Annals and Magazine of Natural History

Series 5

ISSN: 0374-5481 (Print) (Online) Journal homepage: <http://www.tandfonline.com/loi/tnah11>

I.—Materials towards the history of Anchinia

A. Kowalevsky & J. Barrois

To cite this article: A. Kowalevsky & J. Barrois (1883) I.—Materials towards the history of Anchinia, *Annals and Magazine of Natural History*, 12:67, 1-20, DOI: [10.1080/00222938309459566](https://doi.org/10.1080/00222938309459566)

To link to this article: <http://dx.doi.org/10.1080/00222938309459566>

Published online: 07 Oct 2009.

Submit your article to this journal [↗](#)

Article views: 3

View related articles [↗](#)

Citing articles: 7 View citing articles [↗](#)

THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[FIFTH SERIES.]

"..... per litora spargite muscum,
 Naiades, et circum vitreos considite fontes:
 Pollice virgineo teneros hic carpite flores:
 Floribus et pictum, divæ, replete canistrum.
 At vos, o Nymphæ Craterides, ite sub undas
 It e, recurvato variata corallia trunco
 Vellite muscosis e rupibus, et mihi concha
 Ferte, Dea pelagi, et pingui conchylia succo."
N. Parthenii Giannettasii Ecl. 1.

No. 67. JULY 1883.

I.—*Materials towards the History of Anchinia.*
 By A. KOWALEVSKY and J. BARROIS *.

[Plates I.-III.]

ANCHINIA is one of the most interesting and least known forms of the whole group of Tunicata. Established by Rathke in 1833 upon notes left by Eschscholtz, this genus has since that time been studied by only a few observers; the only somewhat complete description that we know is that which Carl Vogt has left us of the *Anchinia rubra*, met with in very great numbers at Villafranca, where he found it floating in thousands at the surface of the sea during the months of December and January.

1. The species obtained by us at the same place also possesses a large spot of red pigment in the middle of the body, and other spots of the same colour upon each of the two large papillæ which surmount the incurrent and excurrent apertures. It made its appearance at Villafranca a little later

* Translated by W. S. Dallas, F.L.S., from the 'Journal de l'Anatomie et de la Physiologie,' tome xix. January and February 1883. We are indebted to the kindness of M. Jules Barrois and of the conductors of the above journal for permission to have impressions of the three plates illustrating this memoir.

Ann. & Mag. N. Hist. Ser. 5. Vol. xii.

1

Fig. 5.

Fig. 5.

Fig. 4.

Fig. 7.

Fig. 2.

Imp. Buquet, Paris.

Fig. 1.

Fig. 9.

Fig. 6.

Imp. Bequaet, Paris.

Fig. 8.

Fig. 10.

Fig. 11.

than the time indicated by Vogt; we have only found it occasionally between the months of February and April, and each time in very small numbers.

2. The only form of *Anchinia* that is known (Pl. II. fig. 1) consists of fragments of zooid-bearing stolons of perfect transparency, which are found floating, like the *Salpæ* and *Pyrosomes*, at the surface of the sea.

Our materials for investigation have been rather scanty; we have met with the *Anchinia* only three times, and the first time in bad weather and in a state unfit for examination. Of the two colonies afterwards captured the first alone bore, as described by Vogt, zooids in different stages of gemmation; it is this that we have made use of in our investigations. The second presented zooids all of the same grade, in the adult state. This is a state mentioned by Rathke, but not met with by Carl Vogt. Its existence shows that there is not in this case continuous gemmation at the surface of the stolon, but an unequally rapid development of a series of previously formed germs.

We have not had the opportunity of confirming the observation of Vogt, who, in the great number of specimens examined by him, constantly found one individual surpassing the others in size and attaining as much as a centimetre in length. Nothing of this kind existed in the two specimens examined by us.

3. No observer has as yet given us any information as to the form of generation represented by the zooids attached to the surface of the stolon. Vogt did not detect in them any distinct traces of a stolon or of genital organs; one only of the specimens examined by him showed more or less oviform bodies; but he does not come to any decided conclusion upon this point, and it is even difficult to make out exactly what the *olive-green* bodies indicated by him in this individual really represent.

In our *Anchinia* we have always found perfectly visible genital organs, consisting of a testis and an ovary (Pl. III. fig. 8, *t, o*), situated at the lower part of the intestine, between the heart and the peduncle, and opening by a common canal into the right expansion of the cloacal sac; it is therefore now absolutely certain that the known *Anchinia* is a *sexual form*.

4. The stolon upon which the zooids are fixed is, according to Vogt, a cylindrical contractile canal, with thick walls, composed of longitudinal and transverse fibres, and lined within with a very fine vibratile epithelium.

Unfortunately we have been unable to study the structure

of the stolon in much detail; we have not seen muscular fibres in it; it appeared to us to be a simple hollow tube, formed of a single series of epithelial cells, and enveloped in a very thick tunic, containing here and there stellate cells. The most remarkable thing to be noted in the stolon is a series of large cells (Pl. II. fig. 1, *c*) superimposed upon the epithelium, and placed upon the median line between the zooids.

The latter are arranged upon a somewhat irregular line and [each] implanted upon a slight projection formed by the epithelium of the stolon; this projection is separated from the peduncle by a double septum composed of epithelial cells; these septa separate at the period when the bud becomes detached from the stolon.

