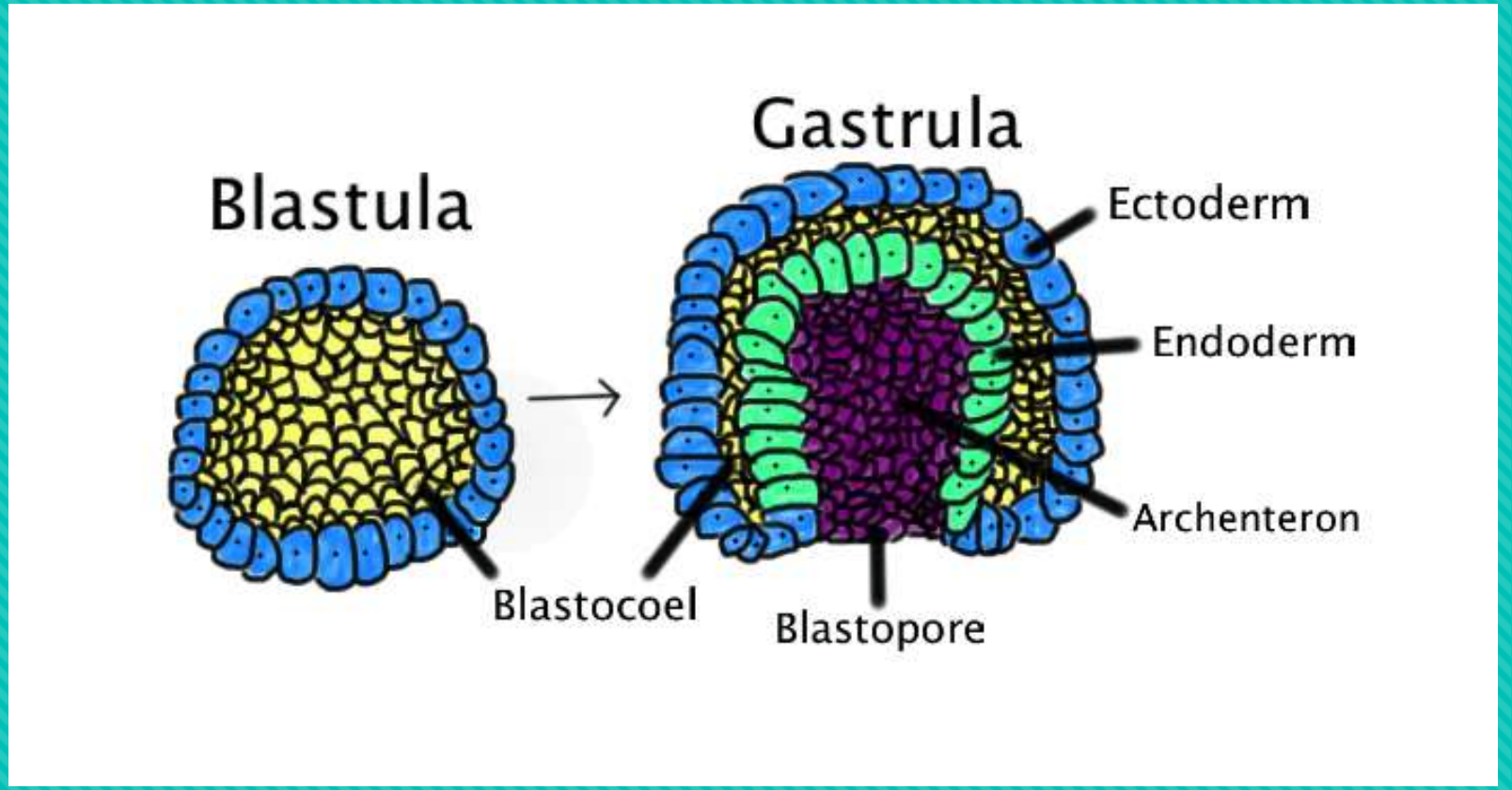
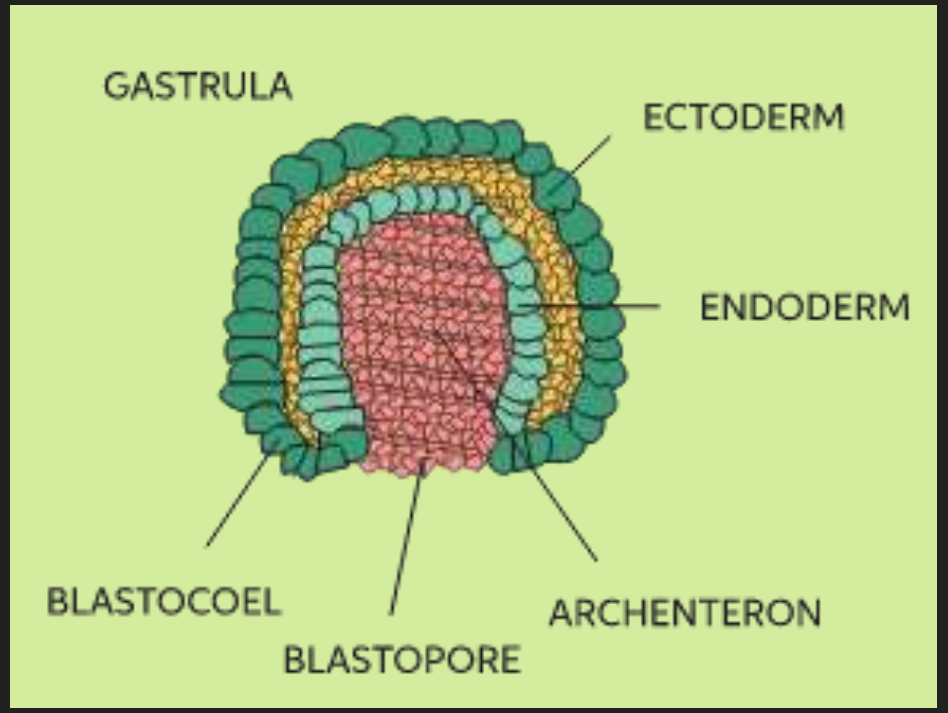
