Sense-organs are highly developed; the eye exhibits a very special elaboration of structure in the Dibranchiata, and a remarkable archaic form in the Nautilus. Otocysts are present in all. The typical osphradium is not present,

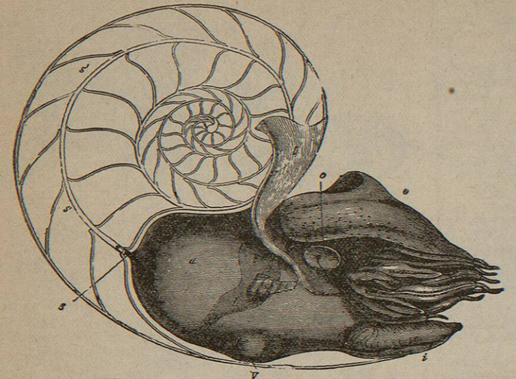

Fig. 89.—Lateral view of the female Pearly Nautilus, contracted by spirit and lying in its shell, the right half of which is cut away (from Gegenbaur, after Owen). *a*, visceral hump; *b*, portion of the free edge of the mantle-skirt reflected on to the shell,—the edge of the mantle-skirt can be traced downwards and forwards around the base of the mid-foot or siphon; *f*, *h*, superficial origin of the retractor muscle of the mid-foot (siphon), more or less firmly attached to the shell, of which a small piece (*s*) is seen between the letters *l*, *f*; *s* (farther back) points to the siphuncular pedicle, which is broken off short and not continued, as in the perfect state, through the whole length of the siphuncle of the shell, also marked *s* and *s'*; *o* points to the right eye; *t* is placed near the extremities of the contracted tentacles of the outer or annular lobe of the fore-foot,—the jointed tentacles are seen protruding a little from their long cylindrical sheaths; *v*, the dorsal "hood" formed by an enlargement in this region of the annular lobe of the fore-foot (*m.* in figs. 90, 91); *V*, a swelling of the mantle-skirt, indicating the position on its inner face of the nidamental gland (see fig. 101, *g.n.*).

except in Nautilus, but other organs are present in the

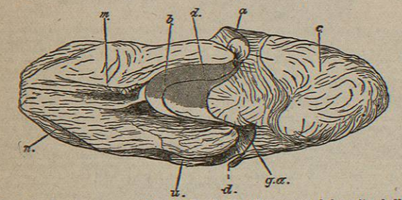

Fig. 90.—Spirit specimen of female Pearly Nautilus, removed from its shell, and seen from the antero-dorsal aspect (drawn from nature by A. G. Bourne). *m.*, the dorsal "hood" formed by the enlargement of the outer or annular lobe of the fore-foot, and corresponding to the sheaths of two tentacles (*g*, *g* in fig. 88); *n.*, tentacular sheaths of lateral portion of the annular lobe; *u.*, the left eye; *b.*, the nuchal plate, continuous at its right and left posterior angles with the roof of the mid-foot, and corresponding to the nuchal cartilage of Sepia; *a.*, visceral hump; *d.*, the free margin of the mantle-skirt, the middle letter *d.* points to that portion of the mantle-skirt which is reflected over a part of the shell as seen in fig. 89, *b*; the cup-like fossa to which *b.* and *d.* point in the present figure is occupied by the coil of the shell; *g.a.* points to the lateral continuation of the nuchal plate *b.* to join the roof of the mid-foot or siphon.

cephalic region, to which an olfactory function is ascribed both in Nautilus and in the other Siphonopoda.

The gonads are always separated in male and female individuals. The genital aperture and duct is sometimes single, when it is the left; sometimes the typical pair is developed right and left of the anus. The males of nearly all Siphonopoda have been shown to be characterized by a peculiar modification of the arm-like processes or lobes of the fore-foot, connected with the copulative function. The term hectocotylization is applied to this modification (see figs. 88, 95, 96). Elaborate spermatophores or sperm-ropes are formed by all Siphonopoda, and very usually the female possesses special capsule-forming and nidamental glands for providing envelopes to the eggs (fig 101, *g.n.*). The egg of all Siphonopoda is large, and the development is much modified by the presence of an excessive amount of food-material diffused in the protoplasm of the egg-cell. Trochosphere and veliger stages of development are consequently not recognizable.

The Siphonopoda are divisible into two orders, the names of which (due to Owen) describe the number of gill-plumes present; but in fact there are several characters of as great importance as those derived from the gills by which the members of these two orders are separated from one another.

Order 1.—**Tetrabranchiata** (= Schizosiphona, Tentaculifera).

Characters.—Siphonopodous Cephalopods in which the inrolled lateral margins of the mid-foot are not fused, but form a siphon by apposition (fig. 101). The circum-oral lobes of the fore-foot carry numerous sheathed tentacles (not suckers) (fig. 88). There are two pairs of ctenidial gills (hence Tetrabranchiata), and two pairs of nephridia, consequently four nephridial apertures (fig. 101). The viscero-pericardial chamber opens by two independent apertures to the exterior and not into the nephridial sacs. There are two oviducts (right and left) in the female and two sperm-ducts in the male, the left duct in both sexes being rudimentary.

