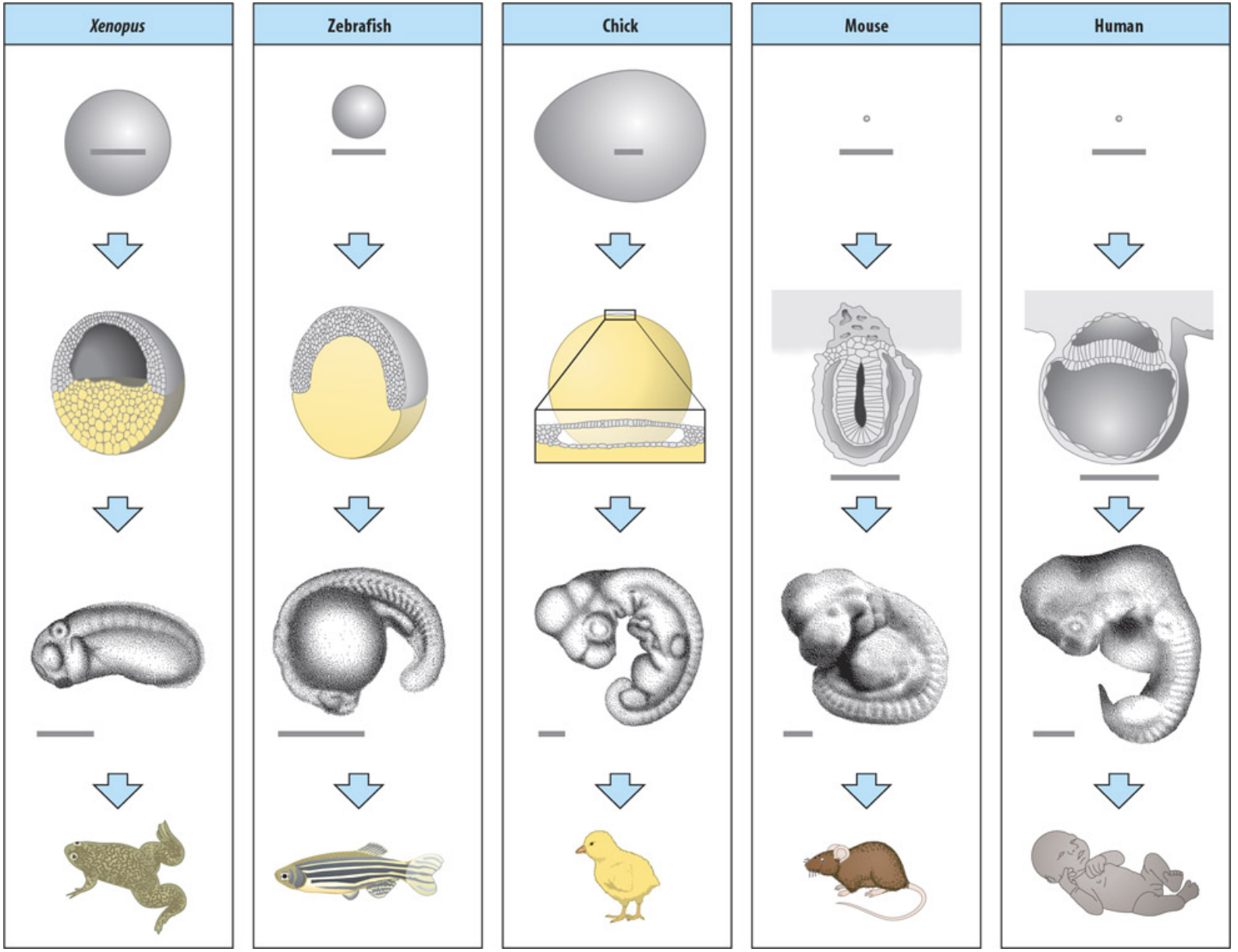
Examples of vertebrate development



Blastulation

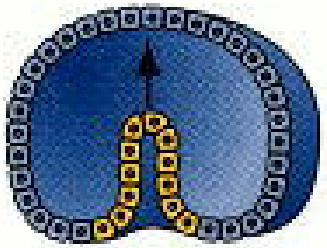
- Formation of the blastula
  - Hollow ball of cells
  - Blastomeres surrounding blastocoel cavity

Gastrulation

- Formation of the gastrula
  - Develops the three germ layers
  - Mitosis and cellular movements
    - Invagination
    - Involution
    - Ingression
    - Delamination
    - Epiboly

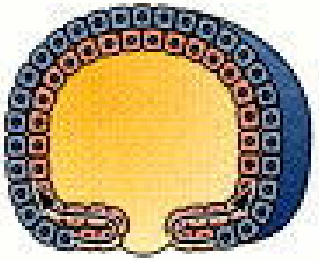
Cellular Movement During Gastrulation

Invagination:
Infolding of cell sheet into embryo



Example :
Sea urchin endoderm

Involution:
Inturning of cell sheet over the basal surface of an outer layer

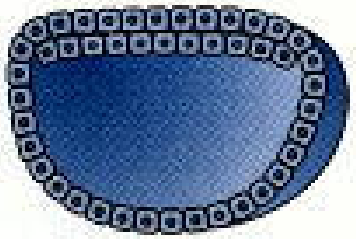


Example :
Amphibian mesoderm

Ingression:
Migration of individual cells into the embryo

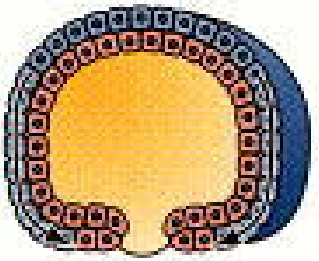
Example :
Sea urchin mesoderm, *Drosophila* neuroblasts

Delamination:
Splitting or migration of one sheet into two sheets



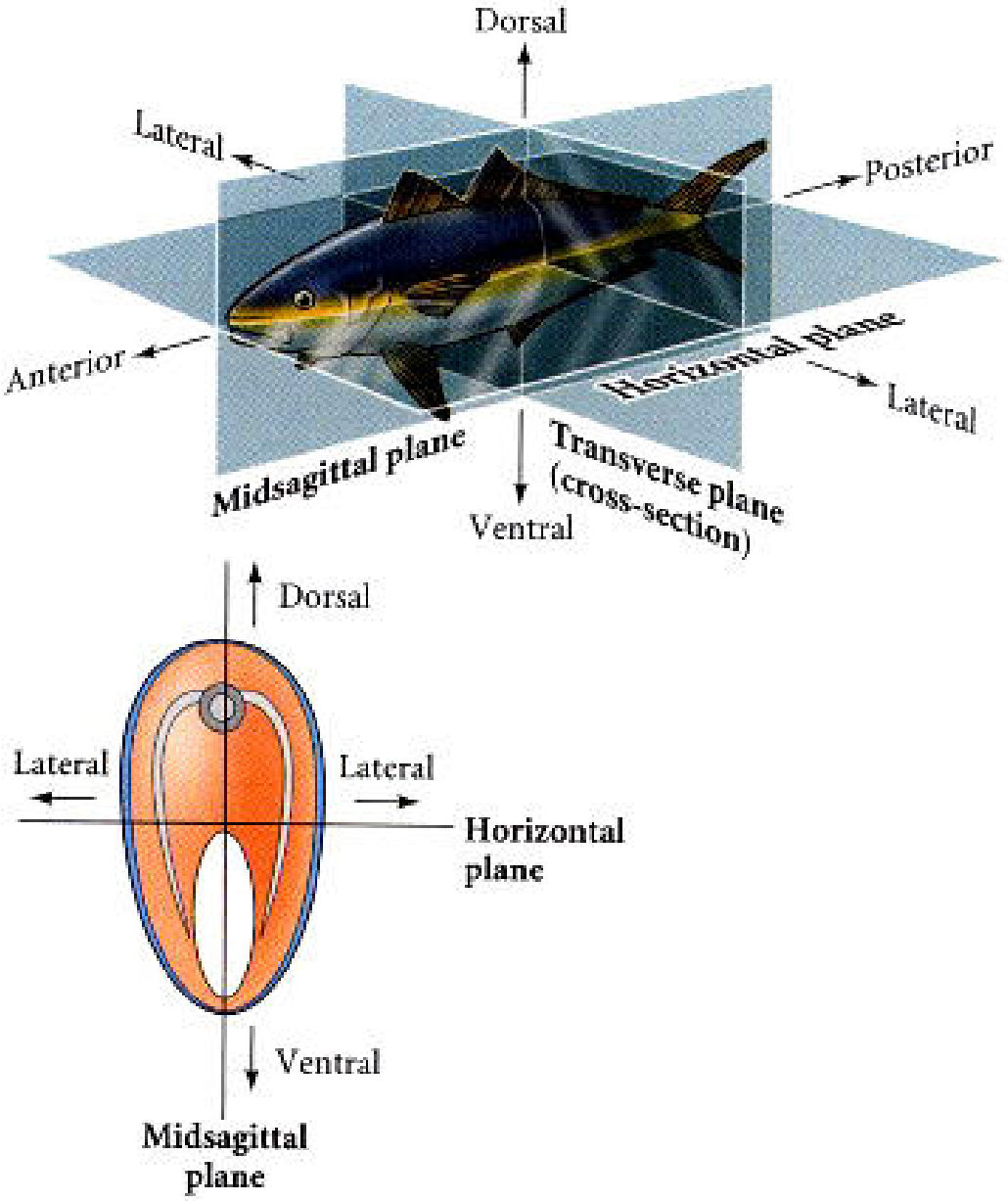
Example :
Mammalian and bird hypoblast formation

Epiboly:
The expansion of one cell sheet over other cells

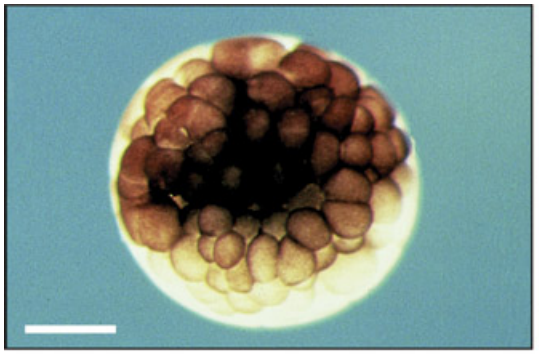


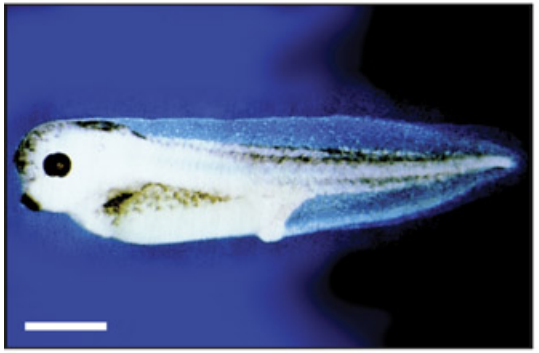
Example :
Ectoderm formation in amphibians, sea urchins, and tunicates

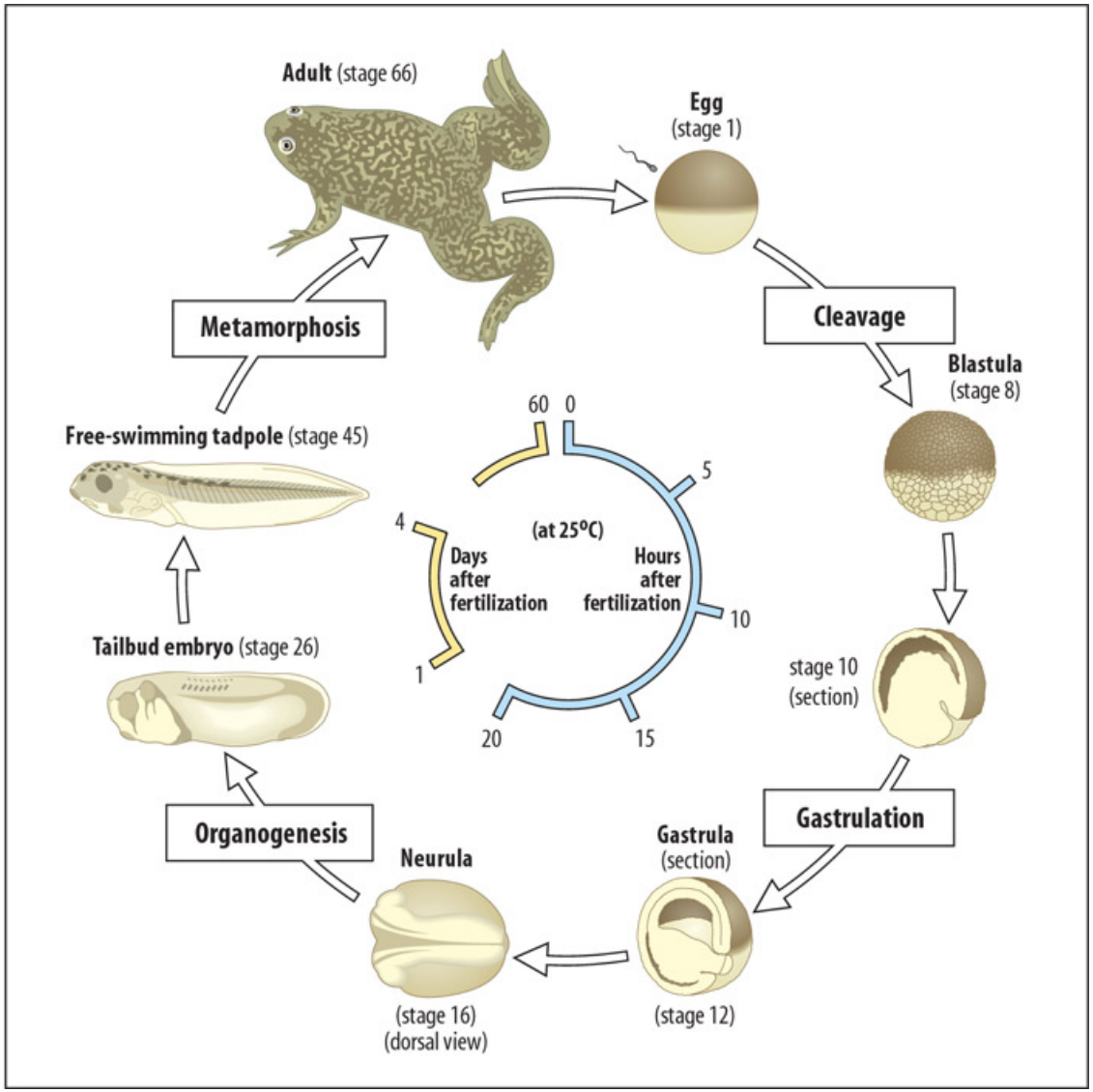
Axis Formation



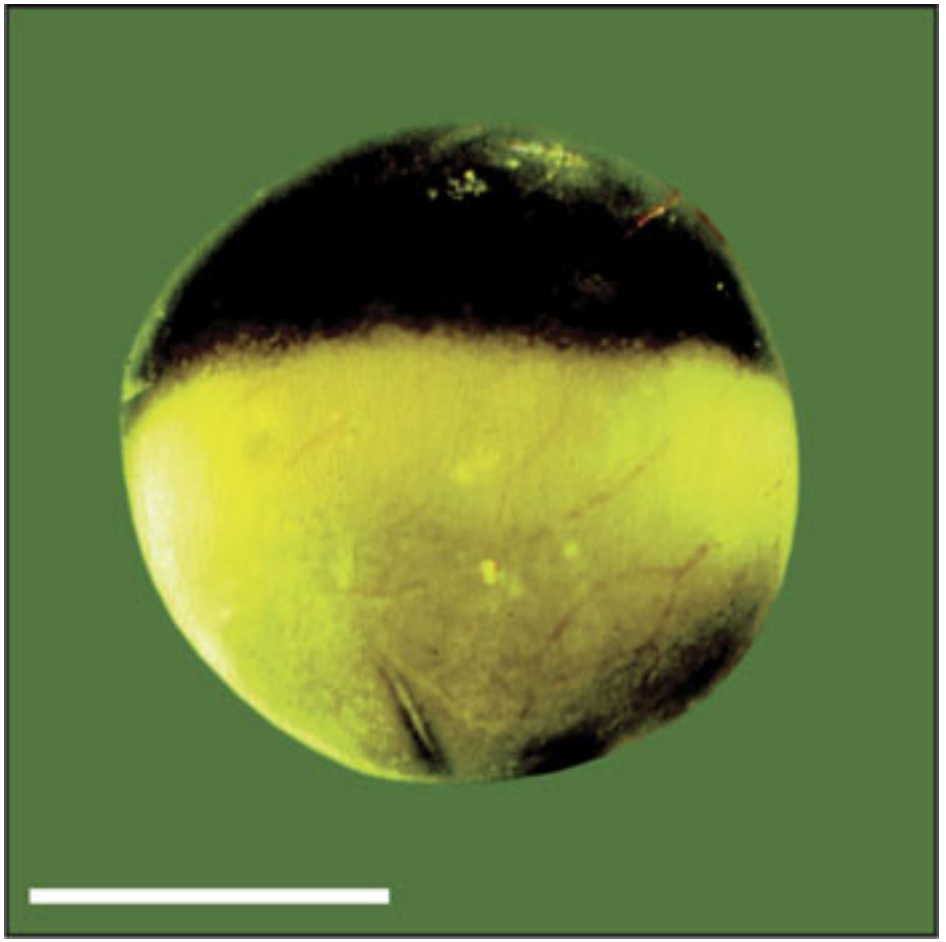
Frog life cycle







Frog oocyte



Fertilization

- Animal hemisphere
  - Sperm entry point
    - Establishes the dorsal/ventral axis
    - Ventral side – sperm entry
    - Dorsal side – gray crescent
    - Organized by sperm centriole

