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Chapter 18
The Evolution of Invertebrate Diversity

PowerPoint Lectures
Campbell Biology: Concepts & Connections, 8th Edition, Global Edition
REECE • TAYLOR • SIMON • DICKEY • HOGAN

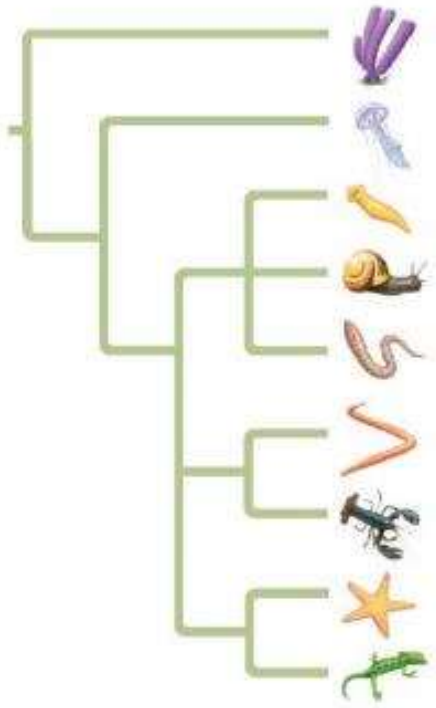
Lecture by Edward J. Zalisko

Introduction

- The vast diversity of insects encompasses a wide variety of
  - shapes and sizes,
  - habitats,
  - diets,
  - mating habits, and
  - other characteristics.
- With more than a million species—nearly three-quarters of all animal species—insects are exemplars of animal diversity.

Figure 18.0-2

Chapter 18: Big Ideas



Animal Evolution and Diversity 18.1-18.4

Invertebrate Diversity 18.5-18.16

ANIMAL EVOLUTION AND DIVERSITY

18.1 What is an animal?

- Animals are
  - eukaryotic,
  - multicellular heterotrophs, and
  - have cells that lack cell walls.

异营性

- Animals also use **ingestion**, the eating of food.
- Fungi absorb nutrients after digesting food outside their body.

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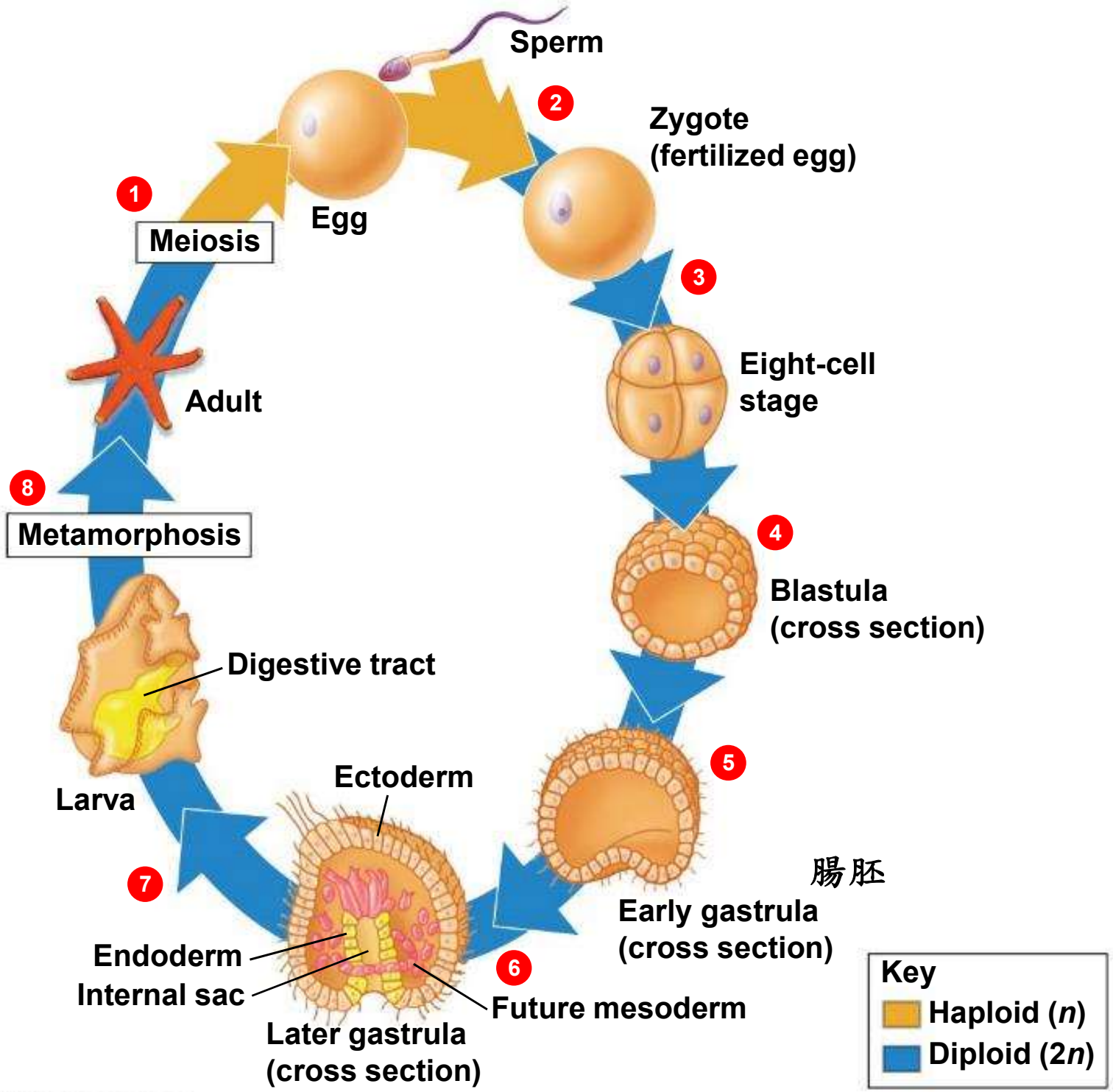
18.1 What is an animal?

- Most adult animals are diploid and reproduce sexually.
  - The eggs and sperm
    - are produced by meiosis,
    - are the only haploid cells, and
    - fuse during fertilization to form a zygote.
  - The zygote divides by mitosis to form a hollow ball of cells called a **blastula**. 囊胚
- One side of the blastula folds in and cells become rearranged to form a **gastrula** that establishes three embryonic layers. 腸胚
  - **Endoderm** forms a lining of the future digestive tract. 內胚層
  - **Ectoderm** forms an outer layer that will give rise to the skin and nervous system. 外胚層
  - **Mesoderm** forms a middle layer that will give rise to muscles and most internal organs. 中胚層

18.1 What is an animal?

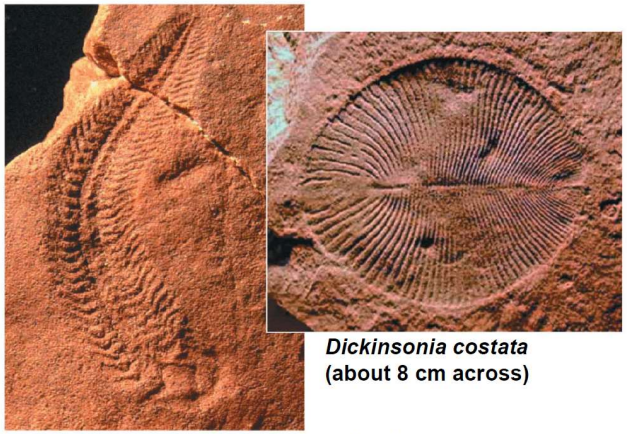
- After the gastrula stage, many animals develop directly into adults.
- Other animals, such as the sea star, develop into one or more larval stages.
  - A **larva** is an immature individual that looks different from the adult animal.
  - A larva undergoes a major change in body form, called **metamorphosis**, and becomes a reproductively mature adult.
- Clusters of master control homeotic genes control transformation of the zygote into an adult animal.

Figure 18.1b-8



18.2 Animal diversification began more than half a billion years ago

- The lineage that gave rise to animals is thought to have diverged from a flagellated unikont ancestor more than 1 billion years ago. 單鞭毛生物
- The oldest generally accepted animal fossils that have been found are 575–550 million years old.
- Animal diversification appears to have accelerated rapidly from 535 to 525 million years ago, during the Cambrian period, known as the Cambrian explosion. 寒武紀大爆發
- The most celebrated source of Cambrian fossils is the Burgess Shale containing a cornucopia of perfectly preserved animal fossils. (1909, Canadian Rockies of British Columbia, Canada)



Dickinsonia costata (about 8 cm across)

Spriggina floundersi (about 3 cm long)

18.2 Animal diversification began more than half a billion years ago

- The Cambrian explosion may have been caused by

  1

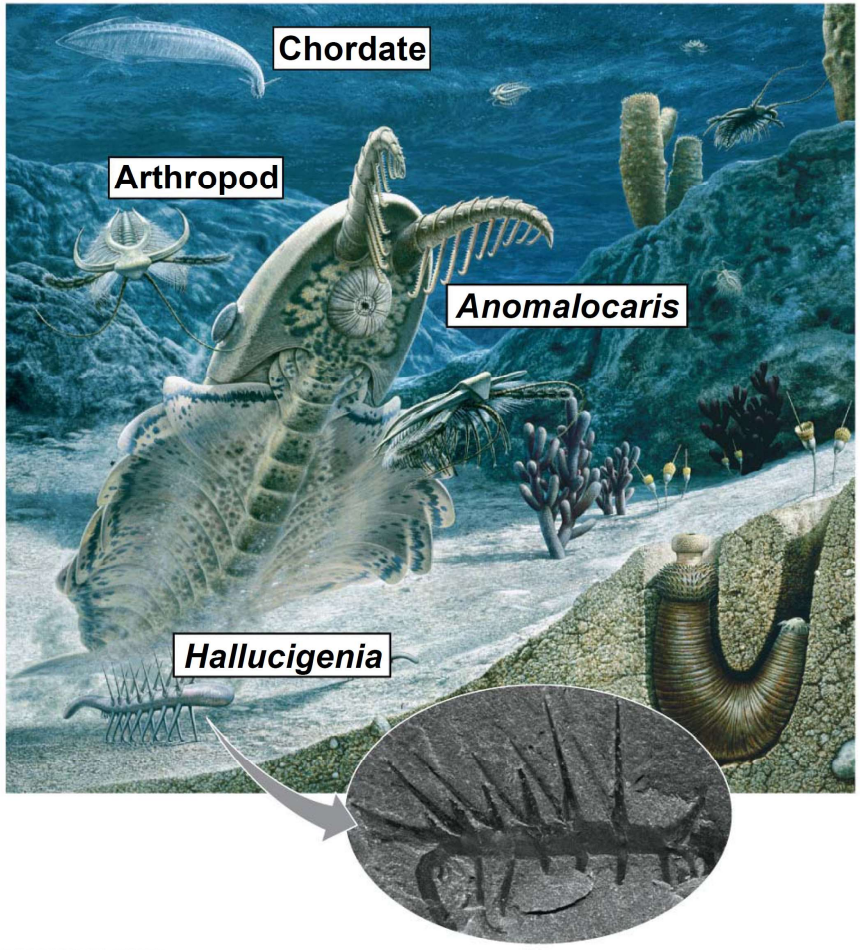
  - increasingly complex predator-prey relationships or

  2

  - an increase in atmospheric oxygen.

- Much of the diversity in body form among the animal phyla is associated with variations in where and when

3 homeotic genes are expressed within developing embryos.



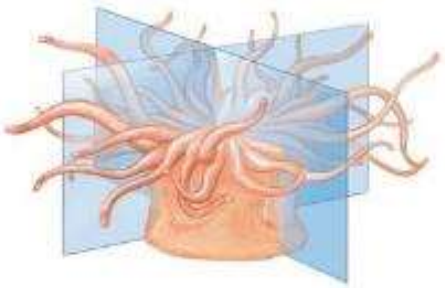
- Of the 35 or so animal phyla (門), all but one are invertebrates (無脊椎), named because they lack vertebra.
- Roughly 96% of animals are **invertebrates**, animals that lack a backbone.

18.3 Animals can be characterized by basic features of their "body plan"

- Animal body plans vary in
  - symmetry,
  - presence of true tissues,
  - number of embryonic layers,
  - presence of a body cavity, and
  - details of their embryonic development.