A large external shell either coiled or straight is present, and is not enclosed by reflexions of the mantle-skirt, except such narrow-mouthed shells as that of Gomphoceras, which were probably enclosed by the

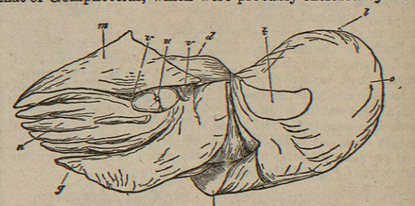

Fig. 91.—Lateral view of the same specimen as that drawn in fig. 90. Letters as in that figure with the following additions—*e* points to the concave margin of the mantle-skirt leading into the sub-pallial chamber; *g*, the mid-foot or siphon; *k*, the superficial origin of its retractor muscles closely applied to the shell and serving to hold the animal in its place; *i*, the siphuncular pedicle of the visceral hump broken off short; *v v*, the superior and inferior ophthalmic tentacles.

mantle as in the Dibranch Spirula. The shell consists of a series of chambers, the last formed of which is occupied by the body of the animal, the hinder ones (successively deserted) containing gas (fig. 89).

The pair of cephalic eyes are hollow chambers (fig. 118, A) opening to the exterior by minute orifices (pinhole camera), and devoid of refractive structures. A pair of osphradia are present at the base of the gills (fig. 101, *olf*). Salivary glands are wanting. An ink-sac is *not* present. Branchial hearts are *not* developed on the branchial advehent vessels.

Family 1.—*Nautilidæ*.
Genera: [*Orthoceras*], Breyn., [*Cyrtoceras*], Goldfuss; [*Gomphoceras*], Münster; [*Phragmoceras*], Brod.; [*Gyroceras*], Meyer; [*Ascoceras*], Barraude; [*Oncoceras*], Hall; [*Lituites*], Breyn.; [*Trochoceras*], Barraude; *Nautilus*, L. (figs. 88, 89, 90, &c); [*Clymenia*], Münst.; [*Nothoceras*], Barraude.

Family 2.—*Ammonitidæ*.
Genera: [*Bactrites*], Sandberg; [*Goniatites*], de Haan; [*Rhabdoceras*], Hauer; [*Clydonites*], Hauer; [*Cochloceras*], Hauer; [*Baculina*], d'Orb.; [*Ceratites*], de Haan; [*Baculites*], Lam.; [*Toxoceras*], d'Orb.; [*Crioceras*], Leveillé; [*Ptychoceras*], d'Orb.; [*Hamites*], Parkinson; [*Ancyloceras*], d'Orb.; [*Scaphites*], Parkinson; [*Ammonites*], Breyn.; [*Turrilites*], Lam.; [*Heliceras*], d'Orb.; [*Heteroceras*], d'Orb.

N.B.—The names in brackets are those of extinct genera.

Order 2.—**Dibranchiata** (= Holosiphona, Acetabulifera).

Characters.—Siphonopodous Cephalopods in which the inflected lateral margins of the mid-foot are fused so as to form a complete tubular siphon (fig. 96, *r*). The circum-oral lobes of the fore-foot carry suckers disposed upon them in rows (as in the Pteropod Pneumodermon), *not* tentacles (see figs. 92, 95, 96). There is a single pair of typical ctenidia (fig. 103) acting as gills (hence Dibranchiata), and

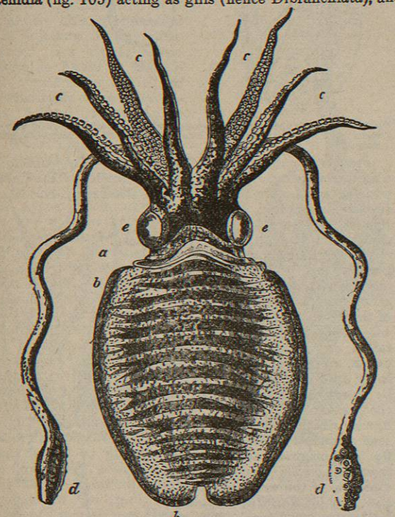

Fig. 92.—*Sepia officinalis*, L., half the natural size, as seen when dead, the long prehensile arms being withdrawn from the pouches at the side of the head, in which they are carried during life when not actually in use. *a*, neck; *b*, lateral fin of the mantle-sac; *c*, the eight shorter arms of the fore-foot; *d*, the two long prehensile arms; *e*, the eyes.

a single pair of nephridia opening by apertures right and left of the median anus (fig. 103, *r*), and by similar internal pores into the pericardial chamber, which consequently does not open directly to the surface as in Nautilus. The oviducts are sometimes paired right and left (Octopoda), sometimes that of one side only is developed (Decapoda, except Ommastrephes). The sperm-duct is always single except, according to Keferstein, in *Eledone moschata*.

