Review of Dr. Richard Goldschmidt's Monograph of Amphioxides.[1]

By

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AMONG the many acquisitions of the German Expedition to the Deep Sea in the S.S. "Valdivia" (1898—1899), which was organised under the direction of Professor Carl Chun, not the least valuable was the relatively large series (27 specimens) of pelagic Acraniata belonging to the genus Amphioxides, Gill. This material was entrusted to the skilled hands of Dr. Richard Goldschmidt, who may be congratulated on his important monograph, which takes its place in a section of zoological literature associated with the honoured names of Johannes Müller, A. von Kölliker, de Quatrefages, Kowalevsky, Hatschek, Huxley, Ray Lankester, van Wijhe.

Dr. Goldschmidt's memoir will almost certainly tend to enhance the morphological importance of Amphioxus (if it be permitted still to employ this name in a cursory, non-italicized sense), based as it is upon such careful observation and logical deduction. It is, however, frequently necessary to discount the force of logic when dealing with discussions of the kind before us.

The type species of Amphioxides was originally described from a single specimen taken in the Pacific Ocean, under the name Branchiostoma pelagicum by Dr. Günther (1889) in his report on the Pelagic Fishes collected during the "Challenger" Expedition. Further examples from the Indian Ocean have been recorded by C. Forster Cooper

[1] Richard Goldschmidt, "Amphioxides," 'Wiss. Ergebn. der deutschen Tiefsee-Expedition,' Bd. xii, 1905, pp. 92, ten plates and ten text-figures.

(1903),[1] W. M. Tattersall (1903),[2] and G. H. Parker (1904).[3] Two other species have been added by Dr. Goldschmidt, A. valdiviæ and A. stenurus. All three species were taken during the "Valdivia" Expedition at considerable depths in the vertical tow-net in the high seas, often several hundred miles from the nearest coast. Specimens were also obtained in the Atlantic Ocean;[4] the distribution of the genus is therefore circumequatorial, but there is no correlation between the specific forms and their geographical range. In the Bay of Bengal, 300 miles east of Ceylon, twelve examples were captured simultaneously at one station between a depth of 2500 metres and the surface, of which nine belonged to A. valdiviæ, three to A. pelagicus. Off the west coast of Africa A. valdiviæ was taken south of Teneriffe and A. pelagicus in the Gulf of Guinea. Lastly, all three species have been taken in the neighbourhood of the Seychelles.

No sexually mature individual has yet been seen. Dr. Goldschmidt has found the immature gonads developing only on the right side, lying in the gonocœl which is shut off from the ventral ends of the myotomes. No specimens in the "Valdivia" collection exceed 10 mm. in length. At this size the gonads were observed to be as far developed as in a Branchiostoma lanceolatum of 28 mm.

[1] C. F. Cooper, "Cephalochorda," 'Fauna and Geography of the Maldive and Laccadive Archipelagoes' (J. Stanley Gardiner), vol. i, part 4, 1903, p. 352.

[2] W. M. Tattersall, "Report on the Cephalochorda collected by Professor Herdman at Ceylon in 1902," 'Ceylon Pearl Oyster Fisheries,' part 1, 1903, p. 214.

[3] G. H. Parker, "Maldive Cephalochordates," 'Bull. Mus. Harvard,' vol. xlvi, 1904.

[4] It is interesting to note that no examples were procured during the "Plankton" Expedition. Hensen (Einige Ergebnisse der Plankton Exped., 1892, p. 24—25) says that they frequently obtained young Amphioxus lanceolatus up to some centimetres in length, as many as two to ten individuals in one catch of the Plankton Net in the North Atlantic. He notes that it is remarkable that they should remain so long at the surface over great depths, because Amphioxus is a coastal and littoral form, only the larvæ being pelagic in the coastal zone. These observations are important as indicating that the prolongation of the pelagic life does not involve a persistence of the larval asymmetry in A. lanceolatus.