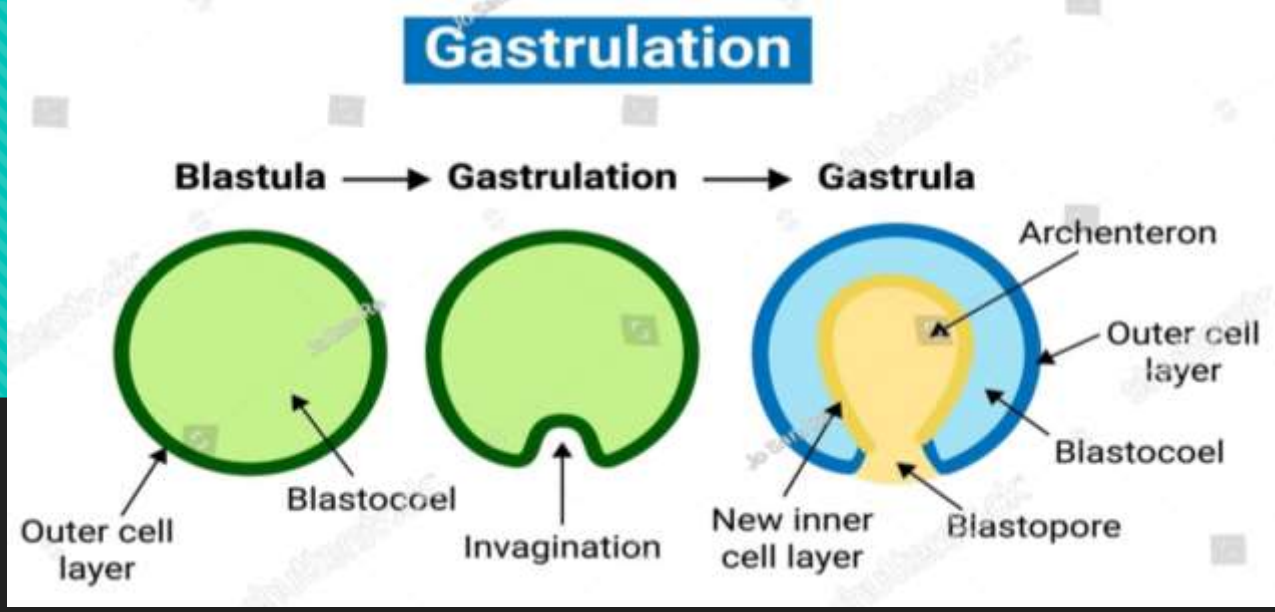
Gastrulation



