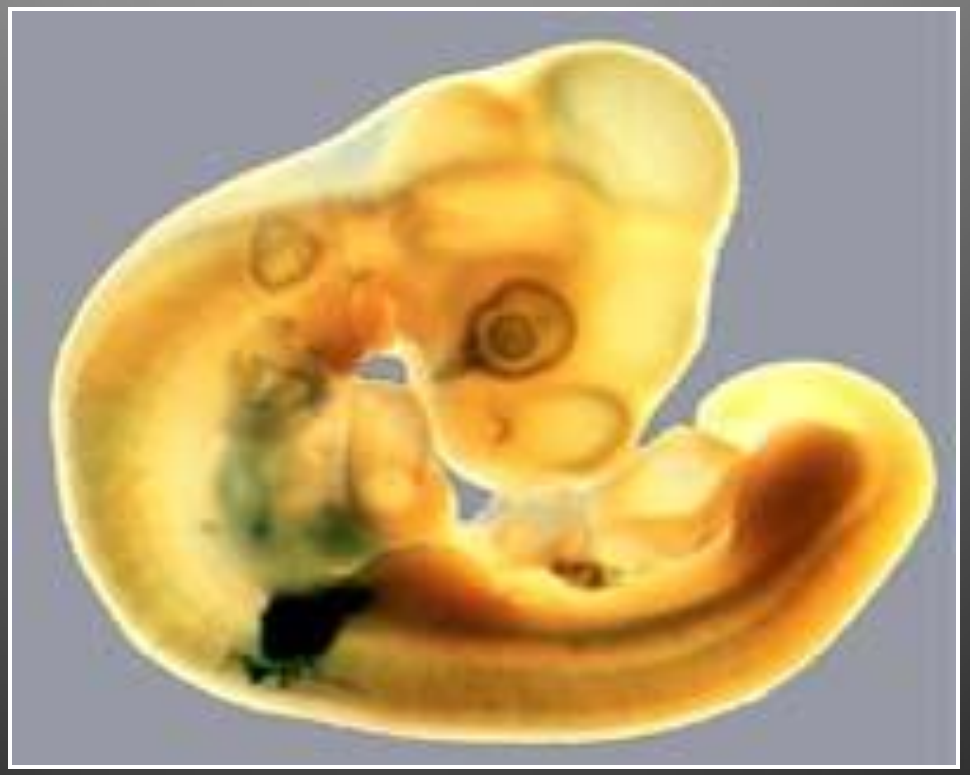
Gastrulation, Mechanism, Types of Movements and Fate Maps



GASTRULATION is a complex series of cell movements that:

--rearranges cells, giving them new neighbors
--results in the formation of 3 GERM LAYERS that will form the subsequent embryo: ectoderm, endoderm and mesoderm
--forms the main body axes of the embryo (they were specified earlier but not formed)

Gastrulation

Gastrulation is a process involving a complex series of cell shape changes and cell movements that occurs in the blastula

-It establishes the basic body plan and creates the three **primary germ** layers

-**Ectoderm** – Exterior

-**Mesoderm** – Middle

-**Endoderm** – Inner

Gastrulation

TABLE 53.3	Developmental Fates of the Primary Germ Layers in Vertebrates
Ectoderm	Epidermis of skin, nervous system, sense organs
Mesoderm	Skeleton, muscles, blood vessels, heart, blood, gonads, kidneys, dermis of skin
Endoderm	Lining of digestive and respiratory tracts, liver, pancreas, thymus, thyroid

Gastrulation

Cells move during gastrulation using a variety of cell shape changes

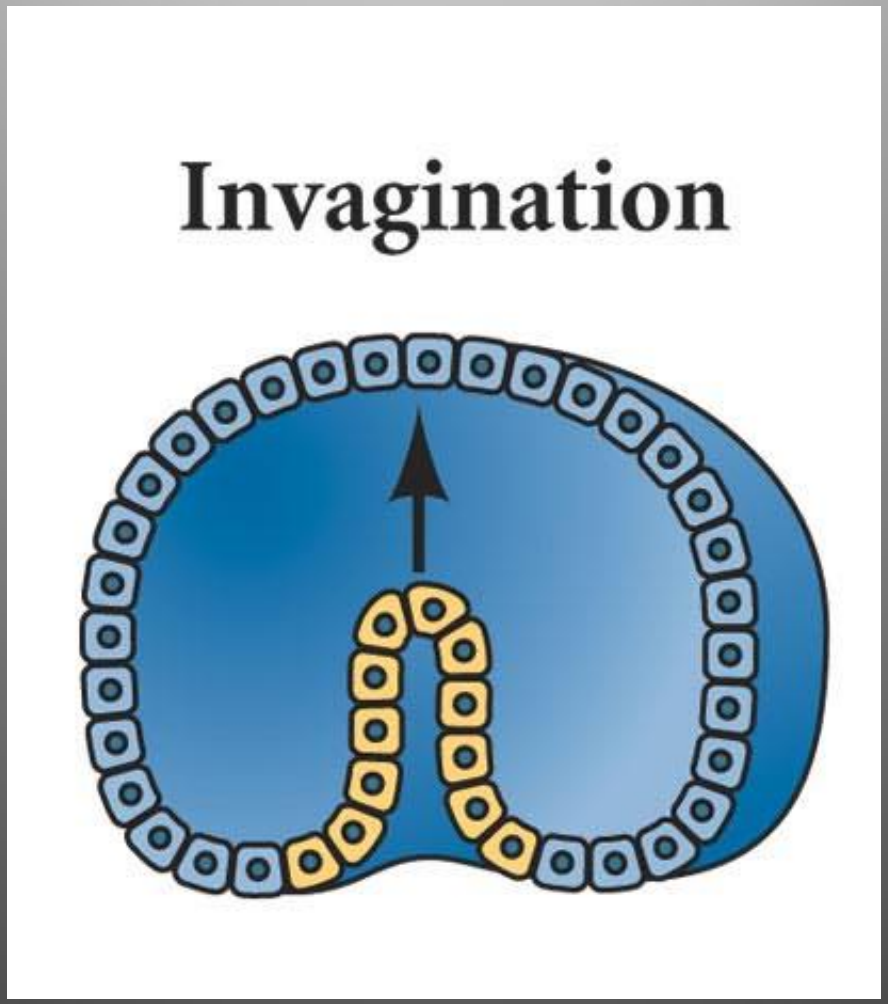
-Cells that are tightly attached to each other via junctions will move as cell sheets

