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The position of the Sea Spiders, amongst the Articulates, and the speculations as to the relationship of this to other orders, have been almost entirely based on the anatomy of the adult animal. Krüyer, in 1840, described some embryos, and Dohrn and Hock have carried this a step further. Owing to the extreme difficulties of technique, nothing is known of the internal changes that take place during development.

A study of the germ layers and their subsequent differentiation into organs ought to throw, I thought, some light on the phylogeny of these most interesting animals. Material for work was collected during the summer of 1889 at Wood's Holl, Mass., and I am under very great obligations to Professor McDonald for the opportunity to collect and study at the laboratory of the Fish Commission Station.

Three species of Pycnogonids are found amongst the sea-weeds and hydroids about Wood's Holl, viz.: Phoxichilidium orbiculare, Tanystylum orbiculare, and Pallene empsua. During July and August these carry eggs.

The first two genera have a small free-swimming, six-legged larval stage. In Pallene the eggs are much larger, resulting in abbreviated development, and the young leave the cluster of eggs, carried by the male, in a practically adult condition.

In Phoxichilidium and Tanystylum the egg undergoes a regular segmentation into 2, 4, 8, 16; all the segments being equal. After one or two more divisions a condition is reached as shown by Fig. 6. Here the segments have the form of pyramids, with the apices together at the centre of the egg. A nucleus is at the outer part of each pyramid. The egg continues to divide, the pyramids becoming smaller, and then each pyramid divides into an outer and an inner part, each part with a single nucleus. See Fig. 7. Here we have a most perfect delamination, resulting in an outer circle of ectodermal cells and an inner mass of cells. Both inner and outer cells continue to divide. Many of the inner cells now break down, as is seen in the endoderm of many Coelenterate planulæ, and the cells of the outer circle become smaller; the line of demarcation between inner and outer cells remains sharp and distinct. It is very difficult to follow out the fate of these two cell masses. Many of the inner cells seem to form a yolk-like substance, with a few scattered nuclei, while the outer cells form undoubtedly the ectoderm of the adult. I believe the endoderm to be formed from some of the nuclei of the inner cells, but I cannot be entirely certain of this, nor have I any observations as to the origin of the mesoderm.

In Pallene, on account of the much larger and more manageable eggs, I have been able to carry out in much more detail the origin and fate of the germ layers. The eggs measure .25 mm. in diameter, and have 125 times the volume of the preceding species. The segmentation is quite interesting, and I had the good fortune to be able to follow it quite far along in the living egg.
The first furrow divides the egg into two very unequal parts—a large macromere and a small micromere. The latter is about one-fourth the size of the first. Each segment has a single nucleus. The next furrow—at right angles to last—divides each of the first two into two equal halves. In some cases the larger cell divided five minutes before the smaller, but in other cases the reverse process took place. The furrows dividing the egg into these four parts nearly coincide for the micromeres and macromeres. The third furrow divides both micromeres and macromeres into four each, and is at right angles to the first two planes of division. The next furrow is seen to divide the four macromeres into eight, is at right angles to the last two furrows, or is parallel to the first plane of segmentation. At the same time each micromere divides into two, but no definite plane of division is apparent. There are now eight micromeres and eight macromeres. Each of the eight macromeres divides into two in planes at right angles to the last furrow or parallel to the second and third planes of division. This is followed later by a division in the macromere in a plane at right angles to the last or parallel to the first and fourth; but only those cells above the horizontal furrow (fourth) were seen to divide. The micromeres were not seen to keep pace with these last divisions, so that the upper (micromere) pole of the egg is covered with a mass of cells of about the same size. Sections of eggs in this stage show pyramidal figures somewhat similar to Fig. 6, but the upper pyramids are smaller, and some do not run to the centre of the egg. Each pyramid has a nucleus in its outer part, and each nucleus is accompanied by a mass of protoplasm which sends out processes into the surrounding yolk of the cell. Soon after this the formation of yolk pyramids ceases, and the nuclei (and their protoplasm) lie at the periphery of the egg. At the upper pole the nuclei are much more numerous, but smaller than at the lower, and the protoplasm forms a thick covering to the egg. Here, also, the blastoderm develops rapidly. At the lower pole there are scattered nuclei at the surface of the yolk.

The early separation of the egg into two unequal parts is apparently closely connected with the more rapid development of the embryo in the region of the smaller segment. About the time when the pyramids become lost (and perhaps at that time) each of the peripheral nuclei divides radially into an outer and an inner nucleus—each of course with its cell protoplasm. It takes place first over the upper pole, and not till very late over the lower area. This is undoubtedly the same thing as the delamination in the smaller eggs. The differences are these—that in Pallene the pyramids do not divide themselves each into two cells, but only the nuclei and protoplasm; and this takes place later at the lower than at the upper pole. The delaminated nuclei remain just under the outer cells—ectoderm—and only exceptionally do one or two wander into the yolk. These nuclei form the endoderm of the mid-gut after having devoured the yolk. The protoplasmic layer at the upper pole becomes wider and the nuclei more numerous, each nucleus being the centre of a distinct cell. At one place may be seen from surface veins an opaque area (much like the early stage of the primitive cumulus in spiders), and sections show that here an invagination of ectoderm is forming—the stomodeum. Around its periphery there is a collection of cells which are, no doubt, the beginnings of the mesoderm. The stomodeum increases in depth, and at this time the
appendages and their nerve ganglia may be seen on the surface. Above
and anterior to the stomodeum are the thickenings of epiblast to form the
brain. On each side of the invagination the first pair of appendages arises.
Behind the stomodeum five pairs of large ganglia appear, and on each
side of the three posterior pairs are formed the fourth, fifth and sixth pairs of
appendages.

At the “lower” pole of the embryo (at this time the dorsal and poste-
rior) the nuclei are slowly multiplying and cover the surface with thin
protoplasm. Now the embryo lengthens in the antero-posterior direction,
the appendages and their ganglia become more conspicuous, and there is
seen a slight invagination in the centre of each ventral ganglion. There are five
pairs of these invaginations corresponding with the same number of gan-
glia, and I shall call them the ventral organs.

Cross sections of embryos show distinctly a wide ingrowth of the surface
epithelium into the centre of each ganglion. The cells of its walls are
rather high, with a clear outer portion, and with large nuclei. Fig. 8
shows such a cross section. These organs close on their outer surface,
and there remains in the centre of each ganglion a cavity, which is rather
longer than wide from side to side, and persists till quite late in embryonic
life.

I need only refer to similar (?) invaginations in Peripatus, and more,
especially to a section of a pair of these organs figured by Sedgwick for
the ventral organs of the jaws of Peripatus (Studies Morph. Lab., Cambridge,
Vol. IV, Pt. 1, Plate 16, Fig. 4), which easily suggests a comparison with
an early stage in the development of the ventral organ of Pallene. Although
I have looked very carefully I have not satisfied myself as yet as to whether
or not there are any invaginations for the brain of the Sea Spiders. The
appendages grow in length, and into each there is pushed an outgrowth
from the mesenteron. These outgrowths contain yolk, and this is covered
by a layer of endodermal cells. Along the ventral half of the embryo there
are scattered mesoderm cells, and these extend into the appendages between
the endoderm and ectoderm cells.

In Pallene the second pair of appendages, which are found in other py-
ognoids, never appear, and seem to have been completely dropped from
the ontogeny. The third pair of appendages (the egg carriers of the male)
appear at the time when the young is about to leave the parent. Two pairs
of nerve ganglia develop for these appendages, and each ganglion contains
a ventral organ. Later the two pairs form a single pair with four ventral
organs. The presence of these ventral organs is conclusive proof as to the
errorfulness of Schinkewitsch’s hypothesis, that the third pair of append-
ages are outgrowths of the second pair. The fourth, fifth and sixth pairs
of appendages appear (as already given) simultaneously and quite early.
The seventh appears a little before the embryos leave the parent. Like-
wise do the ganglia of the seventh appear quite late. There is in addi-
tion one pair of ganglia for the rudimentary abdomen. The yolk mass
becomes smaller as it is eaten by the endoderm cells, and exceptionally a
wandering endoderm cell may be found in the mass of yolk. As the yolk
disappears a number of schizocoels appear in the mesoderm between the
body walls and the digestive tract. Dorsally the heart appears as a simple
tube. The stomodeum communicates with the mesenteron and the pro-
toderm forms very late—at the time when the seventh pair of appendages
appear. Soon the embryo leaves the parent and no doubt crawls off among
the sea weeds and hydroids to shift for itself.
The Phylogeny of the Pycnogonida.

It will be impossible to give here the hearing of these embryological facts upon the phylogeny of the group, and I reserve for the future a fuller discussion.

It seems to me, however, that when all the embryological phenomena are taken together they give quite strong evidence for the relationship of the Pycnogonida to the Arachnids. Dohrn and Hooke have each recently reached independently the belief that the group must be considered an isolated one, with a more or less independent origin from the Annelids. I hesitate before offering an opinion against those who are so well qualified to speak authoritatively on the subject. On the other hand their opinions are based largely on the adult anatomy of the group, as little or nothing has been known concerning the germ layers, &c., of these animals; and it is chiefly on embryological grounds that I believe a comparison with the other groups of Arthropods must be based.

It is generally believed that the adults are in many respects degenerate and adapted to a very special habitat—the abdomen has become lost, or almost so, and all traces of respiratory organs are gone, the general surface of the body functioning as such: also that the group is an old one, and not derivable from any existing groups of Arthropods. So far we are together. Without going into details, it does not seem probable that the group is closely related to the Crustacea, nor very closely to the Insects. Here I can only use the tout ensemble of the above facts as evidence for this statement. We are then left to decide between an independent origin for the group and an alliance with the Arachnids. If there are any special reasons for an alliance with the Arachnids, I believe such facts must turn the greater weight of evidence towards such a relationship. Briefly then in this connection these considerations must be given:

1. The process of multipolar delamination to form the endoderm is, I believe, common to the two groups. We have it represented in its greatest simplicity in the majority of the Pycnogonida, while Pallene furnishes an analogy to the changes which an accumulation of food yolk will cause in this process, and renders a comparison with the Arachnida quite possible. I will refer to Metchnikoff's figures for Chelifier, and to Balfour's embryology for the Spiders (Vol. I, page 119, Sec. Ed.). Here we read: "It appears to me probable that at the time when the superficial layer of protoplasm is segmented off from the yolk below, the nuclei undergo division, and that a nucleus with surrounding protoplasm is left with each yolk column." Compare Fig. 6 and 7, and see account of Pallene.

