CHAPTER 47: ANIMAL DEVELOPMENT

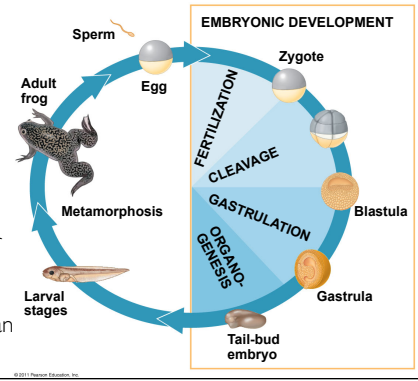
AP Biology 2013

1

ZYGOTE TO ADULT

- Preformation - 18th century theory that the egg or sperm contained an embryo
  - The embryo was thought to be a preformed miniature infant (homunculus) that becomes larger during development
- We now know:
  - An organism's development is determined by the genome of the zygote and by differences that arise between early embryonic cells
  - Cell differentiation - specialization of cells in their structure and function
  - Morphogenesis - process by which an animal takes shape

Fig. 47.2



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DEVELOPMENTAL EVENTS

- Fertilization - main function is to bring the haploid nuclei of sperm and egg together to form a diploid zygote
  - Contact of the sperm on the egg's surface initiates metabolic reactions within the egg that trigger embryonic development
  - Acrosomal reaction - when sperm meets egg, hydrolytic enzymes that digest material surrounding the egg are released
  - Gamete contact blocks polyspermy

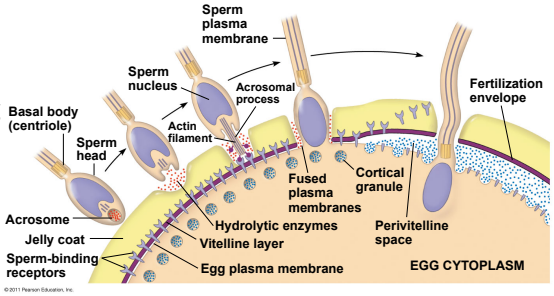

Fig. 47.3

3

DEVELOPMENTAL EVENTS

- Fertilization:
  - Fusion of egg and sperm also initiates the cortical reaction which causes a rise in Ca^{2+} that stimulates cortical granules to release their contents outside the egg
  - These changes cause the formation of a fertilization envelope that also acts as a block to polyspermy

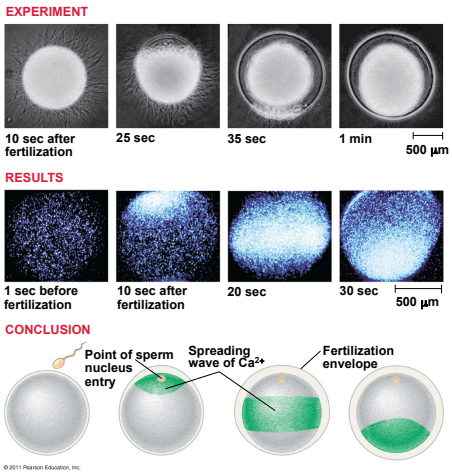

Fig. 47.4

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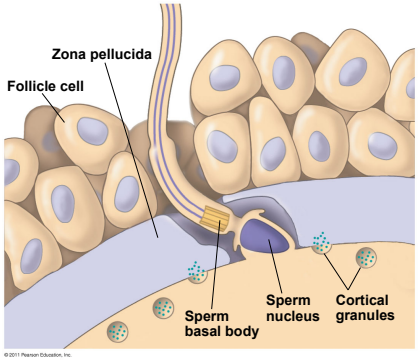
DEVELOPMENTAL EVENTS

Fig. 47.5

- Activation of the Egg
  - Because of the rise in Ca^{2+} in the egg's cytosol, the rate of cellular respiration and protein synthesis increases substantially
- In mammals, the cortical reaction modifies the zona pellucida as a slow block to polyspermy