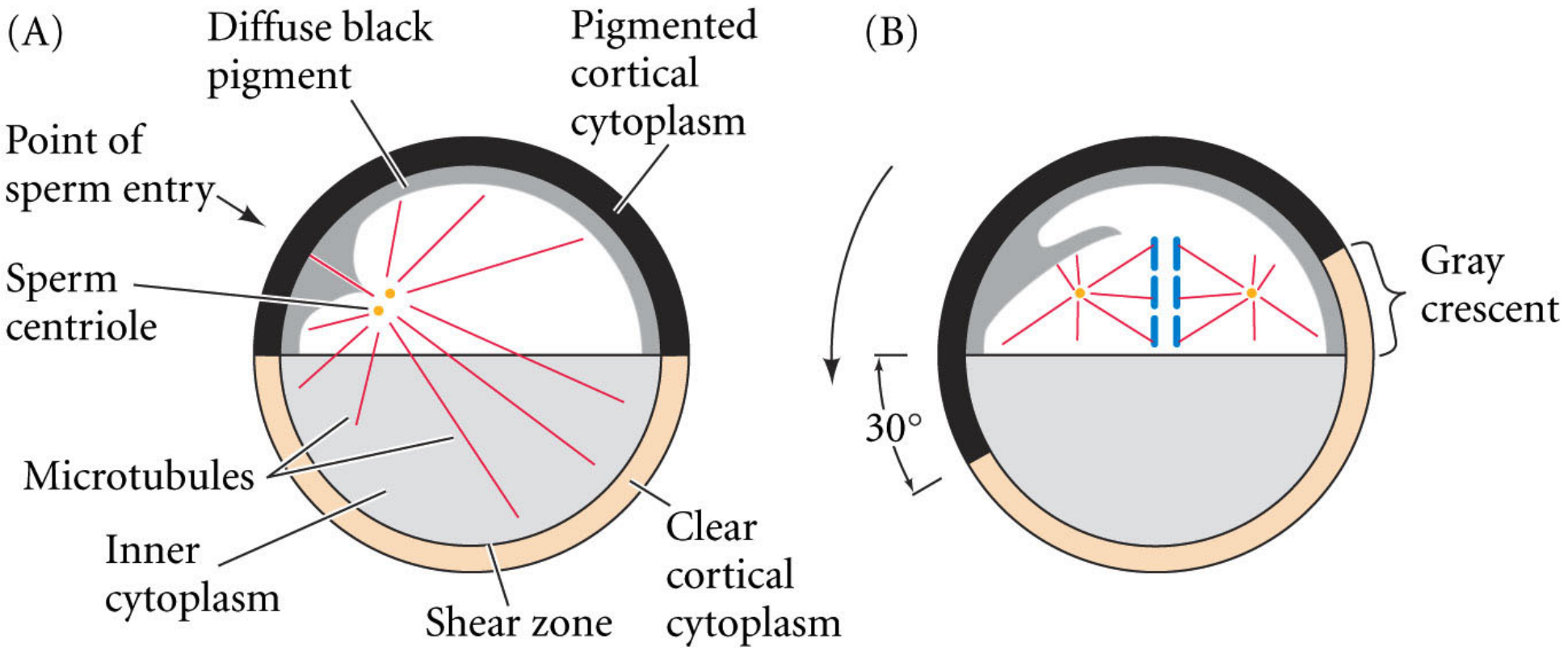
Cleavage

- Unequal radial holoblastic cleavage
  - Yolk retards division of vegetal pole
    - Second cleavage starts before first is finished

Gray Crescent

- Opposite to sperm entry
- Results from rotation of cortical layer of oocyte

10.2 Reorganization of cytoplasm in the newly fertilized frog egg (Part 1)



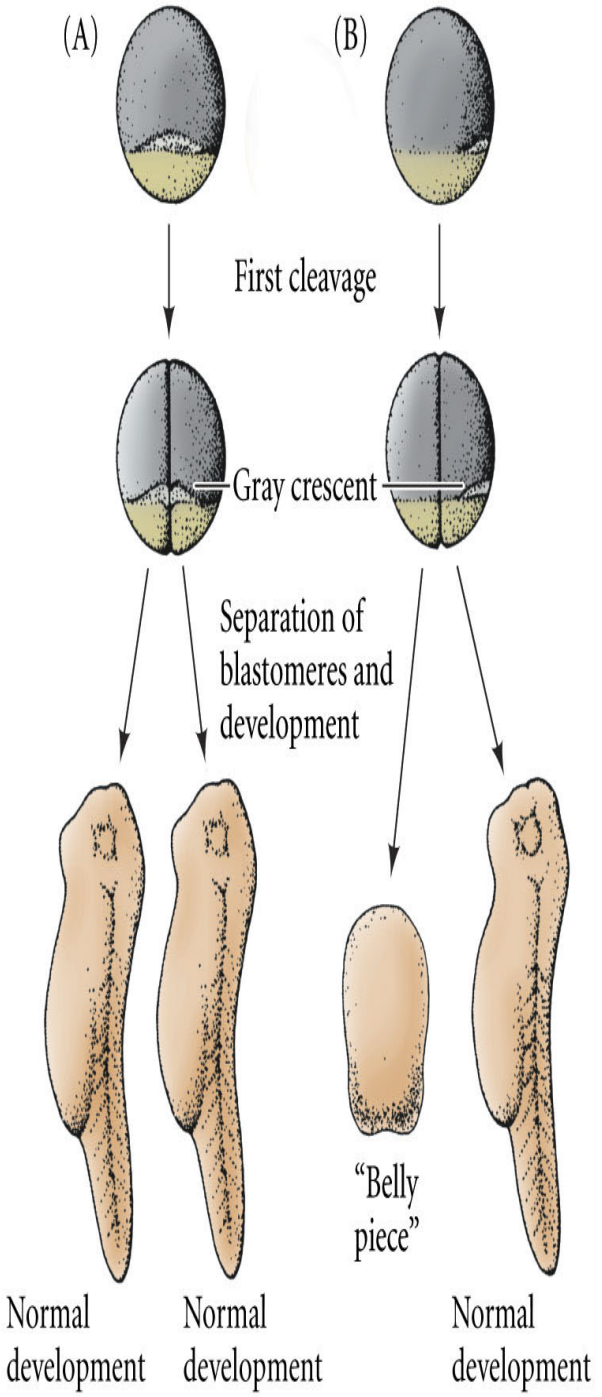
Regulative Development

A blastomere has greater potential than its normal cell fate

Blastomere fate determined by neighboring cells

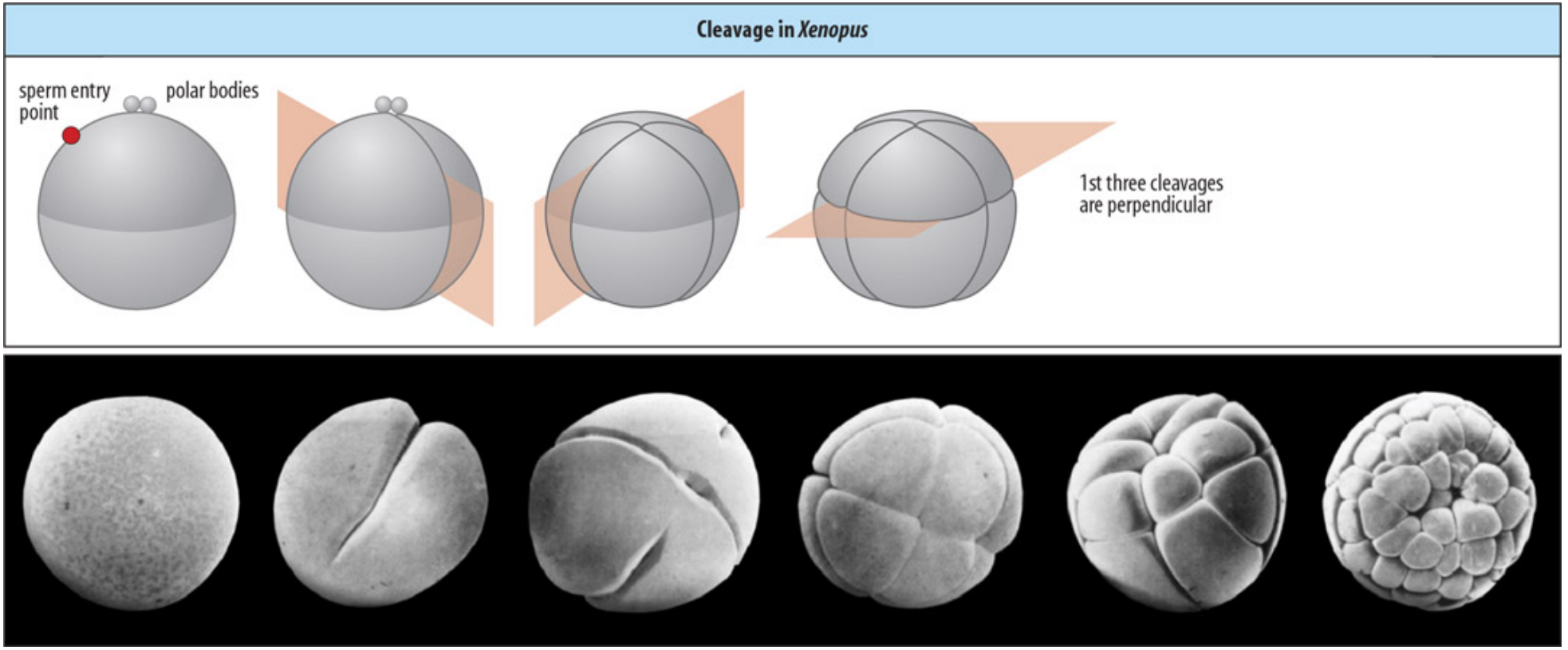
Spemann

- Blastomeres equivalent when they both have gray crescent.
- Gray crescent necessary for dorsal structures



DEVELOPMENTAL BIOLOGY, Eighth Edition, Figure 10.17 © 2006 Sinauer Associates, Inc.

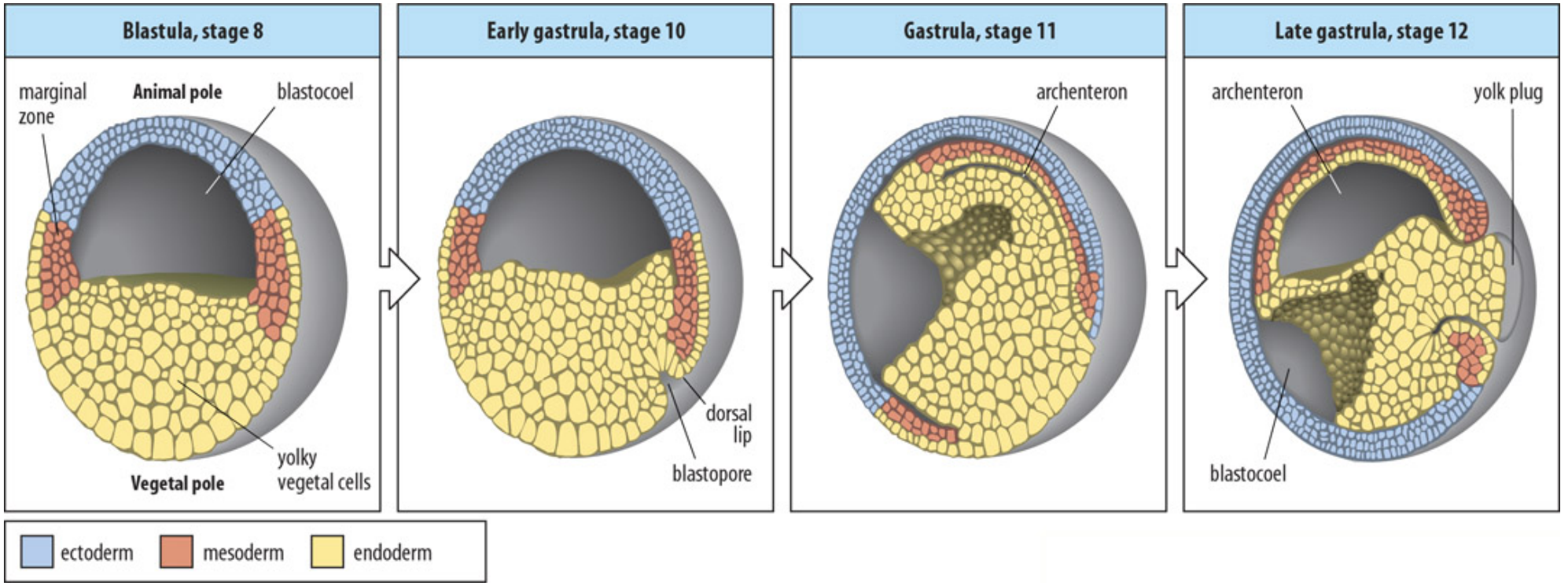
Frog cleavage



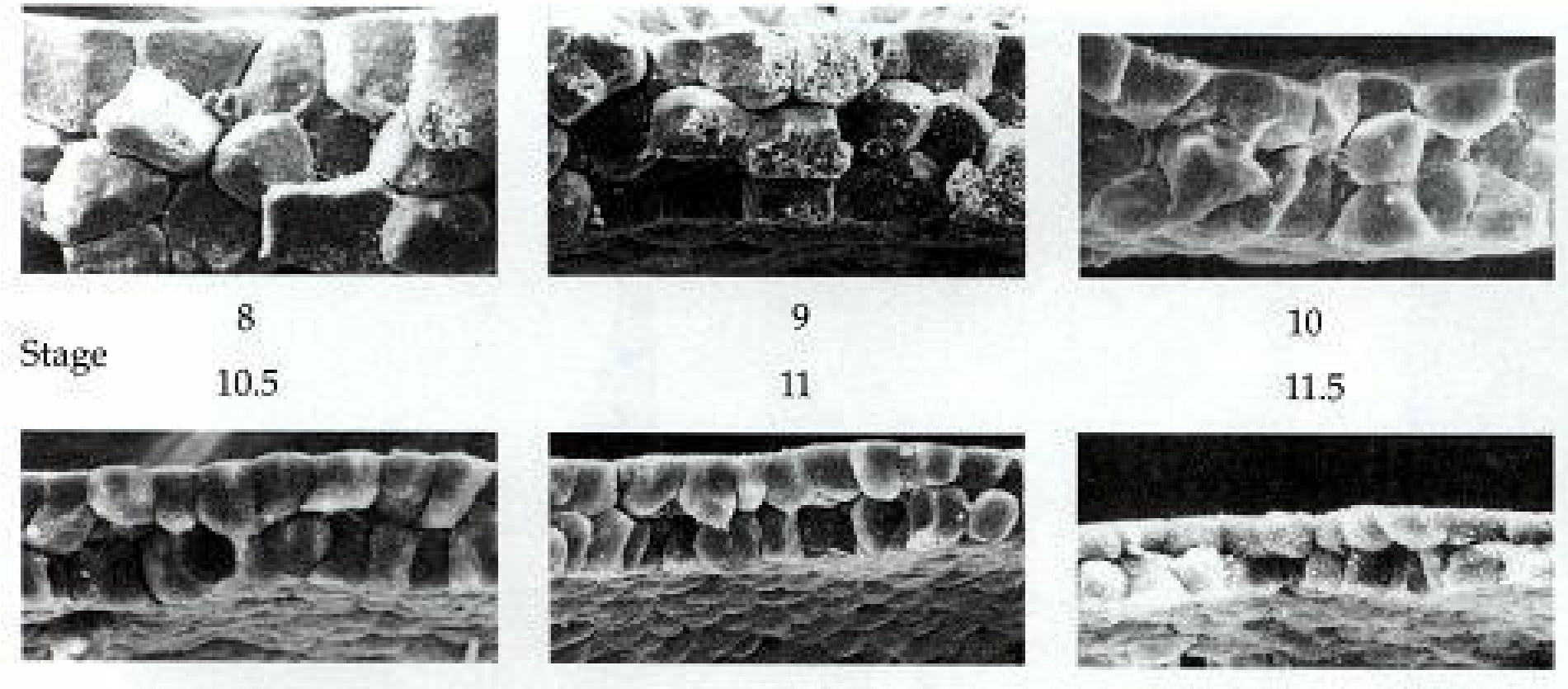
Mid-blastula Transition

- Genome activated
  - Embryonic DNA transcribed
- Cell blastomeres become mobile
- What triggers MBT?
  - Factors deposited in egg reduced by presence of new chromatin
  - Once threshold level is reached – MBT occurs