2. The formation of an opaque area (Pallene) at the place where the stomodeal invagination appears.

3. The early formation of mesoderm at this place—the primitive cumulus of Spiders. (?)

4. The general mode of appearing of ganglia and appendages.

5. The body cavity of the appendages and the early presence of mesoderm.

6. The formation of endodermal pouches from the mid-gut into the appendages, these pouches containing yolk in the embryo. Compare Chelifer and Spiders.

7. The large "upper lip" of Chelifer suggests an homology with the proboscis of pycnogonids.

8. The first (Chelate) appendages appear at the sides of the stomodeum and subsequently move forward, and are innervated from part of the supra-esophageal ganglia (brain). They will in this bear out a close comparison with Chelifer (or with Arachnids.)

9. The lumen of the invagination of the stomodeum is triangular in
outline and remains so in the adult. Schimkewitsch describes a similar triangular invagination in the Spiders, and compares it directly to that of the Pycnogonids.

The full meaning of the ventral organs I cannot discuss now. I have compared them to similar organs of Peripatus. It may be that in this respect the Pycnogonids show a very primitive structure, common to them and to Peripatus, and if so, traces ought to occur most probably in other Arachnids.

The absence of brain invaginations would be a more weighty objection against the relationship of the two groups, and really the only good objection I know from the embryology.

The openings of the reproductive organs of the adult on the legs cannot be fairly urged against my comparison, for we have so far no explanation of the meaning; and on the other hand this gives little better foundation for a relationship with the Annelids.

All the above comparisons are not of equal weight, and some may be wrong; but taken all in all, I must appeal to them to bear out the hypothesis of the relationship of the Pycnogonids to the Arachnids.

Baltimore, March 15, 1890.
A Contribution to the Embryology and Phylogeny of the Pycnogonida.

In the year 1767 Carl Linne in the twelfth edition of his Systema Naturae described under the name of Phalanxium, a Pycnogonid here for the first time. The question raised whether the group is to range under the Crustacea or the Isopoda.

A hundred years elapsed and the problem remained unsettled; the group was placed now here, now there, now amongst the Crustacea or amongst the Isopoda. Then Prof. Diels attempted the solution from the standpoint of Embryology, instituting a comparison of even identity between the Pycnogonid-Larva and the Lamellibranchs, believing the Pycnogonids to have diverged from the Crustacea at this point.
During the following twenty-five years opinions once more vacillated between Arachnidan and Crustacean affinities. Recently Prof. Dolan & Dr. Hoek have each independently monographed the group, placing the morphology of the order on a very firm basis. Independently likewise they each reached the conclusion that the group is to be placed neither with the Arachnida nor with the Crustacea, so the three groups have come down in parallel lines. The early stages of the embryology of the Sea-spiders have been practically untouched, so before any final decision as to the affinities of the group is to be made, these stages in the development should be known to take equal rank with Comparative Anatomy in disentangling the affinities of the group.
For many reasons the present paper attempts in no way to give a complete answer from the embryological side. The very great difficulties of technique had already to be overcome. The time at command prevented a detailed description of the different organs arising from the germ layers, as not much remains that might be done.

In the summer of '89 material for work was collected at Woods Hole, Mass. Through the courtesy of Prof. MacDonald I was enabled to collect a study at the station of the U.S. Fish Commission at this place. To Prof. MacDonald I am also indebted for many other kindnesses extended during my stay at Woods Hole.

Three genera of Pycnogonida — each with a single species — are to be found at this place, viz., Pallene empusa, Phoxichilotrum...
maricillate Smith (Amphiprionus centus, Wilson) on Pampasthrium orbicular. During July, August, and September these are found with eggs. Pallene inhabits the hydroids (Pulciareia, Pennaria) on the piles of the rocks and common on the red-sea-weeds below low-tide mark. The hydroids or sea-weeds as soon as collected were brought into the laboratory and worked over piece by piece. Each bunch was immersed quickly both in forwards and backwards in a dish containing a small amount of water so that the Pycnogonids were shaken loose so could be easily picked out. The other genera were more easily found by separating the masses of hydroids or could be easily seen clinging to the piles. The males of Pallene carry on each pair of ovigerous legs a small
bunches of 990. Each bunch contains from one or two to fifteen or twenty eggs.

The eggs of *Physocelitisidium* *Tamydyclus* are individually much smaller than the are "lasi," but every numerous so that the bunches are much larger especially so in the former. *Physocelitisidium* carries several bunches strung along on each ovigerous leg of the male, the bunches are white and very conspicuous against the purple color of the adult. *Tamydyclus* has smaller bunches of eggs with the individual eggs large, the masses are carried as if they form a circle of clusters held against the ventral side of the male. The adults with eggs were put into alcoholic pere-sulphuric acid for several hours and then gradually carried through different grades of alcohol of increasing strength.
Other methods of hardening gave far less satisfactory results in boiling water or Flemming's solution.

To prepare the eggs or embryos for study they were passed through absolute alcohol (1 hr), turpentine (2-4 hrs), soft paraffine (1 hr), hard paraffine (1-2 hrs). They were cut in paraffine and fixed on the slide with albumen fixative. Then back again through turpentine, absolute alcohol, 95%, 80%, 70% alcohols to Flemming's berylgum chromoxylin where they remain for a very long time (12-48 hrs), then washed fifteen minutes in acid alcohol, run up again through the alcohols to turpentine and into balsam. In Palleme each egg was, in many cases, pricked with a very sharp needle before going into absolute alcohol, it is necessary to do this under a dissecting microscope.
By these methods very excellent results were often obtained, so after many failures of other methods was found to be the only satisfactory one.

In Pallasae the larger size of the egg makes a study of the earlier stages much easier, but the other genera have a much simpler development so it seems better to give first an account of these.

To Prof. W. K. Brooks I am greatly indebted for help or suggestions during the work.

**Tany stylium** & **Physocelidium**

The egg of *Tany stylium* measure .08 mm. in diameter (in preserved specimens) of those of *Physocelidium* .03 mm.

In both animals there is a regular segmentation. In Plate III, figure a is
a surface view of an egg of Pachyptilium, divided into two equal parts; in figure 6 an egg into four cut with the segments shifted around, or figure C an egg into eight equal parts. Similarly figures 6 and C for the two of four cell stages of Tanyptilium. The eight celled stage I did not obtain for this species.

Figure 6 is a surface view of an egg of Tanyptilium at about the twenty-four celled stage & an optical section of an egg at this stage shows each cell to run from the periphery to the center of the egg where they all come together at a point. Each cell is three pyramidal in shape & contains a single nucleus. In Plate 1 figure 8 there is a section of an egg at a later stage than the last. This and the following sections
are from eggs which were cut in paraffin. The section is a later stage than the preceding surface seen so that the pyramids are narrower than before.

Figure 11 shows a somewhat older stage for Prochelidium. Very soon after this — perhaps after the next cleavage — a most important change takes place in the egg. I have not seen the actual change in the living eggs, but serial sections have not the slightest doubt as to the process. Each nucleus divides radially into two + This is followed by division of each pyramid into two parts in a plane at right angles to the radius, of the circle, lying in the pyramid. This is shown by Plate 5 Figure 9 for Panoglyptum.

Here it is seen that by a process of
multipolar delamination. The egg divides into two germ-layers — an outer peripheral circle of cells and an inner mass of cells; these latter soon round off to leave no trace of the former pyramidal arrangement. In figure 9 one cell is still seen running from the periphery to the center. This section does not show a nucleus in the inner part. The inner cell I shall speak of as the entoblast or the inner circle as the entoblast. This figure 9 is somewhat diagrammatic inasmuch as only part of the inner cells is shown for usually they are more closely packed together than here shown. In this case it is due to a part of the section having broken away (redrawn in figure) to set some of the inner cells...
In figure 11 is a more accurate drawing
of an egg of Pampelphleum immediately
after delamination has taken place.
Exactly similar changes were seen
in the eggs of Phocaebelidium, but the
figures just given serve in every respect
for both species. The central as well
as the peripheral cells continue to
divide but soon the ends blast cells
lose their well defined boundaries
so the nuclei seem in part to disappear.
The result is that we have in the center
of each egg, a granular yolk cell
scattered nucleus in it. Here there
is an indication of a cell boundary.
During this time the scioloblast cells
have divided tangentially so have
become much smaller yet at all time;
a distinct boundary remains between scioloblasts
ends last. Figure 12 for Phocaehelidum
now an embryo at this stage.
It is here seen that the ectoblast cells
over one hemisphere are somewhat
higher than at the opposite side and
this very constant in sections of both
species at this stage of development.
After this it becomes difficult to
follow out the fate of the germ-layers.
The outer cells become smaller or
flatter to form the ectoblast and the
inner cells arranged into organs
the most conspicuous of which is the
digestive tract.
There is a triangular invagination
to form the stomodaeum. The
prosops is appears between the
first pair of appendages which
have now begun to form.
There appendages are very conspicuous in surface view where they project beyond the surface of the body. Between them appears the slightly projecting proboscis about the middle of the embryo. The second or third pairs of appendages which are small and inconspicuous, Dohrn has given excellent figures of embryos at this stage both in his earlier paper and in his later monograph. Soon after this the egg coverings swell up somewhat and the embryos finally break out of the egg, so that the appendages now can straighten out.