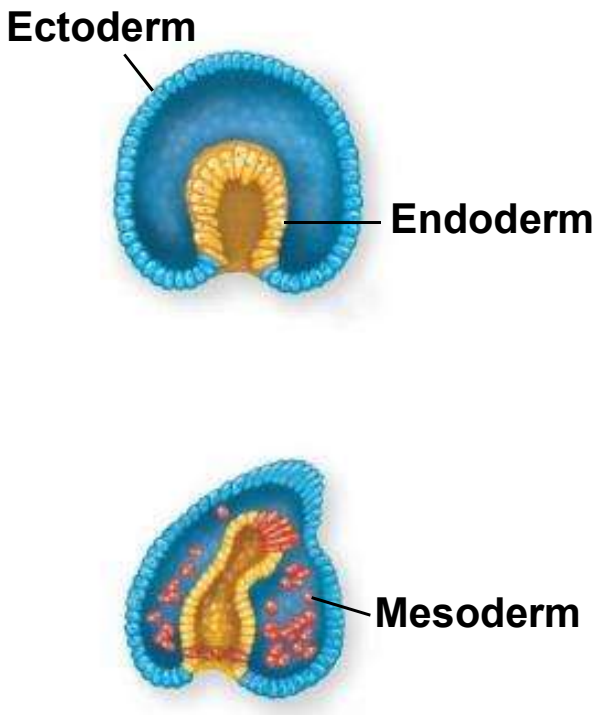
Type of symmetry

Radial



Bilateral

Embryonic development: two or three tissue layers



Embryonic development: body cavity

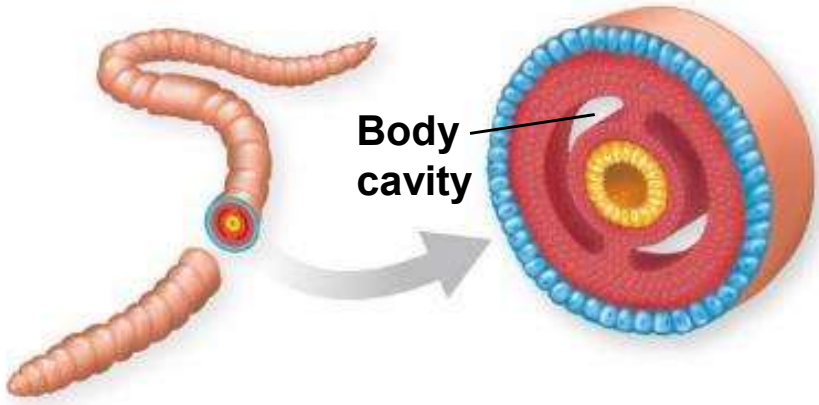


Figure 18.3-3

Embryonic development: tissue layers

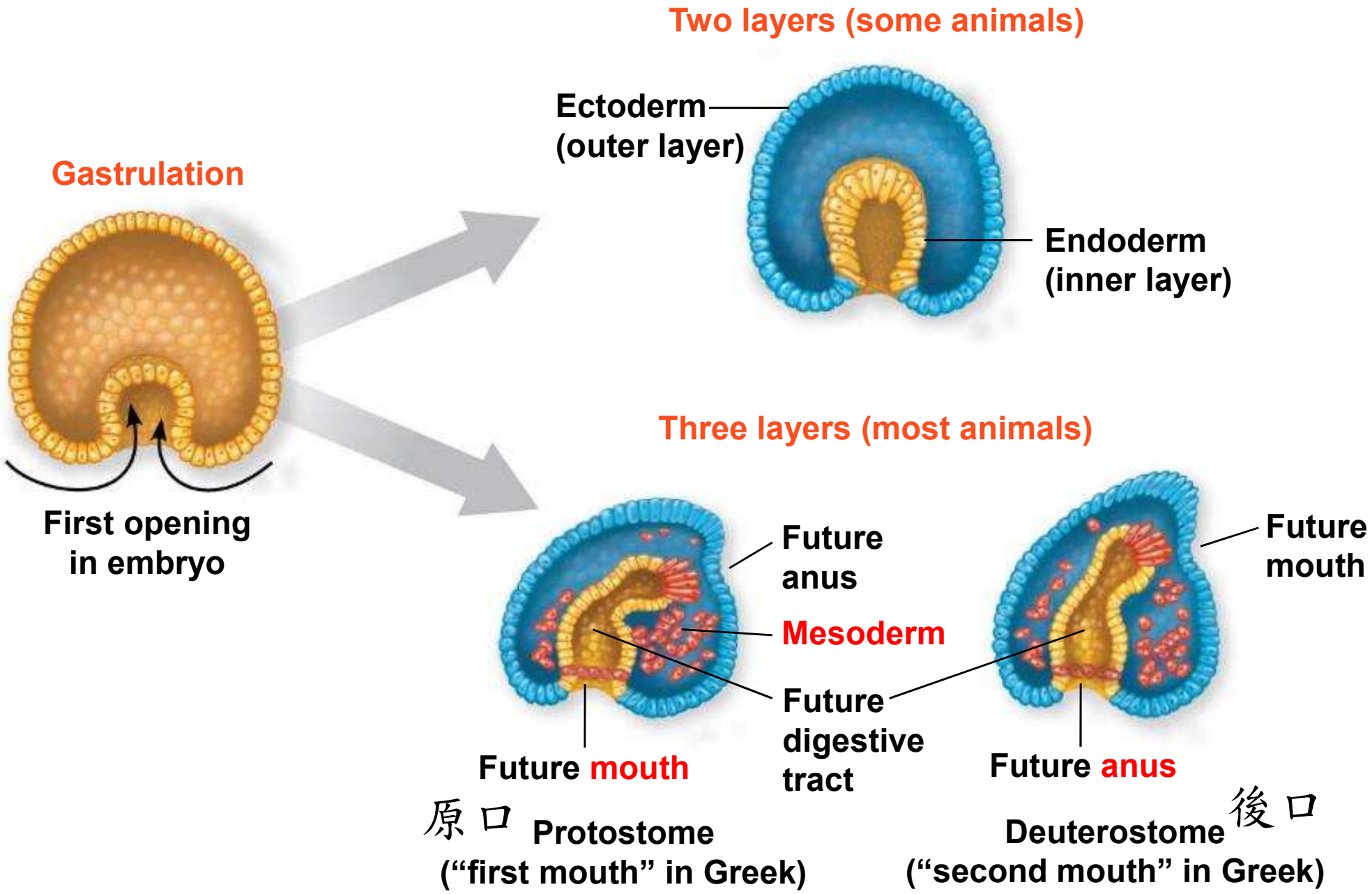
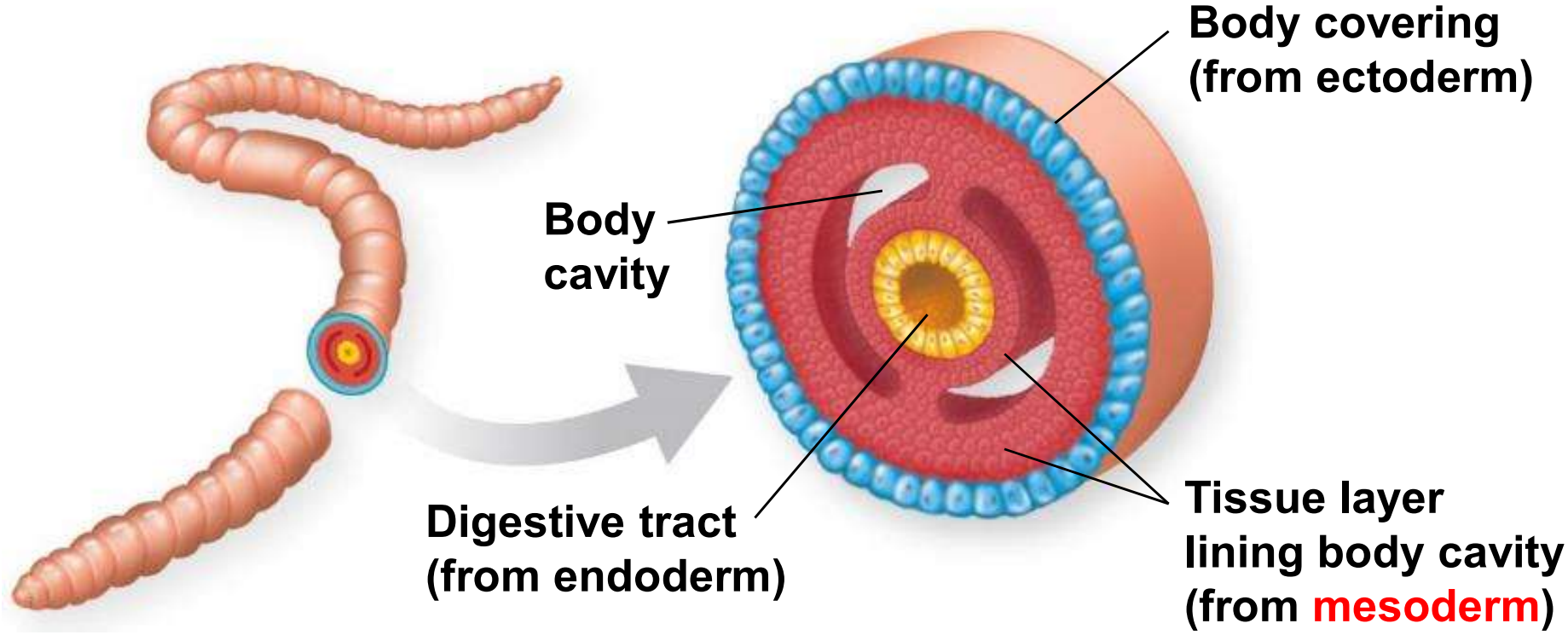


Figure 18.3-4

Embryonic development: body cavity (helps protect organs from injury)



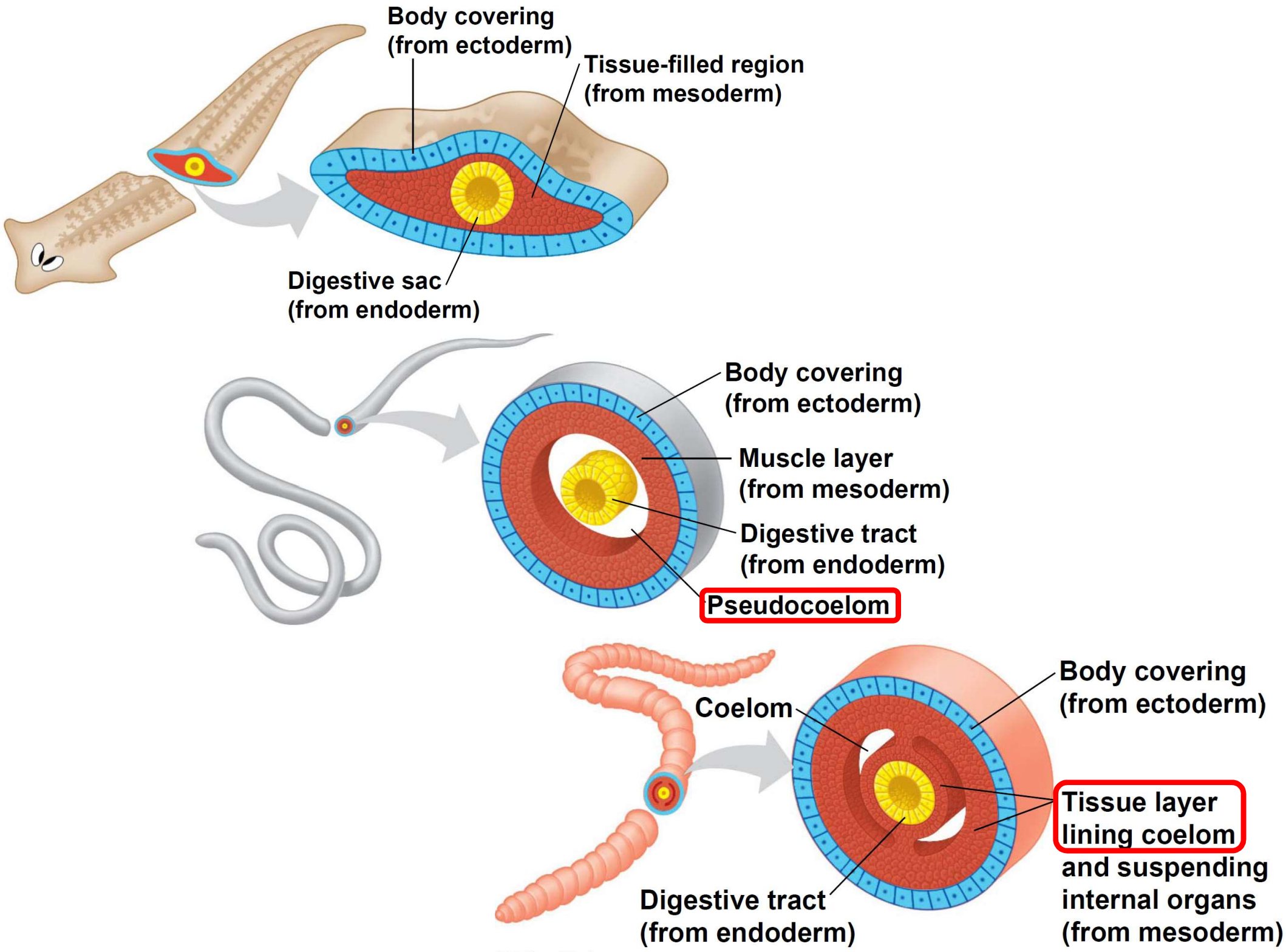
18.3 Animals can be characterized by basic features of their "body plan"

- Symmetry
  - Animals that have **radial symmetry** have a top and bottom but lack back and front or right and left sides. An imaginary slice through the central axis divides them into mirror images.
  - Animals with **bilateral symmetry** have mirror-image right and left sides and a
    - distinct head, or **anterior** end,
    - tail, or **posterior** end,
    - back, or **dorsal**, surface, and
    - bottom, or **ventral**, surface.
- Tissues
  - Tissues are collections of specialized cells that perform special functions.
  - Sponges are the only animals that lack true tissues.
- Embryonic layers
  - Some animals have only ectoderm and endoderm.
  - Most animals have: ectoderm, mesoderm, and endoderm.

18.3 Animals can be characterized by basic features of their "body plan"

- Animals with three embryonic layers may have a **body cavity**, a fluid-filled space between the digestive tract and outer body wall that
  - cushions internal organs and that
  - enables them to grow and move independently of the body wall.
  - In soft-bodied animals, fluid in the body cavity forms a **hydrostatic skeleton**.
  - A **true coelom** is completely lined by tissues derived from mesoderm.
  - A **pseudocoelom** is a body cavity that is not completely lined by tissues derived from mesoderm.
- Animals with three tissue layers can be separated into two groups based on details of their embryonic development. For example, the opening formed during gastrulation develops into the
  - mouth in **protostomes** 原口
  - anus in **deuterostomes** 後口

體腔

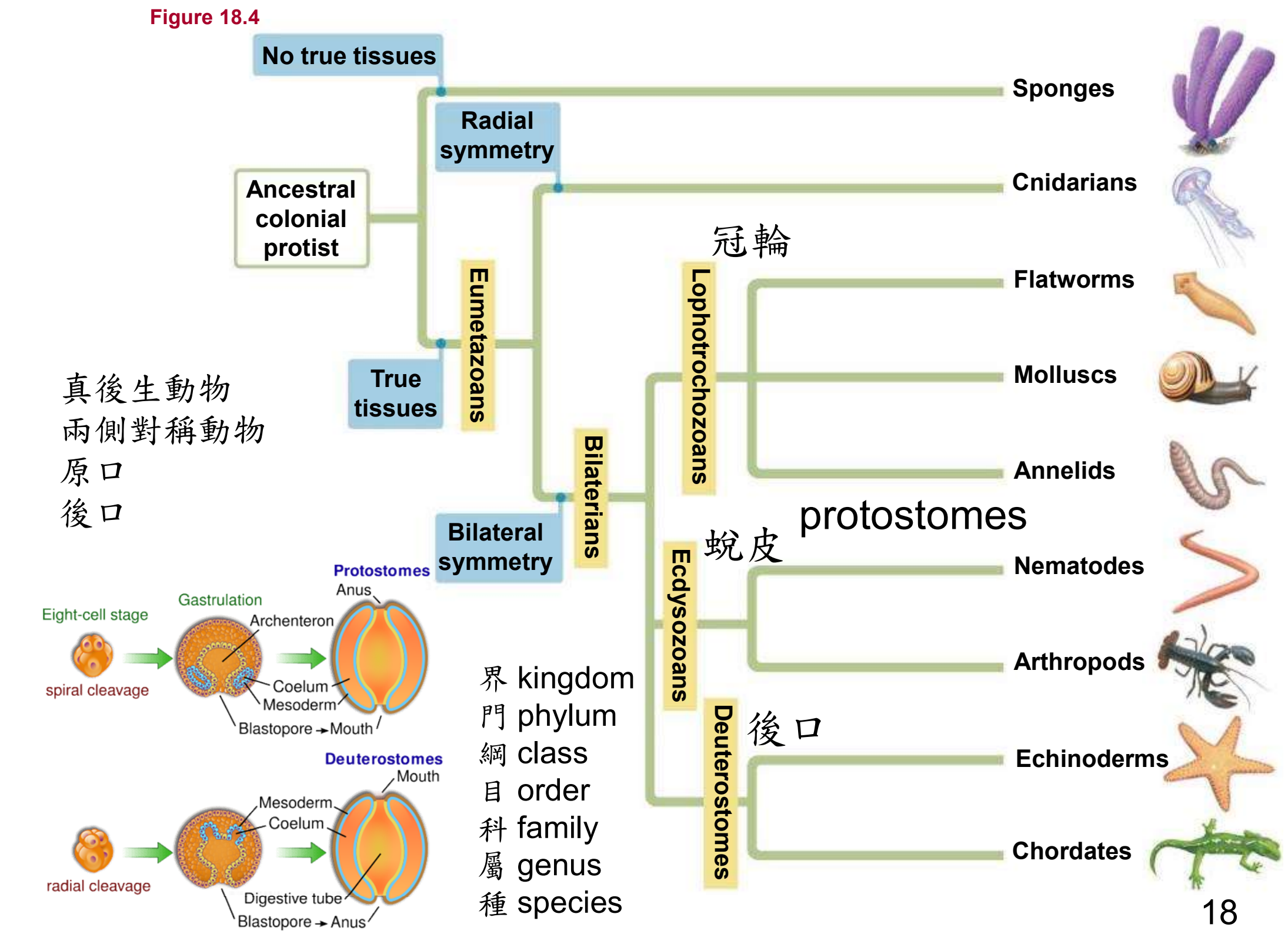

Body covering
(from ectoderm)
Tissue-filled region
(from mesoderm)
Digestive sac
(from endoderm)
Body covering
(from ectoderm)
Muscle layer
(from mesoderm)
Digestive tract
(from endoderm)
Pseudocoelom
Coelom
Body covering
(from ectoderm)
Tissue layer
lining coelom
and suspending
internal organs
(from mesoderm)
Digestive tract
(from endoderm)

18.4 Body plans and molecular comparisons of animals can be used to build phylogenetic trees

- One phylogenetic tree recently revised to reflect new information distinguishes between
  - sponges (without true tissues) and **eumetazoans** (animals with true tissues),
  - animals with two tissue layers and radial symmetry and animals with three tissue layers and bilateral symmetry (**bilaterians**),
  - protostomes and deuterostomes, and
  - ecdysozoans and lophotrochozoans.

