Chapter 33

Invertebrates

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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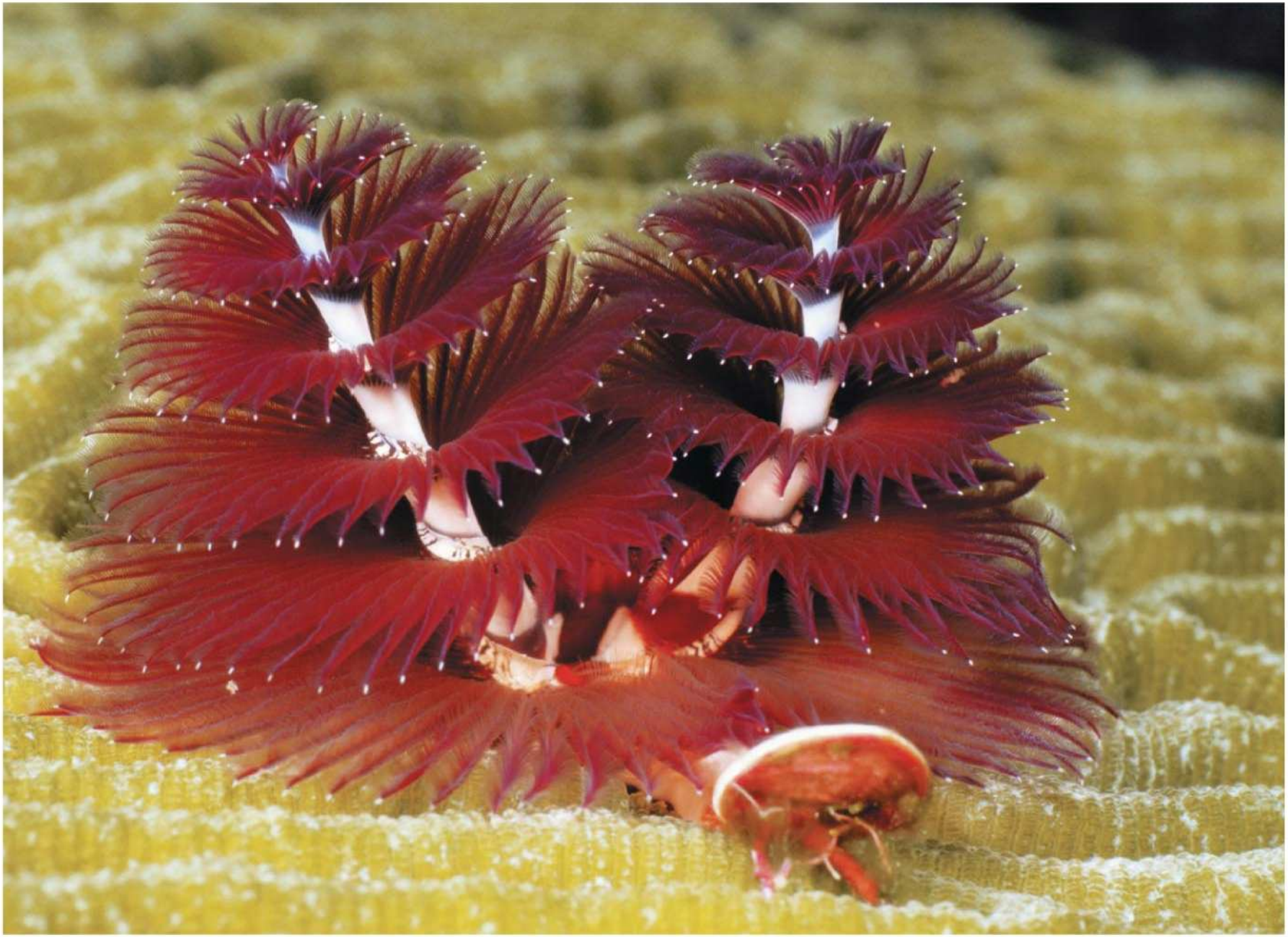
Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

Fig. 33-1



Overview: Life Without a Backbone

- **Invertebrates** are animals that lack a backbone
- They account for 95% of known animal species

Fig. 33-2

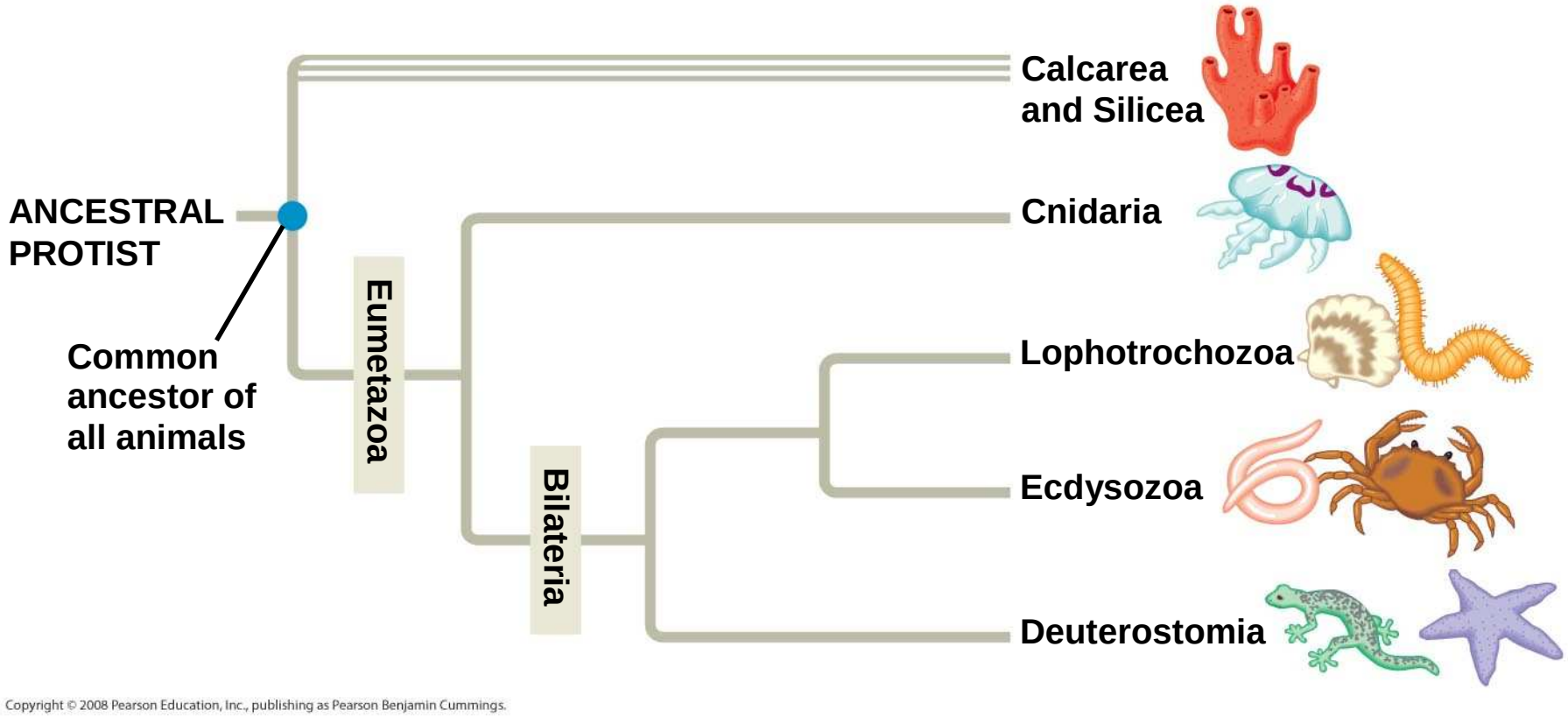


Fig. 33-3-1

Calcarea and Silicea (5,500 species)

