THE EISENHOWER LIBRARY

3 1151 02721 4091

54 357

Library

Johns Hopkins University

The
Larva of *Asterias vulgaris*.

A dissertation submitted
to the Board of University
Studies of the Johns Hopkins
University for the degree of
Doctor of Philosophy.

By
George Wilton Field,
of Brockton, Mass.

Baltimore,
1892.

54357

When the egg is laid it is
in the form of a completely yellowish white
egg, which has a diameter of 1.5 mm.
The egg is oval, flattened at the ends, the
shorter end being pointed and the longer
end being rounded. The egg is covered with
a thin, white, granular coat, which is
the chorion. The egg is attached to the
uterine wall by a short, white, thread-like
stalk, which is the yolk stalk.

The development of the embryo
begins after the cleavage of the egg. It
is divided into 4 stages. The first stage is
the cleavage of the egg into 4 cells. The
second stage is the cleavage of the 4 cells
into 8 cells. The third stage is the
cleavage of the 8 cells into 16 cells. The
fourth stage is the cleavage of the 16 cells
into 32 cells. The embryo is now ready
to be implanted in the uterine wall.

Development of the embryo.

which process extends in the 2nd or 3rd week
about: soon on the outside of the
embryo the blastomeres become
flattened and more extensively cover
the surface of the yolk. Then follow
the first traces of mesodermic forma-
tion. In the region of the inner columnar
cells, the future entoderm forms
then some cells sink into the flg-
mentation cavity and become
mesodermic cells. Usually the entire cell
sinks into the cavity, but, re-
peatedly there is a transverse division
and only the inner half becomes in-
tegrated. (Fig. 6.) The inner half of the portion
of the plate becomes flattened and is
primarily mesodermic. During the pro-
gress of the invagination, the outer
columnar cells in position with the

the most effective method of securing
the full representation of the people
of the United States in Congress
is to have a direct election of
members of the House of Representatives
by the people of each State.
The

present method of electing members
of the House of Representatives is
based on the representation of equal
numbers of electors by each State
and is a method of electing
members of the House of Representatives
which is based on the principle of
equal representation of each State
in the House of Representatives.
The present method of electing
members of the House of Representatives
is based on the principle of equal
representation of each State in the
House of Representatives.

as if the whole organism had been a
ladder of the kind of which it is composed
by so much individual variation.

After the
formation of the water tube the lateral
muscles gradually increase in size and number
until the body is composed of the same
muscles. The body is covered with rows of
flattened mesenchymatous cells, the
band not approaching the middle, these form
the skeleton with the exception of the median
ridge cells which form the coelenteron
network within the segmentation circle,
which is support for the water tube.

Formation of the water-tubes and branches.

After the completion of the body of the
tentacles in the formation of the water-tubes in

the ground the vegetation is the forest of
the interior. Growing upon these
cliffs are the same great trees as
found in the interior at the same
elevation. Fig. 9 is one of the
great trees of the forest, at the same height
the vegetation of the same water flowing down it
the same small plants. In the
lower part of the river the forest of
water trees of the same kind, w.c. 1000 feet
to 1000 feet. The vegetation is
all similar to the forest of the
interior.

The

The river is a little wider than
the vegetation of the interior. The
vegetation is the same as the
interior, but the trees are
not so tall as in the interior. There
is a little more vegetation in the
interior.

very minute forms were isolated from
these submerged examinations of the
the same type was found to have been
which in the intermediate the presence
observed. But these facts have well
of forming of sets of small, but
more considerable of a similar size
in the surface collections with the habit-
ually symmetrical water holes as a rule
taken; in the specimens the water here on
the right side was found to be abundant
though the hole above still remained
and the exceedingly small of water here
was with two water holes, hence the effect
for the stage is a definite one in
the nature, and as a paleontological
condition in the water to be
seen in the most recent manner.

Formation pale Related Bands.