-**Invagination** – Cell sheet dents inward

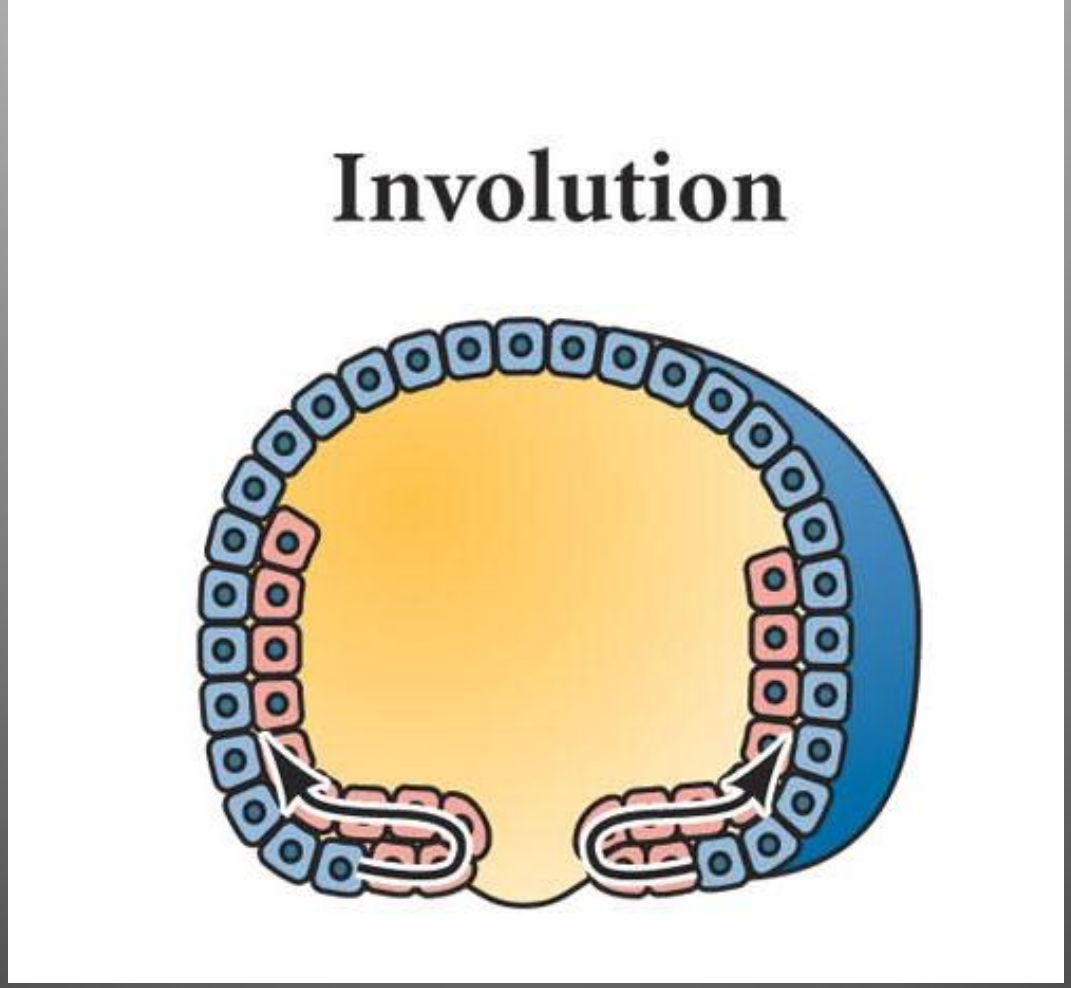
-**Involution** – Cell sheet rolls inward

-**Delamination** – Cell sheet splits in two

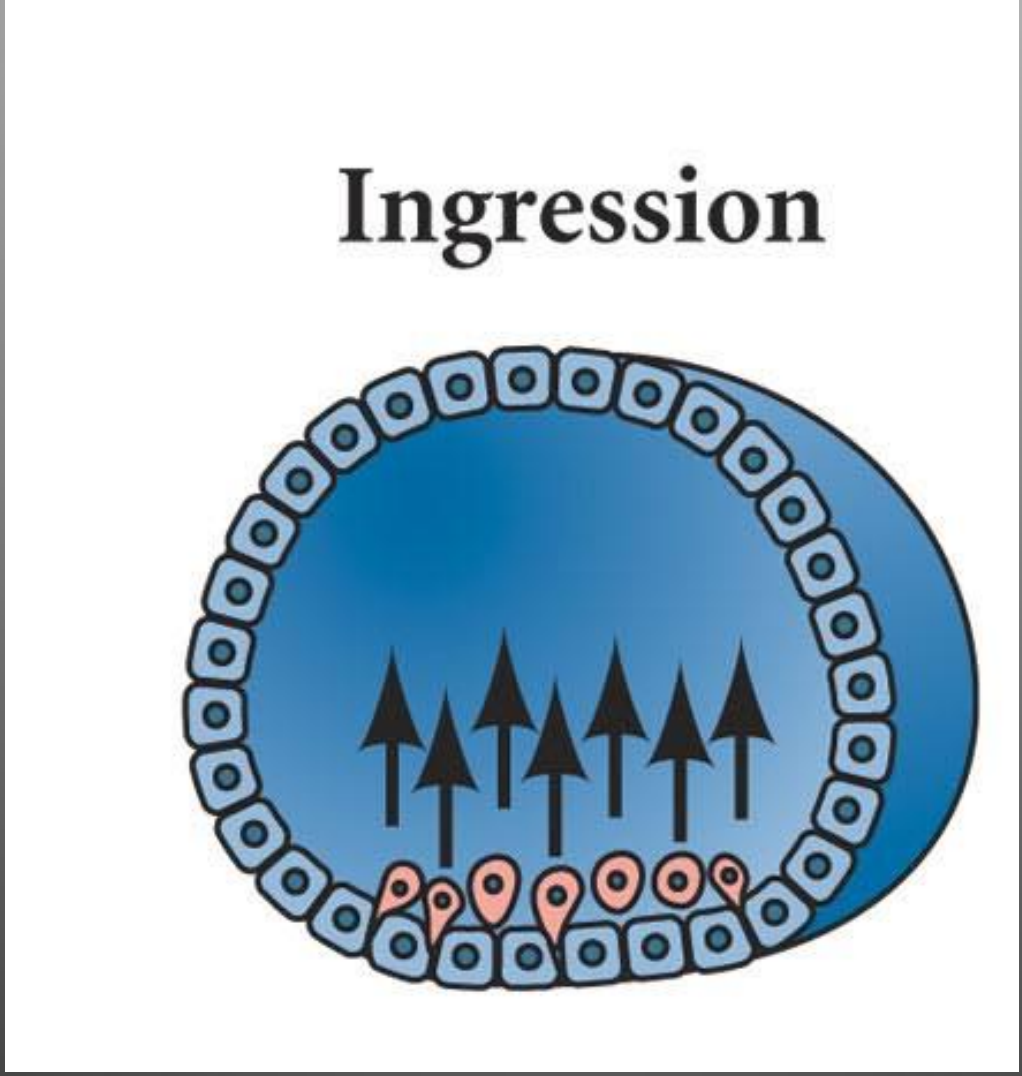
-**Ingression** – Cells break away from cell sheet and migrate as individual cells



