CHAPTER 7: GASTRULATION

1. Definition:

Gastrulation is the biological process during which the blastula is transformed into a gastrula with **three primary germ layers:**

- **Ectoderm** (outer layer)
- **Mesoderm** (middle layer)
- **Endoderm** (inner layer)

Key Points:

- It marks the beginning of the formation of tissues and organs.
- Cell movements like invagination, involution, ingression, delamination, and epiboly occur.
- It establishes the basic body plan, including the anterior-posterior and dorsal-ventral axes.

Importance:

Gastrulation is crucial because it:

- Determines the body axes
- Lays the foundation for organogenesis (formation of organs)
- Initiates cell differentiation based on the germ layers

2. **Stages of Gastrulation** (generalized for vertebrates like humans, frogs, birds)

2.1. Formation of the Primitive Streak

The **primitive streak** is the **first visible sign of gastrulation** in vertebrate embryos (like birds, mammals, and humans). It plays a crucial role in setting up the body's **basic structure**.

It's a **linear groove** that appears on the surface of the **epiblast** (the upper layer of the blastula). It marks the **midline** of the embryo and shows where **cells will start to move inward** to form the three germ layers.

- **Steps of Primitive Streak Formation:**

a. **Epiblast Cell Rearrangement**

- Cells in the posterior part of the epiblast begin to **migrate toward the midline**.

b. **Streak Appears Posteriorly and Grows Anteriorly**

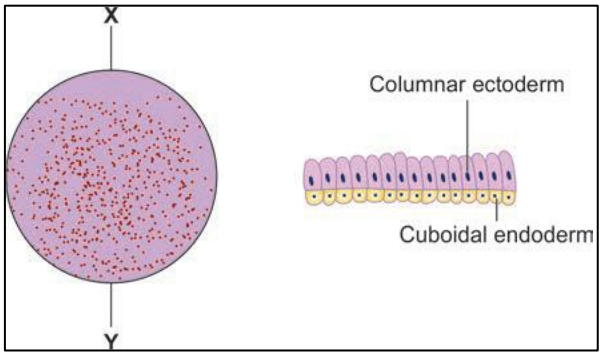
- A **shallow groove** forms called the **primitive streak**.
- It **elongates toward the head (anterior)** of the embryo.

c. **Formation of the Primitive Node (Hensen's Node)**

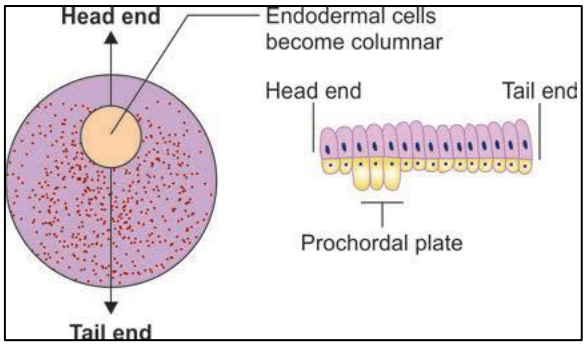
- At the front of the streak, a **bulge forms** called the **primitive node**.
- This node is critical for **organizing body structure**, including the notochord.

d. **Cell Migration Through the Streak**

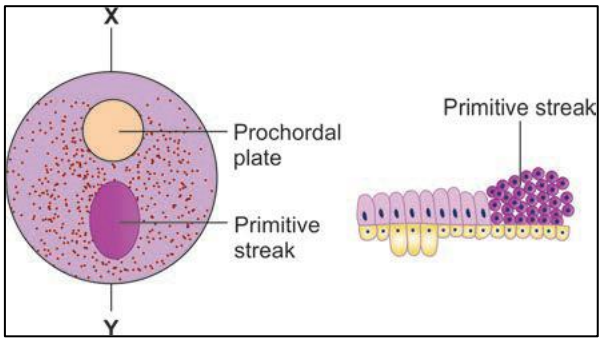
- Epiblast cells **move inward** (a process called **ingression**) through the streak.
- These cells **differentiate** into:
  - **Endoderm** (first)
  - **Mesoderm** (second)
  - Remaining epiblast becomes **ectoderm**