A plate-like shell is developed in a closed sac formed by the mantle (figs. 98, 99), except in the Octopoda, which have none, and in Spirula (fig. 100, D) and the extinct Belemnitidæ, which have a small chambered shell resembling that of Nautilus with or without the addition of plate-like and cylindrical accessory developments (fig. 100, C).

The pair of cephalic eyes are highly-developed vesicles with a refractive lens (fig. 120), cornea, and lid-folds,—the vesicle being in the embryo an open sac like that of Nautilus (fig. 119). Osphradia are not present, but cephalic olfactory organs are recognized. One or two pairs of large salivary glands with long ducts are present. An ink-sac formed as a diverticulum of the rectum and opening near the anus is present in all Dibranchiata (fig. 103, *t*), and has been detected even in the fossil Belemnitidæ. Branchial hearts are developed on the two branchial advehent blood-vessels (fig. 104, *vc'*, *vi*).

The Dibranchiata are divisible into two sub-orders, according to the number and character of the arm-like sucker-bearing processes of the fore-foot.

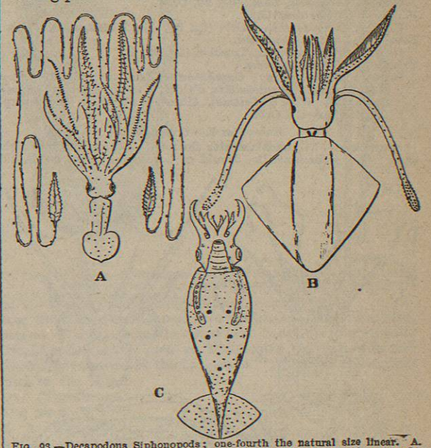

Fig. 93.—Decapodous Siphonopods; one-fourth the natural size linear. A. *Cheiroteuthis Veranyi*, d'Orb. (from the Mediterranean). B. *Thysanoteuthis rhombus*, Troschel (from Messina). C. *Loligopsis cyclura*, Fér. and d'Orb. (from the Atlantic Ocean).

Sub-order 1.—*Decapoda*.

Characters.—Dibranchiata with the fore-foot drawn out into eight shorter and two longer arms (prehensile arms), the latter being placed right and left between the third and fourth shorter arms. The suckers are stalked and strengthened by a horny ring. The eyes are large and have a horizontal in place of a sphincter-like lid. The body is elongated and provided with lateral fins (lamelliform expansions of the mantle). The mouth has a buccal membrane. The mantle-margin is locked to the base of the siphon by a specially-developed cartilaginous apparatus. Numerous water-pores are present in the head and anterior region of the body, leading into recesses of the integument of unknown significance. The oviduct is single; large nidamental glands are present. The viscero-pericardial space is large, and lodges the ovary (Sepia). There is always a shell present which is enclosed by the upgrowth of the mantle, so as to become "internal."

Section *a.*—*Decapoda Calciphora*.

Character—Internal shell calcareous.

Family 1.—*Spirulidæ*.
Genus: *Spirula*, Lam. (fig. 100, D).

Family 2.—*Belemnitidæ*.
Genera: [*Spiralirostra*], d'Orb. (fig. 100, C); [*Belopteva*], Desh.; [*Belemnosis*], Ehr.: [*Conoteuthis*], d'Orb. (fig. 100, A); [*Acanthoteuthis*], R. Wag.: [*Belemnites*], Lister, 1678: [*Belemnitella*], d'Orb.; [*Xiphoteuthis*], Huxley.

Family 3.—*Sepiadæ*.
Genera: *Sepia*, L. (figs. 92, 98, &c.); [*Belosepia*], Voltz; *Coccoteuthis*, Owen.

Section *b*.—*Decapoda Chondrophora.*

Character.—Internal shell horny.

Sub-section *α*.—*Myopsidæ* (d'Orb.).

Eye with closed cornea, so that the surrounding water does not touch the lens; mostly frequenters of the coast.

Family 1.—*Loligidæ.*

Genera: *Loligo*, Schneid. (figs. 99, &c.); *Loliolus*, Steenstrup; *Sepioteuthis*, Blv.; [*Teuthopsis*], Desl.; [*Leptoteuthis*], Meyer; [*Eclemnosepia*], Ag.; [*Belóteuthis*], Münst.

Family 2.—*Sepiolidæ.*

Genera: *Sepiola*, Schneid.; *Rossia*, Owen.

Sub-section *β*.—*Oigopsidæ* (d'Orb.).

Eye with open cornea, so that the surrounding water bathes the anterior surface of the lens; mostly pelagic animals

Family 3.—*Cranchiadæ.*

Genus: *Cranchia*, Leach (fig. 94, C).

Family 4.—*Loligopsidæ.*

Genus: *Loligopsis*, Lam. (fig. 93, C).