蛻皮動物　　冠輪動物 (觸手冠動物（Lophophorata）+ 擔輪動物（Trochozoa）

Figure 18.4


No true tissues
Radial symmetry
Ancestral colonial protist
True tissues
Eumetazoans
Bilaterians
Bilateral symmetry
Lophotrochozoans
Ecdysozoans
Deuterostomes
Sponges
Cnidarians
Flatworms
Molluscs
Annelids
Nematodes
Arthropods
Echinoderms
Chordates
冠輪
蛻皮
後口
protostomes
真後生動物
兩側對稱動物
原口
後口
Protostomes
Anus
Gastrulation
Eight-cell stage
Archenteron
spiral cleavage
Coelum
Mesoderm
Blastopore → Mouth
Deuterostomes
Mouth
Mesoderm
Coelum
radial cleavage
Digestive tube
Blastopore → Anus
界 kingdom
門 phylum
綱 class
目 order
科 family
屬 genus
種 species

18.4 Body plans and molecular comparisons of animals can be used to build phylogenetic trees

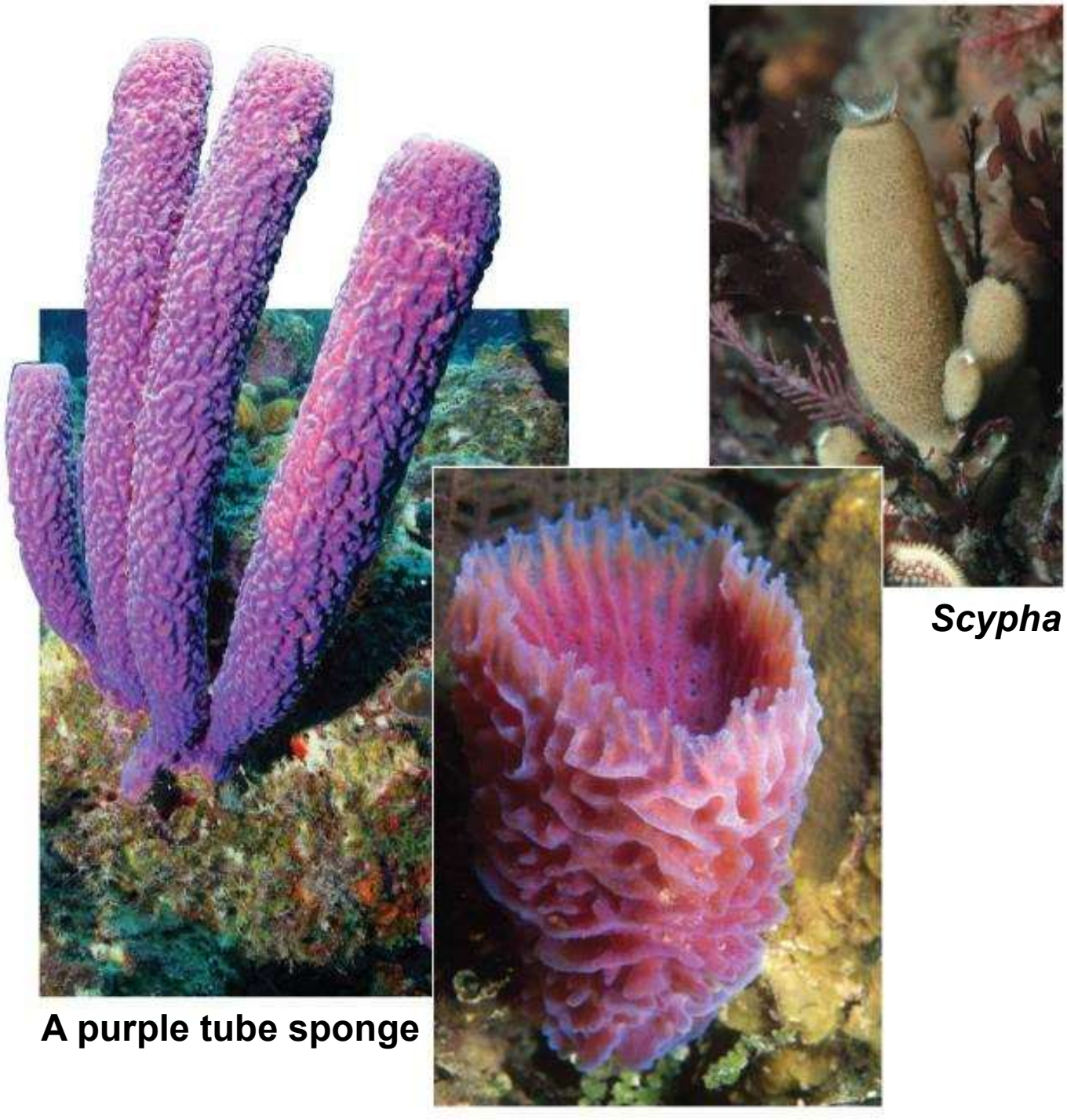
- Because animals diversified so rapidly on the scale of geologic time, it is difficult to sort out the evolutionary relationships among phyla using the fossil record.
- One diagram of evolutionary relationships uses morphology to construct a phylogenetic tree. This tree distinguishes between 系統發生樹
  - sponges and **eumetazoans** (animals with true tissues), 真後生動物
  - animals with radial or bilateral symmetry (**bilaterians**),
  - protostomes and deuterostomes.
- All phylogenetic trees are hypotheses for the key events in the evolutionary history of animals.
- Researchers are increasingly adding molecular comparisons to the construction of these trees.

INVERTEBRATE DIVERSITY

18.5 Sponges have a relatively simple, porous body

- **Sponges** (phylum Porifera) are simple, sedentary animals without true tissues.
- Water enters through pores in the body wall into a central cavity and then flows out through a larger opening.
- The body of a sponge consists of two layers of cells separated by a gelatinous region.
  - The inner layer of flagellated **choanocytes** filters food and engulfs it by phagocytosis.
  - **Amoebocytes** wander through the middle body region and produce skeletal fibers composed of
    - flexible protein and
    - mineralized particles called spicules.

Figure 18.5a-0

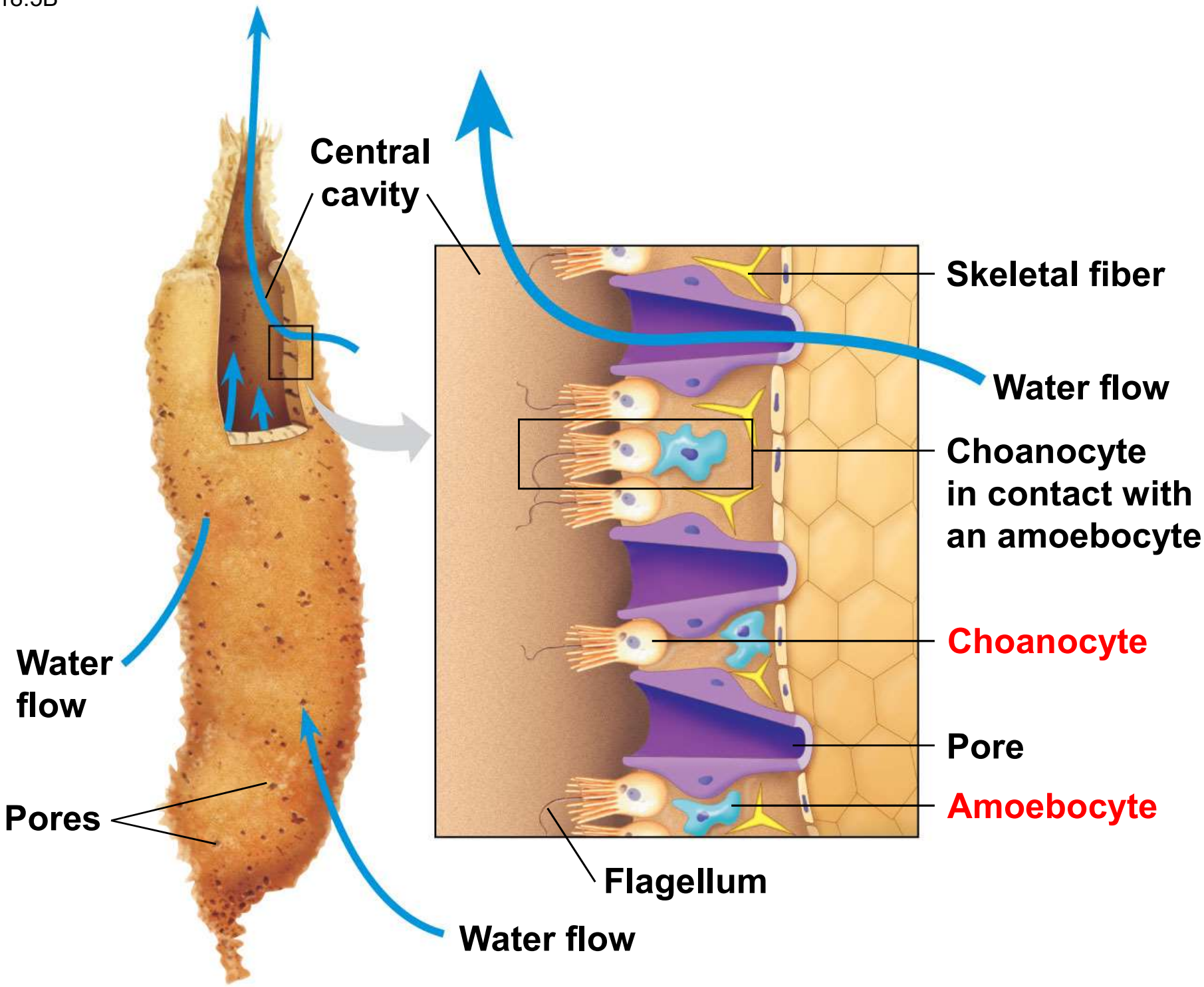


Scypha

A purple tube sponge

An azure vase sponge

Figure 18.5B



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18.5 Sponges have a relatively simple, porous body

- Sponges are **suspension feeders**, filtering food particles from water passed through food-trapping equipment.
  - To grow by 100 g, a sponge must filter roughly 1,000 kg of water.
  - Choanocytes trap food particles in mucus on the membranous collars that surround their flagella.
- Adult sponges are **sessile** and cannot escape from predators.
- They deter pathogens, parasites, and predators by producing defensive toxins and antibiotics. Some of these compounds may prove useful to humans as new drugs.
- Biologists hypothesize that sponge lineages arose very early from the multicellular organisms that gave rise to the animal kingdom.

18.6 Cnidarians are radial animals with tentacles and stinging cells

- **Cnidarians** (phylum Cnidaria)
  - are characterized by radial symmetry and
  - have only **two tissue layers**:
    - an outer epidermis,
    - an inner cell layer lining the digestive cavity, and
    - a jelly-filled middle region may have scattered amoeboid cells.
- Cnidarians exhibit two kinds of radially symmetrical body forms.
  - The most sedentary **polyp** body is cylindrical with tentacles projecting from one end.
  - The more mobile **medusa** form is exemplified by a marine jelly.

Figure 18.6A

A hydra (about 2–25 mm tall)

A sea anemone 海葵 (about 6 cm in diameter)

A marine jelly (about 6 cm in diameter)

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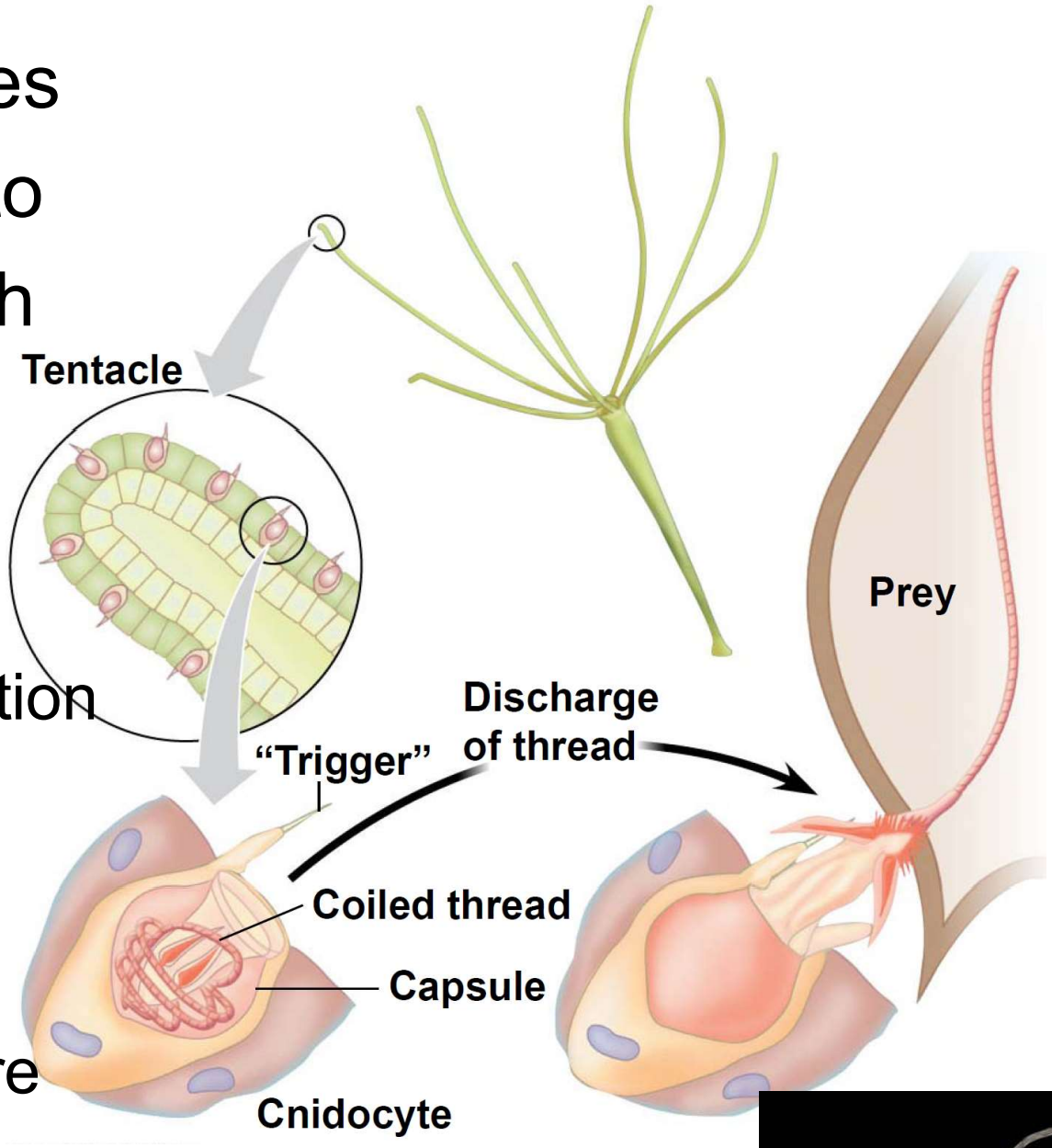
18.6 Cnidarians are radial animals with tentacles and stinging cells