Amphioxides is remarkable for the possession of many
characters which are proper to the larva of the European
species of Amphioxus, e. g. the absence of a closed atrial
chamber, a sinistral slit-like mouth, an unpaired series of
gill-clefts which lie in the mid-ventral line, an anterior dextral
endostyle, a club-shaped gland, and a sinistral præoral pit.
On account of these and some other characters the genus is
made the type of a new family, Amphioxididæ Goldschmidt,
in contrast with the first family, Branchiostomidæ Bona-
parte, 1846.

The characters mentioned above are regarded by Dr.
Goldschmidt as being essentially primitive, emphatically not
as indications of a persistent larval organisation. In other
words, in his opinion Amphioxides is the most primitive
Acraniate, and stands more or less in the direct line of
Vertebrate descent.

One of the finest additions to our knowledge of the anatomy
of Amphioxus which has been made in recent years is
Professor J. W. van Wijhe's discovery of the sinistral inner-
vation of the mouth. Anyone who has handled Amphioxus
will probably subscribe to this statement. The conclusion
drawn by van Wijhe from this discovery and accepted by
Goldschmidt, namely, that the mouth of Amphioxus is from
the beginning to the end an organ of the left side, may seem
to be clearly indicated, and is held by Dr. Goldschmidt to be
a fact of primary phylogenetic significance in Amphioxides
where the sinistral position of the mouth is said to be
dependent upon the structure of the pharynx. It may be
mentioned here that my own theory is still what it was
fifteen years ago so far as its essential point is concerned,
that the mouth, or situs oris, of the lancelet has migrated
from a dorsal position such as it holds in the Ascidian larva.

The pharynx of Amphioxides is characterised by the
presence in its floor of a median series of gill-perforations to
the number of thirty-four, opening directly to the exterior
on the ventral side of the body between the metapleural
folds. Above the gill-arches the wall of the pharynx projects

inwards as a ridge on each side, delimiting a dorsal pars
nutritoria from a ventral pars respiratoria. The gill-
openings are simple clefts destitute of tongue-bars, but the
gill-arches which bound them are considerably folded, and
exhibit a bilaterally symmetrical structure being incompletely
divided by a deep median groove into right and left halves.
The gill-arches are somital, the gill-slits intersomital, in their
topographical relation to the myotomes.
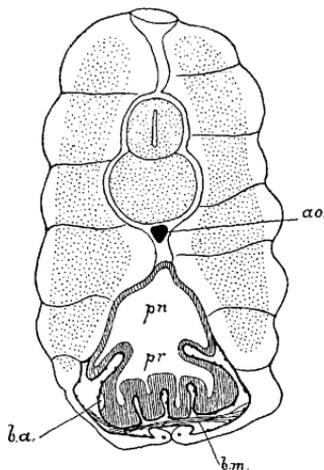
The primitive condition of the pharynx of Amphioxides

Fig. 1.—A. pelagicus. Section through the middle of the
branchial region. After Goldschmidt. *ao.* Aorta. *b.a.* Branchial
artery. *b.m.* Branchial muscle. *p.n.* Pars nutritoria of pharynx.
p.r. Pars respiratoria.

would therefore consist in the median ventral series of un-
paired gill-slits, the partial separation of the ventral pars
respiratoria from the dorsal pars nutritoria, and, con-
sequent thereupon, the perforation of a sinistral mouth into
the dorsal division, and the development of a ciliated
glandular organ, the endostyle, opposite to the mouth, also
leading up to the dorsal division. The club-shaped gland is

regarded as an accessory organ to the endostyle ; it is well developed in Amphioxides, opening into the pharynx behind the posterior end of the endostyle into the dorsal nutritive portion. Goldschmidt has not found an external orifice of the gland such as was first observed by Hatschek (1881), and subsequently confirmed by Lankester and Willey (1890), and Willey (1891) in the larva of Branchiostoma lanceolatum.

Now there is a reflection which must occur to the minds of those who may be conversant with the living larvæ of Amphioxus, and with the extreme contractility of their tissues, which may raise a doubt concerning the fundamental importance of the lateral ridges of the pharynx of Amphi- oxides as interpreted by Dr. Goldschmidt. There is not a shadow of doubt that the gill-slits and gill-arches of Amphioxides would wear a very different appearance from that which they present in Dr. Goldschmidt's excellent figures if they were seen fully expanded with the body in a state of turgidity, and it seems not unlikely that under those conditions the projecting ridges[1] of the pharynx would vanish and the folds of the gill-arches straighten out.