A sponge

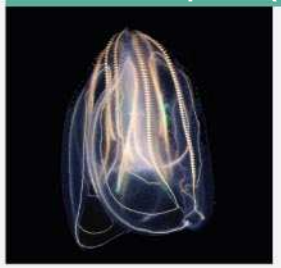
Placozoa (1 species)

A placozoan (LM)

Cnidaria (10,000 species)

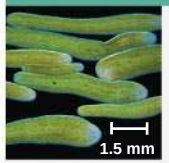
A jelly

Ctenophora (100 species)



A ctenophore, or comb jelly

Acoela (400 species)



Acoel flatworms (LM)

LOPHOTROCHOZOANS

Platyhelminthes (20,000 species)

A marine flatworm

Rotifera (1,800 species)

A rotifer (LM)

Ectoprocta (4,500 species)

Ectoprocts

Brachiopoda (335 species)

A brachiopod

Fig. 33-3-2

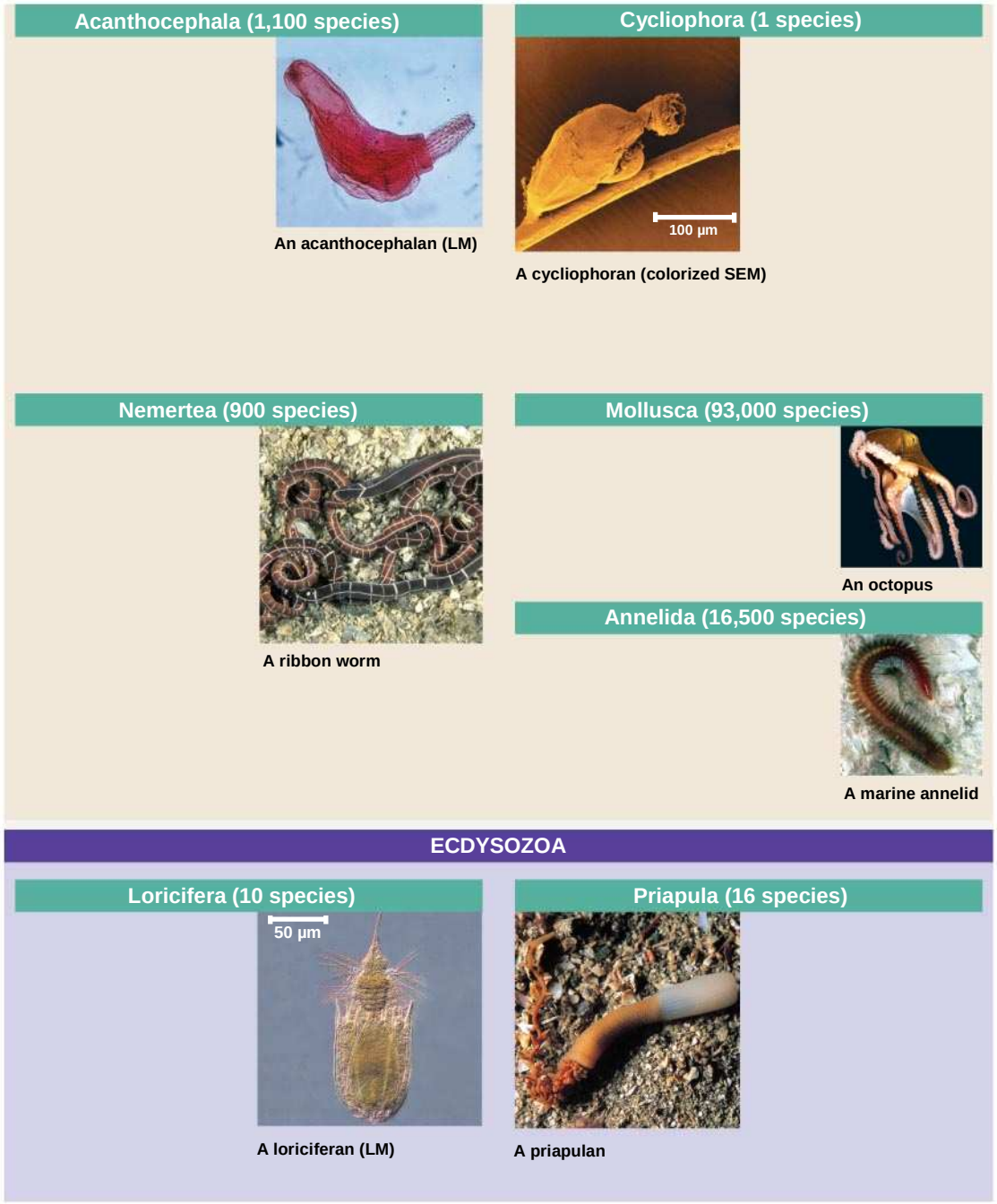


Fig. 33-3-3

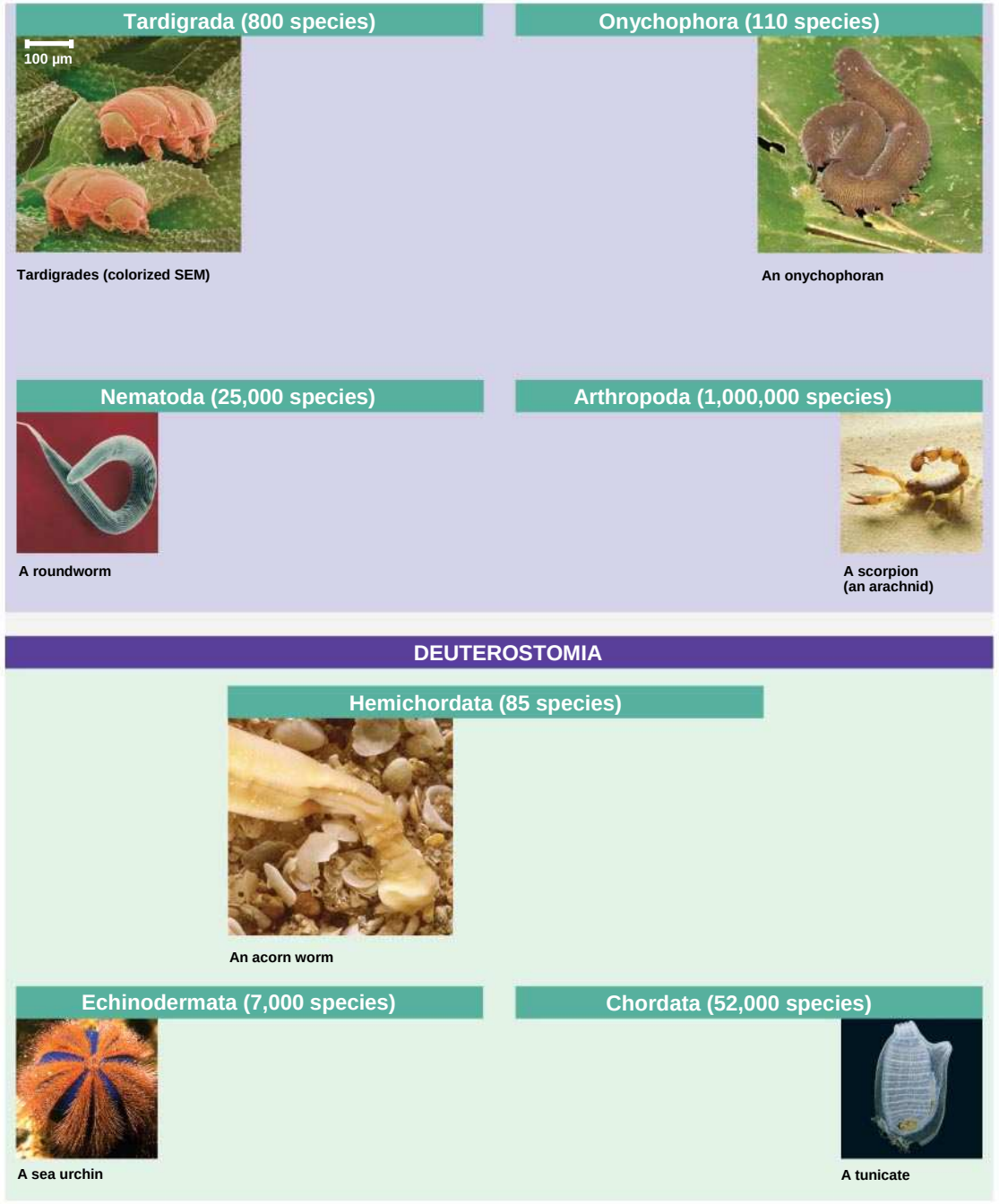
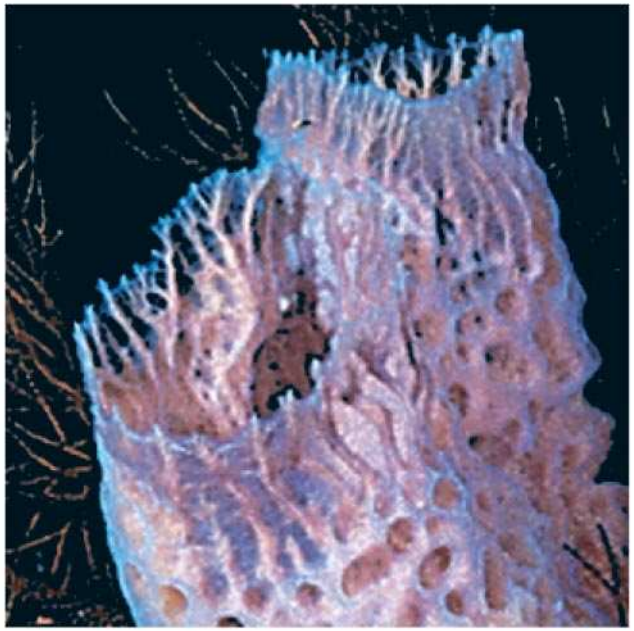