I. *Description of Anchinia.*

Anchinia (Pl. III. fig. 8), like *Pyrosoma* and *Doliolum*, is a type of Tunicate in which the two apertures, incurrent and excurrent, are directly opposite to each other. The two cavities to which they give access, namely the pharyngeal sac (*Ph*) and the median portion of the cloaca (*cm*), are not, as in the *Ascidia*, attached to one another, but they face each other, and are situated at the two extremities (fig. 8). Between the two there is a space in which the digestive tube is lodged. In consequence of the separation of these two large cavities, the digestive tube, which in the *Ascidia* is situated below these cavities, is included between them in *Anchinia*; it is moreover surrounded to the right and left by the lateral expansions of the cloaca (*cl*), which spread over the pharyngeal sac to form the branchia. It is therefore included in a sort of case, which only communicates above and below with the rest of the general cavity. Fig. 11, which represents a transverse section passing through the two apertures, will serve better than any explanation to render this arrangement intelligible.

Pyrosoma and *Doliolum* also present the same arrangement but with differences which it is important to note. In *Pyrosoma* the median portion of the cloaca is exceedingly small, in fact quite rudimentary, and out of all proportion to the pharyngeal sac, which occupies an enormous space. Its lateral portions, on the contrary, are much developed, and completely cover the whole of the pharyngeal sac, the entire wall of which is converted into branchia.

In *Doliolum* it is quite otherwise. The lateral portions of the cloaca are rudimentary; they do not cover the pharyngeal sac, of which the branchia occupies only the posterior por-

tion ; on the other hand the *median portion* of the cloaca attains a considerable development, and has a volume nearly equal to that of the *pharyngeal cavity*.

Anchinia presents this interesting peculiarity :—As regards the arrangement of the great cavities and of the branchia it represents the exact intermediary between the above two great types, *Pyrosoma* and *Doliolum*. In it the median portion of the cloacal cavity is already large, but its dimensions are still very restricted as compared with those of the pharyngeal sac ; its lateral parts are likewise better marked off from the median portion than in *Doliolum*, but incomparably less developed than in *Pyrosoma*, and only cover a small portion of the pharyngeal sac. Lastly, the branchia consists, as in *Doliolum*, of a single series of long clefts parallel to the endostyle ; but it is wider than in *Doliolum* (fig. 8), and in this respect somewhat approaches that of *Pyrosoma*.

Anchinia is certainly the most complete transition type that we know between the *Salpa* form and the *Ascidia* form, regarded as representing the two extreme types from the standpoint of the arrangement of the two great cavities. It is the most instructive form to study for any one who wishes to form a notion of these important relations.

I pass now to a more detailed description :—

1. *General form*.—The body is very short and thickset, not at all elongated in the form of a little barrel, but extended especially in the direction of its height ; its general aspect does not at all resemble that presented by the *Doliola*, but nearly approaches that of the lateral buds destitute of cloaca which are observed upon their tails.

2. *Cloaca*.—Fig. 8 shows the boundaries of the median and lateral portions of the cloaca. The line *lm* indicates the limit of the median portion, and the line *li* that of the left lateral expansion. A little above the buccal aperture (*b*) there is a point (*p*) where the median portion comes almost into contact with the pharyngeal sac, which causes the lateral expansion to appear divided into two distinct parts—an inferior very large one (*cl*) covering the digestive tube, and a superior very small one (*ls*) only surrounding a vacant space belonging to the general cavity, a space which, in the living animal seen in profile, appears as a triangular part of dark colour, already seen and figured by Vogt, who, however, did not attempt to give any explanation of it.

3. *General cavity*.—The two great cavities (pharyngeal and cloacal) so completely occupy the interior of the body that there remains only a mere fissure to represent the general cavity. We observe, however, two great dilatations—one

formed by the cavity of the peduncle (*cp*), the other placed behind the upper part of the pharyngeal sac (*cs*) ; further, we must reckon as forming part of the general cavity the spaces *ls*, *li*, bounded by the lateral expansions of the cloaca, the former empty, the latter lodging the digestive tube and the genital organs.

4. *Pharyngeal sac*.—The pharyngeal sac, which, of itself, occupies at least two thirds of the internal space, has, like the whole body, a much elevated and abbreviated form ; its ventral portion is occupied by the endostyle, which is very short in accordance with the general form. At its posterior portion are placed the branchiæ, in the middle and towards the upper part of which the mouth opens. Lastly, it is traversed through nearly its whole extent by a vibratile line (*lv*), which terminates at the top of the dorsal surface in a spiral, which at this point forms a special organ, *sp*. The nervous ganglion and the vibratile pit are situated a little in front of this spiral organ.

5. *Special organs*. a. *Ciliary band*.—The vibratile band as usual surrounds the incurrent orifice ; but in *Anchinia* it is easy to trace it to a great distance on each side. Above it is seen to continue beyond the vibratile (olfactory ?) pit and as far as the upper part of the pharyngeal sac, where, becoming recurved, it unites with the band of the opposite side, *sp*, forming at this point the spiral organ already mentioned ; in the middle of the spiral formed by the recurved extremity of the vibratile band, the wall of the pharyngeal sac gives off a small cæcum which projects into the general cavity and consists of peculiar cells, smaller than in the rest of the wall and furnished with very strongly refractive nuclei (fig. 8, *sp*).

The same organ exists in *Doliolum*, in which it likewise forms the extremity of the ciliary band, but does not occupy the same situation ; it is nearer the incurrent aperture, and *in front of* the nervous ganglion and the olfactory pit.

