Warm-up

- Objective:
  - Explain the stages of embryonic development.
- Warm-up:
- What hormone stimulates the anterior pituitary to release hormones?

1. Testosterone
2. Progesterone
3. Luteinizing hormone (LH)
4. Follicle stimulating hormone (FSH)
5. Gonadotropin releasing hormone (GnRH)

Warm-up

- Objective:
  - Explain the stages of embryonic development.
- Warm-up:

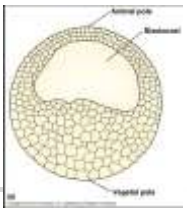
Which is FALSE about embryonic development?

a) Early embryonic division is deuterostomes is spiral
b) The hollow ball stage is called the blastula
c) The end of gastrulation is defined by the formation of primary germ layers
d) The archenteron is the primary gut
e) The opening in the gastrula is called the blastopore

Draw the development

- Show the process of development from zygote to early organogenesis
  - Be sure to label the neural tube, notochord, somites

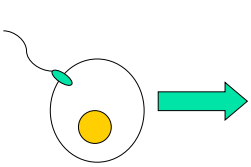
Chapter 47

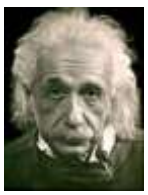


Development

What is the most complex problem in Biology?

The most complex problem





How to get from here to there →

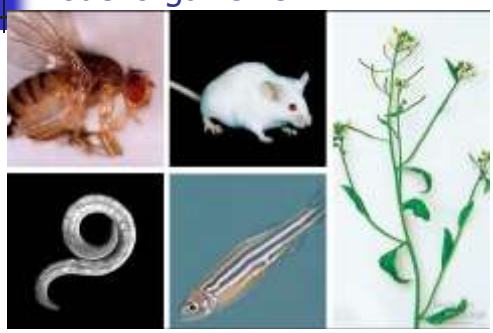
Development: cellular level

- Cell division
- Differentiation
  - Cells become specialized in structure & function
    - If each kind of cell has the same genes, how can they be so different?
    - Shutting off genes = loss of totipotency
  - Morphogenesis
    - "creation of form" = give organism shape
    - Basic body plan
      - Polarity
        - One end is different than the other
      - Symmetry
        - Left & right side of body mirror the other
      - Asymmetry
        - Look at your hand.....

Development: Step-by-step

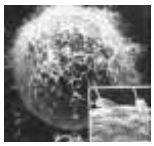
- Gamete formation
- Fertilization
- Cleavage (cell division, mitosis)
- Gastrulation (morphogenesis)
- Organ formation (differentiation)
- Growth & tissue formation (differentiation)

Model organisms



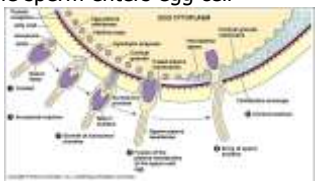
Fertilization

- Joining of egg nucleus & sperm nucleus
  - How does sperm get through egg cell membrane?
  - How to protect against fertilization by multiple sperm?
  - How is the rest of development triggered?



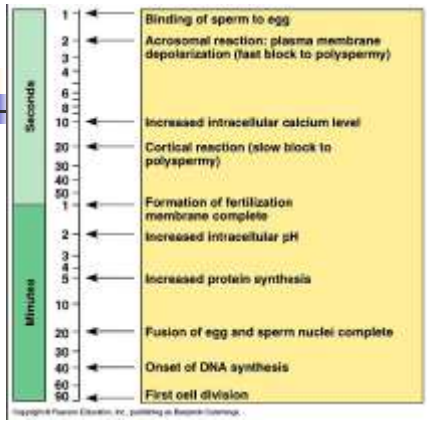
Fertilization

- Joining of sperm & egg
  - Only sperm nucleus enters egg cell
    - Sea urchin
  - Whole sperm enters egg cell