Frog gastrulation



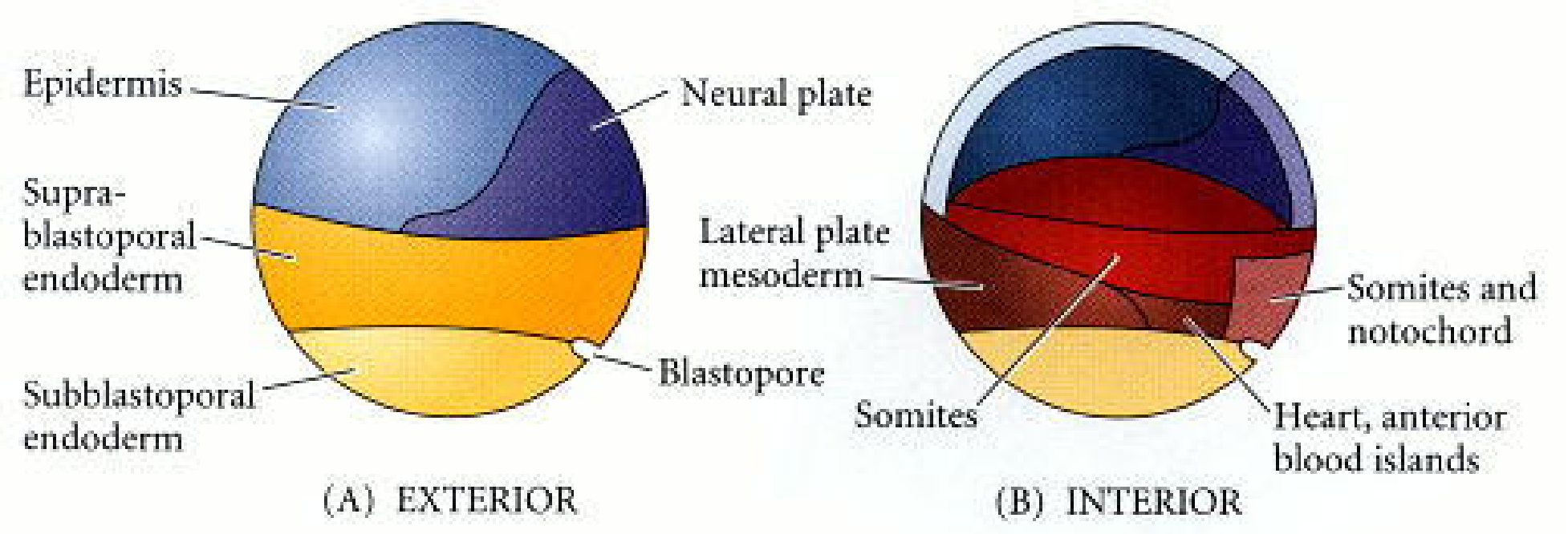
Epiboly of Ectoderm



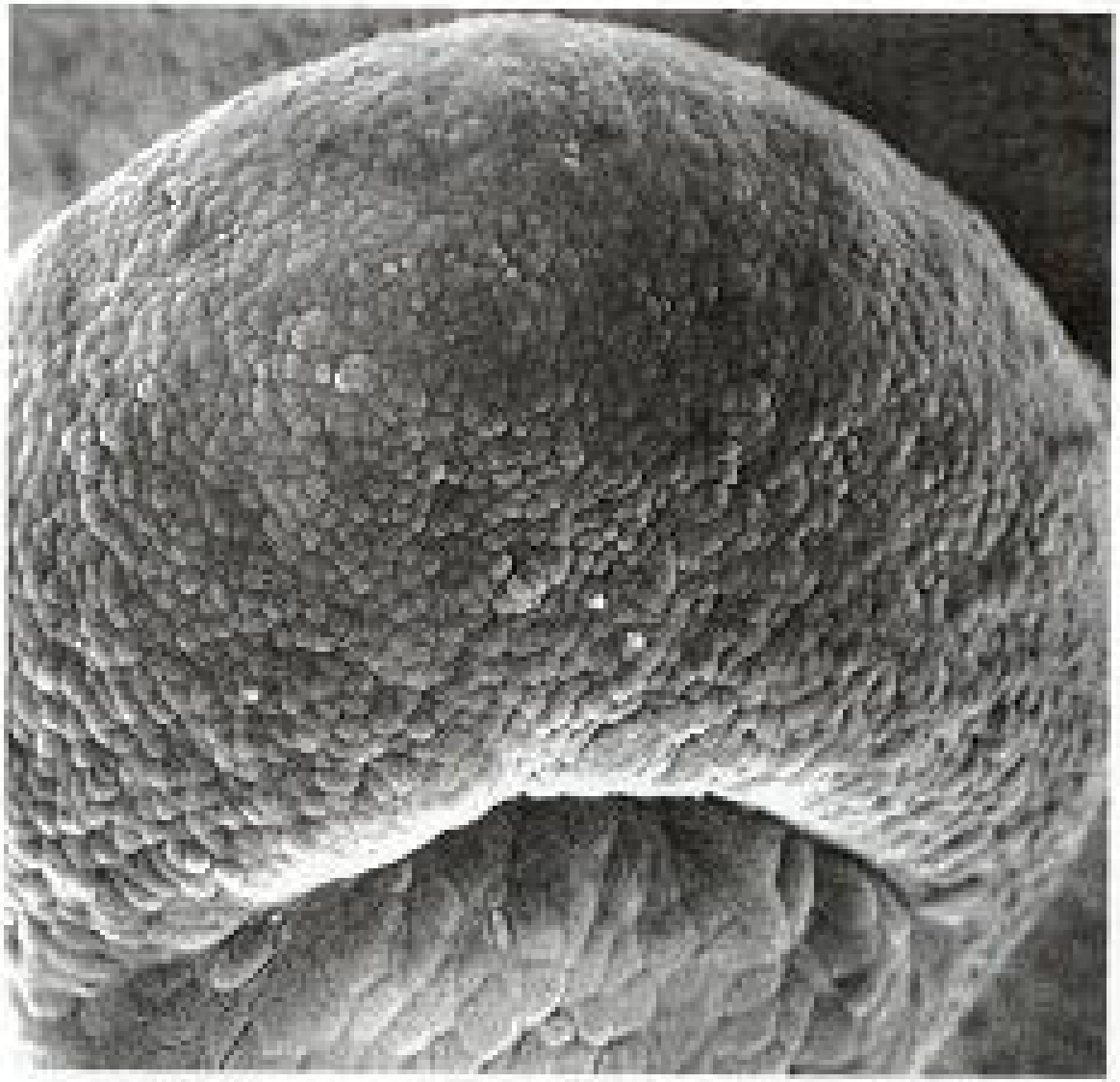
Amphibian Axis

- Animal hemispheres will become ectoderm
- Vegetal hemispheres will become endoderm
- Equatorial region will become mesoderm