In Plate IV. Figure 1X is a surface view of a larva of lampyridæ as seen from the ventral surface. Dohrn speaks of this as the Pantopod-larva or stock called Pentonymphon
Its general characters are shown in the figure. There are three pairs of appendages. The first pair chelate with the movable claw working outwards or downwards, the second and third pairs have distally a sharp spine, in the middle of the limb a large segment or proximally a prolongation of the body which may be regarded as the basal segment of the appendage. Between the first pair of appendages the proboscis projects forwards, with the mouth opening at its distal end. Behind the base of the proboscis is seen the pair of ventral ganglia. From these the circumoesophageal commissure ascends upwards around the oesophagus obliquely and gives off on each side a pair of nerves to
The second and third pairs of appendages. Dorsal to these ganglia -
for in all, the two pairs being fused,
is seen the outline of the mesenteron,
which ends blindly behind.
About the middle of the embryo, just
back of the pair of ganglia is
seen a pair of ovoid masses which
are the beginnings of another pair of
ventral ganglia.
In the basal joint of the first pair
of appendages is an opaque mass
composed of large cells, from which
runs out a duct towards the base of
the spine, and Dohrn has traced it
out to the very tip of the spine, where
it opens to the exterior. This
organ is a gland and its duct is the
long tube in the spine.
A dorsal view of the embryo shows the brain, just above a little in front of the neural ganglia. On its upper surface are a pair of small pigmented eyes. A transverse section through the body of this Panipoda larva is shown in Plate 1. It passes through the center of the body and below it is the large central ganglionic mass. It passes through the base and the third pair of appendages. Above it cuts the posterior part of the brain. In the center of the section is the digestive tract. This is cut at a point where it is about to give off diverticula to the first and third pairs of appendages. The first of these is marked D'. The second is D". Below the digestive tract is the second
pair of ganglia which sends out
nerves to the corresponding appendages
Above the digestive tract the section at
B cuts the posterior part of the brain.
The cavity of the body has a few
scattered mesoblast cells in it and
a few bits of broken muscle fibres.
These fibres in the living embryo
seemed to connect the the mid gut
to the body-walls.
In the base of the legs are seen
general cells which at M are arranged,
in part, around a central cavity.
This cavity does not seem to connect
with the mid gut but it seems very proba-
able that it represents the body cavity
in the legs, that the surrounding cells
are of mesoblastic origin. InPattern
as we shall see later there are
animal cavities which are undoubtedly mesoblastic in origin.

The mid-gut ends blindly behind as is seen in other sections.

In figure 14 is shown part of a section through a more anterior part of the body. The section passes through the brain above & the first pair of ganglia below. These two are connected by the circum-oesophageal ring. This commissure is composed of both cells and fibers. In the next section in the new figured a broad band of nerve fibres passes on each side from the brain to the ventral ganglia. In figure 14 a few of these fibers may also be seen in the middle of the commissure lies the cross-section of the oesophagus. Its lumen is irregular and its walls
composed of a layer of cells which are clear around the periphery of the triangle. Around the oesophagus are a few scattered mesoblast cells. From the brain B there is part of a substance which projects vertically towards the oesophagus and is quite conspicuous in sections of the Pankopod larva in this region. On each side of the brain are seen a pair of diverticula of the mid-gut. These go to the first pair of appendages and are traceable to D' of figure 13. The first pair of appendages are as Dobson has shown innervated from the brain.

The section of the embryo following figure 12 gives a cross section of the pair of simple eyes. A part of
This section is shown by figure 15. In the middle line of this section, above the posterior part of the brain. The schizoblast is thickened beneath the cuticle. Immediately on each side of the middle line appear the sacs of eyes. Each is seen in section and is composed of three cells—two clear outer ones with large nuclei and an inner much pigmented cell. Around the eyes the schizoblast is quite thick. On each side it sinks down slightly from the surface, suggesting that the eye may be here increased in size.

In figure 16 is a section through the third pair of cerebral ganglia, which we pass on the ventral side of the embryo posterior to the pairs of first opening.
ganglion. The section shows that at this place the epithelial is greatly thickened & the cells columnar with clear outer portions. In the ganglion on the left of the section the cuticle suddenly dips down into the center of the ganglion where it becomes extremely thin. This was not as clearly seen on the right hand ganglion but traces of it were seen here also. These structures I shall speak of as the ventral organs so we shall come across them again in Palleca where they are worked out in greater detail.

Palleca empusa.

There is great variability in the size of the eggs on the ovigerous legs of the males. The average size
Of these which seem to be normal
eggs is .25 mm; but often bunches
contain one or more much smaller
eggs, some of which seem to begin
devolution. These very small eggs
are most probably immature or acciden
tal. Although the eggs of Palaeon
are much larger than in the preced
ing animals — having 12.5 times
the volume — yet the yolk is
almost transparent so that nuclear
divisions of the segmenting egg are
clearly seen from the surface.
The adult is remarkably translucent
as consequence most difficult to see
as it rests quietly among the kelp
d or sea-weeds. It seems that the
eggs have adapted themselves for
purposes of protection by thus becomi
transparent, from a less time necessarily elapsed after the animals are collected before they can be examined so that I have been unable to see the egression of the polar bodies. The nucleus of the egg and accompanying protoplasm is extremely large and situated near the center of the egg.

Each division of the nucleus is accompanied by a division of its surrounding protoplasm so that in surface views it is impossible to separate them one from the other. In the figures of Plate III the darker masses in each cell indicate the position of the nucleus of protoplasm but for the sake of brevity I shall speak of this simply as the nucleus.
In the unsegmented egg the nucleus is seen to elongate 0 to divide into two halves 0 this is immediately followed by division of the egg itself into two parts. The first fusion divides the egg into two unequal segments.

Figure A Plate III shows an egg after the first division. Each segment contains a single nucleus (Haeckl has made a different observation from this, see infra). After this first segmentation the segments flatten somewhat to remain so during the resting period. The second division came in about three quarters of an hour (in an hour) after the first. The nucleus of the smaller segment — the micromere — divided first and then the segment itself into equal parts.
This was followed five minutes later by the division of the nucleus of the large segment—the macromere—then the macromere itself.

In figure 18 an egg is shown as seen from above after its second division which is indicated by 3—2.

The plane of segmentation of the micromere & macromere are drawn in this figure as though they coincided, but this is not the rule. The plane of segmentation of the micromere may be turned at as much as 30° (n exceptionally about 45°) to that of the macromeres. I think it should be considered as one of the same plane of one of the same division, a rule of individual variations.

The segments again flatten together.
after an interval of about an hour the third division commences. The plane of division is at right angles to the last so is shown by figure C in which the egg is seen from above. Again the plane of micro-mere & macro-mere do not quite coincide; the number 2 - 2 indicate the second division & 3 - 3 give the plane of the present (third) division. This plane is a zigzag line lying between 3 - 3. If we examine the opposite pole — the lower — of an egg at this stage we find the large macro-meres come together as shown in D although there are many differences in this respect. So for the planes of division of micro-meres & macro-meres have been supposed to coincide or to be referred to the same
division plane but after this stage is reached (8 segments) the planes cannot be considered identical. About an hour after division the first system comes on. This division plane is shown for the macromeres in side view in figure in E, by the line 4-4 and is seen to be parallel to the first plane of segmentation 1-1. The four macromeres become eight. About the same time—may be five minutes before or after—the micromeres divide. In figure E they are drawn after division has taken place. and figure F shows how these cells are divided—the curved lines indicating twin-cells. As we see from the very nature of the division of the macromeres
It is impossible to have their plane of division correspond with that of the micromeres and the division lines of the latter lie in a plane at right angles to the plane of division of the micromeres. We have now eight macromeres; eight micromeres after a resting period of about an hour. The fifth rhythm begins.

The nuclei of the macromeres of figure E show by their elongation how they are to divide, so that plane of division lies between them or at right angles to the last division plane. Fig C shows the egg after division into eight micromeres but the micromeres had not as yet divided so remain eight in number. Even however they do divide but no definite
plane of division of all of the segments was discovered. There are now 16 macromeres + 16 micromeres.

The next plane of segmentation of the macromeres—after the digitate system comes in after another resting period of an hour—this is shown by figure H at 6-6—6-6. The two planes are at right angles to the last two (5-5) and are parallel to the first of fourth (1-1, 4-4).

I did not see the sixteen micromeres divide into thirty-two nor could I trace them further. There are 32 macromeres + 16 micromeres, in all 48 cells. After an hour's interval the macromeres lying between the planes 1-1 and 4-4 in figure H were each seen to have two nuclei. But this
did not seem to be the case with
the macromeres of the Lower polze.
The egg had been under observation
for many hours and did not develop
further or that this last attempt
at division in the upper macromere
may have no special significance.

Besides the general facts of segmentation
as just given, several interesting
variations in the method of segmen-
tation of the egg were clearly made out.
In the example given above the
micromeres divided first (at the
second segmentation) giving two micromeres
to one macromere. In two other
observations this was also true but
in three other cases the macromere
divided five minutes before the micro-
meres. And again in the last case.
The two macromeres divided into four before the two micromeres divided into four, so that the greater amount of yolk of the macromere did not occur in itself is retarded segmentation. In several later stages (32 micromeres) the microneres, the rhythm of macromeres a macromere given above did not so closely correspond and the micromeres seemed to drop behind.

If the accumulation of yolk has been a very recent event in the egg of Palleria, the variations in size may not this interpretation — these differences in the method of segmentation may be due in part to the segments of the egg struggling to give asynchronous beats at each rhythm but being hampered by the presence of the yolk.
If the first plane of segmentation of Paddle corresponds with the first plane of division of Placodermum or any other form — and a priori this seems most probable — so it not conceivable that the acquisition of yolk to one half of the egg might cause great changes in the synchronism of segmentation of the two parts; if so it is easy to imagine we have here an egg in a period of variation that one or another of the above changes may become fixed for the species. Later stages of segmentation than those described are difficult to follow or to distinguish between macromere or micromere of the upper pole but in general the cells around the upper pole are
smaller & more numerous than at the
tower. Figure H Plate III shows
the central (or macromere) hemi-
sphere of an egg at a later stage
than any of the preceding.
The outer ends of the cells, as
seen in the figures are polygonal
& the nuclei lie very near to the
surface. The whole cell is pyramidal
in shape with its apex at the center
of the egg with polygonal base at the
periphery of the egg, with the nuclei
in the base of the pyramids. Each
nucleus is still accompanied by a
surrounding mass of protoplasm
so without doubt this protoplasm
which is seen from surface views.
At this time the cells of the
tower pots rarely divide or remain
for a long time almost constant in
size & number, but the cells at
the upper pole undergo rapid changes
so our attention must now be turned
almost entirely to that region.
The next change which we can
see in surface views is at the
upper pole where a whitish opaque
area is forming, so which may be
profitably compared to the similar
formation in spiders eggs so called-the
Primitive Caruncle. This is
due to an accumulation of cells at
this point where an invagination is
about to take place to form the stomo-
daeum.

