Morphogenesis in animals involves specific changes in cell shape, position, and survival

- After cleavage, the rate of cell division slows and the normal cell cycle is restored
- **Morphogenesis**, the process by which cells occupy their appropriate locations, involves
  - **Gastrulation**, the movement of cells from the blastula surface to the interior of the embryo
  - **Organogenesis**, the formation of organs

Gastrulation

- **Gastrulation** rearranges the cells of a blastula into a three-layered embryo, called a **gastrula**
- The three layers produced by gastrulation are called embryonic **germ layers**
  - The **ectoderm** forms the outer layer
  - The **endoderm** lines the digestive tract
  - The **mesoderm** partly fills the space between the endoderm and ectoderm
- Each germ layer contributes to specific structures in the adult animal

Figure 47.8

ECTODERM (outer layer of embryo)

- Epidermis of skin and its derivatives (including sweat glands, hair follicles)
- Nervous and sensory systems
- Pituitary gland, adrenal medulla
- Jaws and teeth
- Germ cells

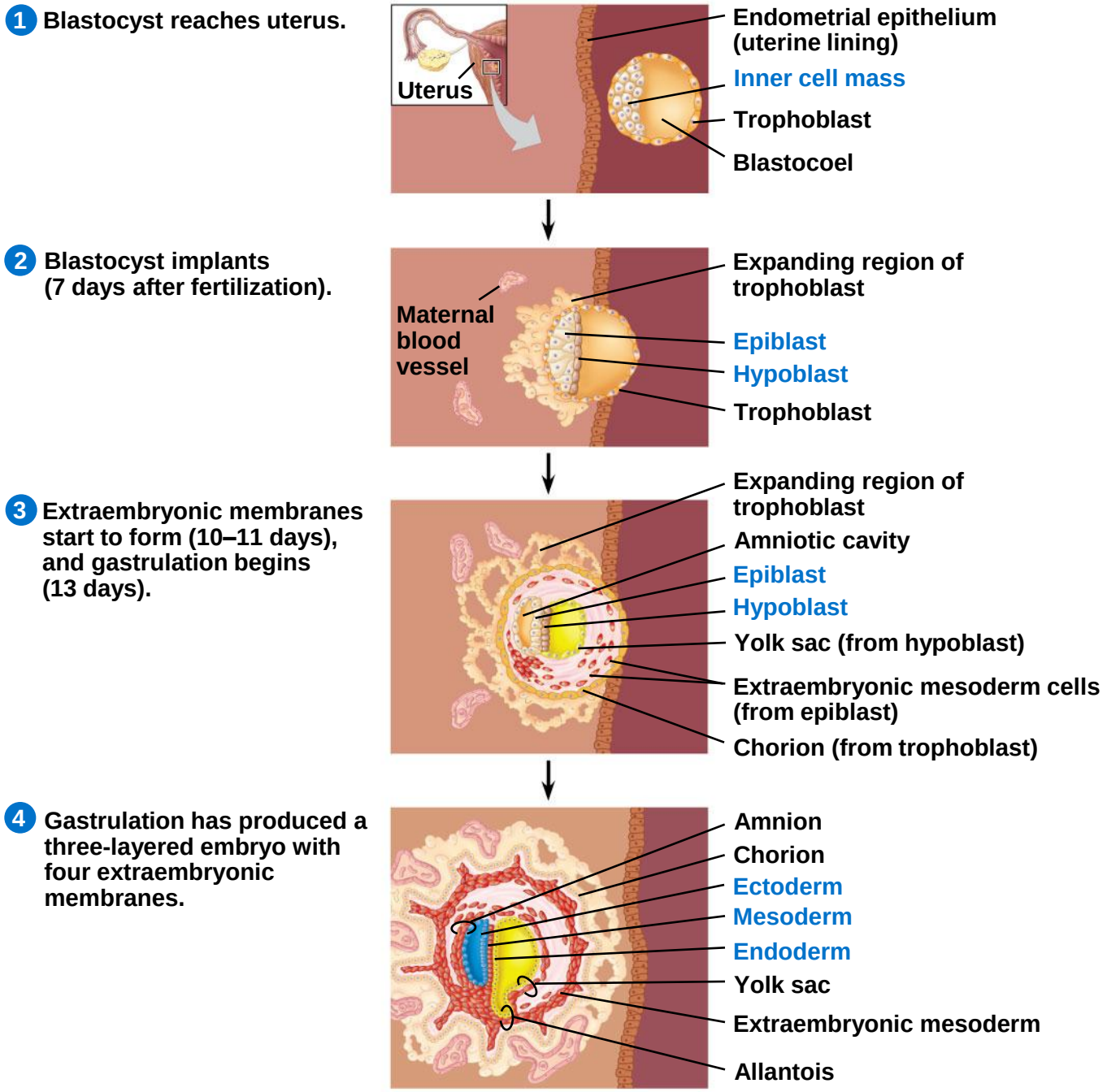
MESODERM (middle layer of embryo)