Circumoral band 3. In the time of the completion of the permeation until the formation of the larval digestive tract, all the cells of the surface, of the oesophagus and intestine are ciliated. These cilia serve for locomotion and for propelling water through the digestive tract. But very early this condition of general ciliation gives way to the restricting of the cilia to definite band-like areas. Often even before the completion of the oesophagus the ectodermal walls of the ventral surface become flattened and lose their cilia. There are left however two narrow transversely extending ciliated areas projecting slightly above the surface, one upon the bulging portion of the body anterior to the mouth, the other posterior, between the mouth

and some (fig 13. c.v.b.) to the area where
the cilia have disappeared extends dorsally
by where the bands intersect, the postoral
one being of greater length. The original
body cilia disappear last at the apex
of the preoral lobe. Fig 11. shows a stage
where the ends of the two parts of the cil-
iated bands pass into the remnant
of the original general ciliation. Later
by the further disappearance of the orig-
inal cilia the two ends of the preoral
portion unite with the corresponding
ends of the postoral portion, thus form-
ing a single continuous bilaterally
symmetrical ciliated band, by Se-
mon named the circumoral band.
The course of this band is shown in
figs. 12 and 14. c.v.b. Whether the legs of
the band touch, fuse or remain sepa-

rated at the apex of the preoral lobe is somewhat difficult to determine. Known in *Asterias rubens* finds that they touch; in *Asterias vulgaris* I am inclined to believe that they are separated. (figs. 23 and 25.)

At the apex of the preoral lobe the ectoderm cells are elongated over a small area. The outer part of the cell is clearer with fine granules while at the bases of the cells are what appear to be the cut ends of fibres suggesting nerve fibres. This may possibly be regarded as a very simple apical plate. It is the same as that referred to above in case of the gastrula. (fig 9.) The direction of locomotion has been reversed. At first the blastopore was directed forwards; now the blastopore has become

the larval anus ~~is~~ is near the posterior end. The reversal of direction in locomotion takes place at the time of the formation of the mouth.

Adoral band. At first the entire surface of the larval oesophagus is ciliated. The first trace of this ciliated band immediately surrounding the mouth and sending a loop into the oesophagus, called by Jensen the adoral band, is a thickened circular rim of ectoderm closely surrounding the mouth opening. (fig 12. a. v. b.) Later with the formation of the depression of the body wall around the mouth, the circumference of this ring increases and it seems to surround the rim of the oral depression. (fig 17. a. v. b.) It is to be noticed that up to this time there is

no connection whatever between the circumoral and the adoral ciliated band.
But later the transverse gincoral portion of the circumoral band becomes pushed toward the hinder end of the larva, and thus to crawl over the oral depression, and almost cover the mouth. (fig. 24) In this way the anterior part of the adoral band comes to touch and fuse with the posterior transverse gincoral portion of the circumoral band. Thus the connection between these two bands is secondary and not primary as was ^{at first} supposed by Semper in his earlier work (36) but corrected in his recent paper. (38)

The cilia of the oesophagus are present in the same way as in the circumoral band.

Further History of the Enterprise

General Considerations:-

The biological importance of the distribution of the various parts of the skeleton is first into two the symmetrically opposite halves: (1) the lateral parts being taken together and regarded as (2) the cranial and (3) the vertebral axis.

The arguments in regard to the former are chiefly based upon the accounts for the position of the brain case for the two sides of the brain, the all forces in such a symmetrical system and for the purpose of affecting the formation, when view successively through years and the influence of the system of the two sides, the whole system of symmetrical composition does not seem to be well grounded. Even when the occurrence of the cranial axis is

stained with iodine. Some of the specimens
plotted to show the relation with the other
and it was the only one of the group for
which a good specimen was found in the same place.

211

In order to believe that in the life history
a form has been secondarily intro-
duced for the purpose of increasing
the distribution through a new
portion of the form, we must believe
there is no doubt that many other
the whole form was a secondary introduction
but there is no doubt
that the form was introduced with the new
form. The introduction is accidental; while
clearly, total, and may be a good
one. The introduction of the whole form
is a central condition for the
form. The form is a good form.

is found in the same way in the same
which is known as the "Berg" theory
there must be a connection between the
force to which it is due in the
case the moving function through
the whole this may be observed in
other functions, and the same is
not only a part of the whole but
in fact is many ways to be compared
able to the repetition of similar
to be repeated in the whole.

