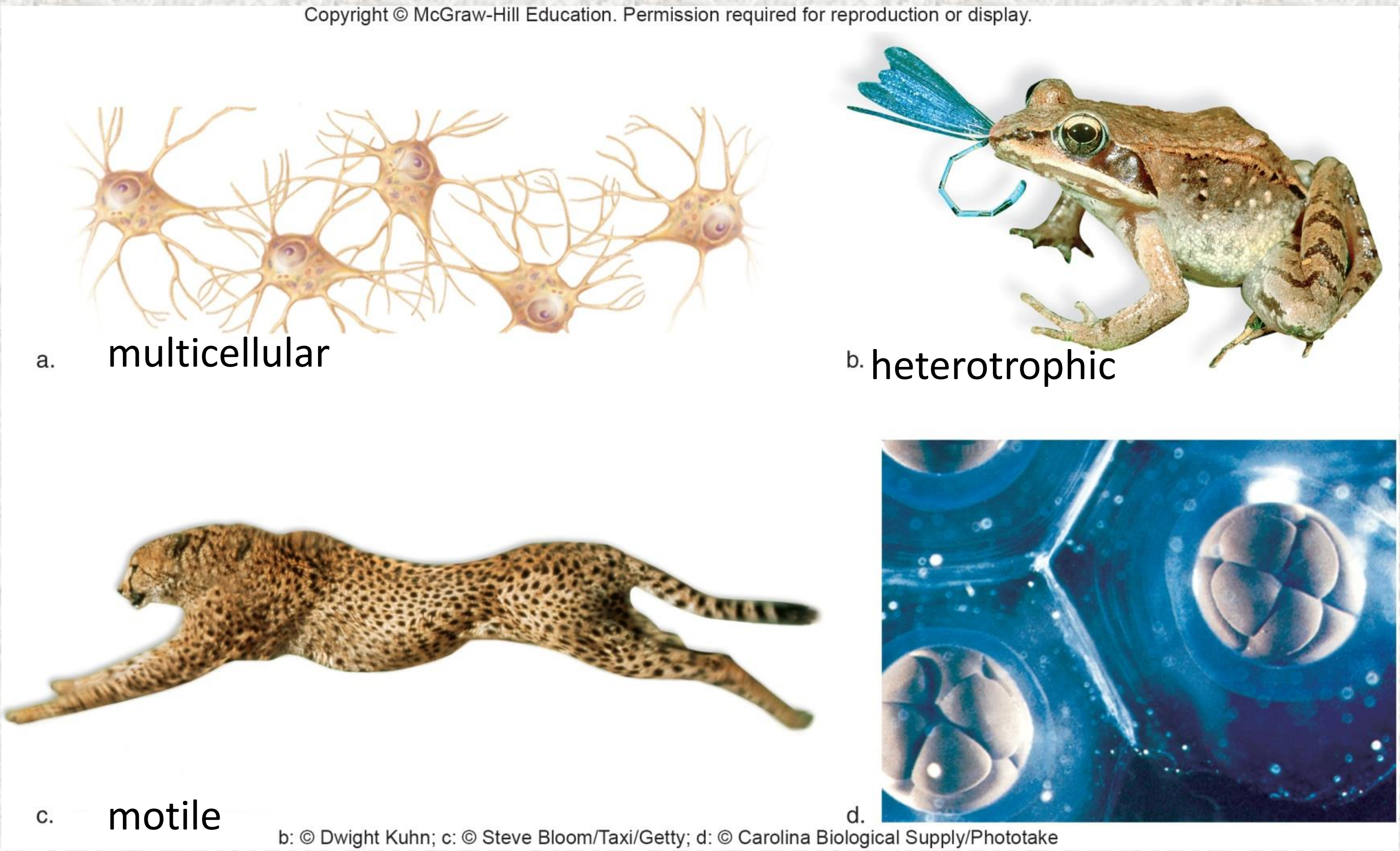
Animal Origins and Evolution

Common Features of Animals

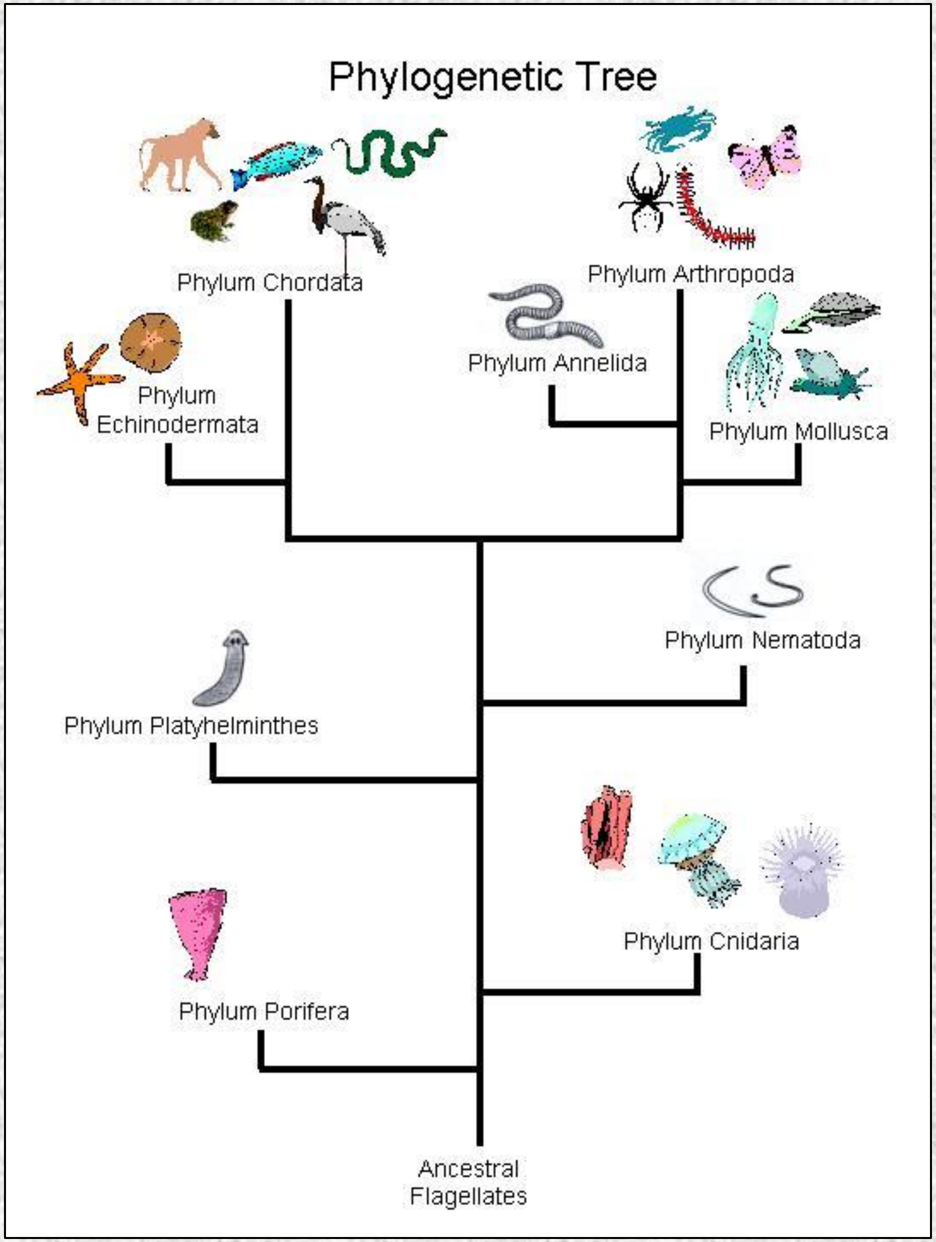


Sexual reproduction, embryo

Evolution of Animals

- All animals are multicellular and heterotrophic, which means they must acquire nutrients from an external source.
  - Fungi digest their food externally and absorb nutrients.
  - Animals ingest (eat) whole food and digest internally.
- Animals have a variety of life cycles.
  - Many reproduce sexually and some asexually and some combine both life cycles.
  - Many animals have a diploid life cycle.
- Animals are descended from a single common ancestor.
  - Within the animal lineage are two main branches: **invertebrates** and **vertebrates**.
    - Vertebrates are animals that at some stage have a spinal cord (backbone), whereas invertebrates do not.

Animal Origins and Evolution



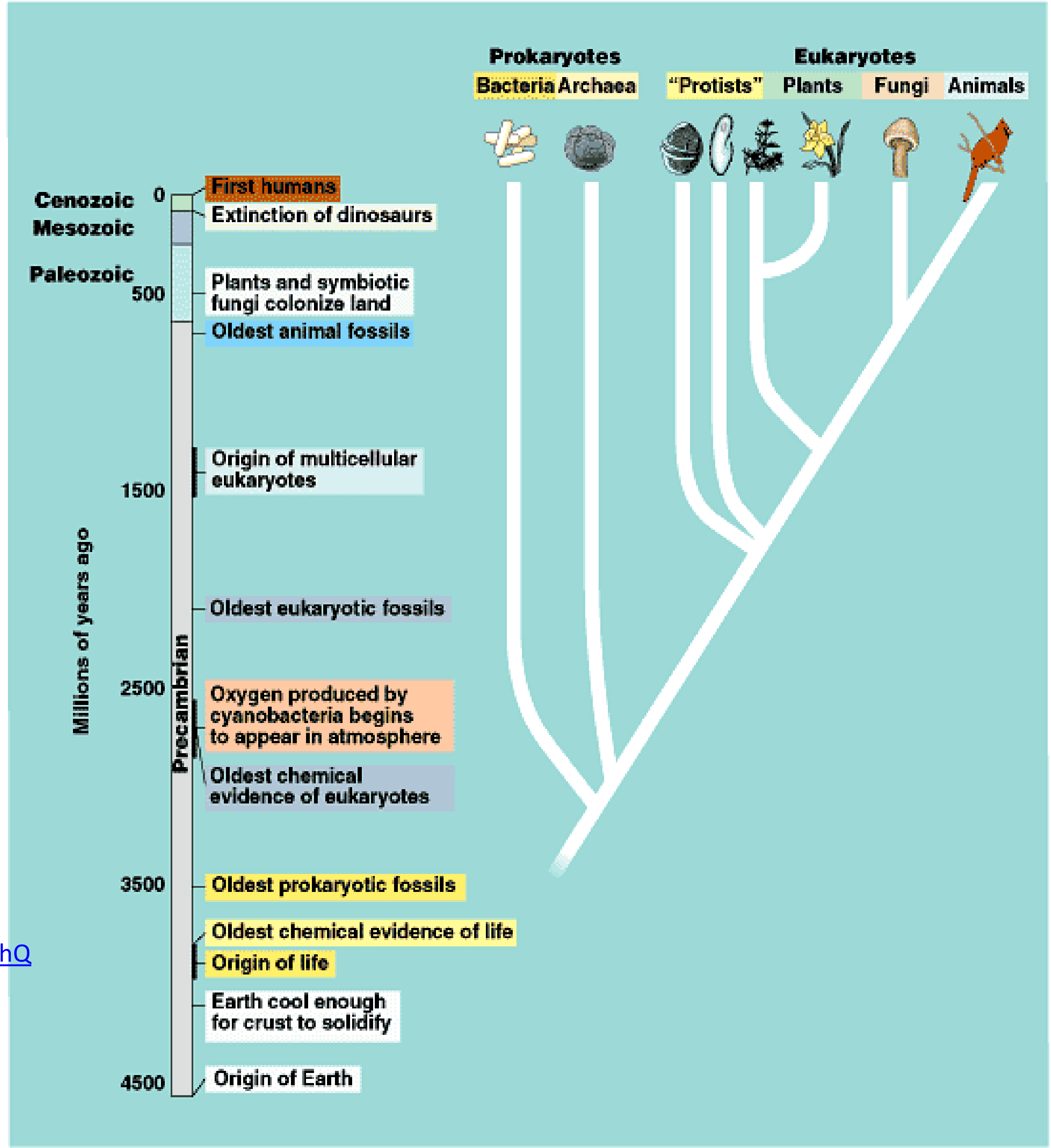
Some major episodes in the history of life.

Note that molecular evidence puts origin of animals at 1 BYA.

YouTube Video

The Story Of Earth And Life

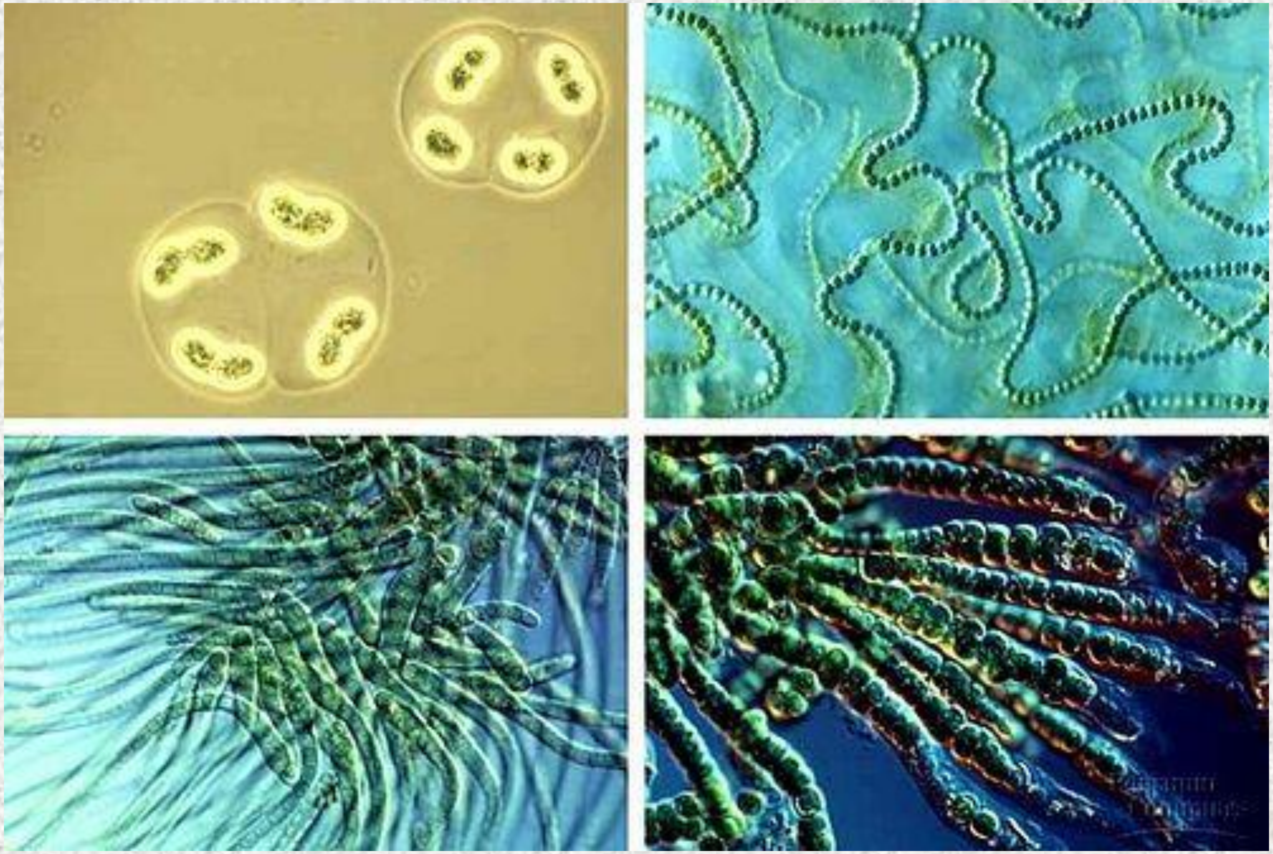
https://www.youtube.com/watch?v=Y1DPzY6o6hQ