Fig. 33-3a

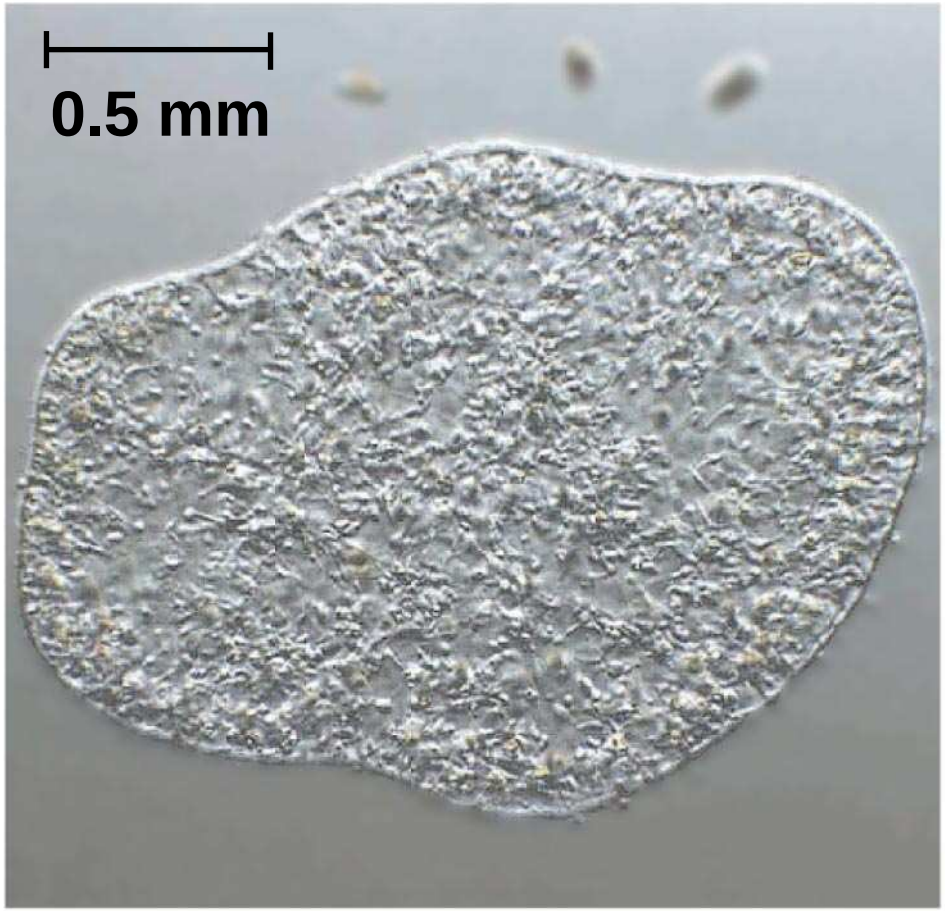


A sponge

Fig. 33-3b

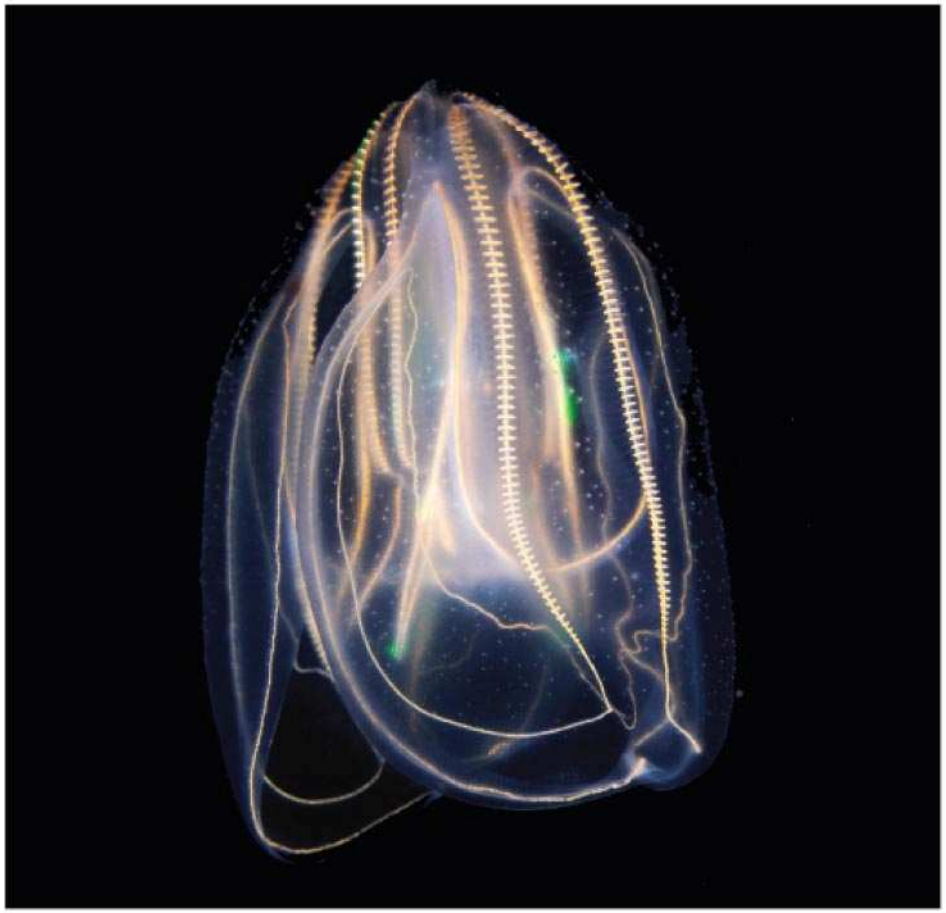
A jelly

Fig. 33-3c



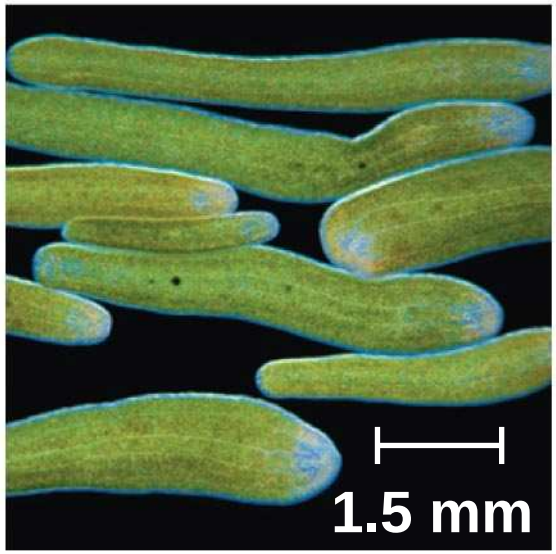
A placozoan (LM)