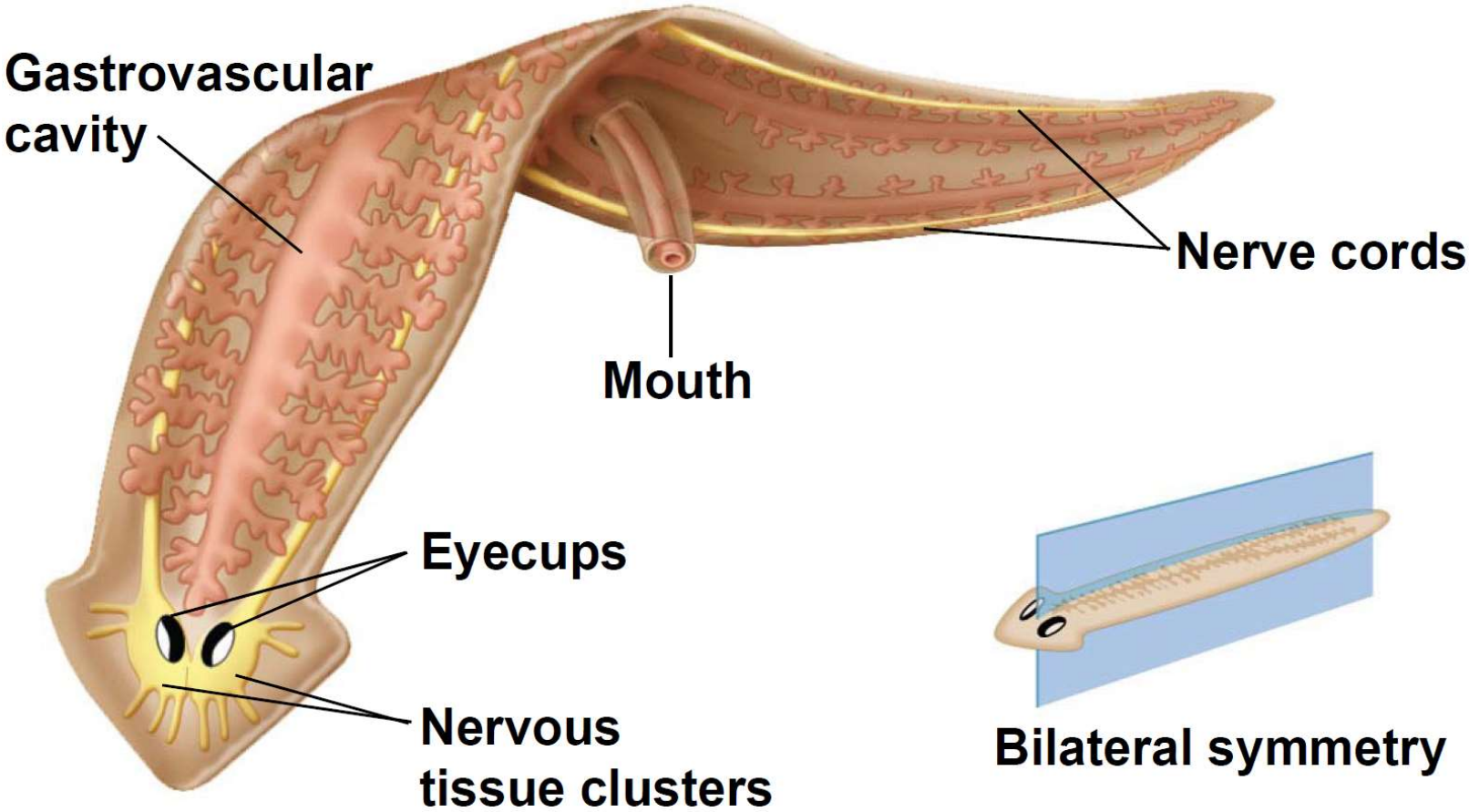
- Cnidarians are carnivores that use their tentacles to capture prey and to push prey into their mouths.
  - The mouth leads to the **gastrovascular cavity**, which functions in digestion and circulation and as a hydrostatic skeleton.
  - **Cnidocytes** are unique stinging cells that capture prey and function in defense.



choanoflagellate

18.7 Flatworms are the simplest bilateral animals

- The vast majority of animal species belong to the clade Bilateria, consisting of animals with bilateral symmetry.
- **Flatworms** (phylum Platyhelminthes) are the simplest bilaterians.
- Flatworms live in marine, freshwater, and damp terrestrial habitats.
- Some are parasitic and others are free-living.



18.7 Flatworms are the simplest bilateral animals

- There are three major groups of flatworms.
  1. **Free-living flatworms** (planarians) have
     - heads with light-sensitive eyespots,
     - flaps to detect chemicals,
     - dense clusters of nerve cells that form a simple brain and a pair of nerve cords that runs the length of the body, and
     - a branched gastrovascular cavity with a single opening.
  2. **Flukes** are parasitic flatworms with

吸虫

     - complex life cycles and
     - suckers to attach to their hosts.

3. **Tapeworms** 條蟲

are parasitic,

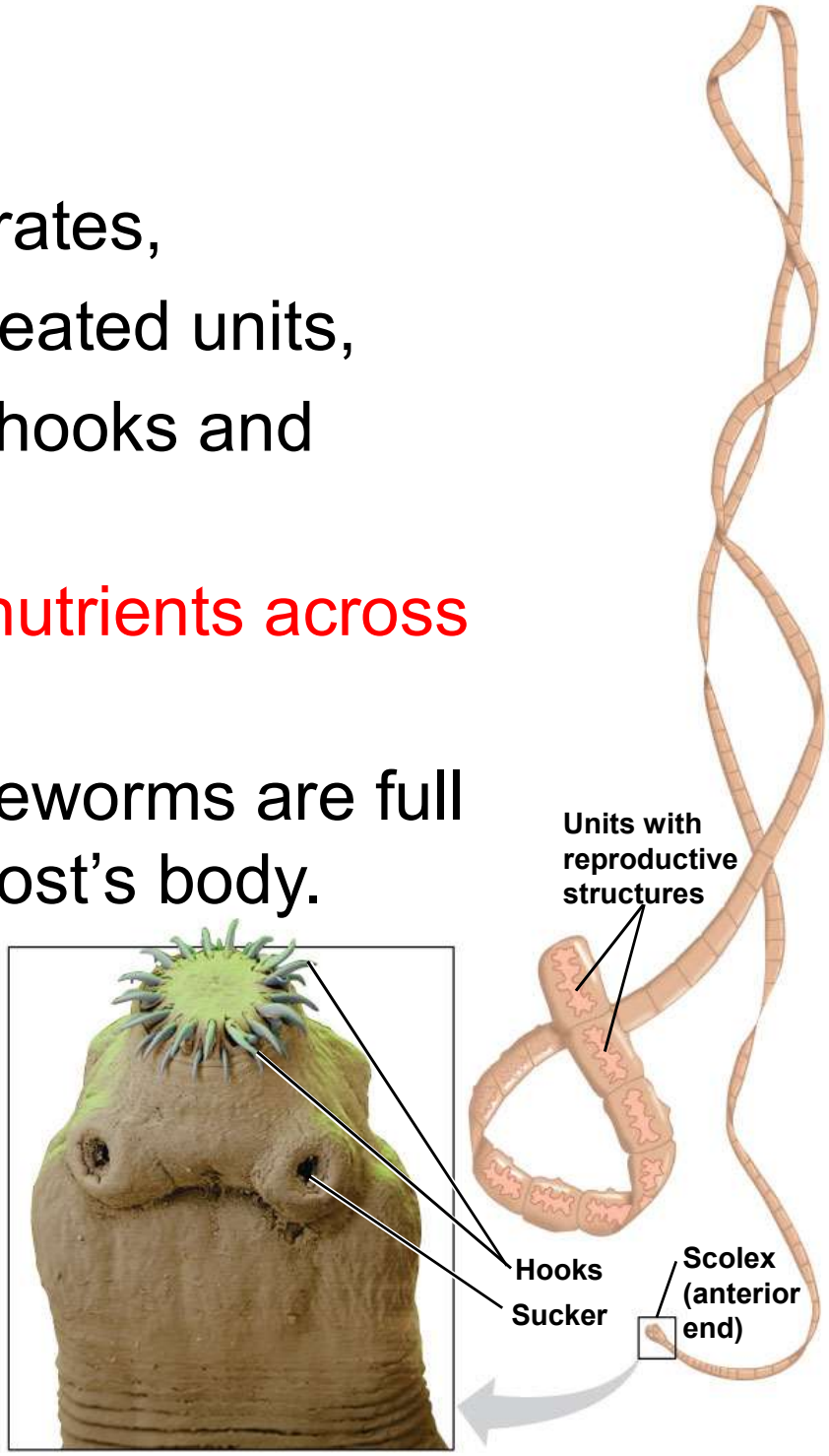
inhabit the digestive tracts of vertebrates,

consist of a ribbonlike body with repeated units,

have an anterior *scolex* armed with hooks and suckers that grasp the host,

have no mouth, and simply absorb nutrients across their body surface.

The units at the posterior end of tapeworms are full of ripe eggs that pass out of the host's body.



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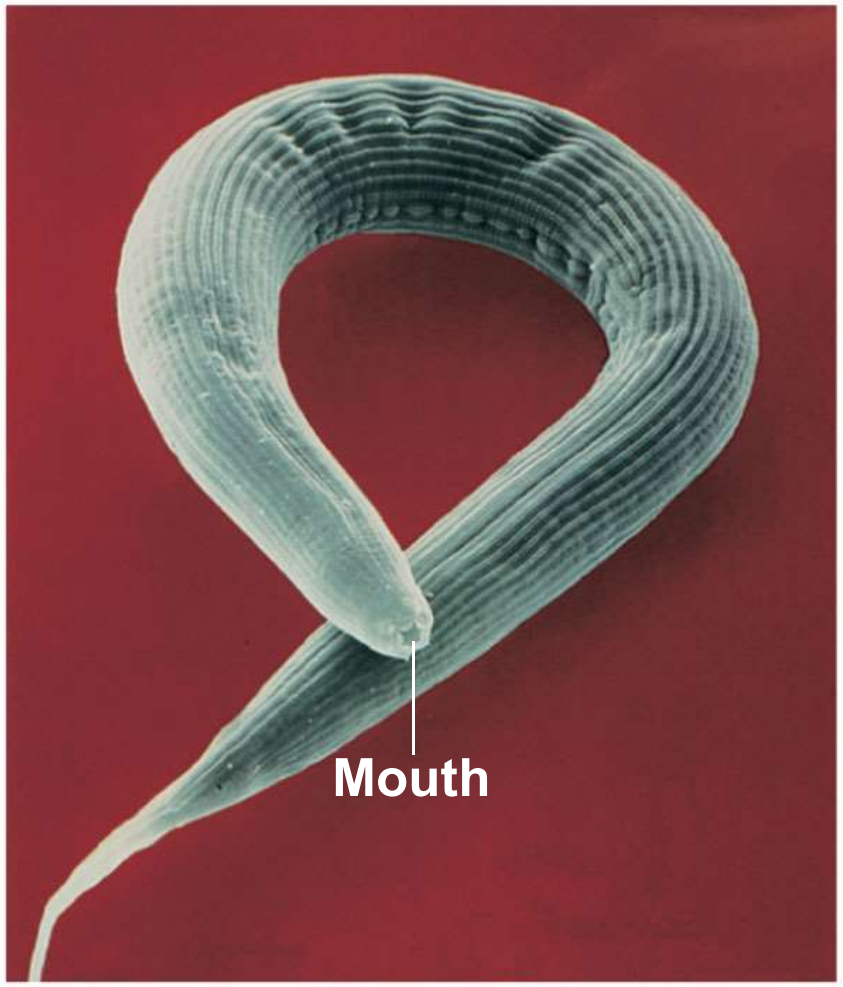
18.8 Nematodes have a pseudocoelom and a complete digestive tract

- **Nematodes** or roundworms (phylum Nematoda) are abundant and diverse, with an estimated 500,000 species. Nematodes have
  - bilateral symmetry,
  - **three tissue layers**,
  - a nonliving cuticle covering the body that prevents them from drying out,
  - a fluid-filled body cavity that functions to distribute nutrients, and
  - a **complete digestive tract** with a mouth and anus.
- Although about 25,000 species of nematodes have been named, estimates of the total number of species range as high as 500,000.
- Humans host at least 50 species of parasitic nematodes.