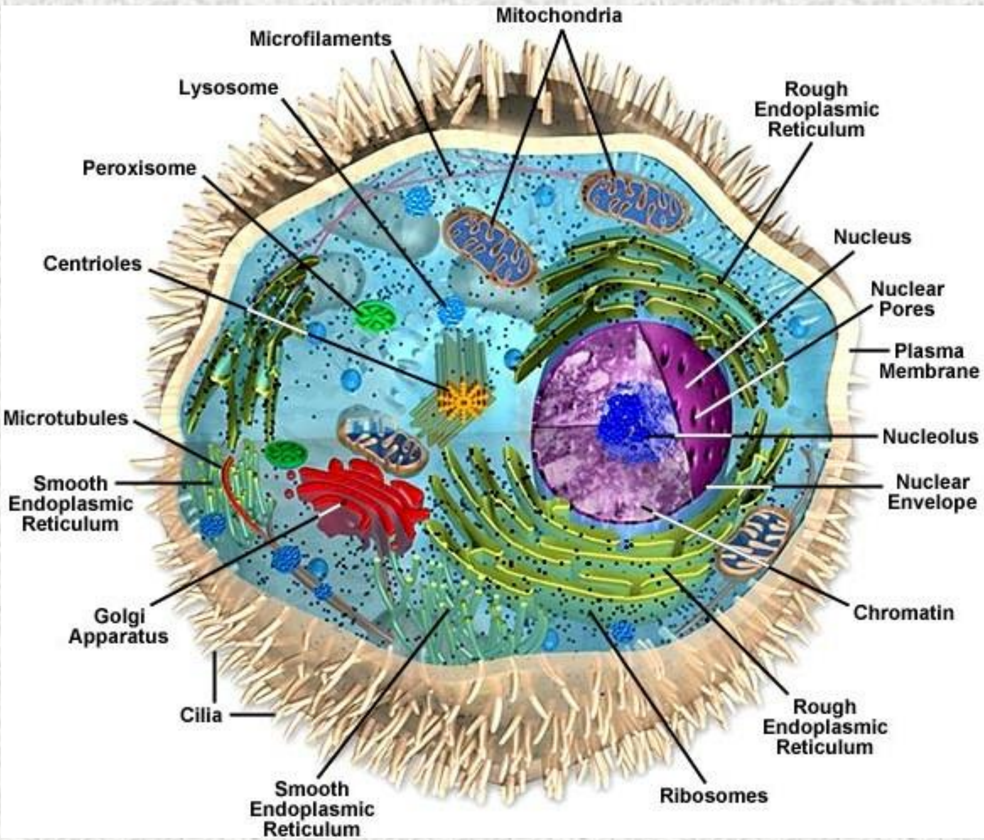
Archean Eon: 4-2 BYA

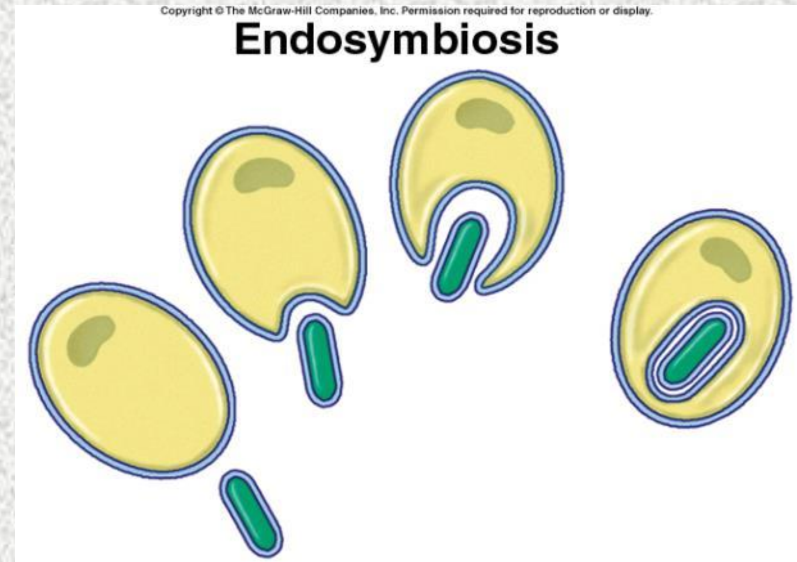
Great Age of Bacteria

Cyanobacteria – Photosynthesis – Oxygen – 2.5 BYA



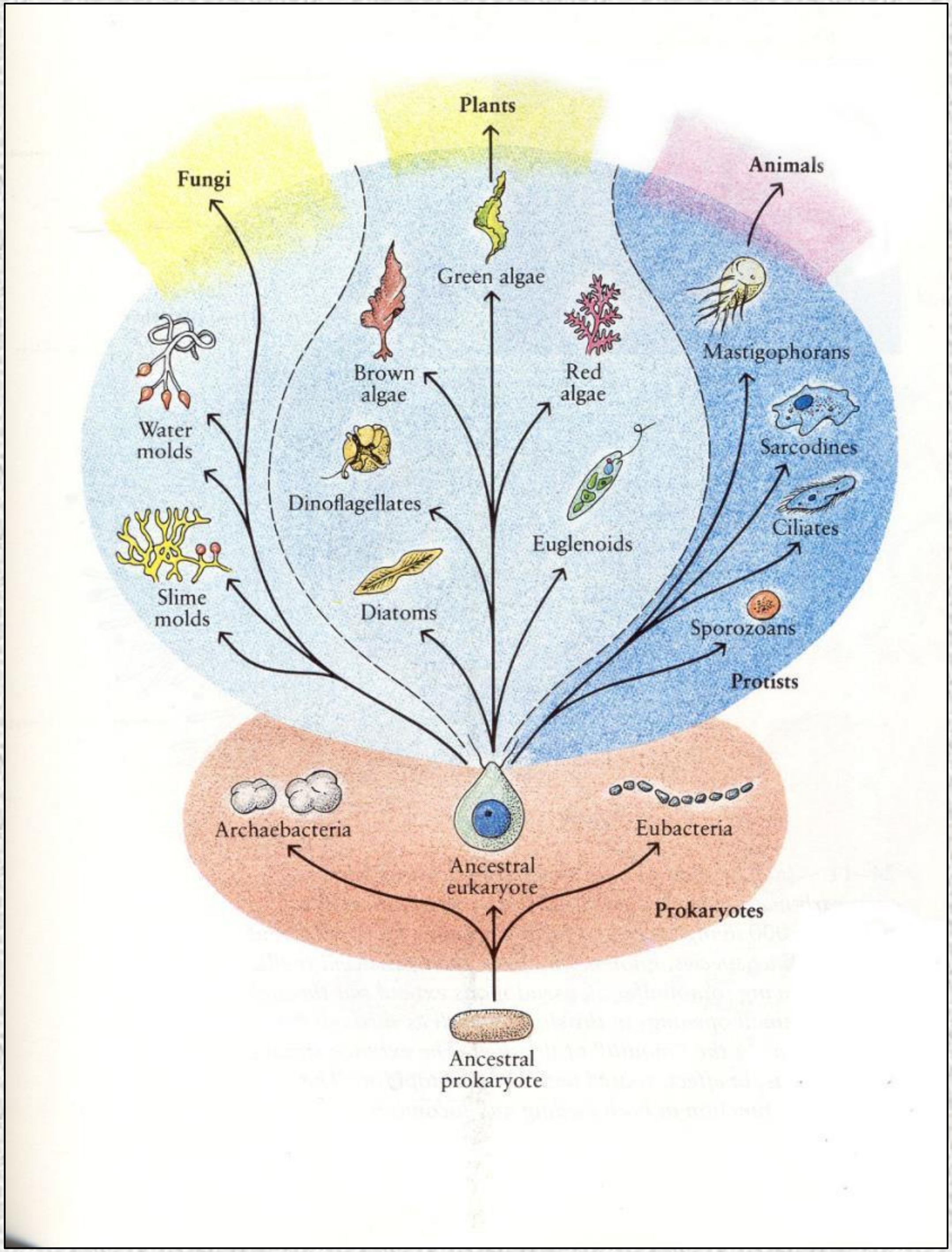
The origin and early evolution of the eukaryotes, about 2 BYA

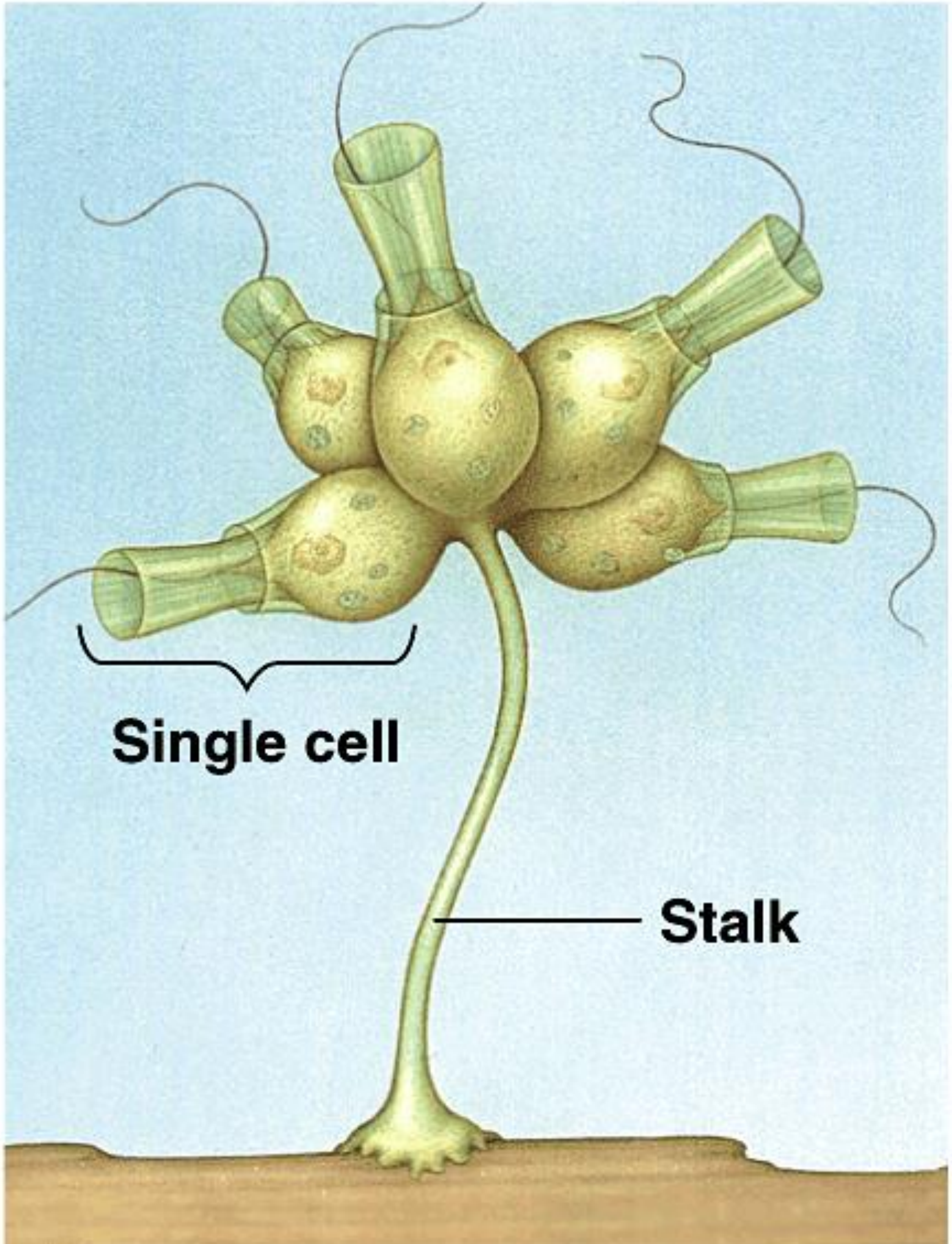




Multicellular Animals Protista Ancestor

- Plants, animals, and fungi trace their ancestry to protists
- Common ancestor of animals and fungi was aquatic, flagellated, single-celled protist.

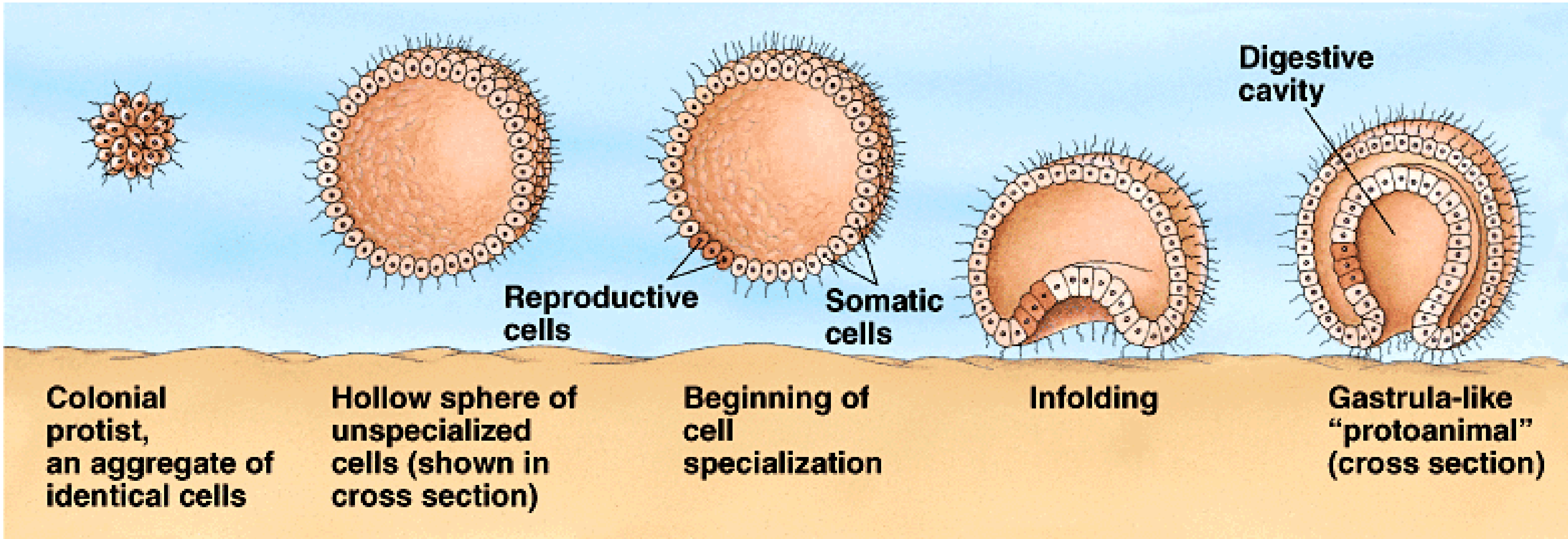




Metazoan animals probably evolved from colonial, flagellated protists, like this Choanoflagellate.

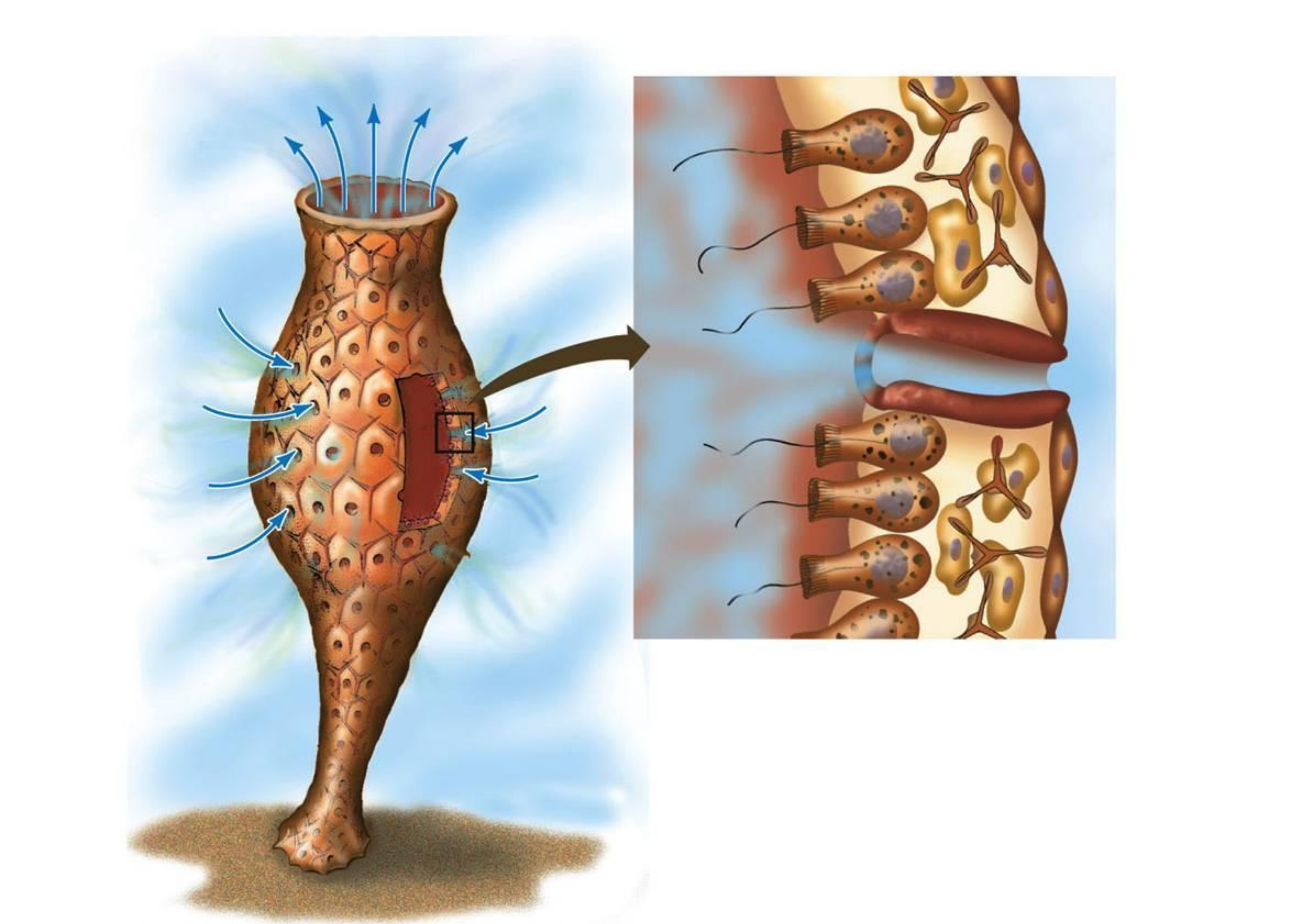
Found as individuals or colonies.

One hypothesis for the origin of animals with tissues from a flagellated protist.