Invagination- the infolding of a region of cells

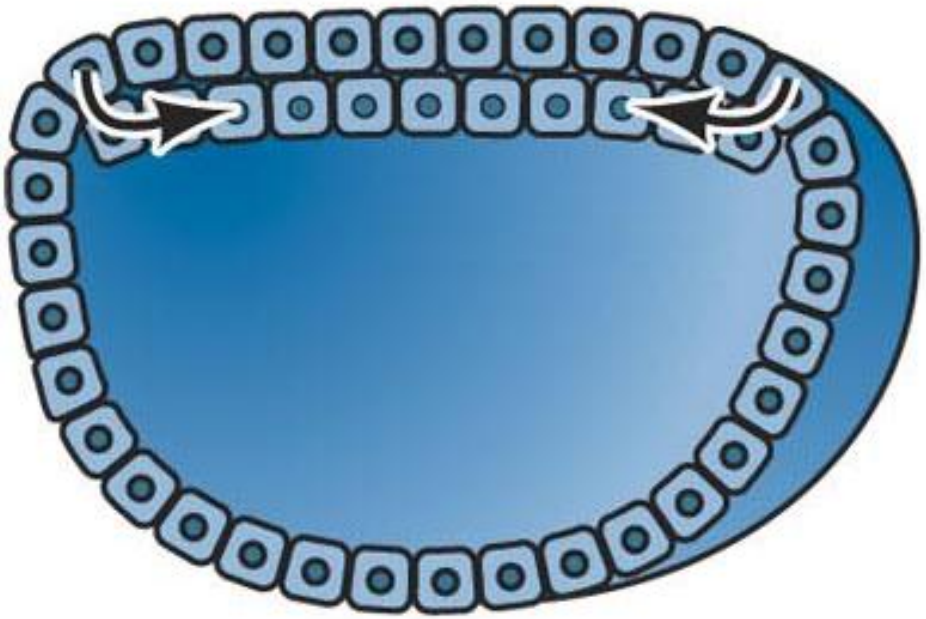


Involution- the inturning of an expanding outer layer of cells

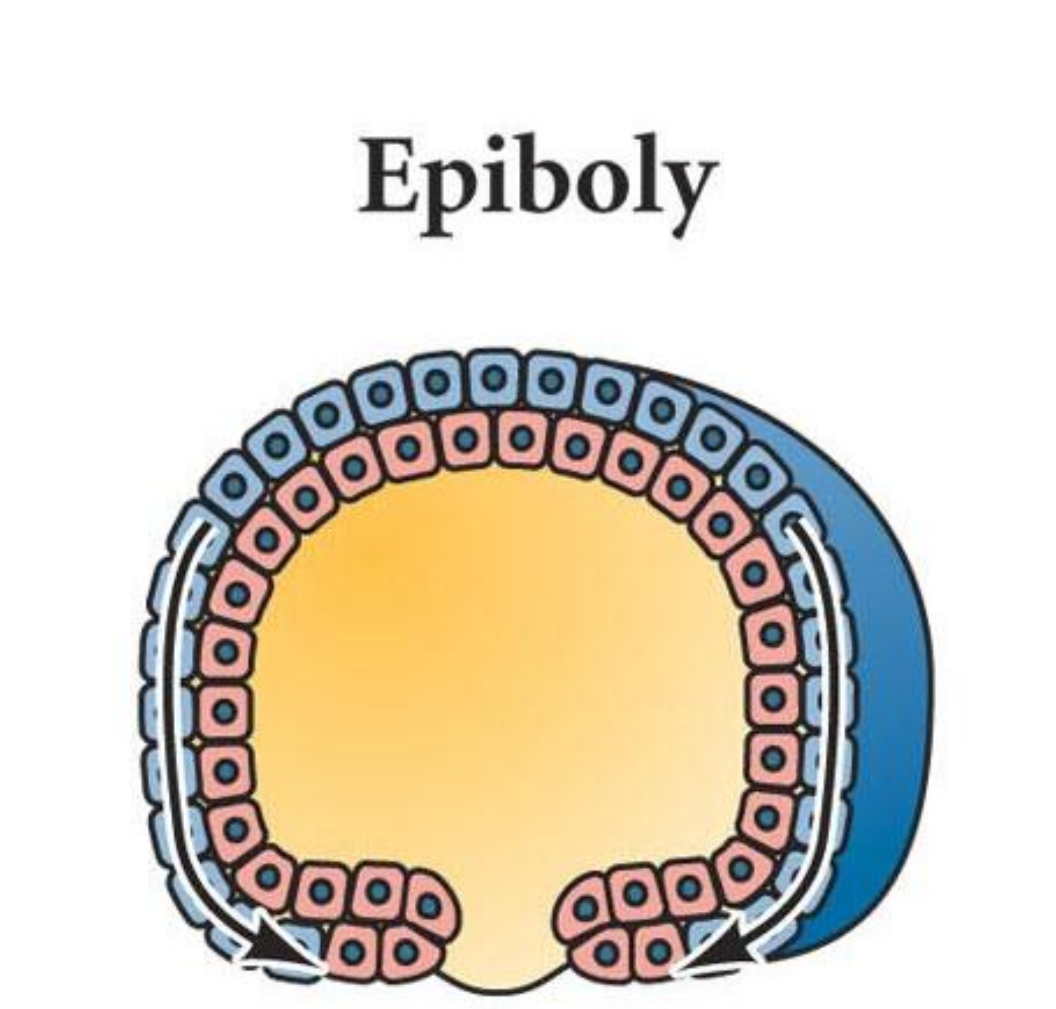


Ingression- the migration of individual cells from surface to interior

Delamination

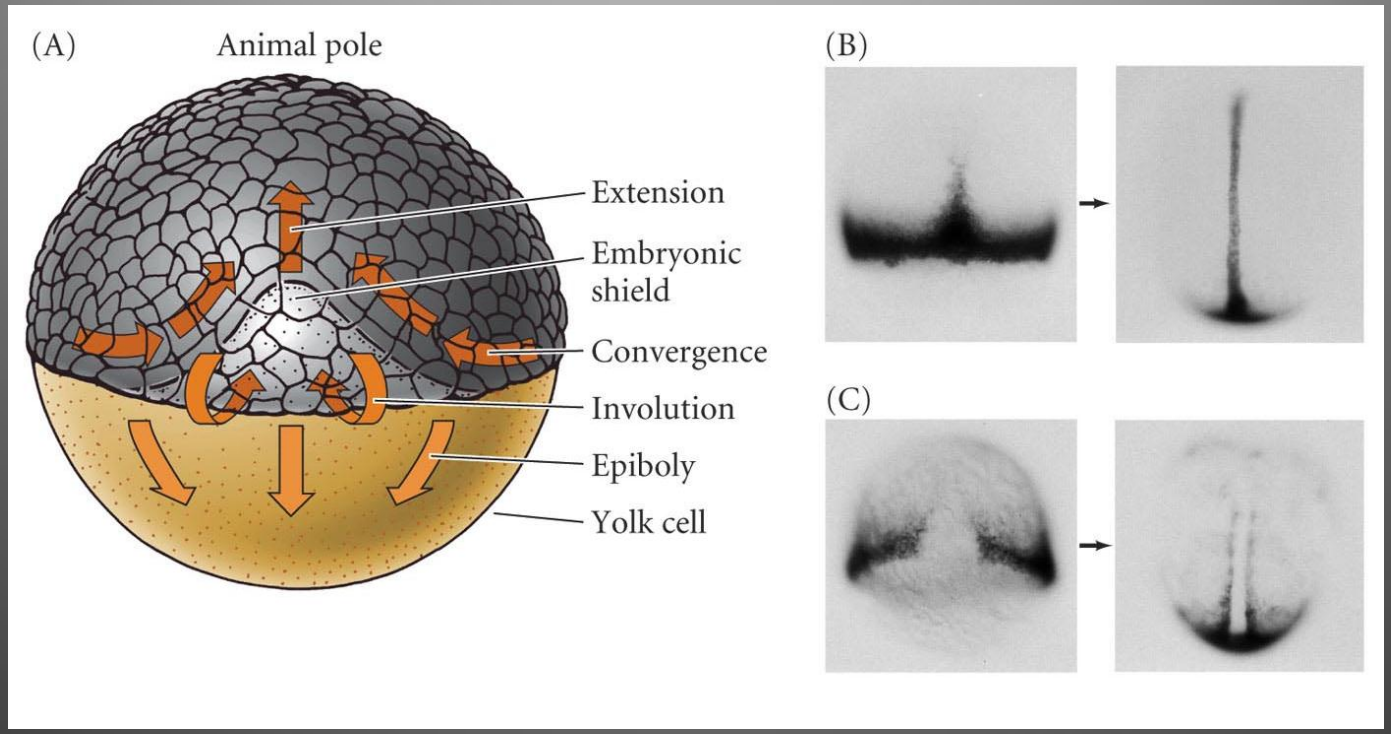


Delamination- the splitting of one sheet of cells into two parallel sheets of cells