Again, it follows, from the interpretation of facts which has been outlined above, that the anterior dextral position of the endostyle, with its unequal limbs, is also a primitive feature ; but Goldschmidt has not observed in Amphioxides those paired ciliated peripharyngeal bands which proceed upwards and backwards from the anterior ends of the endo- style in the larva of Amphioxus, and offer such a striking analogy with the similar organs of the Tunicata. These bands, while distinctly pointing to an affinity with the Ascidians, also indicate that the endostyle, although asym-

[1] These ridges, the so-called limiting folds or plicæ limitantes, are described as being lined by cylindrical flagellate cells, the long flagellum of which is connected through the cell-body with the nucleus by a clear and deeply staining rod. It seems highly probable, after all, that they are homo- logous with the peripharyngeal bands of Amphioxus. Forster Cooper also figures them in larvæ of Amphioxides taken at the Maldive Islands.
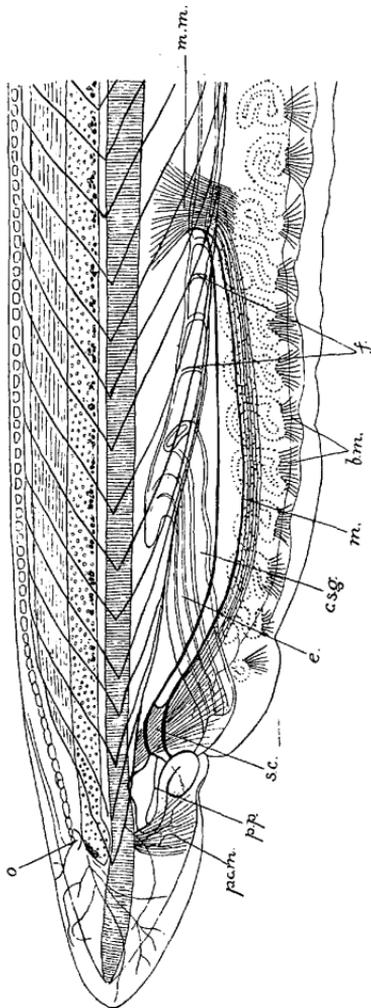
Fig. 2.—A. valdiviæ. Anterior region of the body from the left side. After Goldschmidt, somewhat simplified. *b.m.* Branchial muscles. *c.s.g.* Club-shaped gland. *e.* Endostyle. *f.* Semilunar folds or visceral septa. *m.* Lower lip of mouth. *m.m.* Muscle of lower lip (occlusor oris). *o.* Olfactory pit. *o.* Olfactory pit. *p.c.m.* Constrictor muscle of præoral pit. *p.p.* Præoral pit. *s.c.* Sulcus communicans between præoral pit and mouth.

metrical in the larva of Amphioxus, was originally sym-
metrical.

The gill-slits of Amphioxides are arranged eumeta-
merically, that is to say, there is, in general, an exact
correspondence between branchiomerism and myomerism in
the branchial region.   An individual having twenty-nine
gill-slits, for example, will have thirty gill-arches, of which
the first arch corresponds with the first myotome, while the
thirtieth arch lies in the thirtieth segment.   This applies to
two of the species, A. pelagicus and A. stenurus.   In A.
valdiviæ repeated counting showed that there were more
gill-slits than myotomes in the branchial region, so that in a
specimen with twenty-seven gill-arches the last lay in the
twenty-third segment, or, more correctly, under the twenty-
third myotome.   Such a specimen is interpreted as having
four supernumerary gill-arches ; the highest number observed
was seven.   The supernumerary arches are considered to
indicate the occurrence of prosomital gill-slits in A. valdiviæ.
This unexpected interpretation appears simpler in the writing
than in the illustration (fig. 2).   Those who can appreciate
it will be able to make the best use of it.   For my part, the
lack of coincidence between gill-slits and myotomes in A.
valdiviæ appears as an indication of the independence of
branchiomerism and myomerism in the Acraniata, however
closely they may be correlated.

