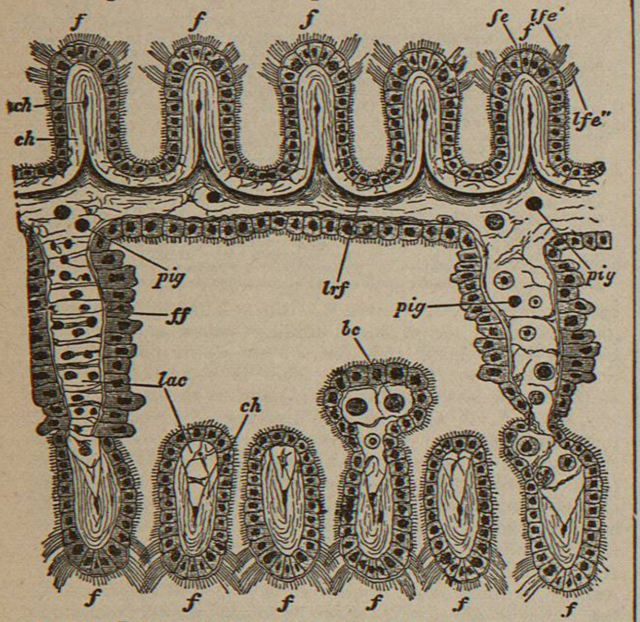

FIG. 136.—Transverse section of the outer gill-plate of *Dreissena polymorpha* (after Holman Peck). *f*, constituent gill-filaments: *ff*, fibrous sub-epidermic tissue; *ch*, chitonous substance of the filaments; *nch*, cells related to the chitonous substance; *lac*, lacunar tissue; *pig*, pigment-cells; *bc*, blood-corpuscles; *fe*, frontal epithelium; *lfe'*, *lfe''*, two rows of latero-frontal epithelial cells with long cilia; *lrf*, fibrous, possibly muscular, substance of the inter-filamenter junctions.

of the outer gill-plate is that which serves to receive the ova (fig. 137, A). The young are nourished by a substance formed by the cells which cover the spongy inter-lamellar outgrowths.

There are certain other points in the modification of the typical ctenidium which must be noted in order to understand the ctenidium of Anodon. The axis of each ctenidium, right and left, starts from a point well forward near the labial tentacles, but it is at first only a ridge, and does not project as a free cylindrical axis until the back part of

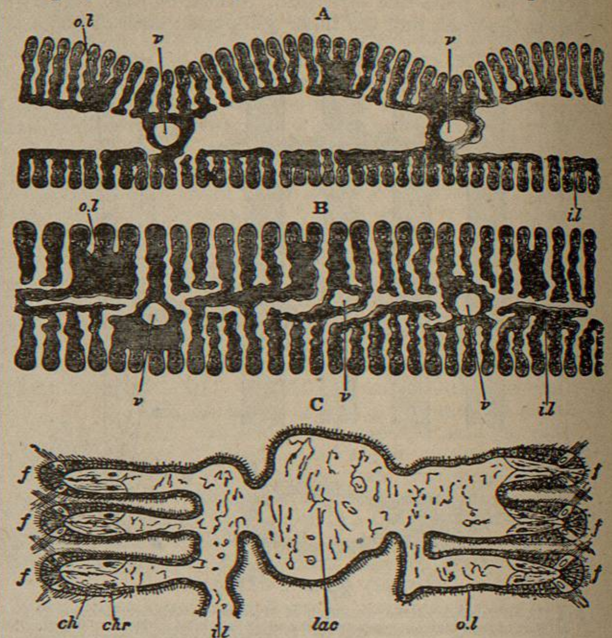

FIG. 137.—Transverse sections of gill-plates of Anodon (after Peck). A. Outer gill-plate. B. Inner gill-plate. C. A portion of B more highly magnified. *o.l*, outer lamella; *i.l*, inner lamella; *v*, blood-vessel; *f*, constituent filaments; *lac*, lacunar tissue; *ch*, chitonous substance of the filament; *chr*, chitonous rod embedded in the softer substance *ch*.

the foot is reached. This is difficult to see at all in Anodon, but if the mantle-skirt be entirely cleared away, and if the dependent lamellæ which spring from the ctenidial axis be carefully cropped away so as to leave the axis itself intact, we obtain the form shown in fig. 131, where *g* and *h* are respectively the left and the right ctenidial axes projecting freely beyond the body. In Arca this can be seen with far less trouble, for the filaments are more easily removed than are the consolidated lamellæ formed by the filaments of Anodon, and in Arca the free axes of the ctenidia are large and firm in texture (fig. 132, *c*, *d*).