- 6.1 Definition and Concept.
- 6.2 Basic cell movements in gastrulation: Epiboly, Emboly, Convergence, Invagination, Ingression & Involution with reference to frog.
- 6.3 Concept of Organizer : Primary, Secondary and Tertiary.



Definition and Concept



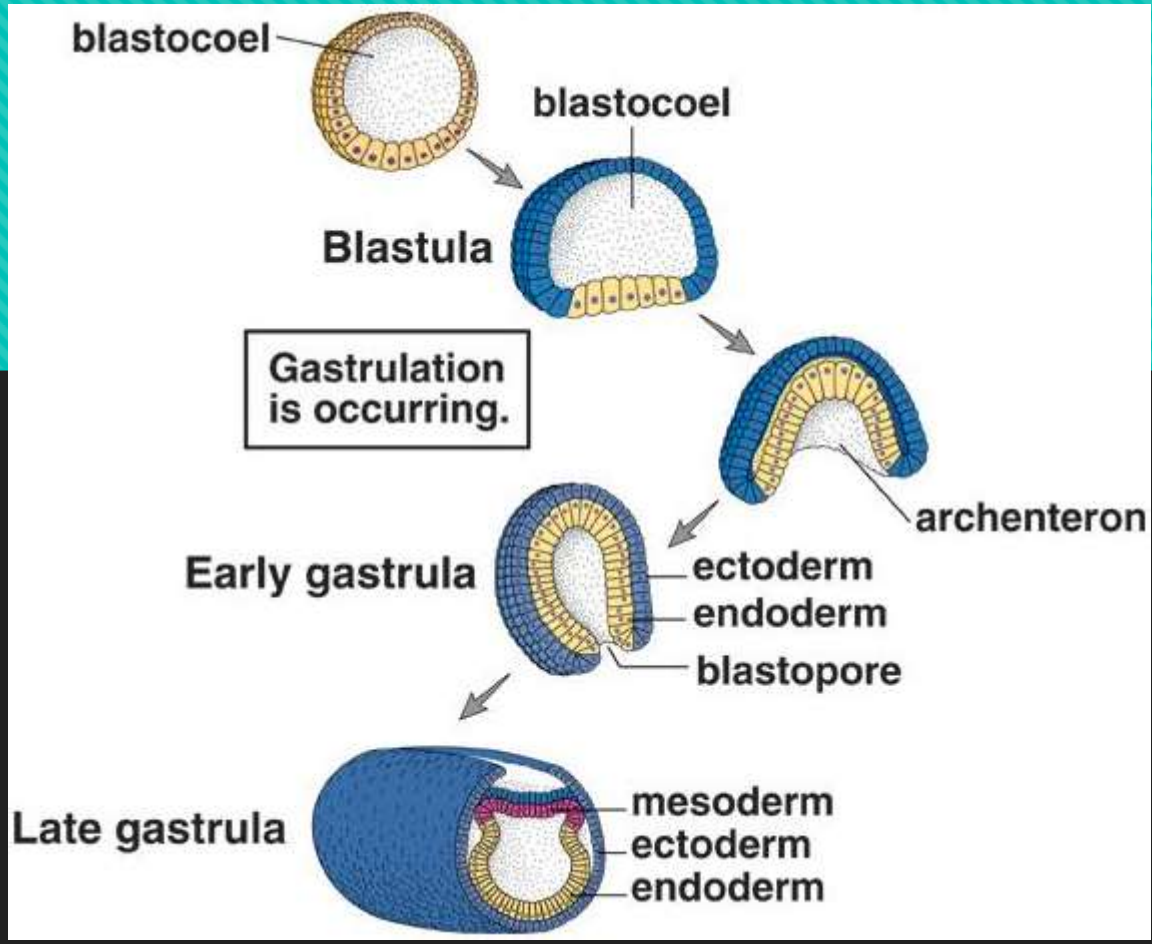
- Gastrulation is the process during embryonic development that changes the embryo from a blastula with a single layer of cells to a gastrula containing multiple layers of cells.
- Gastrulation typically involves the blastula folding in upon itself or dividing, which creates two layers of cells.
- Organisms that do not form a third layer are known as diploblastic organisms.
- These include the jellyfish and related animals.
- Triploblastic organisms contain a third layer, the mesoderm, which is created from one of the first two layers.

- Triploblastic organisms account for the majority of higher animals.

- The layers created by gastrulation become germ layers, or special tissues that give rise to specific parts of the organism.
- These germ layers always give rise to the same types of tissues, even in very different animals.
- The endoderm will give rise to the gut and associated organs.
- The ectoderm is the outermost layer, and will create the skin and the nervous system.
- Between them lies the mesoderm, which will created the connective tissues and musculature in most organisms.
- Before gastrulation, these layers are not defined. Gastrulation proceeds differently based on the organism it is taking place in and the type of blastula it starts from.

- Gastrulation is a fundamental phase of animal embryogenesis during which germ layers are specified, rearranged, and shaped into a body plan with organ rudiments.

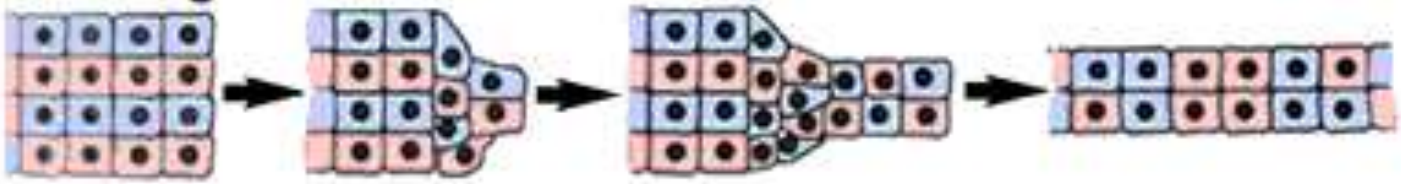
- The term gastrulation, derived from the Greek word gaster, denoting stomach or gut, is a fundamental process of animal embryogenesis that employs cellular rearrangements and movements to reposition and shape the germ layers, thus creating the internal organization as well as the external form of developing animals.