Family 5.—*Cheiroteuthidæ.*

Genera: *Cheiroteuthis*, d'Orb. (fig. 93, A); *Histioteuthis*, d'Orb.

Family 6.—*Thysanoteuthidæ.*

Genus: *Thysanoteuthis*, Troschel (fig. 93, B).

Family 7.—*Onychoteuthidæ.*

Genera: *Gonatus*, Gray; *Onychoteuthis*, Lichtenst. (fig. 97); *Onychia*, Lesueur; *Enoploteuthis*, d'Orb., *Veranya*, Krohn; [*Plesioteuthis*], A. Wag.; [*Celæno*], Münst.; *Dosidicus*, Steenstrup; *Ommastrephes*, d'Orb.

Sub-order 2.—*Octopoda.*

Characters.—Dibranchiata with the fore-foot drawn out into eight arms only; suckers sessile, devoid of horny ring; eyes small, the

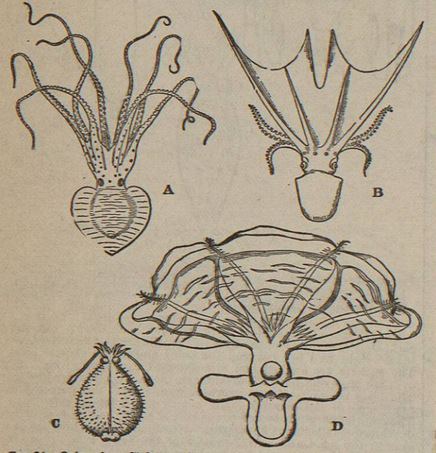

Fig. 94.—Octopodous Siphonopods; one-fourth the natural size linear. A. *Pinnoctopus cordiformis*, Quoy. and Gain (from New Zealand). B. *Tremoctopus violaceus*, Ver. (from the Mediterranean). C. *Cranchia scabra*, Owen (from the Atlantic Ocean; one of the Decapoda). D. *Cirrhoteuthis Müllerí*, Esch. (from the Greenland coast).

outer skin can be closed over them by a sphincter-like movement. The body is short and rounded; the mantle has no cartilaginous locking apparatus, and is always fused to the head dorsally by a broad nuchal band. No buccal membrane surrounds the mouth. The siphon is devoid of valves. The oviducts are paired; there are no nidamental glands. The viscero-pericardial space is reduced to two narrow canals, passing from the nephridia to the capsule of the genital gland. There is no shell on or in the visceral hump.

Family 1.—*Cirrhoteuthidæ.*

Genus: *Cirrhoteuthis*, Esch. (*Sciadephorus*, Reinh.) (fig. 94, D).

Family 2.—*Octopodidæ.*

Genera: *Pinnoctopus*, d'Orb. (fig. 94, A); *Octopus*, Lam. (fig. 95); *Scæurgus*, Trosch.; *Eledone*, Leach; *Bolitæna*, Steenstrup.

Family 3.—*Philonexidæ.*

Genera: *Tremoctopus*, Delle Chiaje (*Philonexis*, d'Orb.) (fig. 94, B); *Parasira*, Steenstrup (*Octopus catenulatus*, Fér., is the female, and *Octopus carena*, Ver., is the male of the one species of this genus according to Steenstrup (fig. 96)); *Argonauta*, L. (the shell of this genus is formed only in the female by the expanded ends of the two large "arms" of the fore-foot).

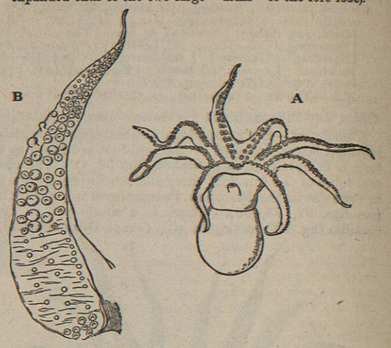

Fig. 95.—A. Male specimen of *Octopus grœnlandicus*, with the third arm of the right side hectocotylized. B. The extremity of the hectocotylized arm magnified.

Further Remarks on the Cephalopoda.—In order to give a more precise conception of the organization of the Cephalopoda in a concrete form we select the Pearly-Nautilus for further description, and in passing its structure in review we shall take the opportunity of comparing here and there the peculiarities presented by that animal with those obtaining in allied forms. In the last edition of this work the Pearly Nautilus was made the subject of a detailed exposition by Professor Owen, and it has seemed accordingly appropriate that it should be somewhat fully treated on the present occasion also. The figures which illustrate the present description are (excepting fig. 89) original, and prepared from dissections (made under the direction of the writer) of a male and female *Nautilus pompilius*, lately purchased for the Museum of University College, London.