Vogt has already described it in *Anchinia* under the name of the "lacet recourbé en crochet."

In the opposite direction the vibratile band reaches the endostyle, curves in order to follow it in its whole length, and then rises at its other extremity, to be continued in the median line, between the two branchiæ, to lose itself in the mouth, where, no doubt, it gives origin to the spiral furrow, so well described by Vogt. ("In the anterior part of the digestive tube there is a spiral cord which descends along the œsophagus, commencing from the mouth, and terminating near the stomach by becoming confounded with the general lining of the stomachal cavity.")

The vibratile band is composed of small cells of elongated form, with a large nucleus and small cell-body; these cells are closely juxtaposed in the direction of their length.

The vibratile band appears to have very intimate relations with the endostyle; from the two extremities of that organ we see issue a band having the same structure as the vibratile band, with which it unites at its two points of curvature. Unfortunately we have not succeeded in making out to what portion of the endostyle these two bands belong by penetrating into the interior of the organ.

b. *Nervous ganglion*.—This is situated rather far from the incurrent aperture, but not far from the upper extremity occupied by the spiral organ. It consists of an epithelial portion always united by a slender cord to the upper part of the ciliary pit, and of a mass of nerve-cells which surmounts this. The funiculus which unites the ganglion with the olfactory pit is always very short, never attaining a length comparable to that which occurs in *Doliolum*. The nervous ganglion always remains very near the pit.

c. *Nerves*.—Viewed from the side (fig. 8, left side), the nervous ganglion is seen to give origin to five nerves.

The first pair (1) runs directly forward, passes at but a short distance from the *vibratile pit*, traverses the ciliary band, and terminates about the median line near the upper margin of the incurrent aperture.

The second pair (2), which is longer, follows nearly the same course, but runs lower down, and terminates at the level of the inferior margin of the same aperture.

The third (3) forms a strong and very apparent nervous filament. It runs directly backwards and downwards, and divides not far from its origin, and a little before attaining the branchiæ, into two distinct branches. The first of these branches passes above the branchia towards the tenth fissure, and terminates at the upper part of the excurrent orifice. The second, which is longer, likewise passes over the branchia, about the twelfth or thirteenth fissure, and terminates behind the intestine towards the posterior part of the point of attachment of the peduncle.

The fourth (4) is only a very short filament directed towards the summit of the branchia, and also divided into two very slender branches.

The fifth (5), a little way from its origin, unites with a nerve originating from the opposite side; then the common trunk formed by their union runs backward and to the left of the spiral organ, to reach the great dilatation (*cs*) of the general cavity; it traverses this lacuna in a curve, and reaches

the space included between the two small superior cæca of the cloaca. Lastly, after having traversed this space it terminates at the upper part of the œsophagus, beyond which we have not been able to trace it.

d. *Muscles*.—The muscles are not, like those of *Doliolum*, arranged in bands like the hoops of a barrel. We have only two circular muscles placed round each of the two apertures. To these two muscles at each end we have to add a very characteristic S-shaped muscle which occurs nearly in the middle of the body. This brings the number of muscles of the cutaneous envelope to five. All these muscles are composed of long fibre-cells.

e. *Apertures*.—The incurrent and excurrent apertures are, as usual, furnished with papillæ. Those of the incurrent aperture are tolerably large and generally to the number of from eleven to thirteen, arranged as follows:—on the ventral side two pairs of large papillæ; on the dorsal side two analogous pairs; and lastly, at the sides, between the preceding, sometimes one, sometimes two pairs of considerably smaller papillæ; there is also on the dorsal side, on the median line above the aperture, a large unpaired papilla, furnished with red pigment. At the excurrent aperture the papillæ consist of small teeth regularly spaced to the number of seven on each side; further, on the dorsal side we see rise a long filament with red pigment, and into which the sphincter muscle of this aperture penetrates for two thirds of its length.

This long filament occupies the same place as the dorsal stolon of *Doliolum*, and is not without resemblance in aspect to that stolon, at least in the young state before gemmation. Transverse sections show that it is filled with large very granular cells (fig. 9, *cell*). The skin has not the same structure as on the rest of the body; the layer which constitutes the wall is composed of a fibrous envelope (*fb*), having large cells (*ec*), somewhat analogous to the disseminated cells which are met with in the midst of the tunic. In the interior, in the midst of the large granular cells, we sometimes also find some of these cells *ec*. At *m*, and on the side where the tunic is thinnest (the side turned towards the aperture), we see the section of the two muscles given off by the sphincter of the excurrent aperture.

f. *Digestive tube*.—The digestive tube opens, on the one hand, at the upper part of the pharyngeal sac, and, on the other, in the median part of the cloaca. It is formed by a recurved tube, composed of an œsophagus, a stomach, and an intestine. The stomach, which is short and inflated, bears at its lower part a ramified gland, well known in the

Ascidia. Finally the whole of the digestive tube is surrounded by a network of cells (*r*), which may be regarded as the kidney.

g. *Generative organs*.—The genital glands are situated in the space included between the pharyngeal sac and the cloaca, and in the lower part of this space; they are placed to the right of the intestine, between it and the cloacal expansion of the right side; and both open by a common aperture (*oc*) at the lower part of this cloacal expansion. The mature testis (*t*) consists of a narrow deferent duct and of a voluminous ramified gland, partly concealed by the branchia, and which clothes the whole anterior portion of the intestine. The ovary consists of a common wall (*o*) which contains ova (*ov*) at different stages. The oldest ova are situated at the extremity of the sac on the side opposite to the aperture; then follow two or three ova less and less developed, and finally a small mass of indifferent cells which are placed quite close to the aperture.

