CHAPTER 47:
ANIMAL DEVELOPMENT

AP Biology 2013

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

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
DEVELOPMENTAL EVENTS

• Fertilization:
  - Fusion of egg and sperm also initiates the cortical reaction which causes a rise in Ca\textsuperscript{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.

CONCLUSION

Fig. 47.4

DEVELOPMENTAL EVENTS

• Activation of the Egg
  - Because of the rise in Ca\textsuperscript{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.

CONCLUSION

Fig. 47.5

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).

CONCLUSION

Figs. 47.6
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)

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

GASTRULATION FROG VS. CHICK

Figs. 47.8-47.9

ENDODERM (inner layer of embryo)
- Gut and associated organs
- Endocrine system
- Reproductive system

Figs. 47.10

Figs. 47.11
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

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

Fig. 47.13

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

Figs. 47.15 & 47.16
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

DEVELOPMENTAL FATE

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

P GRANULES IN C. ELEGANS

1. Newly fertilized egg
2. Zygote prior to first division
3. Two-cell embryo
4. Four-cell embryo
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.

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.

Figs. 47.21 & 47.22

Figs. 47.24 & 47.25