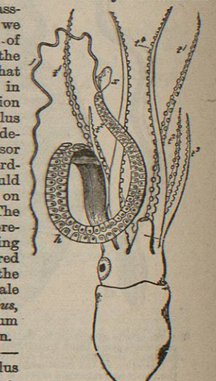

Fig. 96.—Male of *Parasira catenulata*, Steenstrup (*Octopus carena*, Ver.), showing the hectocotylized arm. β_1, β_2, β_3, β_4, the first, second, third, and fourth arms or processes of the fore-foot; A, the third arm of the right side hectocotylized; *x*, the apical sac of the hectocotylized arm; *y*, the filament which issues from the sac when development is complete; *i*, the siphon. (From Gegenbaur.)

Visceral Hump and Shell.—The visceral hump of Nautilus (if we exclude from consideration the fine siphuncular pedicle which it trails, as it were, behind it) is very little, if at all, affected by the coiled form of the shell which it carries, since the animal always slips forward in the shell as it grows, and inhabits a chamber which is practically cylindrical (fig. 89). Were the deserted chambers thrown off instead of being accumulated behind the inhabited chamber as a coiled series of air-chambers, we should have a more correct indication in the shell of the extent and form of the animal's

body. Amongst Gastropods it is not very unusual to find the animal slipping forward in its shell as growth advances and leaving an unoccupied chamber in the apex of the shell. This may indeed become shut off from the occupied cavity by a transverse septum, and a series of such septa may be formed (fig. 42), but in no Gastropod are these apical chambers known to contain a gas during the life of the animal in whose shell they occur. A further peculiarity of the Nautilus shell and of that of the allied extinct Ammonites, Scaphites, Orthoceras, &c., and of the living Spirula, is that the series of deserted air-chambers are traversed by a cord-like pedicle extending from the centro-dorsal area of the visceral hump to the smallest and first-formed chamber of the series. No structure comparable to this siphuncular pedicle is known in any other Mollusca. Its closest representative is found in the so-called "contractile cord" of the remarkable form Rhabdopleura, referred according to present knowledge to the Polyzoa. There appears to be no doubt that the deserted chambers of the Nautilus shell contain in the healthy living animal a gas which serves to lessen the specific gravity of the whole organism. The gas is said to be of the same composition as the atmosphere, with a larger proportion of nitrogen. With regard to its origin we have only conjectures. Each septum shutting off an air-containing chamber is formed during a period of quiescence, probably after the reproductive act, when the visceral mass of the Nautilus may be slightly shrunk, and gas is secreted from the dorsal integument so as to fill up the space previously occupied by the animal. A certain stage is reached in the growth of the animal when no new chambers are formed. The whole process of the loosening of the animal in its chamber and of its slipping forward when a new septum is formed, as well as the mode in which the air-chambers may be used as a hydrostatic apparatus, and the relation to this use, if any, of the siphuncular pedicle, is involved in obscurity, and is the subject of much ingenious speculation. In connexion with the secretion of gas by the animal, besides the parallel cases ranging from the Protozoon Arcella to the Physoclistic Fishes, from the Hydroid Siphonophora to the insect-larva Corethra, we have the identical phenomenon observed in the closely-allied Sepia when recently hatched. Here, in the pores of the internal rudimentary shell, gas is observable, which has necessarily been liberated by the tissues which secrete

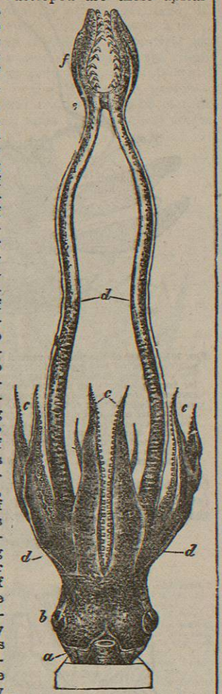

Fig. 97.—Head and circum-oral processes of the fore-foot of Onychoteuthis (from Owen). *a*, neck; *b*, eye; *c*, the eight short arms; *d*, long prehensile arms, the clavate extremities of which are provided with suckers at *e*, and with a double row of hooks beyond at *f*. The temporary conjunction of the arms by means of the suckers enables them to act in combination.

the shell, and not derived from any external source (Huxley).

The coiled shell of Nautilus, and by analogy that of the Ammonites, is peculiar in its relation to the body of the animal, inasmuch as the curvature of the coil proceeding

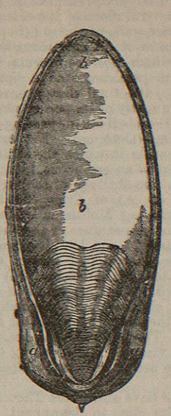

Fig. 98.

Fig. 99.

Fig. 98.—The calcareous internal shell of *Sepia officinalis*, the so-called cuttle-bone. *a*, lateral expansion; *b*, anterior cancellated region; *c*, laminated region, the laminæ enclosing air.