In A. valdiviæ the ventral halves of the anterior myo-
meres are bent backwards at a very acute angle in correlation
with the great length of the mouth, 1—1·4 mm. (fig. 2).
This again strikes me as being a slight myomeric disturbance
independent of the gill-slits.

Above the gill-arches and between every two gill-slits the
pars nutritoria of the pharynx is fused with the body-
wall, the lines of fusion coinciding with the dissepiments of
the myotomes.   Between two lines of fusion the body-cavity
extends upwards as a pouch to the base of the notochord.
Seen from the side, the lines of fusion appear as semilunar
folds (fig. 2).   This is the inter-segmental concrescence of the

gut with the myosepta, in other words, a partial segmentation
of the ventral mesoderm.

The metapleural folds closely resemble the corresponding
structures in the larva of B. lanceolatum; the right fold is
larger than the left (especially in A. valdiviæ), and reaches
farther forwards. Goldschmidt finds, in general accord with
previous observations on Branchiostoma by MacBride
(1898) and van Wijhe (1902), that in Amphioxides the
pterygocœl or metapleural lymph-space communicates in front
by a fine opening with the general body-cavity, on the left
side behind the mouth, on the right side in front of the
mouth.   Posteriorly the metapleural folds terminate freely,
directly behind the last gill-slit, and are thus independent of
the median ventral fin as in Branchiostoma. Goldschmidt
says that they cannot serve as equilibrating organs in
Amphioxides on account of their ventral position and
asymmetry; he thinks they are gill-covers and can become
turgid by fluid-pressure, thus approximating together and
closing under the gill-clefts, synchronously with the respi-
ratory movements.   This view, however, is not confirmed
by observations on the living larvæ of Branchiostoma.
Another suggestion made by Dr. Goldschmidt may conve-
niently be mentioned in this place. He says (p. 32) that in
life the lateral folds of the pharynx (plicæ limitantes)
may be capable of being pressed together and so prevent
food from falling into the pars respiratoria. I think this
is highly improbable, and our author seems to overlook the
circumstance that the ingestion of food and the respiratory
current in Acraniata are alike effected by ciliary action.

From the arrangement of the branchial musculature which
is described in detail, Goldschmidt deduces a mechanism of
breathing by expansion and reduction of the body-cavity,
analogous to lung-breathing. As I have stated above, how-
ever, the respiration of Branchiostoma, like that of Asci-
dians, is primarily promoted by ciliary currents, not by
muscular contraction. The branchial muscles serve only for
the protection and regulation of the branchial apparatus.

Their contraction occurs under stimulus, but, far from inducing respiratory currents, it temporarily inhibits them. In point of fact rhythmic muscular respiratory movements have not been observed in Acraniata.

The gill-arches of Amphioxides (fig. 3) possess the essential qualifications of a true vertebrate gill-arch, namely, the endodermal pharyngeal epithelium; the ectodermal portion of the body-wall; the branchial cœlom; the branchial muscles, which are true visceral muscles derived from the wall of the cœlom. They appear, in the preserved material, to pro-
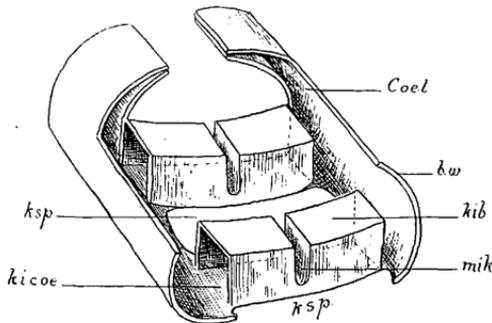

Fig. 3.—Diagram representing the structure of the branchial apparatus of Amphioxides. The ventral half of the body with the pars respiratoria has been exposed by a frontal incision. From Goldschmidt. *ksp.* Gill-slit. *kib.* Gill-arch. *mik.* Median furrow of gill-arch. *ki.coe.* Cœlom of gill-arch. *Coel.* General cœlom. *b.w.* Body-wall.