Soon there are
other opaque areas formed at the
surface, which we seem to occupy
definite positions and are the Thicknesses
for the brain, ventral ganglia appendages. These are shown in figures I & II. Plate IV. In figure I we have a surface view of the head region of a young embryo. In the upper part of the figure are first the two oral thickenings to form the brain or cephalo-pharyngeal ganglion. At this stage they just touch in the middle line. Below this and in the middle line is the thickening of the stomodaeal invagination. In the center is a triangular shaped cavity - the cavity of the invagination. The base of the triangle is towards the brain. On each side are the thickenings of the first pair of appendages. In the lower part of this is a slight depression and indicates the line between the claw.
of the next segment of the limb against which it works. Posterior to them various thickenings appear two rows of opaque areas, the nerve ganglia. Three pairs of them are seen in this figure, the first two being somewhat smaller than the third.

On each side of the last pair appear part of the thickenings of the first pair of ambulatory legs (the fourth pair of appendages).

Figure 2 is a continuation of the last figure & shows the ventral un节ured part of the same entry. The upper pair of ganglia are the second pair, & were seen in figure 1 & the second pair of this is the third of the first figure. On each side of this third pair of ganglia are again the first pair of walking legs.
Two more pairs of ganglia follow this third. On each side of the fourth fifth pairs of ganglia appear the second or third pairs of walking legs in embryo at a stage later than the last is shown by figure 111.

Here the embryo has elongated in an antero-posterior direction so that the figure shows only the ventral side of the animal. Figure 112 is a dorsal view of an embryo at the same stage. These figures show that the region about the stomodaeum has grown forward with the opening of the stomodaeum at its distal end. This not growth is seen in the figures as a forward prolongation of the embryo in the middle line. On each side of it are seen the first pair of appendages which have the
grown forward.

On the ventral side of the embryo appear on each side of the middle line five pairs of large ganglia. See Figure 111. On each side of the last pair pairs appear the three pairs of walking legs, which are longer than on the last figure, are bent 90° and stick out from the surface of the embryo. Posterior to the last pair of ganglia the embryo has a thickened mass of undifferentiated substance.

In a dorsal view — figure 112 — we see the brain enclosed in the large yolk mass of the embryo. The two halves of the brain have come together and each half is slightly lobed. Around the periphery of the yolk appear six pairs of arteries.
o behind the thickened protoplasm mass of the embryo.
Returning to the central view of the embryo - Figure II there is seen a most interesting structure in the center of each ganglion. Each is an invagination of the surface into a ganglion to these invaginations are elliptical in outline with the long axis corresponding to that of the embryo. These structures I shall call the Central Organs 0 by means of serial sections we shall later study them in more detail.
In the next stage, shown by figure V the embryo is more oval in outline. The appendages have also elongated to become more bent. The posterior pair have begun to grow forward between the more anterior pairs.
important change is in the position of the first two pairs of ganglia which now appear as one pair of rather large ganglia. This pair of ganglia still shows its double structure by the presence of two pairs of ventral organs. The third pair of ganglia also shows a pair of ventral organs but the more posterior ganglia are covered by the posterior appendages so that these ganglia cannot be seen from the surface.

After this stage is passed, the appendages grow enormously in length and the embryo becomes flattened from side to side.

A figure of an embryo at this stage is shown, in side view in figure VI. The first appendage is chelate.
Joint near its base, one also sees it has moved more dorsally to the proboscis.

Beyond o beneath this appendage appears the proboscis which has much elongated. Near the base of the appendage is seen part of the brain. This figure also shows that the yolk mass is seen to continue into the center of each ambulatory limb. The thin pair of legs are much bent to each ends in a spine-like process. The body is seen to end behind in a knot-like projection. The neural ganglia are shown between the bases of the legs o the length of each of this stage is about equal to its length.

In older embryos the yolk begins to
disappear at the sides of the embryo to become thicker. After this the embryo lengthens a great deal. The appendages grow much longer and become segmented. Another pair of appendages appears behind the first pair of walking legs & the knob-like projection at the end of the embryo is pushed more dorsally to form the rudimentary abdomen. Four pairs of eye spots appear over the posterior end of the brain. After these changes have taken place we reach a stage shown by figures VII & VIII. The first figure is a ventral view of the embryo at a time when it is ready to leave the parent. The three pairs of segmented walking-legs have
become straightened out at the sides of the body, in the figures only the proximal ends are shown.

The fourth pair of walking legs appears at the posterior end of the body.

The first pair of appendages - the chelecorae are now attached quite dorsally to the proboscis which appears between o below them. Each has three segments including the terminal one which acts together with the second to form the pinicere.

On the sides of the body just in front of the first pair of ambulatory legs are a pair of projections, one on each side. These are the beginnings of the third pair of limbs - the opisthos leggs.

I have seen no traces of the second pair of appendages in the majority of females.
Fine pair of large ganja lie near the "body" in addition a small ganja pair.

The first pair as we have seen is entirely composed of the first 5 second pairs.

The next pair -- the third -- between the first pair of ambulatory legs, etc.

The fourth pair of ganglia lies between the second pair of legs; the fifth near the base of the third pair of legs or the pithole, each of these ganglia is smaller than those in front, at the base of the fourth pair of legs.

The small seventh pair of ganglia belongs to the rudimentary abdomen.

It does not lie in a plane with the more anterior ones but like the pithole is dorsal to the one in front of it as partially shown in the figures.
The aerophagus is seen to start at the
distal end of the protocere is descends
on the body where it is not easily followed
on account of its transparency.
The prolongations of the mid-gut
into the legs is not shown in the
figures except for the last pair of
innominate legs.

In figure VIII is a dorsal view of the
same embryo. Four pairs of large
ventral ganglia, and in addition the
small rudimentary ganglia of the abdomen.
The first, first & second pairs are
bundled by the brain.
On the surface of the brain are seen
four small pigmented eyes.
The aerophagus is triangular in shape in
cross section, with the broad base turned
upwards & this base is seen from the
surface. At the posterior end of the animal the rudimentary abdomen is seen, 0 at its end is the opening of the anus.

**Internal Changes.**

Sections of the early stages of segmentation give little information in addition to that we see from surface views. They show that each prickle is contained in a separate segment and many of these segments run to the center of the egg. True cells derived from the micromere cannot reach to the center of the sphere.

**Figure 1. Plate 1** is a section of an egg at this stage when there are thirty-two micromeres. The upper part of the figure is probably in the region of the micromeres. In the center of the egg...
appears a clear cavity without yolk, but this is not constant for all eggs. In some it is certainly absent but I am unable to say whether or not it is caused by hardening agents. What seems to be a similar cavity is found in the eggs of some spiders. The whole egg is divided up into two segments in the form of pyramids. In some of these in this figure can be traced to the center, but other sections show each pyramid of the macrospores to have its apex at or near the center of the egg. The nuclei are situated around the periphery of the section of the protoplasm, which invariably accompanies each nucleus, sends out fine pseudopodial filaments into the surrounding...
Figure 2 is in the same shape as the part of an embryo 60 days passes through the micromeres at the upper pole. These micromeres and their nuclei are seen to be smaller than the cells elsewhere. The pyramids are seen to fall short of the center of the egg, there is no central cavity present in this egg.

Sections of eggs some 80 days older than the first show that the nuclei of the upper pole have rapidly increased, and they have migrated to the surface of the ootheca which loses its pyramidal structure over the upper surface. The protoplasm surrounding each nucleus fuses with that of surrounding nuclei, though how close such fuses is formed I cannot say.
Such a condition is shown in Figure 2, where the protoplasm forms a cap over the upper surface of the yolk. The nuclei in this section are abnormally large, which is probable due to the hardening process, but the section seems normal in other respects. The lower area of the same egg shows three or four scattered nuclei near the surface of the yolk.

At this stage of development, there is a single layer of cells at the surface of the yolk. Between this stage and the next which I have figured, there is a gap. In this next section, Figure 4, we see the number of nuclei at the upper pole to be more numerous than before, and much smaller. The protoplasmic cap has become larger.
o its protoplasm is for the most part without the ameboid processes of the first figure.

A very important change has taken place between these two stages, viz., the formation of an inner layer of cells. Within the area of the cap appear a few somewhat flattened cells in figure 4, which send out processes into the underlying yolk. Two of these cells are shown in this figure. I have not made out any definite arrangement for these cells, but they seem to lie only under the upper surface of the embryo. Where these cells come from is at what time they appear must in part be a matter of conjecture, but much light is thrown on their possible origin by a
study of some other older stages. In figure 5 is a section of such a stage. The number of nuclei in the outer germ layer has nearly doubled, and the area itself covers a much greater surface of the egg than in the last stage. Under the blastoderm are seen five inner cells, with their pseudopodial extension. The larger number of these cells here than in the last figure is due in part to the greater thickness of the sections. At the lower pole are two nuclei. There below is the outer germ layer, although they show (as did all the outer at an earlier stage) the protoplasmic extensions into the yolk. This section itself throws little light on the cells of the
inner layer but in other sections at a similar stage I have found which seems to furnish the solution of the problem. From such sections I have drawn figures 6 and 7.