Figure 18.8A



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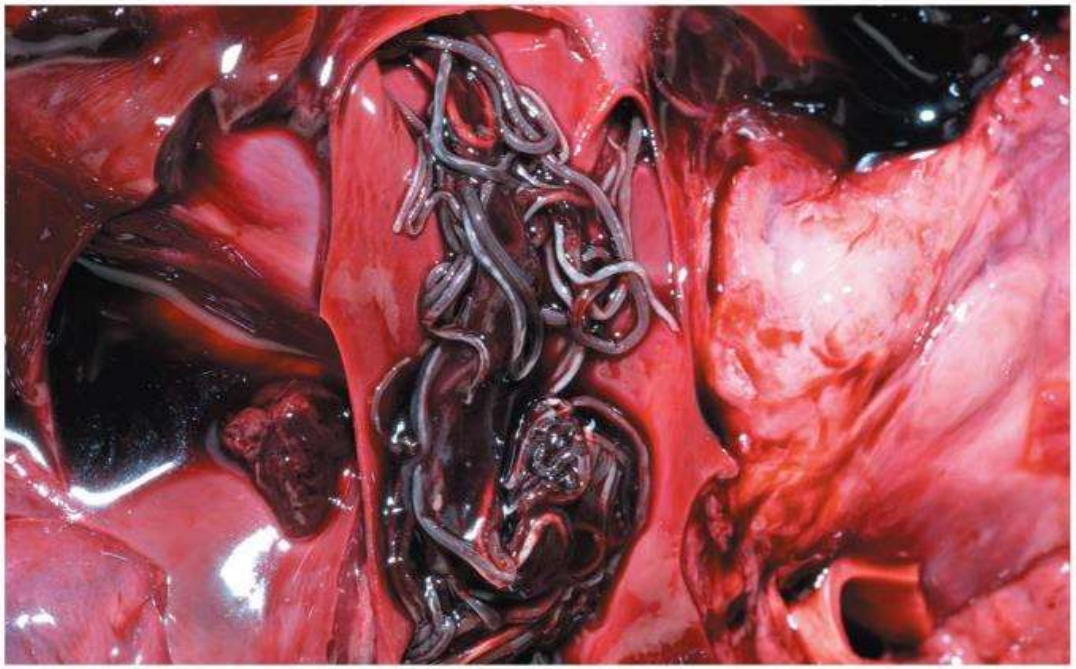


心絲蟲

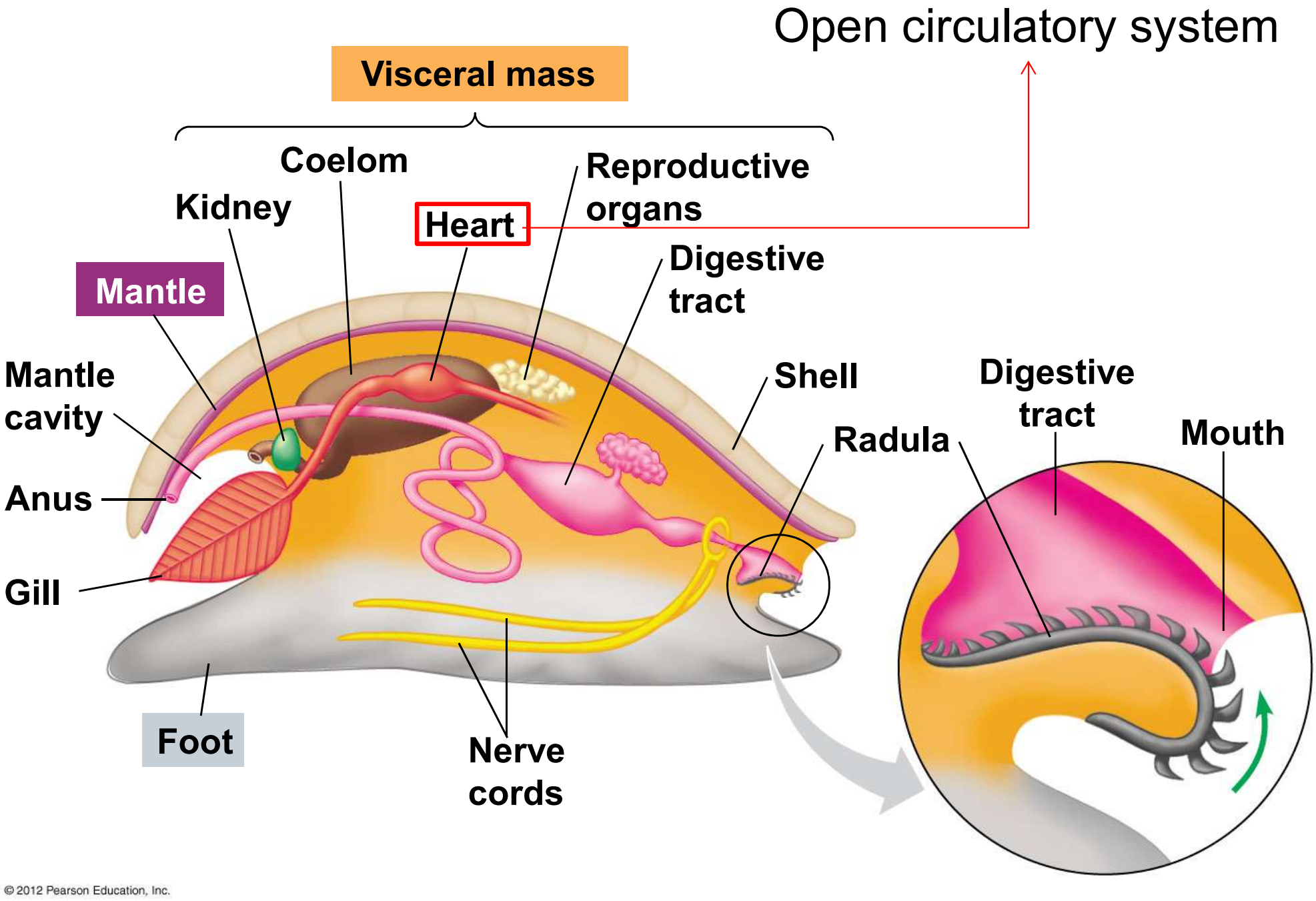
Dog heart infested by heartworm

18.9 Diverse molluscs are variations on a common body plan

- **Molluscs** (phylum Mollusca) have
  - a muscular **foot** that functions in locomotion,
  - a **visceral mass** containing most of the internal organs,
  - a **mantle**, which may secrete a shell that encloses the visceral mass, and
  - a **circulatory system** that pumps blood and distributes nutrients and oxygen throughout the body.
  - Many molluscs feed with a rasping **radula**, used to scrape up food.
  - Most molluscs have separate sexes, with reproductive organs located in the visceral mass.
  - The life cycle of many marine molluscs includes a ciliated larva called a trochophore.

內臟團

Figure 18.9A



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18.9 Diverse molluscs are variations on a common body plan

- **Gastropods** are the largest group of molluscs and include the snails and slugs. 腹足綱
  - found in fresh water, salt water, and terrestrial environments,
  - the only molluscs that live on land, using the mantle cavity as a lung, and
  - often protected by a single, spiral shell.
  - Slugs have lost their mantle and shell and have long colorful projections that function as gills.
- **Bivalves** 雙殼綱
  - include clams, oysters, mussels, and scallops and
  - have shells divided into two halves that are hinged together.
  - Most bivalves are sedentary suspension feeders, attached to the substrate by strong threads.

Figure 18.9D

A scallop (about 7 cm In diameter)

Mussels (each about 6 cm long)

18.9 Diverse molluscs are variations on a common body plan

- **Cephalopods** 頭足綱
  - include squids, octopuses, and nautiluses,
  - are fast, agile predators,
  - have large brains and sophisticated sense organs, including complex image-focusing eyes, and
  - a shell that is large in a nautilus, small and internal in a squid, or missing in an octopus.
  - Squid are fast, streamlined predators that use a muscular siphon for jet propulsion.
  - Octopuses live on the seafloor, where they creep about as active predators.
  - The so-called colossal squid, which lives in the ocean depths near Antarctica, is the largest of all invertebrates.

鸚鵡螺

Figure 18.9E

A squid (internal shell)

A chambered nautilus (about 21 cm in diameter)

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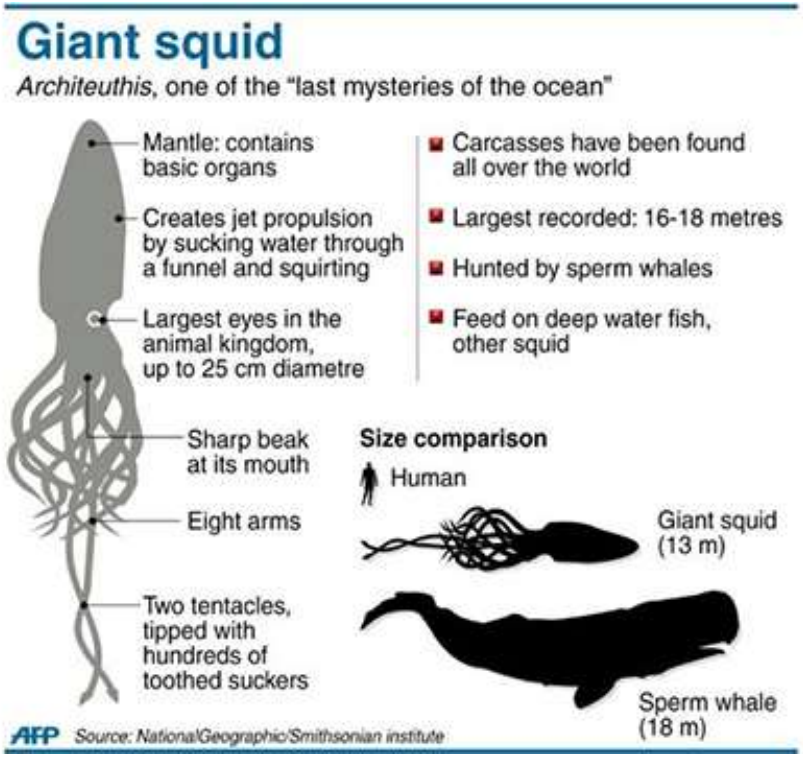

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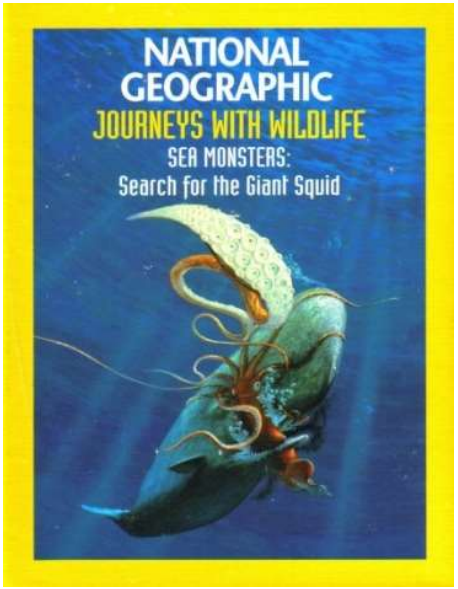
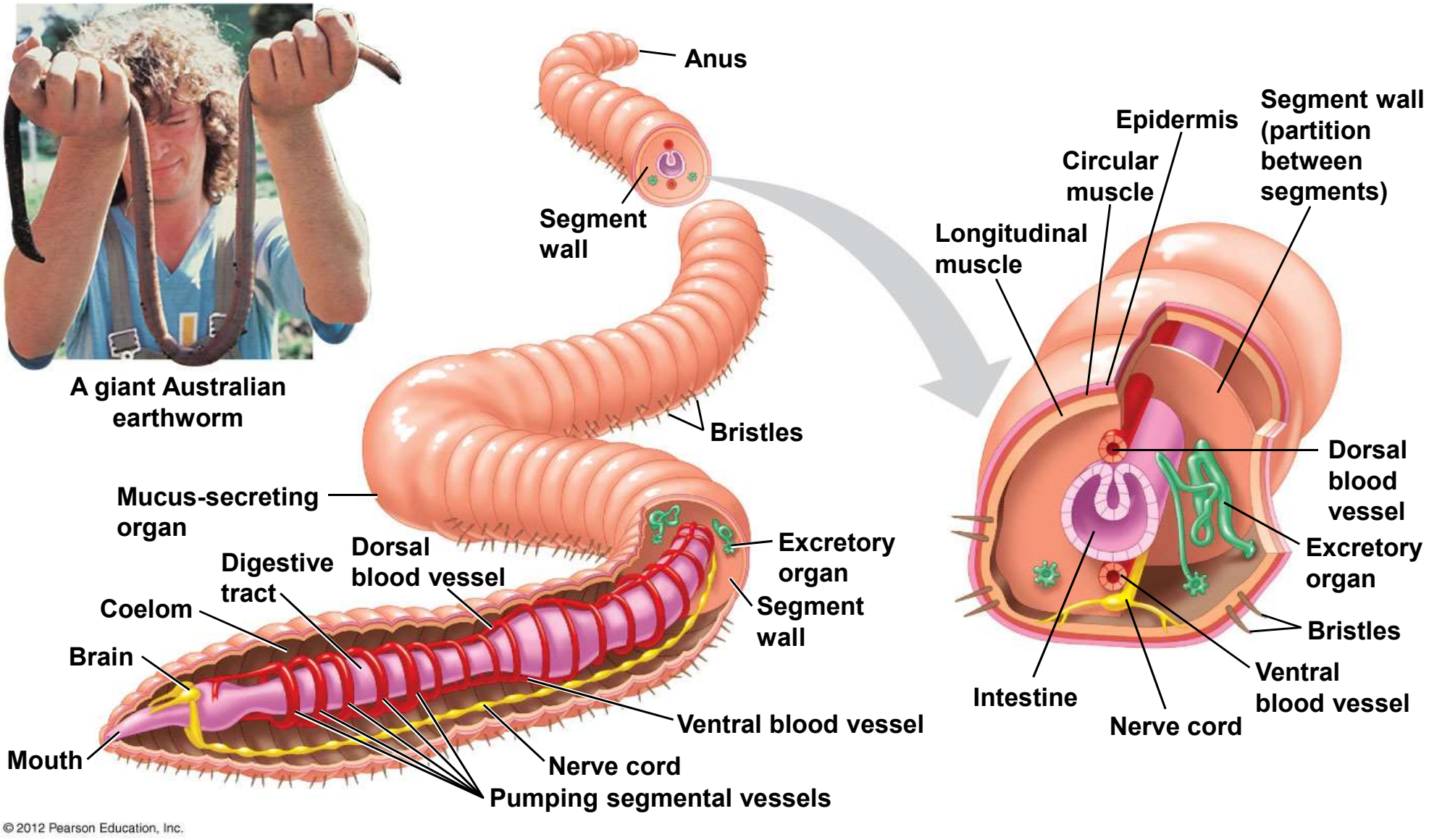


18.10 Annelids are segmented worms

- **Annelids** (phylum Annelida) have
  - **segmentation**, the subdivision of the body along its length into a series of repeated parts,
  - a true coelom that functions as a hydrostatic skeleton,
  - a nervous system that includes a simple brain and ventral nerve cord, and
  - a **closed circulatory system** in which blood remains enclosed in vessels throughout the body.
  - Many invertebrates, such as molluscs and arthropods, have an **open circulatory system** in which blood is pumped through vessels into open body cavities.
- Annelids are found in damp soil, the sea, and most freshwater habitats.
- The three groups of annelids are
  - earthworms and their relatives; polychaetes, and leeches.
- Earthworms ingest soil and extract nutrients, aerating soil and improving its texture.