Gastrea Hypothesis – proposed by Haeckel in 1870s
Infolding created two layers of cells

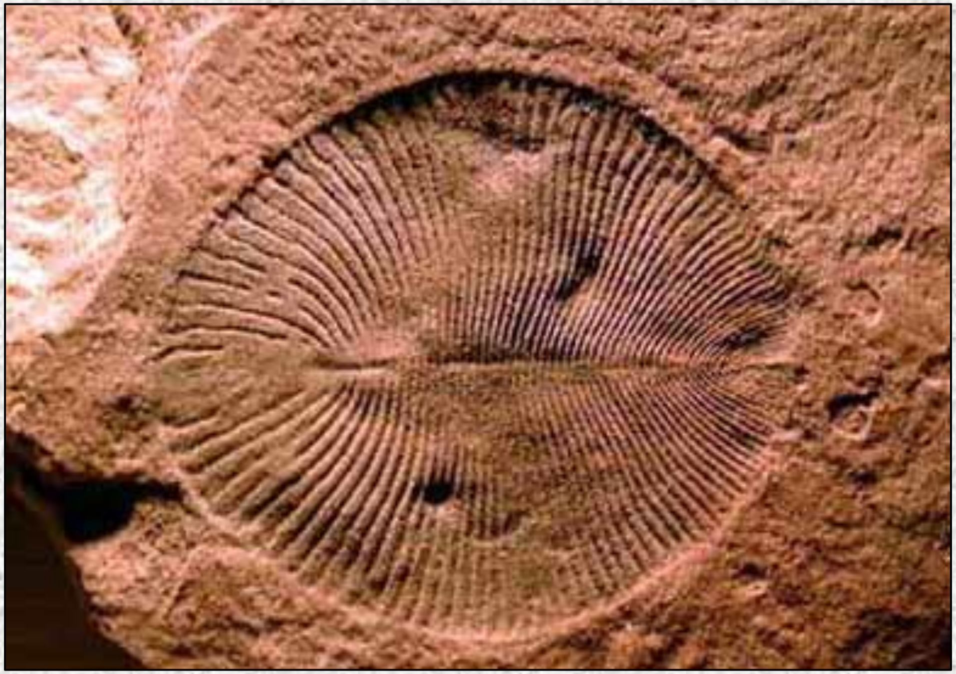
Individual sponge cells resemble Choanoflagellates



LIFE 8e, Figure 31.7

Ediacaran Fossils – 600-542 MYA

- Just before the Cambrian explosion, worldwide proliferation of multicellular organisms
- Flat, segmented, soft-bodied.
- Ancestral to jellyfish or soft-bodied arthropods? Or an extinct kingdom of life?
- Few or none survived into the Paleozoic era.



Ediacaran Life - 600-542 MYA

All of these were soft-bodied, and are known only from impressions
Became extinct in early Cambrian

The Cambrian Explosion

- Most animal phyla originated in a relatively brief span of geologic time, 40 MY.
- During the Cambrian Explosion (543 to 524 million years ago), nearly all major body plans appeared

Between about 542 and 510 million years ago, skeletonized organisms appeared in a huge explosion of diversity (in geological time).

This event is called *The Cambrian Explosion*.

Seascapes changed…

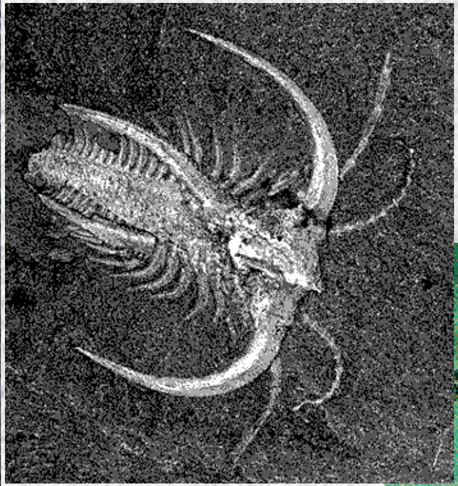
From peaceful oasis…

…to war zone with weapons and armor

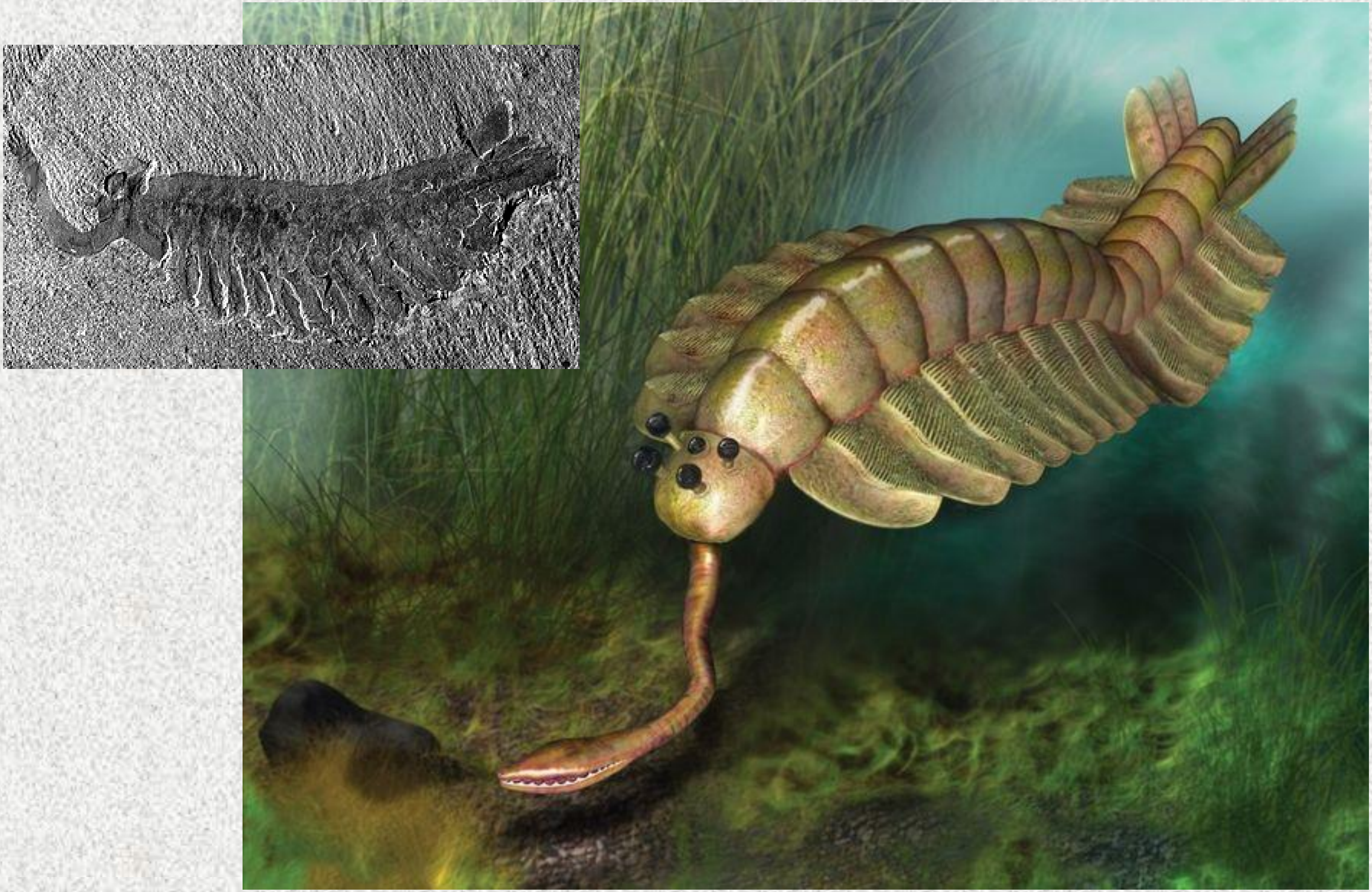
Cambrian Explosion

Cambrian YouTube Video
https://www.youtube.com/watch?v=Y1DPzY6o6hQ

Cambrian Seas

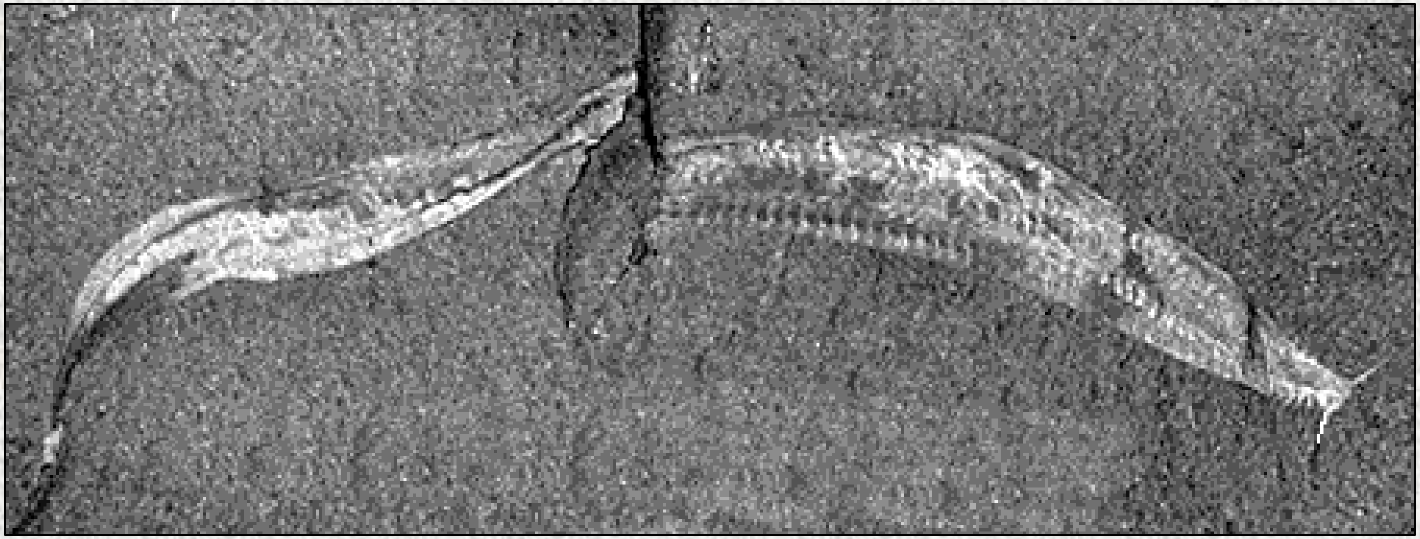


Some Cambrian creatures very strange - *Opabinia*



Pikaia

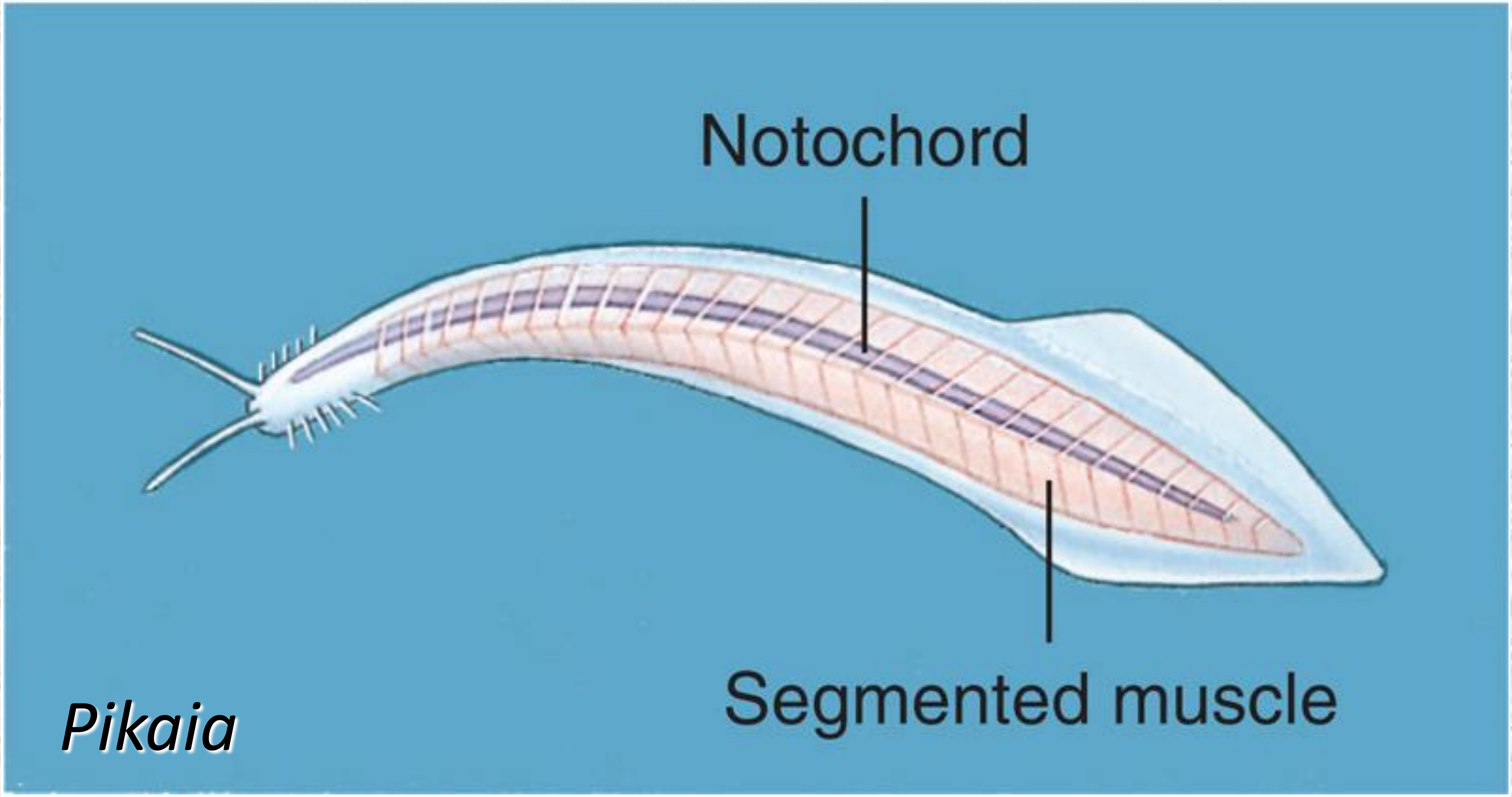
One of earliest known Chordates



A notochord (an internal band of elastic tissue that could be flexed by muscle packs down its length) allowed early chordates to swim without the burden of heavy external armor.

We ultimately evolved from an animal that looked like this !

Figure 23.10



Characteristics of Animals

- Multicellular
- Heterotrophs – digest internally
- Require oxygen
- Reproduce sexually (mostly, a few asexual)
- Go through blastula stage
- Motile at some point
- Tissues – muscles and nerves
- Eggs much larger than sperm
- Diverse

Animal Phylogeny

- Biologists categorize animals by:
  - General features of body structure
  - More recently, using genetic data
- One major branch point distinguishes sponges from all other animals because, unlike more complex animals, sponges lack true tissues.
- A second major evolutionary split is based on body symmetry.
  - **Radial symmetry** refers to animals that are identical all around a central axis.
  - **Bilateral symmetry** exists where there is only one way to split the animal into equal halves.

Evolution of Body Plans

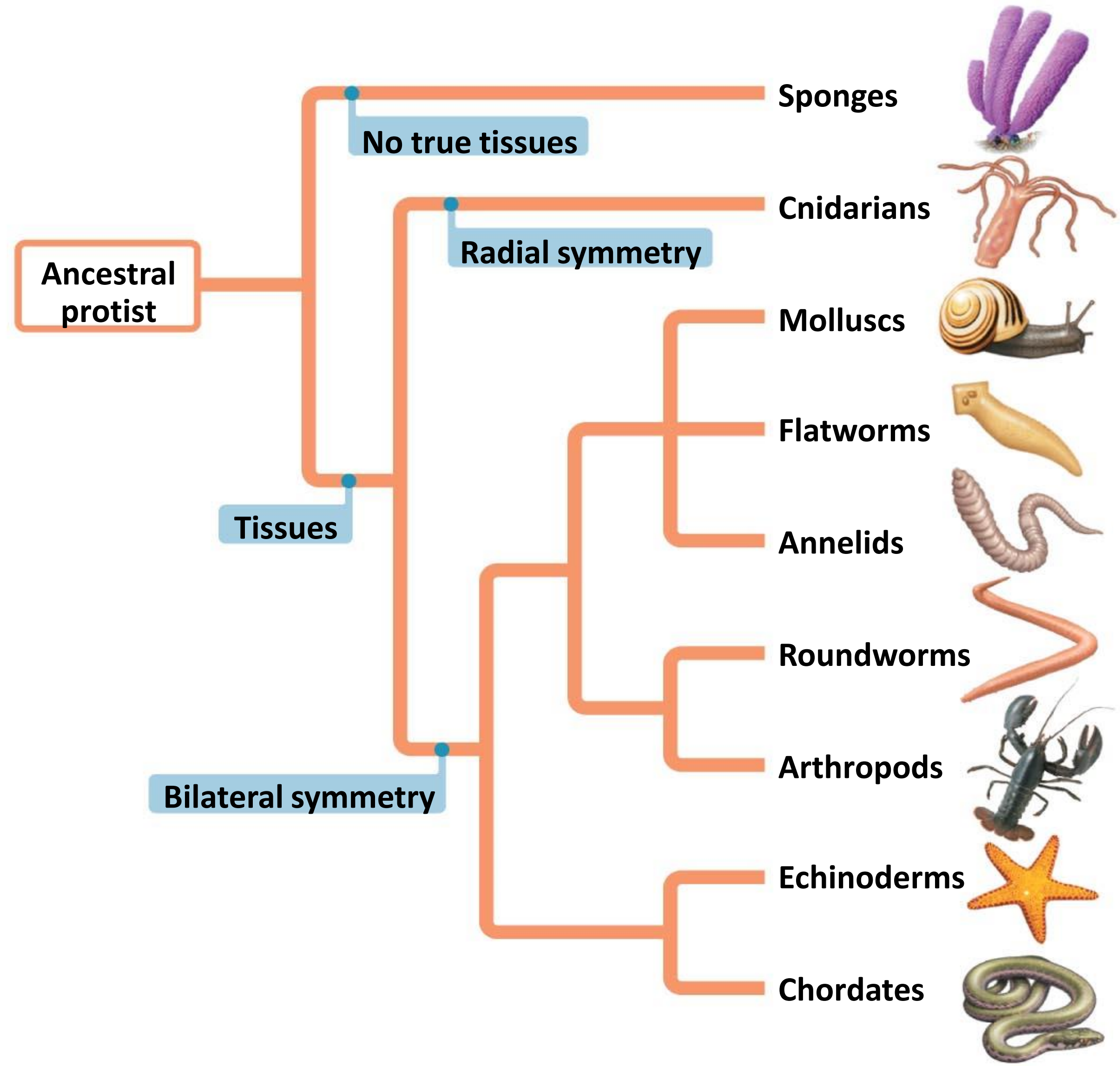


Figure 17.5

Animal Symmetry

A basic feature of a multicellular body is the presence or absence of a plane of symmetry

- **asymmetry** – irregular shape
- **radial symmetry** - at least two planes of symmetry.
- **bilateral symmetry** - a single plane of symmetry; face their environment in one direction.

