EARLY DEVELOPMENT OF FROG AND CHICK UPTO GASTRULATION

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MORULATION AND BLASTULATION IN FROG AND CHICK

Cleavage splits the fertilized egg into smaller cells called blastomeres. These blastomere increases in the typical double sequence of 2, 4, 8, 16 so on. Cleavage forms the layers where each layer is loosely joined together by a stacking gel. This heap of cohering, sticky blastomeres is known as Morula. This has been named as its resemblance to mulberry (Morula means mulberry in Latin). The arrangement of blastomere varies among animals. For example: In a megalecithal egg, a planoconvex-like mass of blastomere is formed. The morula stage is followed by the next phase of development called a blastula. Cleavage led to an increase in the number of blastomeres. This blastomere undergoes a rearrangement which results in arranging themselves into a single cell thick epithelium called blastoderm. A fluid-filled space or cavity called blastocoel appears between the blastomeres. This hollow, spherical and nonepithelial thick embryonic stage is called a blastula. This process of creating a blastula is known as blastulation.

Morulation in Frog: Cleavage is the early stage of embryogenesis. The cleavage leads the ovum cell partitioning from a single cell to a 32 cell using orders of 2-4-8-16 and finally 32. Cleavage in frogs produces unequal microsomes with a smaller one (micromere) and the larger one (megamere). The cleavage after 32 cells becomes quite difficult to follow. Micromeres divide more rapidly as compared with megamere. This is because micromere has less or lacks yolk. The zygote starts to appear like a mulberry-shaped solid ball of the cell. This mulberry-shaped ball of a cell is known as a morula.