These are taken from the periphery of the cap of cells at a cone, much point as P in figure 5. Figure 6 shows two cells which have just separated from the outer layer of cells; we also see beyond these a single mass of protoplasm with two nuclei which presumably have just divided. I have not seen any karyokinetic figures in nuclei dividing in this direction but it is possible we have here a direct division as Heider has recently shown in the trophoblast at a similar stage of development.
although it is equally as possible it is due to pros preserving agents.

Again in figure 7 we see a single mass of protoplasm with two nuclei which have just divided. Then I believe to give a clue to the origin of the inner cells of the pieces but figures 9 to point out that they too have had a similar origin from the outer layer.

Keeping before us the process of delamination in Phoradendron, then I think we may regard these inner nuclei of Pablaea to have come from the outer cells by delamination over that we may push the comparison a step farther and consider that each cell of the outer layer to have given rise at one time in its history to an inner cell.
Then that the outer cells continued to divide tangentially to form the blastoderm. The reasons for such a belief are there. In cross-section the number of inner nuclei are slightly in excess of the peripheral nuclei of the lower pole. See figures 4, 5. As the outer cells of the upper pole were at the beginning more numerous than the peripheral cells of the lower pole we ought to get, if the hypothesis be true, exactly what we do find. Further, at the periphery of the blastoderm where the inner cells of the lower pole are added on we can always see such a method of multiplication taking place. The differences between this process
That in Phocaedusium are then; that multipolar determination does not take place simultaneously in all the cells at once but in Pallas'slowly progresses as the cap of cells makes its way to the lower pole of the egg, incorporating into itself as it goes the outer cells which cells as they are added on first fall off an inner cell.

After this stage we pass to other embryos where there two layers - ectoblast and endoblast, begin to differentiate into organs. The first to appear is the stomatodaeum which results from an invagination of ectoblast. This is shown by figure 17 Plate II. Here it is near the ecto that at one point has pushed inwards around
The prepuce of the invagination appears several cells with branching and anastomosing pseudo-podina. Then I believe to be the first appearance of the mesoblast.

A few of the cells drawn in the figure belong with no doubt to the entoblast; or at this stage it is difficult to separate the two.

The section passes longitudinally through the umbigo; a part median to the stomadaenum there is a thickening of the ectoblast to form the first ventral ganglion. Lateral the cells that are found much branched into blast cells which are still comparatively few in number. Whether the circum-stomodaeal mesoblast comes from ectoblast or entoblast I am unable
To say. Dorsally to the cephalic hip.

Dorsally the cephalic hip

termes continues for a short distance

t then becomes exceeding their.

From this stage we pass to embryos

of this age represented by figures 1 + 11.

Plate IV. The first figure, 16,

is a cross section through the stomat-

odarium of 1 (see figure 18 of the

figure). The invagination is deeper

than in the last section of its

furrow is closed. The ectoblast cells

of its wall are two layers thick.

On each side of this central invag-

nation are other appear to be

a lateral invagination. These

superficial invaginations have given

me endless trouble, even now I

feel some uncertainty as to my

interpretation of them. On each
side of these is seen the thickened section of the first pair of appendages. The lateral ingrowths are I believe caused by the growth of these appendages which tend to grow outwards as they increase in size but are prevented from doing so by the egg coverings. The result is that the section becomes folded on itself to make room for the growing appendages. This view is strengthened by the presence of some who consider invaginations at the side of the other appendages.

This part which is pushed in and corresponds to the dark furrow between each appendage of figure 3. The cells forming the stomodaeum The meso blast around the stomodaeum
under the appendages has increased. It is now clearly distinguishable from the inner covering of the sacro-blest, which lies only at the parapophysis of the yolk, & between it & the mesoblast.

In figure 14 we have a section from the same series as the last, but more anterior. It shows the region of the brain corresponding to those 14 of figure 15. The section is entirely in front of the stomodaeum & cuts the two brain thickenings of the surface view. Here again the celo-blest is seen to be distinctly folded. It is folding (imagination!) is directly continuous with the last. At first sight this seems nothing more than a forward continuation of the last groove, but it is not clear why the folding of the appendage should exist
any influence over the part of the brain.
Against it might be interpreted as folding due to the brain, but I can see no
good reason why such thickening and growths should produce the groove.
There is one other possibility viz that there may represent invaginations into the
brain itself. Against such a view is the absence of surface view of any such
invaginations, and that the folds are directly continuous with, a quite similar to
the groove between the parolfactory or the appendages; so that I cannot hold this
either as a true solution.
Beneath these invaginations appears the pair of thickenings for the brain, which
are seen to be continuous across the middle line. On the inner surface of these lobes are
seen a few into-blast cells is shown.
The next figure, 20, passes through the middle of the brain, but is further forward than the last. See Plate III. The left side indicates the place of the section. The cells of the colobomatous area is pressed into those of the brain. Sections still farther forward, where the two lobes are still cut show the brain thickenings on each side is separated from each other. We see in surface views of embyros at this stage that the ventral ganglions have appeared is figure 21 is a section through two of these. The first pair. But only do we see that the ventral furrows greatly thickened in two places on each side the middle line but the internal cells of each mass show certain peculiarities. The are much elongated at right angles to the surface & their inner points come together at the middle point of the surface of the
ganglia. The left-hand ganglion in the figure is cut through the central portion of the ganglion on the right a little to one side. The nuclei lie in the inner parts of the cells of the outer parts of the cells are clear and transparent while their inner ends are more granular. This difference in the parts of the cells is very constant through the later stages. The cells form a structure which I have called the central dysans.

In figure 22 is a section of a pair of ventral ganglia from an embryo at stage III. Here there is in the middle of each ventral ganglion a wide incarceration lined by columnar cells with their clear outer portions turned towards the cavity of the incision. The nuclei in these cells are larger than those in other parts of the ganglion and are seen quite often in process...
of tectokinetic division. The spindles
of the dividing nuclei are in some
as right angles to the division of the cells
are either parallel to this axis.
A narrow connection of small mictoblasts
runs across the middle line from ganglion
to ganglion. The next figure, 23, is
from an embryo at about stage 2.
The inner edges of the incisumation have
turned in until they have nearly met
abobe the cavity of the incisumation.
In other respects the section is similar to the
last. At the next stage, shown by figure
24, the arched over is completed s
fusion has taken place so that there is a
cavity in each ganglion. Each cavity
does not run through the whole length of each
ganglion but lies only in its middle portion.
There is no communication between the cavities.
of different ganglia. In this figure each ganglion has increased in size and the cells have become more numerous so that the neighboring ganglia are connected by a cross commissure of fibres. Further the nuclei of the outer cells (those lining the cavity) are now more like the nuclei of the ganglion cells. Later stages show that the central cavity of each ganglion disappears although they seem to persist for quite a long after they have been enclosed by the ganglia. That this structure may have functioned as an organ in some ancestral form, I believe possible first because they are distinctly marked differentiated before any imagination takes place, secondly because their cells are histologically distinct from the surrounding cells but still from the cells of the ganglion beneath. So lasting from
The arrangement of the cells which suggest a sense organ comparable to the simple aciculata organs of many animals. It also seems probable that we have exactly similar structures in the Pauco-po-do-carva of the other Pycnogonida. Returning to stage III we have a cross section of the body drawn in figure 25. The section passes through the middle of the body in the plane of a pair of walking legs. The large mass of yolk is still seen filling the upper part of the embryo. Over the central surface of the yolk, the endoblast cells form a continuous covering and are indicated by N in the figure. At the base of the appendage the endoblast sends out a prolongation which is filled with yolk while the endoblast cells are here thinner.
more closely packed than elsewhere.
Into each of the six somite tips is a similar protrusion of ectoblast from the mid-sut. Beyond these denticula there is in each dig a definitely marked cavity in the mesoblast. In figure 25 the surrounding mesoblast is shown by M.
As the protrusions of the mid-sut push into the legs, these cavities cannot be made out so have either become lost or are too complicated to follow out.
Besides these cavities which would seem to be body cavities we should come to others later in development which seem to be pleurocysts. The surrounding mesoderm of these is irregular and quite different from that around the body-cavity proper.
The ectoderm over the appendages is thinner than elsewhere. The neural ganglia at
This stage has in most cases the ventral organs although in this figure none are shown. The brain has closed in the early stages. The part of the dorsal surface is quite thin of the mesoblast has not appeared in that part of the area yet. Figure 26 is a drawing of a cross section through the head of an embryo at a stage a little later than 19 but not 20 days old. The section passes through the brain above and the second pair of ganglia below. Between the brain and the neural ganglia the alemadaenum is seen. The alemadaenum is seen to be triangular in outline with its base turned upwards.

On each side of the alemadaenum appear cross sections of the first pair of post-mandibular. A single row of entobranchial
cells surrounds the central mass of yolk. Scattered mesoblast cells are found around + between these different structures leaving here and there openings between the cells. Such stigmata are shown by SS in the figure.

Going to stage V we find that sections give little more than was seen in the proceeding figures. The proliferations of the mid-foot into the legs have grown longer as seen from surface views the first second pairs of ganglia have formed.

In stage VI the yolk-mass continues to fill the central or upper part of the embryo, but at now begins to decrease in quantity. This may be due in part to the fact that part of it becomes absorbed and built up into the tissues of the embryo and in part to its extension into the legs.
A cross section of an embryo at a stage a little older than 12, or in a plane of a pair of limbs, is shown in Figure 27. The ventral ganglia have increased enormously in size and have now a large amount of ground-substance.

In the middle of the section lies the mid-gut with its contained yolk which has decreased very much as compared with preceding stages.

Figure 28 is drawn a section of another embryo, and at about the same stage as the last, but cuts the embryo between a pair of legs. Above the large ganglion is near the digestive tract which is completely separated from the body wall by a series of oblong coeels. The uppermost of these, lying in the middle line is the heart.
At the sides of the mid gut opposite the well marked cavities of a third between the mesentery and the outer wall. Also below there are two or more spaces but these called perhaps none of the others are artefacts. The mesentery is covered on its outer side by a distinct layer of mesoblast cells. Cross section of some of the legs, lying below the body, are also shown in the figure.