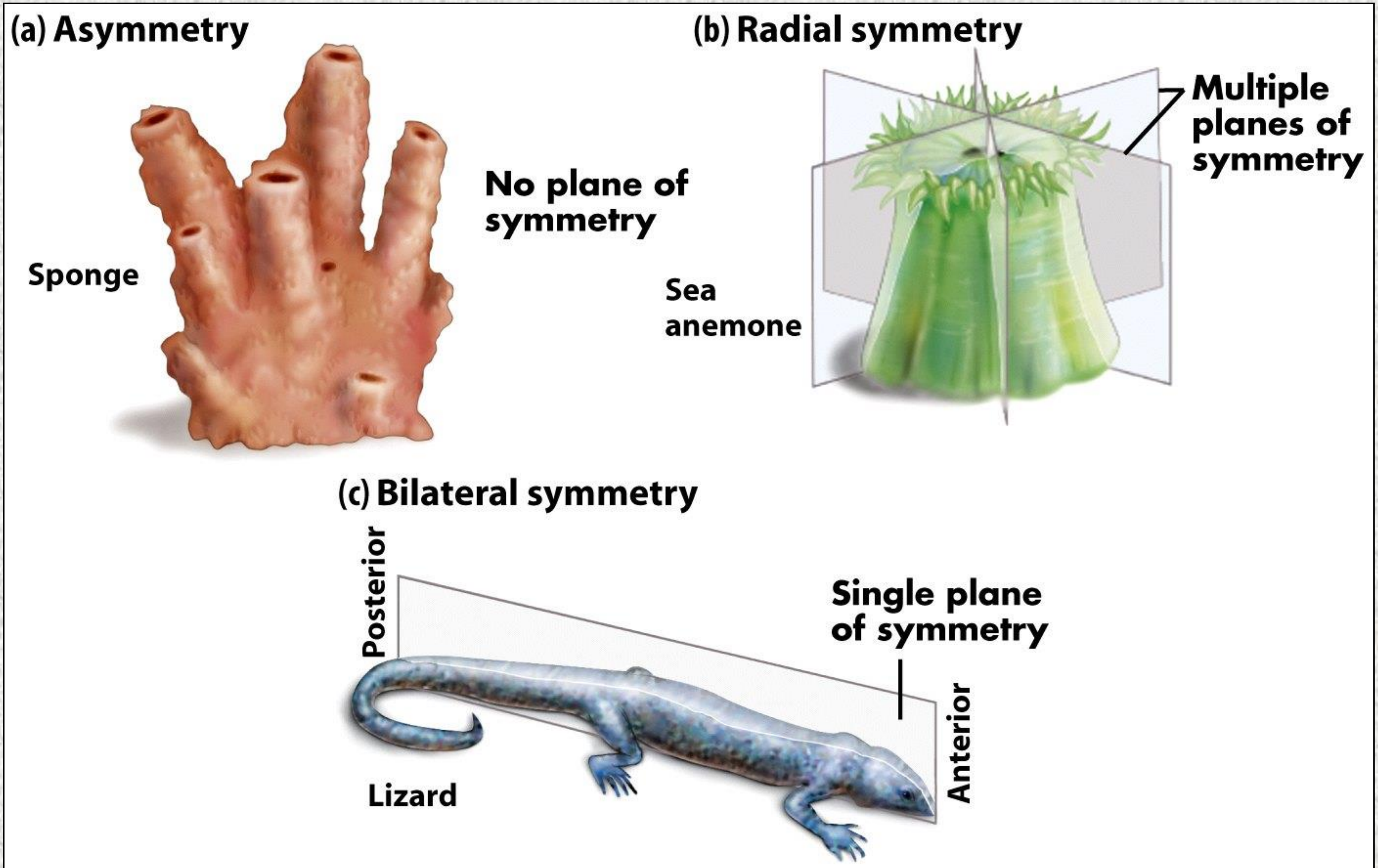
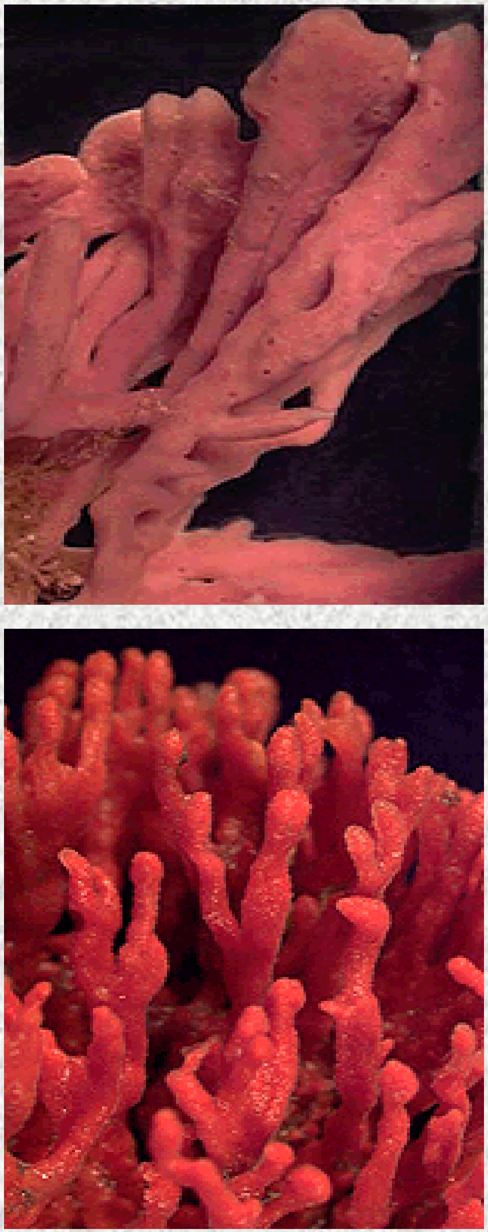


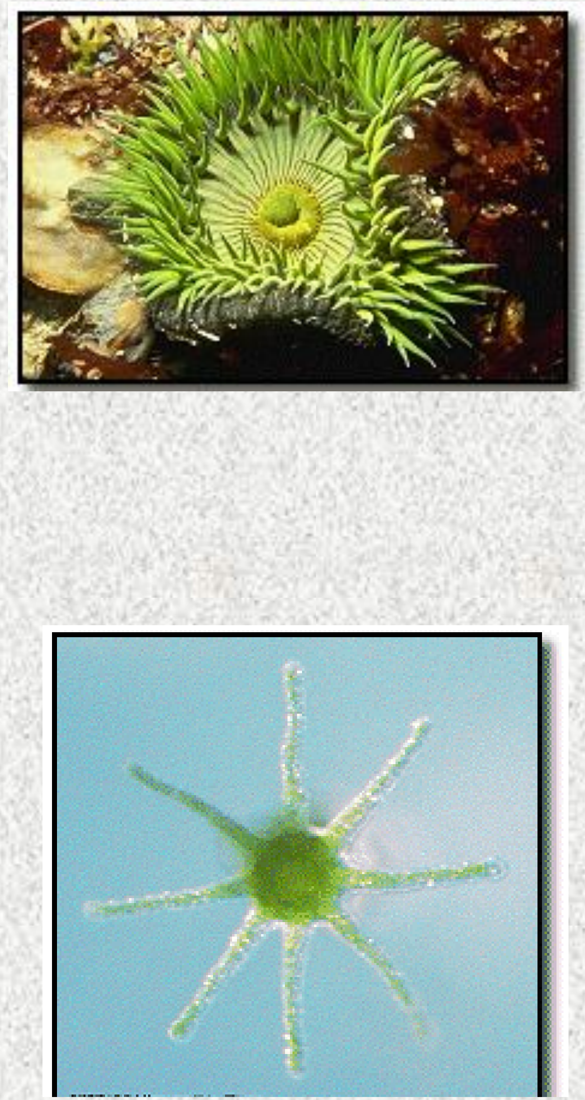
Figure 31-5 Biological Science, 2/e

Animal Symmetry

- **Asymmetrical** occurs mainly among sponges.
- **Radial symmetry** occurs among the Cnidarians (jellyfish) and Echinoderms (starfish, sea urchins).
- **Bilateral symmetry** commonest form of symmetry. Strongly associated with cephalization or development of a head with associated sensory and feeding apparatus.



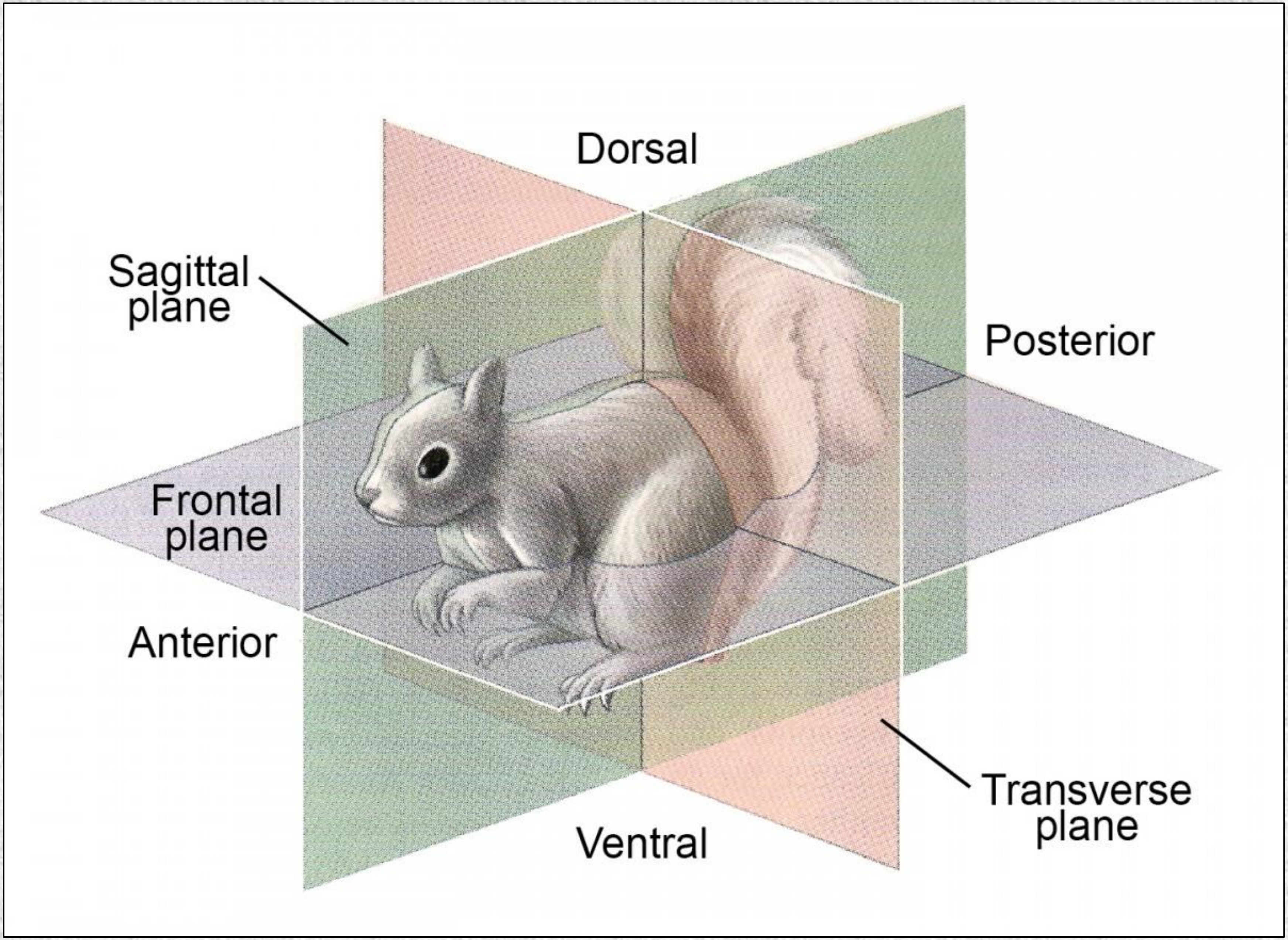
No symmetry



Radial symmetry

Bilateral symmetry

Animal Symmetry



Cephalization

Bilateral symmetry allowed:

- Evolution of a head, or anterior region, where structures for feeding, sensing the environment, and processing information are concentrated
- Concentration of neural tissue (eyes, brain, senses)

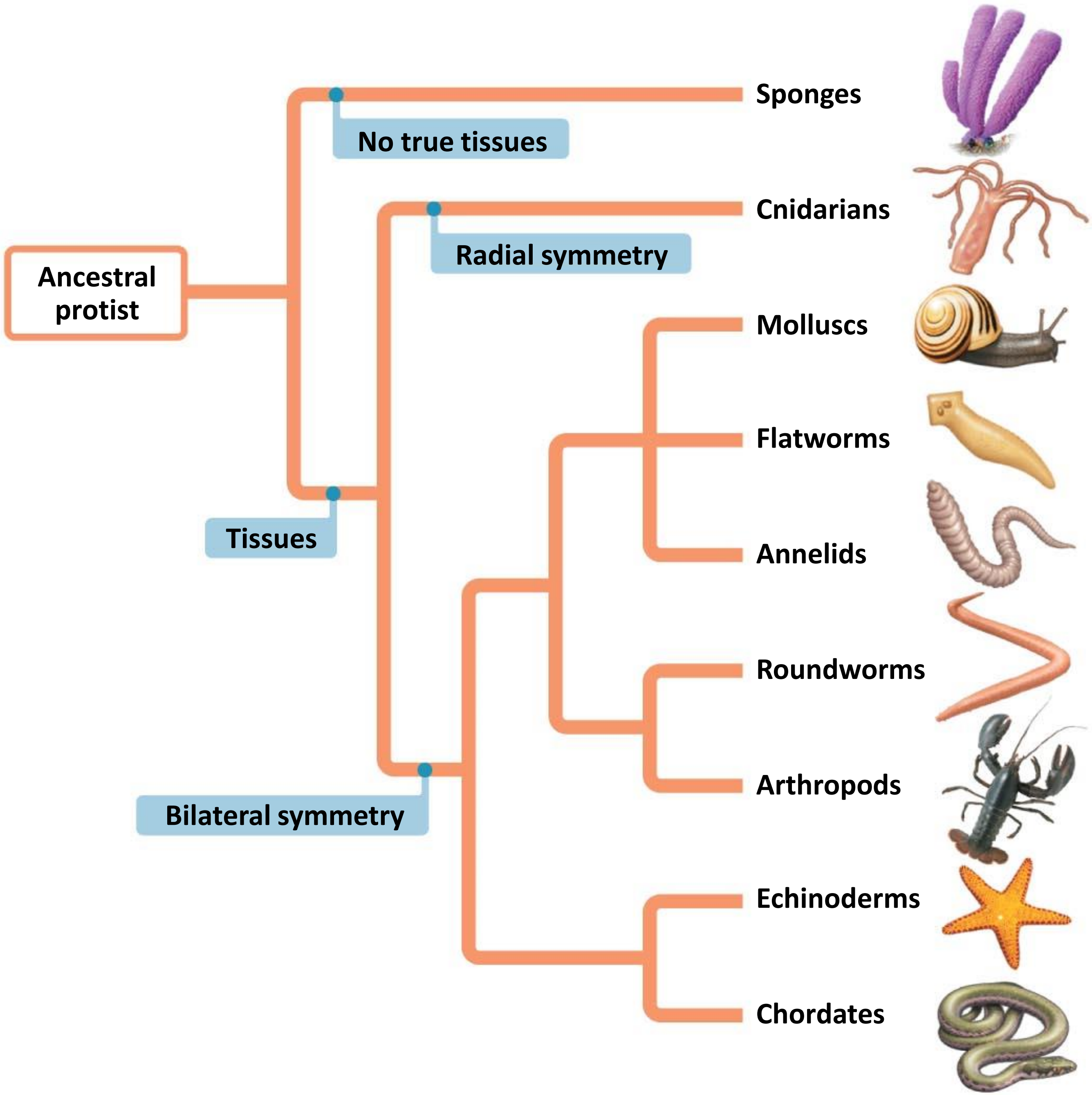

Ancestral protist
No true tissues
Tissues
Radial symmetry
Bilateral symmetry
Sponges
Cnidarians
Molluscs
Flatworms
Annelids
Roundworms
Arthropods
Echinoderms
Chordates

Figure 17.5

Development of body plans

- An animal’s body results from division of cells during embryonic development.

- Differences in developmental patterns have been used to classify more complex animals so an understanding of basic embryology is necessary to follow this.