Fig. 99.—The horny internal shell or gladius or pen of Loligo.

from the centro-dorsal area is towards the head or forward, instead of away from the head and backwards as in other discoid coiled shells such as Planorbis; the coil is in fact absolutely reversed in the two cases. Amongst the extinct allies of the Nautilus (Tetrabranchiata) we find shells of a variety of shapes, open coils such as Scaphites, leading on to perfectly cylindrical shells with chamber succeeding chamber in a straight line (Orthoceras), whence again we may pass to the cork-screw spires formed by the shell of Turrilites.

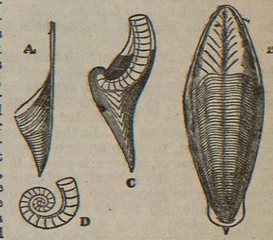

Fig. 100.—Internal shells of Cephalopoda Siphonopoda. A. Shell of *Conoceratites duponianus*, d'Orb. (from the Neocomian of France). B. Shell of *Sepia orbignyana*, Fér. (Mediterranean). C. Shell of *Spirulirostra Bellardii*, d'Orb. (from the Miocene of Turin). The specimen is cut so as to show in section the chambered shell and the laminated "guard" deposited upon its surface. D. Shell of *Spirula lævis*, Gray (New Zealand).

Whilst the Tetrabranchiata, so far as we can recognize their remains, are characterized by these large chambered shells, which, as in Nautilus, were with the exception of some narrow-mouthed forms such as Gomphoceras but very partially covered by reflexions of the mantle-skirt (fig. 89, *b*), the Dibranchiata present an interesting series of gradations, in which we trace—(*a*) the diminution in relative size of the chambered shell; (*b*) its complete investiture by reflected folds of the mantle (Spirula, fig. 100, D); (*c*) the concrescence

of the folds of the mantle to form a definitely-closed shell-sac; (*d*) the secretion by these mantle-folds or walls of the shell-sac of additional laminæ of calcareous shell-substance, which invest the original shell and completely alter its appearance (Spirulirostra, fig. 100, C; Belemnites); (*e*) the gradual dwindling and total disappearance of the original chambered shell, and survival alone of the calcareous laminæ deposited by the inner walls of the sac (Sepia, fig. 100, B); (*f*) the disappearance of all calcareous substance from the pen or plate which now represents the contents of the shell-sac, and its persistence as a horny body simply (Loligo, fig. 99); (*g*) the total disappearance of the shell-sac itself, and consequently of its pen or plate, nevertheless the rudiments of the shell-sac appearing in the embryo and then evanescing (Octopus). The early appearance of the sac of the mantle in which the shell is enclosed, in Dibranchiata, has led to an erroneous identification of this sac with the primitive shell-sac of the archi-Mollusc (fig. 1), of Chiton (fig. 10, A), of Arion (fig. 69, D, *a*), and of the normally-developing Molluscan embryo (figs. 68 and 72***, *sh*). The first appearance of the shell-sac of Dibranchiata is seen in figs. 121 and 122, its formation as an open upgrowth of the centro-dorsal area of the embryo having been demonstrated by Lankester (34) in 1873, who subsequently showed (35) that the same shell-sac appears and disappears without closing up in Argonauta and Octopus, and pointed out the distinctness of this sac and the primitive shell-gland. The shell of the female Argonauta is not formed by the visceral hump, but by the enlarged arms of the foot, which are in life always closely applied to it.

The shell of such Pteropoda as have shells (the Thecosomata) is excessively light, and fits close to the animal, no air-chambers being formed. It is important to note that in this division of the Cephalopoda there is the same tendency, which is carried so far in the Dibranchiate Siphonopods, for the mantle-skirt to be reflected over and closely applied to the shell (*e.g.*, Cavolinia, figs. 79 and 80). But in Pteropoda there is no complete formation of a closed sac by the reflected mantle, no thickening of the enclosed shell, no dwindling of the original shell and substitution for it of a laminated plate. The variety of form of the glass-like shells of Pteropoda is a peculiarity of that group.

Head, Foot, Mantle-skirt, and Sub-pallial Chamber.—In the Pearly Nautilus the ovoid visceral hump is completely encircled by the free flap of integument known as mantle-skirt (fig. 91, *d*, *e*). In the antero-dorsal region this flap is enlarged so as to be reflected a little over the coil of the shell which rests on it. In the postero-ventral region the flap is deepest, forming an extensive sub-pallial chamber, at the entrance of which *e* is placed in fig. 91. A view of the interior of the sub-pallial chamber, as seen when the mantle-skirt is retroverted and the observer faces in the direction indicated by the reference line passing from *e* in fig. 91. is given in fig. 101. With this should be compared the similar view of the sub-pallial chamber of the Dibranchiate Sepia (fig. 103). It should be noted as a difference between Nautilus and the Dibranchiates that in the former the nidamental gland (in the female) lies on that surface of the pallial chamber formed by the dependent mantle-flap (figs. 101, *g.n.*; 89, *V*), whilst in the latter it lies on the surface formed by the body-wall; in fact in the former the base of the fold forming the mantle-skirt comprises in its area a part of what is unreflected visceral hump in the latter.