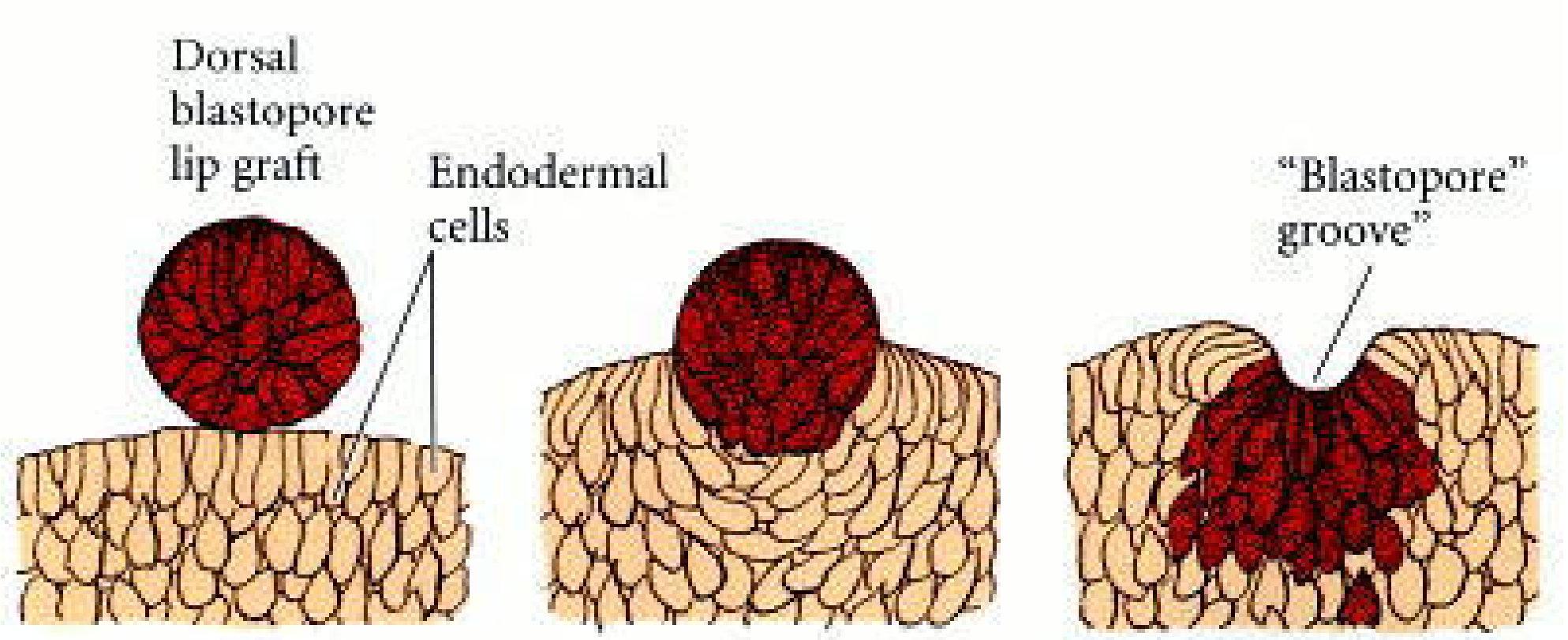
Early Fate Map



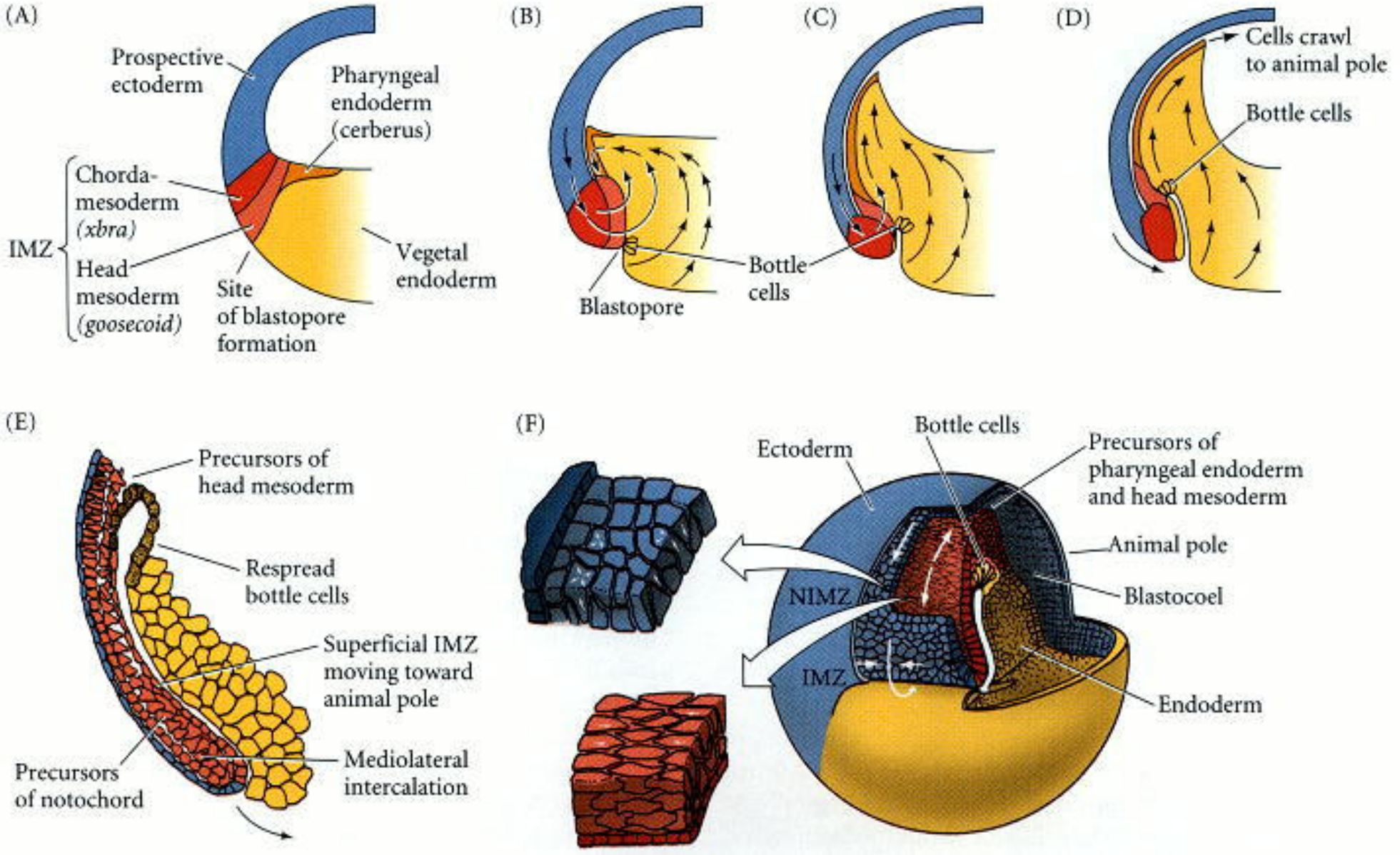
Dorsal blastopore lip



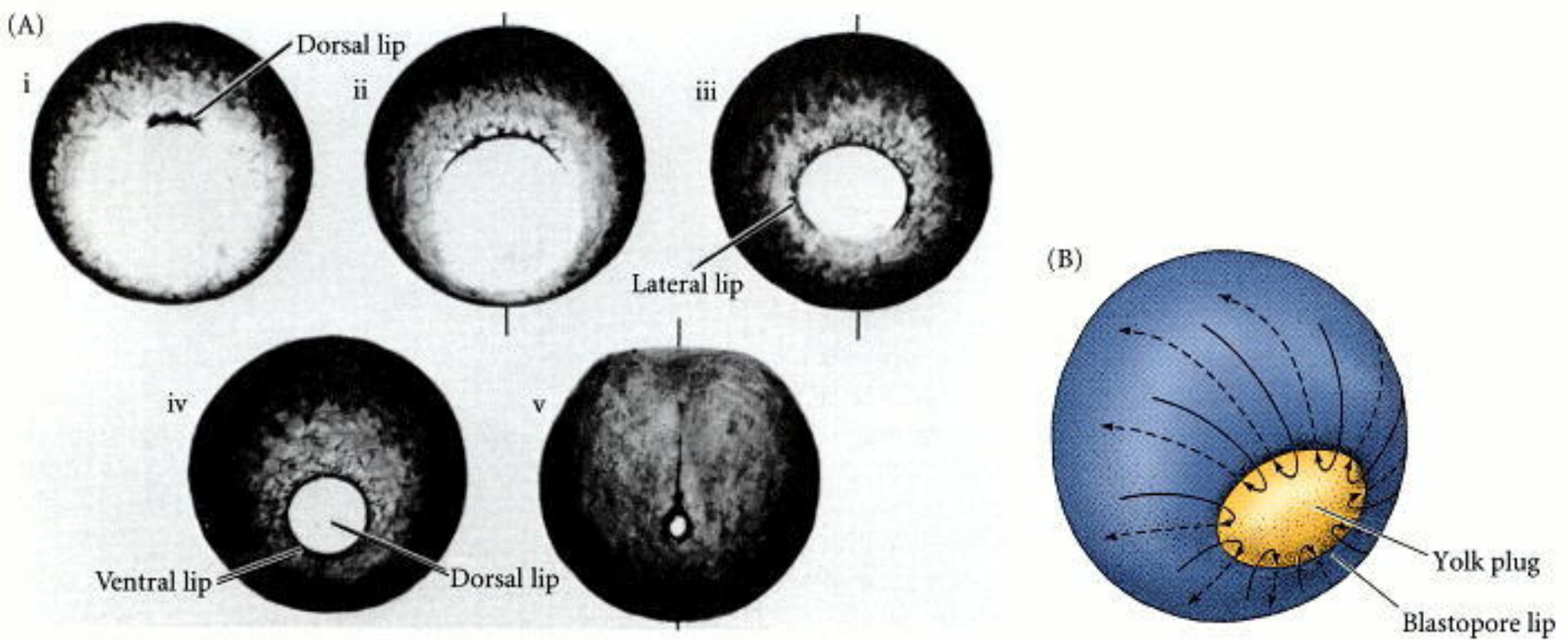
Cell from dorsal marginal zone for blastopore groove



