

GASTRULATION

Animals have bodies of diverse shapes with internal collections of organs of unique morphology and function. Such sophisticated body architecture is elaborated during embryonic development, whereby a fertilized egg undergoes a program of cell divisions, fate specification, and movements.

One key process of embryogenesis is determination of the anteroposterior (AP), dorsoventral (DV), and left-right (LR) embryonic axes. Other aspects of embryogenesis are specification of the germ layers, endoderm, mesoderm, and ectoderm, as well as their subsequent patterning and diversification of cell fates along the embryonic axes. These processes occur very early during development when most embryos consist of a relatively small number of morphologically similar cells arranged in simple structures, such as cell balls or sheets, which can be flat or cup shaped.

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.

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.

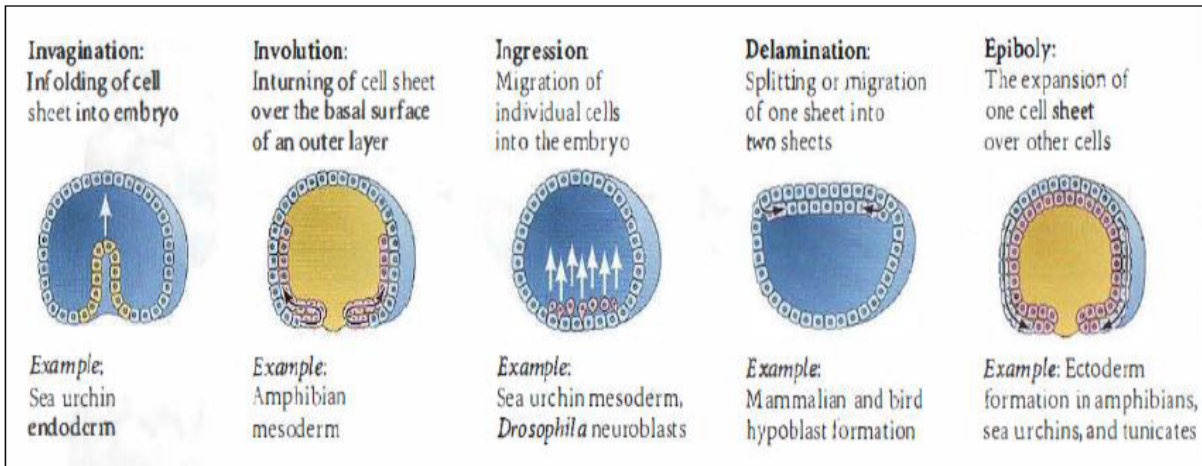
b. Groups of cells move by:

- 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

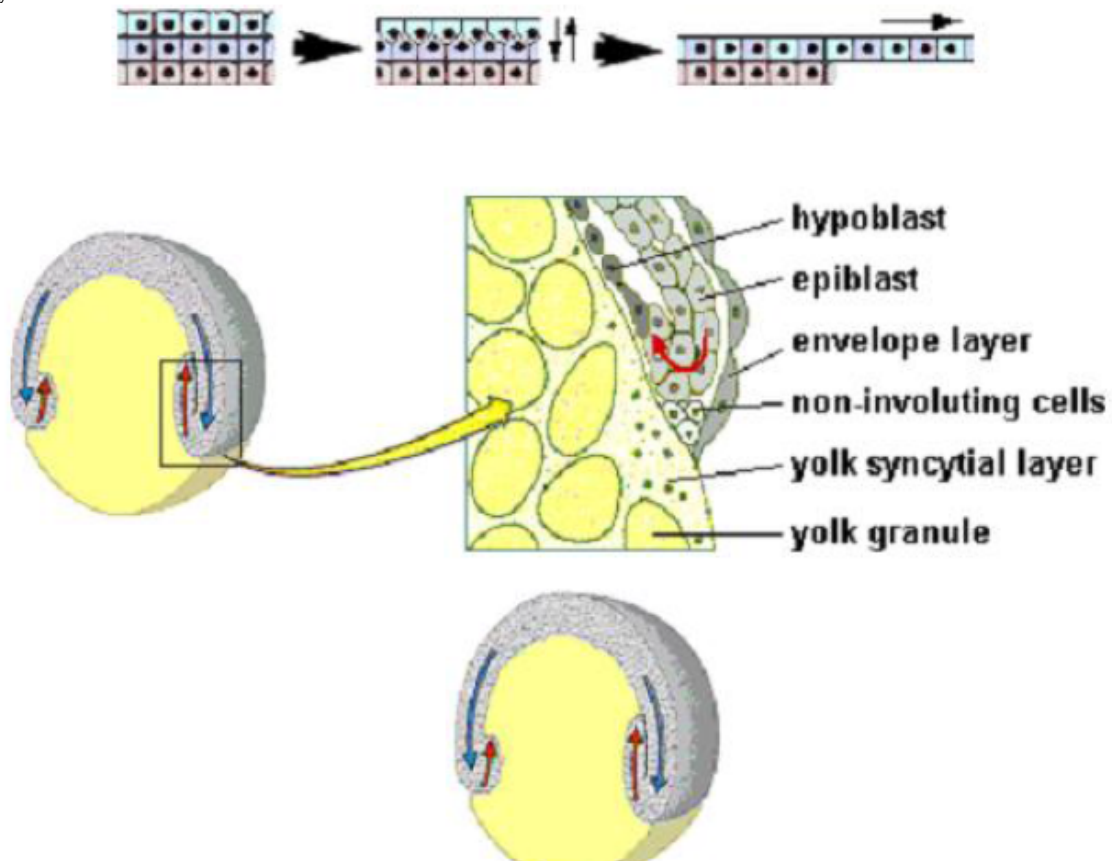
iv. DELAMINATION -splitting 1 cell sheet into 2 or more parallel sheets.

v. CONVERGENT EXTENSION -elongation of a cell layer in one dimension with shortening in another.



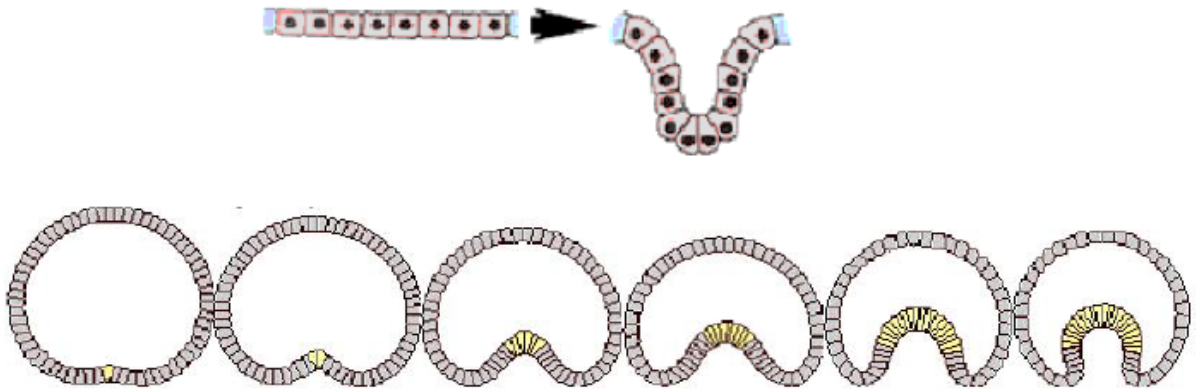
Types of cell movements during gastrulation.

Epiboly:



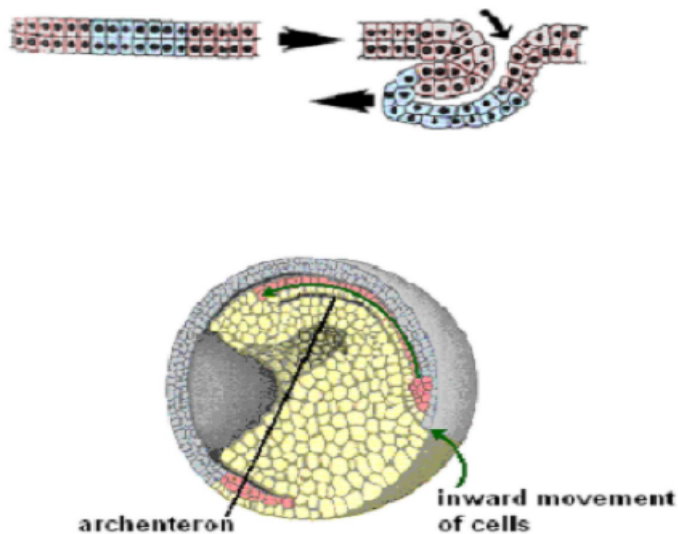
In the late blastula, the anterior half consists of micromeres which constitute the ectoderm while the posterior megameres constitute the endoderm. The germ ring forms the mesoderm. During epiboly the ectoderm overgrows backwards on the endoderm; ultimately the entire embryo (except for the small area 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.

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 gastropore. As the gastrocoel increases in size the blastocoels 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:



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. 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.

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.

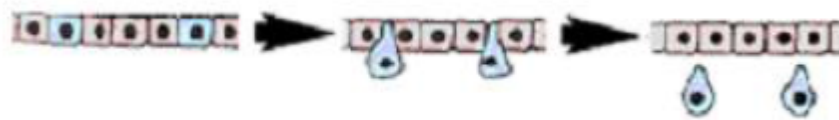
Infiltration:

This involves the detachment of individual cells or groups of cells from the surface of the blastula and their falling into the blastocoels. In the blastocoels they arrange themselves as a single layer.

Divergence:

It refers to the migration of involuted cells from the blastopore or primitive streak. In divergence the cells move in different directions from a single point. The involuted cells of notochord and mesoderm migrate and diverge from the blastopore and primitive streak to their future positions within the developing embryo.

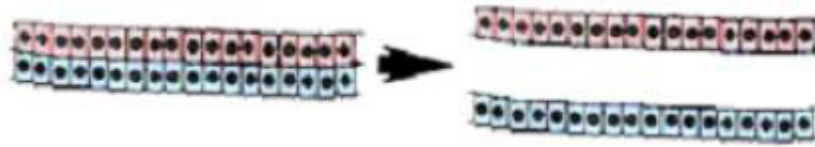
Ingression:



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

Delamination:



The word delamination means mass separation of groups of cells from other cell groups. The separation of endodermal, mesodermal and notochordal cells from each other in teleost fishes is a good example for delamination. According to a widely accepted view the endoderm formation in birds takesplace by delamination.

Germ Layer theory and derivatives of germ layers In 1817, pander described a trilaminar condition of the chick blastoderm. Later this trilayer concept was proved true for many types of embryos and this concept became an accepted embryological principle. Towards the end of 19th century the terms ectoderm, endoderm and mesoderm were introduced to refer to the outer, inner and middle layers of the embryo respectively. The adult organs do not arise directly from the cells derived by the cleavages of the zygote. The embryonic cells are at first arranged into layers called germ layers from which various organs are formed. This concept is known as germ layer theory.

Tissues and organs of animals arise from layers, or blocks, of embryonic cells called primary germ layers. Their development from a nondescript form in the early embryo to their form in late embryonic through adult stages is called differentiation. One layer, ectoderm (Gr. ektos, outside derm, skin), gives rise to the outer body wall. Endoderm (Gr. endo, within) forms the inner lining of the digestive cavity. Mesoderm (Gr. meso, in the middle) gives rise to tissues between ectoderm and endoderm. Undifferentiated mesoderm (called mesenchyme) develops into muscles, blood and blood vessels, skeletal elements, and other connective tissues.

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

Significance of gastrulation

1. Due to morphogenetic movements various arrangements of the cells take place.
2. Rate of cell division gradually diminishes
3. Rate of oxidation increases
4. Qualitative increase of metabolism takes place
5. Nucleus becomes more active in the activities of embryonic cells.
6. Presumptive structures are placed in the right position of the embryo
7. For the morphogenesis of the nervous system gastrulation is very important.