The apertures of the two pairs of nephridia, of the viscero-pericardial sac, of the genital ducts, and of the anus are shown in position on the body-wall of the pallial chamber of Nautilus in figs. 101, 102. There are nine apertures in all, one median (the anus), and four paired. Besides these apertures we notice *two* pairs of gill-plumes which are undoubtedly typical ctenidia, and a short papilla (the

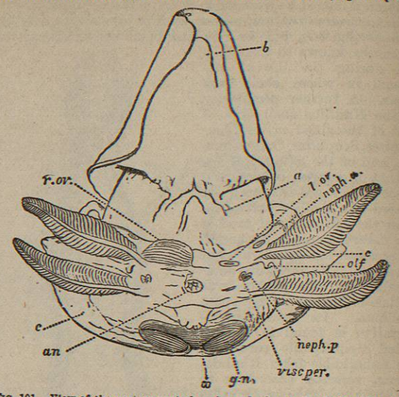

Fig. 101.—View of the postero-ventral surface of a female Pearly Nautilus, the mantle-skirt (*c*) being completely reflected so as to show the inner wall of the sub-pallial chamber (drawn from nature by A. G. Bourne). *a*, muscular band passing from the mid-foot to the integument; *b*, the valve on the surface of the funnel-like mid-foot, partially concealed by the inrolled lateral margin of the latter; *c*, the mantle-skirt retroverted; *an*, the median anus; *x*, post-anal papilla of unknown significance; *g.n.*, nidamental gland; *r.ov.*, aperture of the right oviduct; *l.ov.*, aperture of the rudimentary left oviduct (pyriform sac of Owen); *neph.a.*, aperture of the left anterior nephridium; *neph.p.* aperture of the left posterior nephridium; *viscper.*, left aperture of the viscero-pericardial sac; *olf*, the left osphradium placed near the base of the anterior gill-plume. The four gill-plumes (ctenidia) are not lettered.

osphradium) between each anterior and posterior gill-plume (see figs. 101, 102, and explanation). As compared with this in a Dibranchiate, we find (fig. 103) only four apertures, viz., the median anus with adjacent orifice of the ink-sac, the single pair of nephridial apertures, and one asymmetrical genital aperture (on the left side), except in female Octopoda and a few others where the genital ducts and their apertures are paired. No viscero-pericardial pores are present on the surface of the pallial chamber, since in the Dibranchiata the viscero-pericardial

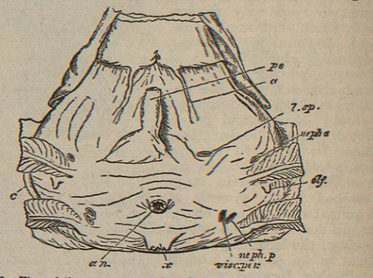

Fig. 102.—View of the postero-ventral surface of a male Pearly Nautilus, the mantle-skirt (*c*) being completely reflected so as to show the inner wall of the sub-pallial chamber, and the four ctenidia and the foot cut short (drawn from nature by A. G. Bourne). *pe.*, penis, being the enlarged termination of the right spermatic duct; *l.sp.*, aperture of the rudimentary left spermatic duct (pyriform sac of Owen). Other letters as in fig. 101.

sac opens by a pore into each nephridium instead of directly to the surface. A single pair of ctenidia (gill-plumes) is present instead of the two pairs in Nautilus. The existence of two pairs of ctenidia and of two pairs of nephridia in Nautilus, placed one behind the other, is highly remarkable. The interest of this arrangement is in relation to the general morphology of the Mollusca, for it is impossible to view this repetition of organs in a linear series as anything else than an instance of metameric segmentation, comparable to the segmentation of the ringed worms and Arthropods. The only other example which we have of this metamerism in the Mollusca is presented by the Chitons. There we find not two pairs of ctenidia merely, but sixteen pairs (in some species more) accom-

