

Unit V

5.4 Gastrulation in Frog

1. Meaning of Gastrulation: The blastula passes into the stage called gastrula by the process—Gastrulation. This process is extremely important in the ontogenetic process of an animal, because the blue-print of the future organisation is laid down during this phase.

During this crucial and dynamic process major presumptive organ-forming areas of the blastula become reorganised in a fashion that allows their ready transformation into the fundamental body plan of a species. Gastrulation is essentially a process of migration of cells from one place to the other in the embryo. Besides movement of cells, considerable nuclear differentiation also takes place.

In almost all animals it results in:

- (i) The establishment and differentiation of three primary germinal layers—ectoderm, mesoderm and endoderm,
- (ii) The establishment of nuclear differentiation and
- (iii) The beginning of the control of genetic factors over development.

2. Basic Mechanism in Gastrulation: The process of gastrulation involves following three cellular activities, cell-movement, cell-contact and cell-division. All these mechanisms are carried in a nicely coordinated and integrated way.

Morphogenetic Movement of Cells in Gastrulation:

During gastrulation, cells from one region of embryo move to another to take up their future fateful position. Two terms, emboly and epiboly which are quite opposite in their meanings, are generally applied to explain the process of movement.

Following types of cells movement occur:

Epiboly: It involves the extension along the anteroposterior axis and peripheral divergence.

Emboly: The inward movement of cells is classified into different types depending on the behaviour of migrating cells.

These are:

(i) **Invagination:** It denotes the infold-ing of a layer of cells to form a cavity en-circled by infolded cells. Generally in the gastrulation of Amphioxus and frog, the wall of the blastoderm is pushed inside the blastocoel. This creates a new cavity called the archenteron which communicates with the exterior by a blastopore.

This process of inpushing goes on and the inpushed layer forms the walls of the cavity. The archenteron (or primitive gut) completely obliterates the blastocoel.

(ii) **Involution:** It implies the inward rotation of cells as seen in the gastrulation of amphibian and avian eggs. From one end near the edge of the blastoderm, the cells begin to move inwards to form the inner lining of the blastoderm.

(iii) **Convergence:**It means the movement of cells to a particular region of the gastrula. In amphibian egg, the migration of cells to the external edge of the blastoporal lip is designated as convergence.

(iv) **Divergence:**This phenomenon is opposite to convergence, when involuted cells diverge to take up their future positions inside the gastrula.

(v) **Infiltration:**During this process, cells of the blastoderm infiltrate near the bottom of the blastocoel to form a second layer.

(vi) **Delamination:** This is a process of separation of a group of cells from others to form discrete cellular masses.

(vii) **Extension:** The elongation of presumptive areas after they have moved inside the embryo is called the extension.

(viii) **Cell proliferation:**It means the increase in the number of cells during gastrulation.

(ix) **Convergence:**It is similar to convergence. The cells from two sides migrate anteriorly along one axis, but in convergence the cells from two sides unite together and then move anteriorly.

Gastrulation in Frog:

In late amphibian blastula, the presumptive organ forming areas are oriented around the blastocoelic cavity. The hypoblast is situated at the vegetal pole, while the epiblast is located at the animal pole. In the epiblast the notochordal cells, neural plate and epidermal areas are situated along the anteroposterior axis of the blastula with the notochordal cells located at the most posterior position.

At the end of the cleavage all the blastomeres remain stationary and none of them have shifted from its original position. But at the onset of gastrulation a great mass migration started to occupy their definite

position in the developing embryo. Gastrulation begins with the appearance of a small cleft-like invagination at one side and just above the grey crescent (Fig. 5.18).