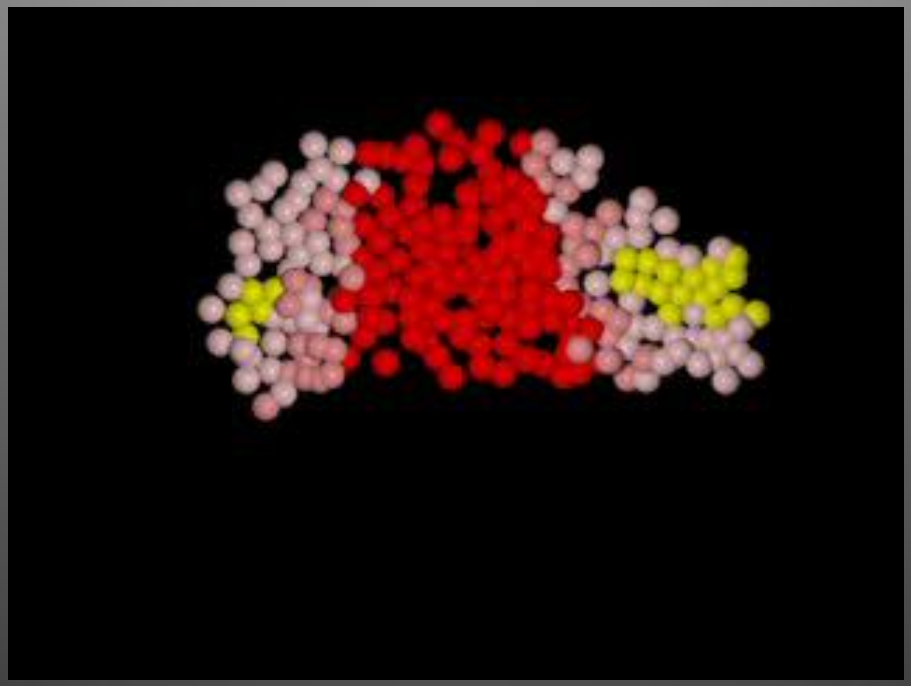
Epiboly- the movement of epithelial sheets that spread as a unit to cover the embryo

Convergent Extension



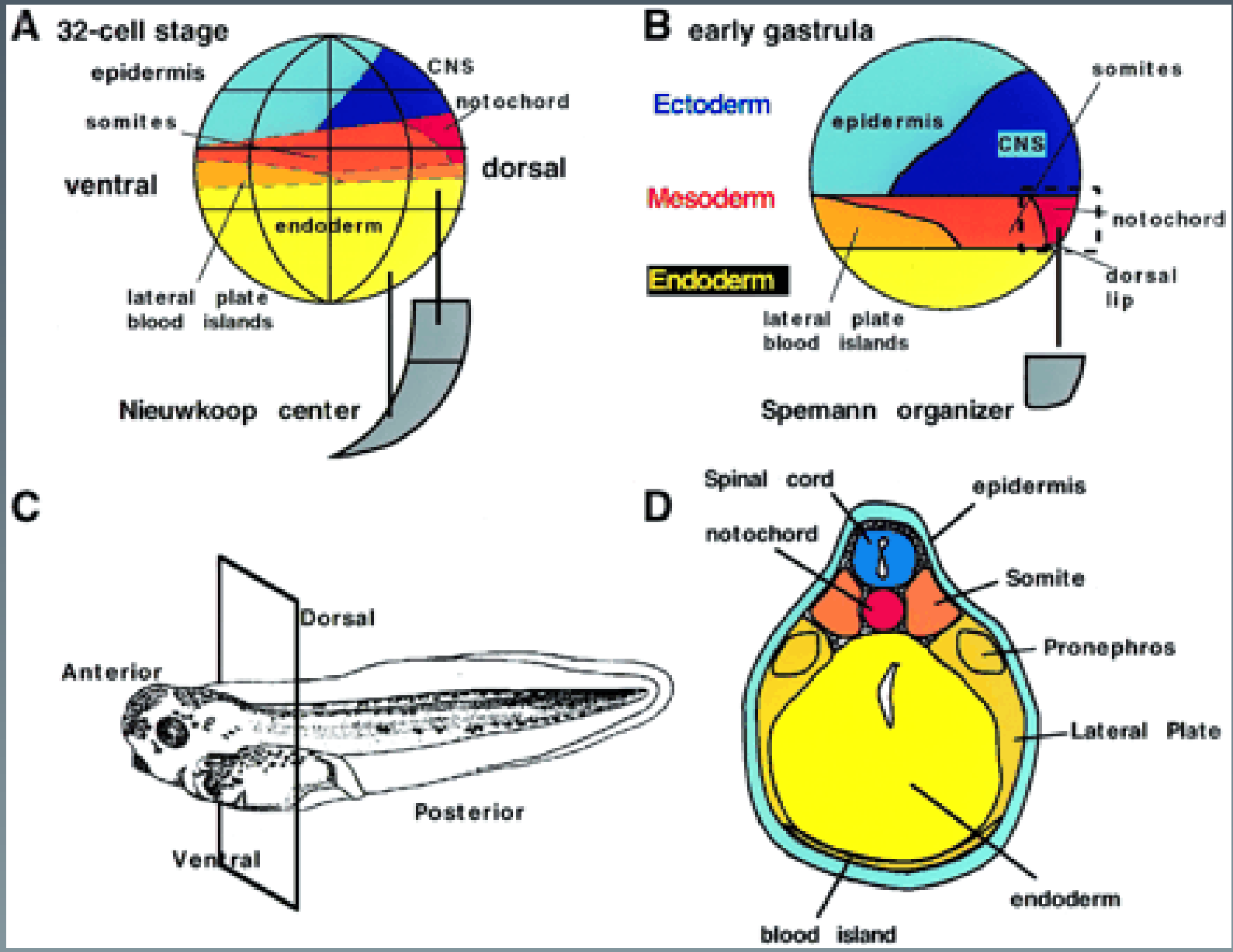
Convergent extension- the lengthening of a group of cells in the long axis while shortening in the perpendicular axis

Cell Movements during Convergent Extension in Zebrafish



Fate Maps

- FATE MAPS = diagram of blastula/blastodisc showing the "fate" of each part.
- Fate mapping technique developed by Vogt in 1920s. Involves …
  - Marking surface of blastula with vital dyes
  - Dyes retained by cells for prolonged periods, but don't interfere with normal cellular processes
  - Follow movements of marked cells during gastrulation to ultimate locations in later embryos