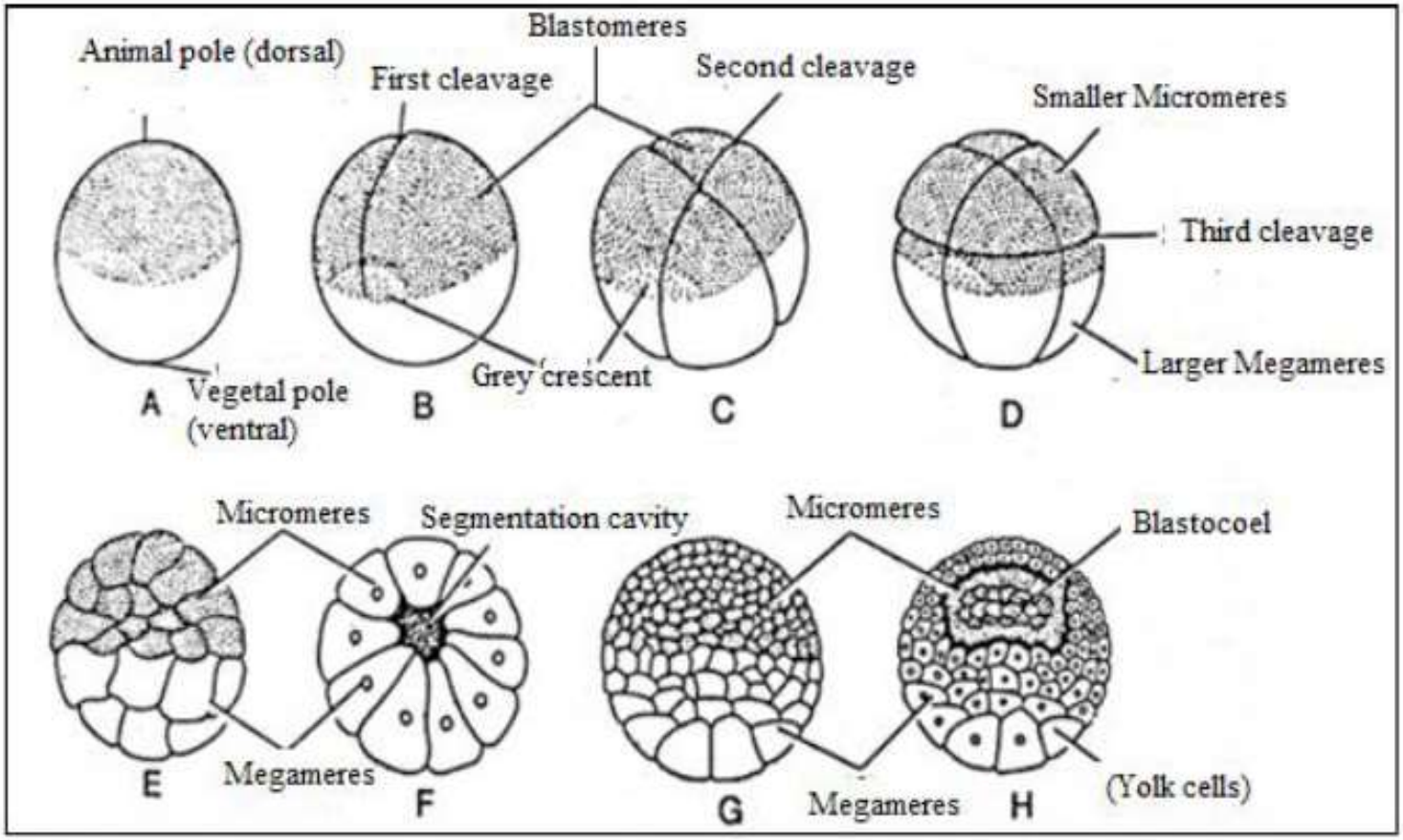


Fig 3.13: Morulation in frog

Morulation in Chick: Cleavage starts to happen after 3 hours of fertilization. In birds due to the availability of enormous yolk, the cleavage cannot happen in one furrow. This led to the rise of small-sized cells called mesomeres. Cleavage in birds is initially restricted to blastodisc with yolk remaining unaffected. The first cleavage is restricted to the area around the center of the blastodisc. It is superficial with no blastomere formed. The second cleavage just happens at the right angle to the first cleavage. 3rd Cleavage is formed just parallel to the first and is vertical. Thus eight blastomeres are formed with no signs of a boundary. 4th Cleavage results in the formation of eight central blastomeres and eight peripheral blastomeres. It is after the 4th Cleavage a clear demarcation of a cell is seen. The eight central blastomeres get completely separated from the yolk. After the 4th cleavage division becomes irregular. The central blastomeres and peripheral blastomeres start to divide rapidly. The cell of peripheral blastomere is added with central blastomeres resulting in increased volume. These cells start to arrange themselves resulting in the formation of a cavity called the blastocoel. The cleavage in birds is partial, teloblastic, or meroblastic.

