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Topic: Gastrulation in Chick

Gastrulation in Chick

Gastrulation is a phase early in the embryonic development of most animals, during which the single-layered blastula is reorganized into a multilayered structure known as the gastrula.

Before gastrulation, the embryo is a continuous epithelial sheet of cells; by the end of gastrulation, the embryo has begun differentiation to establish distinct cell lineages, set up the basic axes of the body (e.g. dorsal-ventral, anterior-posterior), and internalized one or more cell types including the prospective gut. In triploblastic organisms the gastrula is trilaminar ("three-layered"). These three *germ layers* are known as the ectoderm, mesoderm,and endoderm.

Gastrulation involves the creation of the blastopore, an opening into the archenteron.

In Chick, gastrulation occurs in the following sequence:

(i) The embryo becomes asymmetric;

(ii) The primitive streak forms;

(iii) cells from the epiblast at the primitive streak undergo an epithelial to mesenchymal transition and ingress at the primitive streak to form the germ layers.

As the cells converge to form the primitive streak, a depression forms with in the streak—the primitive groove, through this primitive groove the migrating cells pass into the blastocoel.

At the anterior end of the primitive streak is a regional thickening of cells called the primitive knot or Hensen's node.

There is a funnel shaped depression in the centre of the node through which cells can pass into the blastocoel. As soon as the primitive streak is formed, blastoderm cells begin to migrate over the lips of the primitive streak and into the blastocoel.

The cells which migrate through the Henson's node pass down into the blastocoel and migrate anteriorly form head mesoderm and notochord, and those cells which pass through the lateral portion of the primitive streak forms the majority of endodermal and mesodermal tissues.

The cells entering the inside of the avian embryo form a loosely connected mesenchyme. Moreover, no true archenteron is formed in avian gastrula.

As the cells enter the primitive streak, the streak elongates toward the future head region. At the same time, the secondary hypoblastic cells continue to migrate anteriorly from the posterior margin of the blastoderm.

The first cells to migrate through the primitive streak are those destined to become the foregut. Inside the blastocoel, these cells migrate anteriorly and eventually displace the hypoblast cells in the anterior portion of the embryo.

The next cells entering the blastocoel through Hensen's node also move anteriorly, but they do not move as far ventrally as the presumptive endodermal cells.

These cells remain between the endoderm and the epiblast to form the head mesoderm and the chorda mesoderm (notochordal) cells. These early ingressing cells have all moved anteriorly, pushing up the anterior midline region of the epiblast to form the head process. Meanwhile, cells continue migrating inward through the primitive streak.

As they enter the blastocoel, these cells separate into two streams. One stream moves deeper and joins the hypoblast along its mid-line, displacing the hypoblast cells to the sides.

These deep-moving cells give rise to all the endodermal organs of the embryo as well as to most of the extra embryonic membranes.

The second migrating stream spreads throughout the blastocoel as a loose sheet, roughly mid-way between the hypoblast and the epiblast.

This sheet gives rise to mesodermal portions of the embryo and extra embryonic membranes.

By 22 hours of incubation, most of the presumptive endodermal cells are in the interior of the embryo, although presumptive mesodermal cells continue to migrate inward for a longer time.

Now the second phase of gastrulation begins. While the mesodermal ingression continues, the primitive streak starts to regress (disappearance of primitive streak) moving Hensen's node from near the centre of the area pellucida to a more posterior position.