Figure 18.10A



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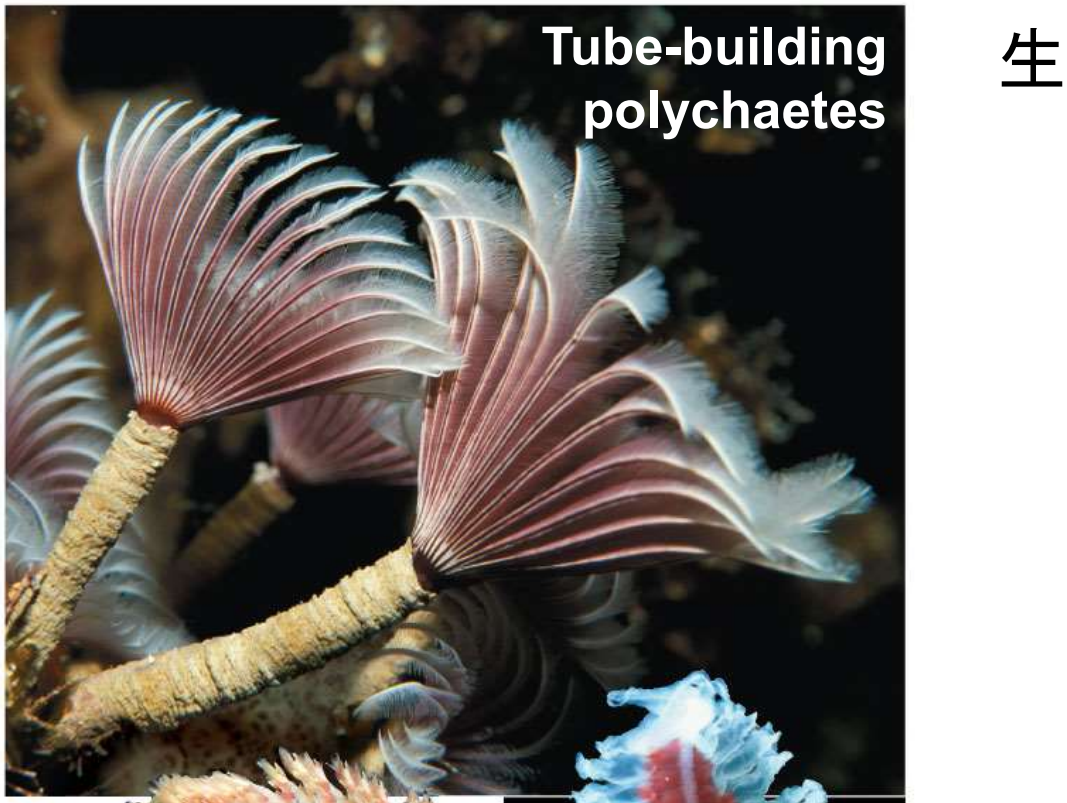
18.10 Annelids are segmented worms

- **Polychaetes** are the largest group of annelids.
  多毛類
  - Each polychaete segment has a pair of fleshy appendages with stiff bristles or chaetae.
  - Polychaetes search for prey on the seafloor or live in tubes and filter food particles.
- Most **leeches** are free-living carnivores, but some suck blood.
  蛭類
  - Blood-sucking leeches use razor-like jaws, secrete an anesthetic and an anticoagulant, and suck up to 10 times their own weight in blood.

Figure 18.10B



A sandworm

A free-swimming polychaete

生態指標

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Leech & bloodletting

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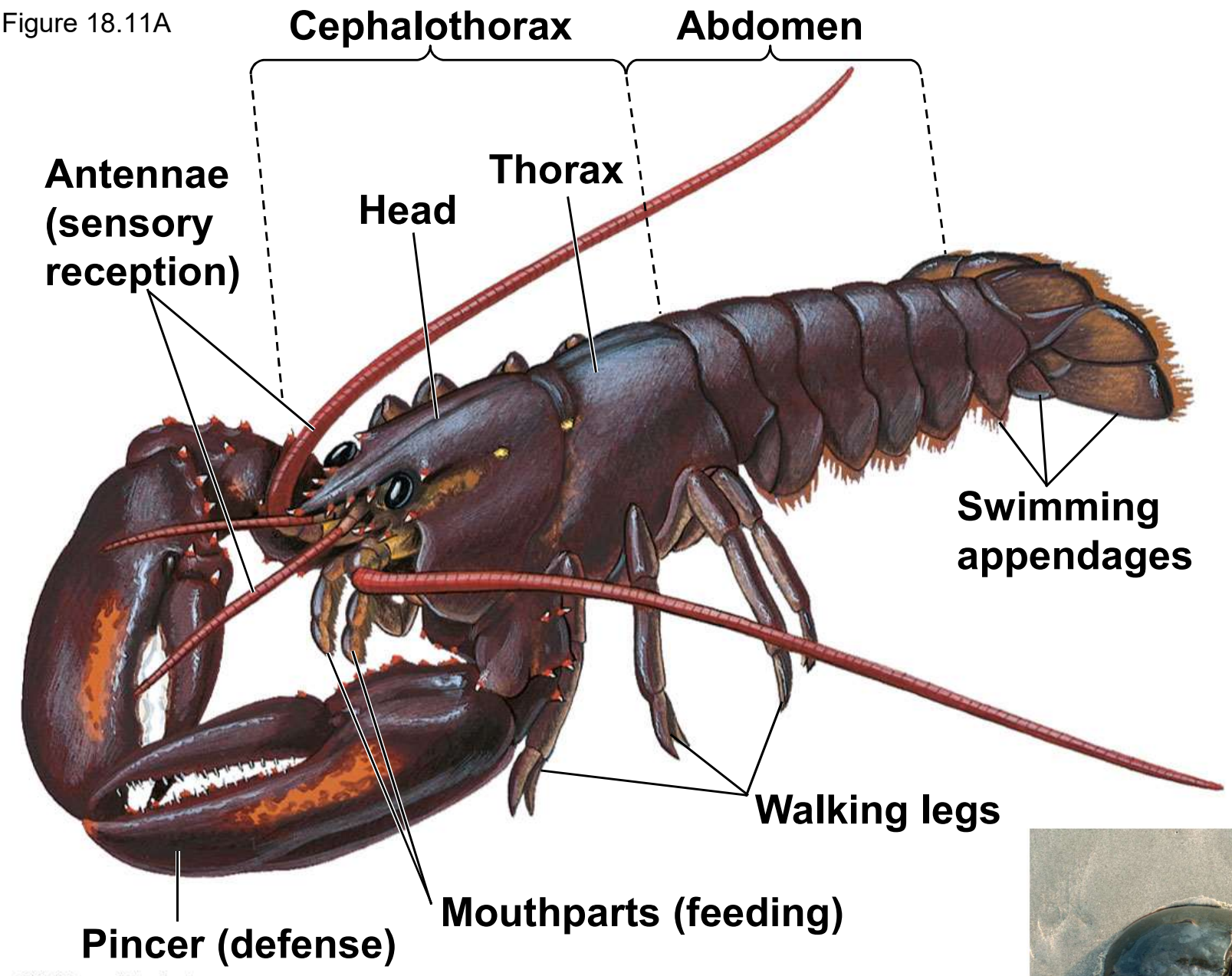
18.11 Arthropods are segmented animals with jointed appendages and an exoskeleton

- There are over a million species of **arthropods** (phylum Arthropoda), including crayfish, lobsters, crabs, barnacles, spiders, ticks, and insects.
- The diversity and success of arthropods are due to their
  - segmentation,
  - a hard exoskeleton, and
  - jointed appendages, for which the phylum is named.
- Arthropods have
  - an **open circulatory system** and
  - an **exoskeleton**, an external skeleton that protects the animal but must be shed in the process of **molting** to permit growth.
  - The body of most arthropods includes a head, thorax, and abdomen, although these segments may be fused.

Figure 18.11A



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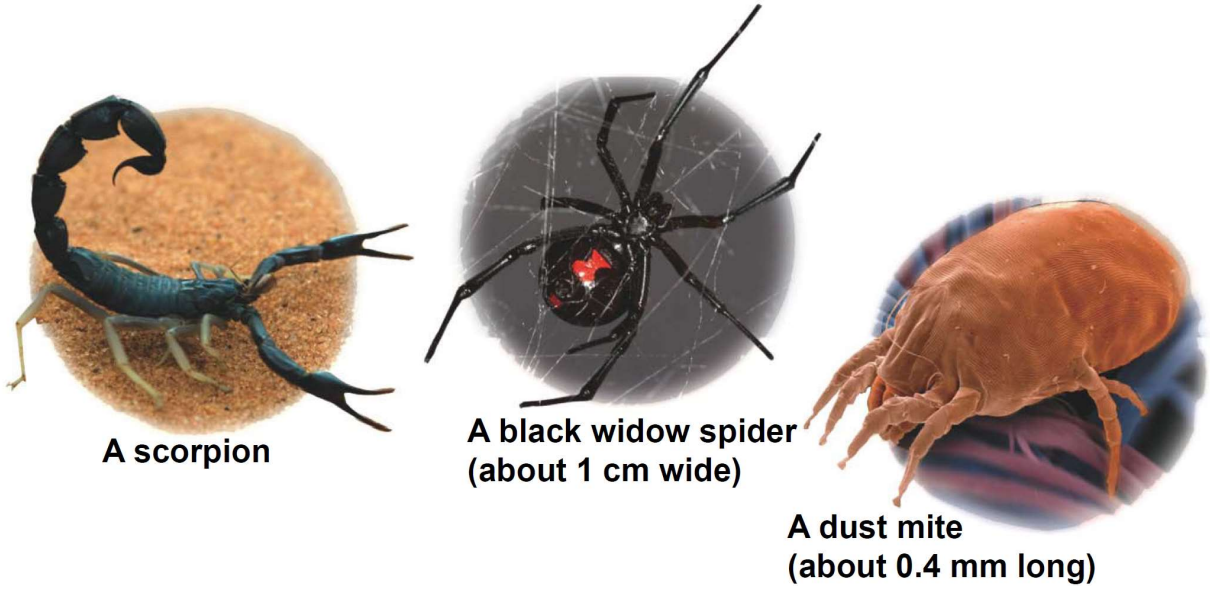
18.11 Arthropods are segmented animals with jointed appendages and an exoskeleton

- Living arthropods represent four major lineages.
  1. **Chelicerates** (鉗角亞門) include **horseshoe crabs** (鱟) and **arachnids**, such as spiders, scorpions, mites, and ticks (蜱).
     - Most are terrestrial.
     - Scorpions are nocturnal hunters.
     - Spiders are a diverse group that typically hunt insects or trap them in webs of silk that they spin from specialized glands on their abdomen.
     - Mites do not carry infectious diseases, but many people are allergic to them.

Arachnid 蜘蛛, 8 legs



18.11 Arthropods are segmented animals with jointed appendages and an exoskeleton

2. Millipedes and centipedes are identified by the number of jointed legs per body segment.
   - **Millipedes** are herbivores that have two pairs of short legs per body segment.
   - **Centipedes** are carnivores that have one pair of legs per body segment.

How millipedes walk - 120fps slow motion
http://www.youtube.com/watch?v=xI-wn4CQBhs


A millipedes, ~7 cm 馬陸


Giant Peruvian centipedes, ~30 cm, 蜈蚣

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18.11 Arthropods are segmented animals with jointed appendages and an exoskeleton

甲殼類

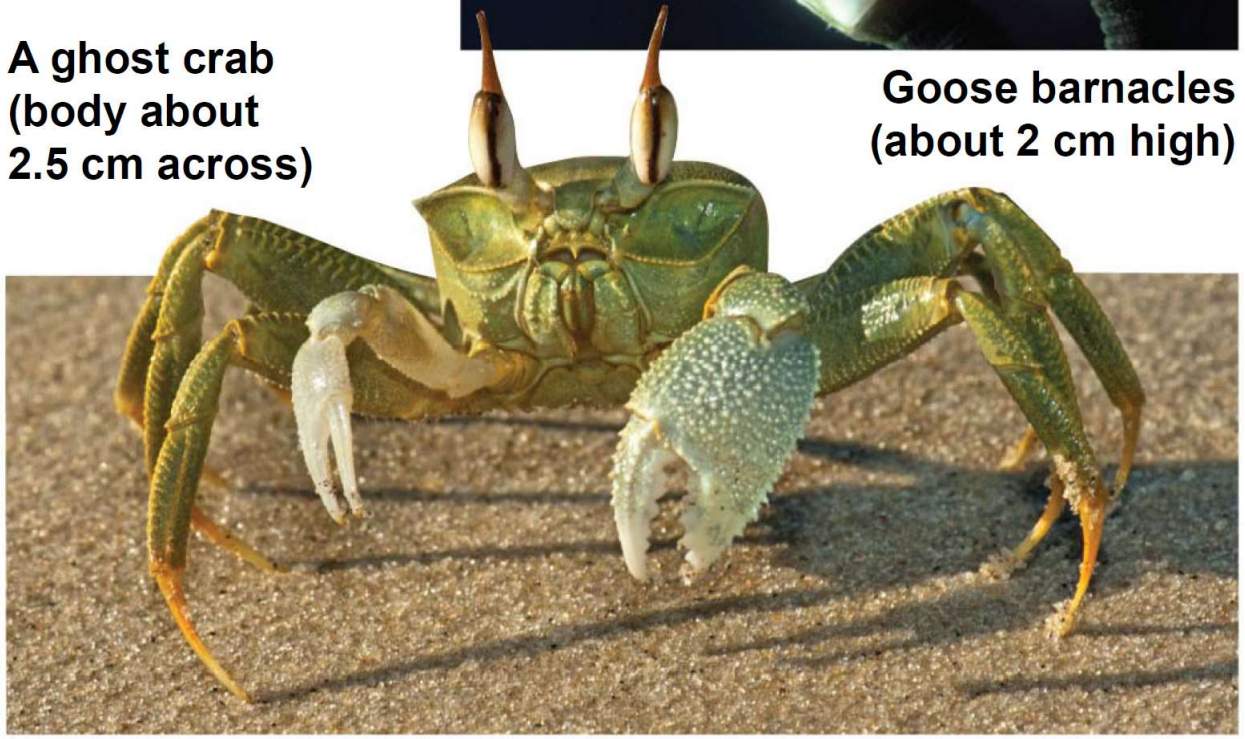
3. **Crustaceans** are nearly all aquatic. They include crabs, shrimp, and barnacles, which feed with jointed appendages.

藤壺

4. **Insects** are the fourth lineage of arthropods, addressed next.

A ghost crab (body about 2.5 cm across)

Goose barnacles (about 2 cm high)



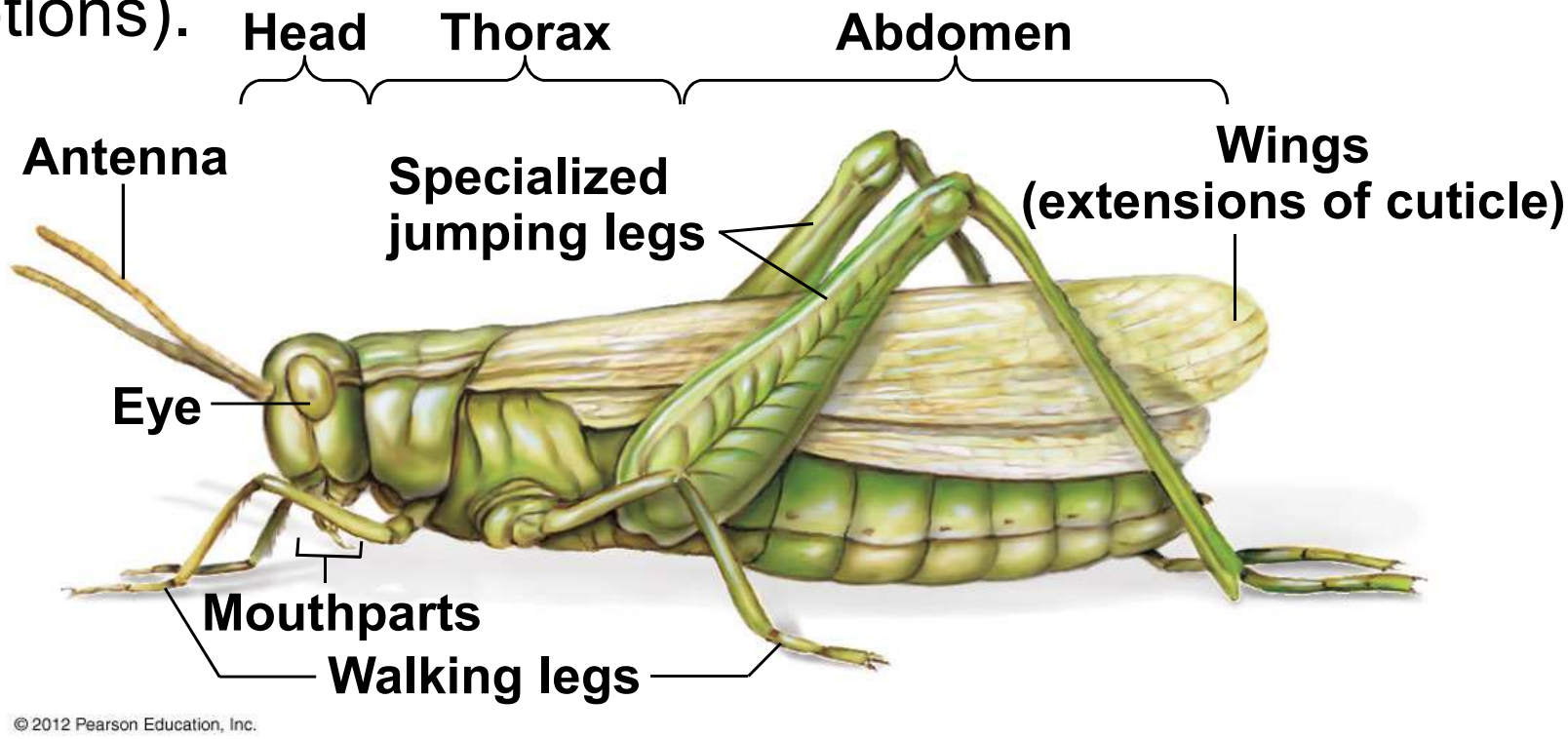
軟殼蟹

Soft-shell crabs

A species?