Differences in Early Development

Three events in early development differ in protostomes and deuterostomes

- Cleavage
- Gastrulation
- Coelom formation

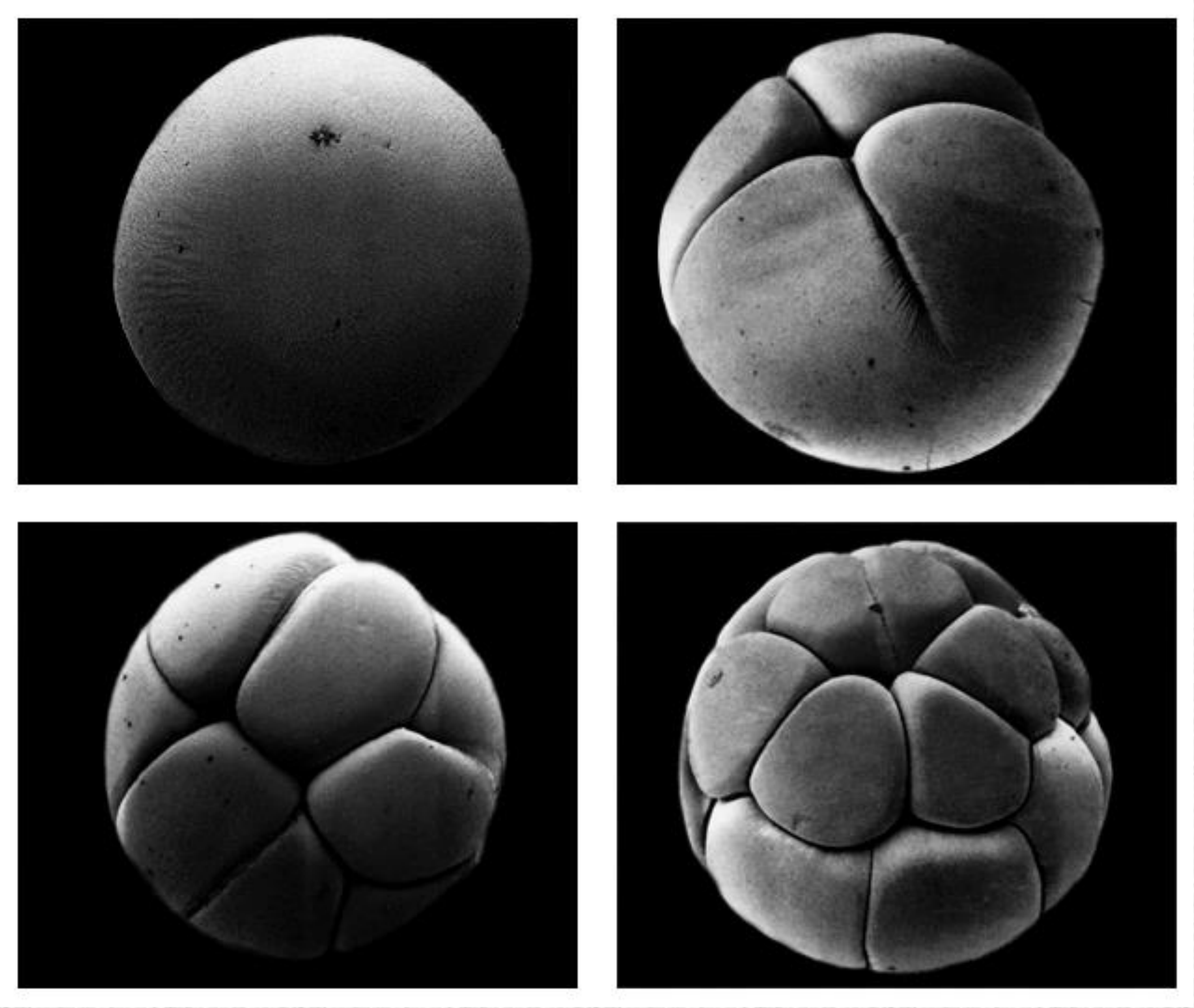
Embryonic development

- Once an egg is fertilized it becomes a **zygote**. This cell divides into a large number of cells called **blastomeres**.

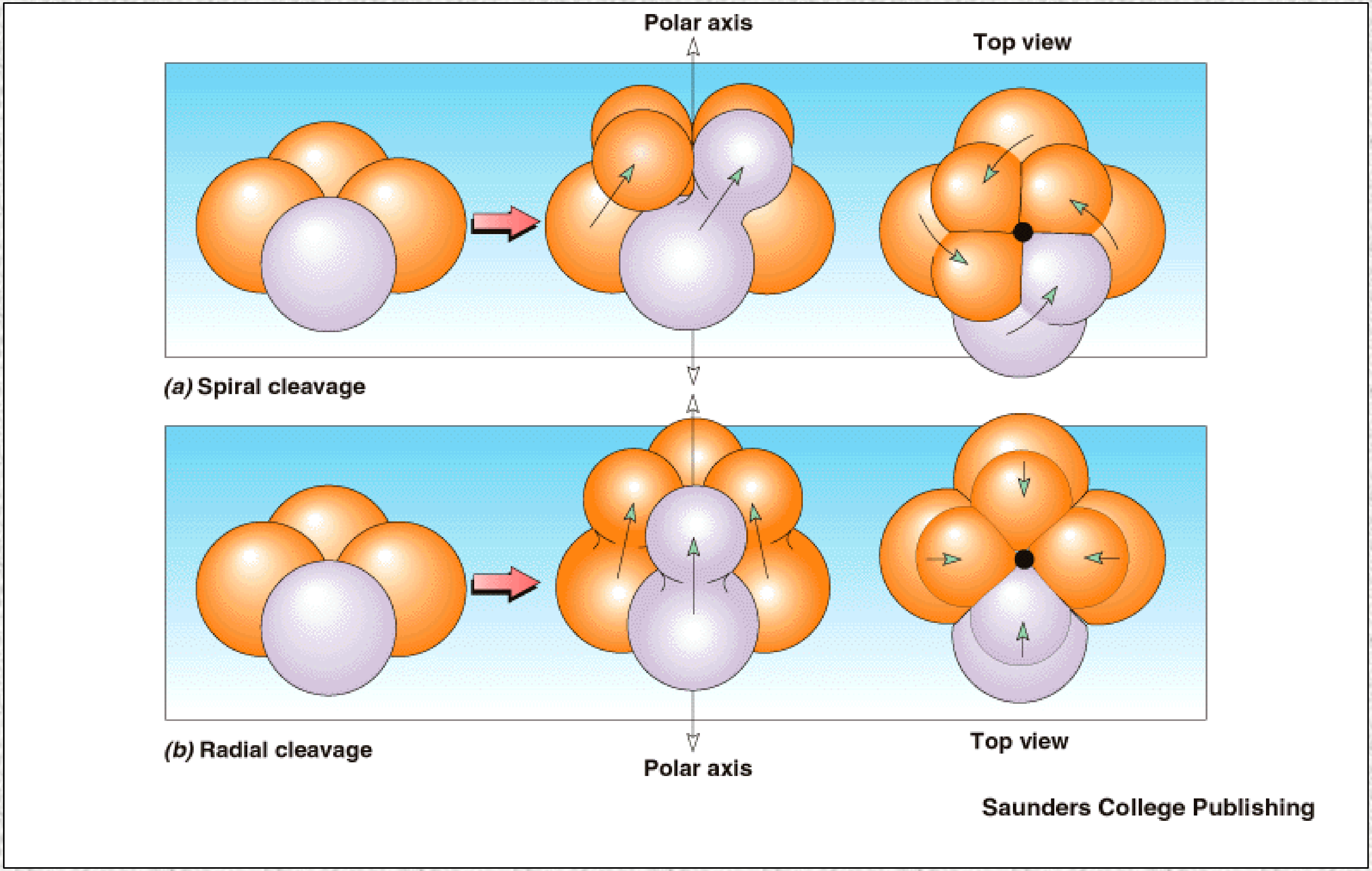
- Cleavage of cells proceeds until a fluid-filled hollow ball of cells is formed. This is a ***blastula***.

- In multicellular animals other than sponges the blastula invaginates to begin forming the future gut. At this stage the embryo is a ***gastrula***.

Embryonic Development - Cleavage in a frog embryo



Spiral and Radial Cleavage



Cleavage
(zygote undergoes rapid divisions, eventually forming a ball of cells)

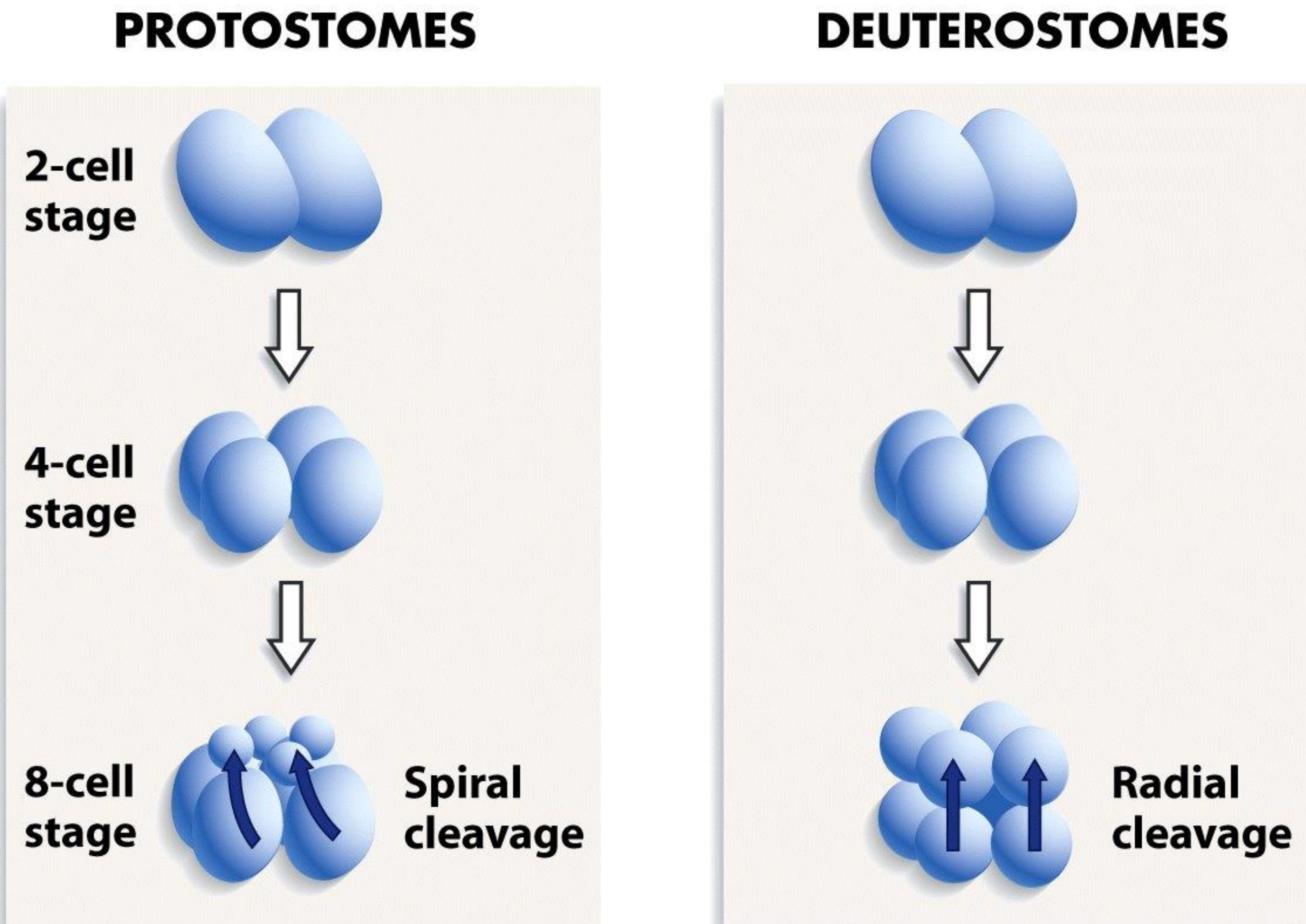
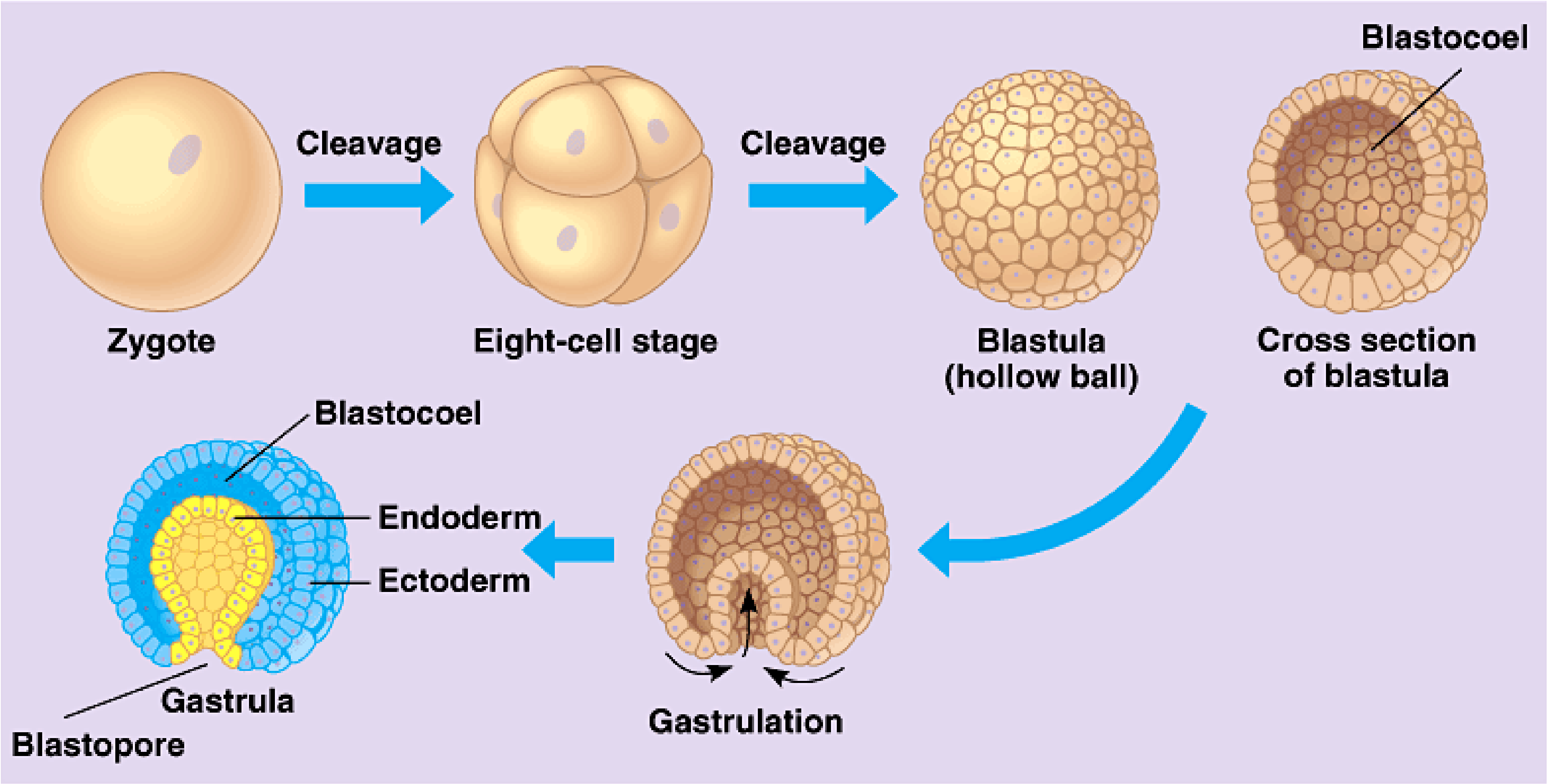


Figure 31-8a Biological Science, 2/e

Embryonic development

- Once an egg is fertilized it becomes a **zygote**. This cell divides into a large number of cells called **blastomeres**.
- Cleavage of cells proceeds until a fluid-filled hollow ball of cells is formed. This is a ***blastula***.
- In multicellular animals other than sponges the blastula invaginates to begin forming the future gut. At this stage the embryo is a ***gastrula***.

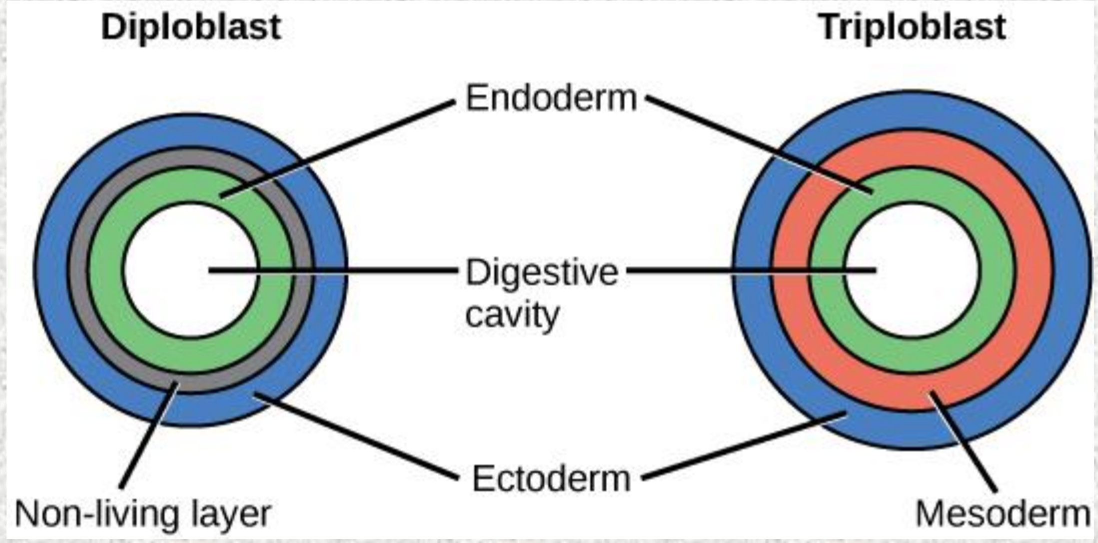
Early embryonic development



The first tissue layers that appear are called **germ** layers.