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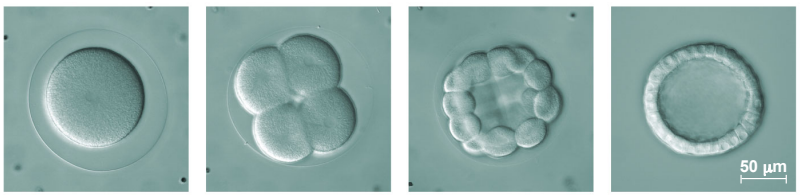
DEVELOPMENTAL EVENTS

- Cleavage - period of rapid cell division without growth
  - Many animals (not mammals) have defined polarity (distribution of yolk with vegetal pole having the most and the animal pole having the least)



Figs. 47.6

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DEVELOPMENTAL EVENTS

- Cleavage planes follow a specific pattern relative to the animal and vegetal poles
- Meroblastic cleavage - incomplete division of the egg (yolk-rich eggs like reptiles and birds)
- Holoblastic cleavage - complete division of the egg (little or moderate amounts of yolk like sea urchins and frogs)

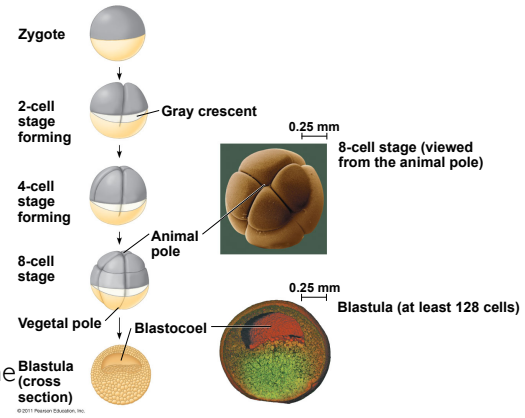

Fig. 47.7

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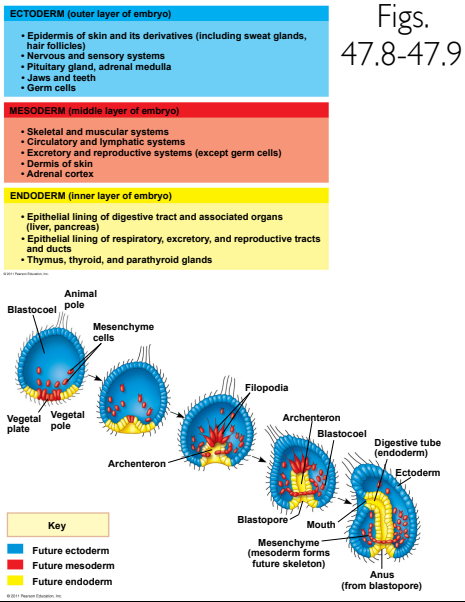
DEVELOPMENTAL EVENTS

- Morphogenesis - cells occupy their appropriate locations
- Gastrulation - rearranges the cells of the blastula into a three-layered embryo called a gastrula that has a primitive gut
  - Three embryonic germ layers:
    - Ectoderm - outer layer of gastrula
    - Endoderm - lines the embryonic digestive tract
    - Mesoderm - partially fills the space between the ectoderm and endoderm

Figs. 47.8-47.9



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GASTRULATION FROG VS. CHICK

Fig. 47.10

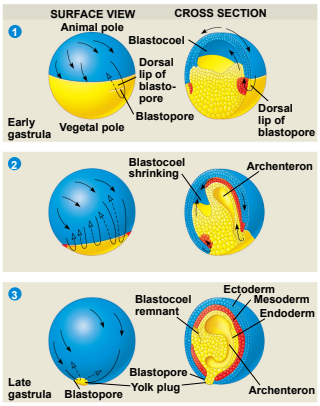
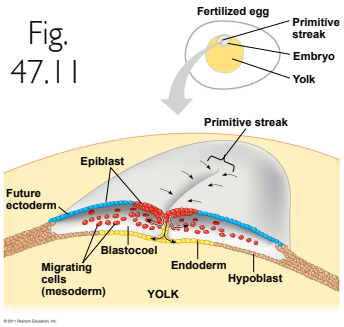