Between stage VII and stage VIII there is a considerable gap. During this period the embryo has lengthened so the fourth pair of walking legs has appeared. The rudimentary abdomen has been pushed up dorso-laterally so the procloacum invaginated until at stage VII it has opened into the mesentery.
The eyes are now seen but at stage VI they are seen in sections as from the openings of the epibranchial above the brain. In stage VII - VIII we find by sections that the yolk has almost completely disappeared from the digestive tract. Cross sections also show the large nerve ganglia, the mid-gut with its diverticula, on the dorsal part of the mid-gut. The tubular heart, running from the first walking leg to the third.

Figure 16 is from a cross section through the posterior part of the embryo and one of the mid-gut at its juncture with the foregut. Below the digestive tract D is a pair of small ganglia, V7, which are the ganglia of the rudimentary abdomen. On account of the shifting of the abdomen to the dorsal side, these ganglia
have been carried above the first central ganglia, which are shown at V 6.

But this is not all; for this eighth pair of ganglia has itself been affected by the shifting of the abdomen in turn lying above or back of the fifth pair of ganglia. In the eighth pair of ganglia, as shown in the figure, we have evident traces of the central organs. In the upper part of the section on each side of the middle line are the diverticula of the fourth pair of walking legs. A few scattered mesoderm cells appear in the cavity of the body.

The embryo should leave the male at about this time for I have never found older embryos attached only exceptionally ones as old as these last figured
Comparisons. Comparing the embryology of the two types represented by Phorocleidium and Palene we find that most of the changes of the latter may be considered by considering it an abbreviation of the type represented by Phorocleidium.

An exact comparison of the segmentation of the two forms would be of interest but in order that such a comparison should be of value the exact orientation of the segmentation plane would be essential. Such observations are wanting.

It would seem a priori most probable that the first planes in each must correspond so that the unequal segmentation of the egg of Palene has been caused by the greater accumulation of yolk in that part of the egg which corresponds to the mesomeres. It is also probable the smaller segments
The micromeres—correspond either to the anterior or to the central part of the embryo. Which of these is correct it is difficult to say. The embryo differentiates earlier in what corresponds to the anterior region of the adult than over the whole central surface, which suggests that the smaller cells may have adapted themselves to this early differentiation; but it seems equally possible that this may be due to phylogenetic laws in this particular case rather than to any mechanical connection with the micromere differentiation. So that for the present the question must remain unsettled until by actual experiment (which would not be difficult) the orientation of the segmentation planes be determined.

There is an observation on the segmentation of the egg of Patella depressastra by Hook, which,
was mentioned in the previous description of segmentaria of Palleurus empuca.

He says "Le fractionnement commence par le fractionnement du noyau, et seulement après que quatorze noyaux sont formés, un premier fractionnement dévient l'œuf en une partie plus grand et une autre beaucoup plus petite. Chaque partie contient deux noyaux qui dans le plus petit segment sont plus rapprochés d'une de l'autre que dans l'autre segment."

I cannot believe this accurate observation in the light of what I have observed over and over again in Palleurus empuca.

There is a stage which corresponds exactly with the description but the egg itself has previously divided into two with a single nucleus in each segment subsequently.
each of these nuclei divides into two just before the segment itself divides. So at the same time the first furrow becomes more distinct again as the segments round off to form the second furrow. This seems to be the stage which Hyatt has described as the first segmentation.

But does it seem probable that the differences of our observations are due to their having been made on different species for in each case the egg is approximately the same size.

The changes which take place in the formation of the endoderm of Pallea may also I believe be referred to the simpler changes of Plakochitodinum or and perhaps in this respect an excellent basis for further comparison with other forms having much yolk present. In Plakochitodinum the
pyramidal segments and de into an inner
and inner cell while in Pallene
The nuclei alone divide although
delamination is still multipolar it is
not syncytial as over the egg.
A further comparison of the mesoderm I
can make is give owing to lack of
complete observations of the changes of
Phorochitnia. In both types the
anophysis enveragates with a triangular
limen as in each the proctodaeum
forms quite late in development.
The few observations I have made on the
ventral organs of Tassythum leave no
doubt that it is the same structure as
in Pallene. Prof. Sedgewick has
described in Peripatus paired ventral organs
correspond in number of position with the
pairs of ventral ganglia.
Comparing figure 21 Plate 11 with his
figure for the ventral organs of the jaws
vol. 15. Pt. I. Plate 10. fig. 4.) a striking
similarity is seen in addition to the
same pores in less account of the ventral organs
but they are slightly unjaquard from
the surface.

Whether these structures are in any way
related it is impossible to say but it
deserves while to call attention to the
close similarity both in position and structure
between these organs in the two groups.
A comparison of the appendages of their
order of development is of interest.
Prof. Sclater has most carefully worked out
the transformations of the larval form to
through his skill we have a very thorough
knowledge of the transformation of the craneos.
According to his account the six-legged larvae of the Pyrgus wounds, with the Pariopod development passes into the adult condition by the body elongating behind the first pair of appendages. The walking legs appearing from before backwards in much the same way as Prof. Claus believes the typical mammalia to pass into the adult.

During the growth of the walking legs, the second pair of appendages of the Pariopod Larva has increased a little in size but the third pair loses its activity. The whole appendage becomes a simple prolongation of the coelom. At a later stage, when the Larva has increased in size this third pair grows out again to form the venigerous legs. In Pterygota we have seen that the first...
fifth sextal pair of appendages appear simultaneously in the embryo. The second comes in very much later. The third after the second. The second did not appear at all in the entogony so that in the young Palæna, the only appendages in the young embryo that correspond to those of the Pentopodæa are those of the first pair.

The development of Palæna has become so much abbreviated that there is only a trace of the true Pentopodæa found in its entogony.
Phylogeny.

There is a general agreement that the Pygopodidae are to be placed within the large group of Orthopoda, but after

this there is the greatest divergence of opinion as to which group of Orthopoda they are most nearly allied.

In general there are two prominent categories to which all or nearly all of

if these theories may be referred.

One set of workers believe in a Crustacean

relationship, a another set placed

the Pygopodidae among the Crustacea.

It is needless to give here the reasons

assigned for these opinions as Prof.

Dohrn has given in his monograph

of the Panthopoda of the Gulf of Naples

a most complete and exhaustive bibliography

of the literature.
The two most important views which we have at present are those of Dohrn or of Haeckel; but as the latter agrees with one so much that the former has given up in his more recent papers.

In an appendix to his papers in the Archives de Zoologie Experimentale Dr. Haeckel gives a summary of Dohrn's recent theory as to the Phylogenetic position of the Pygrosomids; he has at the same time contrasted his own views with Dohrn's so that a translation of a part of this section will best bring out the resemblances and differences of their opinions.
"For the Crustacea Dolfin repeats the Kspleins Theory (of Dietz, Beerler, & Claus) and adopts that of Hatches, who believes the Crustacea to have descended from parents which had the form of Phytopodods, just as these Phonopterods have in turn descended from Annelids. From these same Annelids, according to Dolfin, the Pygopods have come down. The number of their segments was originally more numerous than we now see them. The presence of a pair of rudimentary ganglia in connection with the last pair of ventral ganglia allows us to add an eighth pair of appendages, so together with the first all of these appendages were originally home types, .... The received doctrine from the intestine ...tach appendage enclosed within itself a reproductive organ
with a special general opening.

(The so-called accessory organs of the palpi or of the ovigerous legs are the rudimentary sexual organs of these appendages). The appendages were much shorter than we now see them, the heart showed many openings &c &c. The supposed ancestor that Dolium reconstructs might be very well compared to an Amelobor.

We also notice that Dolium persists in his opinion, published in his work of 1879, that the Pycnozooids have a parentage neither with the Arachnids nor with the Crustacea. (They have developed by the side of the last & altogether independently). In this I am in accordance with Dolium.

I was struck in the first place by the
very general presence in the Pycnogonids
of a characteristic larval form (the Protomys-
phon) in its presence suggested to me
the idea of their descent from an ancestor
resembling some sort of a larva which
took its place by the side of the hypothetical
ancestor of the Crustacea — the Sampsonia
or This by the side of a third (the ancestor
of the Annelids); so that all three groups
would have descended from a common
ancestor. I had tried to obtain in
this way an explanation of the affinities
of the three groups of animals (annelids,
Pycnogonids, Crustacea).
 Doctrine on the contrary took into account
the larval forms but constructed a
Phylogeny comparing to gather these
animals having a considerable number
of segments. It is true I did not wri...
To deny that such a method of looking at it have not just as good a basis of reason, only it appears to me at present that it can be defended just as little or certainly no better than the Cuvierian theory.

No one affirms that the intestinal diverticula which now in Phocichela, in Symposium pecto into the proboscis were originally [unbelievably] in the palps or vigorous legs. The homology of the glandular organs of appendages II or III with parts of the sexual organs is not based on any observation ---. But since I believe there are certain things which lesson, Dobson's arguments in favor of the Annelid theory, I believe that at bottom and the contents of pages 82-115 of his work confirms this opinion---
ideas of the author of mine upon the Phylogeny as well for Crustacea as for the Pycnogonida are not very different. At first I saw only the weak side of Dobson's theory that he does not give any explanation of the almost universal presence in the phylogeny of these animals of a characteristic larval form (the larval Protonymphon which for myself is a true primary larva in the sense of Balfour). So far I cannot adopt a theory which seems to arise a form of Arthropods with many segments from an Annelid with the same number of appendages; but such is not the opinion of Dobson as clearly expressed in the following paragraph.

Thus the larva of the greater part of the Pycnogonida may be regarded, with a grain of salt, as a form much like the ancestor.
"...and if on the other hand, the absence of...

an anal opening, the presence of the first pair of appendages, the long claws with their accessory spines, the structure of the proboscis with its triturating apparatus, its ganglia, the form of the cutaneous glands with their integumentary hairs can only be considered as having been acquired in a much later stage of transmitted to casual life where they are found at present; but what remains in the larva that we may regard as really as inherited from its original condition. Nothing but the nervous system is the brain of ganglia, an intestine, three pairs of appendages of a form modified according to circumstances or two eyes!