- These give rise to organs and organ systems.

- *Diploblastic* – Two tissue layers
- *Triploblastic* – Three tissue layers



Germ layers

- **Endoderm** - innermost germ layer of an embryo. Forms the gut, liver, pancreas.

- **Ectoderm** - Outer layer of cells in early embryo. Surrounds the blastocoel. Forms outer epithelium of body and nervous system.

- **Mesoderm** - Third germ layer formed in gastrula between ectoderm and endoderm. Gives rise to connective tissue, muscle, urogenital and vascular systems and peritoneum.

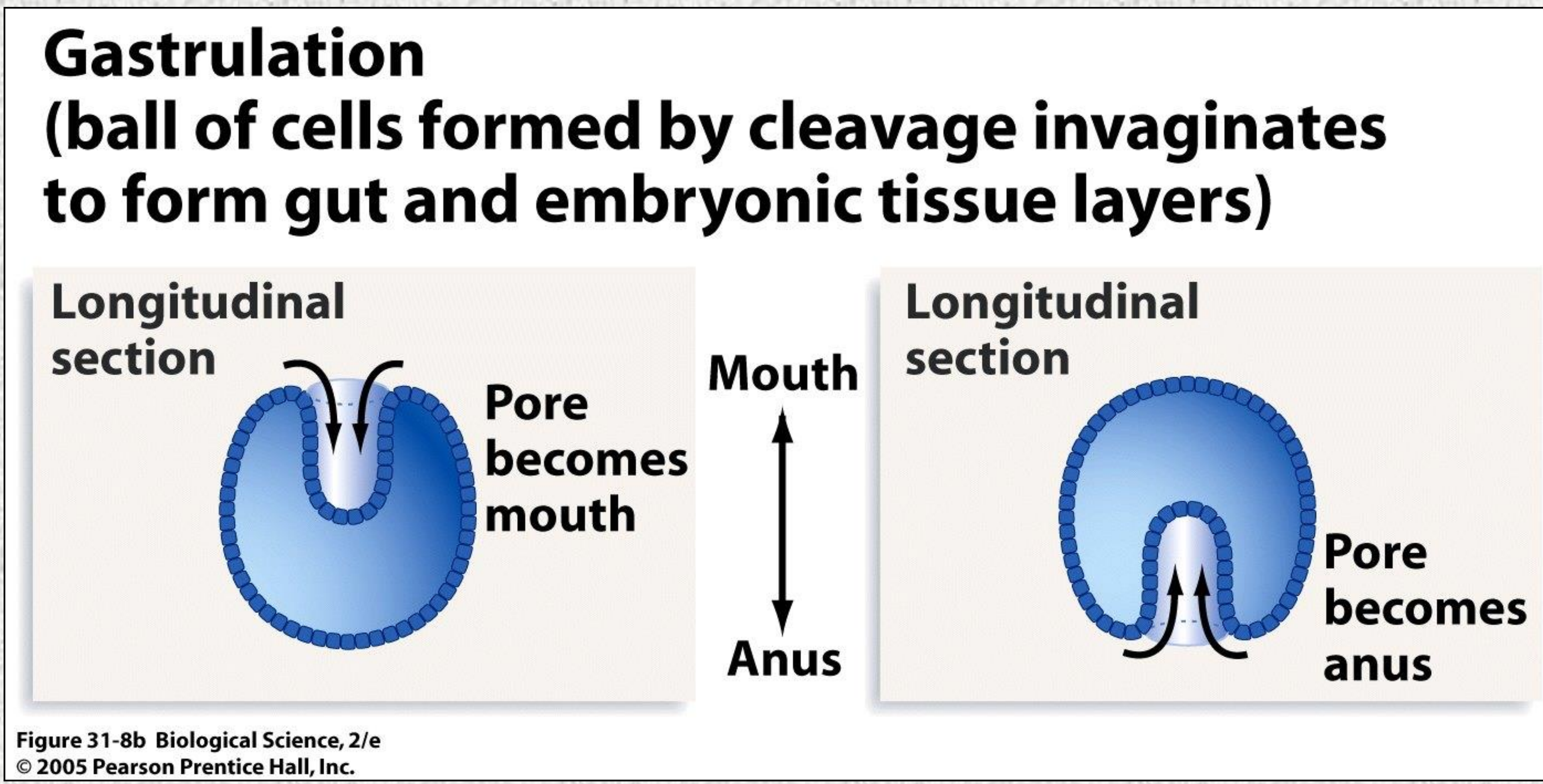


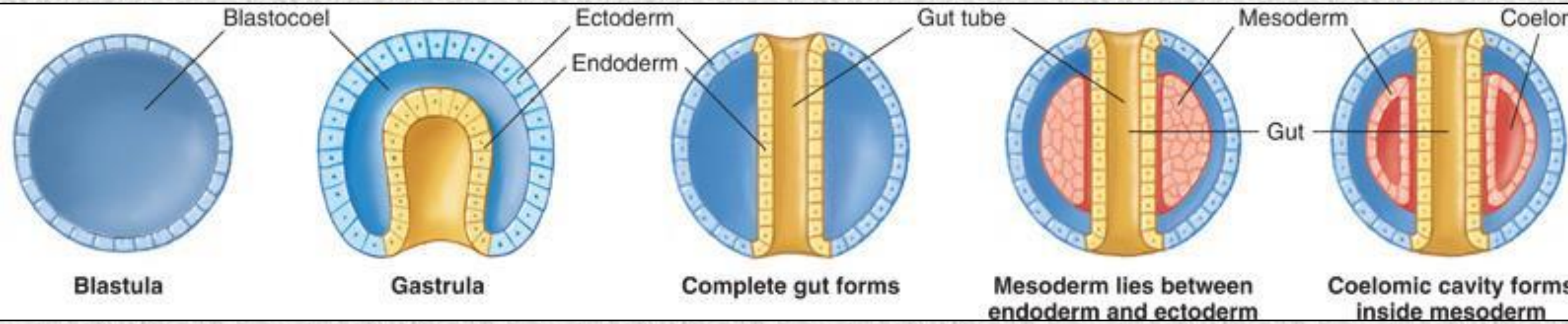
Figure 31-8b Biological Science, 2/e

Protostome Deuterostome

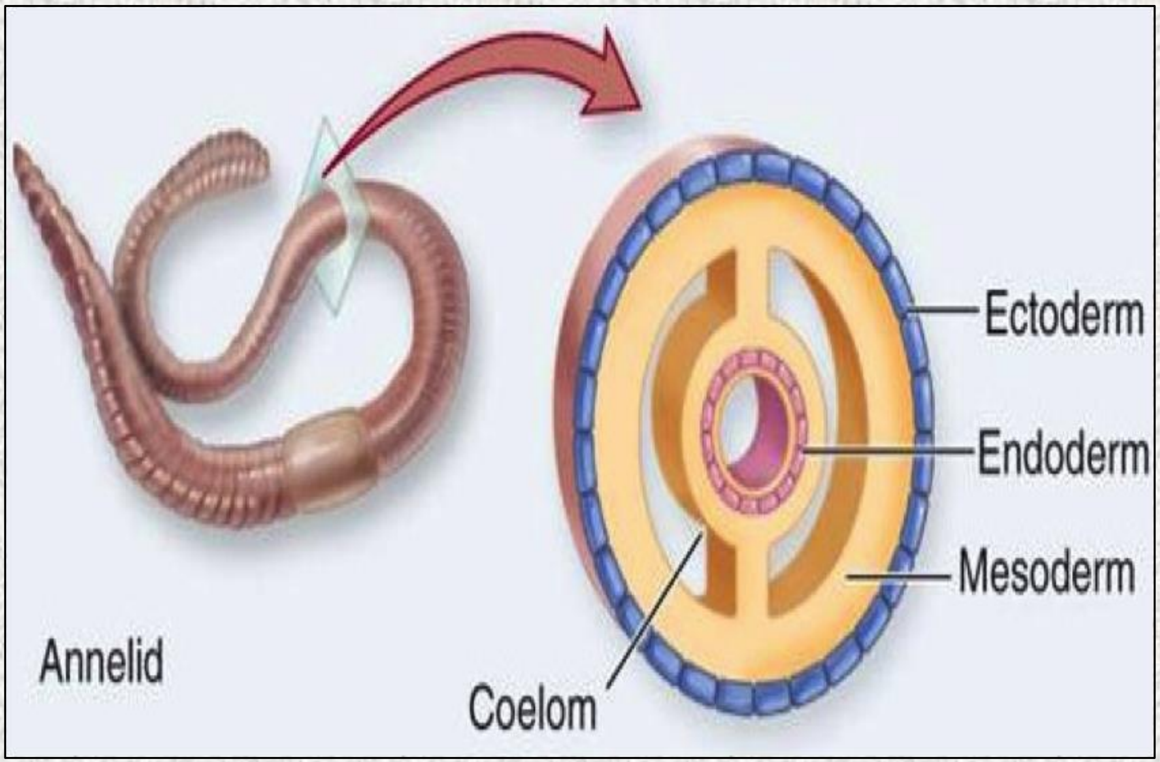
Coeloms

- The coelom is a cavity entirely surrounded by mesoderm.
- A coelom provides a tube-within-a-tube arrangement which has many advantages:
  - Allows flexibility in arranging visceral organs
  - permits greater size and complexity by exposing more cells to surface exchange
  - fluid-filled ceolom can act as a hydrostatic skeleton

Coeloms



Blastocoel
Ectoderm
Endoderm
Gut tube
Mesoderm
Coelom
Gut
Blastula
Gastrula
Complete gut forms
Mesoderm lies between endoderm and ectoderm
Coelomic cavity forms inside mesoderm



Ectoderm
Endoderm
Mesoderm
Annelid
Coelom

The tube-within-a-tube body plan

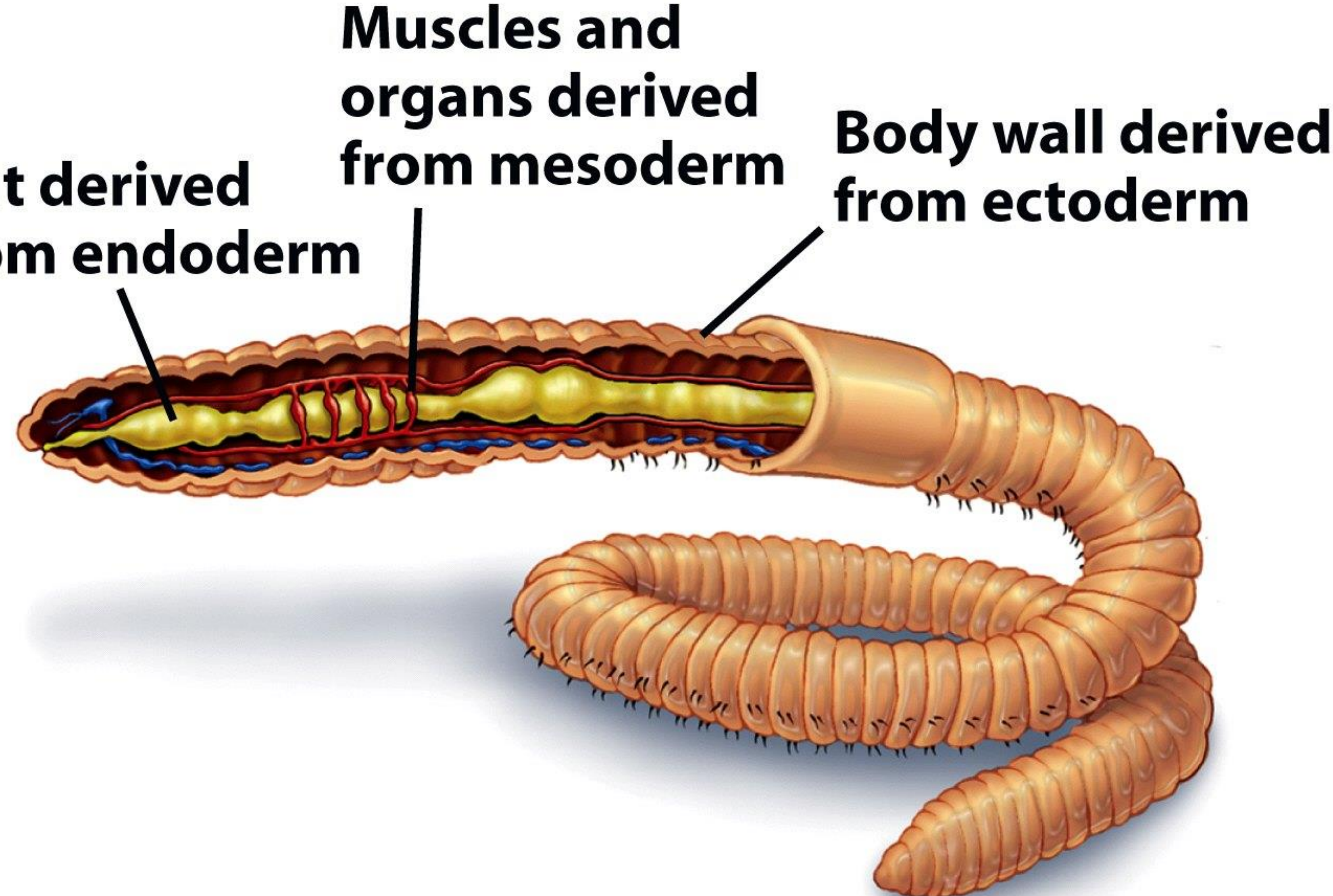
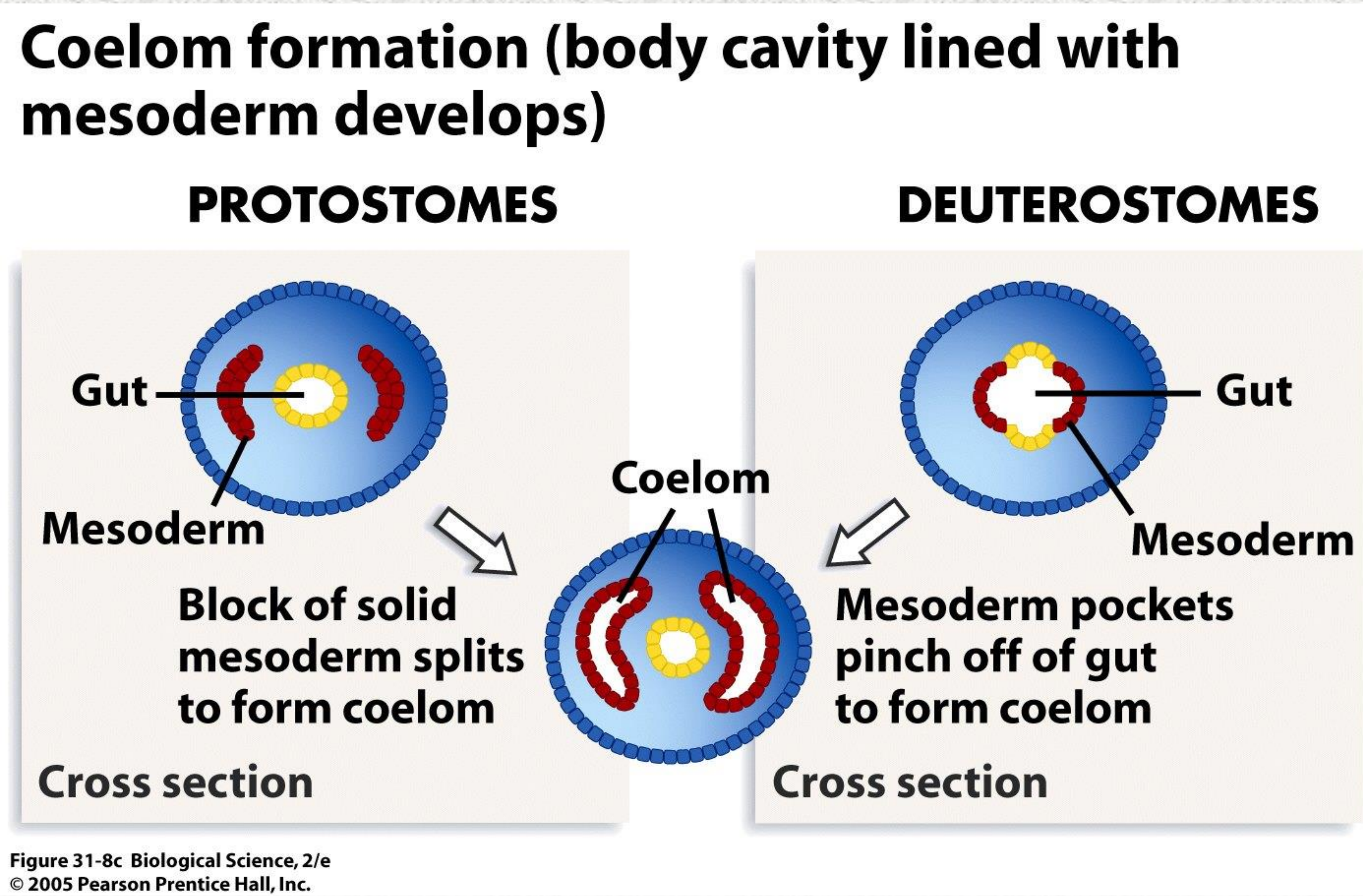
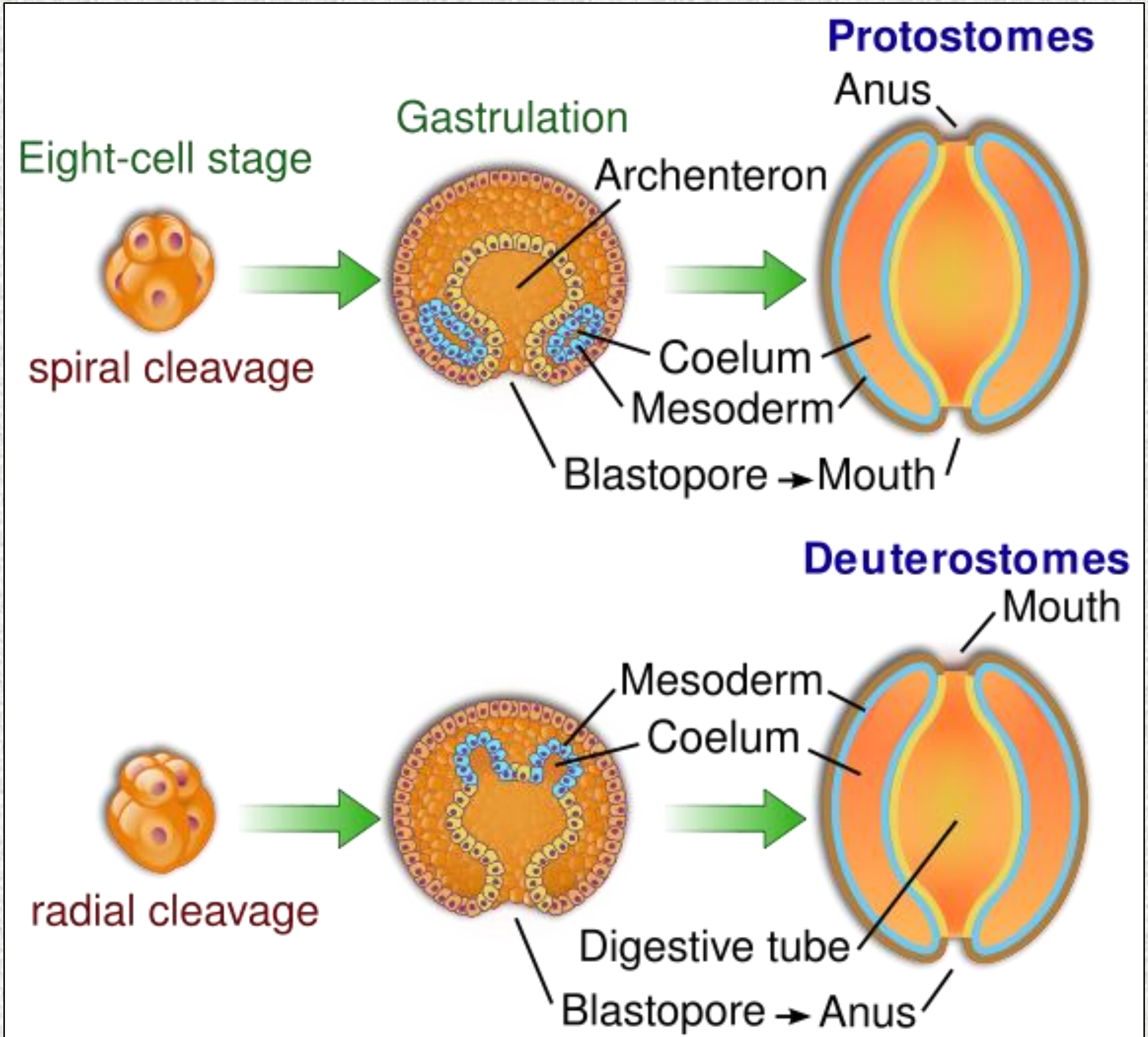