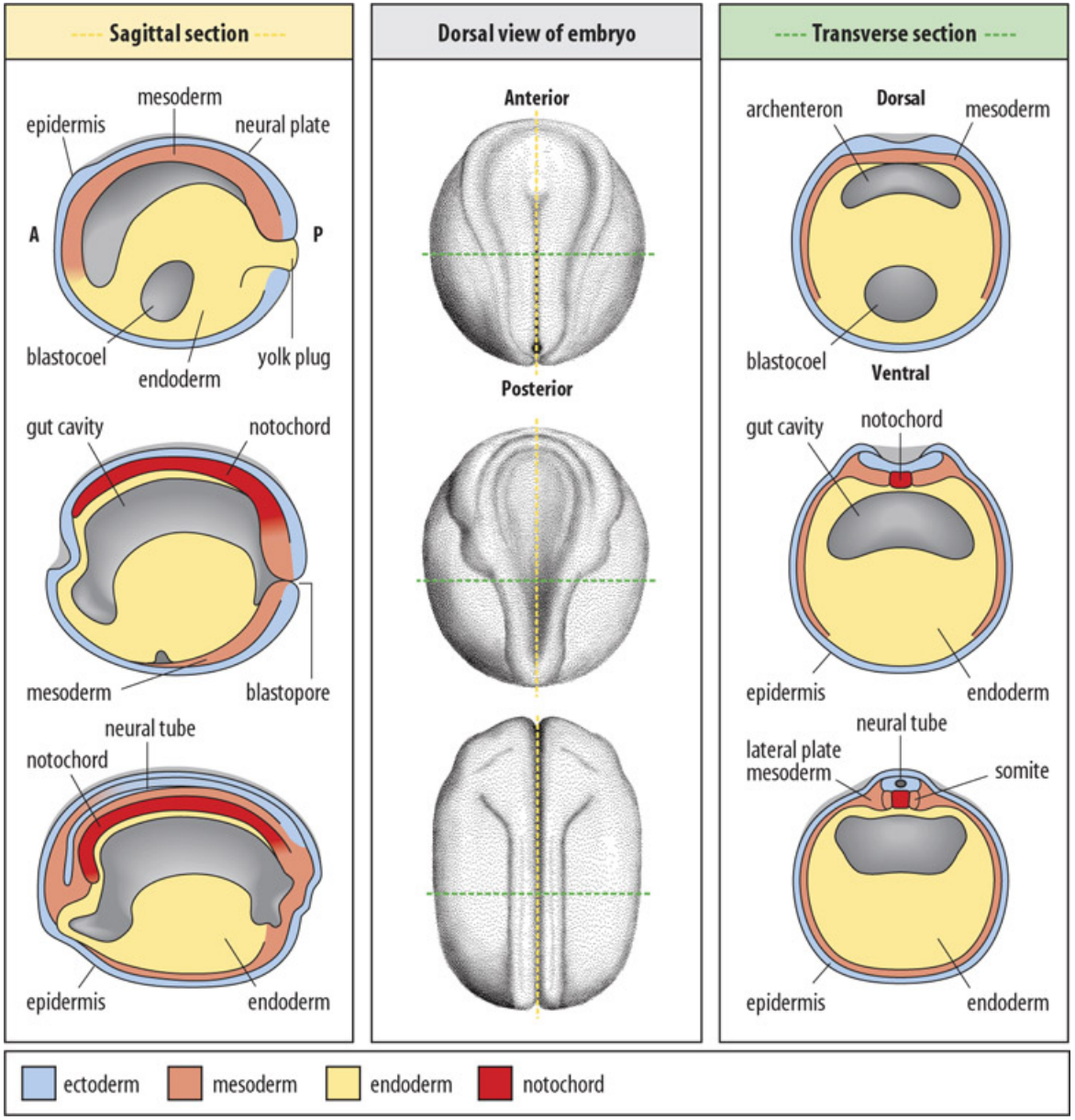
Involution at blastopore



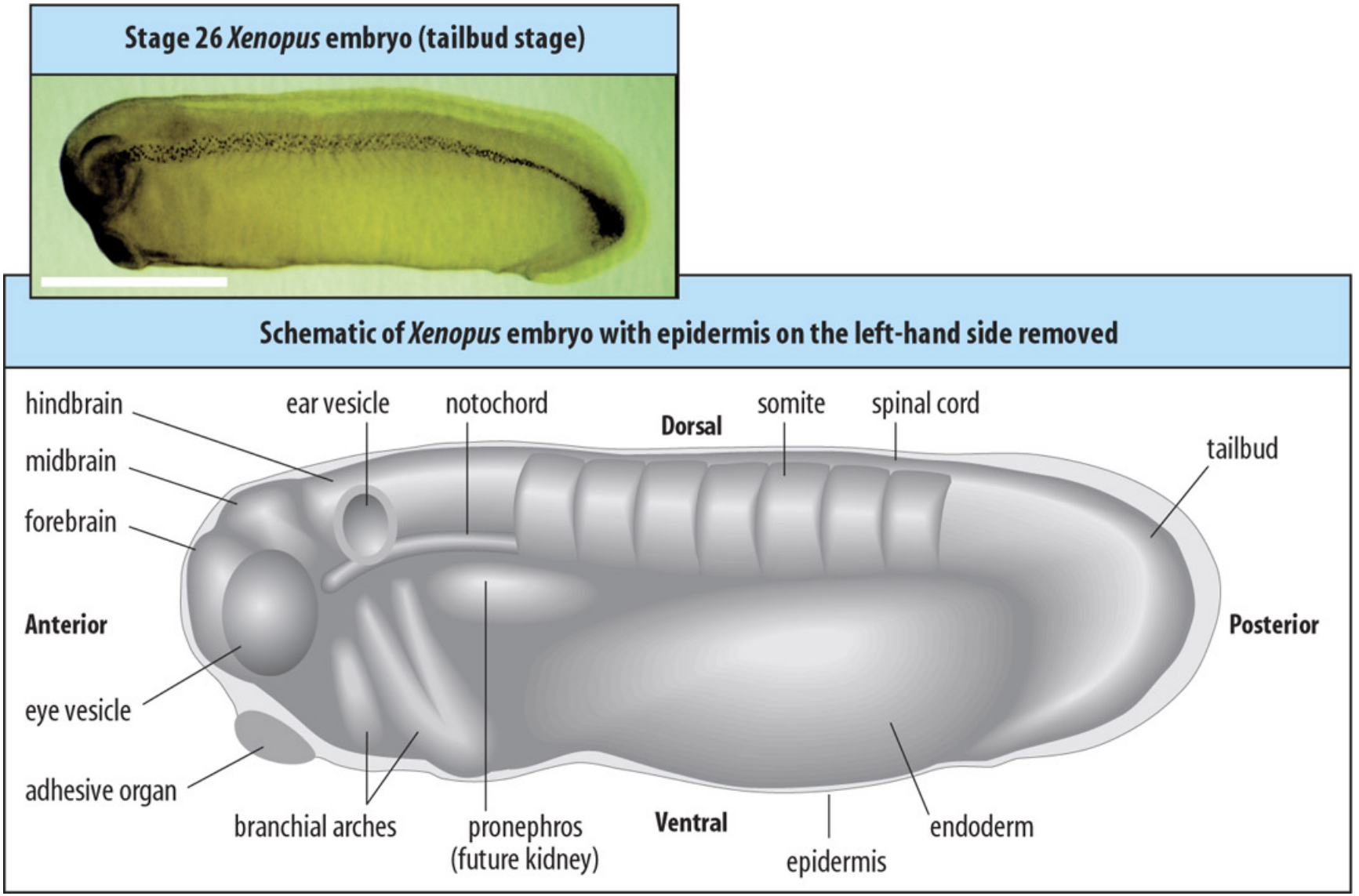
Blastopore formation



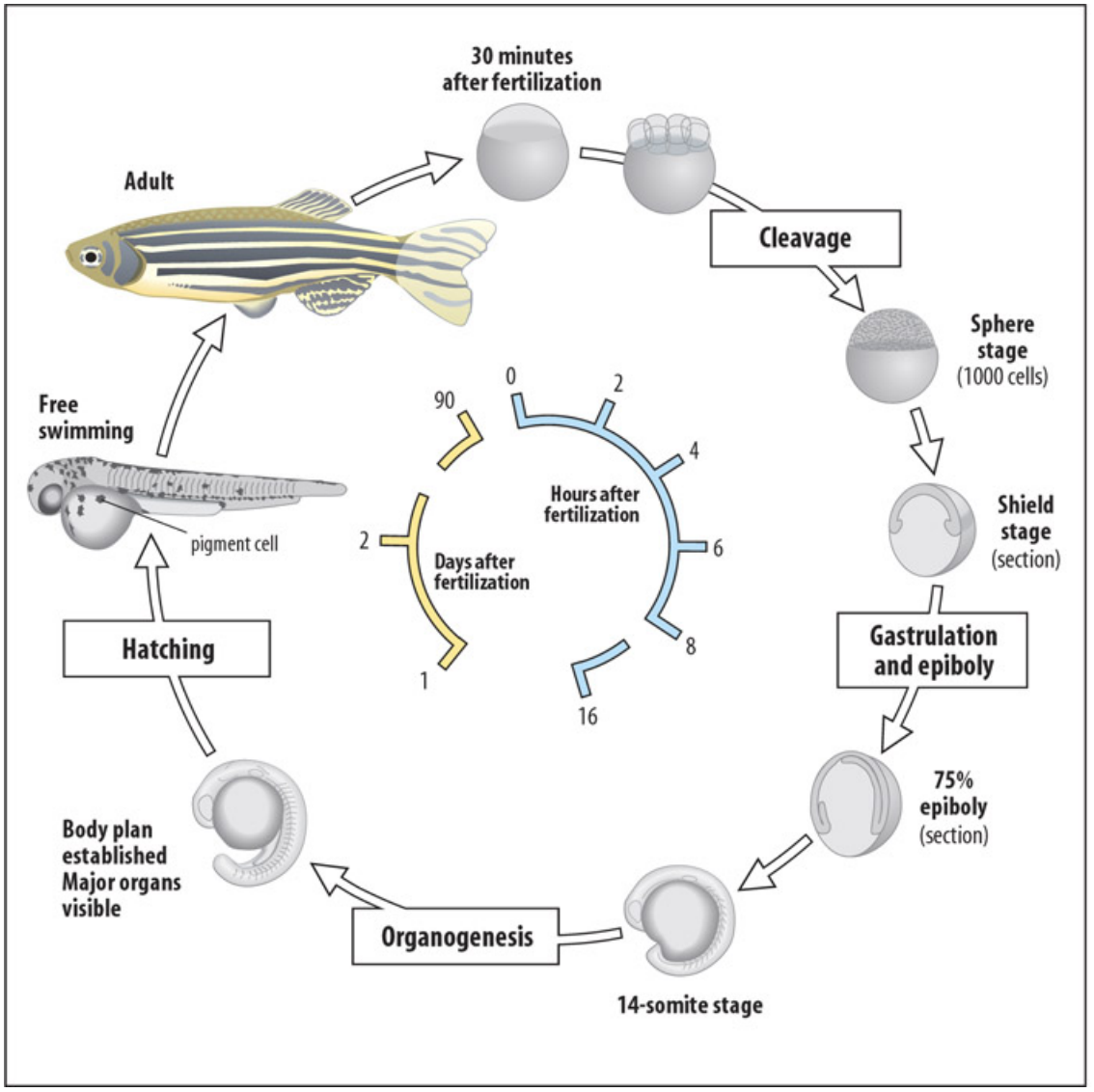
Neurulation in frogs

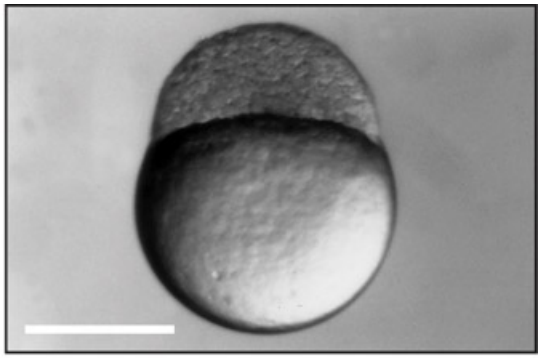


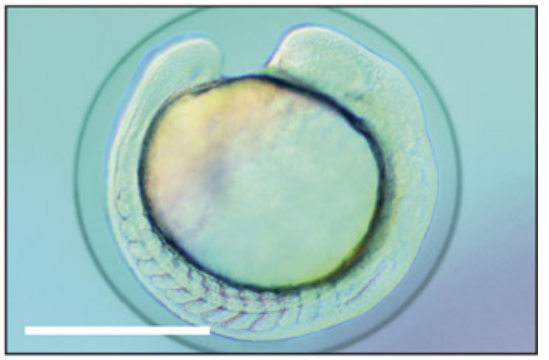
Frog tailbud stage



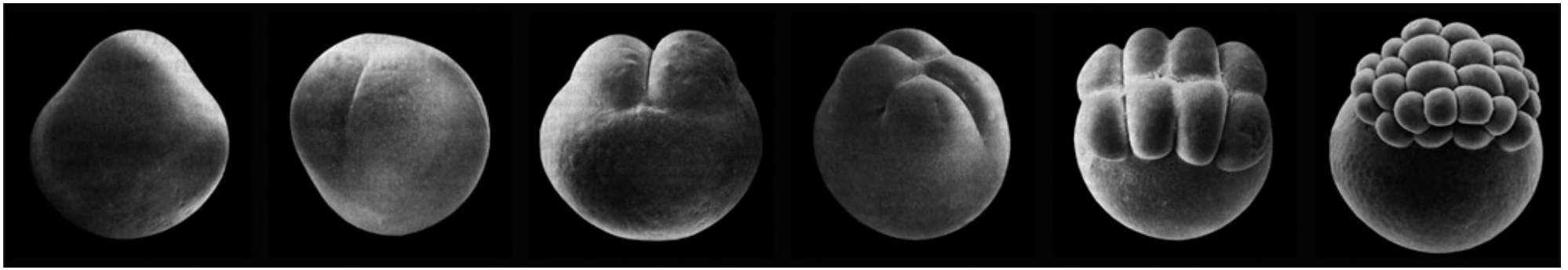
Zebrafish life cycle



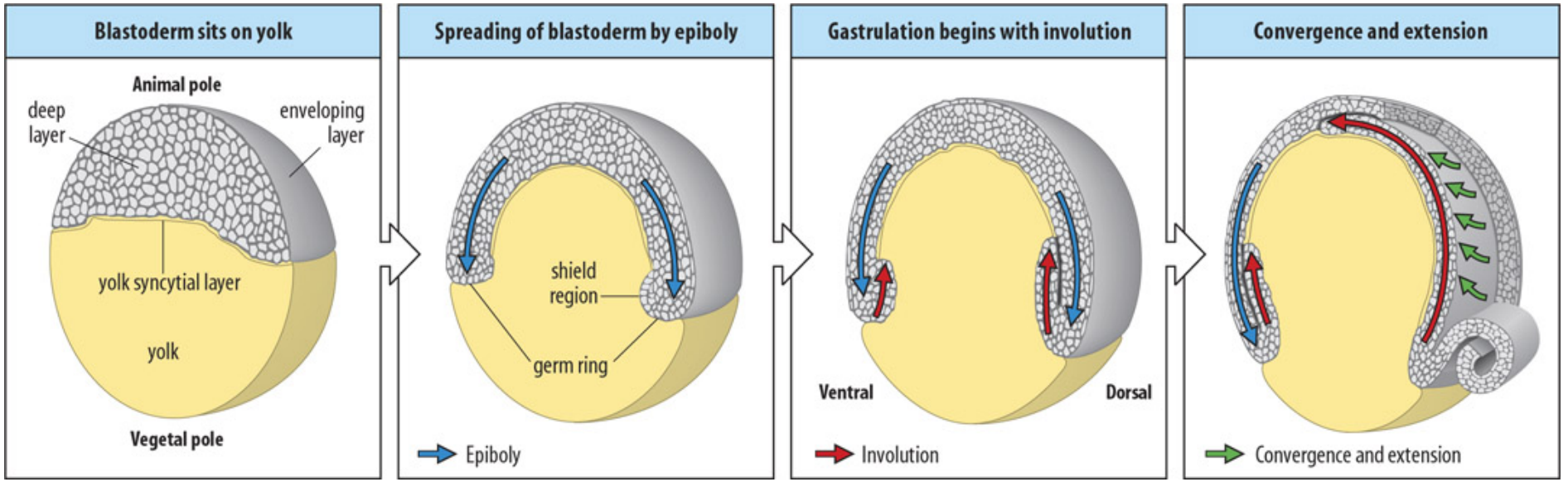




Cleavage in zebrafish



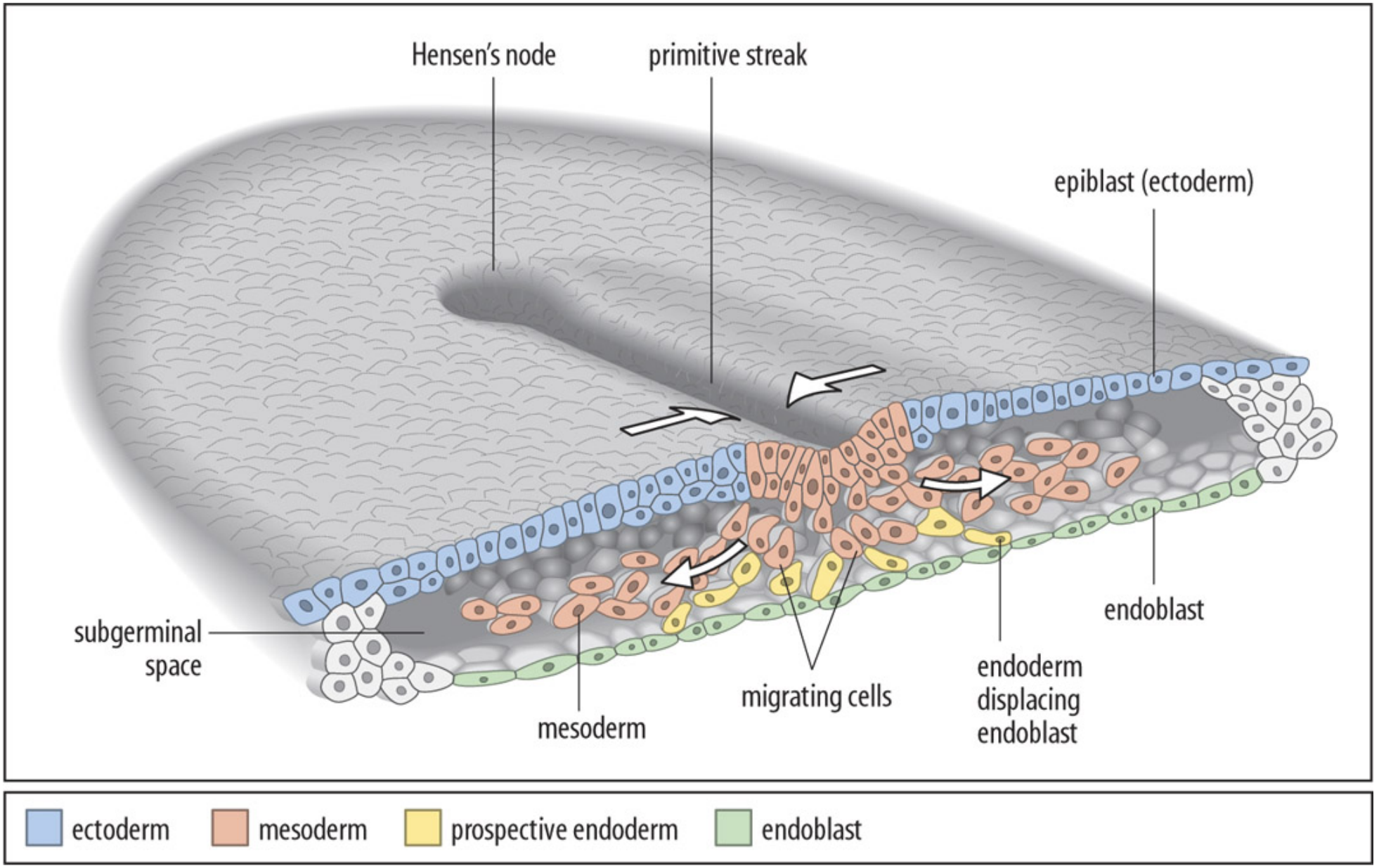
Gastrulation in zebrafish



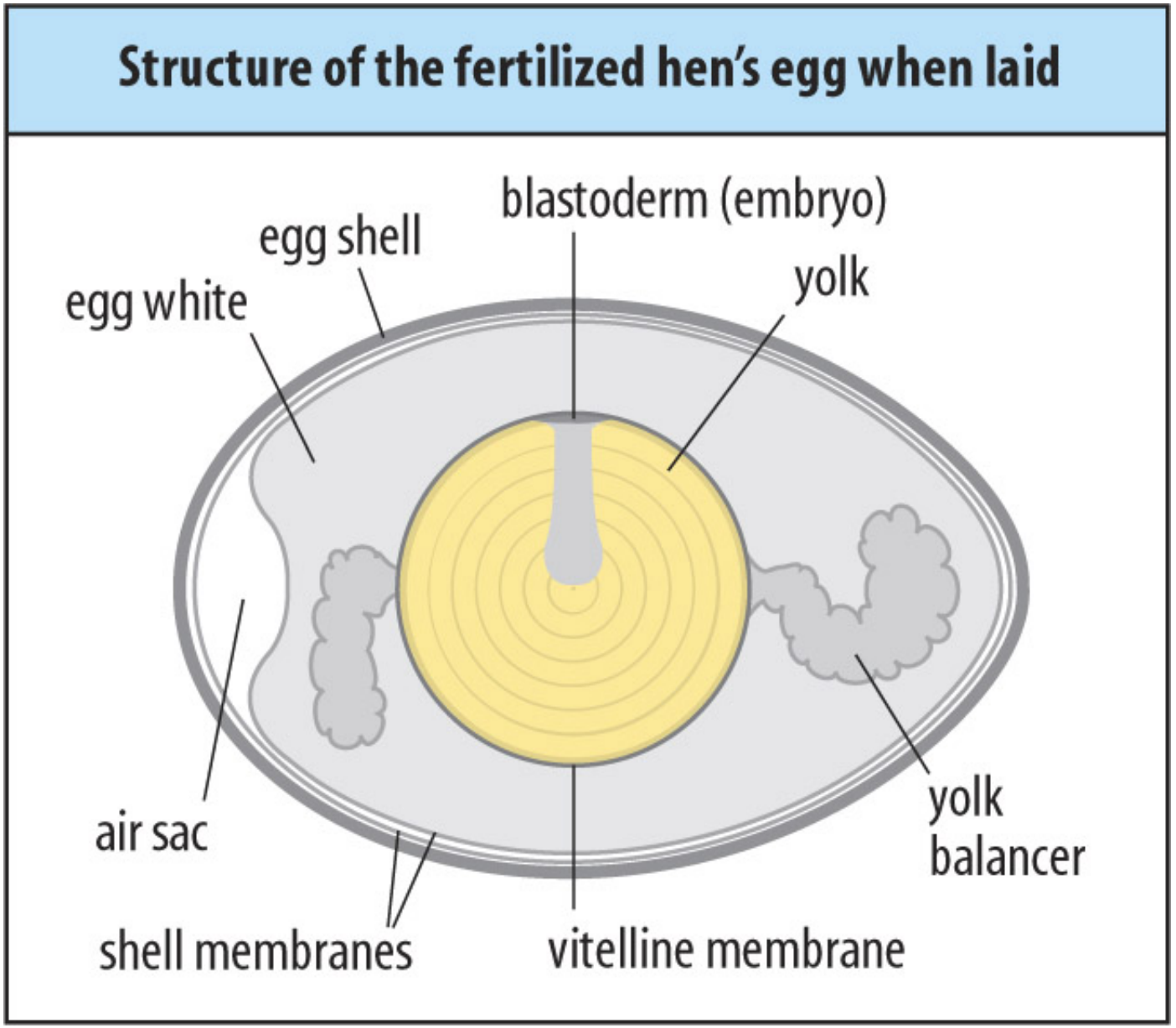
Amniotes

- Allows egg development on land
  - Started with the amniotic egg
- Reptiles, birds, mammals

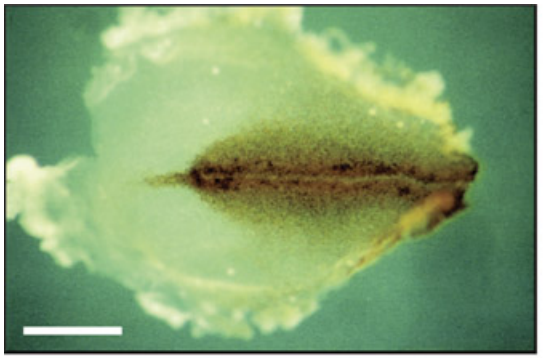
Gastrulation in chick

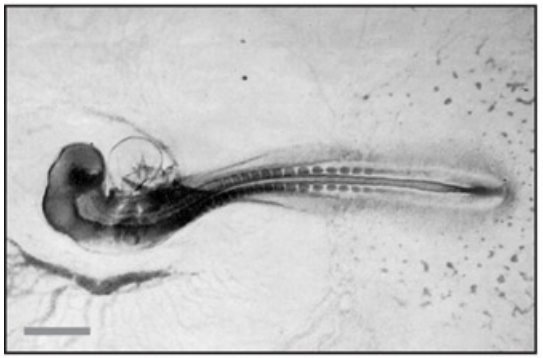


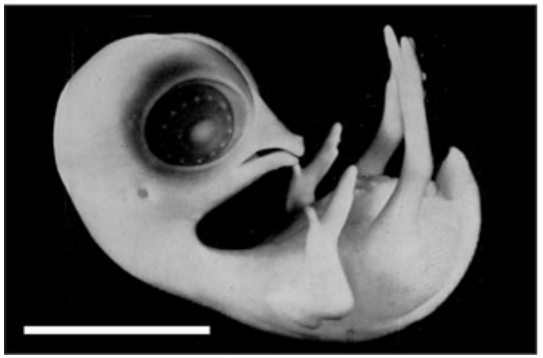
Chicken egg

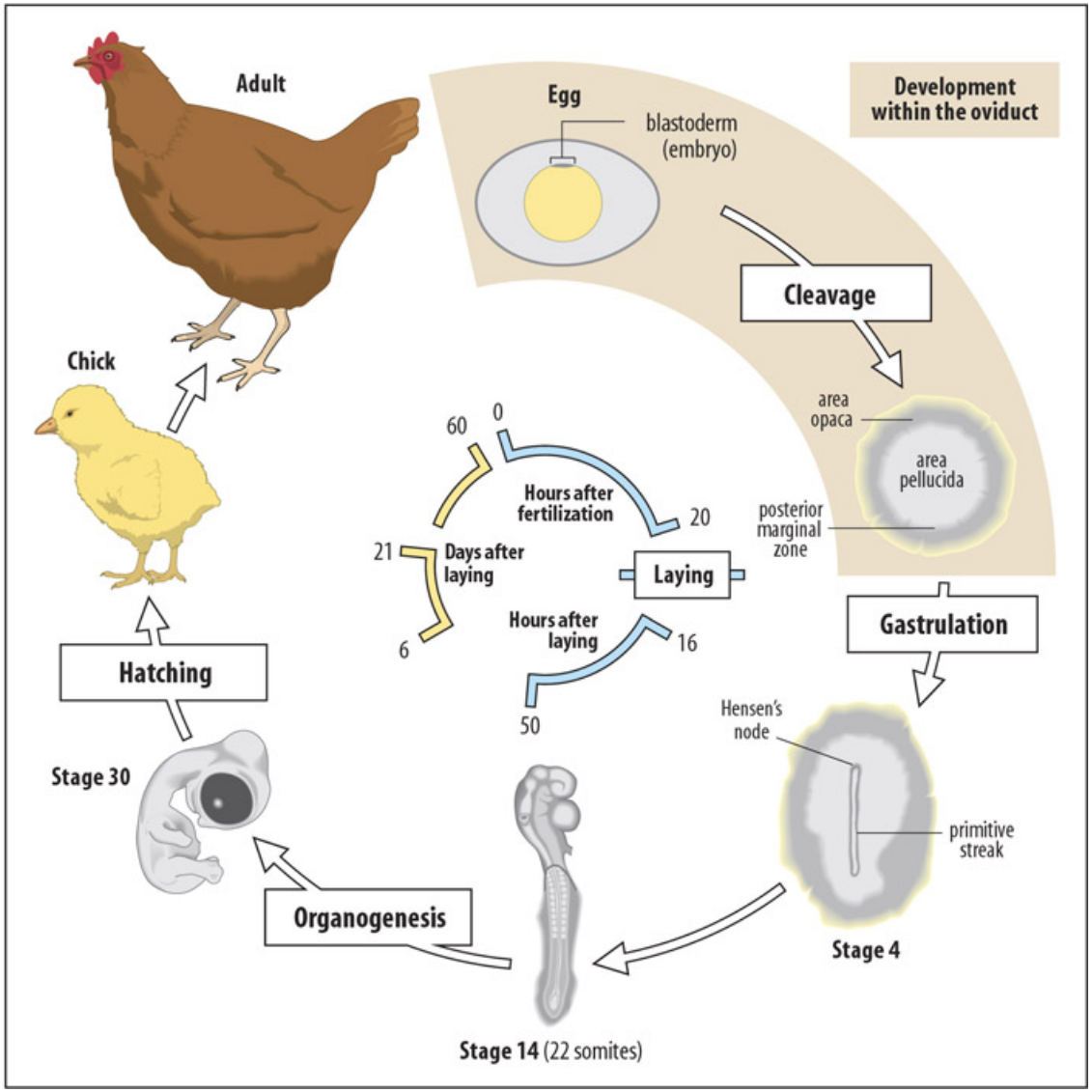

Structure of the fertilized hen's egg when laid
blastoderm (embryo)
egg shell
yolk
egg white
air sac
yolk
balancer
shell membranes
vitelline membrane