h. *Endostyle*.—The very short endostyle presents in transverse sections the structure shown in fig. 10. It is composed of two symmetrical halves, separated by a very deep groove in the buds. Below this groove there is on each side a narrow cell furnished with a very long cilium, which projects out of the cavity of the endostyle. Then comes a zone of radiating cells, at the inner angle of which is seen a small, rounded, and very strongly coloured cell. The radiating zone is succeeded by a second zone, to which carmine attaches itself preferentially; it consists of cells with large nuclei, with no great amount of protoplasm, which alternate more or less, and are not, like the preceding, arranged in a single row. Lastly, this second zone is surmounted by a large clear cell, which bears at its inner angle a rounded and very strongly coloured cell. This last bounds the aperture of the endostyle. The whole inner surface of this organ seemed to be furnished with fine cilia.

It is at the inner angle of the coloured cell that is inserted the wall of the pharyngeal sac, which commences with a cell larger than the others, and the existence of which appears to be constant (fig. 10). From this point the wall acquires its definitive structure, formed of long flattened cells. Nevertheless we do not see it immediately take a direction to the right and left to form the lateral parts of the pharyngeal sac. In fact it begins by rising upwards, and then bends round, forming a small loop occupied by a few thicker small cells; these last are nothing but the section of the vibratile line of each side; and we see therefore that this line, in the part of it which is horizontal and parallel to the endostyle, is not

situated directly upon the wall of the pharyngeal sac, but upon a special fold.

After forming this fold, the layer of flat cells (*end*) bends regularly to the right and left to form the walls of the pharyngeal sac.

i. *Heart and peduncle*.—The heart, as usual, is situated at the posterior extremity of the endostyle; it is placed not far from the genital organs, and, like the latter, occupies a place not distant from the peduncle.

The stout peduncle which unites the *Anchinia* to the stolon persists during the whole life; it is stopped at its lower part by an epithelium thicker than on the rest of the body; and it occupies nearly the same position as the stolon of the colonies of *Pyrosoma*.

II. Gemmation.

1. The youngest stage observed by us (figs. 2, 3) was already completely separated from the stolon (fig. 1. no. 3), but still possessed a rounded form without any trace of the division into body and peduncle.

When detached from the stolon and examined under a greater magnifying-power, this bud presented most of the organs already formed—in the middle the pharyngeal sac with the endostyle, the œsophagus, and the stomach. Around the latter there is a mass of large cells, among which may be observed some still more voluminous; between this last and the endostyle the pericardium; and lastly, above the pharyngeal sac and opposite to the endostyle, the ganglionic mass, hollowed out by a cavity in its posterior portion.

It is to be remarked that, in this first stage, the endostyle occupies nearly the anterior extremity, the pericardium and the ganglionic mass occupy nearly the middle of the two surfaces of the bud; and these relations, which completely alter afterwards, are none the less remarkable and worthy of notice.

Further, we must note the enormous development and the peculiar almost spherical form of the endostyle.

In the early development of the endostyle and its situation at the upper part of the bud there is nothing that need greatly astonish us; we here find the same thing as in the *Salpæ*.

Lastly, we have found nothing at this period that can be referred to a cloacal sac; moreover, as yet there exists no aperture by which the bud is placed in communication with the outer world.

2. In the following stage (fig. 4) the bud has lost its rounded form to acquire a clavate form, in which we already begin to be able to distinguish a division into body and

peduncle (fig. 1, nos. 4 and 5). In it the internal organs present relations absolutely different from those which we have seen in the preceding stage. The cloacal sac is now formed; it occupies the space situated between the ganglionic mass and the peduncle, and presses upwards the ganglionic mass. In consequence the latter, which was previously placed towards the middle of the dorsal surface of the bud, is approximated to its upper part (figs. 1, 3, 4), while the endostyle quits that position to be more or less completely pushed over towards the ventral surface.

The pharyngeal sac of the preceding stage, as well as the cloaca, is in communication with the exterior world; the two apertures (incurrent and excurrent) exist, and are each of them surrounded by two muscles; the digestive tube is completed by the addition of an intestine which opens into the cloaca; and, as before, there exists a rounded stomach, which constitutes its most voluminous part.

The endostyle has already more restricted dimensions relatively to those of the surrounding organs; in its middle part it presents a deep groove which divides it into two parts.

The pharyngeal sac begins to present a thickening (*lv*), which forms the first indication of the vibratile band.

The ganglionic masses possess a much more definite structure than in the preceding stage. There may be distinguished in it two very distinct parts:—(1) a hollow portion united to the pharyngeal sac by a hollow peduncle, and which appears to be only a caecal expansion of the wall of that sac; and (2) a solid portion surmounting the former and composed of ganglionic cells, the latter representing the cerebrum properly so called.

The mass of cells which surrounded the intestine appears better circumscribed than in the previous stage; it has become concentrated into an elongated mass placed to the right of the intestine, and which, in its posterior part, presents some more voluminous cells. This mass represents the common rudiment of the two genital glands, testis and ovary: its posterior part, containing the large cells, will form the ovary; and the large cells themselves are nothing but the ovules.

The whole wall of the body is composed of an epithelium of considerable thickness, except at the level of the genital mass, where it consists of flattened cells.

3. In the succeeding stage (fig. 5, not represented in the general figure) the nervous ganglion has definitively reached the summit of the bud; so that the change of form already indicated in the preceding stage is here completely effected.