Figure 31-9a Biological Science, 2/e

Coelom forms in different ways……




Protostomes
Anus
Gastrulation
Eight-cell stage
Archenteron
spiral cleavage
Coelum
Mesoderm
Blastopore → Mouth
Deuterostomes
Mouth
Mesoderm
Coelum
radial cleavage
Digestive tube
Blastopore → Anus

Protostomes and Deuterostomes

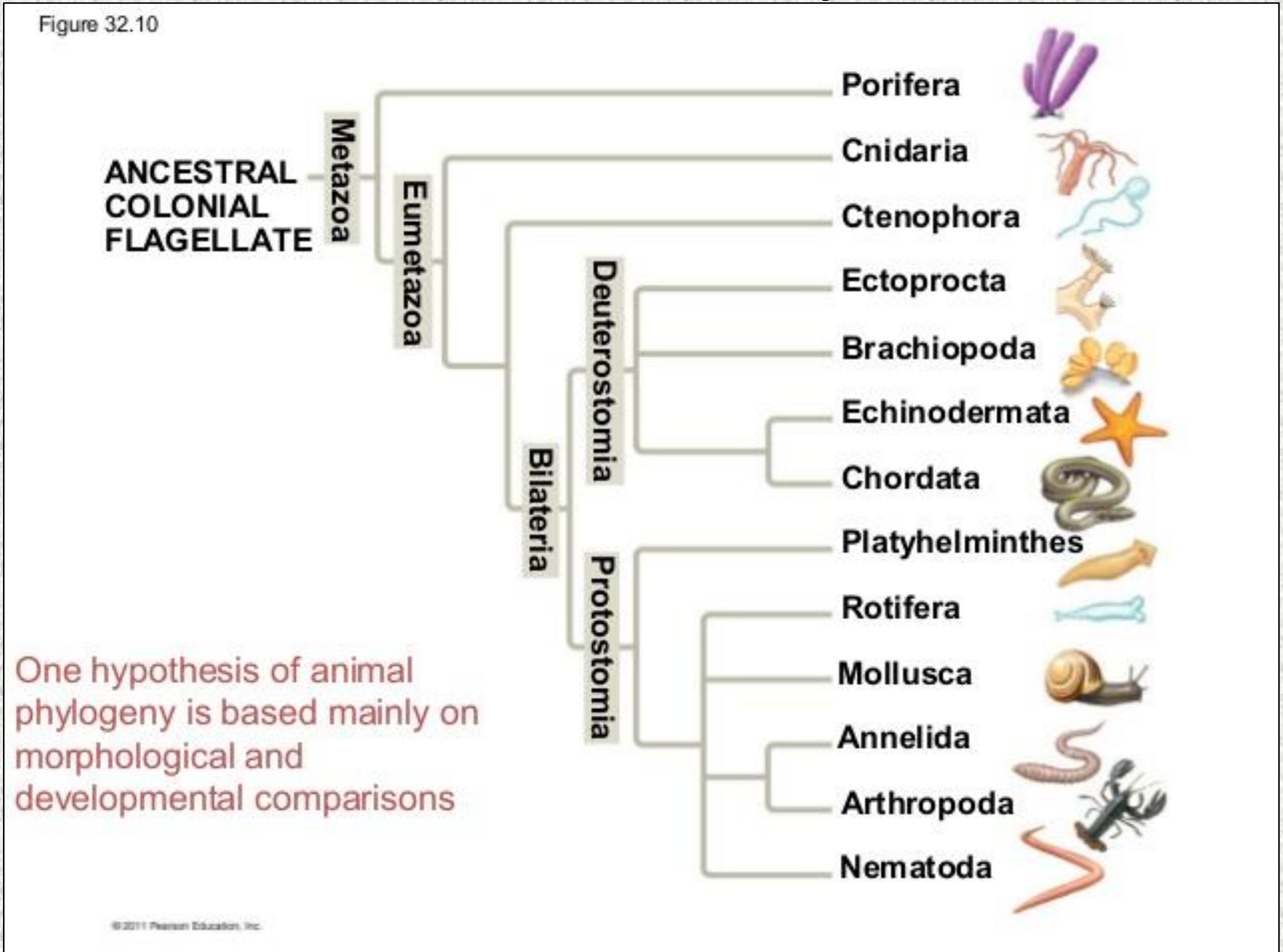
- Within the eucolomates there are two major evolutionary lineages that split early in the history of animals and follow quite different developmental pathways.

These are the protostomes “mouth first” and deuterostomes “mouth second”.

Important differences in development between protostomes and deuterostomes

- The differences in development that distinguish the protostomes and deuterostomes include:
  - Whether cleavage of cells in the early zygote is spiral or radial.
  - Whether or not, if the early blastomere is separated, each cell can develop into a normal larva or not.
  - Whether the blastopore ultimately forms the mouth or anus of the organism.
  - Whether or not the organism possesses a coelom and how that coelom is formed.

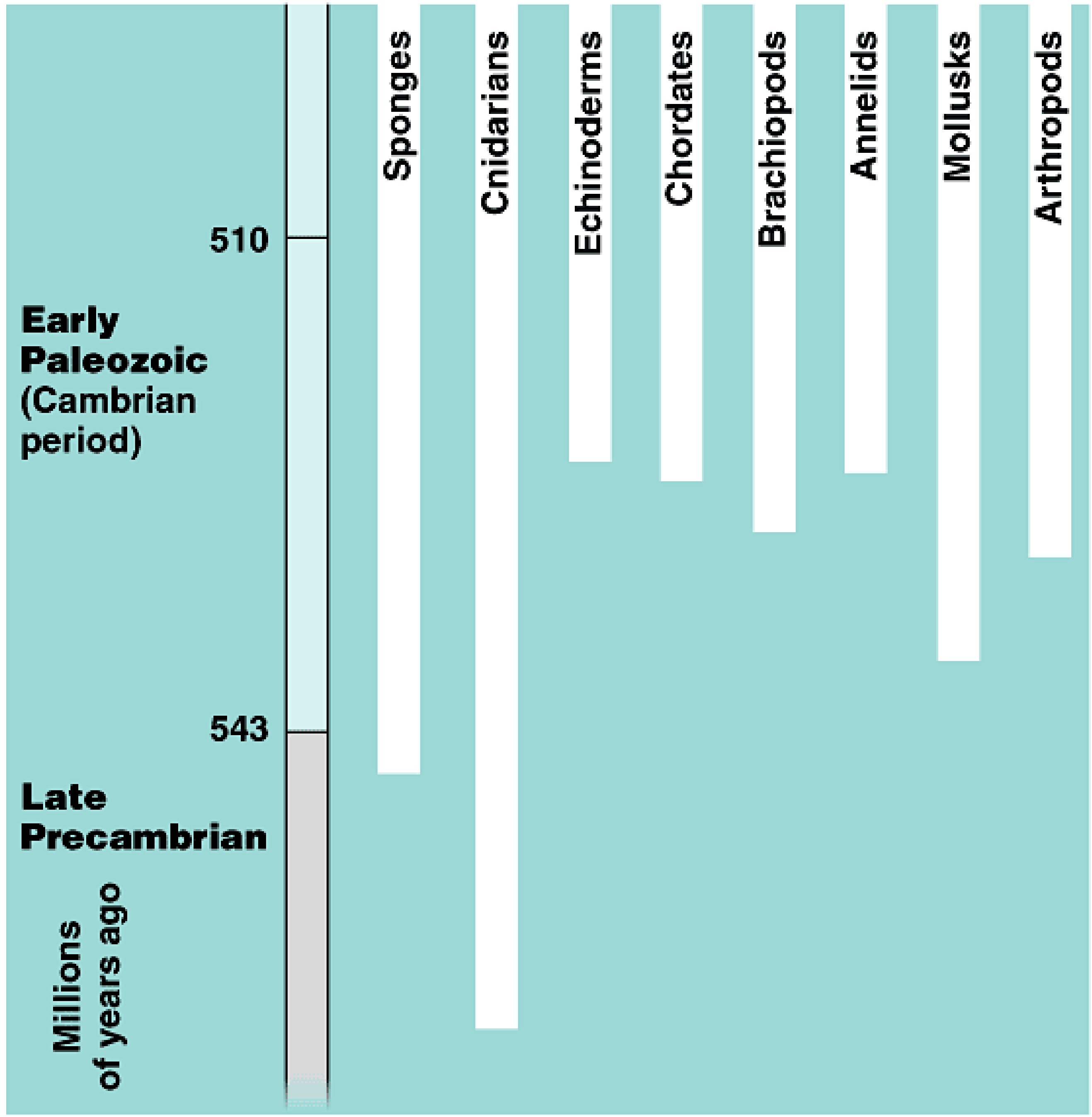
Animal Diversity



Protostomes and Deuterostomes

- Protostomes include the annelids, mollusks, and arthropods.
- Deuterostomes include the echinoderms and vertebrates.

The Cambrian radiation of animals



Macroevolutionary patterns

- **Adaptive Radiation** - evolutionary divergence of members of a single phyletic line into a series of rather different niches or adaptive zones.
- **Punctuated equilibrium** – abrupt changes in fossil record followed by long periods of stasis