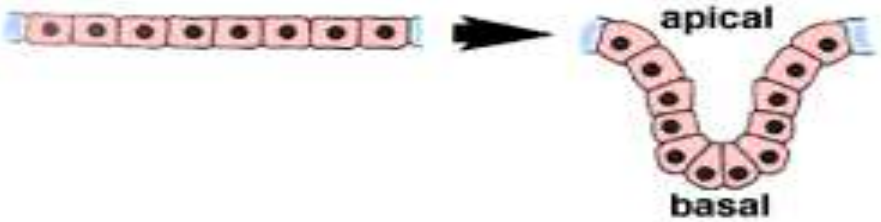
Epiboly

Intercalation

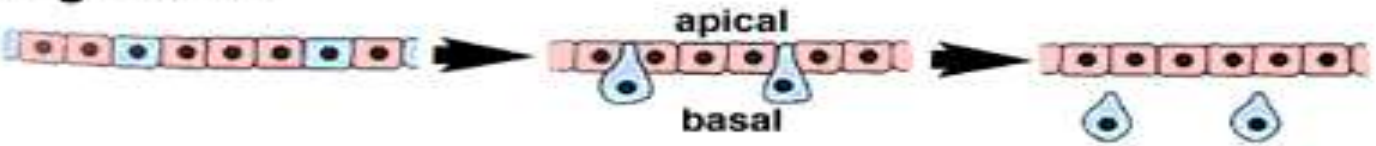
Convergent extension



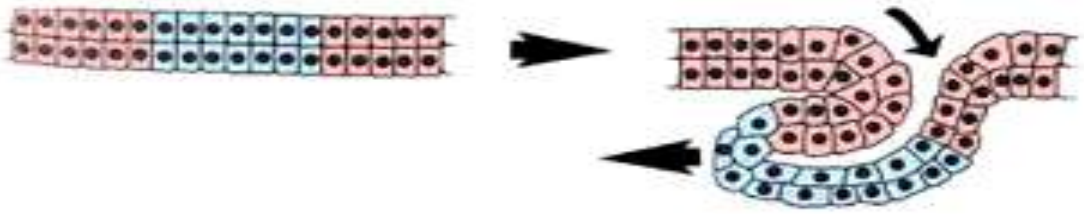
Invagination



Ingression



Involution



GASTRULATION is a complex series of cell movements that:

- a. rearranges cells, giving them new neighbors. These rearrangements put cells in a new environment, with the potential to receive new signals.
- b. results in the formation of the 3 GERM LAYERS that will form most of the subsequent embryo:

ECTODERM, ENDODERM and MESODERM.

- The following general types of morphogenetic movements have been recognized:

a. Individual cells move by:

i. MIGRATION -movement of individual cells over other cells or matrix.

ii. INGRESSION -movement of individual cells or small groups from an epithelium into a cavity.

b. Groups of cells move by:

i. INVAGINATION -local inward buckling of an epithelium

ii. INVOLUTION -inward movement of a cell layer around a point or edge

iii. EPIBOLY -spread of an outside cell layer to envelop a yolk mass or deeper layer

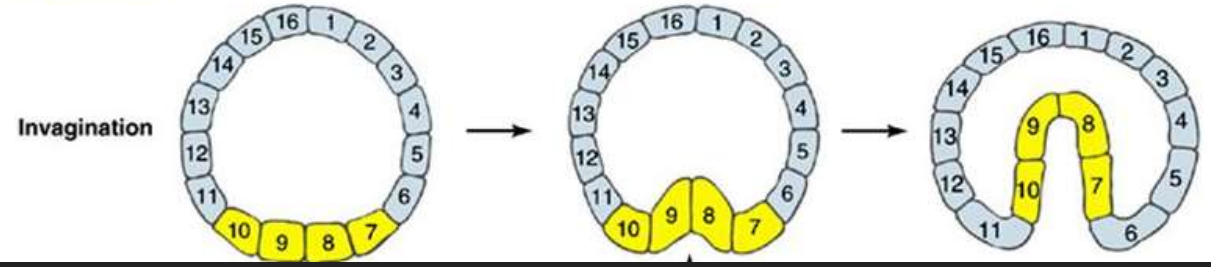
iv. DELAMINATION -splitting 1 cell sheet into 2 or more parallel sheets.

Gastrulation is the first step of morphogenesis

Morphogenesis is the process whereby individual cells undergo complex movements that generate the organ rudiments. Gastrulation generates the three basic germ layers from which organs arise.