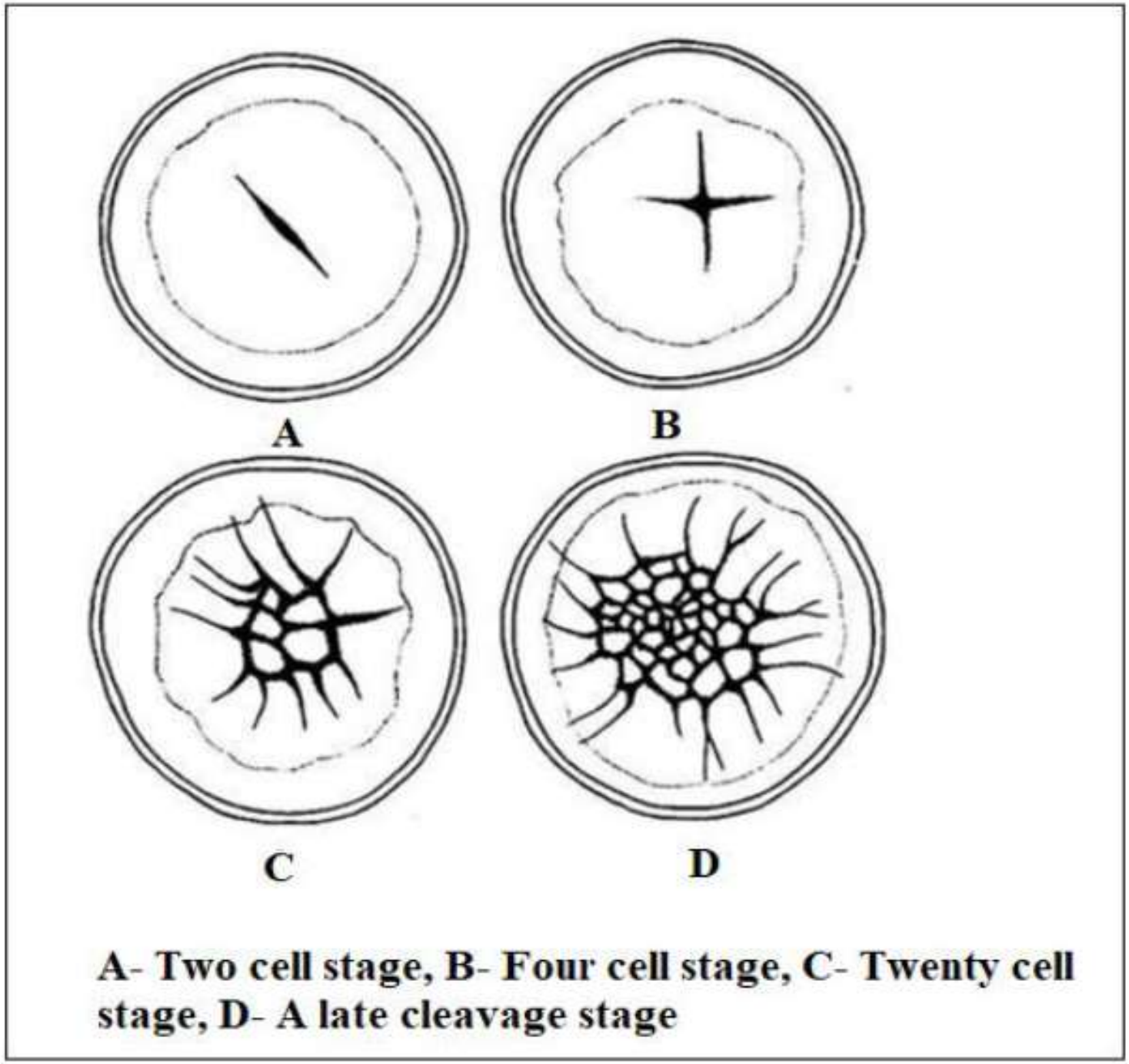


Fig. 3.14: Morulation in chick

Blastulation in Frog: Blastulation stages start after morulation when one cell has grown into 32 cells (blastomere). These blastomeres start to arrange at the periphery and a small fluid cavity or space starts to form within the embryo. This cavity is known as a blastocoel or segmentation cavity. The whole embryo formed is called a blastula. The process of formation of blastula is known as blastulation. After the formation of the blastula, the process of formation of body parts starts with a specific area marked within the cell. These are:

- Presumptive ectoderm: The region of the animal pole of the blastula.
- Presumptive Notochord: An area near the vegetal pole.
- Presumptive Mesoderm: An area close to the notochord.