The whole
is known as a form which has de-
veloped along the phylogenetic line and
is not original in many ways of form
which are not only of the whole but
in several ways a well different-
the function of the whole, and having been
repeated in the whole, the whole is

long, and with a little for the first time
to their own use, a considerable amount
of movement, in a horizontal direction
there, and the formation of long arms for
extension, by means of a series of
successive locomotor movements. The great
length of the arms has probably been
acquired since the time when the first
arms were a means to an end, and not
to an end in themselves, namely, the
metamorphosis did not begin until
after the limbs had become fixed to some
axis, and subsequently in acquiring
the power of movement, which
was not long before fixation. The
long arm like locomotion of the same
kind, the whole contained therein the
necessity for movement, because of loc-
omotion in accordance with the needs of the

would not be significant in itself
if it were in the latter form the
products.

By comparing the chromosomes of spermatocytes, with those of the maturation of the ovum, we are justified in doing since the ovum before maturation is homologous with the sperm mother cell, we find that the first division of the sperm mother cell is comparable to that which in the ovum gives rise to the first polar body: the products of this division are homologous. The second division of the sperm mother cell is comparable to that which gives rise to the second polar body; and finally we have the spermatozoa,

the definition given and the second polar body as strictly homologous parts. That the first polar body is homologous to two spermatozoa is evidenced by the fact that in many cases it divides into two parts after extrusion. Originally these divisions of the egg probably gave rise to parts of equal size, but the advantage of increased food yolk may have led to its unequal distribution, and hence the increased size of one part: the same may possibly be true of the cytoplasm so that now the polar bodies rendered comparatively insignificant, thinner than the loss of food yolk and some of their cytoplasm appear to be extruded from the main cell.

Thus the polar bodies are to be regarded as rudimentary oocytes and hence morphologically equivalent to the ovum as shown by Bütschli.

From the fact that in spermatogenesis it is seen that no part is without the possibility of fusion with a complementary part, that no parts are lost as in the case of the polar bodies, we may regard the phenomena of maturation, not as a necessary process in the formation of both male and female sexual elements, but as a condition peculiar to the egg. The uncertainty of view in the origin of the female reproductive elements of plants may give a little further

support to this belief.

Since the entire sperm mother cell is contained in the four spermatzoa, each spermatogon must consist of cytoplasm and nucleus or a typical cell modified into a form favorable for its function. and since the ovum when ready for fertilization is also a typical cell, modified by the retention of a part of the cytoplasm of the sister cells, and by the addition of more or less food yolk, we find fertilization indefinitely shown to be the fusion of two morphologically equal cells. The stumbling block of previous theoretical conceptions of the phenomena of fertilization has been the condition found in Parthen-

oogenic eggs. The views here plotted seem to bear the test. The diagram shows the homologous stages in the maturation of the parthenogenetic and of the normal ovum, and in the process of spermatogenesis.

Thus if we grant
that the polar bodies, the defini-
tive ova, and the spermatozoa
are homologous cells modified
for certain definite functions,
we are led to the conclusion found
in the conjugation of the Protozoa,
the true ancestral mode of sexual
reproduction, the fusion of two
conal and similar cells, on this
basis the facts of spermatogenesis
viewed in the light of its origin
as a degeneration from the nor-
mal condition, are rendered in-
telligible, whether the relations
be considered as quantitative or
as qualitative, and on this sim-
ple morphological basis physio-
logical theories can be founded.

Dr. Hertwig has called attention to the fact that this mode of spermatogenesis is a mortal blow to Dr. Minot's theory of the hermaphroditism of cells, since observation goes to show that all of the sperm mother cell goes to form the spermatozoa, and that the "Zwischenkörper" of Van Beneden are not homologous to polar bodies.