Chicken life cycle

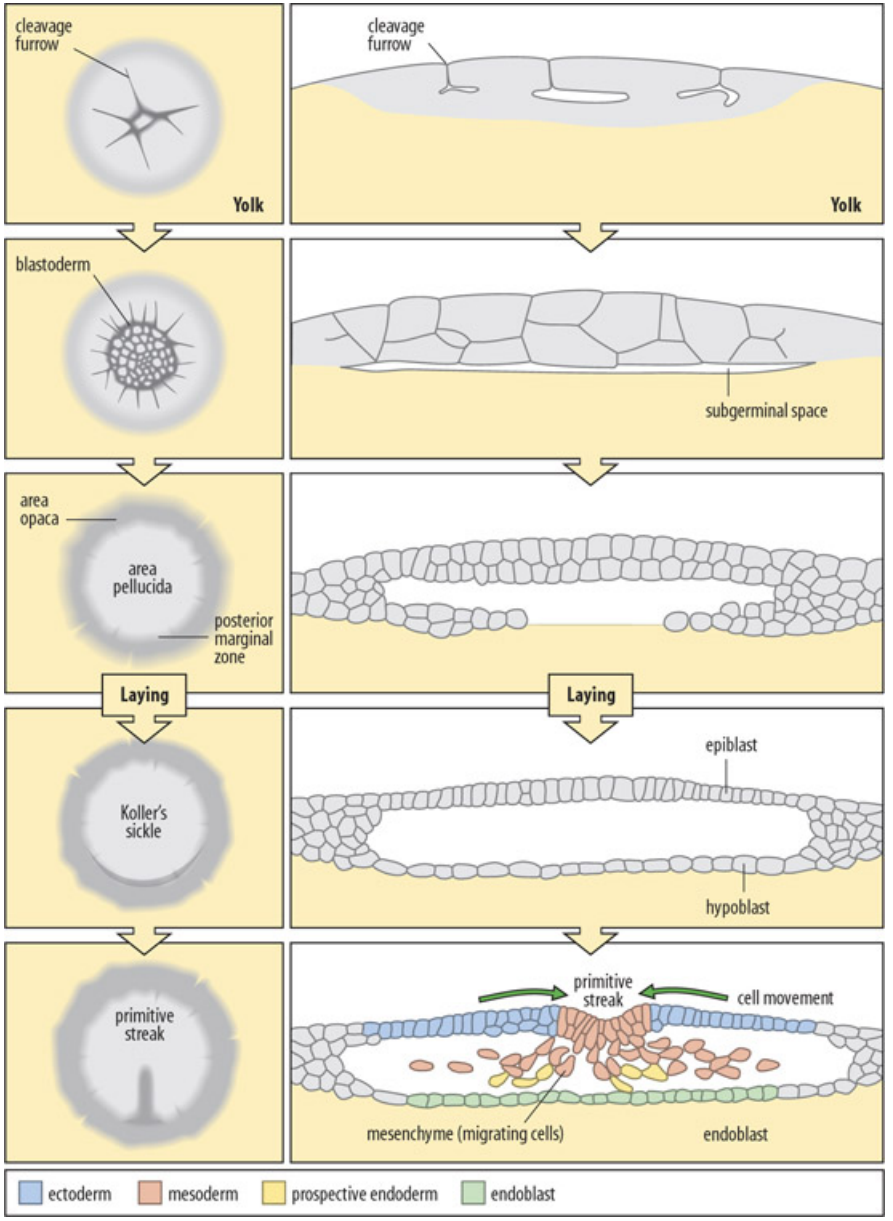








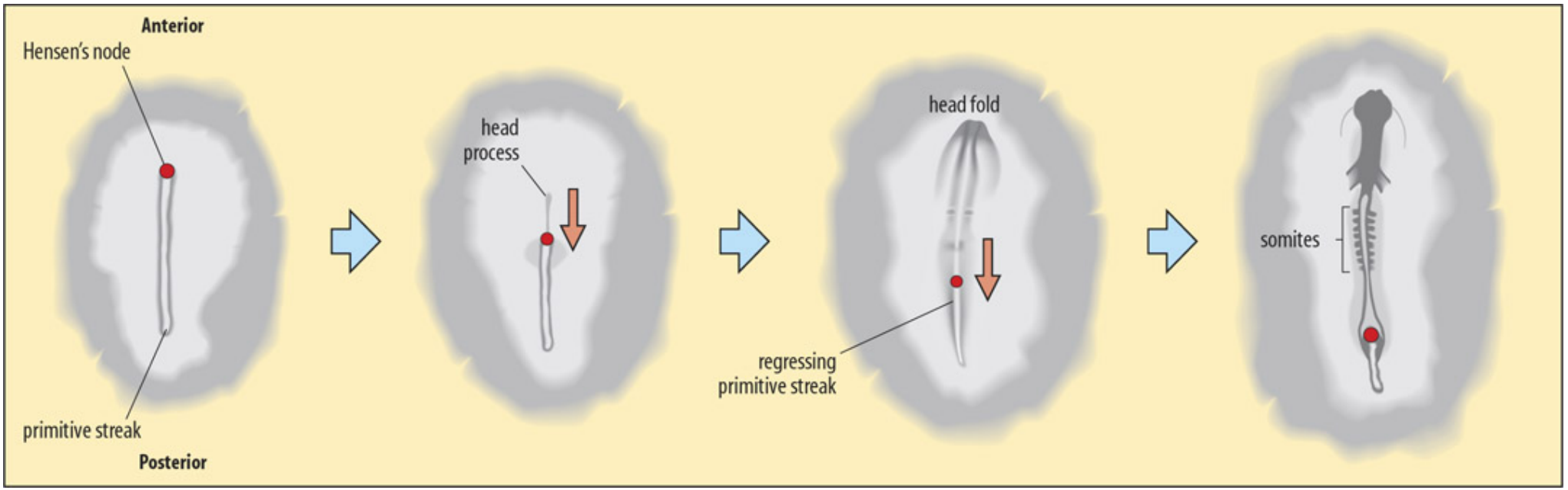
Cleavage and epiblast formation



Primitive Streak

- Determines the location of endoderm and mesoderm ingression during gastrulation
- Analogous to the dorsal fold / organizer in amphibians

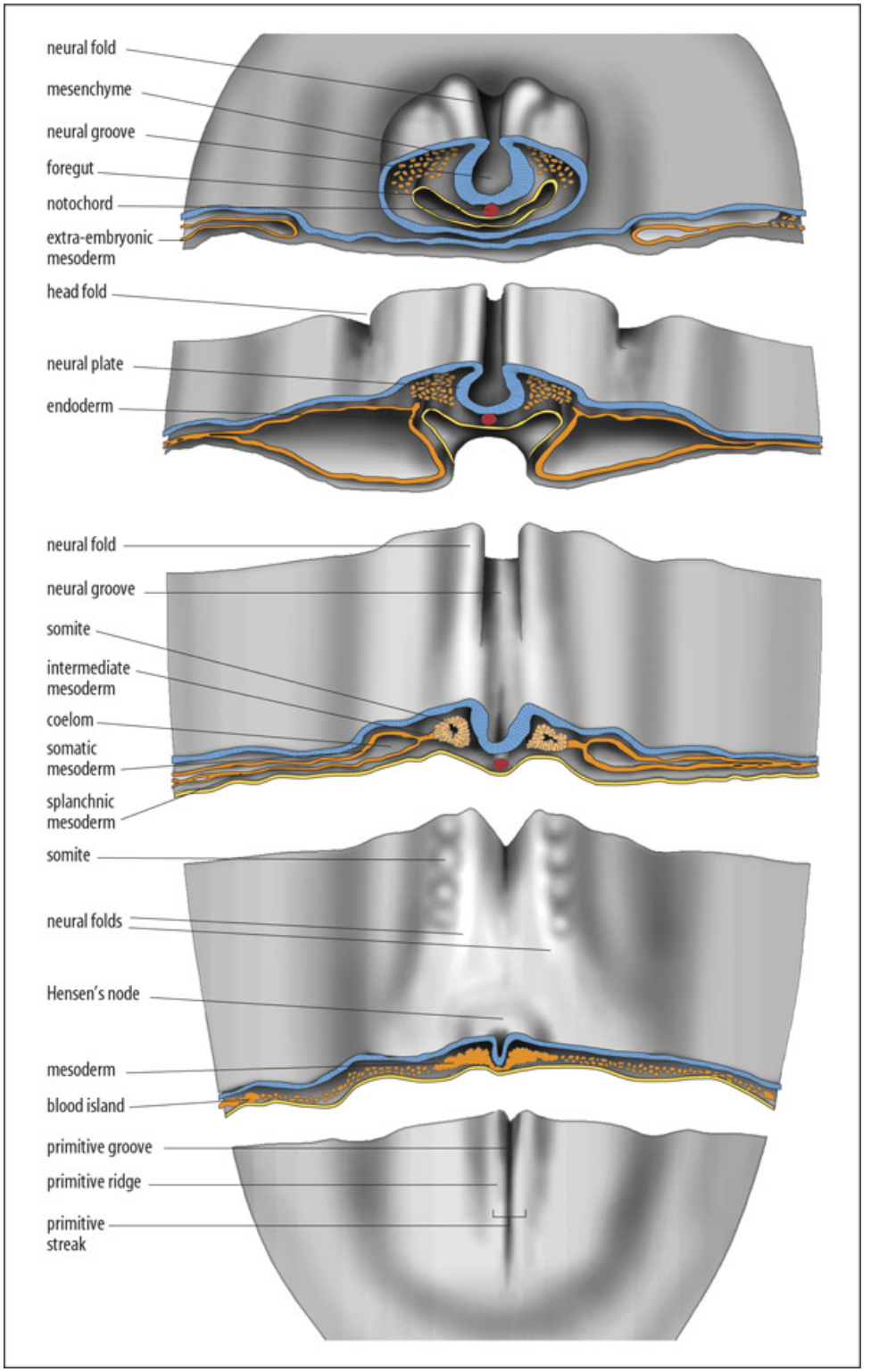
Hensen's node regression

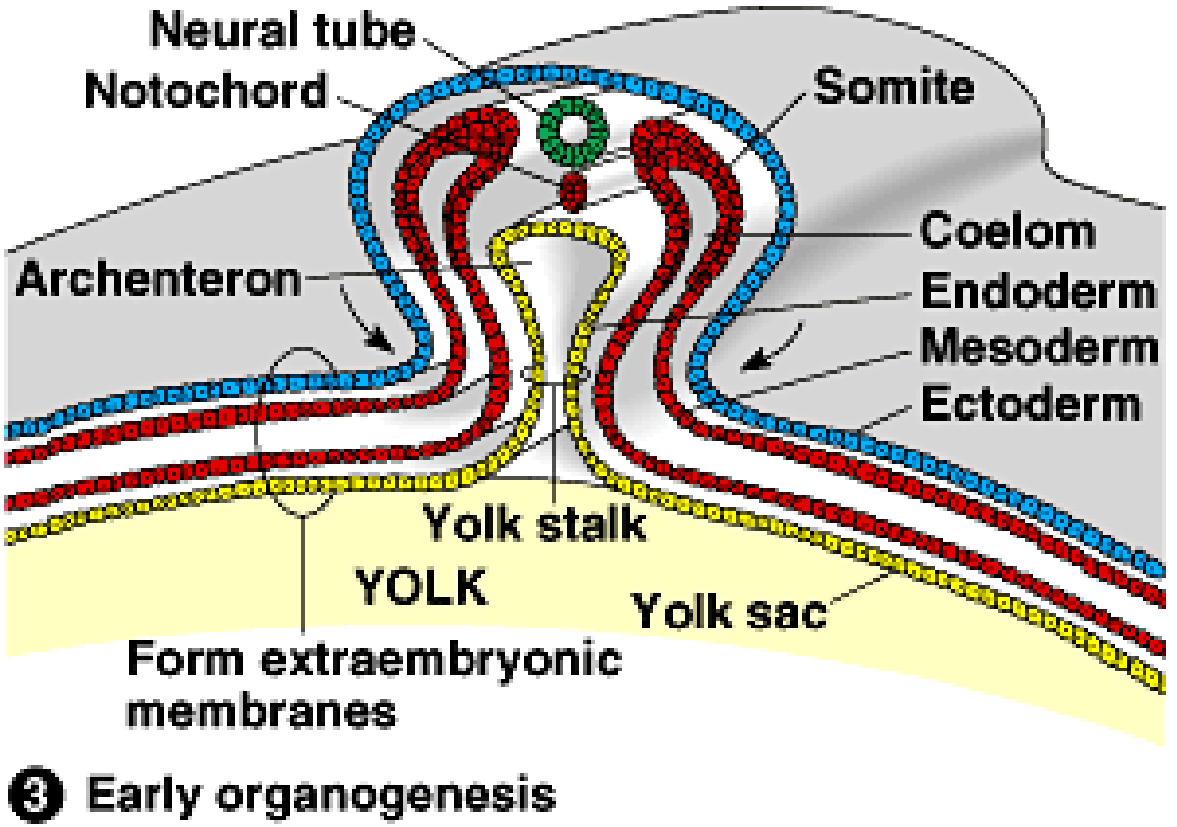


Notochord Development

- As notochord develops at anterior end the primitive streak regresses toward posterior end.