Fig. 47.11



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GASTRULATION IN HUMANS

- Human eggs have very little yolk
- Blastocyst - human equivalent of blastula
- Inner cell mass - cluster of cells at one end of the blastocyst
- Trophoblast - outer epithelial layer that does not contribute to embryo but instead initiates implantation
- Gastrulation

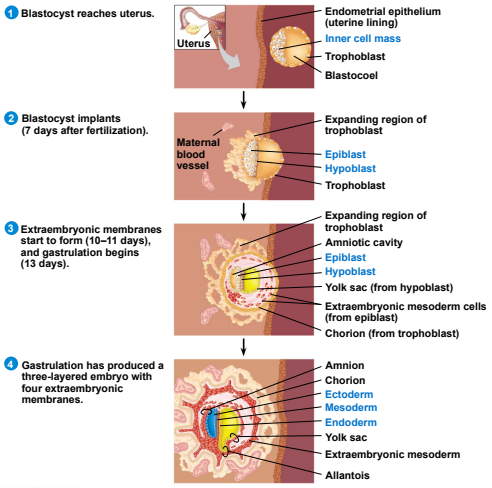

Fig. 47.12

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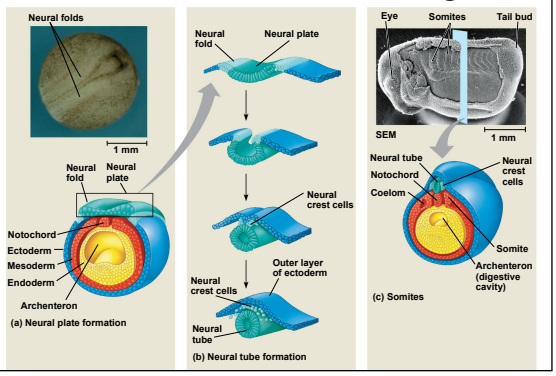
ORGANOGENESIS

- Regions of the three germ layers develop into the rudiments of organs during organogenesis
- Vertebrates form a notochord from the mesoderm and a neural plate from the ectoderm
  - Neural plate curves inward forming the neural tube

Fig. 47.13

Mesoderm also gives rise to the somites (later form vertebrae and muscle) and the coelom



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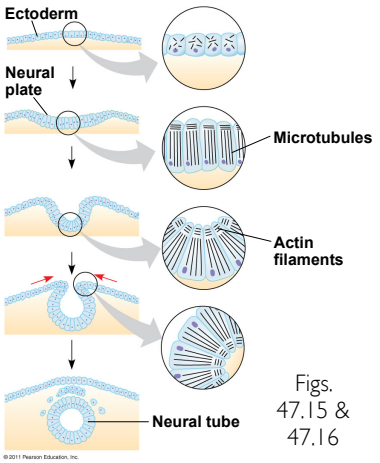
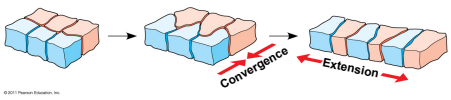
MORPHOGENESIS

- Involves changes in shape, position, and adhesion
- Changes in shape involve reorganization of the cytoskeleton
  - Formation of the neural tube involves microtubules and microfilaments
  - Also impacts cell migration (movement of cells from one place to another) ex. convergent extension



Figs. 47.15 & 47.16

- Tissue invagination is caused by changes in both cells shape and migration during gastrulation



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MORPHOGENESIS

- Apoptosis - programmed cell death
- At various times during development, individual cells, sets of cells, or whole tissues stop developing and are engulfed by neighboring cells

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DEVELOPMENTAL FATE

- Determination - cell or group of cells becomes committed to a particular fate
- Differentiation
  - Embryonic cells must become different from on another
  - Interactions with other embryonic cells influence the fate of cells by causing changes in gene expression
- Fate maps - territorial diagrams of embryonic development