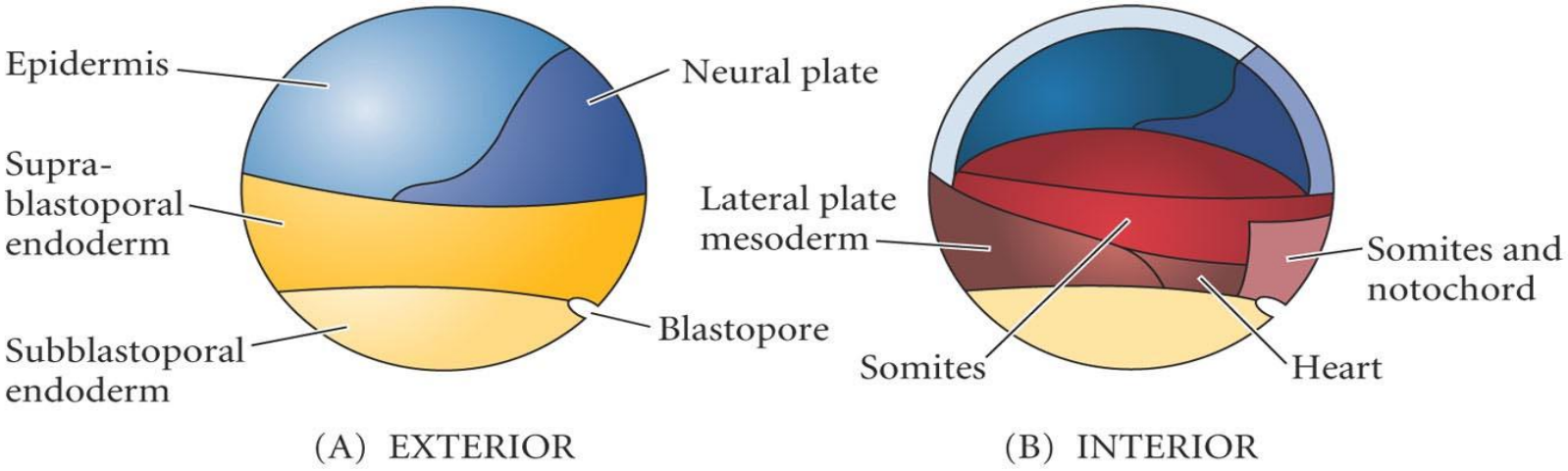


Sample fate map of frog embryo

The fate map of the Xenopus blastula shows the presence of yolky macromeres at the vegetal pole which gives rise to the endoderm. Depending upon the position of the blastopore, the endodermal area can be divided into the sub-blastoporal and supra-blastoporal endoderm.

The cells toward the animal pole gives rise to the ectoderm, which becomes further subdivided into epidermis and the future nervous tissue. The epidermal ectoderm forms at the ventral side of the animal hemisphere, while the neural ectoderm forms at the dorsal side.

Fate Map of the Blastula of the Frog Xenopus

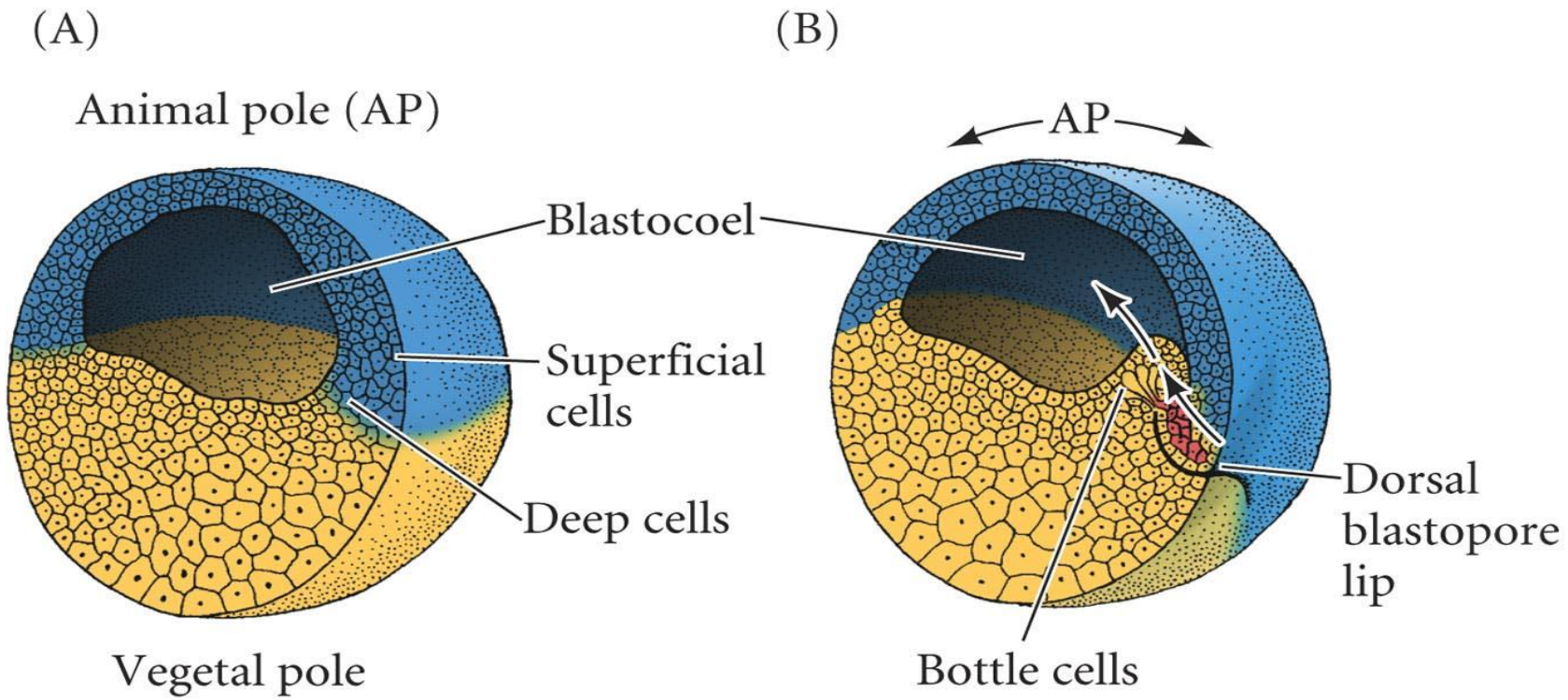


The mesoderm forms a belt-like region, known as the marginal zone, around the equator of the blastula.

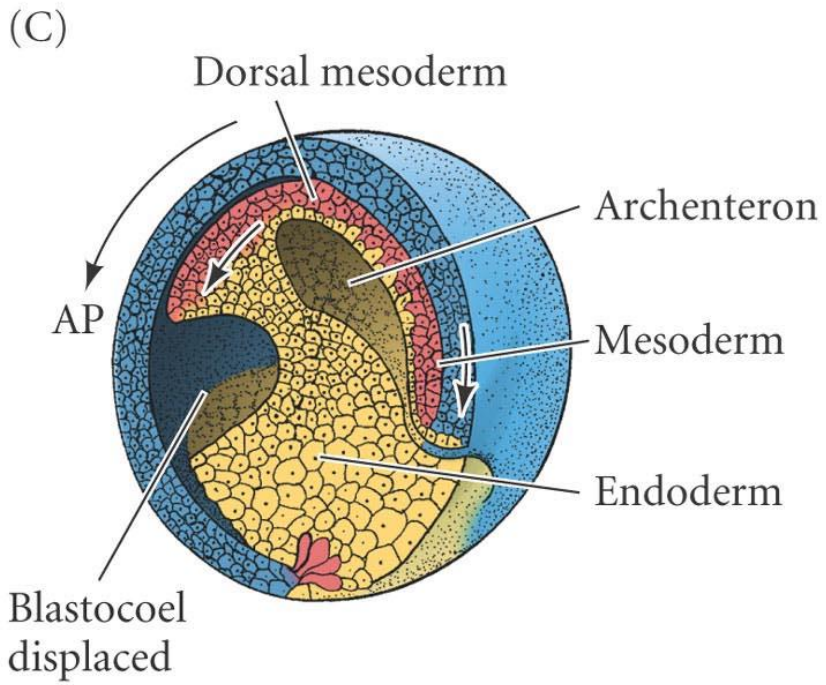
The mesoderm becomes subdivided along the dorsoventral axis of the blastula. The most dorsal mesoderm gives rise to the notochord. From this ventrally, the- mesoderm is differentiated by the somites (which gives rise to muscle tissue), lateral plate (which contains heart and kidney mesoderm) and blood islands.