Taking as the longitudinal axis a line drawn from the ganglionic mass to the pericardium, we can already recognize a general arrangement of the body analogous to that which exists in the adult; but we see that the part which lodges the genital mass is much more developed than in the adult, which causes the peduncle to be much nearer the upper part.

Except for a slightly more advanced development, the internal organs are in the same state as in the preceding stage. The stomach has become narrower, and the intestine more elongated, which causes a notable alteration in the whole aspect of the digestive tube; further, the lateral parts of the cloacal sac have become elongated, so that already they surround the digestive tube and have come to communicate with the pharyngeal sac.

The genital mass now presents a very perceptible division into testis and ovary (fig. 5); it appears disaggregated at its anterior part, thus giving origin to isolated cells, probably the same as those which afterwards occur around the intestine and which apparently represent the kidney.

At the same epoch we begin to see distinctly the ciliary band (*lv*) and the S-shaped muscle, which occupies nearly the middle of the body; further, the heart has been formed in the interior of the pericardium.

4 (fig. 6, and fig. 1. 6-7). Later on the assimilation to the adult becomes easier and easier; nevertheless the posterior part corresponding to the genital mass still for a long time presents a very considerable development, producing a form quite different from that of the adult; lastly, the nervous ganglion has already ceased to occupy the summit of the body, and begins to pass towards the anterior side.

The most remarkable change of this epoch consists in the formation of the branchial fissures between the pharyngeal sac and the lateral portions of the cloaca which cover its posterior surface. The branchial fissures are formed in a single line, and appear nearly all at the same epoch; nevertheless those of the middle are more developed than those of the extremities. They make their appearance at first in the form of small slightly elongated thickenings; and it is only subsequently and very gradually that they acquire the breadth which they afterwards present.

The modifications previously described in the digestive tube have become more and more strongly marked at the epoch under consideration: the stomach has become considerably contracted, and the entire digestive tube has acquired the form of a bent cord which occupies a perfectly vertical position; moreover the intestine has become greatly

elongated, and represents by itself the whole of the posterior branch besides a portion of the anterior; at this stage it also presents an inflated portion, which afterwards disappears and does not exist in the adult.

The ovary, the testis, and the disseminated cells (of the kidney?) are more distinct from each other, and begin to be clearly recognizable.

Finally the margins of the incurrent and excurrent apertures begin to thicken in order to form papillæ, while over the rest of the body, especially at the level of the endostyle and of the nervous ganglion, the epidermis becomes considerably reduced in thickness.

5. In the state represented by fig. 7 the bud has lost all its embryonic character and acquired an aspect which absolutely resembles that of the adult; the summit of the body is no longer occupied by the nervous ganglion, but by the *spiral organ* (as is shown in fig. 1. 7-8, and fig. 7); the general aspect has completely changed; the cells which form the external laminæ as well as the pharyngeal and cloacal sacs have acquired the flat form which they present in the adult; and the general transparency has become very great; the pharyngeal sac has considerably increased; the endostyle has lost its inflated form to acquire an aspect approaching that of its definitive form; and, lastly, the whole region of the genital mass has been reduced in such a manner that the peduncle, instead of retaining its original direction, is now directed downward, occupying a position absolutely different from its previous one and much nearer to the heart. It is this last alteration especially that modifies the general aspect presented by the bud and gives it an absolutely different form.

The internal organs have also undergone modifications of some importance. Of the two muscles which bounded each of the apertures (incurrent and excurrent) the posterior one is now further from the aperture, and the anterior one alone borders it closely. Further, the thickened margin of the posterior aperture begins to be recurved at its upper part to form a sort of hook, into which the muscle penetrates, and which is the commencement of the long filament that occupies this position in the adult.

The branchia has become elongated and recurved, as shown in the figure; but the branchial fissures are only slightly lengthened.

The intestine has continued to be developed in the direction already indicated in the preceding stage; but the kind of cæcum formed previously (*cæ*) at its lower part has disap-

peared, and nothing remains of it except a dilatation of the corresponding region, a dilatation, however, which disappears in the adult to produce a slender and perfectly uniform tube. Lastly, at the base of the stomach we notice the slender tube which represents the ramified gland of the *Ascidia*.

The vibratile band is now very distinctly formed; and it can easily be traced throughout its whole extent up to the spiral organ, which is already present.

The genital masses have decidedly given place to a definitively separated testis and ovary, the former composed of rounded cells and the latter of a follicle containing several ova; both of them open by a common aperture into the right lateral expansion of the cloaca.

Lastly, the disseminated cells have lost all connexion with the genital organs; they are now arranged in groups of four or five around the digestive tube.

6. In the adult the branchial clefts have increased very perceptibly; the peduncle has attained a vertical position and come to be placed in the immediate vicinity of the heart; it is much less apparent than in the preceding stage; and the whole animal has acquired the definitive form of the figure 8. The cells of the kidney are no longer collected into groups as previously, but form a *network* around the digestive tube. The testis presents a deferent canal; and its glandular portion has become elongated and ramified around the stomach, which it partly conceals. Finally, the tunic has become much thickened; and spots of red pigment have made their appearance in the middle of the body and above the apertures.

III. *Affinities.*

We have already put forward some considerations upon the central position, between the two great extreme groups of the Salpæ and *Ascidia*, and especially between *Doliolum* and *Pyrosoma*, that is occupied by *Anchinia* from the point of view of the arrangement of the great cavities. But these general relations give us but little information as to the precise affinities of this interesting type and the exact place which ought to be assigned to it from the complete knowledge of its organization.