Neural Tube Development



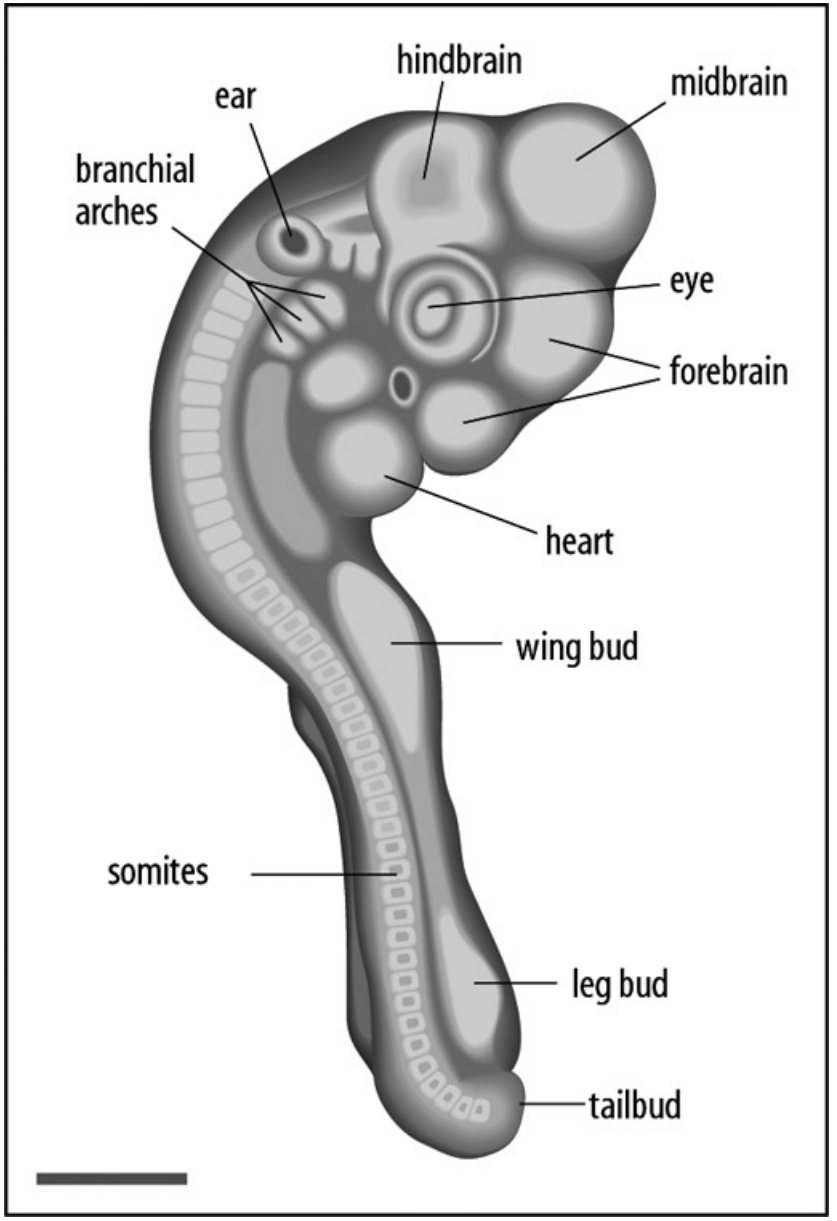


❸ Early organogenesis

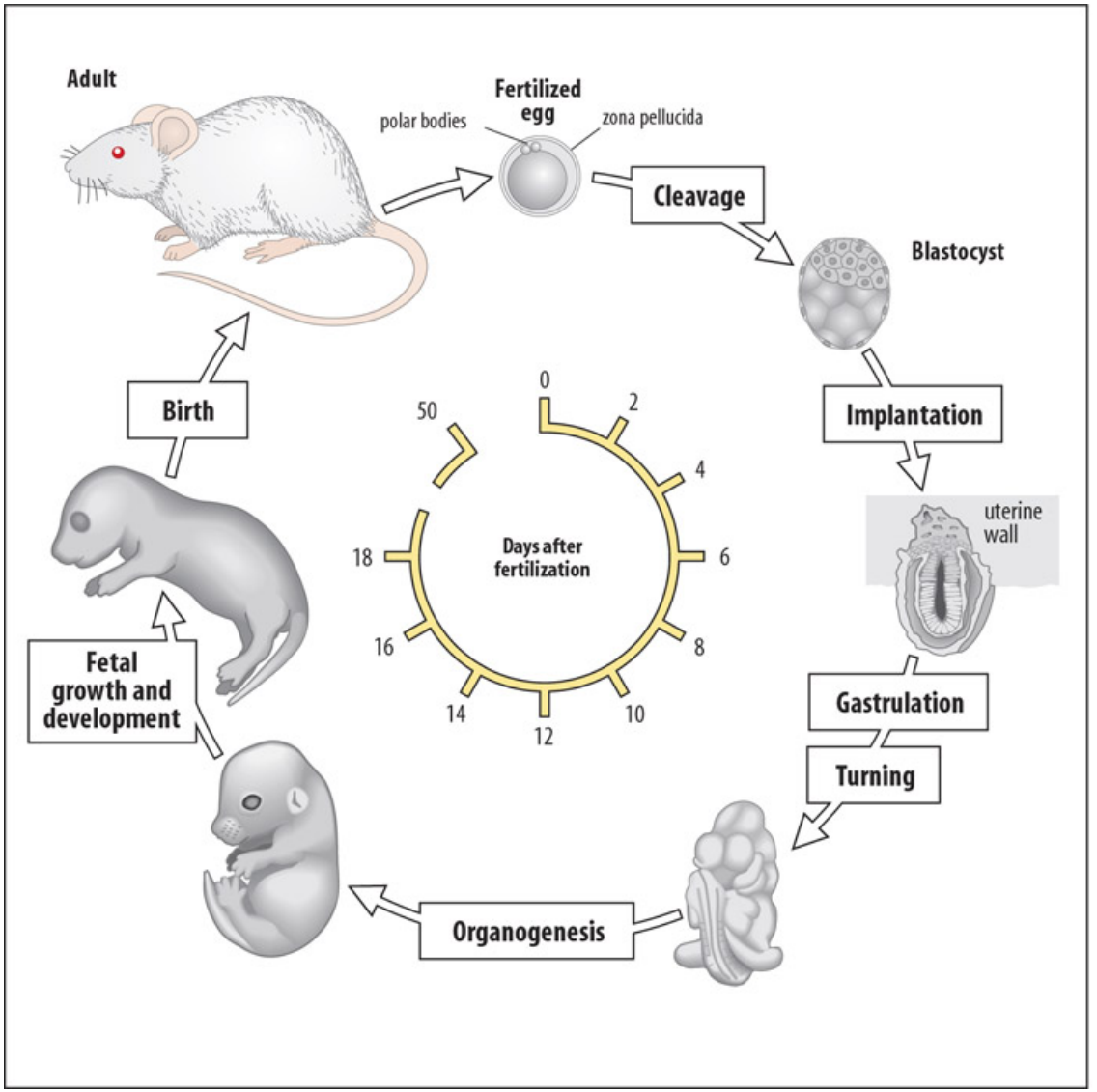
- In early organogenesis the archentreron is formed as lateral folds pinch the embryo away from the yolk.
- The yolk stalk (formed mostly by hypoblast cells) will keep the embryo attached to the yolk.
- The three germ layers and hypoblast cells contribute to the extraembyonic membrane system.