But there are attributes which are found equally in the larva of Ananas..."
with three segments! And of these we take
into consideration that at some time the body of the Pygrosomids, as we believe, showed a great conformity in the segments
(\& the generative organs from this) Thus on
the one hand there was a concentration
\& differentiation \& on the other hand a
reduction in number of segments. These
two conclusions lead us to admit a direct
descent of the Pygrosomids from
another annelid-forms which were
homonomously segmented.
Then the larva of the Pandalopods came
from a larval form with pandalopod-
characters added on, but at the same
time a larva which never had an
independent \& mature existence.

Whatever stock position may be with
respect to the Pandalopod-larva, the egg...
with Dobson in the most important part
of the latter's theory that the Pyxosomids
have come down from the Annelids
independently of the other groups of
Arthropods. In examining the precedent
account we may take it up,
for the sake of clearness in two parts,
the first pertaining to the ancestry of
the adults leaving the larval form out
of account and the second part where the
meaning of the larval form will be
considered.

I believe that if the account I have given
of the early stages of development be
even approximately correct, there is little
or no ground for a comparison between
Crustacea and Pyxosomids, certainly
not with any existing forms.
The multiplication determination of
endosperm in the Procaryotes has no
homologous amongst the Crustacea and in
there any special similarity in the
formation of the organs. There seems
to be no trace of specialization in the
subfamilies of the groups. And if we
have reason for rejecting a relation-
ship between the Panto and Crustace-
as the Lampides — and I believe with
Dohrn that we have — there remains
nothing in common to the subfamilies
of the two groups.

Nor are there any special affinities
between the Jurets or Sea-Spiders, but
there is one striking similarity between
the latter and Peripatus, which I have
already spoken of; but an isolated
fact of this kind gives little ground
for further comparison.
The central organs in the two groups present a striking agreement, but there is no proof forthcoming as to a real homology of the structures. The process of the formation of the endoderm described by Heider and by Wheeler in insects shows a certain resemblance to multipolar delamination, but it is much in a more complicated form than shown by the Pterygoplates. With these two exceptions there seems to be nothing else in common in the analogy.

We are then left to decide between an independent origin for the Pterygoplates or a relationship with the Aschelminthes. Prof. Dohrn has already maintained the first theory of the preceding translation since the conclusion he had reached.
Dr. Streeck Lehmann, as we have seen, holds this opinion, although not agreeing as to details with Mr. Dobson. On the other hand, a study of the early stages of the embryology has brought to light certain facts, which to me, point decidedly toward a community of descent between Acrididae and Pyrenospondia. The latter show undoubted traces of degeneration which we cannot derive them from any existing animals. But I believe the Pyrenospondia and the Acrididae have come down along the same line, or in other words have had ancestors in common long after these ancestors came from Annelide-like forefathers.

The reasons for such a belief are as follows:
101. The Pyrmarys form the endoderm
by a process of multicellular determination
which is shown in its simplest form
in *Physochilidium* or *Tamphylus* or
in a more modified condition in
*Pallene*. In no other group of the
Triploblastica do we find a similar
phenomenon except in the Annelids.

The description of the embryology
of *Chelifer* which Brachnikoff has
given avoids this process, or something
quite analogous, is taken place in it.

The segmentation is both blastic and
a later stage the large cells containing
yolk divide into an outer more
protoplasmic layer of cells or the
inner cells which are very granular.
The outer form the ectoblast and most
probably the inner, judging from his figures.
In the Spiders the process is not so well marked but if the conception which Bover had of the formation of the yolk-nuclei be true, there we may make a direct comparison between the two groups.

He says "It appears to me probable that at the time when the superficial layer of protoplasm is segregated off from the yolk, below the nuclei undergo division so that a nucleus with surrounding protoplasm is left with each yolk column.

This description for the Spiders may be substituted word for word for the process of delamination of Palaeon.

2nd. The first traces of the embryo to appear in Palaeon are a round opaque area at the spot where the
Stomodeum invaginale.

In Schimmelpfennig's recent account for the Spiders he shows that the primitive cæcum lies in the place where the stomodeum invaginale of the place. This is also true for Palsene but here the stomodeum invaginale quite early or perhaps simultaneously with the early formation of mesentery at this place. Further Schimmelpfennig has called attention to the fact that the stomodeum of Spiders in its earliest development is a triangular invagination to be compared directly with the triangular invagination of the resorptions of the Prolegominae.

3rd. The early formation of body cavity, surrounded by mesoblast in the legs of Spiders has an exact parallel in
Pallene or Anoplophantes. Yet however tempting such a comparison may be in this connection it must be admitted I have not conclusively proved this to be true for the Pycnosomiids but only exceedingly probable for them. In both Amblyuchenids & Pycnosomiids we have well marked diverticula from the mid-jug into the legs.

In the Pycnosomiids there go with the chelicerae & the four pairs of walking legs the same holds for the spiders but a comparison of the appendages of the two groups we must suppose that the third pair of Pycnosomiids appendages to have lost their diverticula or the last appendages either to have acquired or more probably inherited them together with the appendages.
In Chelifer, the diverticula appear very early in development, to contain some of the yolk from the mid-gut. This is shown very distinctly in Marcks' and Bover's figures for Chelifer. In this respect the embryos resemble already the embryos of Pycnogonida.

3. In both Anachnidida and Pycnogonida the first pair of appendages are chelate. This in itself would draw attention to the similarities of the two groups, but we learn further that in both groups this first pair of chelate appendages is innervated from the brain. These facts were considered by Balfour sufficiently important to indicate a relationship between the groups. He says, "The presence of chelate appendages..."
incorporated in the adult by the supra-oesophageal ganglia rather than by a common Pyloric for the Pycnogonida & Chelicerida. Though, as shown above, all the appendages in the embryos of true Chelicerae are innervated by post-oral ganglia."

I have not been able to find any post-oral ganglia for Palaeus but the first pairs of appendages arise on the sides of the stomodaeum & palp move forward. In this respect it compares closely with the Spider & the early innervation of this pair from the brain itself may be regarded as a more abbreviated condition than that was seen (by Balfour) in the spiders. Schmiklöffel's figures for Chelifer show the first pair of appendages is more
above or on each side of the proboscis-like upper lips.

If future work verifies Schuchert's suggestion that the proboscis (rösselformige, provisorische Oberlippe) is homologous (entirely or in part) to the proboscis of the Pycnoglossids—as his figure might indicate—then does the whole development of Chelifer show remarkably close resemblance to the Pycnoglossids.

6th. The fourth pair of ambulatory legs—the seventh pair of appendages has been a stumbling block in the way of those who have compared Pycnoglossid with Anomalurid. Sempier and Schinkewitsch have attempted to solve the difficulty by assuming that the third pair of appendages of the Pycnoglossids—the coxal and hypogastric appendages are new structures, other
have called the four pairs of walking lip homologues in the two groups. Prof. Dohrn has shown the impossibility of dropping out in the count, the various lip is been shown that this pair of appendages are homologous with the others.

The two pairs of Sense organs in the larval anterior ganglion we have been from unmistakably to the same conclusion, to give the final proof, if such were really necessary.

We are led then is a comparison of the appendages of the two groups beginning with the chelicerae going back pair for pair which leaves me pair over for the Pycnogonida. Any comparison between the two groups must take into account this extra pair of lips. Balfour has suggested that this last segment was
appendages to represent the first abdominal segment of the Arachnida.

The third pair of appendages of the Pycnozooids have assumed a special function so at this time we might suppose that an additional pair is have been added on from the abdominal segments, but also know that the embryos of Spiders have rudimentary appendages on the abdomen so we have assumed the Pycnozooids have come from the latter group most recently but remotely when these appendages may have been larger or even functional we have come found for a belief of such an origin of the first segment.

There is another fact which may be of importance in this connection but only is the recent "jumped" case...
does also sends by the abdomen but at the same time. The third pair of ganglia also is carried dorsally to above the fifth pair, from which the connecting nerves fibres fans upwards to the sixth. At the present time it is impossible to determine whether this is due to a mechanical adjustment between the shifted abdomen so the last pair of thoracic ganglia or whether the eighth pair, belonging properly to the abdomen, has been part in the general shifting of that structure.

* If we assume with Hatcher a common descent for all Arthropoda so that in the Dendroidea we have general of the anterior segments, about the mouth, suppressed, we might assume that the Spiders have lost a third pair of appendages of the Pauropods retained it as in this way bring into line the other appendages of the groups.
There are certain objections against this comparison which I have attempted to show do not directly oppose yet do not support the hypothesis.

First and most important is the uncertainty of brain invaginations in Pycnonotids. These seem to be present in all the Archontidae and easily seen in the development of the embryos. In the Pycnonotids I have not been able to find such invaginations. We have seen in figure 171 the groove might possibly have caused an interpretation but even if this were true we would expect to find a much more pronounced involution but this does not seem to be the case.

Again the vertebral organs which have been compared with those of Peripatus tend no support to the hypothesis.
It is possible that the Pycnozoids have come from the Arachnids at a time when these latter have had such organs in common with the ancestors of the insects so that they have been fully retained in the Pycnozoids.

Lastly the openings of the reproductive organs. Typically the ovaries & testes of the Sea-Spiders are a pair of organs united posteriorly by a cross commissure. They extend into the walking legs so open on the second joint of these. There are many exceptions to this and they are regarded as secondary.

The openings on the legs have no homologue in the Arachnids nor does it furnish any ground for comparison with other Arthropods. But if we assume the groups to have come directly from this.
Concludes we have no better ground here for a comparison. We are 
prized in need of observations on the development of the actual 
openings, until we get our the question must remain 
an open one.

It seems not improbable however, 
that the openings may be secondary, 
so connected in some way with the secondary 
presence of reproductive organs in the appendages.

I hope to have shown, that these three objections are of negligible value, at 
any rate so long as the present uncertainty 
by surrounds them, so that we have 
sufficient grounds for a comparison 
in the early stages of development, in 
some of the important adult structures of the two groups.
The Panulipod-Larva.

