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Topic: Development of Amphioxus

Development of Amphioxus (Branchiostoma)

Amphioxus embryogenesis was first described by Kowalevsky (1867), who divided it into an early phase of development resembling that of invertebrate deuterosomes (a hollow blastula invaginates to form a gastrula in a similar manner to the sea urchin) and a later phase that is vertebrate.

Development of Amphioxus (Branchiostoma) is indirect involving a larval stage. Early embryology of Amphioxus is simple. Therefore, the transformation of egg, which having less yolk, into a complex and differentiated animal is far easier to follow than in any other vertebrate.

Gametes:

Spermatoza

Spermatozoon of Amphioxus has a typical structure of flagellate spermatozoon, i.e., it contains a spherical head, a very short middle piece and a long tail.

Ova:

The unfertilised ovum or secondary oocyte of Amphioxus is 0.10 mm to 0.12 mm in diameter. It is microlecithal and isolecithal.

Fertilization:

Fertilization is external, taking place in the surrounding sea water where eggs and spermatozoa are shed.

Before fertilization, the ovum has an outer thin vitelline membrane, enclosing a peripheral cytoplasmic layer, central yolk cytoplasm mainly towards the vegetal pole and a fluid filled germinal sac or nucleus towards the animal pole.

During fertilization, the sperm enters the egg near the vegetal pole which provides a stimulus for the egg (secondary oocyte) to undergo its second maturation division, a polar body is extruded which comes to lie near the animal pole inside the fertilization membrane, within perivitelline space.

Early Embryonic Development:

Cleavage and Blastulation:

Cleavage is complete or holoblastic and almost of equal type. First cleavage is meridional which cuts through the egg along its median axis, resulting into two equal sized blastomeres.

The second cleavage is again meridional, but at the right angle to the first and divides the first two blastomeres into four equal-sized blastomeres.

The third division is horizontal passing just above the equator forming four upper smaller micromeres near the polar body, and four lower large macromeres at the vegetal pole.

Fourth cleavage is again meridional cutting all the eight blastomeres synchronously. Sixteen-cell stage is formed having eight micromeres and eight macromeres. Since the cleavage is not exactly through the middle, therefore the resulting blastomeres donot have equal sized patners. The cleaving zygote is not called Morula.

The fifth cleavage is latitudinal or horizontal and synchronous, resulting into thirty-two cells arranged in four tiers.

The sixth cleavage is meridional and synchronous producing sixty four blastomeres. Later cleavages will not be synchronous up to this stage; the blastomeres remain loosely packed and form the morula. Meanwhile, a semifluid material accumulates in the centre of the morula.

It pushes all the blastomeres outward during further cleavage of the morula, so that they become arranged in a single layer called blastoderm, enclosing a central fluid-filled cavity the blastocoel. This embryonic stage is called the blastula and a fully developed blastula of Amphioxus is called the coeloblastula.

Gastrulation:

In Amphioxus, gastrulation is started when there are about 800 cells in the embryo, i.e., between 9th and 10th cleavage.

It involves two basic types of morphogenetic movements of the embryonic cells:

1. Epiboly and

2. Emboly.Both the processes go on side by side.

1. Epiboly:

It is the expansion of ectodermal cells of the embryo.

2. Emboly:

The blastoderm at the vegetal pole (endodermal plate) becomes flat and subsequently bends inwards (invagination). Thus, the embryo, instead of spherical becomes converted into a cup-shaped structure, having a large cavity, the archenteron, opening outside by a wide blastopore.

The cup has double walls, an external and internal epidermis, both of which are continuous with each other over the rim of the cup-shaped embryo.

As the endodermal plate moves inward dorsal notochordal cells involute, move inward along with the endoderm due to which prospective notochordal cells come to lie beneath the prospective neural ectoderm. Similarly, the prospective mesoderm in the ventral lip of the blastopore also moves inward and side by side its lateral horns converge toward the dorsal side of the embryo, so that they come to lie on both sides of the presumptive notochord.

Now the embryo also elongates in antero-posterior direction and in this elongation all the prospective cells take part. The blastopore subsequently narrows due to contraction of the rim of blastopore. The blastopore leads into a newly formed cavity, the archenteron.

Thus, a two layered gastrula is formed, in which the outer layer of cells becomes ciliated but it is enclosed in the vitelline membrane.

Gastrula has an outer layer of ciliated ectoderm cells, in which mid-dorsally are cells of neural plate and ventro-laterally are cells of epidermal ectoderm; the inner cells of the gastrula have a mid-dorsal strip of notochord cells, on the two sides of which are mesoderm cells, and the lateral and ventral inner cells are endoderm.