18.12 EVOLUTION CONNECTION: Insects are the most successful group of animals

- Nearly 75% of all identified animal species are **insects**.
  - There may be as many as 30 million insect species.
- The body of an insect typically includes
  - a head, thorax, abdomen, three sets of legs, and wings (with few exceptions).



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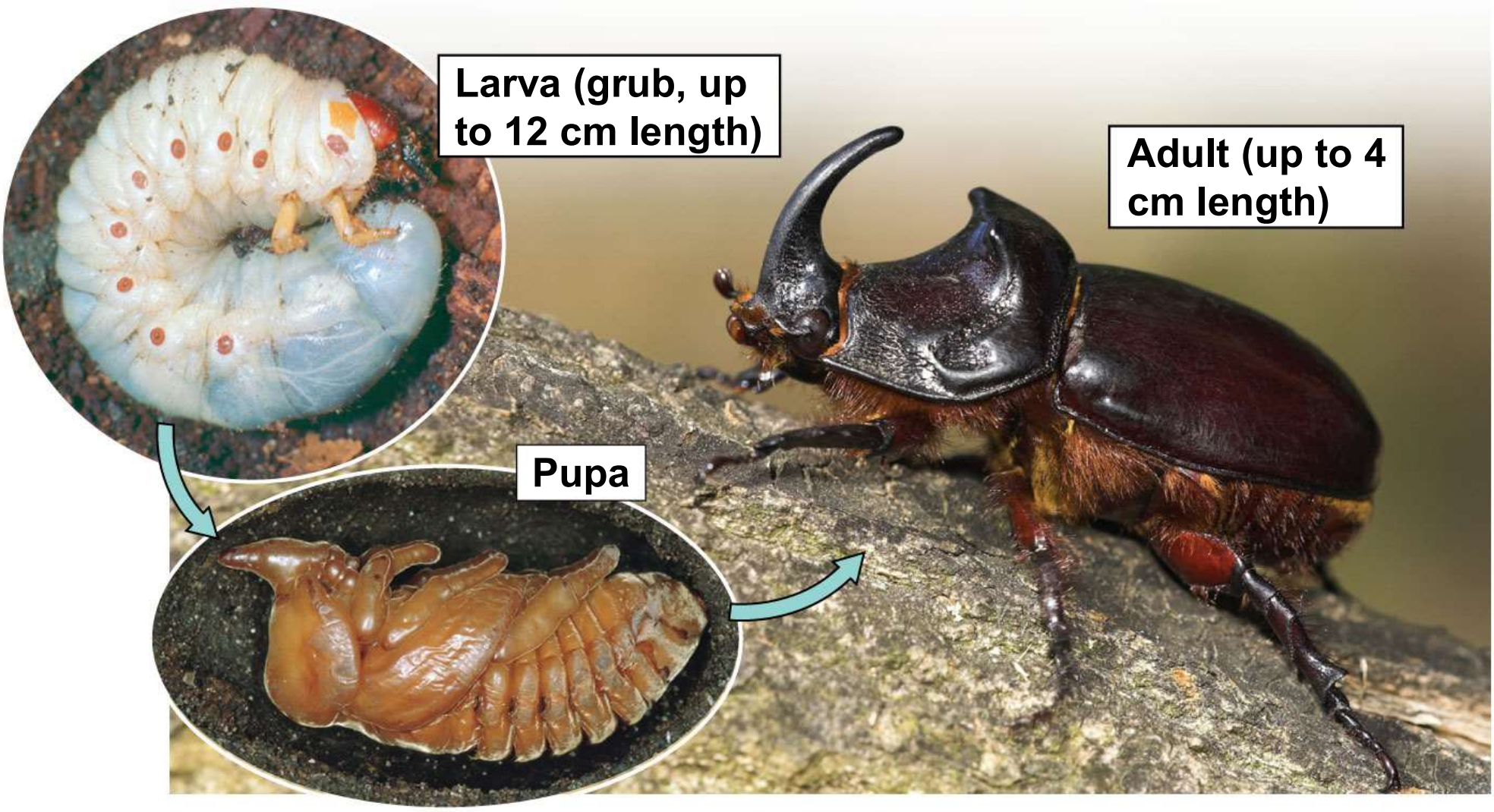
18.12 EVOLUTION CONNECTION: Insects are the most successful group of animals

- The extraordinary success of insects is due to
  - body segmentation, an exoskeleton, jointed appendages, flight, a waterproof cuticle, and a complex life cycle with short generations and large numbers of offspring.
- Insect life cycles often include **metamorphosis**, during which the animal takes on different body forms as it develops from larva to adult. 蛹
  - More than 80% of insect species undergo **complete metamorphosis** in which a free-living larva transforms from a pupa into an adult.
  - Other insect species undergo **incomplete metamorphosis** in which the transition from larva to adult is achieved through multiple molts, but without forming a pupa.

Figure 18.12A



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18.12 EVOLUTION CONNECTION: Insects are the most successful group of animals

- Modular body plan
  - The adult body parts of insects are formed by the fusion of embryonic segments identical to each other.
  - The insect body plan is essentially modular in that each embryonic segment develops independently.
  - Homeotic genes act to modify the structure of insect segments and their appendages.
- Insect mouthparts are adapted for various types of feeding, such as
  - chewing (grasshoppers),
  - biting and tearing prey (mantis螳螂)
  - lapping up fluids (houseflies), and
  - piercing and sucking fluids of plants (aphids) and animals (mosquitoes).

18.12 EVOLUTION CONNECTION: Insects are the most successful group of animals

- Insects have three pairs of legs, which are adapted for
  - walking, jumping, grasping prey, digging in soil, or paddling on water.
- Wings
  - Most adult insects have one or two pairs of wings, allowing dispersal and escape from predators.
  - Because wings are extensions of the cuticle, insects have acquired flight without sacrificing any legs.
- Protective color patterns
  - Many insects have protective color patterns and disguises, including modifications to antennae, wings, and bodies.

Figure 18.12C

A stick insect

A leaf-mimic katydid 紡織娘

A caterpillar resembling a bird dropping

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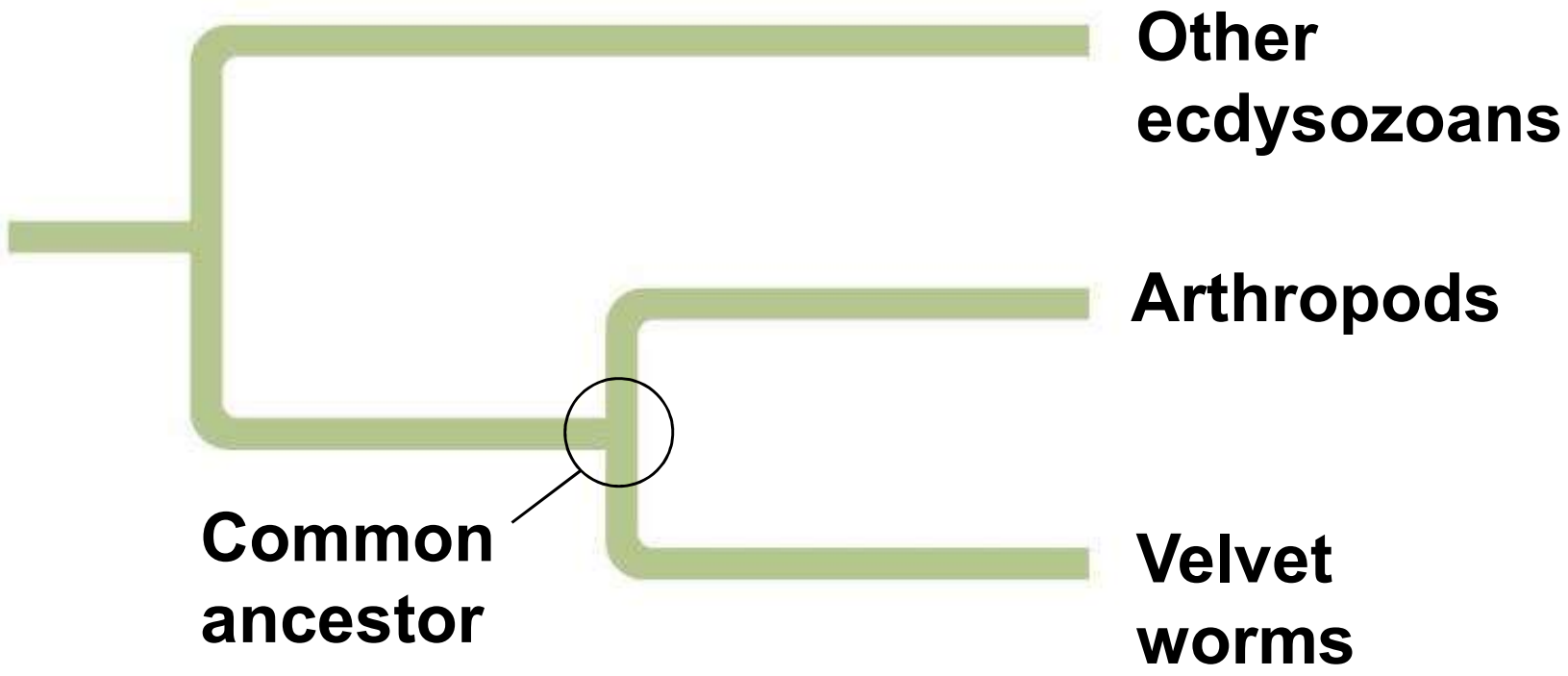
A hawk moth caterpillar

An owl butterfly and a long-eared owl

18.13 SCIENTIFIC THINKING: The genes that build animal bodies are ancient

- The arthropod body plan, with its enormous variety of distinct body segments bearing specialized appendages, is a key factor in the evolutionary success of the phylum.
- How did this body plan evolve?
- One hypothesis proposes that an increase in the number of homeotic genes, the master control genes that direct animal development, led to the diversity of segment and appendage types in arthropods.
- To test this hypothesis, a team of scientists compared homeotic genes in arthropods with velvet worms, their closest living relatives. (Velvet worms are one of the small animal phyla omitted from the prior survey of animal diversity.)

Figure 18.13a



- Results showed that velvet worms have the complete set of arthropod homeotic genes—no additional genes arose after the lineages diverged.
- Therefore, the researchers concluded that body segment diversity did *not* result from the appearance of new homeotic genes in arthropods.

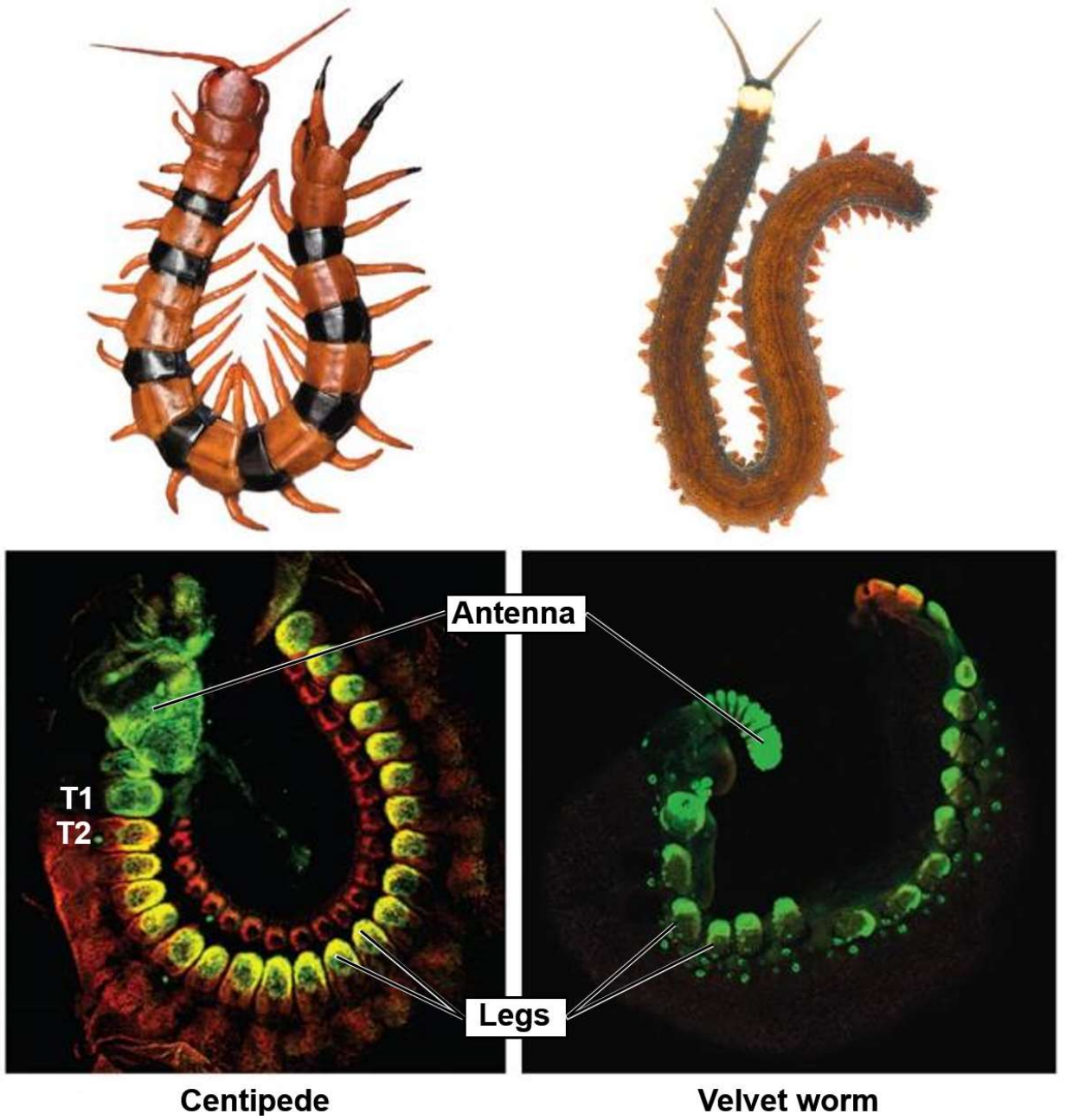
18.13 SCIENTIFIC THINKING: The genes that build animal bodies are ancient

- An alternative hypothesis proposes that changes in the regulation of homeotic gene expression (when and where the genes are transcribed and translated into proteins) led to the diversity of segment and appendage types in arthropods.
- Such changes in developmental genes are known to result in significant morphological changes
- To test this hypothesis, researchers compared gene expression patterns in the embryos of a centipede and a velvet worm.