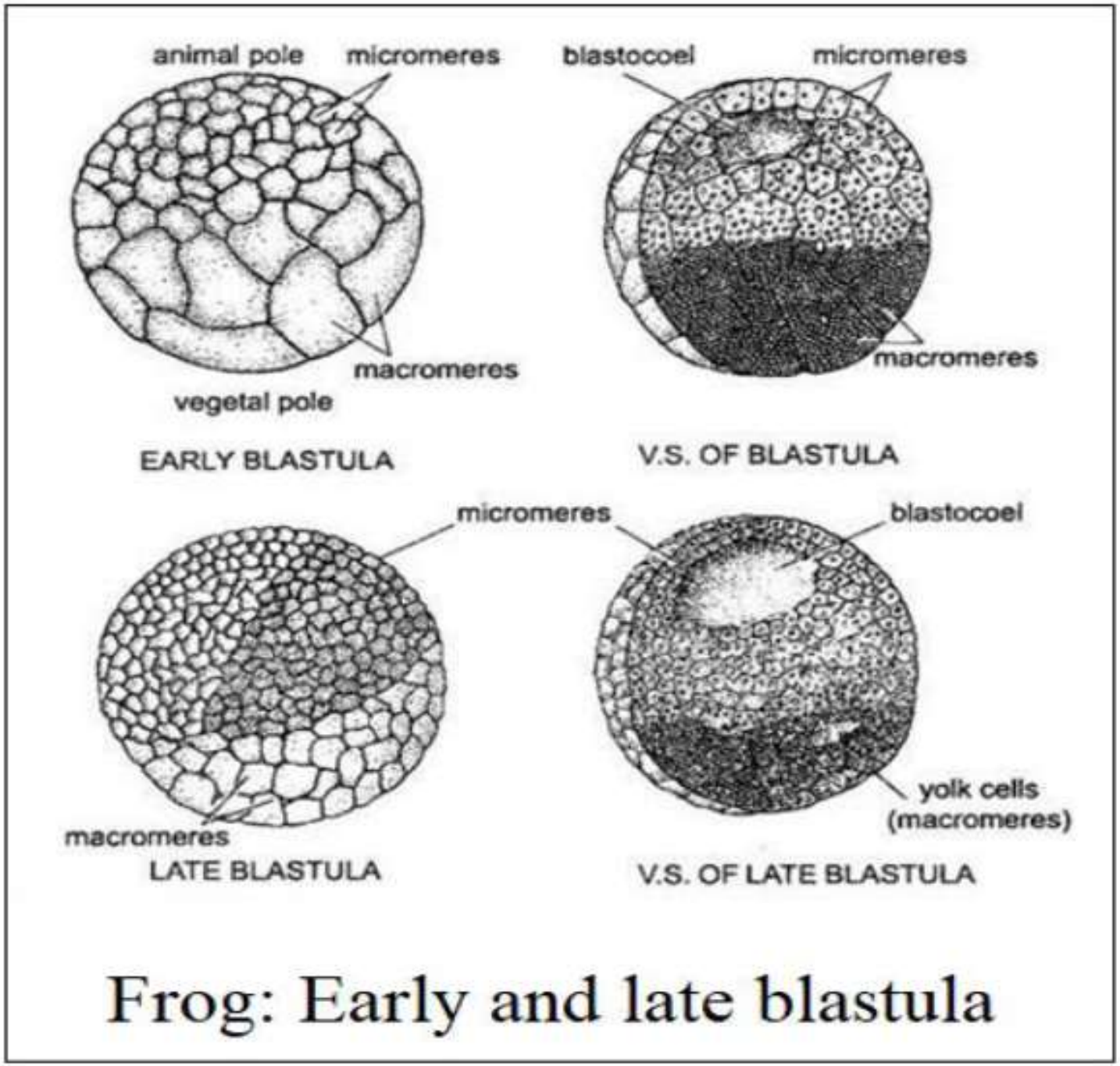


Fig. 3.16: Blastulation in frog

Blastulation in Chick: The morulation stage is of short duration. The cell undergoes further division resulting in the creation of several layers with their complete boundaries. Cell present near the periphery is not free from yolk known as marginal cells. This region is known as the zone of the junction.

The area in the center of the blastoderm is free from yolk with four to five layers of the cell, these cells undergoes arrangement. Space is created between blastoderm and yolk. This created space is known as blastocoel. This region is called area pellucida and is transparent. Area pellucida form the core of the embryo. This region is in contact with a region known as area opaca. Area opaca is responsible for the extra-embryonic structure.

Area opaca is opaque and white. They are differentiated into three more or less distinct zones. In birds, embryo blastomeres grow on the surface of a large yolk sphere. This blastomere forms an outer ring with no well-defined boundary.

An inner layer within the embryo is in close contact with the yolk. Thus two types of cells are found one with large yolk laden and another with small or yolk-free blastomeres. Yolk-laden blastomeres accumulate the under the surface of the blastoderm with yolk free at the surface. This led to the formation of two layers namely the upper layer and lower layer. These layers are called epiblast and the lower layer hypoblast respectively. A thin cleft appears between the epiblast and hypoblast. This cleft is known as blastocoels.