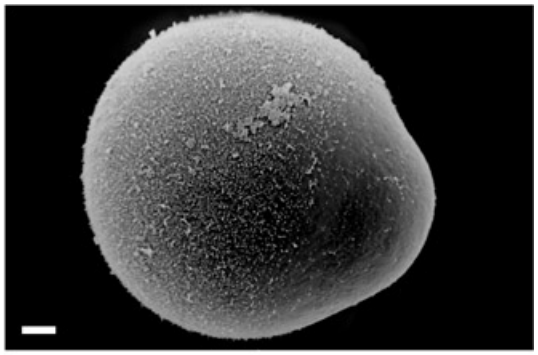
Somites and Neural Tube

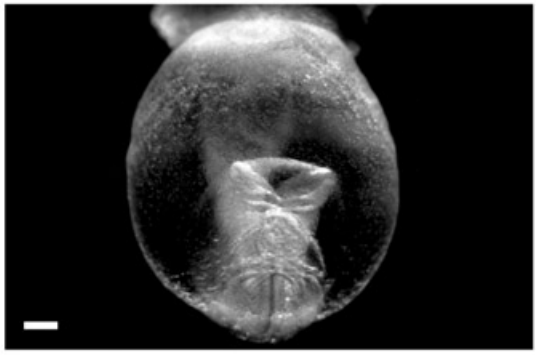
40 Somite Stage



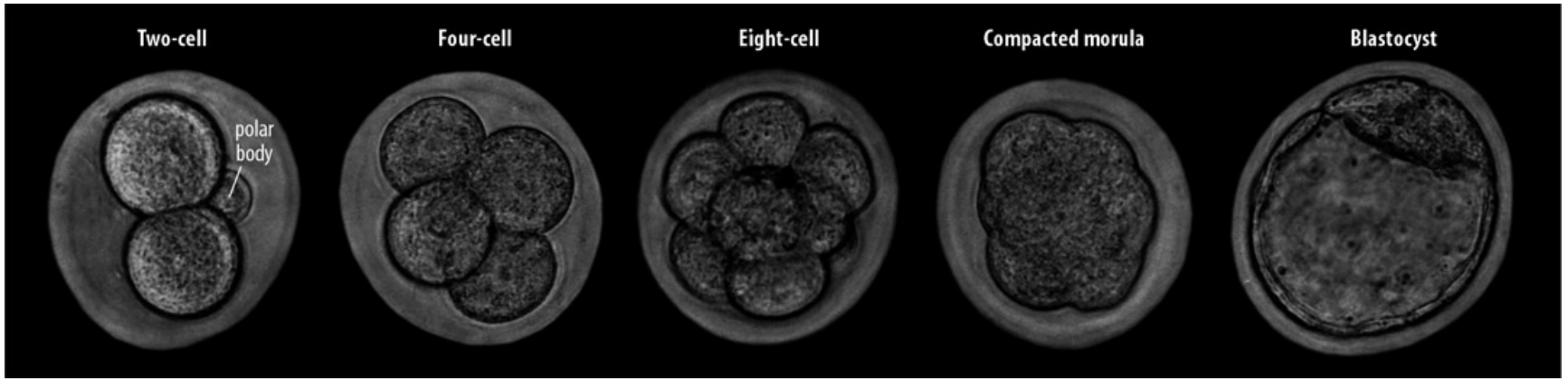
Mammalian Life Cycle



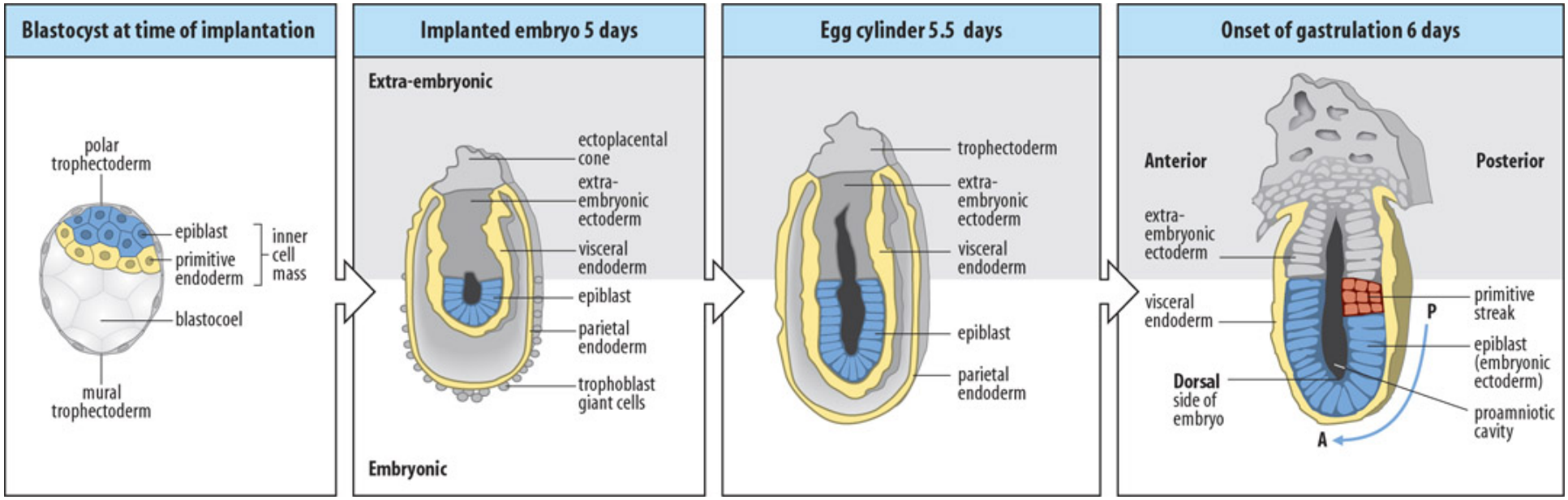




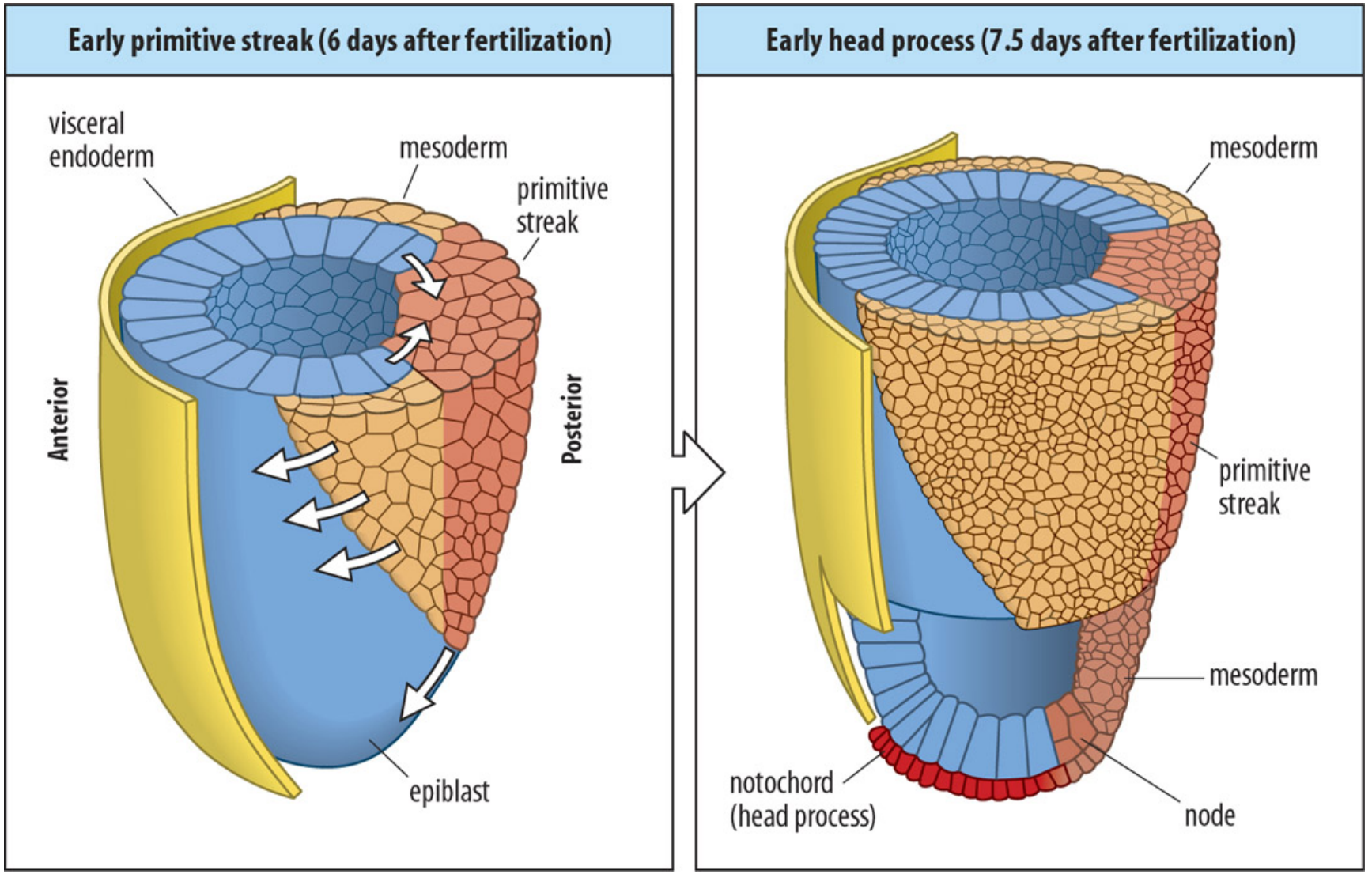
Mammalian Cleavage



Mammalian Gastrulation



Mammalian Primitive Streak

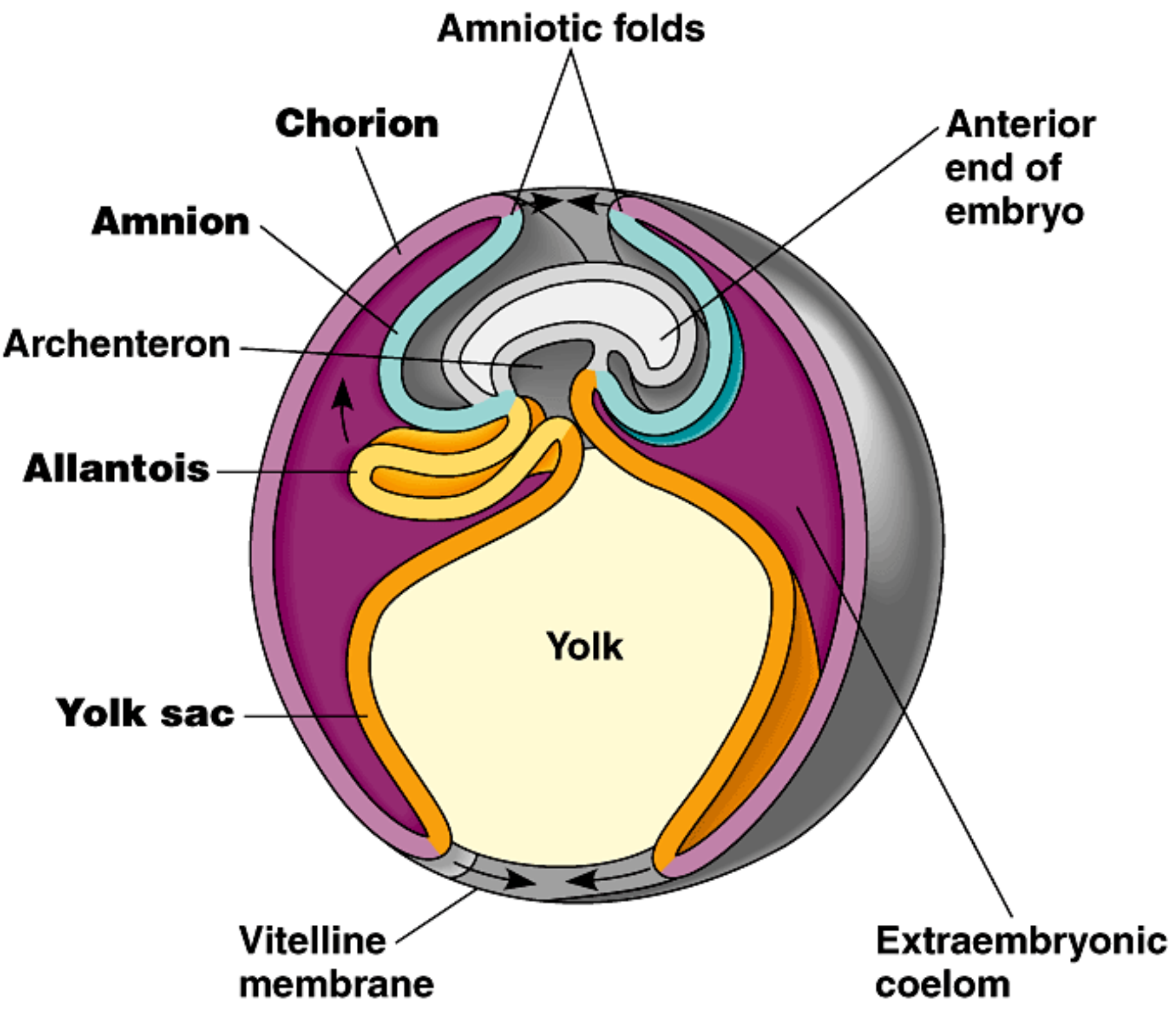


Extraembryonic Membranes

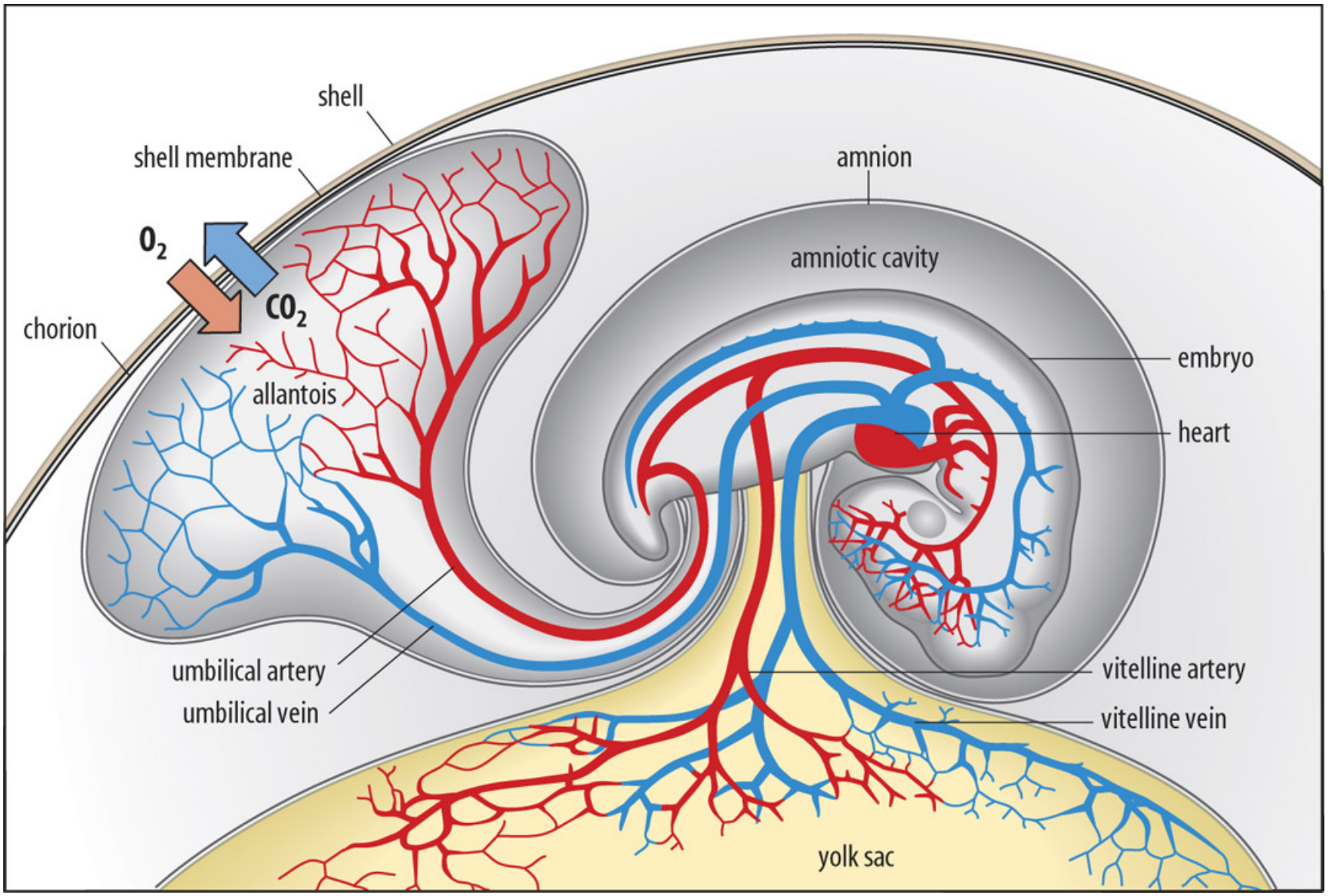
- Membranes that are not part of the developing embryo body
- Required to protect embryo, obtain nutrients, exchange gases and remove waste

Extraembryonic Membranes

- Amnion
  - Surrounds embryo body
- Allantois
  - Gas exchange/nitrogenous waste removal/absorb calcium
- Chorion
  - Gas exchange/shell protection
- Yolk Sac
  - Nutrient absorption

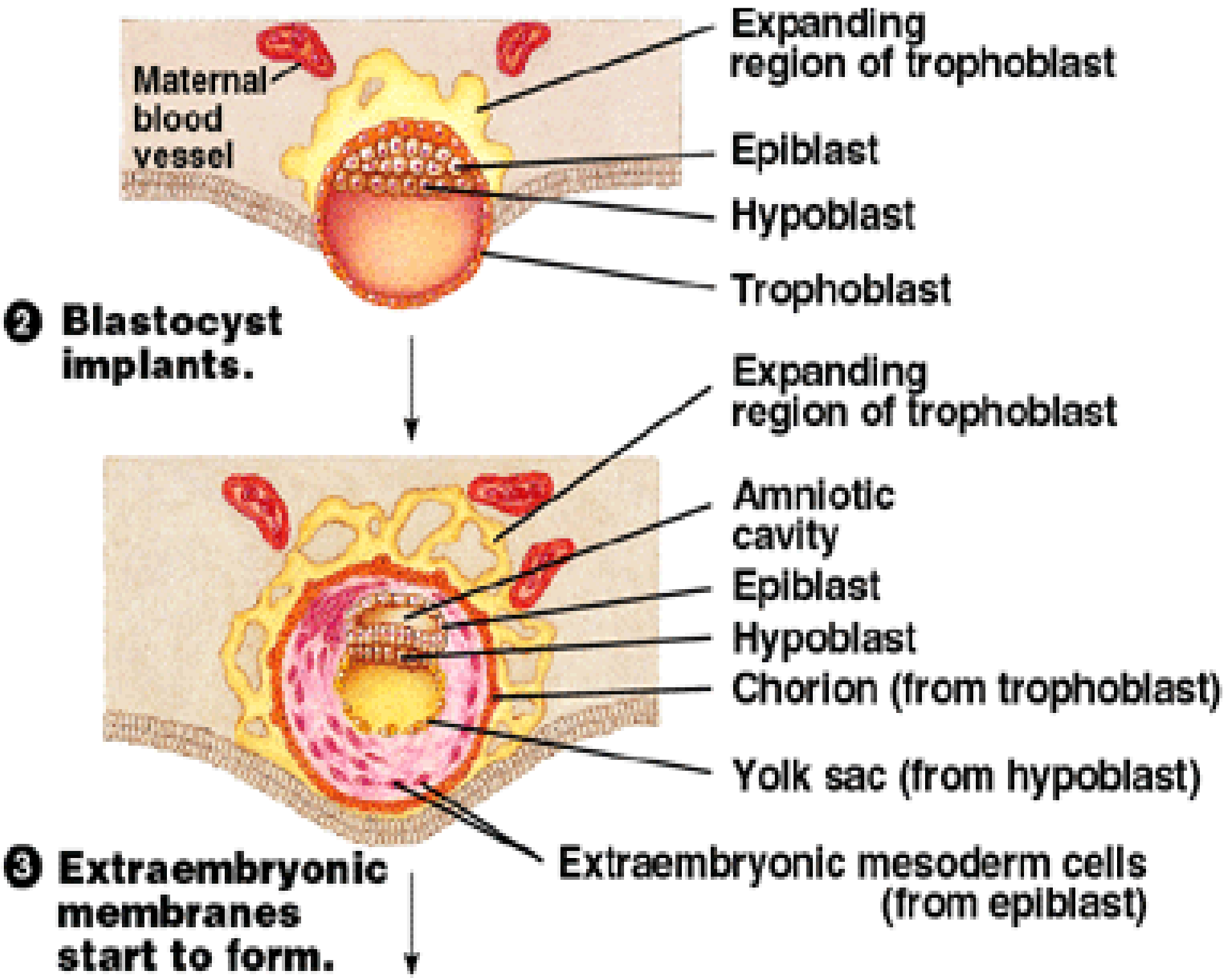

Amniotic folds
Chorion
Anterior end of embryo
Amnion
Archenteron
Allantois
Yolk
Yolk sac
Vitelline membrane
Extraembryonic coelom

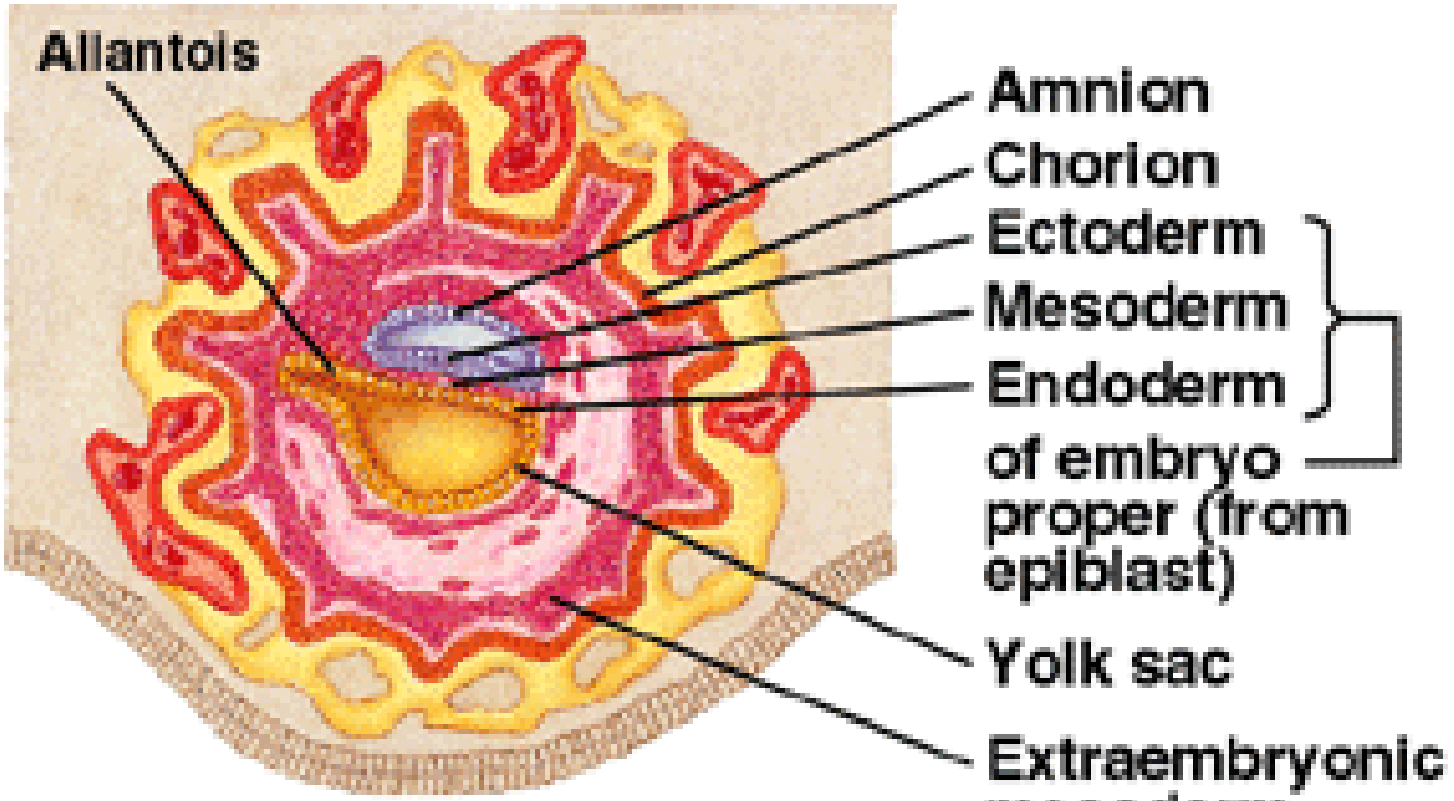
Extra-embryonic membranes



Embryo Implantation

- The trophoblast gives rise to the chorion, which continues to expand into the endometrium and the epiblast begins to form the amnion.


Maternal blood vessel
Expanding region of trophoblast
Epiblast
Hypoblast
Trophoblast
2 Blastocyst implants.
Expanding region of trophoblast
Amniotic cavity
Epiblast
Hypoblast
Chorion (from trophoblast)
Yolk sac (from hypoblast)
Extraembryonic mesoderm cells (from epiblast)
3 Extraembryonic membranes start to form.



4 Gastrulation produces a three-layered embryo with four extraembryonic membranes.

Mammalian Embryonic Membranes

- Homologous with those of shelled eggs
    - **Chorion**: completely surrounds the embryo and other embryonic membranes
    - **Amnion**: encloses the embryo in a fluid-filled amniotic cavity
    - **Yolk sac**: develops from the hypoblast
    - **Allantois**: develops as an outpocketing of the embryo's rudimentary gut. Incorporated into the umbilical cord, where it forms blood vessels