Further, it seems as if the process of spermatogenesis here described for the Starfish is of too general occurrence to be a mere coincidence, and is found in too many widely separated groups, living under too varied conditions to be the result of secondary adaptation.

It is rather to be regarded as a simple primitive type from which the numerous other types have been derived; the variations being conditioned by a greater or less number of divisions of the parent mother cell, resulting in a greater or less number of spermatozoa, as the conditions of life demanded.

Vita.

George Wilton Field, born in North
Bristol, New Brunswick, Nova
Scotia. 2 September 1863.

Education: ~~was~~ ~~as~~ ~~follows:~~ ~~under~~ ~~his~~ ~~instruction~~
until 11 years of age: then entered
the city schools, graduating from
the grammar school in 1878, and
the High School in 1882.

1883 was spent
in geological work in New Brun-
swick and Nova Scotia.

Graduated from
Brown University in 1887 with
degree of A.B.

The summer of 1885 was
taken up by a geological trip
about the Gulf of St. Lawrence.

During the academic year of 1887-88
was a graduate student in Biology,
and assistant in the zoological lab-
oratory at Brown University; from Jan-
uary 1 to June 15 was spent in com-
pany with Prof J.W.P. Jenks of Brown
and Prof C.H. Hitchcock of Dartmouth
in zoological field work in South-
ern Florida.

Entered ~~the~~ ~~University~~ in October 1888 as a grad-
uate student.

The summer of '89 was
spent in work at the Marine lab-
oratory at Woods Hole Mass.

The last four academic
years have been passed at
Brown University.

In June 1890 received an

degree of M. A. from Brown.

From June
to September 1888 worked at the U. S. Fish
Commission laboratory at Woods Hole,
and during the summer of 1889 was
a member of the Chesapeake Biological
Laboratory at Pocomoke.

During the summer
of 1890 gave some assistance in the
Biological Laboratory of the University.

Note.

The original drawings which will accompany this paper have been sent for distance for publication, and are at present inaccessible. These rough diagrams have been prepared merely to make more intelligible the principal facts in the development of the larva. They have been numbered, so far as possible to correspond with the original references. Such references as are underlined in bold pencil refer to these diagrams; those not so underlined refer to the original figures.

Fig. 6.

Fig. 9

Fig. 10

Fig. 16.

Fig. 11.

Fig. 12

Fig. 17

Fig. 23

Fig. 14.

Fig. 13.

Fig. 25

Fig. 26

Fig. 18.

- = ectoderm
- = mesenchyme
- = endoderm
- = enterocoels
- = ciliated areas

- a = anterior
- p = pericardial ventral area
- d = dorsal
- v = ventral

- p.v.a. = pericardial ventral area
- sv. = schyocoele vesicle
- mt. = water tube

- bl = blastopore
- aob = adoral ciliated band
- c.o.b. = circumoral ciliated band
- el = enterocoel
- m = mesoderm
- mm = mesenchymal muscle fibers

Fig 29

Fig 30

Fig 40

Fig 32

Fig 34

Fig 31

- Fig 6. Mesenchyme formation in the blastula.
- " 9. Gastrula stage
- " 10. Formation of enterocoels
- " 16. Enterocoels separate from archenteron.
- " 11. Formation of digestive tract
- " 12. " " circumoral ciliated band.
- " 14. Larva, 3 days old, seen from the right side. (The Auricularia stage of the Bipinnaria).
- " 23. Same, seen from dorsal side.
- " 17. Young larva seen from ventral side
- " 13. Larva, a little younger than fig 17. seen from ventral side.
- " 18. Formation of water pore and pore canal.
- " 25. Anterior end of larva about 6 days old
- " 26. Same, a little later.
- " 29. Larva about 8 days old, seen from right side.
- " 30. " " 14 " " , seen from ventral surface.
- " 40. " " 21 " " seen from left side.
- " 32. Anterior tips of enterocoels. (Compare fig. 30)
- " 34 } Two stages in the formation of the schizocoel vesicle which prob-
- " 31 } forms the so-called "beard"