If we endeavour to compare the preceding description with what we know of the other Tunicata, we find that, as regards the structure of the adult as well as the position of the buds upon the stolon, *Anchinia* presents a great resemblance to *Doliolum*.

As regards the organization of the adult form, we see that

the disposition of all the internal organs especially approaches that of *Doliolum*; the cloaca, the branchia, the endostyle, the intestine, and the genital organs have a form and arrangement almost the same as in the latter. Leaving out of consideration the regular form of a little cask, with muscular bands representing its hoops, which *Doliolum* possesses, the same description might apply to both.

The conformity is still greater if, instead of comparing *Anchinia* with the adult form of *Doliolum*, we compare it with the buds. These are attached to the stolon which bears them, by a peduncle, of which the point of attachment is at the level of the endostyle, and which throws the cloacal aperture towards the dorsal or neural side. The presence of this peduncle and the dorsal position of the aperture of the cloaca constitute of themselves a resemblance of great importance between *Anchinia* and *Doliolum*; but its significance becomes much greater when we consider that the *Anchinie* absolutely resemble the buds of *Doliolum* in the conditions of their existence. We may suppose that the *Anchinie* are *Doliola* which have remained stationary, and which retain throughout life up to sexual maturity the embryonic form of the buds of *Doliolum*. In *Doliolum* the buds, in order to attain to sexual maturity, separate from the stolon and commence an errant life, during which their musculature and their general form become adapted to these new conditions of existence. In *Anchinia* the buds remain attached to the stolon, attain sexual maturity in this state, and retain throughout life the embryonic form of the buds of *Doliolum*.

The more detailed comparison of the buds of *Doliolum* with those of *Anchinia* also reveals great resemblances; the peduncle which attaches the *Doliolum* to the stolon upon which it is implanted has its point of attachment to the animal situated between the endostyle and the cloacal aperture; the same thing occurs in *Anchinia*, as in most of the Tunicata which are reproduced by gemmation; but between these last and *Doliolum* and *Anchinia* there exists a very grave and indeed capital difference: in the Tunicata generally the union which takes place at the level of the peduncle, between the bud and the parent or the stolon which has given origin to it, is quite intimate; the ectoderm of the buds is only the prolongation of the ectoderm of the parent or of the stolon, and its endoderm passes directly into the endoderm of the stolon (as in the Salpæ) or of the parent (as in the Ascidia, *Pyrosoma* &c.). On the contrary, in *Doliolum* and *Anchinia* the peduncle of the bud is simply adherent (attached without intimate union of the tissues) to a small corresponding elevation of the stolon.

The peduncle of the buds of *Anchinia* (fig. 7, *cp*) represents a simple elevation of the ectoderm of the bud; it is quite circumscribed; its tissues, which consist of a cylindrical epithelium, all belong to the embryo and have no genetic relation to the stolon; at the point of adhesion to the stolon its cells are merely superposed upon the cells of the corresponding part of the stolon without there being any amalgamation or intimate union; further, the internal cavity of the peduncle is completely closed and does not communicate with that of the stolon. The buds and the stolon appear to be two distinct structures, which are only approximate and in apposition to one another, without any direct passage between their tissues, and without any amalgamation of the histological elements. We might compare these relations to those which exist, in the Mammalia, between the uterus and the embryo contained in it. The ovum and the embryo to which it gives origin are formations independent of the uterus. The ovum is formed in the ovary, passes into the uterus, becomes attached thereto for a definite purpose; and there are no genetic relations between the two. The same thing appears to take place in *Anchinia*: the buds and the stolon have no genetic relations; the buds are placed upon the stolon for the purpose of their ulterior development; but nothing authorizes us to think that they are produced by the stolon; all our endeavours to detect any relation between the buds and the stolon have been in vain; the youngest buds, like the older ones, were always perfectly independent of the wall of the stolon, whereas, on the contrary, nothing is easier to prove than the direct relations which exist between the organs of the buds of *Pyrosoma*, the *Salpæ*, and the *Ascidia*, and the corresponding organs of the parent. We thus come to the conclusion that the buds of the *Anchinie*, in their genetic relations, are independent of the stolon.

It would be very difficult to explain the apposition of the buds of *Anchinia* if an ingenious discovery of our colleague, M. Oulianine, had not given us the key. Formerly M. Oulianine discovered that the buds of *Doliolum* are not formed upon the stolon of *Doliolum*, but that they originate, as in all the other Tunicata, at the end of the endostyle, upon the organ which has been called the rosette-shaped organ (*rosettenförmige Organ* of the Germans). This organ is the true prolific stolon of *Doliolum*; it produces buds in accordance with the ordinary process in the Tunicata; these buds separate from the rosette-shaped organ, pass to the posterior stolon of the *Doliolum*, become attached to it, and begin to be developed. Thus they are genetically quite independent of the stolon

which bears them. It is to be supposed that an analogous process takes place with the buds of *Anchinia*, and that, after being detached from their place of origin, they become implanted upon the stolon, with which we have been unable to find that they have any genetic relations. This constitutes a further important fact which approximates *Anchinia* to *Doliolum* and separates it from the other Tunicata.

We may now pass to another point, namely the investigation of the arrangement of the buds upon the stolon. As we have already said, we have met with *Anchinia* only on three different occasions.