How do sheets of cells (epithelia) move during gastrulation? 4 methods.

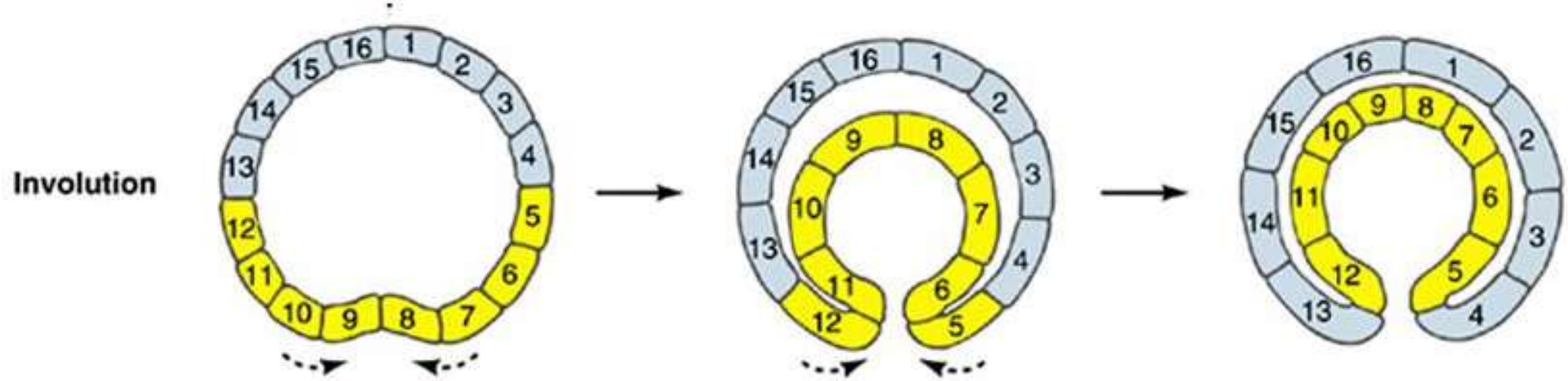
Invagination is the local inward movement of cells from a cavity



Invagination:

- A small depression is formed in the region occupied by the grey crescent area.
- This depression grows inwards and forms the archenteron or gastrocoel or secondary body cavity.
- The outer opening of the gastrocoel is called the gastropole. As the gastrocoel increases in size the blastocoel gets reduced.
- Ultimately only a slit like semicircular cavity indicates the remnants of the blastocoel.
- The blastopore meanwhile becomes expanded and becomes ring shaped.

Involution is similar, but more dramatic. It is an inward expansion of epithelial cells around an edge such as the blastpore.



Involution:

- During this process the cells which have grown backward during epiboly now roll inside at the margin of the blastopore.
- The endoderm is the first to roll inside.
- The cells of the notochord and mesoderm which were formed outside now migrate over the lip of blastopore and become internal and arrange themselves on the roof, sides and the floor of the archenteron.
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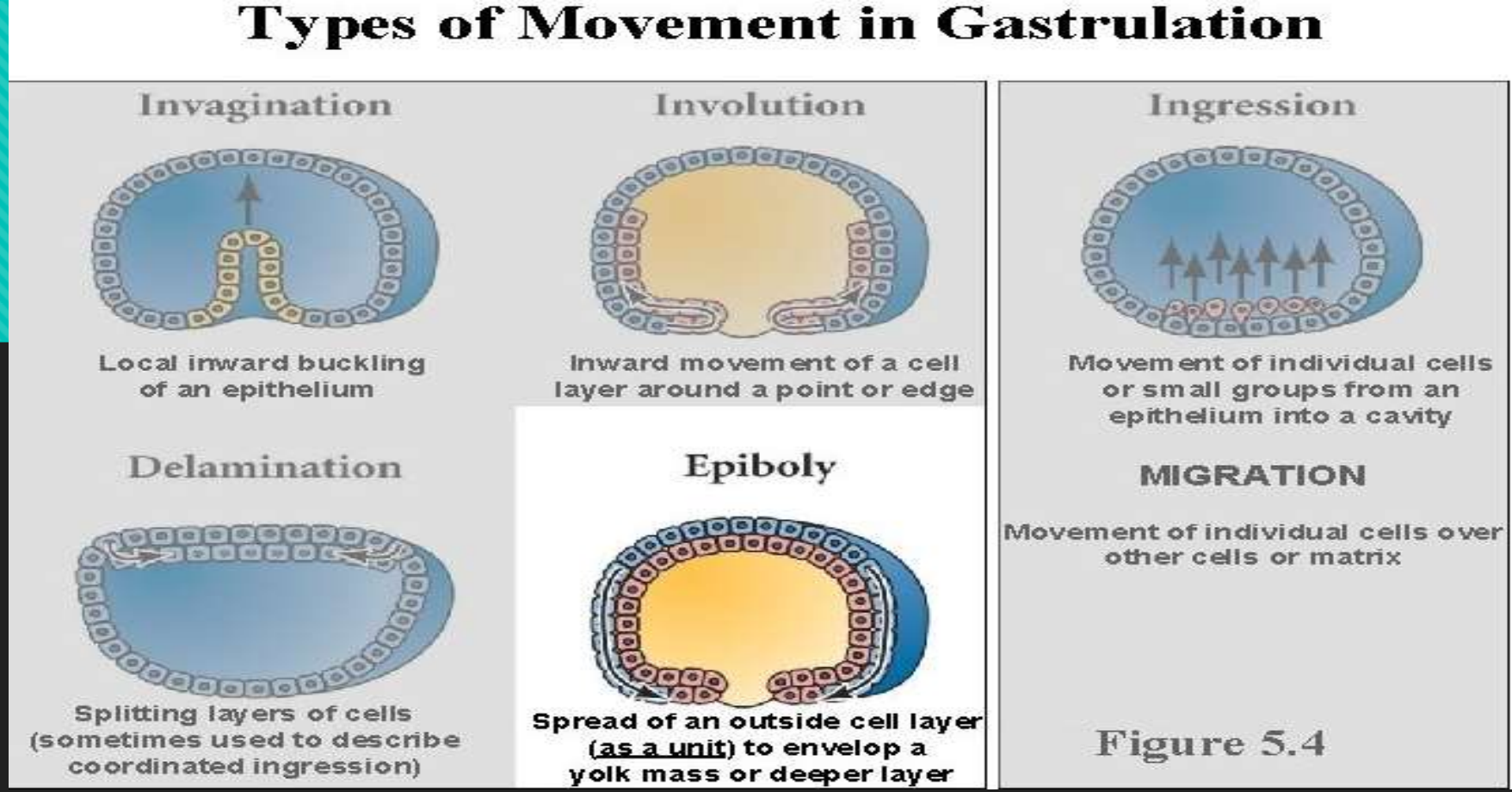
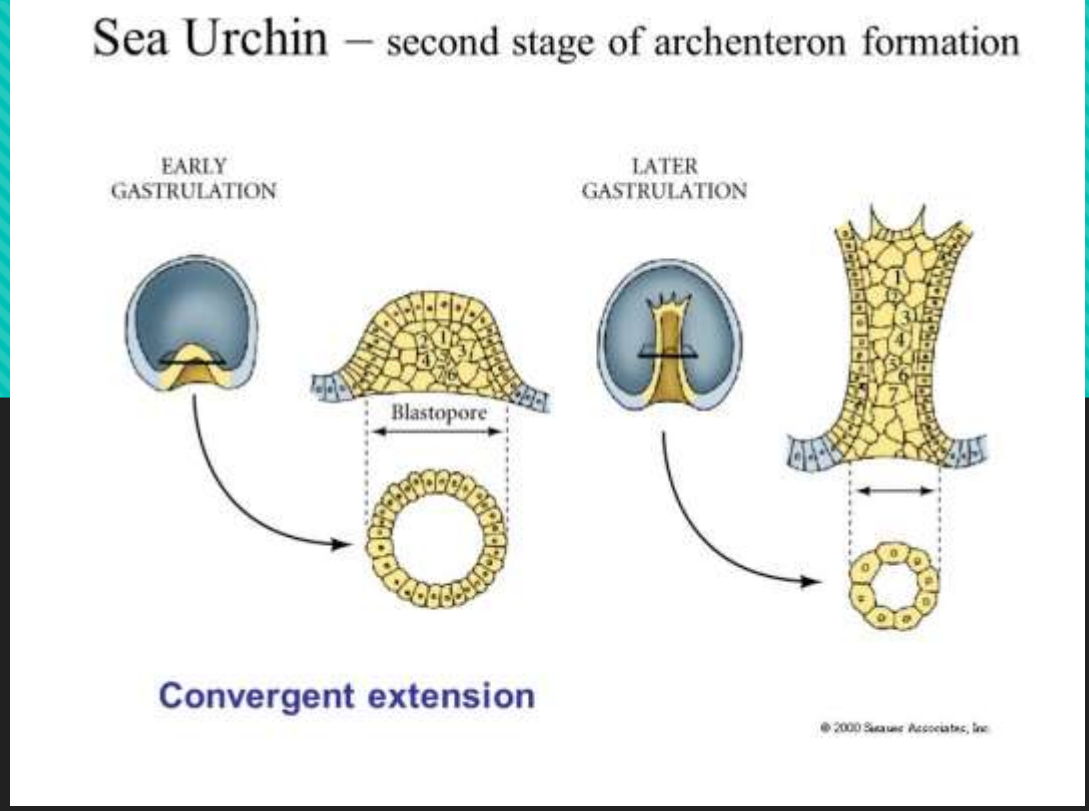
- The notochord cells are found on the roof along the midline.
- While the endoderm forms the anterior, lateral and ventral walls, the mesoderm forms wing like extensions in the archenteron.