Fig. 33-3d



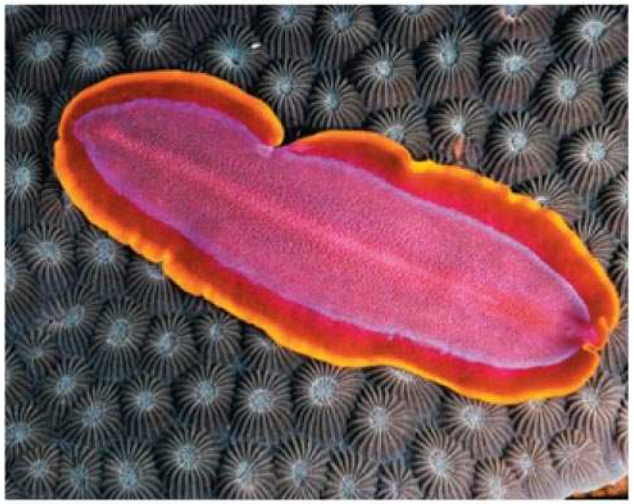
A ctenophore, or comb jelly

Fig. 33-3e



Acoel flatworms (LM)

Fig. 33-3f

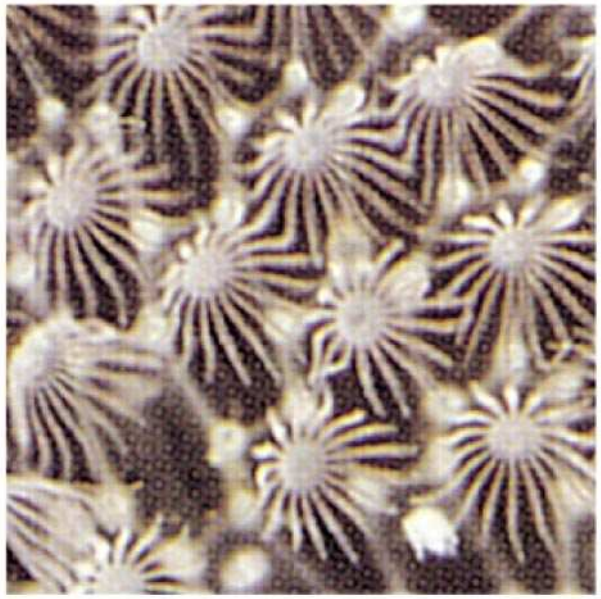


A marine flatworm

Fig. 33-3g

A rotifer (LM)

Fig. 33-3h

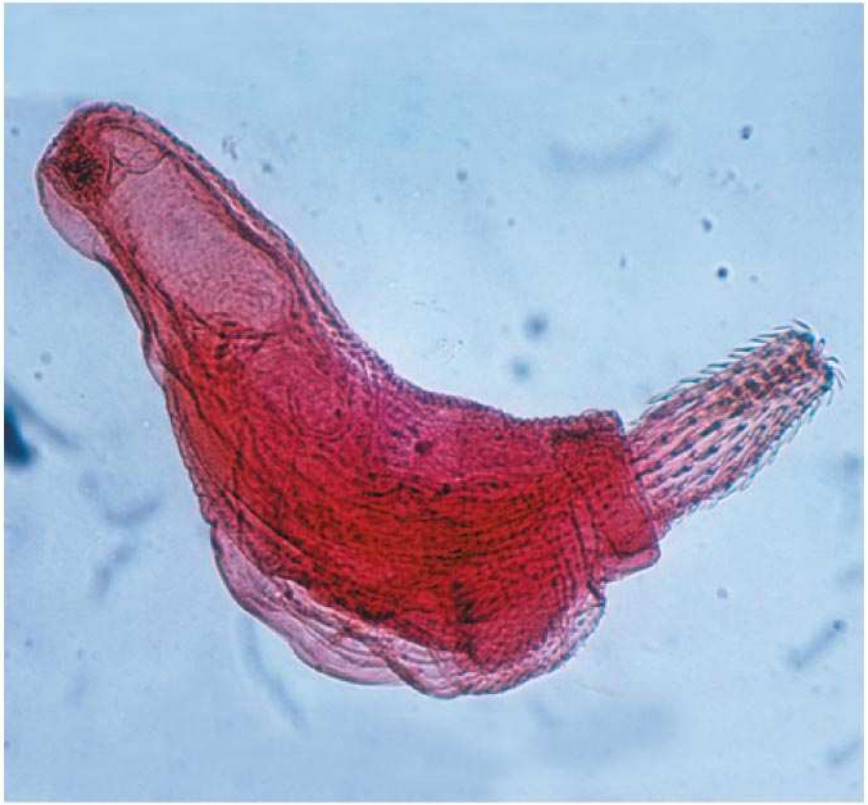


Ectoprocts

Fig. 33-3i

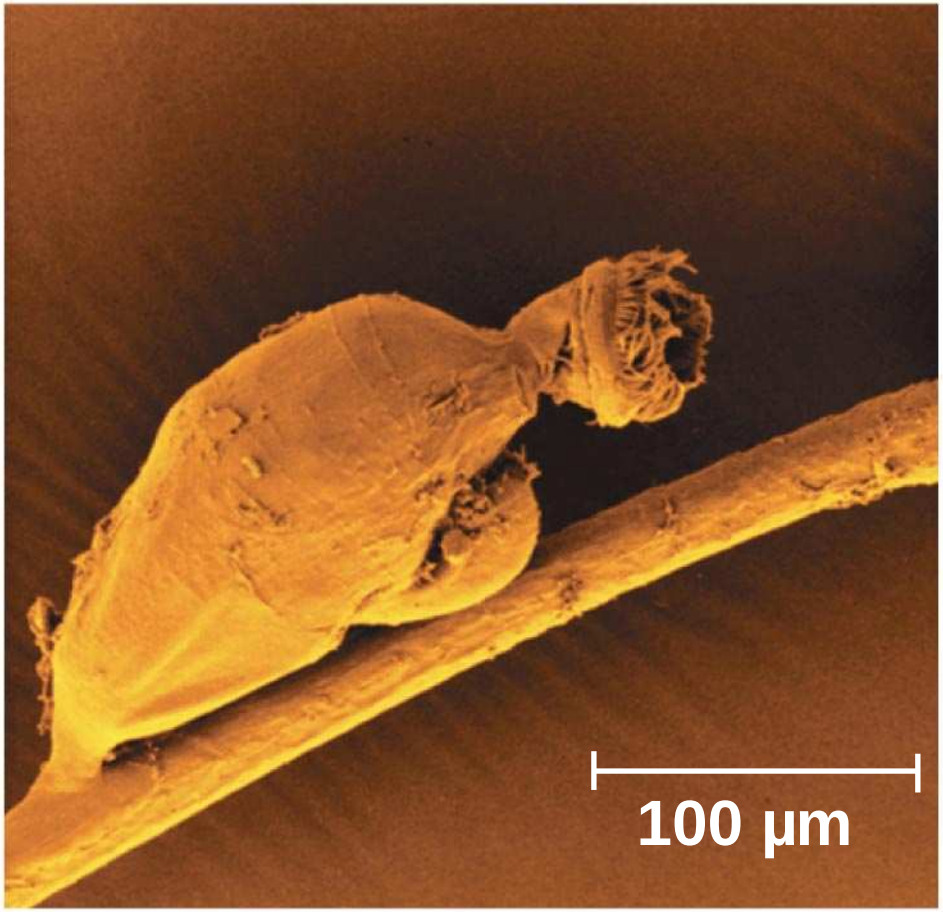
A brachiopod

Fig. 33-3j



An acanthocephalan (LM)