- Skeletal and muscular systems
- Circulatory and lymphatic systems
- Excretory and reproductive systems (except germ cells)
- Dermis of skin
- Adrenal cortex

ENDODERM (inner layer of embryo)

- Epithelial lining of digestive tract and associated organs (liver, pancreas)
- Epithelial lining of respiratory, excretory, and reproductive tracts and ducts
- Thymus, thyroid, and parathyroid glands

Figure 47.12



Developmental Adaptations of Amniotes

- The colonization of land by vertebrates was made possible only after the evolution of
  - The shelled egg of birds and other reptiles as well as monotremes (egg-laying mammals)
  - The uterus of marsupial and eutherian mammals

Organogenesis

- During **organogenesis**, various regions of the germ layers develop into rudimentary organs
- Early in vertebrate organogenesis, the **notochord** forms from mesoderm, and the neural plate forms from ectoderm

- The mechanisms of organogenesis in invertebrates are similar, but the body plan is very different
- For example, the neural tube develops along the ventral side of the embryo in invertebrates, rather than dorsally as occurs in vertebrates

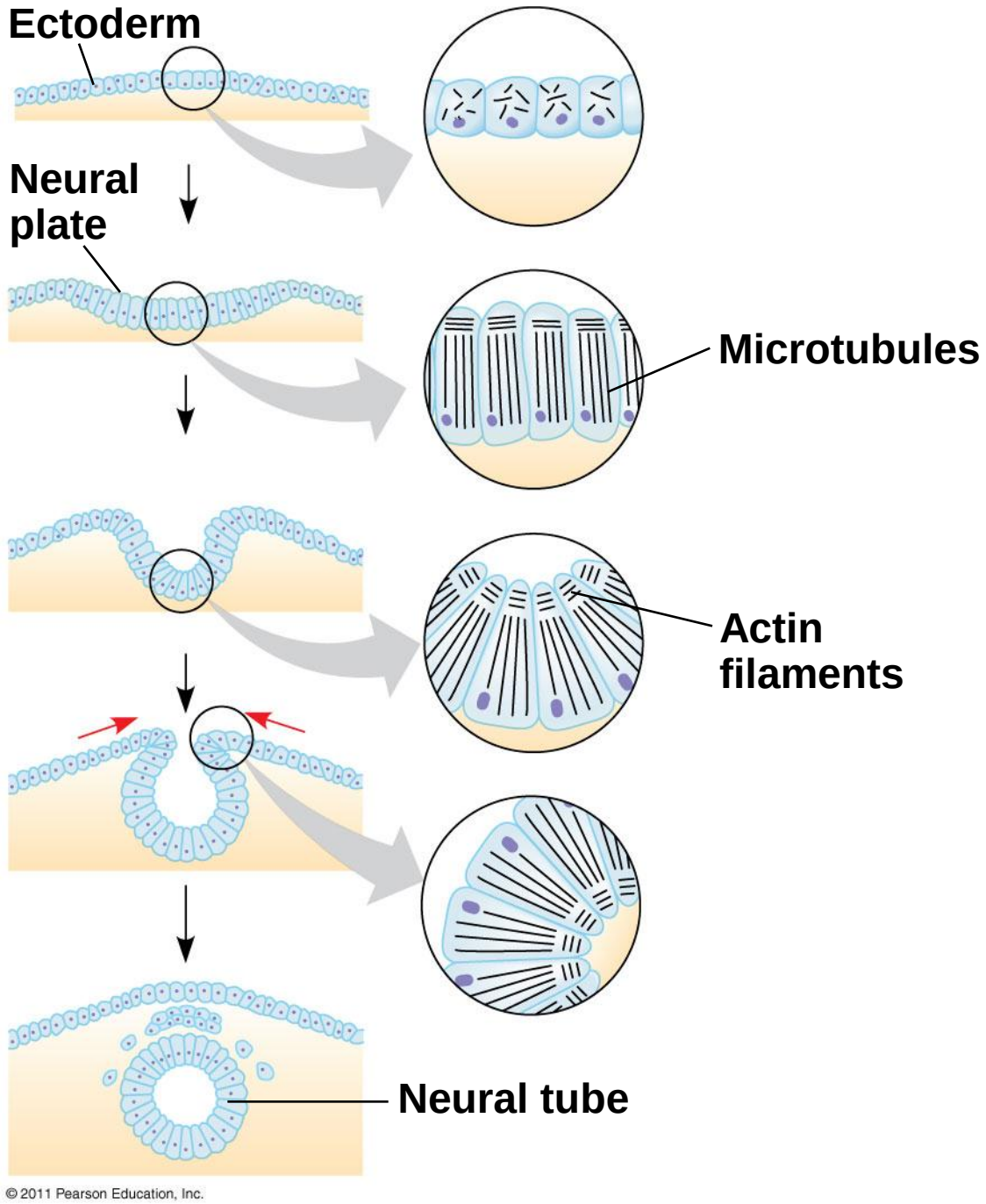
Mechanisms of Morphogenesis

- Morphogenesis in animals but not plants involves movement of cells

The Cytoskeleton in Morphogenesis

- Reorganization of the cytoskeleton is a major force in changing cell shape during development
- For example, in neurulation, microtubules oriented from dorsal to ventral in a sheet of ectodermal cells help lengthen the cells along that axis

Figure 47.15-5

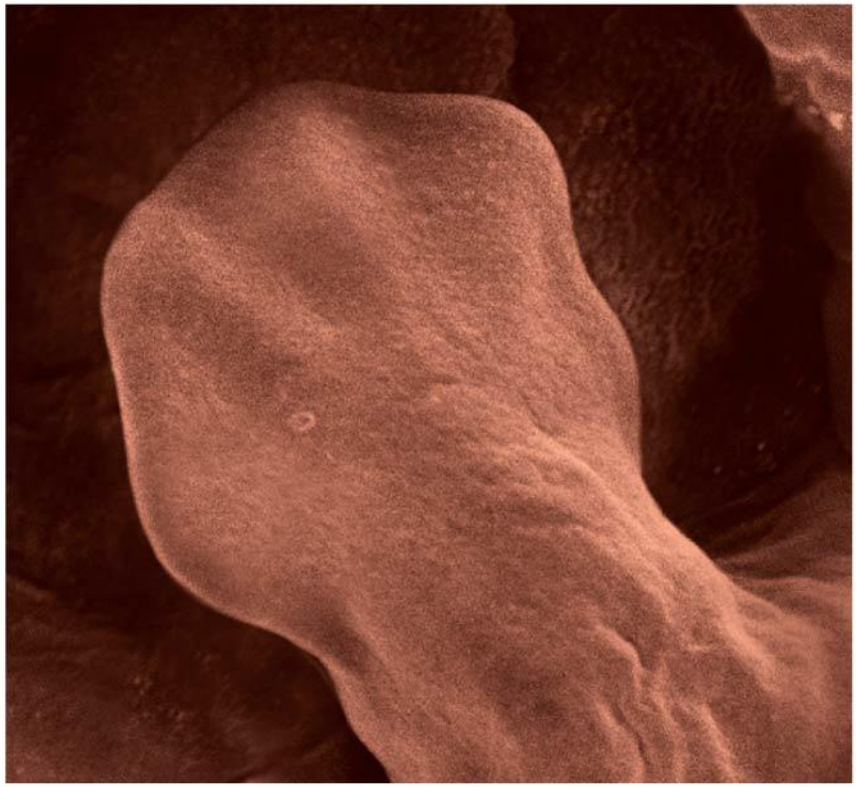


Programmed Cell Death

- Programmed cell death is also called **apoptosis**
- At various times during development, individual cells, sets of cells, or whole tissues stop developing and are engulfed by neighboring cells
- For example, many more neurons are produced in developing embryos than will be needed
- Extra neurons are removed by apoptosis

– Programmed cell death

- selectively kills cells to reshape the embryo and
- is used to form fingers and toes.