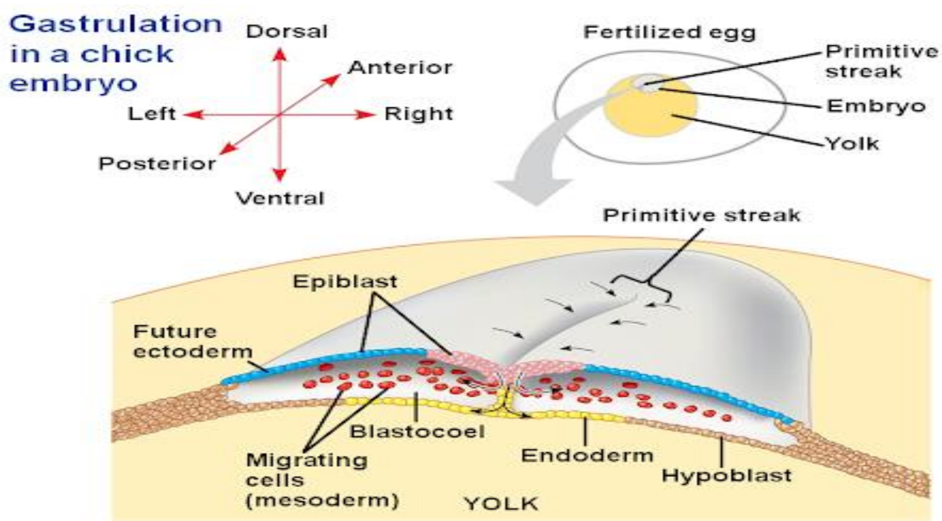

Fig: Gastrulation in Chick embryo

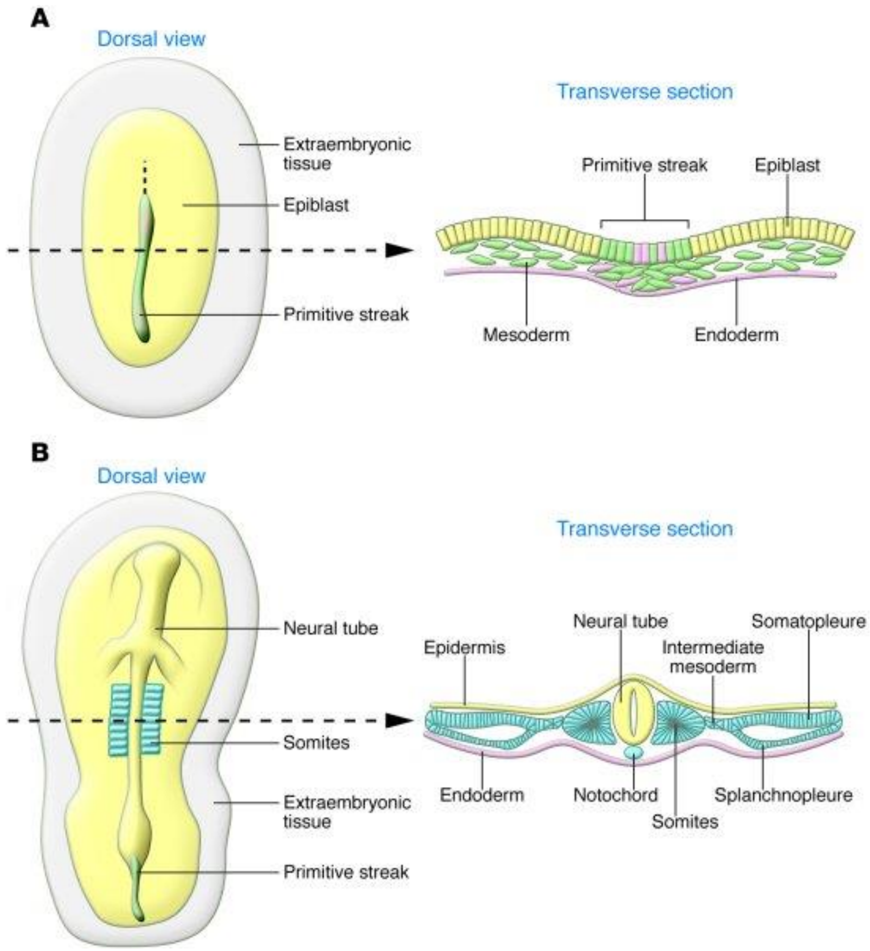

Fig: Gastrulation in Chick embryo

As the node moves further posteriorly, the remaining (posterior) portion of the notochord is laid down.

Finally the node regresses to its most posterior position, eventually forming the anal region in true deuterostome fashion. By this time, the epiblast is formed entirely of presumptive ectodermal cells.

As a consequence of this two-step gastrulation process, avian (and mammalian) embryos exhibit a distinct antero-posterior gradient of developmental maturity.

While the posterior portions of the embryo are undergoing gastrulation, cells at the anterior end are already starting to form organs.

For the next several days the anterior end of the embryo is seen to be more advanced in its development than the posterior end.

While the presumptive mesodermal and endodermal cells are moving inward, the ectodermal precursors surround the yolk by epiboly.

The enclosure of the yolk by the ectoderm takes greater part of 4 days to complete and involves the continuous production of new cellular material at the expense of the yolk and the migration of the- presumptive ectodermal cells along the undersides of the vitelline envelope.

Thus, as avian gastrulation draws to a close, the ectoderm has surrounded the yolk, the endoderm has replaced the hypoblast, and the mesoderm has positioned itself between these two regions.

Thus the fully formed chick gastrula consists of these germ layers-ectoderm, chorda-mesoderm and the endoderm.

Significance of the primitive streak:

The primitive streak with its Hensen's node is analogous to the blastopore and its dorsal lips of amphibian gastrula. The only difference is that the avian blastopore is elongated whereas amphibian blastopore is circular. Some homologies are as follows:

(1) The primitive pit represents the dorsal opening of the blastopore (neurenteric canal).

(2) The primitive node corresponds to the dorsal lip of blastopore (future tail bud).

(3) The primitive groove and folds are comparable to the opposed lateral lips of the blastopore.

(4) The posterior end of primitive streak may be compared with the ventral region of the blastopore (future anal opening).

(5) The first cells which migrate through the primitive streak are those destined to become foregut. This situation is again similar to amphibians.

Cell movement within blastocoels:

The cells of chick embryo passing through the blastopore lip constrict their apical ends to become bottle cells.

Extracellular polysaccharides like hyaluronic acid may play an important role in this migration. They facilitate individual cell migration by coating the surfaces of incoming cells.

Due to this coating the cells remain separated from each other. Hyaluronic acid may be able to keep the cells separated by its ability in water.

Further, the cellular movement of these cells is correlated with the presence of a fibronectin meshwork in the extra cellular basal lamina of the epiblast cells.

This fibronectin rich layer appears on the undersurface of the upper layer shortly before the formation of the primitive streak and disappears in the region of the streak.

Epiboly of the ectoderm:

The marginal area opaca cells are the agents of the ectodermal epiboly because

(i) the blastoderm spreads only when the margins are expanding,

(ii) when the marginal cells are cut away from the rest of the blastoderm, they continue to expand alone.

Thus, it appears that the ectodermal precursor cells are being moved by the actively migrating cells of the area opaca.