Fig. 33-3k



A cycliophoran (colorized SEM)

Fig. 33-3l

A ribbon worm

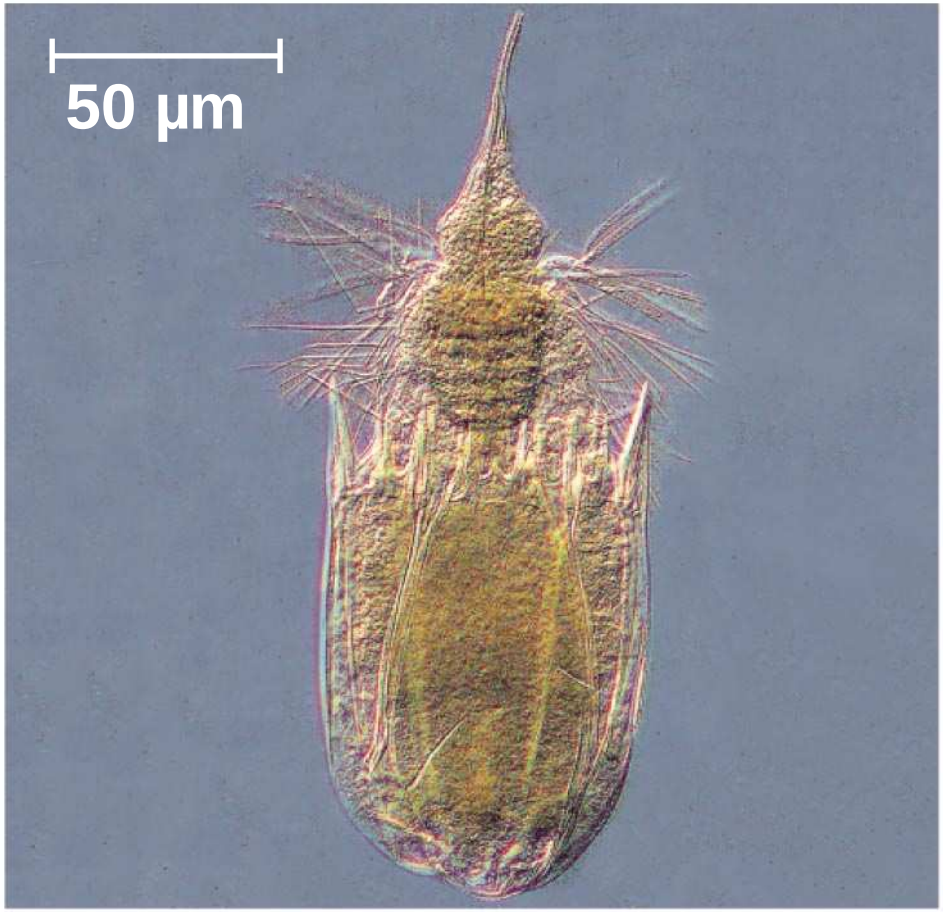
Fig. 33-3m

An octopus

Fig. 33-3n

A marine annelid

Fig. 33-3o

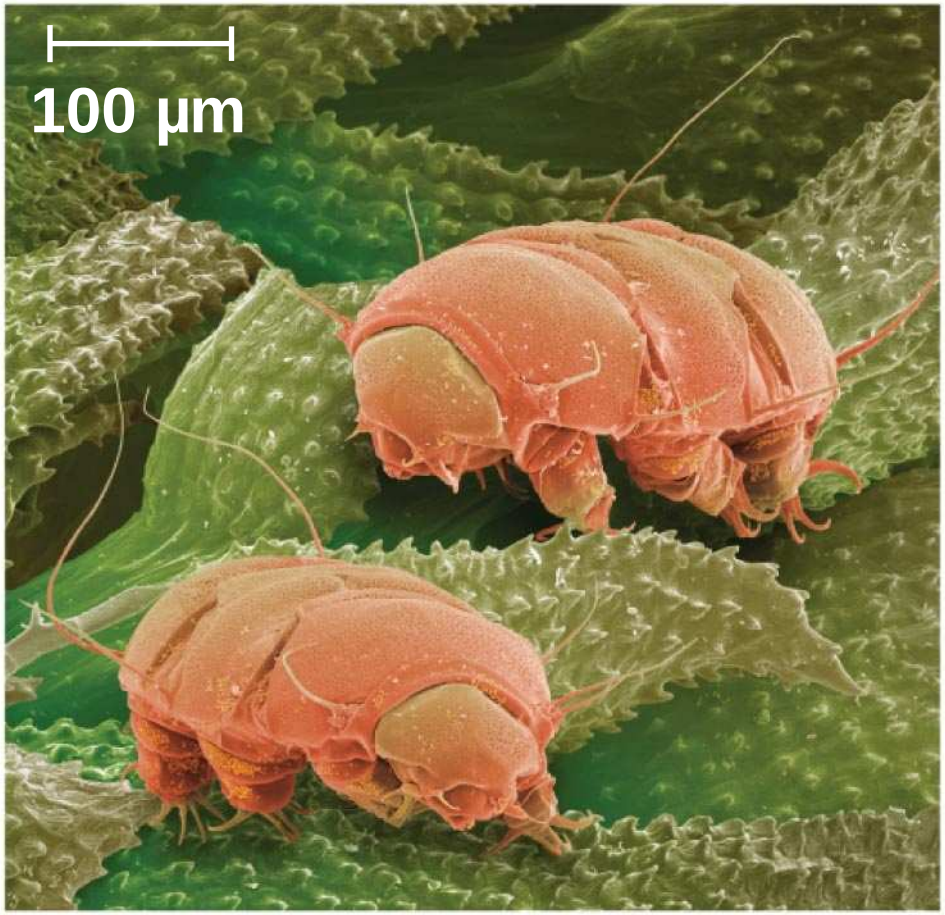


A loriciferan (LM)

Fig. 33-3p

A priapulan

Fig. 33-3q



Tardigrades (colorized SEM)

Fig. 33-3r

An onychophoran

Fig. 33-3s

A roundworm

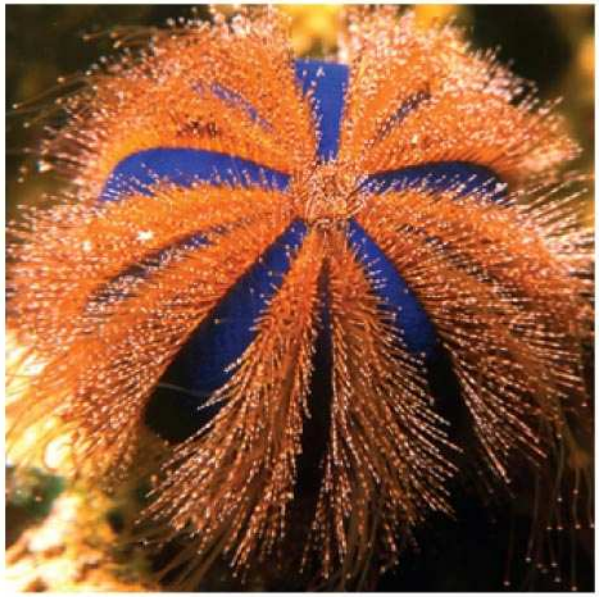
Fig. 33-3t

A scorpion (an arachnid)