If we were to make a vertical section across the long axis of a Lamellibranch which had the axis of its ctenidium free from its origin onwards, we should find such relations as are shown in the diagram fig. 135, A. The gill axis *d* is seen lying in the sub-pallial chamber between the foot *b* and the mantle *c*. From it depend the gill-filaments or lamellæ—formed by united filaments—drawn as black lines *f*. On the left side these lamellæ are represented as having only a small reflected growth, on the right side the reflected ramus or lamella is complete (*fr* and *er*). The actual condition in Anodon at the region where the gills commence anteriorly is shown in fig. 135, B. The axis of the ctenidium is seen to be adherent to, or fused by concrescence with, the body-wall, and moreover on each side the outer lamella of the outer gill-plate is fused to the mantle, whilst the inner lamella of the inner gill-plate is fused to the foot. If we pass a little backwards and take another section nearer the hinder margin of the foot, we

get the arrangement shown diagrammatically in fig. 135, C, and more correctly in fig. 142. In this region the inner lamellæ of the inner gill-plates are no longer affixed to the foot. Passing still further back behind the foot, we find

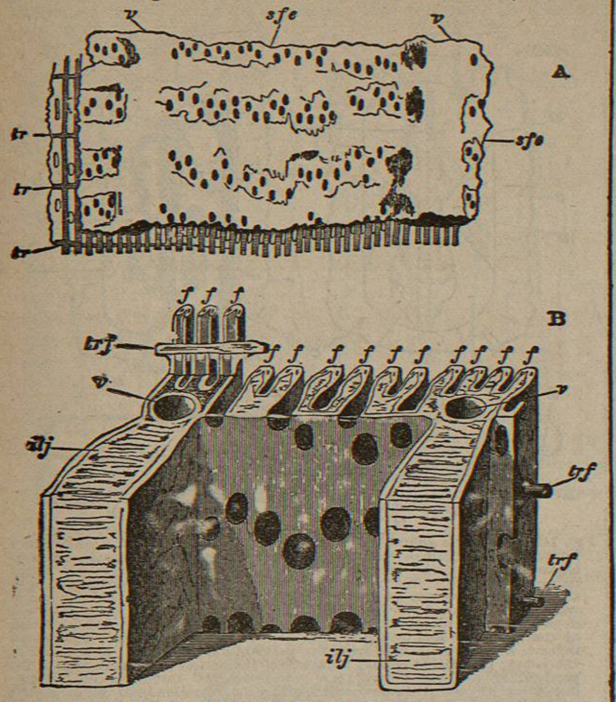

FIG. 138.—Gill-lamellæ of Anodon (after Peck). A. Fragment of the outer lamella of an inner gill-plate torn from the connected inner lamella, the sub-filamentar tissue also partly cut away round the edges so as to expose the filaments, their transverse junctions *tr*, and the "windows" left in the lattice-work; *sfe*, internal surface of the lamella; *v*, vessel. B. Diagram of a block cut from the outer lamella of the outer gill-plate and seen from the inter-lamellar surface (after Peck). *f*, constituent filaments; *trf*, fibrous tissue of the transverse inter-filamentar junctions; *v*, blood-vessel; *ilj*, inter-lamellar junction. The series of oval holes on the back of the lamella are the water-pores which open between the filaments in irregular rows separated horizontally by the transverse inter-filamentar junctions.

in Anodon the condition shown in the section D, fig. 135. The axes *i* are now free; the outer lamellæ of the outer gill-plates (*er*) still adhere by concrescence to the mantle-skirt, whilst the inner lamellæ of the inner gill-plates meet one another and fuse by concrescence at *g*. In the lateral view of the animal with reflected mantle-skirt and gill-plates, the line of concrescence of the inner lamellæ of the inner gill-plates is readily

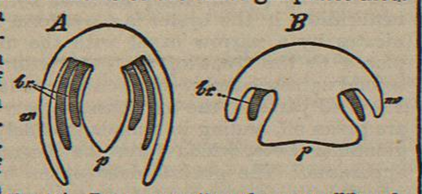

FIG. 139.—Transverse sections of *A*, a Lamellibranch, and *B*, an Isopleurous Gastropod (Chiton), to show the relations of *p*, the foot; *br*, the branchiæ; and *m*, the mantle. (From Gegenbaur.)