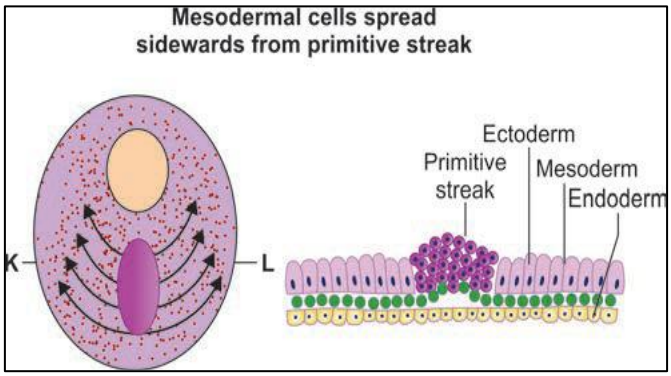
Figs. 30: Embryonic disc before appearance of a central axis. "B" represents a section along the axis XY shown in "A"



Figs. 31: Embryonic disc after establishment of a central axis. "B" represents a section along the central axis



Figs. 32: Appearance of primitive streak. (B) is a section along axis XY shown in (A)



Figs.33: Formation of intraembryonic mesoderm. (B) is a section along axis KL in (A)

2.2. Cell Migration (Ingress)

- Some cells from the surface move **inward** through the primitive streak.
- These migrating cells form new layers beneath the outer layer.

2.3.Formation of Germ Layers

- As cells migrate, **three distinct layers** are formed:
  - **Ectoderm**: outer layer (skin, nervous system)
  - **Mesoderm**: middle layer (muscles, bones, heart)
  - **Endoderm**: inner layer (gut, lungs, liver)

2.4. **Notochord Formation**

- A rod-like structure called the **notochord** forms from mesoderm cells.
- It provides signals for further development and becomes part of the spine in vertebrates.

2.5. Body Axes Are Established

- The **anterior-posterior** (head-to-tail), **dorsal-ventral** (back-belly), and **left-right** axes are defined.
- This gives the embryo a **directional structure**.

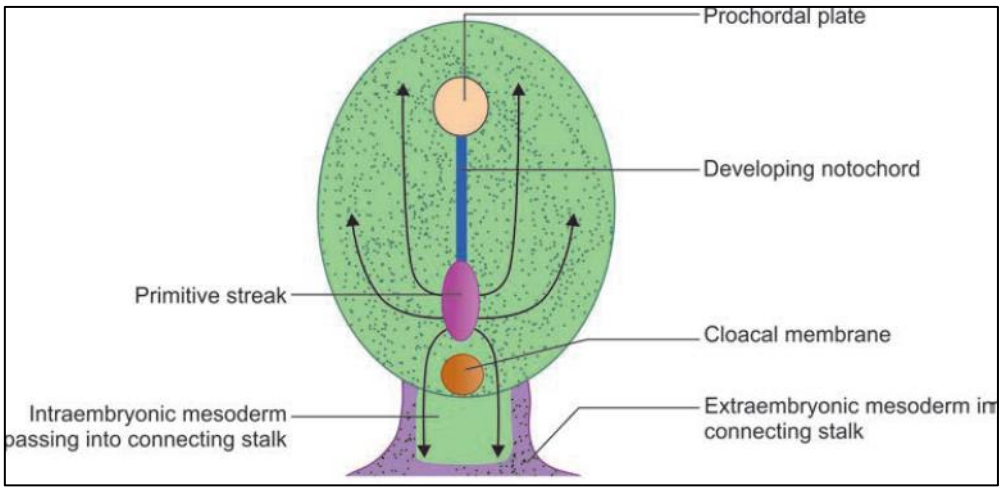


Fig. 34: Spread of intraembryonic mesoderm. Note that the mesoderm comes to lie between ectoderm and endoderm in all parts of the embryonic disc except at the (1) prochordal plate (2) cloacal membrane (3) region of the notochord