ject into the pharynx like hollow sacs between the gill-slits, each arch being apparently divided incompletely into right and left compartments by a median groove, and the suggestion is made that this bilateral disposition may be a stage towards the duplication of the slits. The respiratory epithelium is described as a many-layered ciliated epithelium; a similar appearance may be noted in other species, but it has been shown, in the first place by Langerhans, that

the branchial epithelium consists of very high filiform columnar cells in which the nuclei occur at different levels; it is probable that the appearance of stratification is still further increased by the compression of the epithelium as a consequence of contraction.

What may be described as a sensational conclusion is that which proceeds from the author's comparison of Amphioxides with Branchiostoma, i.e. that the so-called secondary gill-slits which suffer a retardation of development in the larva of Branchiostoma are heterogeneous formations, not homologous with the primary series. Of course this conclusion is not rendered in an arbitrary manner, but is led up to by a number of arguments based upon the grand assumption that Amphioxides alone is primitive, and that the larval development of Branchiostoma points no farther back, but is a mere recapitulation of the characters of the original pelagic Acraniate as represented by the former genus.

Dr. Goldschmidt adopts the method of assuming that his form is primitive, and then explaining the facts on that assumption; and he claims to explain all the facts, whereas other theories only explain some of them. But Amphioxides may be as highly adapted to a pelagic life as Branchiostoma to a benthonic life. I am aware that this is an easy objection, but it is none the less true. In most or many other sharply defined orders, those forms in which an entire organic system is functionally deranged or obsolete, are not usually the most primitive. A simple example is the eyeless condition of many cave animals, deep-sea animals, and othe cryptozoic forms ; another is the limbless condition of some Teleostean Fishes, Batrachia, and Reptiles. They may be primitive in other respects, but not in respect of their lack of parts. Perhaps a closer analogy is afforded by the pelagic Tunicata of the class Copelata which, like the Acraniata, comprises two families, Kowalevskidæ and Appendicularidæ, the former characterised by the absence of an endostyle, but it is not suggested that the Kowalevskidæ

are the more primitive on that account.[1] In the same way it seems to me to be improbable that Amphioxides is primitive in respect of the absence of an atrial chamber, of antimeres to the gill-slits, and of the hepatic cæcum.

Another unexpected conclusion to which Dr. Goldschmidt has been led by his researches is the virtual denial of the homology of the hepatic cæcum of the other Acraniates with the liver of Craniota, but he does not refer to recent work on this organ.[2]

Turning now to the cavities in the rostrum of Amphioxides we find a remarkably clear account of their relations to each other and of their connections with the cavities (myocœl) of the first pair of myotomes. The special character of these myotomes, as compared with those which follow, has been pointed out by Hatschek (1881), and more recently by MacBride (1897), who compared them with the collar cavities of Enteropneusta.

The diagram (fig. 4) and the transverse section (fig. 5) illustrate the arrangement, which is sufficiently elucidated in the explanation of the figures. · Perhaps the most important fact to note is that the ventral rostral cavity is that which represents the right head-cavity of the embryo; it is aptly described as the ontogenetic partner of the præoral pit, for which it provides a splanchnocœl and a visceral musculature.

From the mode of branching of the cephalic nerves, their relation to the ventral rostral cavity, and the alleged prosomital gill-clefts of A. valdiviæ, Dr. Goldschmidt deduces a scheme of the segmentation of the head, for the particulars of which the reader should consult the original monograph. I regret that I cannot follow it myself, chiefly because I cannot believe that there is such a fundamental difference between closely-allied species as would follow if it were actually true that A. valdiviæ is the possessor of pro-

[1] Cf. H. Lohmann, 'Die Appendicularien der Plankton-Expedition,' Kiel and Leipzig, 1896.