Figure 18.13b-0

A green stain indicates expression of a homeotic gene that is involved in the formation of appendages in a wide range of taxa. This gene is expressed in a similar pattern in both centipedes and velvet worms.

A red stain indicates expression of two homeotic genes unique to arthropods and their close relatives.

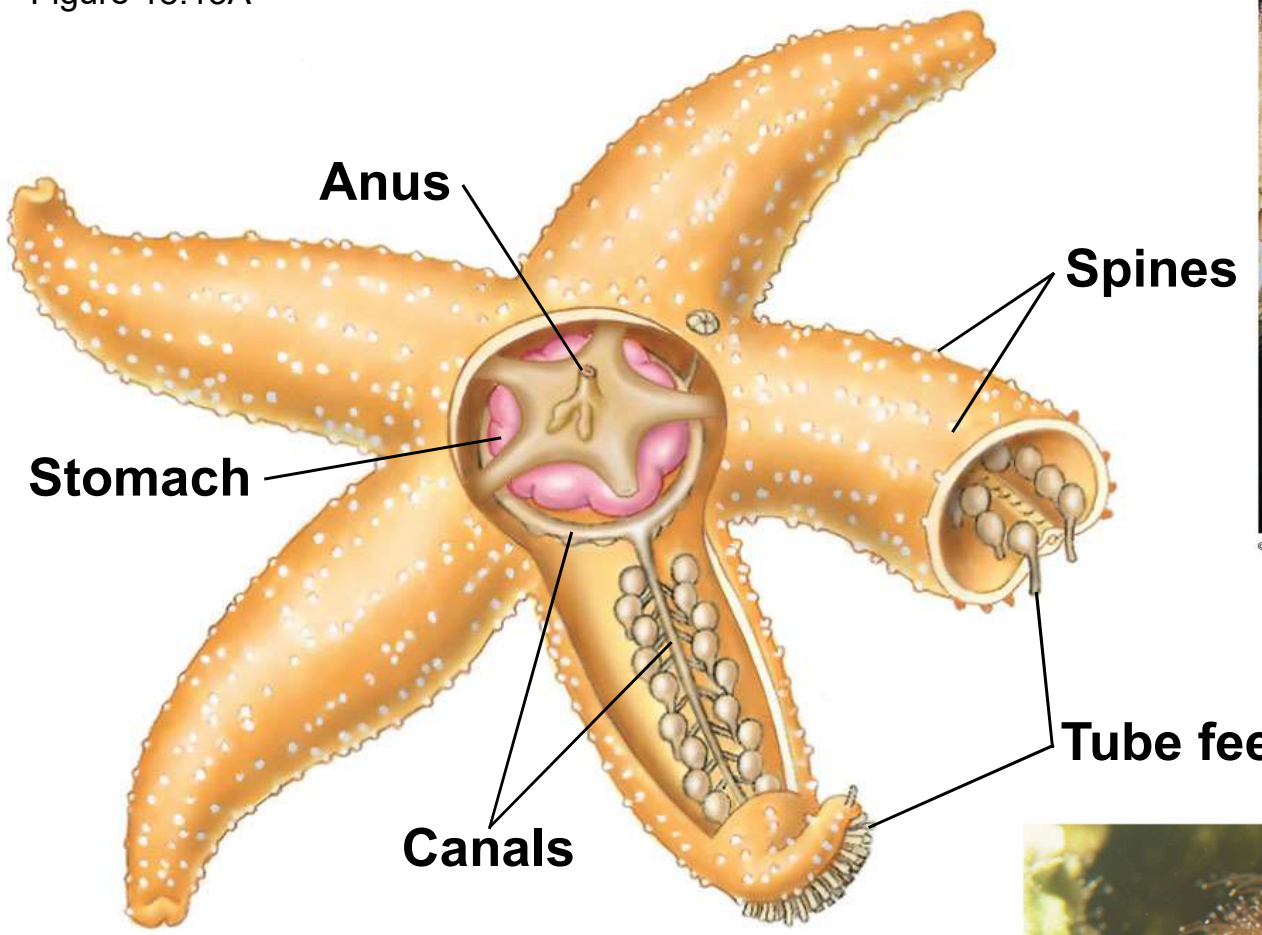


- The velvet worm deploys these genes only in the posterior tip of its body.
- In the centipede, and in other groups of arthropods that have been studied, the locations where the genes are expressed correspond with the boundaries between one segment type and the next.
- The results support the hypothesis that the diversification of arthropods occurred through changes in the regulation of homeotic gene expression.

18.14 Echinoderms have spiny skin, an endoskeleton, and a water vascular system for movement

- **Echinoderms** (phylum Echinodermata) are
  - a diverse group including sea stars, sand dollars, and sea urchins, 海膽 沙海膽
  - slow-moving or sessile,
  - all marine,
  - radially symmetrical, and
  - deuterostomes (along with the chordates).
- Echinoderms have
  - an **endoskeleton** of hard calcareous plates under a thin skin, 鈣質
  - a **water vascular system** based on a network of water-filled canals that branch into extensions called tube feet, and
  - the ability to regenerate lost arms.

Figure 18.13A



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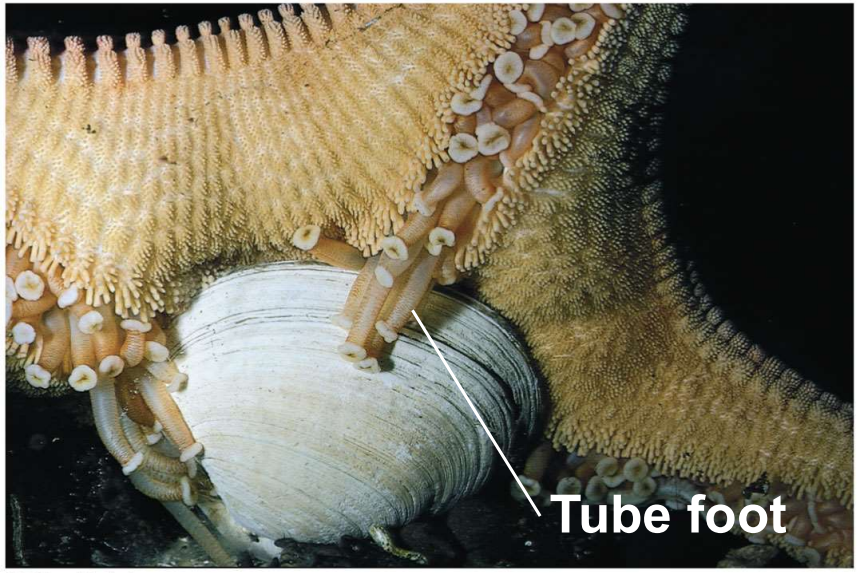

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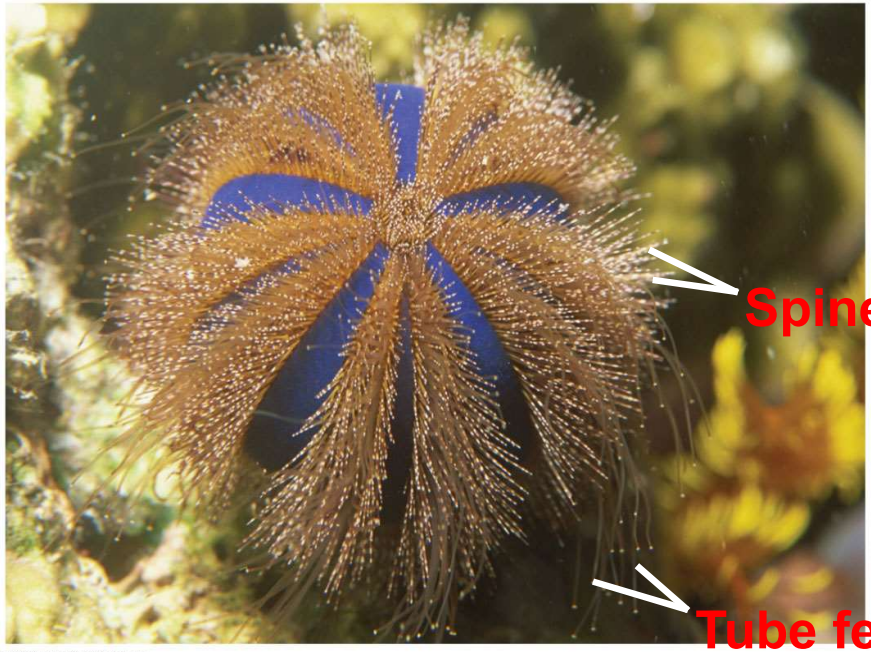

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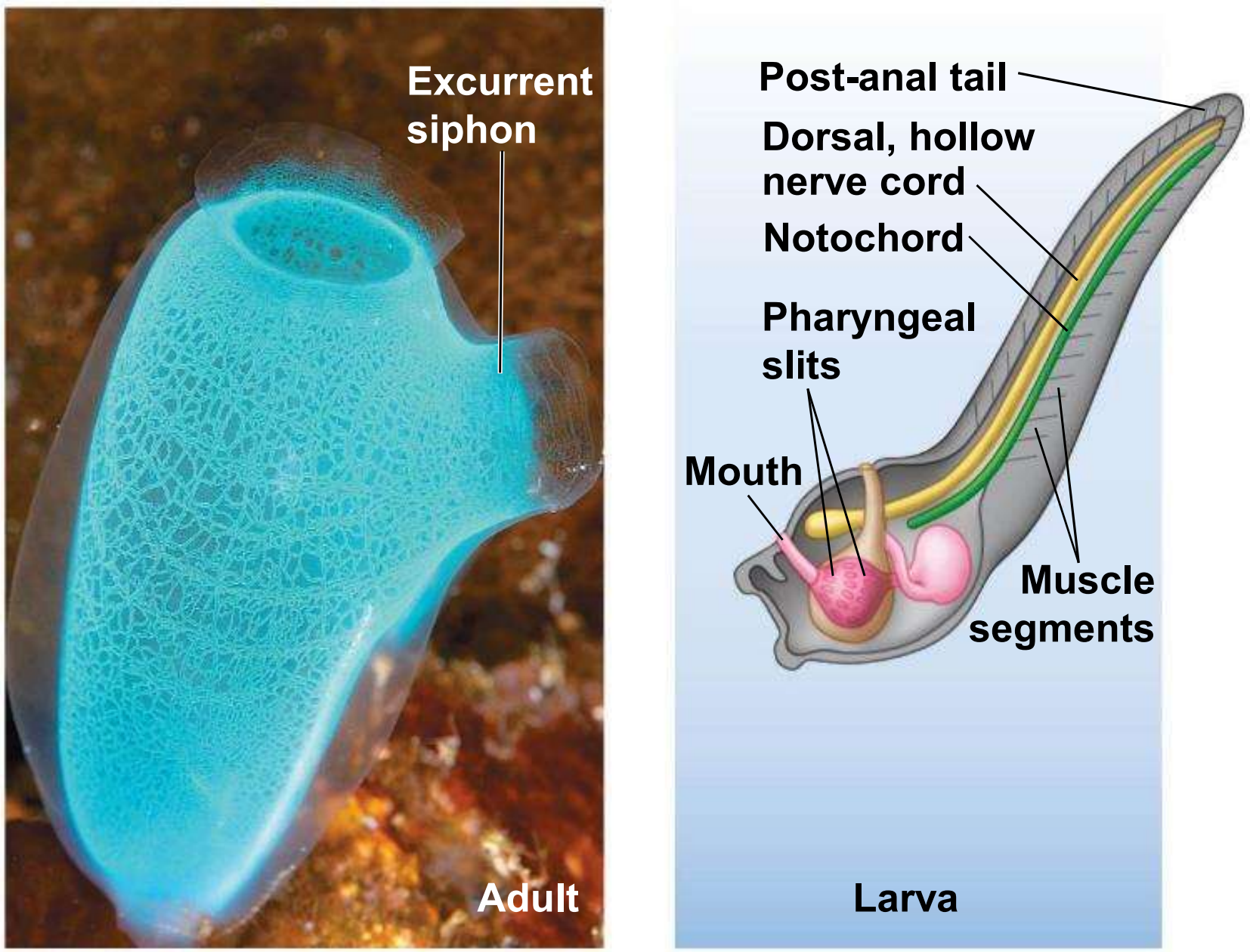
18.14 Echinoderms have spiny skin, an endoskeleton, and a water vascular system for movement

- Other echinoderm groups include
  - brittle stars, which move by thrashing their long, flexible arms,
  - sea lilies, which live attached to the substrate by a stalk, and
  - sea cucumbers, odd elongated animals that resemble their vegetable namesake more than they resemble other echinoderms.

18.15 Our own phylum, Chordata, is distinguished by four features

- **Chordates** (phylum Chordata) are defined by
  - a **dorsal, hollow nerve cord**,
  - a flexible, supportive **notochord**,脊索
  - **pharyngeal slits**, and 咽裂
  - a muscular **post-anal tail**.
- The simplest chordates are tunicates and lancelets, which
  - do not have a backbone and 海鞘 文昌魚
  - use their pharyngeal slits for suspension feeding.
  - Adult **tunicates** are stationary and attached, while the tunicate larva is a tadpole-like organism.
  - **Lancelets** are small, bladelike chordates that live in marine sands.

Figure 18.15a-0



18.16 CONNECTION: Invertebrate diversity is a valuable but threatened resource

- Freshwater mussels filter and improve water quality in natural ecosystems and reduce the cost of water treatment for human uses.
- Most flowering plants are pollinated by animals, chiefly insects.
  - An estimated one-third of the world's food supply depends on pollinators.
  - In the United States, production of fruits and vegetables relies on pollination by bees, mostly non-native honeybees imported from Europe.

You should now be able to

1. Describe the defining characteristics of animals.
2. Describe the general animal life cycle and the basic animal body plan.
3. Describe the Cambrian “explosion” of animal diversity and two hypotheses that have been advanced to explain its occurrence.
4. Characterize the nine animal phyla discussed in this chapter in terms of the following traits:
   a. presence or absence of true tissues,
   b. two or three embryonic tissue layers,
   c. no symmetry, radial symmetry, or bilateral symmetry,
   d. protostomes or deuterostomes, and
   e. ecdysozoans or lophotrochozoans.

You should now be able to

5. Define segmentation, explain its functions, and note the animal phyla where it occurs.
6. Compare the characteristics of the four major arthropod lineages.
7. Describe the common characteristics of insects.
8. Explain how an increase in the number of homeotic genes impacted animal evolution.
9. Explain why invertebrate diversity is a valuable resource.

18.1-4
18.15-16
The rest: understand the title