Blocking polyspermy

- Triggers opening of Na+ channels in egg cell membrane
  - Depolarizes membrane
  - "fast block" to polyspermy
- Triggers signal transduction pathway
  - Release of Ca++ from ER causes cascade reaction across egg
  - "fertilization envelope" forms like a bubble around egg
  - "slow block" to polyspermy



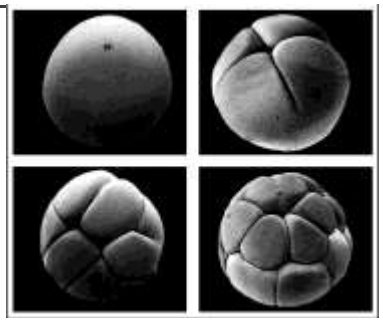
"Fast Block"

- Release of Na+ causes depolarization wave reaction across egg membrane

Cleavage: start of multicellularity

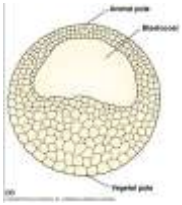
- Repeated mitotic divisions of cytoplasm
  - May be unequal divisions of cytoplasm
    - Cleavage pattern determined by amount of yolk in egg
    - Leaves different contents in each cell
    - Seals development fate of each cell & its descendants
    - Vegetal pole = yolk rich end
    - Animal pole = nearest to the nucleus

Egg → Zygote → Morula



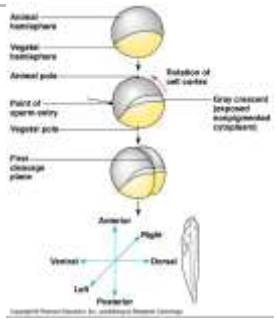
Egg → Morula → Blastula

- Blastula formation
  - Successive division result in blastula
    - Hallow single-layered sphere enclosing a space, the blastocoel



Grey Crescent

- In amphibians
  - Establishes anterior – posterior body axes
- In mammals
  - Polarity may be established by the entry of the sperm into the egg

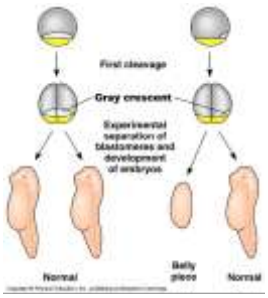


Grey Crescent

- Importance of cytoplasmic determinants
- Also proof of retention of full genetic composition after mitosis

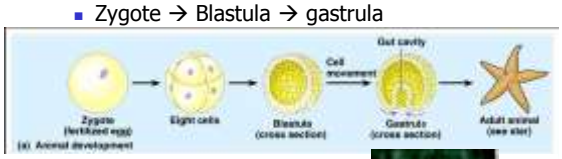
Early Embryonic stages

- Morula
  - Solid ball stage
- Blastula
  - Hallow fluid-filled ball stages
- Gastrula
  - Development of primitive digestive tract (gut) & tissue layers

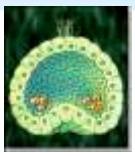


Gastrula

- Zygote → Blastula → gastrula



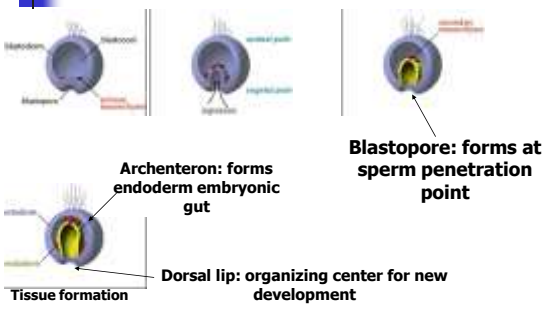
How you looked as a blastula….