[2] Guido Schneider, "Einiges über Resorption und Excretion bei Amphioxus lanceolatus, Yarrell," 'Anat. Anz.,' xvi, 1899, pp. 601—605.
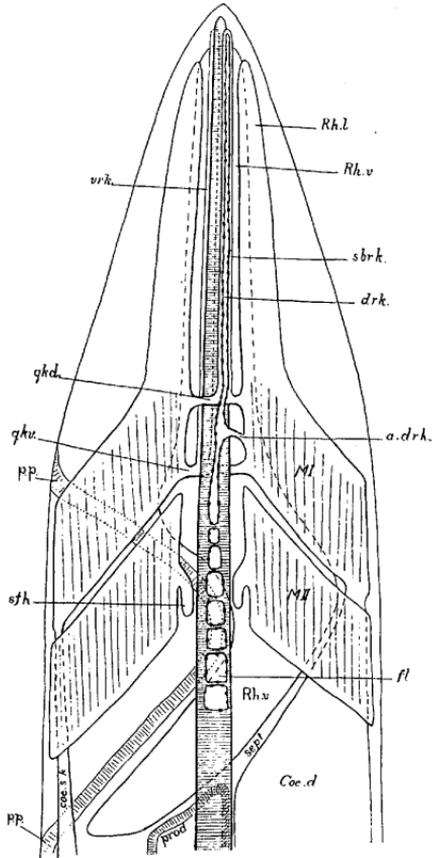
Fig. 4.—A. valdiviæ. Diagram of anterior end from above to show the relations of the rostral cavities. After Goldschmidt, somewhat simplified. *Rh.l.* Lateral rostral cavity proceeding from the first myocœl. *Rh.v.* Ventral rostral cavity. *vrk.* Ventral rostral canal proceeding below the notochord from the ventral canalis communicans (*qkv*) between the first myotomes. *sbrk.* Sub-dorsal rostral canal proceeding above the notochord from the dorsal canalis communicans (*qkd*). *drk.* Dorsal rostral canal continued

somital gill-clefts which are lacking in the other two species.

In his description of Hatschek's nephridium Dr. Goldschmidt records the important discovery of the presence of solenocytes in this small tube, which occurs sinistrally under the noto-chord, and opens into the præoral portion of the gut. In a specimen of 8 mm. it attains the considerable length of half a millimetre. It is closely applied to the anterior end of the aorta, so that only a thin membrane separates the two struc-tures. The part of the tube in the vicinity of the orifice into
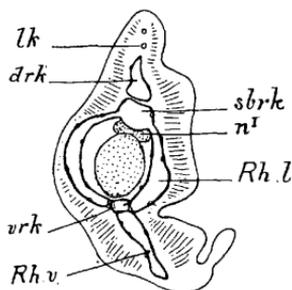

FIG. 5.—A. valdiviæ. Section through rostrum. After Gold-schmidt. *lk.* Lymph-canals which arise from the dorsal rostral canal (*drk*). *sbrk.* Subdorsal rostral canal at its point of origin from the dorsal canalis communicans between the lateral rostral cavities, *Rh.l.* (Anterior ends of cavities of first myotomes.) *vrk.* Ventral rostral canal. *Rh.v.* Ventral rostral cavity.

the præoral gut consists of high cubical cells. Dorsally this epithelium ceases, and gives place to isolated large round

forwards from the fin-chambers (*fl.*), and communicating by a canal on the right side only (*a.drk*) with the cavity of the first myotome. *M.I* and *M.II.* First and second myotomes. *sept.* Septum between the ventral rostral cavity and the splanchnocœl. *Coe.d.* Anterior end of the splanchnocœl on the right side communicating with the first myocœl. *coe.s.k.* Anterior cœlomic canal placing the splanch-nocœl in communication with the first myocœl on the left side. *prod.* Præoral termination of the gut. *p.p.* Anterior and posterior borders of the præoral pit. *sfh.* Sclerotome diverticulum of the second myocœl.