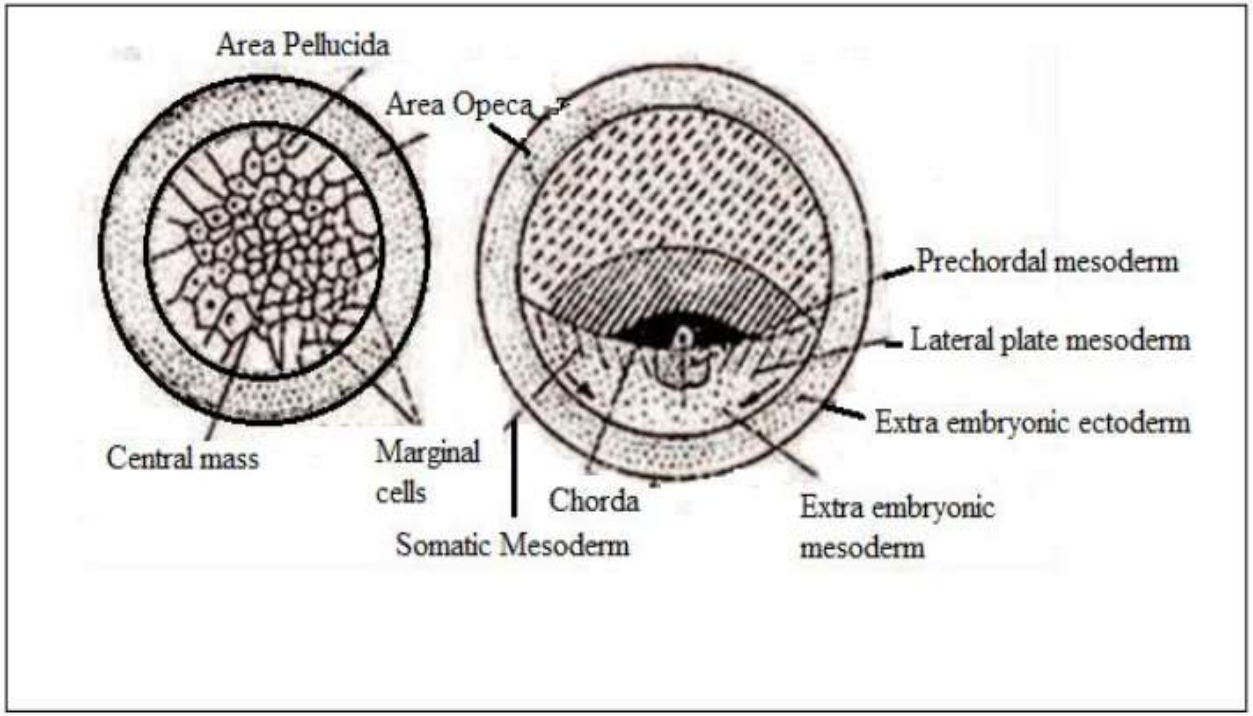


Fig. 3.17: Blastulation in chick

MAJOR EVENTS OF GASTRULATION AND FATE MAPS

Gastrulation is a process of formation of germ layers. This formation involves complex cell movements that rearrange those cells within themselves. This is one of the most important phases of embryonic development.

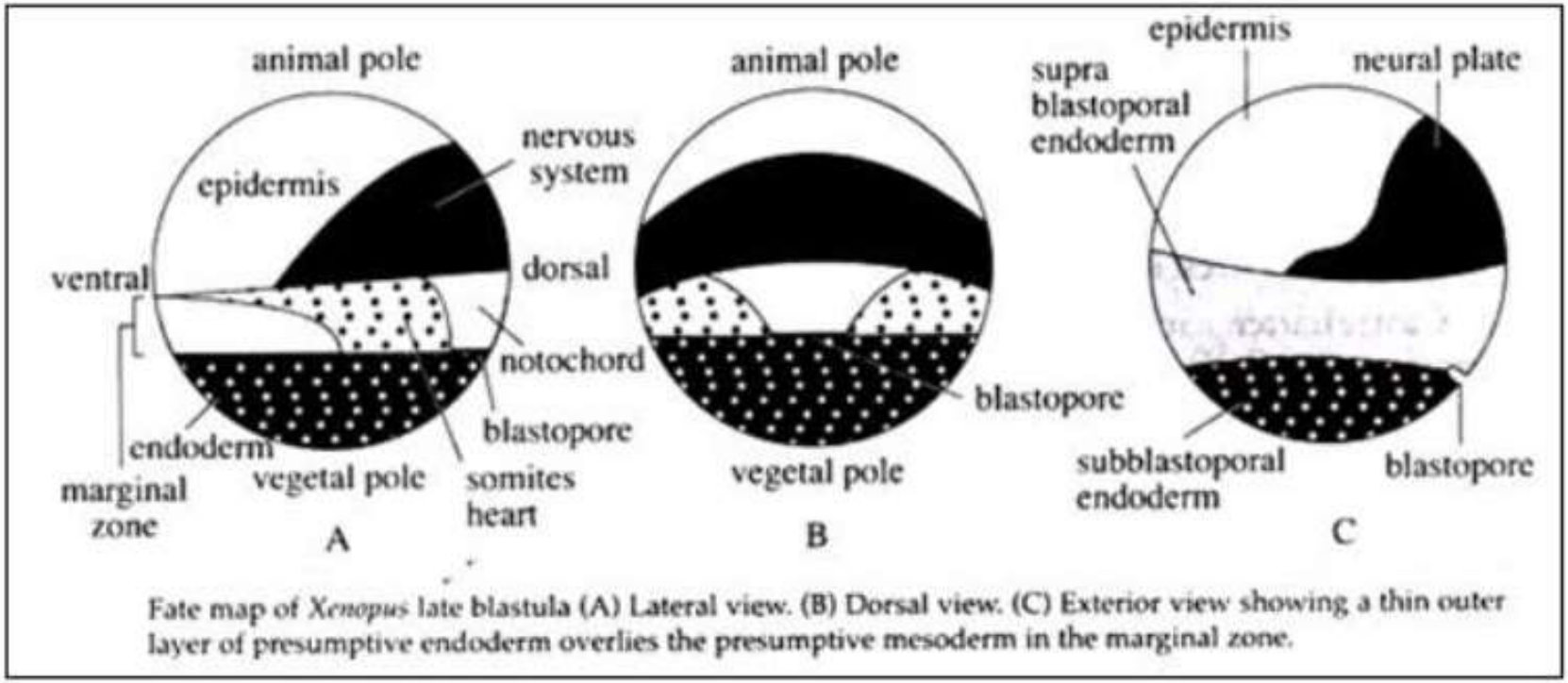
Gastrulation involves the following major events:

1. **Morphogenic Movement (Movement of blastular cells or blastomeres):** Blastomeres move in a different direction to form multiple patterns to develop germ layers and start the process of developing multicellular organisms.
2. **The rate of cell division (Cleavage) is slowed down:** Before reaching the stage of Gastrulation, Cleavage has produced a sufficient number of cells, so the emphasis lay on how to arrange those cells so that they can be used as per the requirement.
3. **Types of Metabolism changes and oxidation rate increases:** Gastrulation emphasized developing germ layers and the start of developing different parts of the animal. This requires a different type of protein synthesis. To facilitate the different proteins that are been secreted and oxidation rate increases.
4. **Nuclei control embryonic cell activities:** Gastrulation starts the process of differentiation where different parts of the animals are formed based on the genetic material. The cell nucleus stores the genetic code and the arrangement of the blastomeres are been done on the basics of the genetic code. Thus, the Nuclei enforce the genetic code in managing the process of gastrulation.
5. **Chemo-Differentiation is started:** Gastrulation initiates the process of chemo-differentiation where the blastomeres are subjected to a different set of chemicals and proteins to mold the blastomere's behavior. This molding of blastomeres results in the development of different parts of the multicellular animals.

Major Events of Fate Map: Fate map is the process of mapping which part of the blastula will develop into which organs in the embryo. It varies from animal to animal.

Fate map in frog: In frog the area demarcated for the different part are already been demarcated at the end of cleavage.

1. Macromeres of vegetal pole will become endoderm.
2. Micromeres of the animal pole will become ectoderm.
3. Prechordal both sides will become mesoderm.
4. Micromeres present near notochord and mesoderm becomes neurectoderm.



Fate map of *Xenopus* late blastula (A) Lateral view. (B) Dorsal view. (C) Exterior view showing a thin outer layer of presumptive endoderm overlies the presumptive mesoderm in the marginal zone.

Fig. 3.20: Fate Map of frog

Fate map in chicks: In chicks after the formation of hypoblast, the area marked for which organs can be detailed:

1. The hypoblast area forms the endoderm.
2. Epiblast forms the various organ of the chick.
3. Area opaca forms the extra-embryonic membrane and blood vessels.
4. Area pellucida forms epidermal ectoderm, neurectoderm, prechordal, notochordal and mesoderm cells.