Epiboly:

- In the late blastula, the anterior half consists of micromeres which constitute the ectoderm while the posterior megameres constitute the endoderm.
- The germ ring forms the mesoderm.
- During epiboly the ectoderm overgrows backwards on the endoderm; ultimately the entire embryo (except for the small area called the yolk plug) is covered by the ectoderm.
- In other words the pigmented micromeres (animal half) grow over the megameres (vegetative half).
- The reason for overgrowth is the rapid rate of division of micromeres.



Convergence:

- Convergence means the movement of cells towards a particular point.
- The presumptive cells of the notochord and mesoderm located on the surface of the blastula move towards the blastopore or primitive streak.

Ingression:
Migration of individual cells into the embryo

Example:
Drosophila neuroblasts

Ingression:

- Ingression involves movement of individual or groups of cells from the external layer of blastula
- into the blastocoels. It is categorized into two types-unipolar and multipolar.
- Unipolar ingression: in which individual cells migrate inwards at one end of a blastoderm.eg.
- Porifera and Coelenterata
- Multipolar ingression: in which individual cells migrate inwards from all points of the blastocoels.
- Eg. *Echidna*

- Following are the derivatives of the three germ layers during development:

Ectoderm

- Nervous tissue
- Epidermis of the skin
- Sensory organs

Endoderm

- Gut tract lining
- Digestive glands
- Respiratory tract lining

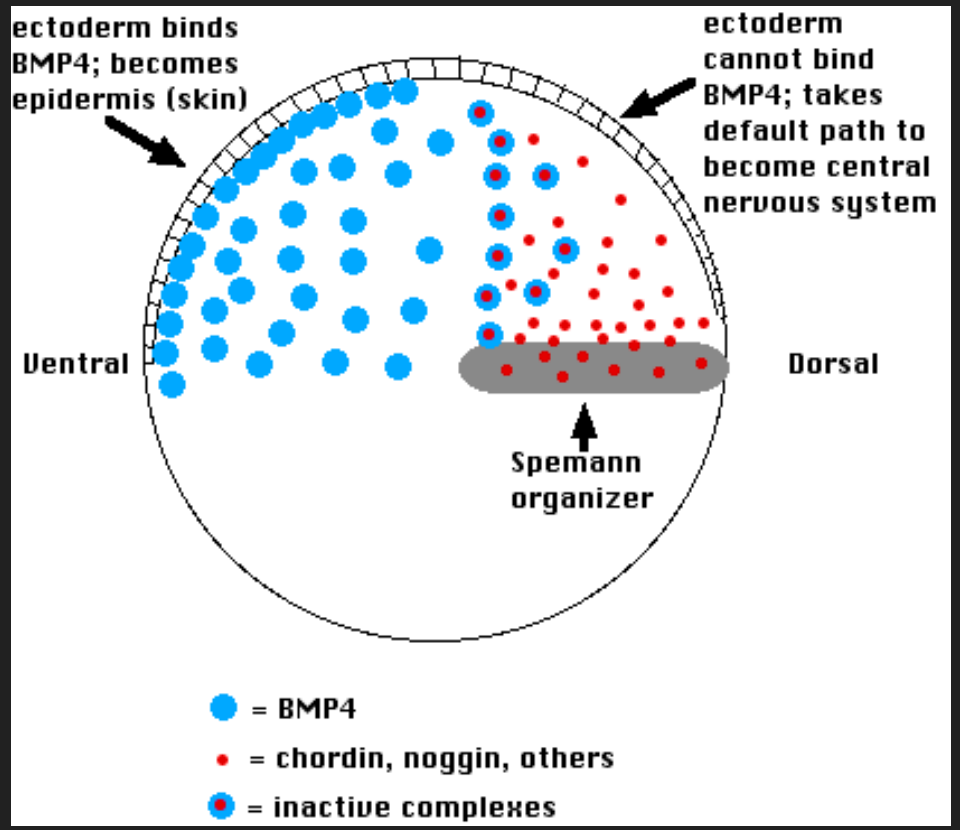
Mesoderm

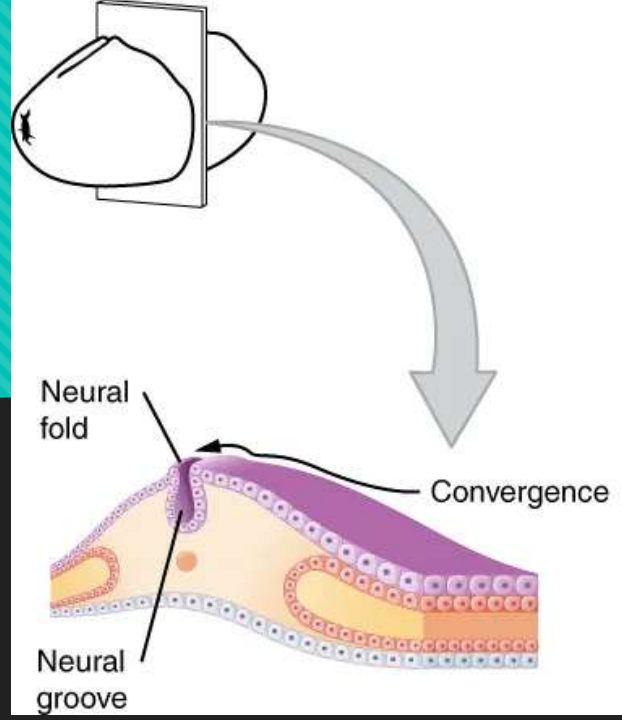
- Connective tissues
- Circulatory system
- Bones, tendons, ligaments
- Dermis of the skin
- Excretory structures
- Reproductive structures
- Muscle

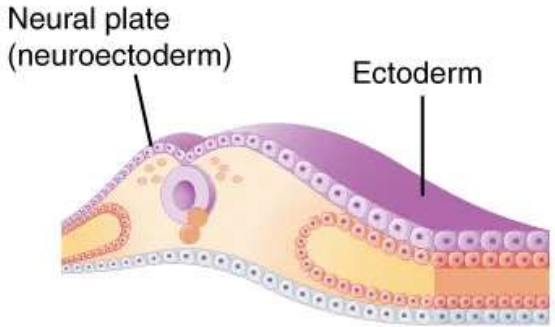
What is an organizer?

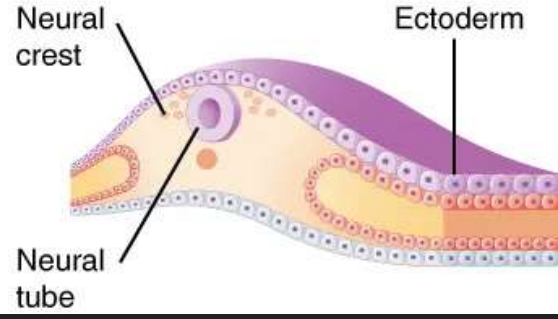
- The effect of embryonic interaction or organizer is a morphogenetic effect by which one organic tissue transmits a chemical substance that influences other embryonic part to produce a structure that otherwise could not come into existence.
- The embryonic tissue which exerts such an influence is called an inductor and the chemical substance secreted by an inductor is known as evocators.
- The tissue on which evocator works and the tissue responses is known as responsive tissue.
- The action of the indicator through evocator is known as induction action or organizer action.