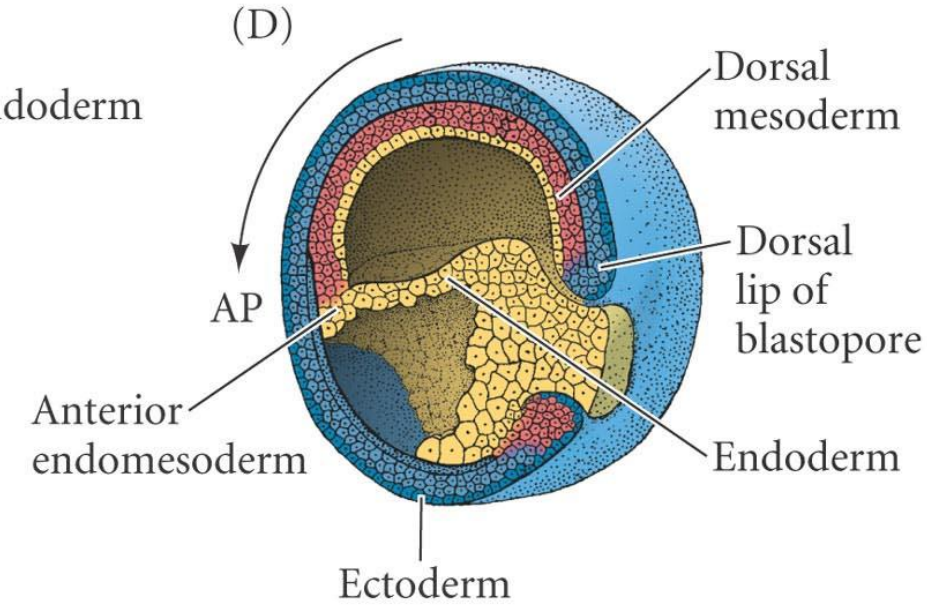
In Xenopus, a thin outer layer of presumptive endoderm overlies the presumptive mesoderm in the marginal zone.

Cell Movements During Frog Gastrulation - Early



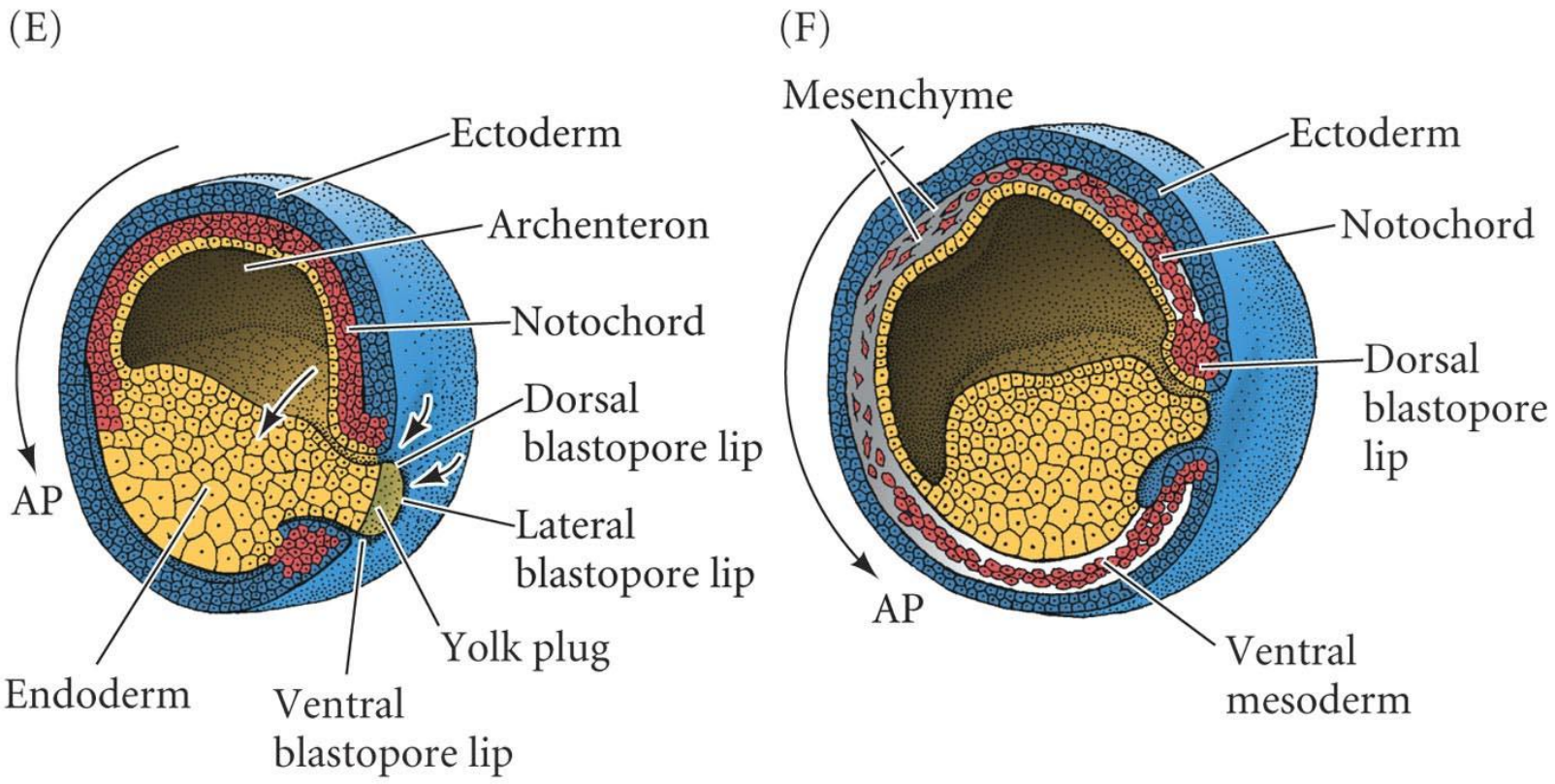
Cell Movements During Frog Gastrulation - Mid