Fig. 33-3u

An acorn worm

Fig. 33-3v



A sea urchin

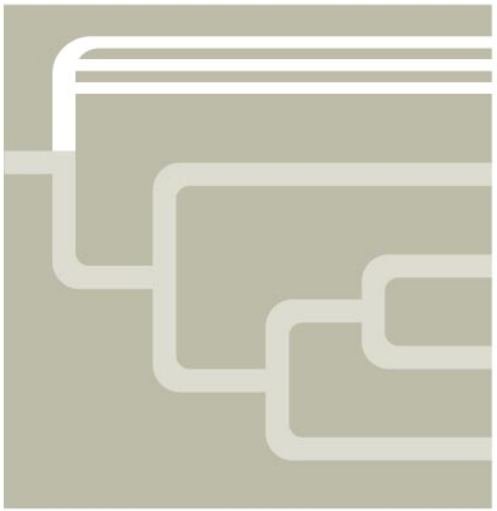
Fig. 33-3w

A tunicate

Concept 33.1: Sponges are basal animals that lack true tissues

- Sponges are sedentary animals from the phyla Calcarea and Silicea
- They live in both fresh and marine waters
- Sponges lack true tissues and organs

Fig. 33-UN1



Calcarea and Silicea

Cnidaria

Lophotrochozoa

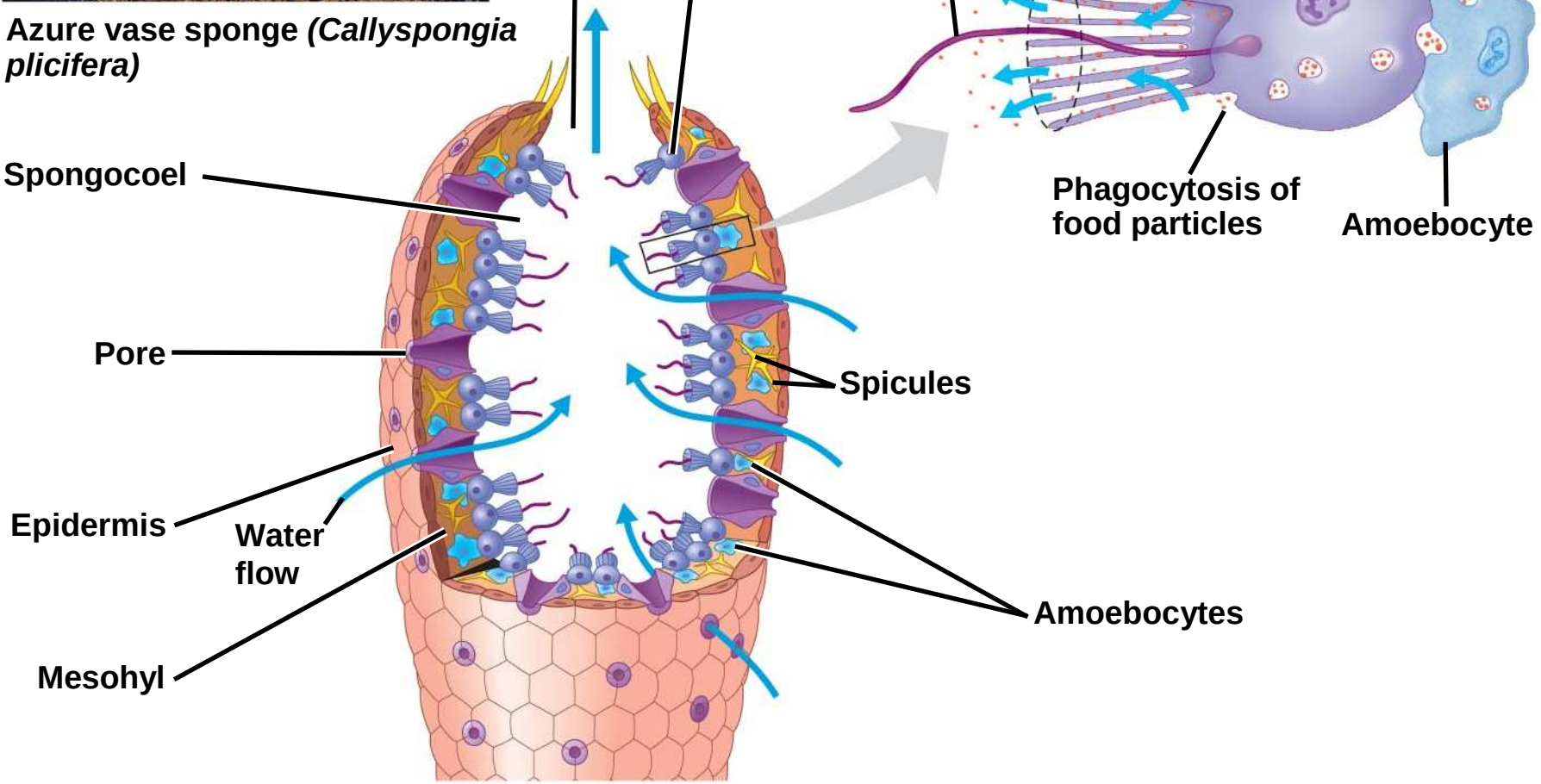
Ecdysozoa

Deuterostomia

- Sponges are **suspension feeders**, capturing food particles suspended in the water that pass through their body
- **Choanocytes**, flagellated collar cells, generate a water current through the sponge and ingest suspended food
- Water is drawn through pores into a cavity called the **spongocoel,** and out through an opening called the **osculum**

Fig. 33-4

Azure vase sponge *(Callyspongia plicifera)*

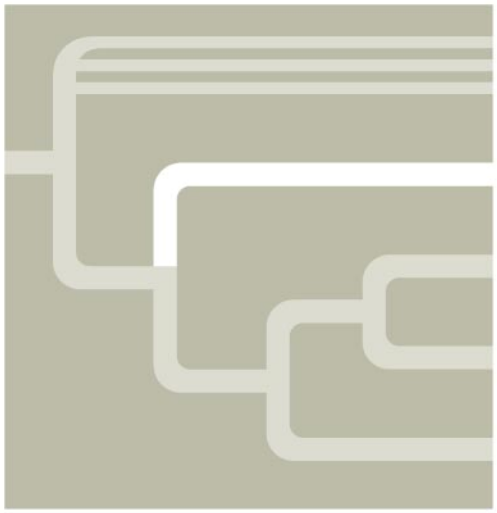


- Sponges consist of a noncellular **mesohyl** layer between two cell layers
- **Amoebocytes** are found in the mesohyl and play roles in digestion and structure
- Most sponges are **hermaphrodites**: Each individual functions as both male and female

Concept 33.2: Cnidarians are an ancient phylum of eumetazoans

- All animals except sponges and a few other groups belong to the clade Eumetazoa, animals with true tissues
- Phylum Cnidaria is one of the oldest groups in this clade