cells which lie upon the membrana limitans of the aorta. These latter cells are identified as solenocytes, since each of them gives off peripherally a long and delicate tubule, which passes straight across the lumen of the nephridium to the opposite wall, where it penetrates between the cells of the cubical epithelium. The solenocytes occur along the entire dorsal wall of the organ, and all the tubules converge towards the orifice, from which numerous fine long flagella depend into the præoral gut; these are the flagella of the solenocytes. Goldschmidt therefore defines Hatschek's nephridium as a portion of the cœlom constricted from the left head-cavity (which gives rise to the præoral pit or præoral organ), and effecting a communication with the præoral gut by a pronephric
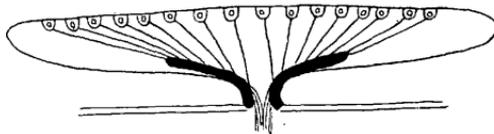

Fig. 6.—Diagram of Hatschek's nephridium, showing solenocytes and the orifice into the præoral gut. After Goldschmidt.

canal. It thus appears that Hatschek's nephridium has a structure analogous to that of Boveri's tubules as corrected by Goodrich.

Dr. Goldschmidt has found no other excretory tubes in Amphioxides, but describes some structures which he calls "Schwammkörper" occurring segmentally on the left side at the dorsal recess of the body-cavity in the region of transition between pharynx and intestine; they appear as a feltwork or mass of spongy tissue with nuclei and solenocyte tubules.[1]

Noteworthy features in the vascular system of Amphioxides are the absence of a portal system, the presence of an unpaired aorta, and especially the fact that the branchial artery, which is a direct continuation of the sub-intestinal

[1] Possibly they have some relation to Lankester's brown funnels (see also Burchardt, 'Jena Zeitschr.,' 1900).

vein, is displaced to the right side. In front of the pharynx the branchial artery bends up more dorsally and ends blindly, co-extensive with the aorta and the præoral gut.

One word concerning the classification adopted by Dr. Goldschmidt. He only recognises two genera of Branchiostomidæ, namely, Branchiostoma, Costa, 1834, and Epigonichthys, Peters, 1876. Opinion may be reserved regarding the necessity of abolishing certain other generic terms which have been introduced, but the resuscitation of Epigonichthys is clearly correct.

A great deal more information is contained in Dr. Goldschmidt's monograph than what I have outlined above. In order to render the presentation of the portion of his theoretical excursions which I have selected for criticism more complete, it should be added that he traces the origin of what he considers to be the primitive condition of the pharynx as determined by the ventral series of gill-slits, to the secondary extension of the segmental musculature towards the ventral side ; this circumstance (and here he is in agreement with Boveri) would also account for the existence and peculiar method of development of the atrial chamber of Amphioxus. It may be admitted that there is very likely a good deal of truth in this correlation when regarded from the point of view of the mechanical conditions of development, without prejudicing supposed morphological or phylogenetic relations one way or the other.

By the courtesy of the Cambridge University Press[1] I am able to reproduce a set of diagrams which may serve a useful purpose as indicating different points of view, and thus helping to clear the issues.

In a recent article Professor van Wijhe[2] states that I have

[1] 'Zoological Results' (A. Willey), part vi, 1902, p. 728. The matter is introduced into that portion of my "Contribution to the Natural History of the Pearly Nautilus," which is devoted to "Personal Narrative." I take this opportunity of noting an unfortunate misprint on page 800 of that publication, where the word "Branchial" should have been "Brachial."

[2] J. W. van Wijhe, "Die Homologisirung des Mundes des Amphioxus und die primitive Leibesgliederung der Wirbelthiere," 'Petrus Camper,' April, 1906, p. 17 of reprint.