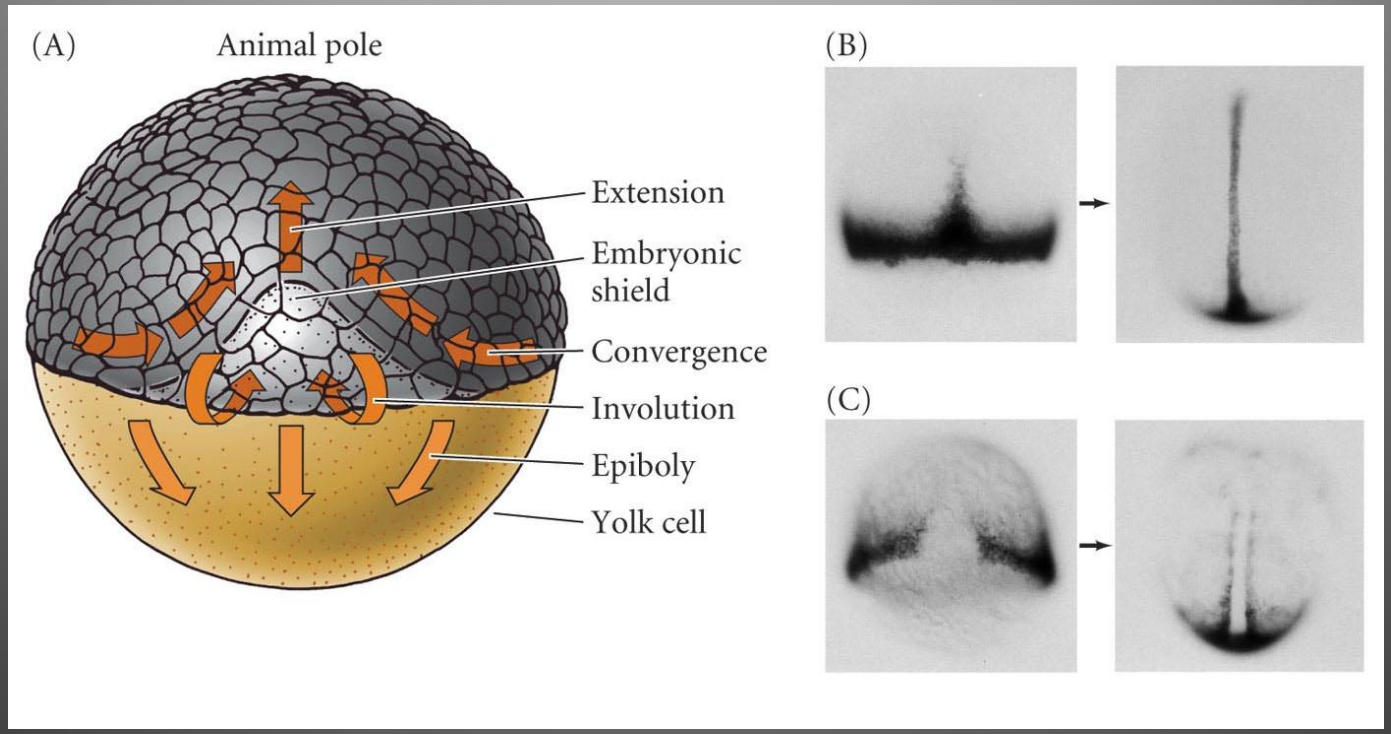


DEVELOPMENTAL BIOLOGY, Seventh Edition, Figure 10.7 (Part 2) Sinauer Associates, Inc.

Cell Movements During Frog Gastrulation - Late



Convergent Extension



Convergent extension- the lengthening of a group of cells in the long axis while shortening in the perpendicular axis

At the end of gastrulation--

--the basic body plan is set up
--the three germ layers have formed and will produce all embryonic structures except the germline