3. Modes of Gastrulation

Gastrulation involves the **movement of cells** from the surface of the embryo into its interior. Based on how this movement occurs, the **five primary modes** of gastrulation are:

1. Invagination

- **Definition**: Inward folding of a sheet of cells to form a depression or groove.
- **Mechanism**: A region of cells on the surface bends inward, forming a structure like a pocket.
- **Example**: Formation of the archenteron (primitive gut) in **sea urchins**, **primitive streak** in mammals and birds.

2. Ingression

- **Definition**: Migration of individual cells from a surface layer into the interior of the embryo.
- **Mechanism**: Cells lose their adhesion, become mesenchymal (loose), and move inwards.
- **Example**: Formation of mesodermal cells in **birds**, **mammals**, and **sea urchins**.

3. Involution

- **Definition**: Inward movement of an expanding outer layer so that it spreads over the internal surface of the embryo.
- **Mechanism**: Cells roll over the edge of an opening (like the blastopore) and spread internally.
- **Example**: Mesoderm formation in **amphibians** like frogs.

4. Epiboly

- **Definition**: Expansion and thinning of epithelial cell sheets to enclose deeper layers.
- **Mechanism**: Cells spread as a unit over the surface of the embryo.
- **Example**: Ectoderm formation in **amphibians**, **fish**, and **mammals**.

5. Delamination

- **Definition**: Splitting of one cellular sheet into two layers.
- **Mechanism**: A single epithelial layer divides into two, creating a new layer.
- **Example**: Formation of the **hypoblast** in birds and mammals.

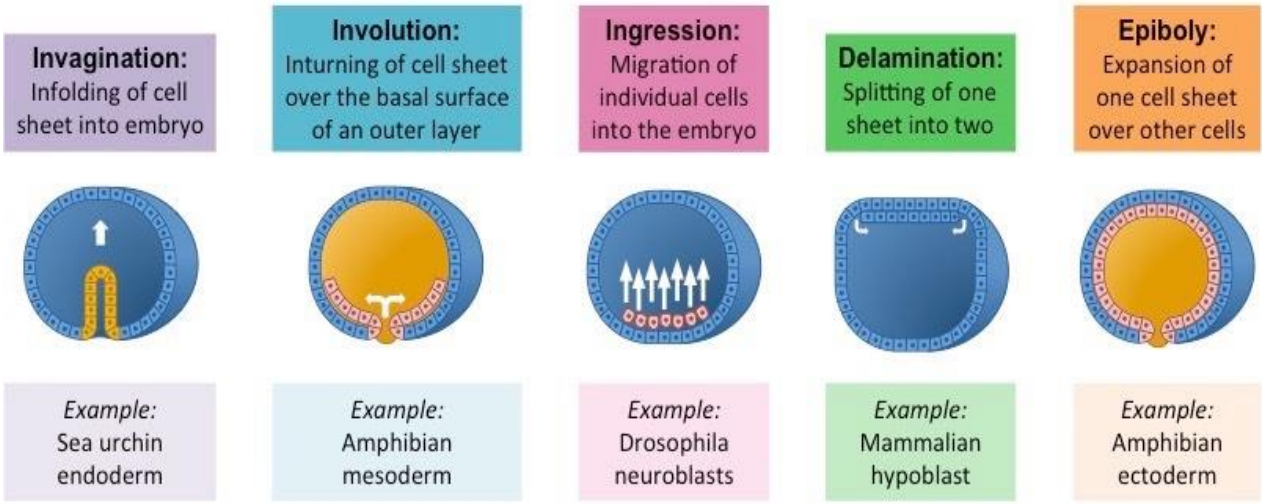


Fig. 35: Types of Cell Movements During Gastrulation