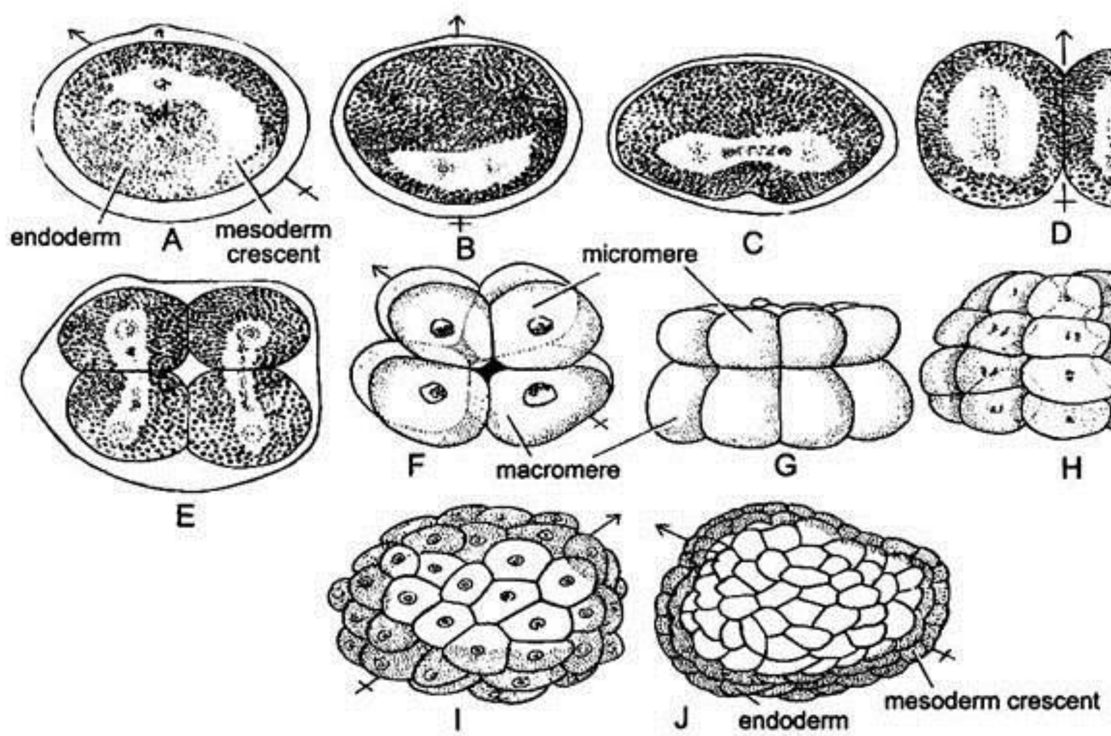

Fig:- Cleavage and blastulation in Amphioxus.

Fate of Germ Cells:

The ectoderm will give rise to epidermis, nervous system and receptors. Endoderm will form the alimentary canal and midgut diverticulum. Mesoderm will form muscles, connective tissue and germ cells.

Formation of Notochord:

The cells which were invaginated from the dorsal lip of the blastopore lie in the mid-dorsal roof of the archenteron. They evaginate dorsally at the anterior end of embryo and become separated from the endoderm. This evagination of notochordal material also continues caudally and ultimately forms a solid, cylindrical cord of cells, which is called the notochord.

Formation of Neural Tube:

The prospective neural ectoderm cells along the mid-dorsal line become flat and thickened to form a neural plate which sinks inwards below the level of lateral epidermal ectoderm. The neural plate is then covered by the free edges of the epidermal ectoderm. At the same time the lateral edges of the neural plate grow upwards and meet in the mid-dorsal line to from a neural tube, enclosing a canal, the neural canal or neurocoel.

The neural tube becomes spinal cord and its canal becomes the central canal of the central nervous system.

Metamorphosis:

The larva continues to feed on plankton of the surface of the sea for about three months, and sinks to the floor of the sea where it grows and undergoes a slow metamorphosis to become an adult in several months.

Following significant changes occurs during metamorphic:

1. In this process ectodermal cilia and club-shaped gland are lost.

2. The mouth shifts from left to antero-ventral side of body. Its margins grow in to form a velum, folds of skin form an oral hood and oral cirri inside which a ciliated wheel organ is formed.

3. Larva acquires the habit of filter-feeding.

4. Gill-slits divide by the appearance of tongue bars and more gill-slits appear behind the first sets.

5. The development of atrium causes the reduction of coelomic cavity in the pharyngeal region, in the myocoel and in gonocoel.

6. Gonads develop from the anterior lower angles of myotomes and project into myocoelic spaces, which are now called gonocoels.

7. The tail region elongates and it assumes a considerable degree of bilateral symmetry to become an adult.