confused topographical with morphological conceptions in
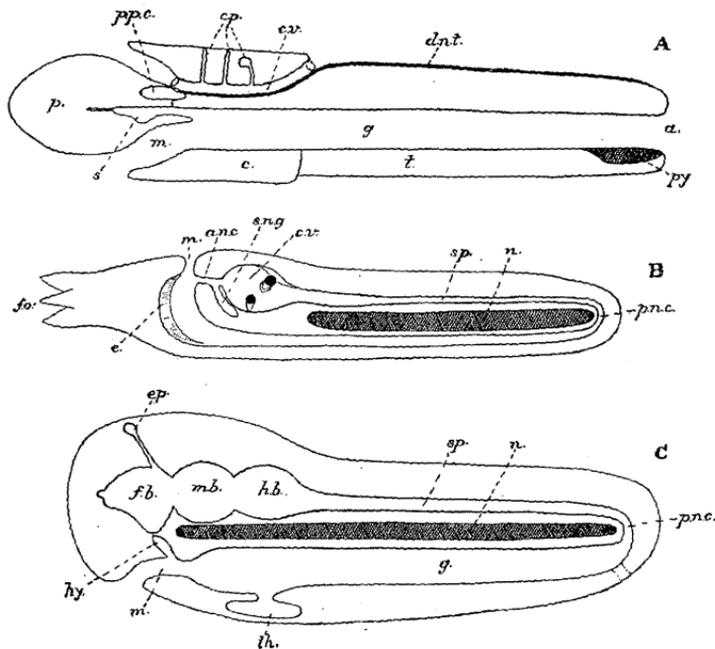regard to the organ of fixation in the larva of Ciona intes-

Fig. 7.—Diagrams of an Enteropneust (A), an Ascidian larva (B),
and a Craniate embryo (C). After Willey ('Zoological Results,'
part vi, 1902), by permission of the Cambridge University Press.

A.—*p*. Proboscis. *p.p.c.* Proboscis pore-canal opening externally
close to the anterior neuropore. *c.v.* Collar nerve-tube. *ep*. Epi-
physial roots. *s*. Stomochord. *m*. Mouth. *c*. Collar region. *g*.
Gut. *t*. Trunk region. *d.n.t.* Dorsal nerve tract. *a*. Anus. *py*.
Pygochord.

B.—*f.o.* Organ of fixation. *e*. Endostyle. *m*. Mouth. *a.n.c.*
Anterior neurenteric canal. *s.n.g.* Subneural gland. *c.v.* Cerebral
vesicle. *sp*. Medullary tube. *p.n.c.* Posterior neurenteric canal.
n. Notochord.

C.—*ep*. Epiphysis cerebri or pineal organ. *f.b.*, *m.b.*, and *h.b.*
Fore-, mid-, and hind-brain. *hy*. Hypophysis cerebri. *th*. Thyroid
gland. Other letters as above.

tinalis which I have likened to a præoral lobe. I may be allowed to remark that whether or not there has been any objective confusion, there has at least been no unconscious mental confusion on my part on this particular point.

The præoral lobe or proboscis should, I suggest, be regarded as an axial organ, forming part of the normal body-length, neither dorsal nor ventral. The functional situs oris is determined by special factors (such as its relation to the anterior neurenteric canal in the Tunicate larva) and should be considered on a basis of its own. The mouth may be dorsal, ventral or lateral in actual position. That the præoral lobe is essentially axial is indicated by the manner and order of its development in the embryos of Acraniates and Enteropneusta, and also in the regeneration of the proboscis of the latter (see Dawydoff, " Ueber die Regeneration der Eichel bei den Enteropneusten," 'Zool. Anz.,' xxv, 1902, pp. 551–6).

In conclusion, as to the relation of the Acrania to the Ascidians, Dr. Goldschmidt is of the opinion that the developmental tendency leads from Amphioxides to Amphioxus, and beyond this in a straight line to the Ascidians, whose organisation appears to him to have arisen by degeneration from the Acrania. In opposition to this theory I submit that the Ascidians have degenerated from an extinct cœlomate perennichordate type, but not from a cephalochordate type.

When, however, Dr. Goldschmidt asserts that the capacity which resides in the pharynx of Acrania, as illustrated in the particular instance of Amphioxides, of forming a gill-slit between the segments over a great region of the body, indicates the original existence of very numerous primitive gill-slits, and supports the theory of the primary polytremism of Vertebrates, I am glad to say that I agree with him heartily.[1]

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[1] Cf. A. Willey, "Enteropneusta from the South Pacific," 'Zoological Results' (Cambridge University Press), part iii, 1899; and R. C. Punnett, "The Enteropneusta," 'Fauna and Geography of the Maldive and Laccadive Archipelagoes,' vol. ii, part 2, 1903, see p. 669.