seen; it is marked *aa* in fig. 124, (5). In the same figure the free part of the inner lamella of the inner gill-plate resting on the foot is marked *z*, whilst the attached part—the most anterior—has been snipped with scissors so as to show the genital and nephridial apertures *x* and *y*. The concrescence, then, of the free edge of the reflected lamellæ of the gill-plates of Anodon is very extensive. It is important, because such a concrescence is by no means universal, and does not occur, for example, in Mytilus or in Arca; further, because when its occurrence is once appreciated, the reduction of the gill-plates of Anodon to the plume-type of the simplest ctenidium presents no difficulty; and, lastly, it has importance in reference to its physiological significance. The mechanical result of the concrescence of the outer lamellæ to the mantle-flap, and of the inner lamellæ to one another as shown in section D, fig. 135, is that the sub-pallial space is divided into two spaces by a horizontal septum. The upper space (*i*) communicates with the outer world by the excurrent or superior siphonal notch of the mantle (fig. 124, *d*); the lower space communicates by the lower siphonal notch (*e* in fig. 124). The only communication between the two spaces, excepting through the trellis-work of the gill-plates, is by the slit (*z* in fig. 124, (5)) left by the non-concrescence of a part of the inner lamella of the inner gill-plate with the foot. A probe (*g*) is introduced through this slit-like passage, and it is seen to pass out by the excurrent siphonal notch. It is through this passage, or indirectly through the pores of the gill-plates, that the water introduced into the lower sub-pallial space must pass on its way to the excurrent siphonal notch. Such a subdivision of the pallial chamber, and direction of the

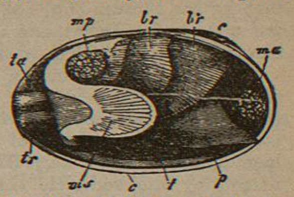

FIG. 140.—Lateral view of a Mactra, the right valve of the shell and right mantle-flap removed, and the siphons retracted. *br*, *br'*, outer and inner gill-plates; *t*, labial tentacle; *ta*, *tr*, upper and lower siphons; *ms*, siphonal muscle of the mantle-flap; *ma*, anterior adductor muscle; *mp*, posterior adductor muscle; *p*, foot; *c*, umbo. (From Gegenbaur.)

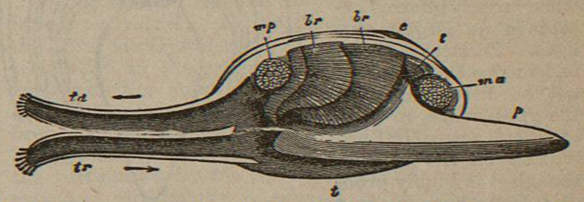

FIG. 141.—The same animal as fig. 140, with its foot and siphons expanded. Letters as in fig. 140. (From Gegenbaur.)

currents set up within it do not exist in a number of Lamellibranchs which have the gill-lamellæ comparatively free (Mytilus, Arca, Trigonia, &c.), and it is in these forms that there is least modification by concrescence of the primary filamentous elements of the lamellæ. Probably the gill-structure of Lamellibranchs will ultimately furnish some classificatory characters of value when they have been thoroughly investigated throughout the class.

The alimentary canal of Anodon is shown in fig. 124, (4). The mouth is placed between the anterior adductor and the foot; the anus opens on a median papilla overlying the posterior adductor, and discharges into the superior pallial chamber along which the excurrent stream passes. The coil of the intestine in Anodon is similar to that of other Lamellibranchs, but the crystalline style and its diverticulum are not present here. The rectum traverses the pericardium, and has the ventricle of the heart wrapped, as it were, around it. This is not an unusual arrangement in Lamellibranchs, and a similar disposition occurs in some Gastropoda (Haliotis). A pair of ducts (*ai*) lead from the first enlargement of the alimentary tract called stomach into a pair of large digestive glands, the so-called liver, the branches of which are closely packed in this region (*af*). The food of the Anodon, as of other Lamellibranchs, consists of microscopic animal and vegetable organisms, which are brought to the mouth by the stream which sets into the sub-pallial chamber at the lower siphonal notch (*e* in fig. 124). Probably a straining of water from solid