ECTODERM--

--skin, nervous system, neural crest

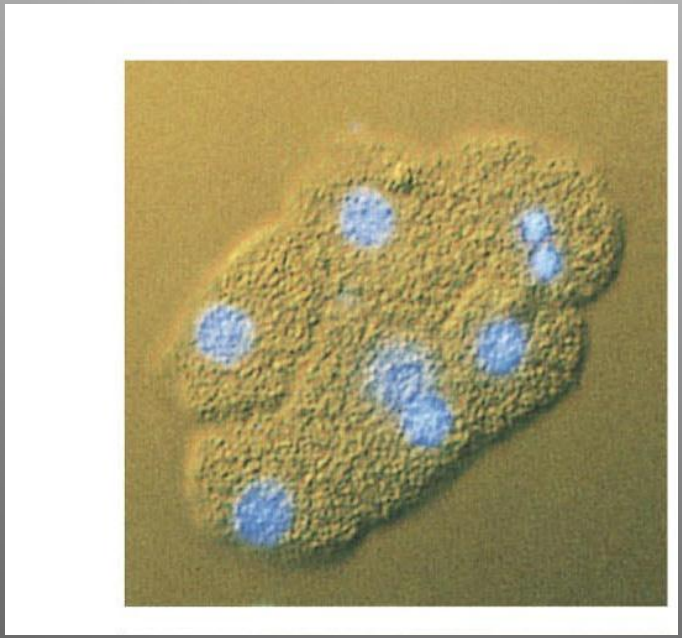
MESODERM--

--muscle, bones, blood and vessels, kidney, gonads, connective tissue

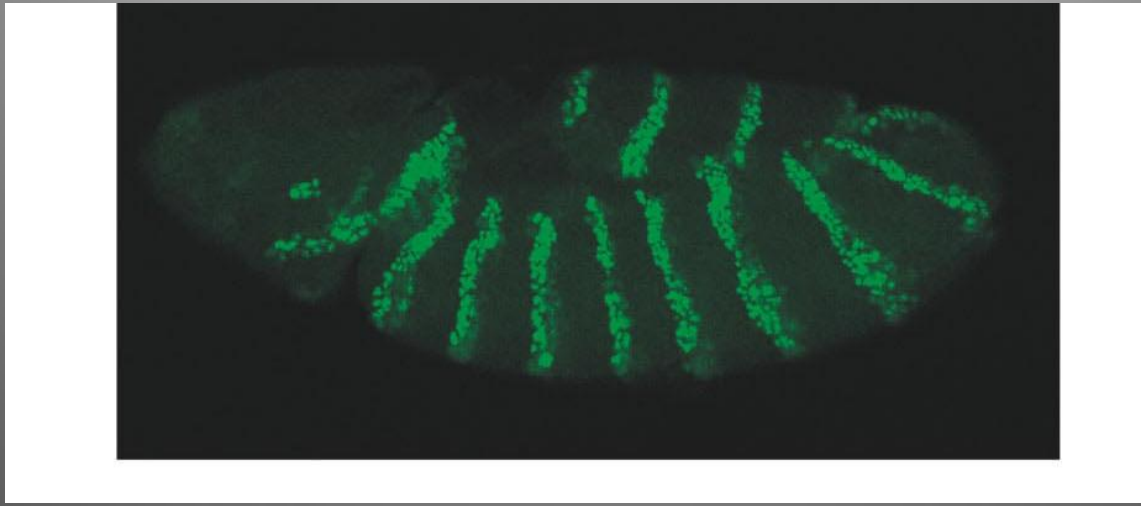
ENDODERM--

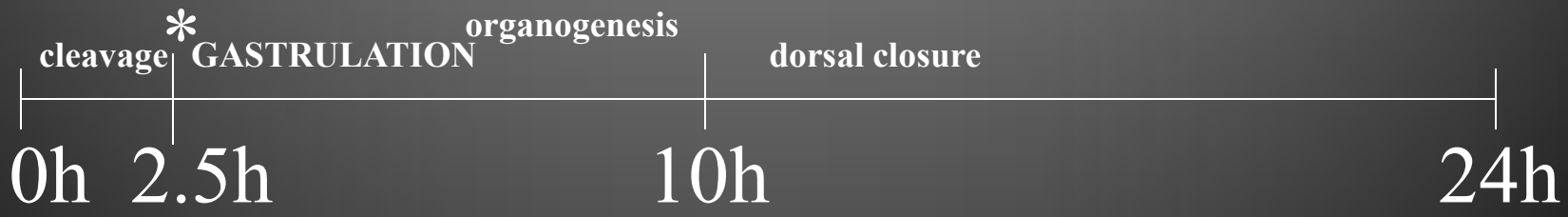
--gut, liver, lungs, pancreas

C. elegans embryogenesis

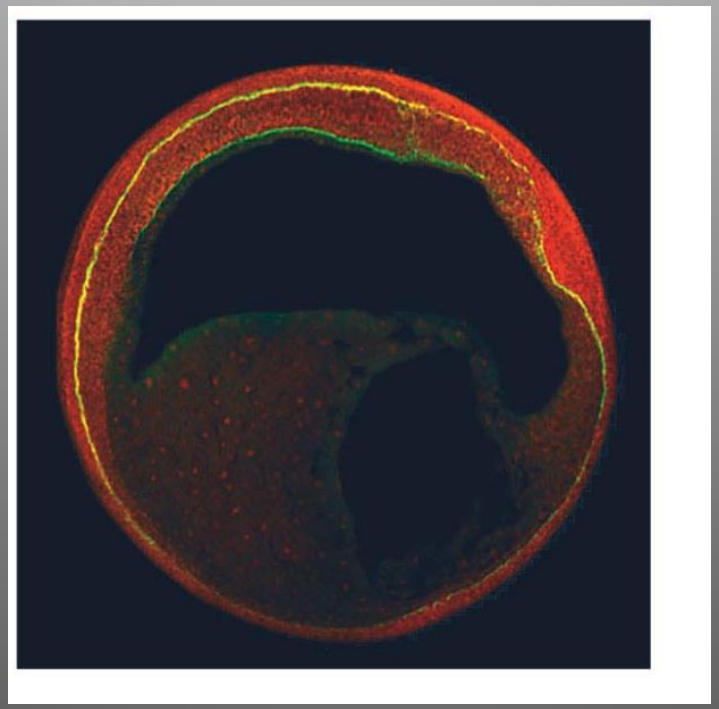


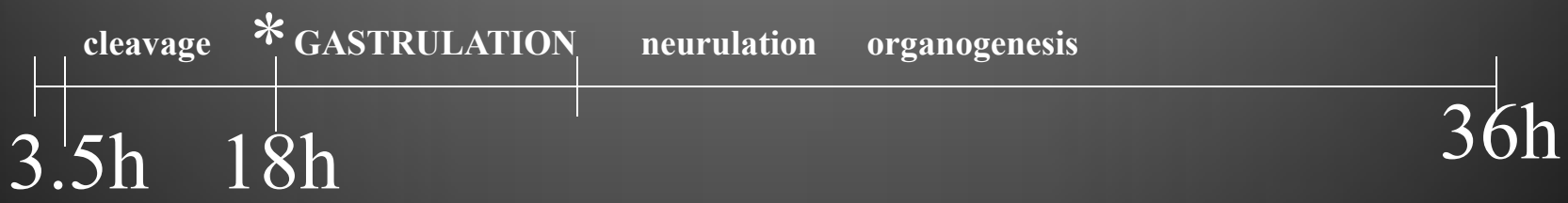
Drosophila embryogenesis



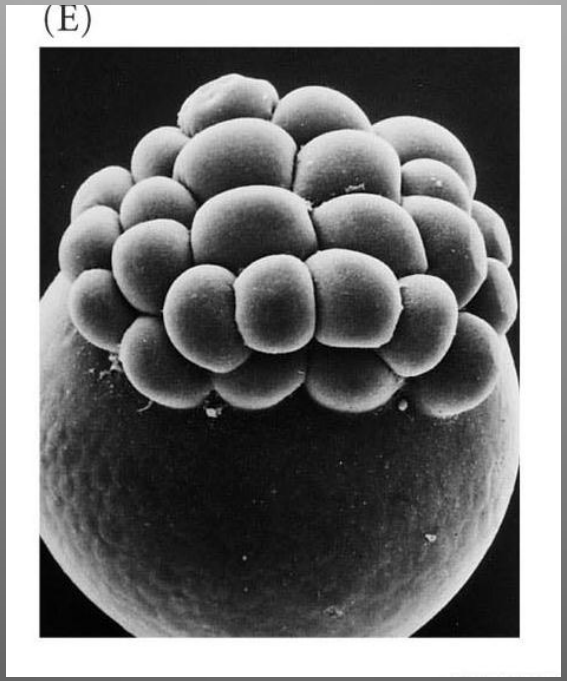


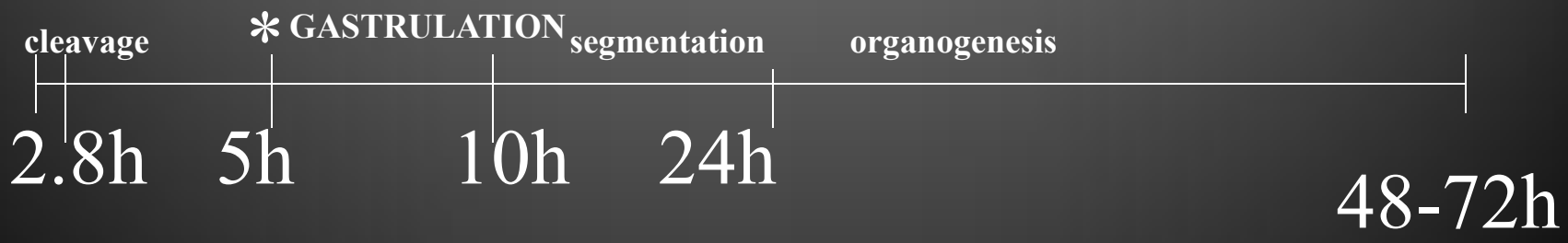
Frog embryogenesis



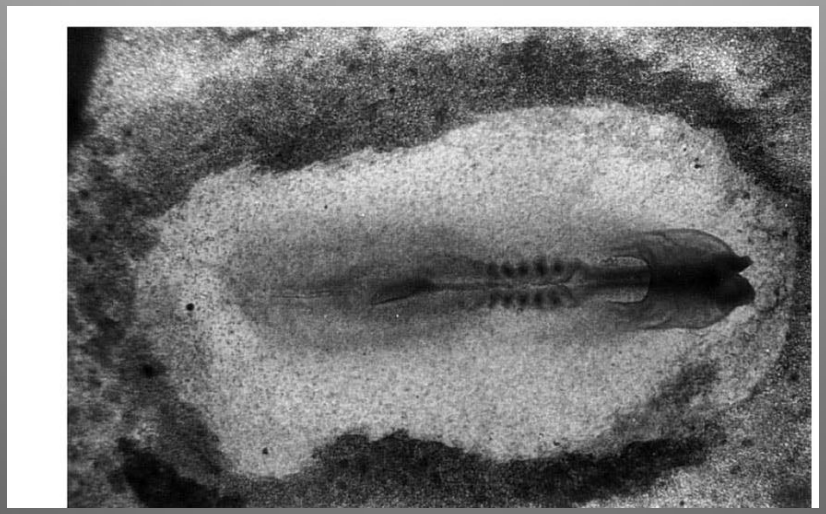


Zebrafish embryogenesis





Chick embryogenesis



Mouse embryogenesis