- This process of induction influences greatly the protein synthesis mechanism of responsive tissues as a result of which definite structure forming cells become very active

- Spemann and Mangold transplanted a blastopore lip between different ectodermal regions of amphibian embryos.
- The transplanted dorsal tissue differentiated mostly into a notochord, while the ectoderm of the host dorsal tissue that was sitting above the transplanted region (blastopore lip) was induced and differentiated to form a Siamese twin containing dorsal tissues such as somites and a neural plate, which would form the central nervous system, forming the bulk of a second axis.
- Spemann and Mangold found the first evidence of the organizing center, thereafter called the “Spemann organizer”, and its major role in the development of vertebrates.









PRIMARY ORGANIZER

- When Spemann transplanted portions, only graft taken from the dorsal lip of the blastopore and the adjoining parts of the marginal zone were found to be able to induce.
- It is the capability of the dorsal lip of the blastopore (when transplanted) to cause the production of a total embryo, that Spemann called Organizer.
- Spemann gave this dynamic region, the name of organizer because of its significance in organizing the development.
- He imagined the organizer initiating the development of the morphogenesis and differentiation by inducing the structure of the neural tube.
- Thus, the dorsal lip of the blastopore is termed as the “Primary organizer”.

SECONDARY, TERTIARY AND QUATERNARY ORGANIZERS

- As gastrulation continues, the different organ system of the embryo are laid down under the power of the primary organizer and they themselves then obtain the influence of inducing later formed structures to develop.
- It is thus probable to know a sequence of secondary, tertiary and quaternary organizers, which are set in a short of chain of command at whose summit is the primary organizer.
- These developed tissues then work together with another tissue in rotation and induce it to develop.
- In other words, one tissue gives the stimulus for the development of the other tissue subsequently.

- The influence that comes from the organizer is known as embryonic induction.
- The chemical basis of this induction is analyzed and finally revealed that these are nucleic acids.

Thank You …….!