The first time there were brought to us only a few mutilated individuals torn from the stolon: all these individuals were well developed; all had perfectly formed ovaries and ramified testes filled with spermatozooids, and with the central part of an opaque white tint, indicating a state of complete maturity.

The second specimen consisted of a chain about 10 centim. long, and bearing buds at different stages of development. We omitted to count the number of buds of different ages; but there were rather more young buds than adults (designating under the latter name the individuals possessing a complete intestine filled with food); we found no regularity in the arrangement of the buds, which, on the contrary, seemed to us to be quite irregular: all along the stolon the adult *Anchinia* were intermixed with young buds of different degrees of development; so that at each point one found mixed together adult individuals capable of feeding themselves, and young buds, the nutrition and growth of which could only be effected at the expense of the nutritive substance accumulated in their cells (as in embryonic cells in general) or by endosmose, at the cost of the nutritive substance contained in the cavity of the stolon.

The presence of adult individuals among the young buds reminds one, to a certain extent, of the arrangement of the buds of *Doliolum*. It is well known that there exist on the dorsal stolon of *Doliolum* two kinds of buds—*median buds*, which will give origin to sexual animals, and *lateral buds* of very peculiar organization; they possess neither genital organs nor proliferous stolon, but have a well-developed intestine and branchiæ which function very early. Gegenbaur, Fol, and Grobben have expressed the opinion that these lateral buds are more properly respiratory and nutritive buds; and it is a fact that their organization is wonderfully well adapted to this purpose. Grobben has discussed the

question in detail, and demonstrated that the lateral buds must really be regarded as individuals charged with the above functions.

Thus upon the stolon of *Doliolum* there exist young median buds of which the organs of nutrition and respiration are not yet developed, and lateral buds which possess large branchiæ as well as a completely developed intestinal canal, and a part of which, thanks to their early development, nourish the less developed buds.

In *Anchinia* there is only one kind of bud; there are none which are specially appropriated to the functions of nutrition and respiration. But among those whose development is more advanced we find a certain number whose organs of digestion and respiration are in complete activity. They can the better perform their functions because they are scattered among younger buds throughout the length of the stolon; and they present a most evident analogy of function with the lateral buds of *Doliolum*.

We have studied the position of the buds upon the stolon, their relations with it, and, lastly, their reciprocal arrangement on its surface; and we have found that in these three points their relations are the same as those which exist between the buds of *Doliolum* and the dorsal stolon.

It is well known that in *Doliolum* this stolon is produced by an asexual form, which loses all its organs of nutrition, and becomes reduced to a mere motory organ—an individual whose business is to carry the chain, and whose brief existence only lasts for the time necessary for the maturation of the buds.

In *Anchinia* we do not know the corresponding asexual form. But the close resemblances that we have just indicated between all the other points of organization and reproduction in *Doliolum* and *Anchinia* appear to us to be so striking as to permit us to conclude that the generation which produces the stolon of *Anchinia* resembles *Doliolum*, or even that it is simply a *Doliolum*.

It remains for us, in conclusion, to discuss a final question—that of the ultimate fate of the buds of *Anchinia*.

It is a fact worthy of remark, that of the three specimens of *Anchinia* which have come into our hands, two furnished us only with individuals which had all arrived at complete maturity, and were furnished with genital organs and a digestive tube perfectly developed. There were no longer any traces of fresh buds, or of parts capable of producing them; there existed in them only a single mode of reproduction—sexual generation.

The first time all the individuals collected had the testes much ramified, opaque, swelled with semen; they had been captured in the muslin net in stormy weather, and were unfortunately few in number, and all more or less mutilated. Our second capture consisted of a well-preserved colony, all the individuals of which were mature and presented voluminous ova; but in them the testes were less developed than in the specimens first brought in.

These observations lead to the supposition that the individuals of a colony of *Anchinia* function sometimes all as males and sometimes all as females; it would then be here as in the *Salpæ*, among which the chains function successively at first as male and then as female chains, owing to the fact that in the same chain the male and female organs do not reach maturity simultaneously.

Sexual reproduction is therefore, above all, the purpose of the buds of *Anchinia*. What is the form to which the ova will give origin? This, for the moment, is impossible to decide. It will be for ulterior researches to answer this grave and important question, the solution of which is no doubt reserved for the zoological station of Villafranca, the only spot where *Anchinia rubra* has been observed.

The individuals which have attained sexual maturity are very easily detached from the stolon, as may be often enough observed in specimens kept in captivity. Is this the case also in a state of freedom? This is difficult to say with any certainty, although the analogy with *Doliolum* renders it probable. In any case, whether the adult *Anchinia* become immediately detached or remain attached for a certain time to the stolon, it is certain that their existence cannot be of long duration. The two surfaces in contact, the extremity of the peduncle and the corresponding projection belonging to the stolon, are only in apposition without intimate union; and their adhesion is too feeble to resist the movement of the waves very long. Now, as the *Anchinia* do not present any organs adapted for pelagic life, they must assuredly perish soon when they are detached from the stolon which sustains them. The life of the *Anchinia* must therefore be very short; they perish, no doubt, after the deposition of the ova, as may be observed in the case of the *Salpæ*.

The buds of *Anchinia* must be regarded, like those of the *Salpæ* and *Doliolum*, as representatives of the sexual generation, and there must be an agamic generation which produces the stolon and gives origin to the buds.