Fig. 33-UN2



Calcarea and Silicea

Cnidaria

Lophotrochozoa

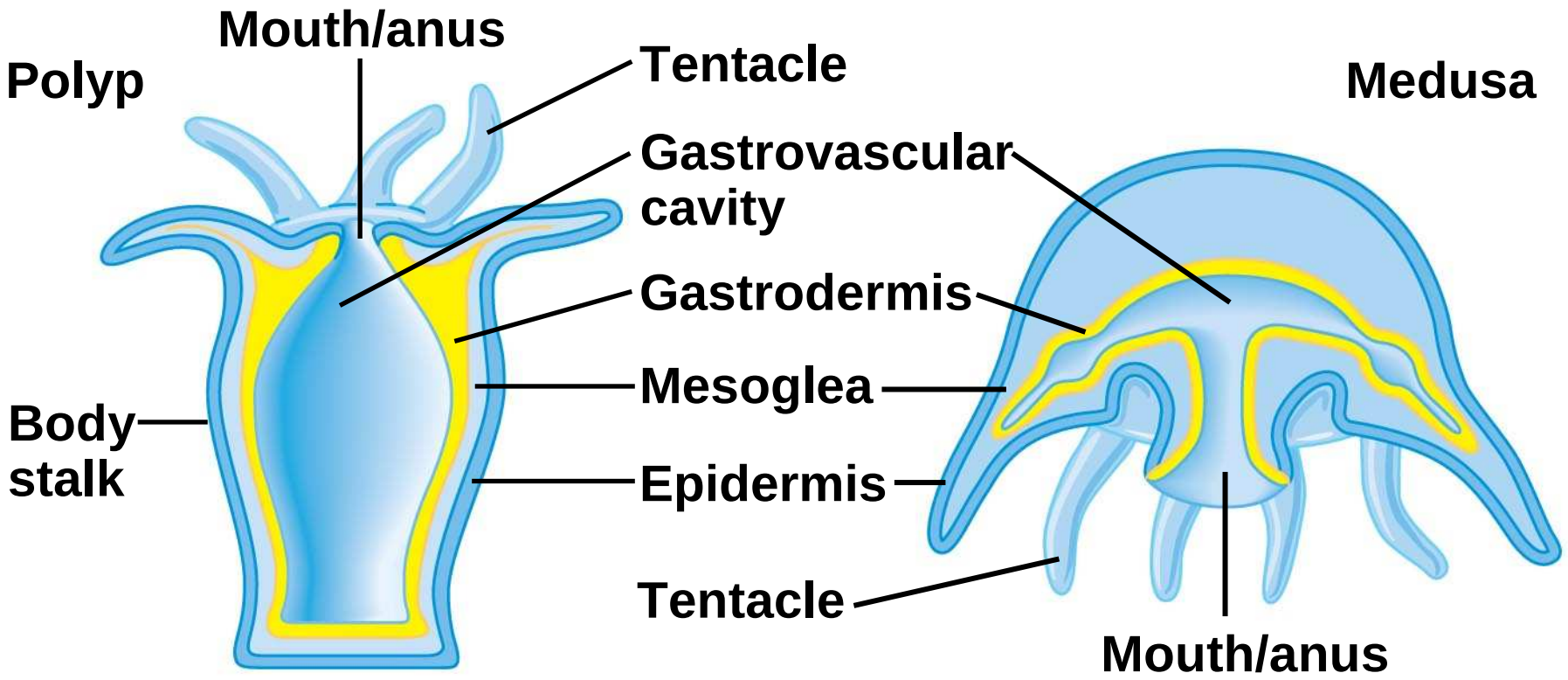
Ecdysozoa

Deuterostomia

- Cnidarians have diversified into a wide range of both sessile and motile forms including jellies, corals, and hydras
- They exhibit a relatively simple diploblastic, radial body plan

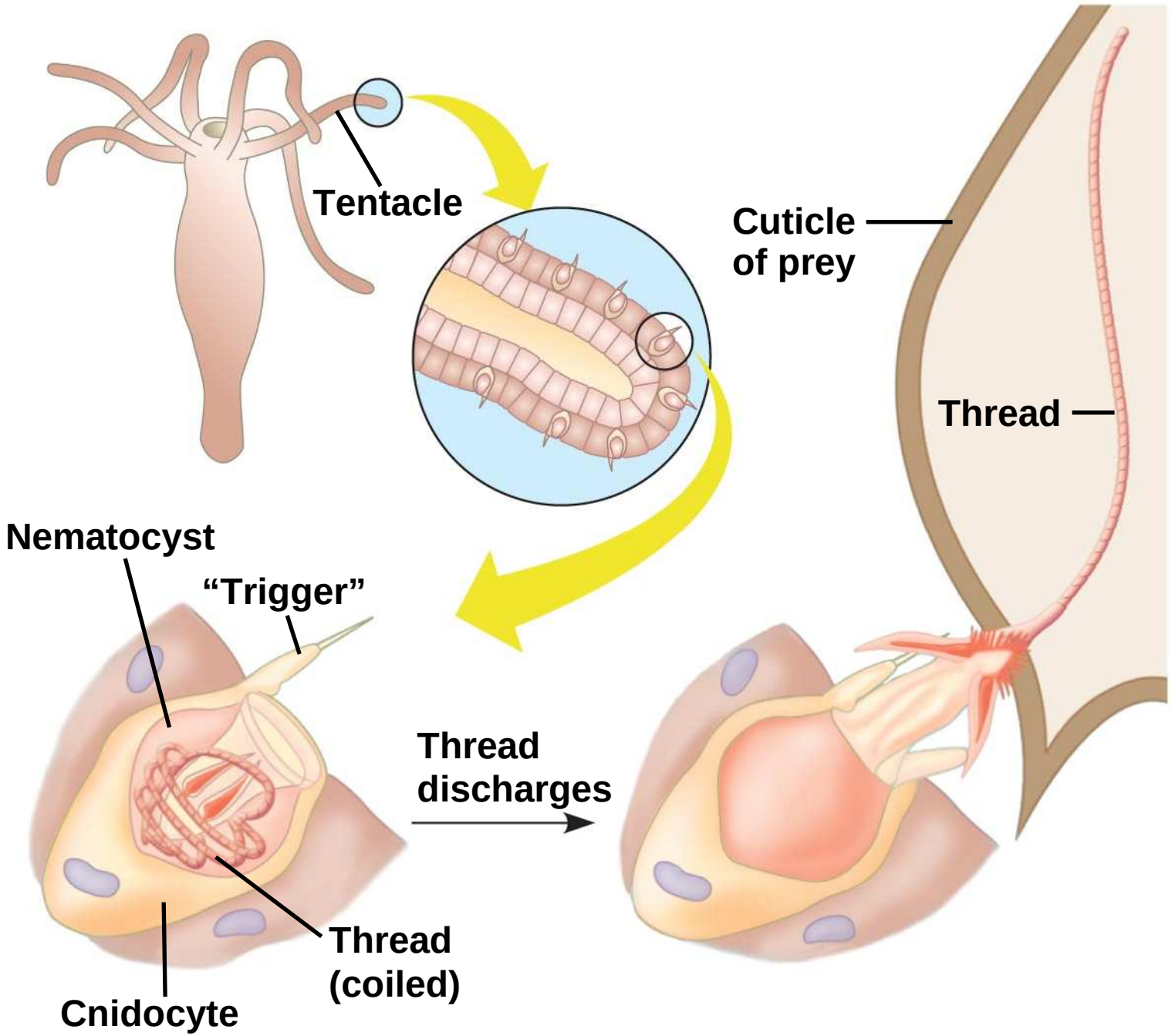
- The basic body plan of a cnidarian is a sac with a central digestive compartment, the **gastrovascular cavity**
- A single opening functions as mouth and anus
- There are two variations on the body plan: the sessile **polyp** and motile **medusa**

Fig. 33-5



- Cnidarians are carnivores that use tentacles to capture prey
- The tentacles are armed with **cnidocytes**, unique cells that function in defense and capture of prey
- **Nematocysts** are specialized organelles within cnidocytes that eject a stinging thread

Fig. 33-6



- Phylum Cnidaria is divided into four major classes:
  - Hydrozoa
  - Scyphozoa
  - Cubozoa
  - Anthozoa

Table 33-1

Table 33.1 Classes of Phylum Cnidaria

Class and Examples	Main Characteristics
Hydrozoa (Portuguese man-of-wars, hydras, *Obelia*, some corals)	Most marine, a few freshwater; both polyp and medusa stages in most species; polyp stage often colonial
Scyphozoa (jellies, sea nettles)	All marine; polyp stage absent or reduced; free-swimming; medusae up to 2 m in diameter
Cubozoa (box jellies, sea wasps)	All marine; box-shaped medusae; complex eyes; potent venom
Anthozoa (sea anemones, most corals, sea fans)	All marine; medusa stage completely absent; most sessile; many colonial