Concept 47.3: Cytoplasmic determinants and inductive signals contribute to cell fate specification

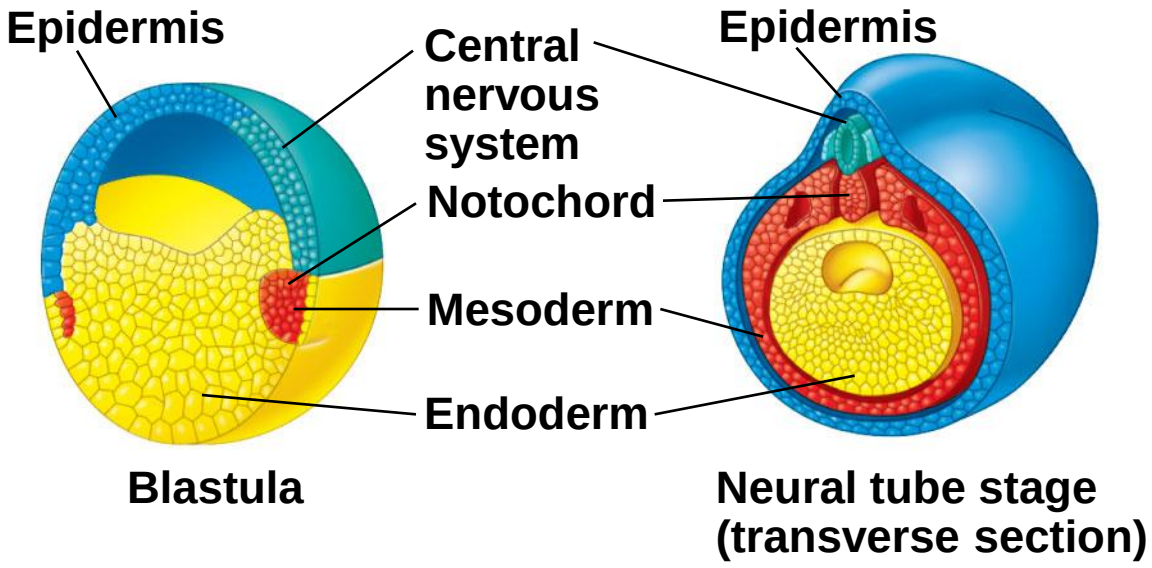
- **Determination** is the term used to describe the process by which a cell or group of cells becomes committed to a particular fate
- **Differentiation** refers to the resulting specialization in structure and function

- Cells in a multicellular organism share the same genome
- Differences in cell types are the result of the expression of different sets of genes

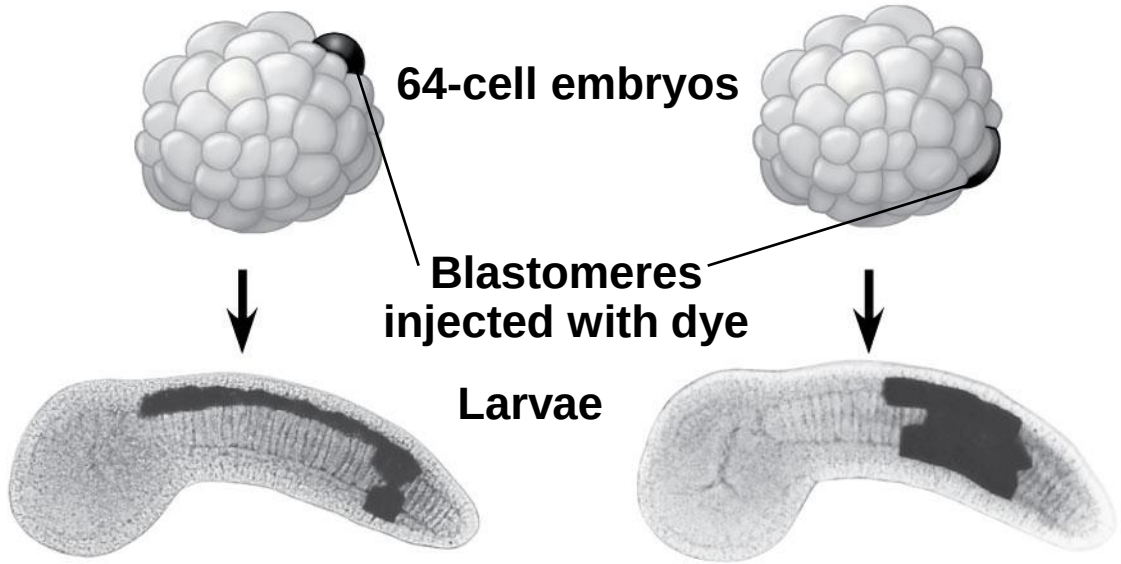
Fate Mapping

- **Fate maps** are diagrams showing organs and other structures that arise from each region of an embryo
- Classic studies using frogs indicated that cell lineage in germ layers is traceable to blastula cells