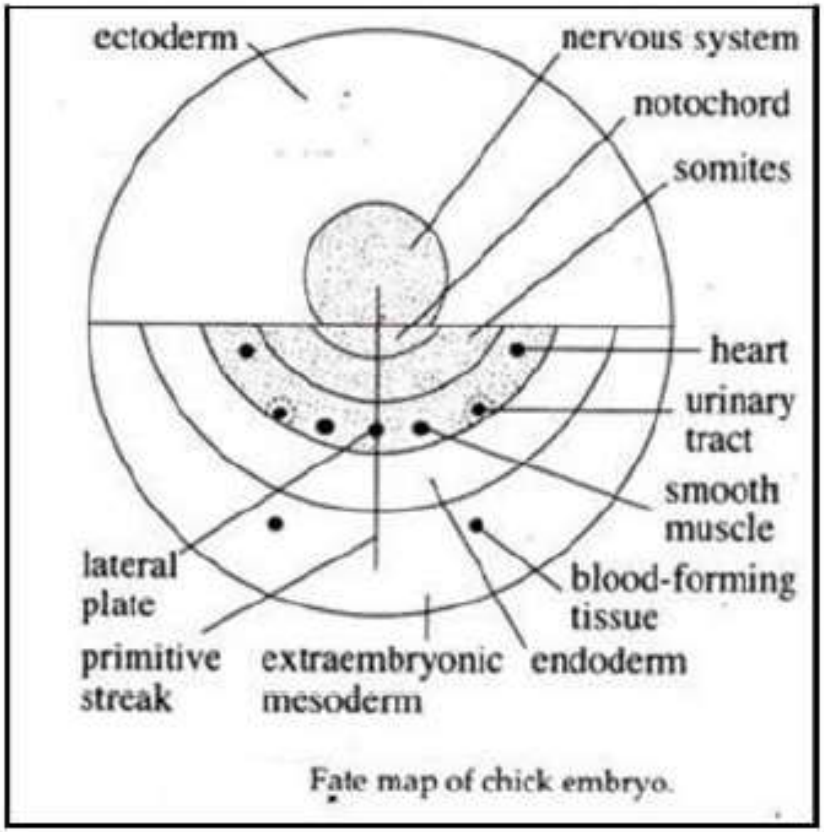


Fig. 3.21: Fate Map of Chicks

MORPHOGENETIC MOVEMENTS IN FROG AND CHICK

Morphogenetic movements occur during gastrulation:

These movements are classified according to the number of cells migrating together.

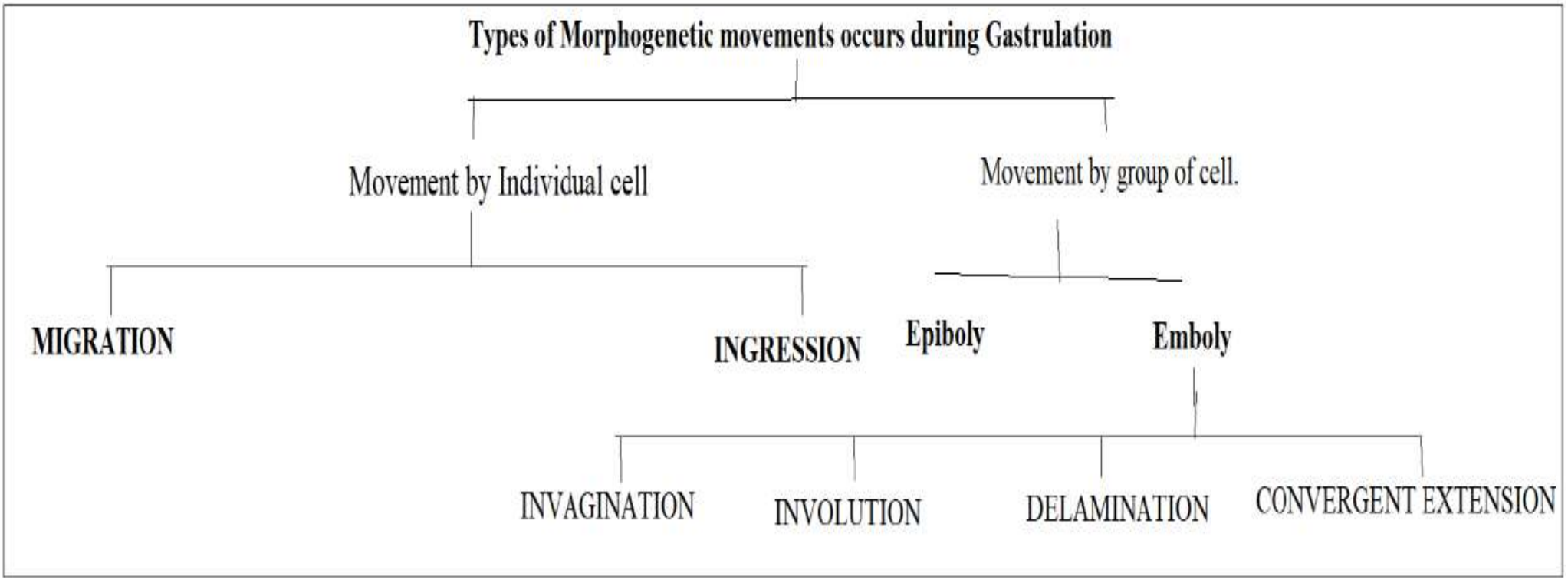
Movement by individual cell:

i. **Migration** – It is a movement where an individual cell moves over to the other cells.

ii. **Ingression**– It is the movement of individual cells from epithelium into a cavity.