All the facts revealed in the course of this investigation lead us to regard *Anchinia* as presenting affinities especially

with *Doliolum*; in this respect we agree completely with M. Grobben*; but we think that the change that he proposes of the name *Anchinia* into *Doliopsis* is premature. It would be more prudent to wait for researches upon the form of generation which produces the stolon, a form which is still absolutely unknown to us; this, however, is a gap which we hope will soon be supplied in consequence of the foundation of a scientific centre at Villafranca.

EXPLANATION OF PLATES I.-III.

<i>a.</i> Anus.	<i>g c.</i> Nervous ganglion (hollow portion).
<i>b.</i> Mouth.	<i>g n.</i> Nervous ganglion (central portion).
<i>br.</i> Branchia.	<i>i.</i> Intestine.
<i>c.</i> Large cells of the upper surface of the stolon.	<i>l i.</i> Limit of the lateral portion of the cloaca.
<i>c c.</i> General cavity.	<i>l m.</i> Limit of the median portion of the cloaca.
<i>cell.</i> Large cells of the interior of the posterior filament (fig. 9).	<i>l s.</i> Superior (small) expansion of the cloaca.
<i>cæ.</i> Cæcum of the intestine (figs. 6 and 7).	<i>l v.</i> Vibratile line.
<i>cl.</i> Lateral part of the cloaca (inferior wing).	<i>m.</i> Cutaneous muscles.
<i>cm.</i> Median part of the cloaca.	<i>o.</i> Ovary.
<i>cp.</i> Cavity of the peduncle.	<i>os.</i> Excurrent aperture (fig. 1).
<i>cs.</i> Superior dilatation of the general cavity.	<i>ov.</i> Ova and ovules.
<i>ec.</i> Cellular envelope (fig. 9).	<i>p.</i> Point of contact of the median portion of the cloaca and the pharyngeal sac.
<i>en.</i> Endostyle.	<i>ph.</i> Pharyngeal sac.
<i>end.</i> Endoderm.	<i>pr.</i> Heart and pericardium.
<i>est.</i> Stomach.	<i>r.</i> Disseminated cells (kidney?).
<i>ex.</i> Ectoderm.	<i>sp.</i> Spiral organ.
<i>æ.</i> Œsophagus.	<i>tun.</i> Tunic.
<i>f.</i> Olfactory pit.	
<i>fb.</i> Fibrous envelope (fig. 9).	

Fig. 1 (Pl. II.). Fragment of stolon bearing zooids of different degrees of development:—3, corresponding to the bud of figures 2 and 3; 4, corresponding to the bud of figure 4; 6-7, corresponding to a stage intermediate between figs. 6 and 7, and so on. Enlarged 20 diameters.

Fig. 2 (Pl. I.). First stage of gemmation, seen from the ventral surface.

Fig. 3. The same stage in profile.

Fig. 4. A more advanced stage.

Fig. 5. A still more advanced stage.

Fig. 6 (Pl. II.). The following stage: the branchial clefts begin to show themselves. × 90 diam.

Fig. 7 (Pl. I.). A more advanced stage: the tissues have lost their embryonic character; and the creature presents a transparency like that of the adult. × 46 diam.

* *Loc. cit.* p. 73.

Fig. 8 (Pl. III.). Adult. The letters *ls* and *cl* represent the superior and inferior expansions of the cloaca, expansions separated at the level of the letter *p*, where the median portion (*cm*) of the cloaca comes into contact with the pharyngeal sac. The line *li* represents the boundary of the lateral portion of the cloaca, and the line *lm* the boundary of its median part.

Fig. 9 (Pl. II.). Transverse section of the filament of the posterior extremity. *cell*, large granular cells contained in its interior; *ec*, transparent cells which form its superficial covering; *fb*, fibrous envelope; *m*, section of the muscles of the aperture, which are produced on the ventral side nearly to the extremity of the filament. $\times 150$ diam.

Fig. 10 (Pl. III.). Transverse section of the endostyle. $\times 250$ diam.

Fig. 11. Transverse section of an *Anchinia* at a stage a little more advanced than *fig. 7* and at the level of the stomach. $\times 30$ diam.

II.—On the Mutual Relations of the *Bunotherian Mammalia*.

By E. D. COPE*.

THE name *Bunotheria* was proposed by me for a series of *Mammalia* which resemble in most technical characters the *Edentata* and the *Rodentia*. That is, they agree with these orders in having small, nearly smooth, cerebral hemispheres, which leave the olfactory lobes and cerebellum entirely exposed, and in some instances the hemispheres do not cover the mesencephalum also. From the two orders in question, however, they are easily distinguished. Their enamel-covered teeth separate them from the *Edentata*, while the articulation of the lower jaw is different from that found in the *Rodentia*. It is a transverse ginglymus with a postglenoid process in the *Bunotheria*, as distinguished from the longitudinal groove, permitting antero-posterior motion, of the *Rodentia*.

Such a group as is thus characterized will include two existing groups recognized as orders—the *Prosimiæ* and the *Insectivora*. The latter group has always been a crux to systematists; and when we consider the skeleton alone, as from the standpoint of the palæontologist, the difficulty is not diminished. Various extinct types discovered in latter years, chiefly in the Eocene formations, have been additions to this intermediate series of forms, giving even closer relations with the orders already adjacent, *i. e.* the *Edentata*, the *Rodentia*, the *Prosimiæ*, and the *Carnivora*. As is known, the groups corresponding to these orders have been named respectively

* From the 'Proceedings of the Academy of Natural Sciences of Philadelphia' for 1883, pp. 77–83.