Gastrulation

- Zygote → blastula → gastrula
  - Rearranges the blastula to form a 3-layered embryo with primitive gut

Gastrulation

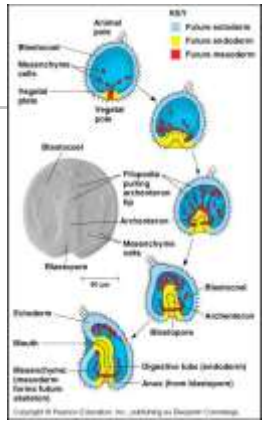


Primary tissue or "germ layers"

- Ectoderm
  - External surfaces: skin
    - Epidermis (skin); nails, hair & glands; tooth enamel; eye lens; epithelia lining of nose, mouth & rectum; nervous system
- Endoderm
  - Internal lining
    - Epithelial lining of digestive tract & respiratory systems; reproductive system & urinary tract; digestive organs
- Mesoderm
  - Middle tissues: muscle, blood bone
    - Notochord: skeletal, muscular, circulatory, lymphatic, excretory & reproductive systems; lining of body cavity

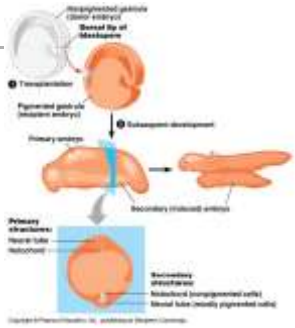
Basic Body Plan

- Archenteron becomes embryonic gut
  - Mouth at one end
  - Anus at the other
- Protostomes
  - "1st mouth"
  - Blastopore = mouth
  - Invertebrates
- Deuterostomes
  - "2nd mouth"
  - Blastopore = anus
  - Echinoderms & vertebrates



Dorsal lip

- Organizer: grafting the dorsal lip of one embryo onto the ventral surface of another embryo results in the development of a second notochord & neutral tube at the site of the graft

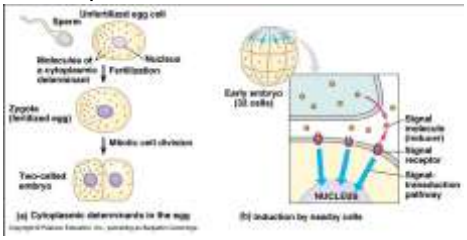


Morphogenesis

- Organization of differentiated cell into tissues & organs
- Cell migration
  - By changes in shape
    - Cells fold inward as pockets by changing shape
  - Cell movement
    - Cell move by pseudopods projecting from the cell body
  - Signals from cues
    - Guided by following chemical gradients
    - Respond to adhesive cues from recognition proteins on adjacent cells

Cell signaling

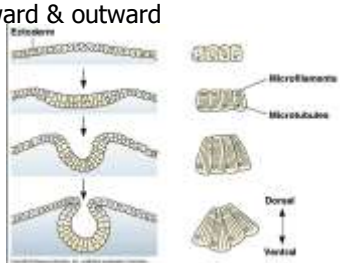
- Regulating the expression of genes that affect the development fate of the cell



Gastrulation

- Cell change size & shape: sheets of cells expand & fold inward & outward

Changes in cell shape involve reorganization of the cytoskeleton



Gastrulation

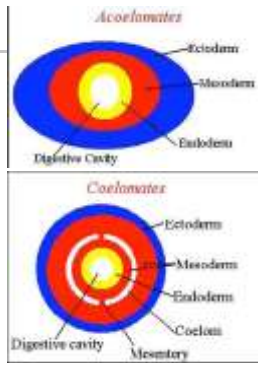
- Cells move by psuedopods

Organ development

- Organ development begins with the formation of:
  - Neural tube
    - Future spinal cord & brain
  - Notochord
    - Primitive skeleton, replaced by vertebrate spinal column
  - Somites
    - Band of tissue that will become muscles & bones

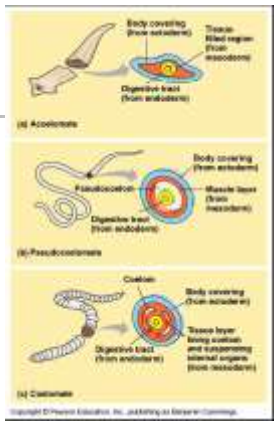
Coelum

- Body cavity formed between layers of mesoderm
  - In which the digestive tract & other internal organs are suspended