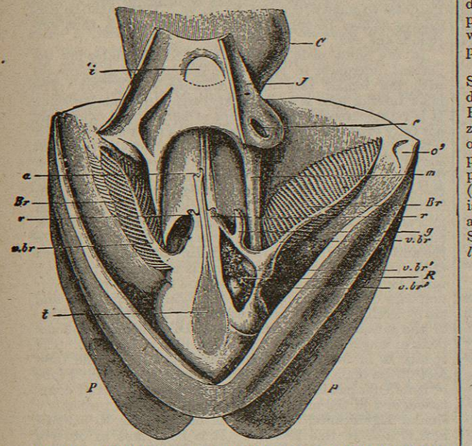

Fig. 103.—View of the postero-ventral surface of a male Sepia, obtained by cutting longitudinally the firm mantle-skirt and drawing the divided halves apart. This figure is strictly comparable with fig. 101. *C*, the head; *J*, the mid-foot or siphon, which has been cut open so as to display the valve *i*; *R*, the glandular tissue of the left nephridium or renal-sac, which has been cut open (see fig. 105); *P*, *P*, the lateral fins of the mantle-skirt; *Br*, the single pair of branchiæ (ctenidia); *a*, the anus,—immediately below it is the opening of the ink-bag; *c*, cartilaginous socket in the siphon to receive *c'*, the cartilaginous knob of the mantle-skirt,—the two constituting the "pallial hinge apparatus" characteristic of Decapoda, not found in Octopoda; *g*, the azygos genital papilla and aperture; *i*, valve of the siphon (possibly the rudimentary hind-foot); *m*, muscular band connected with the fore-foot and mid-foot (siphon) and identical with the muscular mass *k* in fig. 91; *r*, renal papillæ, carrying the apertures of the nephridia; *v.br*, branchial efferent blood-vessel; *r.br'*, bulbous enlargements of the branchial blood-vessels (see figs. 104, 105); *t*, ink-bag. (From Gegenbaur.)

panied by a similar metamerism of the dorsal integument, which carries eight shells. In Chiton the nephridia are not affected by the metamerism as they are in Nautilus. It is impossible on the present occasion to discuss in the way which their importance demands the significance of these two instances among Mollusca of incomplete or partial metamerism; but it would be wrong to pass them by without insisting upon the great importance which the occurrence of these isolated instances of metameric segmentation in a group of otherwise unsegmented organisms possesses, and the light which they may be made to throw upon the nature of metameric segmentation in general.

The foot and head of Nautilus are in the adult inextricably grown together, the eye being the only part belonging primarily to the head which projects from the all-embracing foot. The fore-foot or front portion of the foot in Nautilus has the form of a number of lobes carrying tentacles and completely surrounding the mouth (figs. 88, 89, 91). The mid-foot is a broad median muscular process which exhibits in the most interesting manner a curling in of its margins so as to form an incomplete siphon (fig. 101), a condition which is completed and rendered permanent in the tubular funnel, which is the form presented by the corresponding part of Dibranchiata (fig. 96). The hind-foot possibly is represented by the valvular fold on the surface of the siphon-like mid-foot. In the Pteropoda the wing-like swimming lobes (epipodia or pteropodia) correspond to the two halves of the siphon, and are much the largest element of the foot. The fore-foot surrounding the head is often quite small, but in Clione and Pneumodermon carries lobes and suckers. A hind-foot is in Pteropoda often distinctly present; it is open to doubt as to whether the corresponding region of the foot in Siphonopoda is developed at all.

The lobes of the fore-foot of Nautilus and of the other Siphonopoda require further description. It has been doubted whether these lobes were rightly referred (by Huxley) to the fore-foot, and it has been maintained by some zoologists (Grenacher, Jhering) that they are truly processes of the head. It appears to the present writer to be impossible to doubt that the lobes in question are the fore-portion of the foot when their development is examined (see fig. 121, and especially fig. 72**), further, when the fact is considered that they are innervated by the pedal ganglion, and, lastly, when the comparison of such a Siphonopod as Sepia is made with such a Pteropod as Pneumodermon in its *larval* (fig. 84) as well as in its adult condition (fig. 85). The

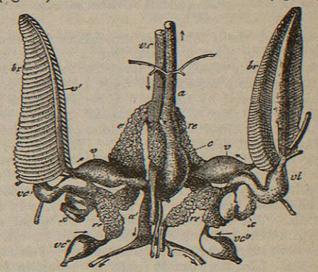

Fig. 104.—Circulatory and excretory organs of Sepia (from Gegenbaur, after John Hunter). *br*, branchiæ (ctenidia); *c*, ventricle of the heart; *a*, anterior artery (aorta); *a'*, posterior artery; *v*, the right and left auricles (enlargements of the efferent branchial veins); *v'*, efferent branchial vein on the free face of the gill-plume; *v.c*, vena cava; *vi*, *vc'*, advehent branchial vessels (branches of the vena cava, see fig. 108); *vc''*, abdominal veins; *x*, branchial hearts and appendages; *re*, *e*, glandular substance of the nephridia developed on the wall of the great veins on their way to the gills. The arrows indicate the direction of the blood-current.

larval Pneumodermon shows clearly that the sucker-bearing processes of that Mollusc are originally far removed from the head and close in position to the pteropodial lobes of the foot. By differential growth they gradually embrace and obliterate the head, as do the similar sucker-bearing processes of Sepia. In both cases the sucker-bearing processes are "fore-foot." The fore-foot of Nautilus completely surrounds the buccal cone (fig. 88, *e*), so as to present an appearance with its expanded tentacles similar to that of the disc of a sea-anemone (Actinia). No figure has hitherto been published exhibiting this circum-oral disc with its tentacles in natural position as when the animal is alive and swimming, the small figure of Valenciennes being deficient in detail. All the published figures represent the actual appearance of the contracted spirit-specimens. Mr A. G.