Groups of cells move by: Types of Morphogenetic movement based on the direction. They are classified as epiboly and emboly.

Epiboly - In this movement, a group of cells arranges themselves to form an outside cell layer to cover the yolk. They do it by thinning the layers. Their movement is over ectoderm.


Types of Morphogenetic movements occurs during Gastrulation
Movement by Individual cell
Movement by group of cell.
MIGRATION
INGRESSION
Epiboly
Emboly
INVAGINATION
INVOLUTION
DELAMINATION
CONVERGENT EXTENSION

Emboly: Their movement is over Endoderm and mesoderm. They are of 4 Types

i. **Invagination**– It is a movement where the cell moves inward.

ii. **Involution** - It is an inward movement of a group of cells or epithelial sheets around a point or an edge. This is done to form an underlying layer.

iii. **Delamination** - In this process cells splits themselves into two different cell layers namely epiblast (outer layer) and hypoblast (inner layer).

iv. **Convergent Extension**– In this process, two or more cell rows move together intending to elongate the structures in one dimension while shortening them in another direction.

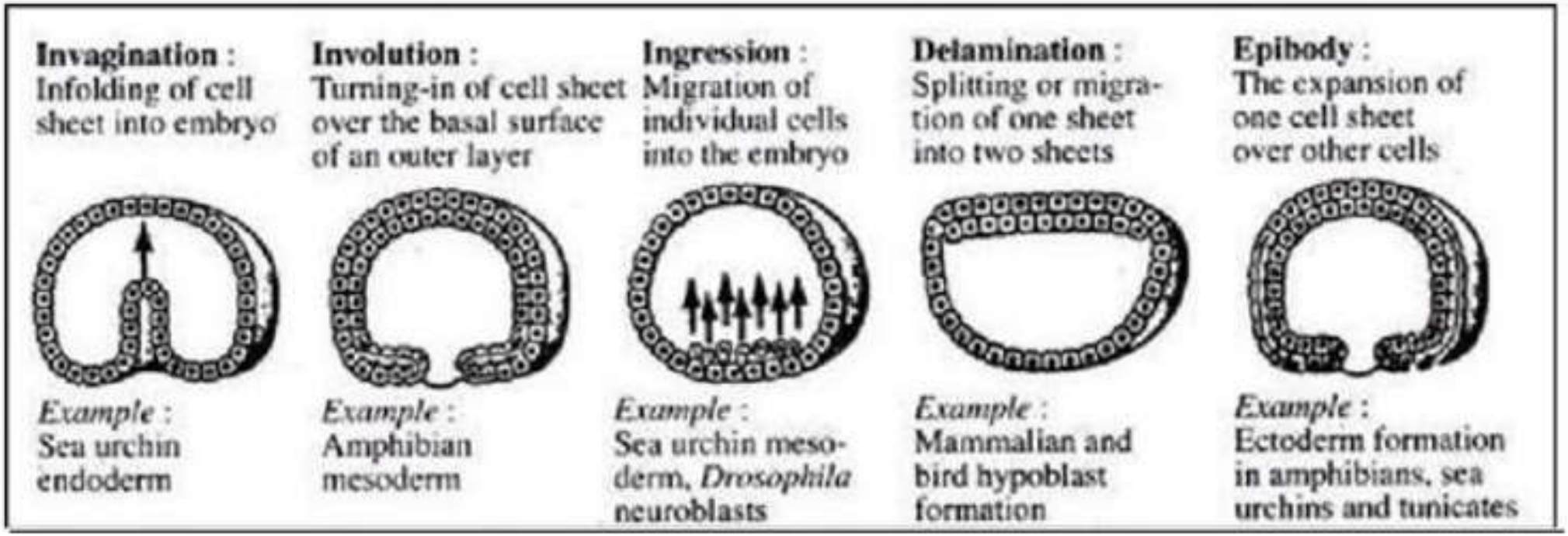


Fig.3.23: Morphogenetic movements

Gastrulation: The process in which a blastula or a single layer of the cell is converted into multiple layers of cells called gastrula is known as gastrulation.

Significance:

- Gastrulation starts the process of a multicellular organism. It sets the process of developing different parts of the body and brings the morphology changes in the embryo.
- Morphological changes bring an increased metabolic activity of the cells.
- Gastrulation brings the three primary germ layers i.e. ectoderm, mesoderm, and endoderm. This starts the process of developing skin.
- Gastrulation shows the influence of paternal chromosomes.
- The Blastocoel cavity is transformed into archenteron.