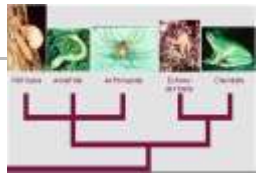
Coelum

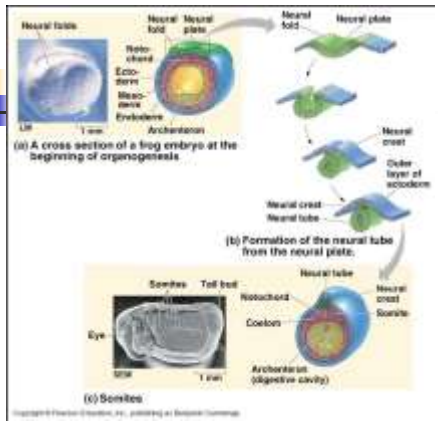
- Acoelomates
  - Flatworms
- Pseudocoelomates
  - Roundworms, nemotodes
- Coelomates
  - Mollusks, annelids, arthropods, echinoderms, & chordata



Coelomates

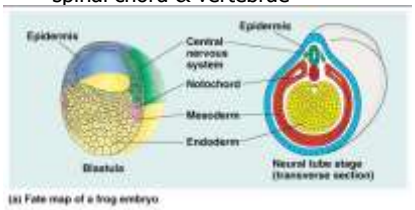
- Molluska
  - Snails, clams
- Annelida
  - Segmented worms
- Arthropoda
  - Spiders & insects
- Echinodermata
  - Marine, starfish, sea urchins
- Chordata
  - Vertebrates





Neural tube development

- Neural tube & notochord
  - Embryotic structures that will become spinal chord & vertebrae

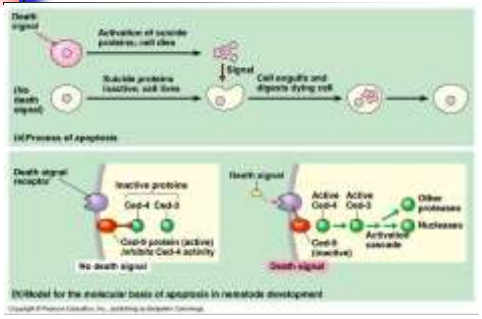


(a) Fate map of a frog embryo

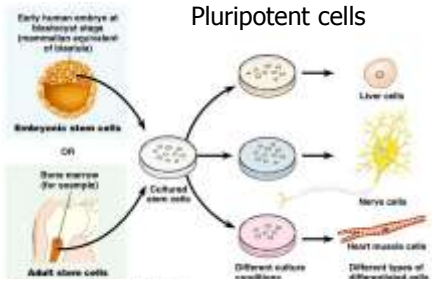
Apoptosis

- Programmed cell death
  - Sculpts body parts
  - Genetically programmed elimination of tissues & cells that were used for only short periods in the embryo or adult
    - Human embryos develop with webs between toes & fingers, but they are not born that way!

Apoptosis



Stem cells



Master control cells

- Homeotic genes
  - Master regulatory genes
  - In flies these genes identify body segments & then turn on other appropriate genes to control further development of those body sections

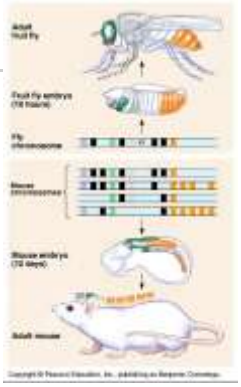
Homeotic genes

- Mutations to homeotic genes produce flies with such strange traits as legs growing out the head in place of antennae
  - Structures characteristic of a particular part of the animal arise in wrong places

Antennapedia flies

Homeobox DNA

- Master control genes evolved early
- Conserved for hundreds of millions of years
- Homologous homeobox genes in fruit flies & vertebrates
  - Keep their chromosomal arrangement



Evolutionary constraints on development

- Basic body plans of the major animals groups have not changed due to a limited number of homeotic genes (master genes)
- These genes have imposed limits
  - Taxonomic/evolutionary
  - Physical
  - Architectural