There is a general resemblance between the Dampfies of the Caudaca or the Larva of the Pycnognoids, but the differences become greater as greater the more closely we examine the two forms. In each the body contains three pairs of appendages but these in the Dampfie show bivalvoous structures while none of the Panulipod-Larval appendages show such structures. Moreover the first pair of appendages of the Panulipod-Larva is oblate or increscuit from the brain. Other characteristics of the Larva are the well marked processes with its triangular reopharynx. The mid-posterior and postpharynx into some of the appendages or the absence of any anal opening.
Have we then any basis for the assumption that this Pauleopod-larva is a modified Trochosphere of the Annelid ancestors? The problem is very similar to that of a supposed relationship between the Lampsilis and the Trochosphere, or in both cases an answer exceeding difficult to give. Prof. Dooran believes that the Pauleo-post-larva is to be regarded as a Trochosphere with the Pycnozoid characteristics reflected onto it. Prof. Lang believes in a similar process for the Lampsilis. Without discussing the latter let us confine our attention to the possibilities of the Pauleopod-larva. What characters have been reflected on Dooran's theory or what remains after these are removed? Prof. Dooran
has given us the answer.

"... the absence of an anal opening, the presence of the first pair of appendages, the long claws with the accessory spine, the structure of the proboscis with its dilating apparatus or its gullets, the form of the tegumentary glands and their characteristic hairs, can only be considered as having been acquired in a much later stage, and transmitted to larval life."

That is to say that almost every characteristic of the larva has been handed back from the adult! And what remains?

"Nothing but the nervous system -- an intestine, three pairs of appendages, two eyes." "But there are the attributes which one finds equally in the larva of Annelids!"
which has been left out of account, viz.
the presence of an arm in the
Trockosphore. How can we account
for its absence on the above hypothesis
when we know the Pantopod-larva
to be a free swimming larval form.
And unless some special reason for
such a loss can be imagined, the
very basis of the comparison between
Pantopod-larva + Trochosphere is gone!
What we have done in the above process
of subtraction is to have removed
the most striking structures of the adult
from the larva, to have left—not a
Trockosphore but only the framework
of the Pycnosomid.
For two main reasons I am unable to
believe in the Phylogeny given by
Dohrn or by Huxley. First because—
it seems to me there are facts derived from the early stages of development which point unmistakably to a relationship between Pycnogonida and Arachnida.

And in the second place I cannot believe any actual homology to exist between the Panius podarca and the Prochopoda, nor any fair reason to assume that the characteristics of the Pycnogonida have been reflected onto a Prochopoda.

If then we start with the assumption that there is a relationship between the Sea-Spiders and Arachnida we may examine into the meaning of the casual form as a corollary to such a position. I have stated that the Pycnogonida are degenerate and probably not derivable from
any existing group. If so how far down in the ancestral tree of the Arachnids have they arisen. The very great differences in the adult structure of the groups indicates an very recent origin and possibly they came in at a time when the Arachnids had the first pair of appendages chelate if these were innervated from the cephalo-pharyngeal ganglia; this cobra from the dorsal ganglia. After the divergence of the Pycnozooids as a group from the general Physiota of the Arachnids the Pantopod-Lava may have developed.

The Pycnozooids have adapted themselves to a very special habitat, so that there must be very great advantages for distribution & intercrossing in a free-
parasitic independent larval form.
And in general what we may suppose to have happened was a decrease in the size of an increase in the number of 1900, with the resulting early development of the free larva that we find to-day. This larva represents the more anterior segments of the adult 3 or 4 or part containing the proboscis, the mouth, the eyes, the anal, and two post-maxillary appendages. Behind this is an undeveloped part which slowly grows in length as the animal increases in size.
The arms belong to the last segment and does not appear until that segment is wholly or in part developed.
If the Ophiouchidae have come from Annelid ancestors with many segments we have a clue to the slight resemblance between the Panarthrod
The Trochoidea. The former represents the most anterior segments of the adult Sea-Spiders, and therefore to some extent the anterior segments of the Annelids or of the Trochoidea. But at no time in the ancestry of the Pycnogonids have Trochoidea or Panacondoan larvae characteristics existed separately as Dobson believes.

Such seems to me the more probable view of the meaning of the Panacondoan larvae. This belief has grown out of my work on the embryology of the group. Whether future work supports or disproves such an hypothesis it is hoped it may be useful if only as furnishing another point of view for looking at the Phylogeny of the Pycnogonids, or may lead to a more complete study of the embryology of the group.
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(For plates)

B = Brain.
D = mid-gut, mesentery.
D', D'', D''', etc. = diverticula of mid-gut.
E = Ectoblast.
N = Entoblast.
M = Mesoblast.
P = Periphery of Blastoderm.
S = Schizo-coelae.
V' = Ventral Ganglia 1-7
H = Heart.
L = Legs.
O = Opening Ventral Organs.
C = Central cavity of Segmenting Egg.
Description of Plates.

Plate 1

Fig 1. Section of segmented egg o membranes of Paclea ampla.

Fig 2. Section of another egg of Paclea at same stage as show central cavity.

Fig 3. Section through upper pole of egg of Paclea. First formation of Blastoderm.

Fig 4. Section through upper pole of egg of Paclea. Later stage than last. Inner cells - Emb blast - are present.

Fig 5. Section through egg of Paclea. Later stage than last. Cap of cells - Blastoderm - covers more of egg than in last.

Fig 6. Section through periphery of Blastoderm. A & B of figure 5.
Plate 1. (continued)

Fig. 7. Section in same region as last.

Fig. 8. Section of segmenting egg of Tanyostrium orbiculare to show pyramidal blastodisc cells.

Fig. 9. Section of egg of Tanyostrium orbiculare to show process of multipolar delamination.

Fig. 10. Same, with delaminated blastoderm.

Fig. 11. Section of segmenting egg of Pleurochiridium maxillare.

Fig. 12. Same, to show degeneration of endoderm.

Fig. 13. Cross-section of the Pauliopod-blenn of Tanyostrium orbiculare.

Fig. 14. Circumoral pharyngeal ring of same.

Fig. 15. Eyes of same.

Fig. 16. Neural organs of same.

Early stage of third pair of ganglia.
Plate II

Section of Palaearcan embryo.

Fig. 17. Longitudinal section through stomodeum of young embryo. First origin of preoral at M.

Fig. 18. Cross-section through stomodeum of older stage. See.sec. 18. Fig. 1. Plate IV.

Fig. 19. Section anterior to last.

See sec. 19. Fig. 1. Plate IV.

Fig. 20. Section anterior to figure 19.

See sec. 20. Fig. 1. Plate IV.

Fig. 21. Cross section of cerebral organs.

See sec. 21. Fig. 1. Plate IV.

Fig. 22. Cross section of cerebral organs at stage III.

Fig. 23. Cross section of cerebral organs at stage V.

Fig. 24. Cross section of cerebral organs at stage VI.
Plate II (continued)

Fig. 25. Cross-section of embryo at Stage III

Fig. 26. Cross-section through brain and pair ventral ganglia of Stage III

Fig. 27. Cross-section of embryo in the plane of a pair of legs. About Stage VII.

Fig. 28. Cross-section of embryo in the plane between a pair of walking legs. About Stage VII.

Fig. 28. Cross-section through the rudimentary abdomen and body of an embryo.
Plate III.

A - J. Pallear ensipusa.
   a - c. Phoebichilidium maxillare.
   d - j. Panythylum orbicularis.

Fig A. Segmenting egg, side view,
   2-celled stage.

Fig B. "       " seen from above,
   4-celled stage.

Fig C. "       " seen from above,
   8-celled stage.

Fig D. "       " seen from below
   8-celled stage.

Fig E. "       " side view
   16-celled stage.

Fig F "       " surface view of
   microwrites; 16-celled stage.

Fig G "       " side view
   16 macrowrites, 8 microwrites.
Plate III (continued)

Fig. H. Segregating egg, side view.
  24 micromeres
  16 micromeres

Fig. J. Segregated egg, Lower Pole
  Base of pyramidal cells
  ohm at surface.

Fig. a. Physcidium 2-celled stage
Fig. b. " 4- " "
Fig. c. " 8 " "

Fig. d. "Vacuatum orbiculare 2-celled stage
Fig. e. " 4- " "
Fig. f. " 32(?) " "
Plate IV

I - III Pallaee

IX Vam paliium.

Fig. I. Surface view of young embryo, to show anterior region.

Fig. II Surface view of neural region of same.

Fig. III Vertical view of embryo with four pairs neural ganglia: first 2 sections separated.

Fig. IV Dorsal view of embryo about same age (a little older perhaps) as last.

Fig. V Vertical view of embryo. First 2 sections neural ganglia have fused.

Fig. VI Side view of embryo showing rudimentary abdomen behind as a continuation of the body on same plane as the body.
Plate IV (continued)

Fig VII Vertical view of embryo at the age when it leaves the parent. Fourth pair of walking legs are seen behind. Third pair of appendages beginning just in front of first pair of walking legs.

Fig VIII Dorsal view of larva showing hair and four eye spots. In both VII & VIII only the proximal ends of the legs are shown.

Fig IX The Panto pod larva (Protomonophris of Holk) of Tanytyrum orbiculare.
Life.

Thomas Hunt Morgan was born Sept. 20th, 1866. Preliminary education received in Public & Private Schools in Maryland. In '80 entered the Preparatory School of the State College of Kentucky; in the Autumn '82 entered the College & graduated in the Spring of '86. Entered Johns Hopkins University in the Autumn of '86. The Summer of '86 was spent at the Boston Marine Laboratory at Annisquam, Mass.; the Summer of '87 at the Harvard School of Botany; of '88 at Beaufort, N. C., & at the U. S. Fish Commission Laboratory at Woods Hole, Mass.; of '89 again at the last place.

The subjects offered for the degree of Doctor of Philosophy were Animal Morphology, Animal Physiology, Histology, Morphological Botany.