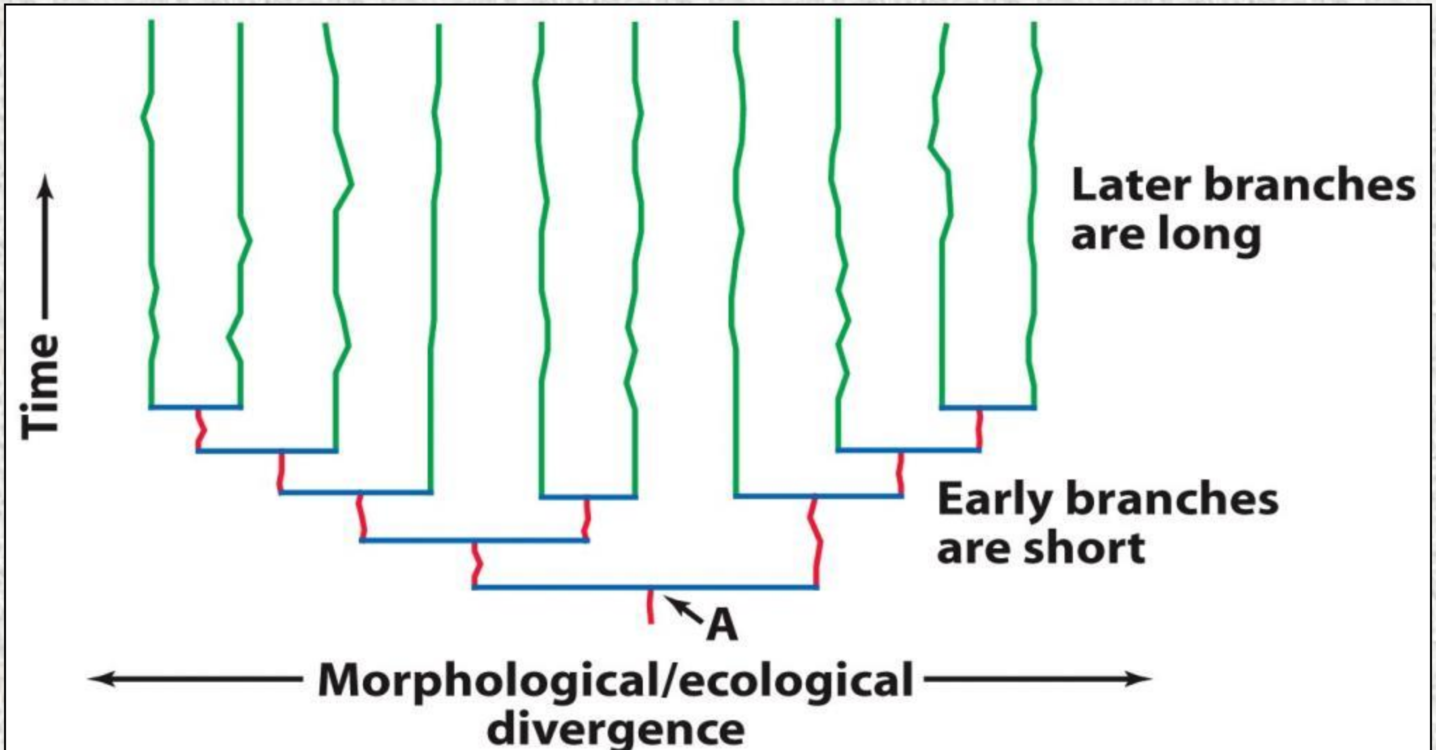


Figure 18-13 Evolutionary Analysis, 4/e

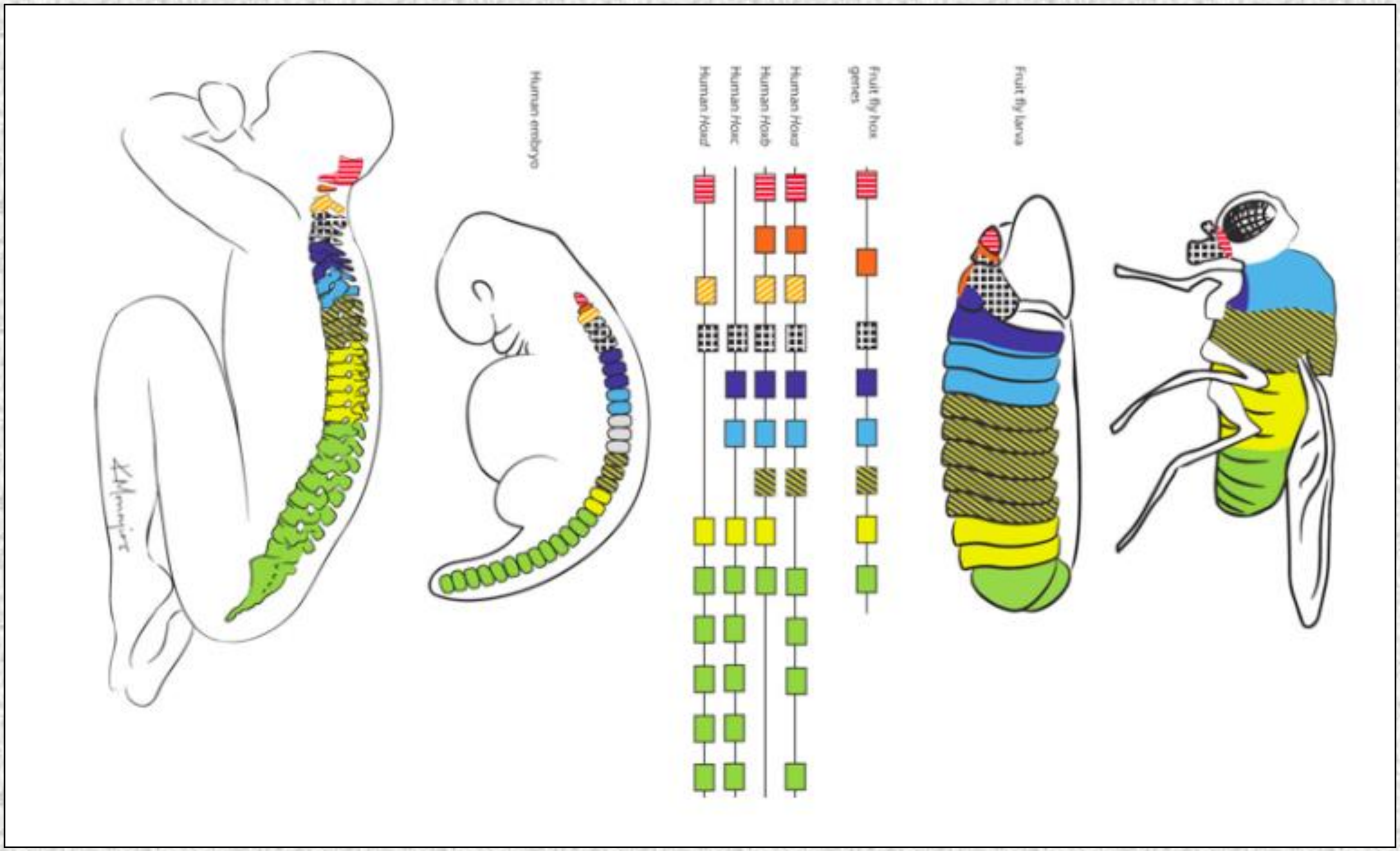
What caused the Cambrian explosion?

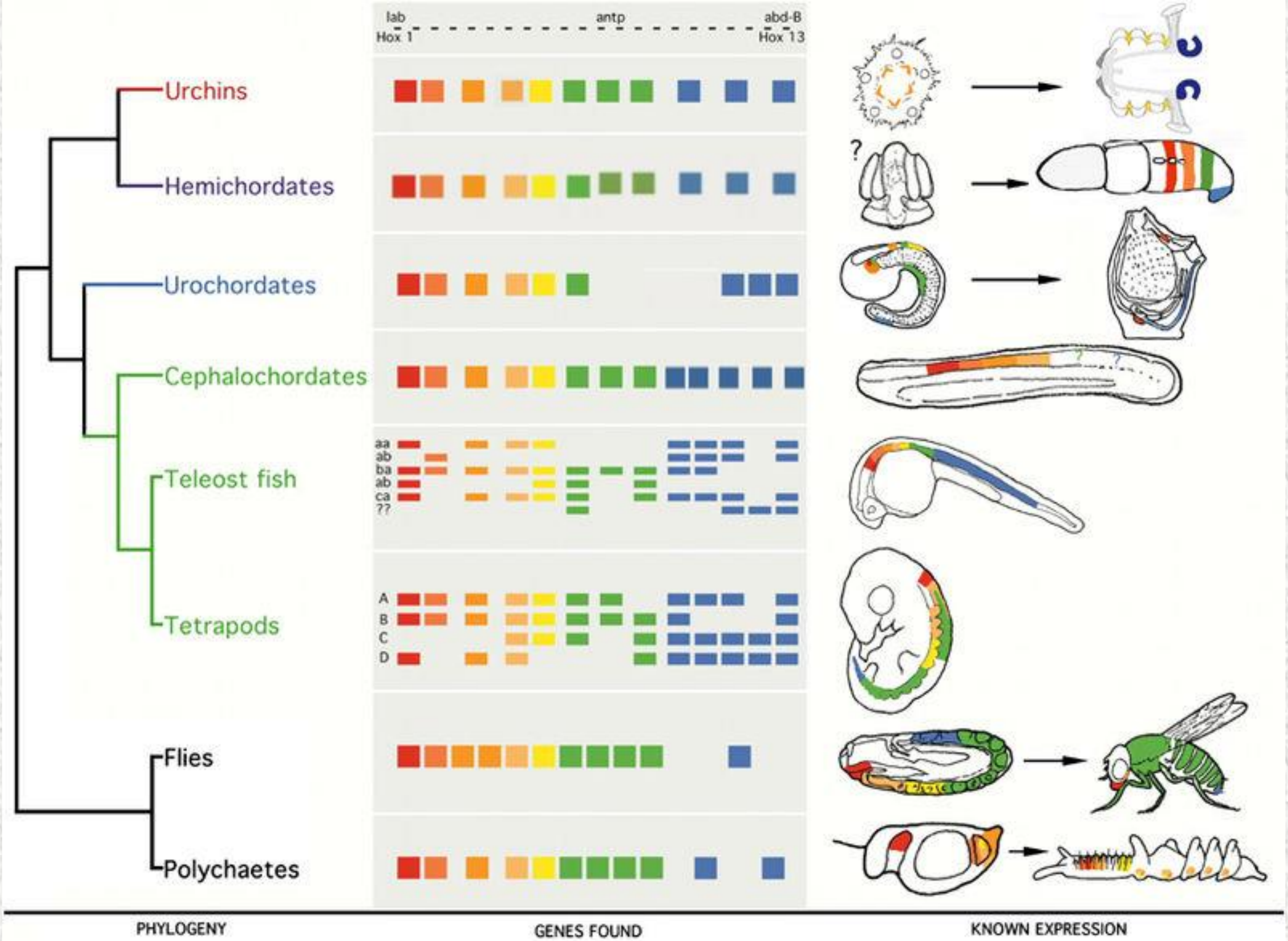
1. Oxygen levels reached present levels that allow for rapid metabolism, larger size, exhibited by animals.

2. Development of predators and escaping predators.
   Increased need for speed and better sensory equipment
   Evolution of eyes.

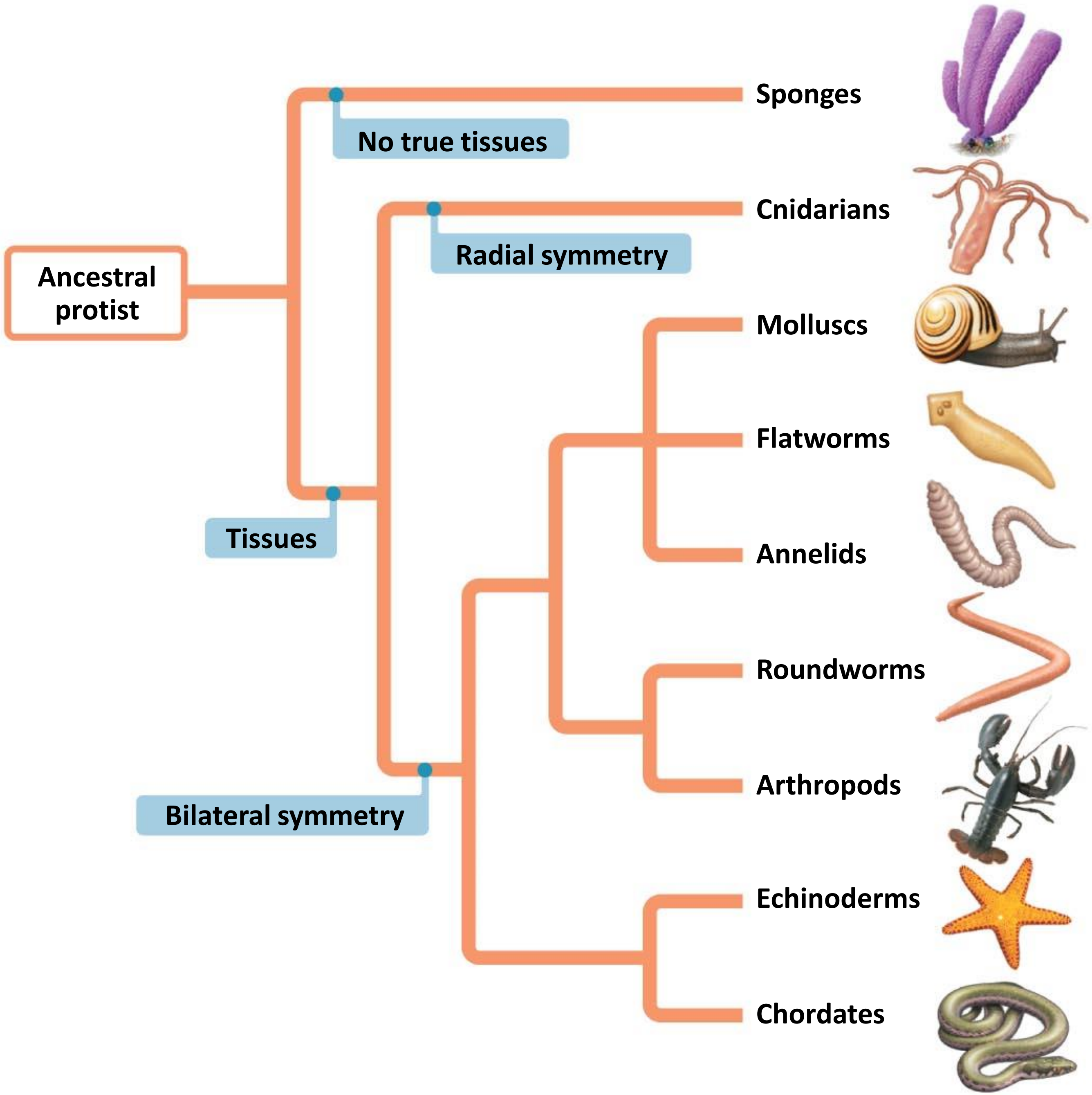
3. Genetic Factors - Homeotic Genes
   - Hox Genes – encode transcription factors that control other genes
   - *Hox* genes evolved at that time and allowed for differential development.
   - Small genetic changes => big morphological differences

Hox genes, responsible for the growth of the different body segments from head to tail, in humans, and in fruit flies. Control development, size, sequence.





- Hox gene clusters in several phyla. Each Hox gene is a colored box, and each organism has about 8 to over 40 Hox genes.
- The multiple copies of Hox genes in more derived vertebrates is due to the fact that this single cluster was duplicated as a result of successive rounds of whole genome duplication in the vertebrate lineage, with subsequent loss of some copies in various lineages



Ancestral protist
No true tissues
Tissues
Radial symmetry
Bilateral symmetry
Sponges
Cnidarians
Molluscs
Flatworms
Annelids
Roundworms
Arthropods
Echinoderms
Chordates

Figure 17.5

TABLE 31.1 An Overview of Major Animal Phyla

Group and Phylum	Common Name or Example Taxa	Estimated Number of Species
Protostomes: Lophotrochozoa		
Porifera	Sponges	5500
Cnidaria	Jellyfish, corals, anemones, hydroids, sea fans	10,000
Ctenophora	Comb jellies	100
Acoelomorpha	Acoelomate worms	10
Rotifera	Rotifers	1800
Platyhelminthes	Flatworms	20,000
Nemertea	Ribbon worms	900
Gastrotricha	Gastrotrichs	450
Acanthocephala	Acanthocephalans	1100
Entoprocta	Entroprocts	150
Gnathostomulida	Gnathostomulids	80
Sipuncula	Peanut worms	320
Echiura	Spoon worms	135
Annelida	Segmented worms	16,500
Mollusca	Mollusks (clams, snails, octopuses)	94,000
Phoronida	Phoronids	20
Ectoprocta	Ectoprocts	4500
Brachiopoda	Brachiopods; lamp shells	335

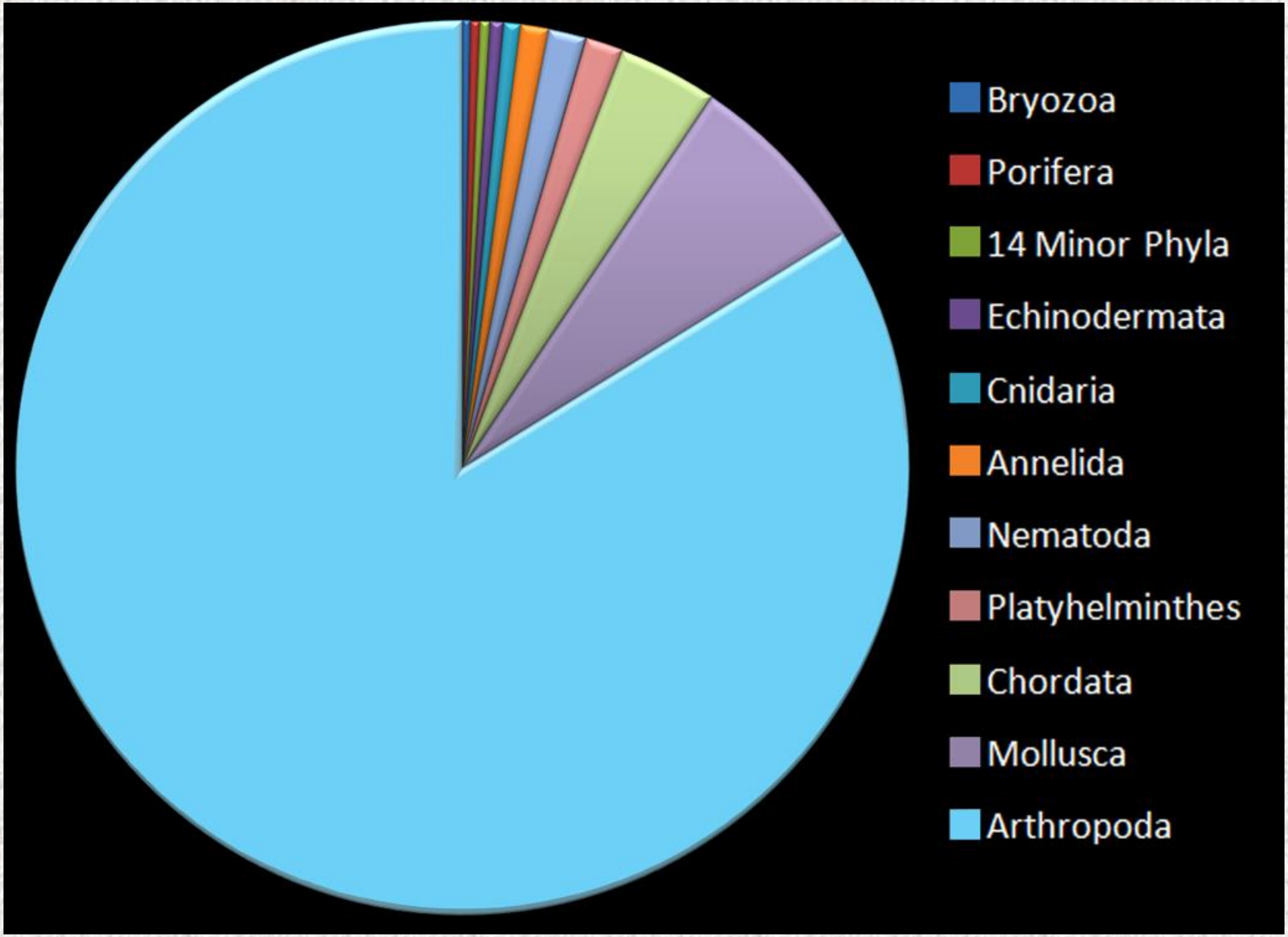
Table 31-1 part 1 Biological Science, 2/e

TABLE 31.1 An Overview of Major Animal Phyla

Group and Phylum	Common Name or Example Taxa	Estimated Number of Species
Protostomes: Ecdysozoa		
Nematoda	Roundworms	25,000
Kinorhyncha	Kinorhynchs	150
Nematomorpha	Hair worms	320
Priapula	Priapulans	16
Onychophora	Velvet worms	110
Tardigrada	Water bears	800
Arthropoda	Arthropods (spiders, insects, crustaceans)	1,100,000
Deuterostomes		
Echinodermata	Echinoderms (sea stars, sea urchins, sea cucumbers)	7000
Chaetognatha	Arrow worms	100
Hemichordata	Acorn worms	85
Chordata	Chordates (tunicates, lancelets, sharks, bony fish, frogs, reptiles, mammals)	50,000

Table 31-1 part 2 Biological Science, 2/e

The relative number of species contributed to the total by each phylum of animals.
97% invertebrates. Lots of Arthropods!



End