Figure 47.17



(a) Fate map of a frog embryo



(b) Cell lineage analysis in a tunicate

- In mammals, embryonic cells remain totipotent until the 8-cell stage, much longer than other organisms
- Progressive restriction of developmental potential is a general feature of development in all animals
- In general tissue-specific fates of cells are fixed by the late gastrula stage

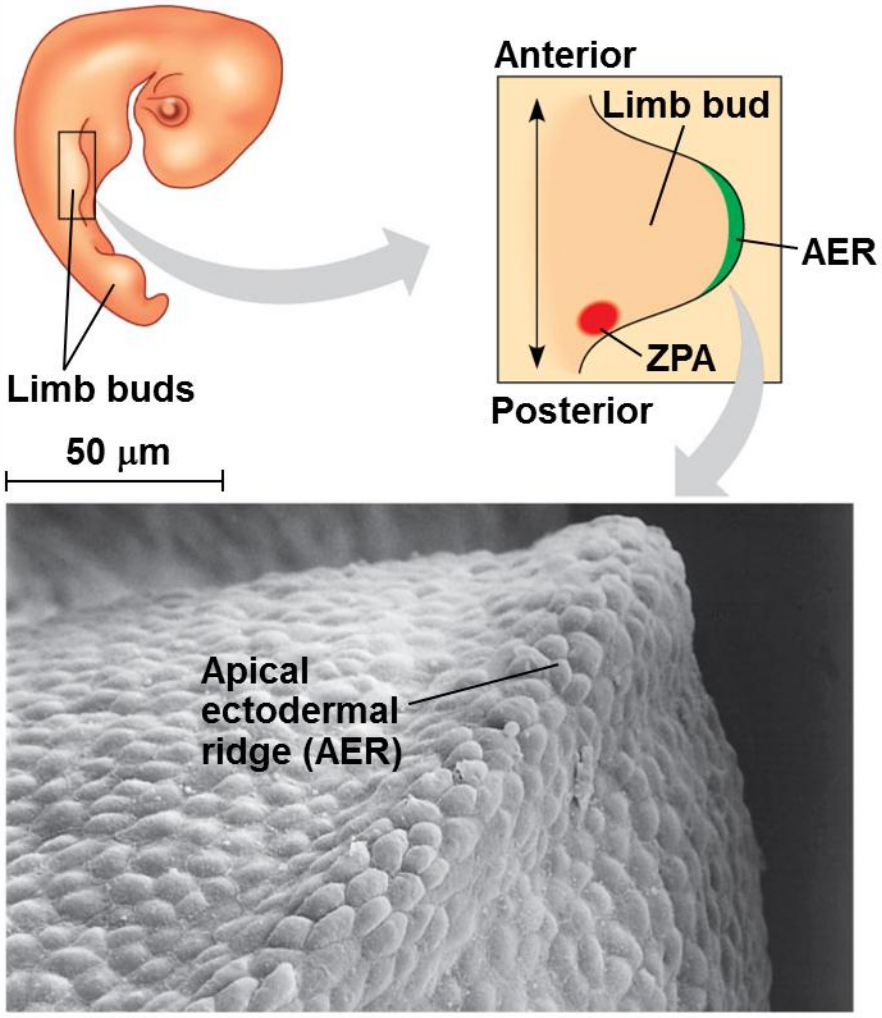
Cell Fate Determination and Pattern Formation by Inductive Signals

- As embryonic cells acquire distinct fates, they influence each other’s fates by induction

Formation of the Vertebrate Limb

- Inductive signals play a major role in **pattern formation**, development of spatial organization
- The molecular cues that control pattern formation are called **positional information**
- This information tells a cell where it is with respect to the body axes
- It determines how the cell and its descendents respond to future molecular signals

- The wings and legs of chicks, like all vertebrate limbs, begin as bumps of tissue called limb buds



- Sonic hedgehog is an inductive signal for limb development
- *Hox* genes also play roles during limb pattern formation

Cilia and Cell Fate

- Ciliary function is essential for proper specification of cell fate in the human embryo
- Motile cilia play roles in left-right specification
- Monocilia (nonmotile cilia) play roles in normal kidney development