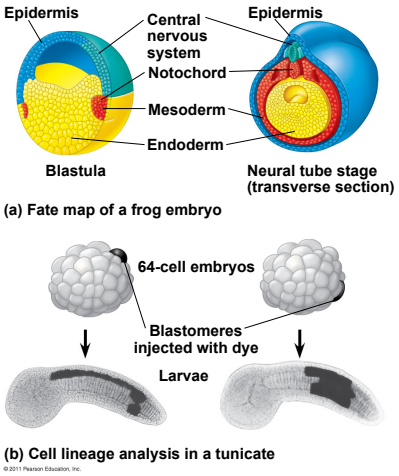

Fig. 47.17

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P GRANULES IN *C. ELEGANS*

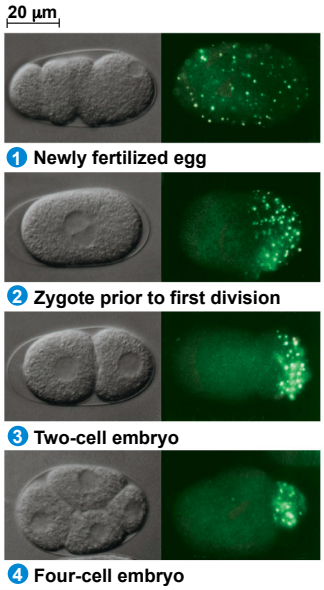

Fig. 47.20

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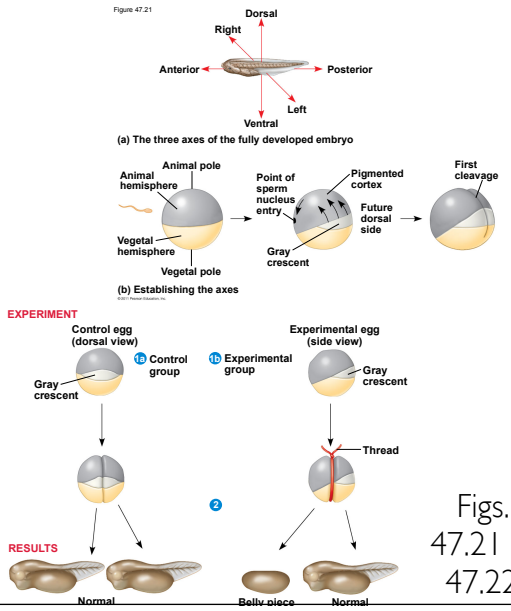
AXES OF EMBRYOS

- Nonamniotic vertebrates - body axes are determined during oogenesis or fertilization
- Amniotes - environmental differences play a role in establishing differences between cells and body axes
- Uneven cytoplasmic determinants are important in establishing body axes



Figs. 47.21 & 47.22

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THE "ORGANIZER"

- Initiates a chain reaction of inductions that result in the formation of the notochord, neural tube, and other organs
- Plays a major role in pattern formation (spatial organization)
- Positional information tells a cell where it is with respect to the animal's body axes
- Wings and legs of chicks begin as limb buds
  - Limb buds respond to positional information

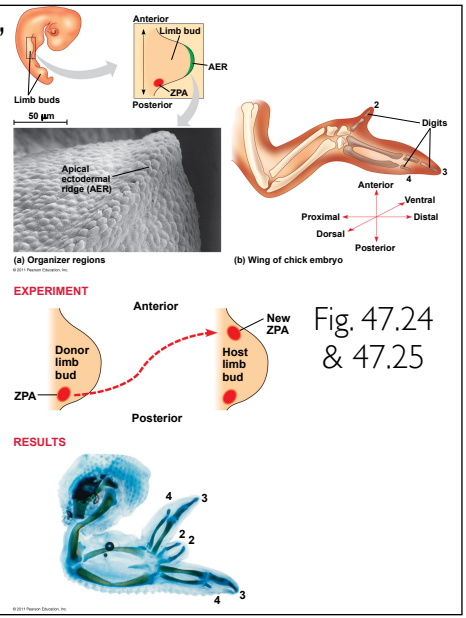

Fig. 47.24 & 47.25

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