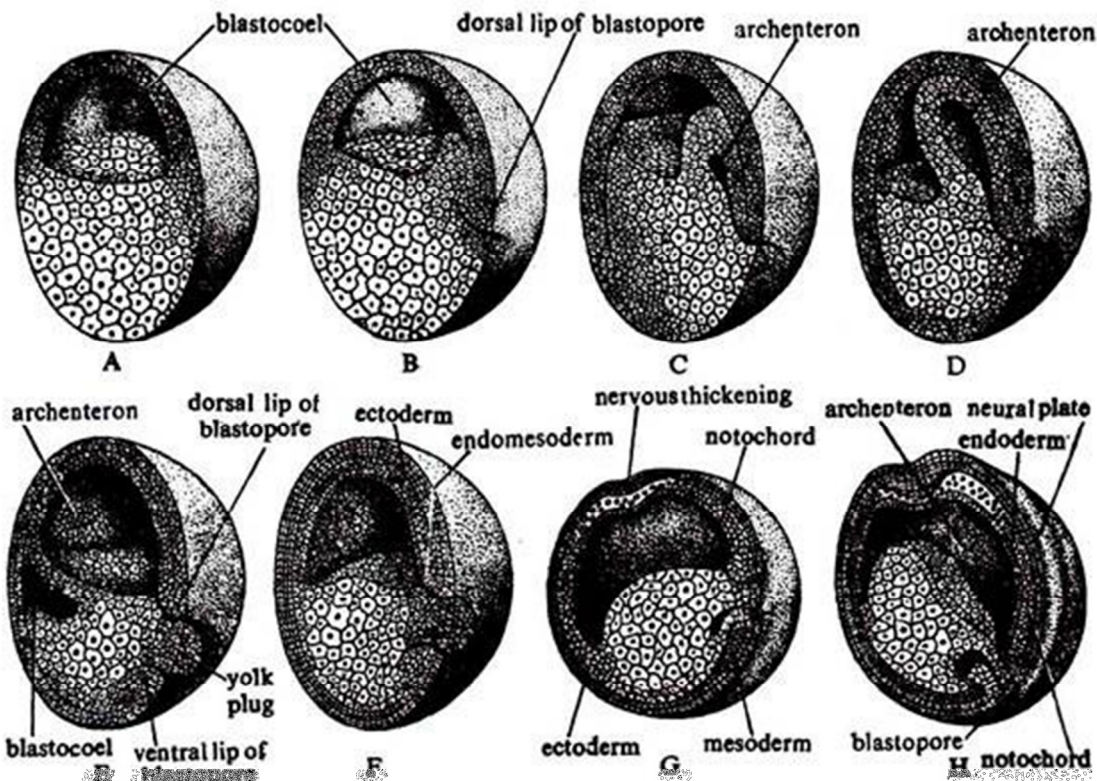


Fig. 5.18: Embryological sectional views of the gastrulating embryo of Frog. (after Huxford). A. Blastula. B. Formation of blastopore. C-D. Enlargement of archenteron and gradual obliteration of blastocoel. F. Total obliteration of blastocoel and formation of endomesoderm. G-H. Completion of gastrulation showing the initiation of neural plate, notochord and differentiation of mesoderm as a middle layer.

This cleft-like invagination is crescent-shaped and represents the dorsal lip of the blastopore. As gastrulation progresses the crescent-shaped cleft continues to expand to assume a semicircular appearance, then becomes horse-shoe-shaped and finally forms a ring. This ring represents the blastopore. The blastopore becomes the focal point for gastrulation activities.

Migration of cells inside the gastrula starts along the newly-formed dorsal lip of blastopore and this inward pushing is caused by the endodermal cells which are folded inward (Fig. 5.19) and forward towards the future anterior end of the embryo. The upper margin of the blastopore is called the dorsal lip of the blastopore and the lower edge is designated as the ventral lip of the blastopore.

As invagination expands within the blastocoel, the prechordal plate cells from the upper part of the dorsal side move inward. The new cavity thus produced is called the archenteron which communicates to the exterior by the blastopore. With the further advancement of invagination, the archenteron continues to expand by obliterating the blastocoel.

The inward moving cells form a new border beneath the outer cells. The roof of the archenteron consists of the involuted layer which includes the endoderm and mesoderm. Beyond this layer lies the ectodermal layer. The floor of the archenteron is made up of a layer of endodermal cells, the derivatives of the large yolk cells which were located in vegetal hemisphere of blastula.

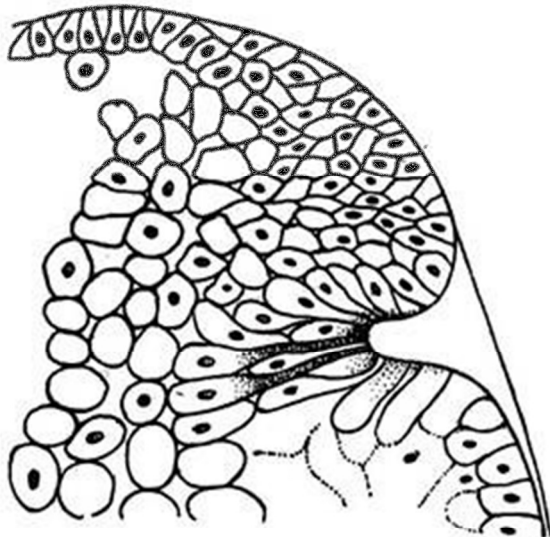


Fig. 5.19. Section through the blastoporal region of an early amphibian gastrula showing the streaming of blastoporal cells into the interior. As invagination begins, certain cells retain their attachment with the surface of the egg but become bottle-like in appearance.

When the inward movement of the cells is in progress through the dorsal lip, another type of movement occurs on the outer side. The pigmented cells of the animal hemisphere started to enclose the macromeres of vegetal hemisphere. After completing the enclosure, the outer cells reach up to the ventral lip of it.

A small mass of macromeres remains uncovered for a while and acts as a plug of the blastopore. It is called yolk plug. At this stage, embryo is made up of two distinct strata, each of which is composed of many layers of cells.

Differentiation of three primary germ-layers:

The blastula of frog is mono-layered which in course of gastrulation becomes converted into a triploblastic stage, i.e., three cell-layered. These three layers are designated as the primary germ-layers (embryonic ectoderm, embryonic mesoderm and embryonic endoderm). All the organs of the developing embryo develop from these three primary germ-layers.

(a) Ectoderm:

The pigmented cells of the animal pole, which spread to enclose the macromeres of the vegetal hemisphere become differentiated into ectoderm.

(b) Endoderm:

The dorsal and lateral sheets of cells which form the roof of the archenteron represent the endoderm as well as mesodermal material. Upon completion of gastrulation, the roof and sides of the archenteron become lined by a single layer of endodermal cells which have differentiated from the involuted several celled thick archenteron roof.

(c) Mesoderm:

As soon as the endodermal sheet becomes separated dorsally and laterally from the involuted cells, mesodermal sheet is being formed between the endoderm and ectoderm. The mesodermal sheet starts its differentiation anteriorly and then proceeds gradually backwards.

The mesodermal sheet is divided into two halves by a narrow band of median cells which develop into notochord. Laterally the mesodermal sheets grow downward and finally the right and left mesodermal sheets unite in the mid-ventral line to become a continuous mesodermal sheet.

The three layers thus formed are ectoderm, mesoderm and endoderm. It is the special feature in amphibian development that gastrulation results into the formation of mesoderm first and then the endoderm.