Fig. 33-7

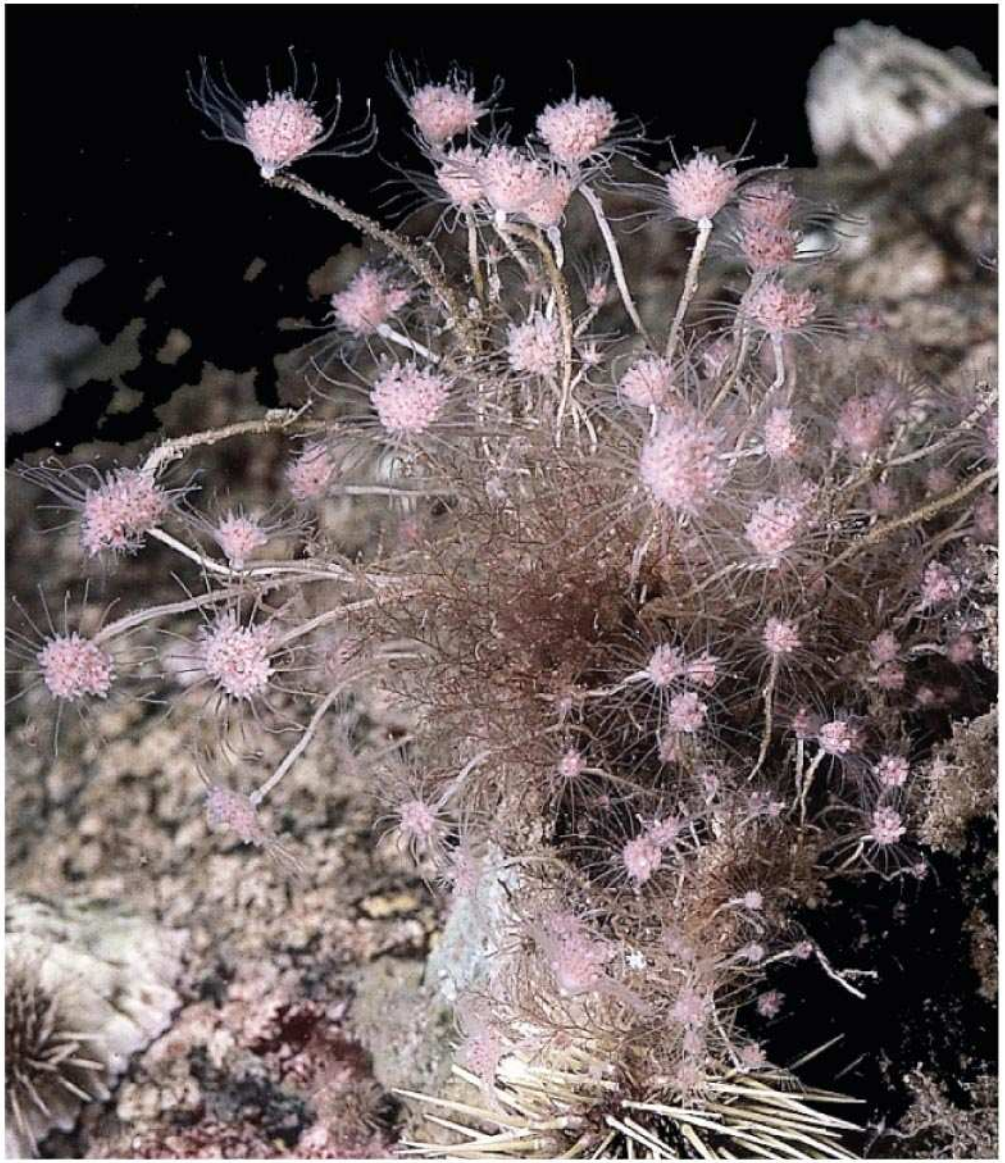
(a) Colonial polyps (class Hydrozoa)

(b) Jellies (class Scyphozoa)

(c) Sea wasp (class Cubozoa)

(d) Sea anemone (class Anthozoa)

Fig. 33-7a



(a) Colonial polyps (class Hydrozoa)

Fig. 33-7b

(b) Jellies (class Scyphozoa)

Fig. 33-7c

(c) Sea wasp (class Cubozoa)

Fig. 33-7d

(d) Sea anemone (class Anthozoa)

Hydrozoans

- Most hydrozoans alternate between polyp and medusa forms

Fig. 33-8-1

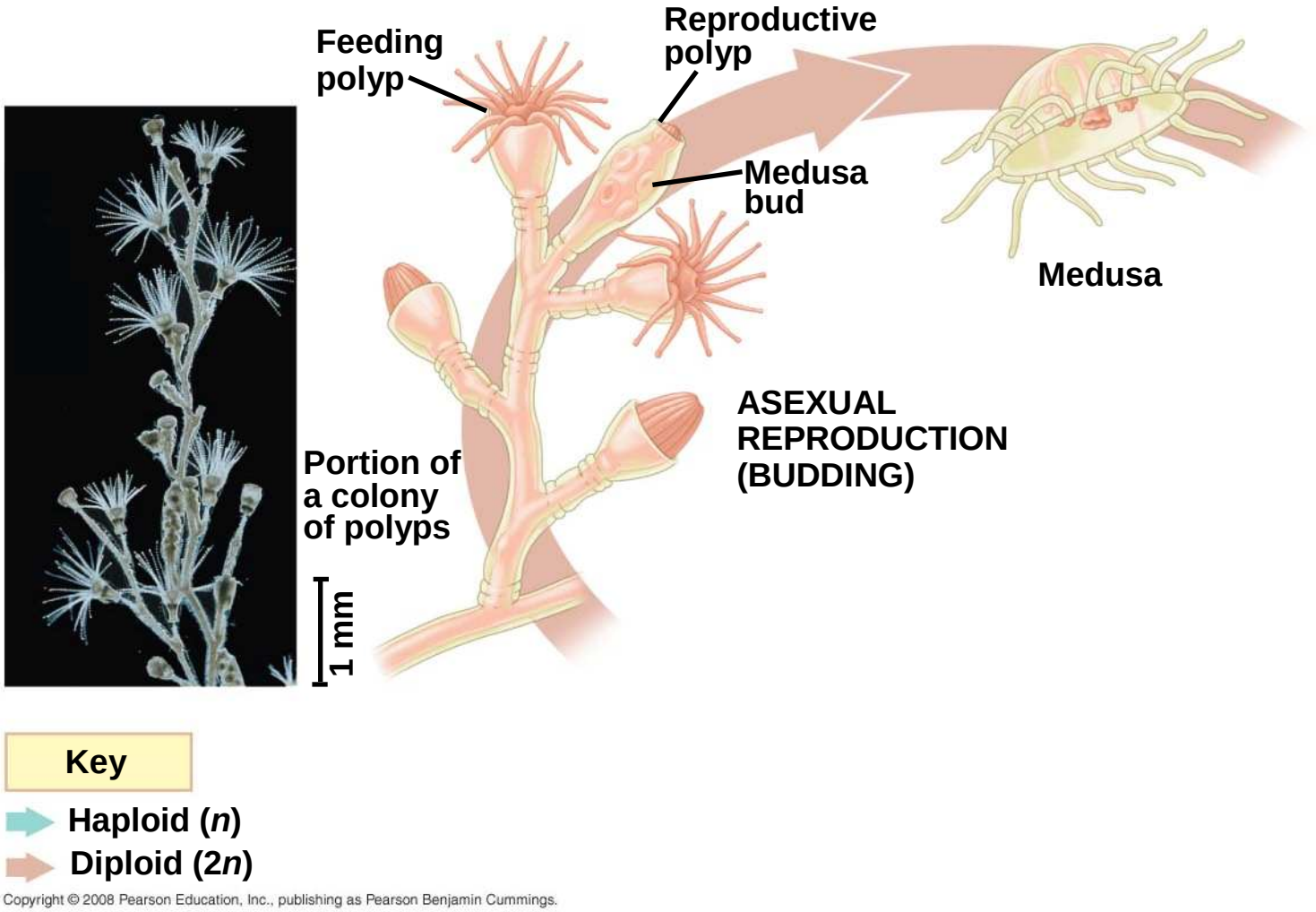


Fig. 33-8-2

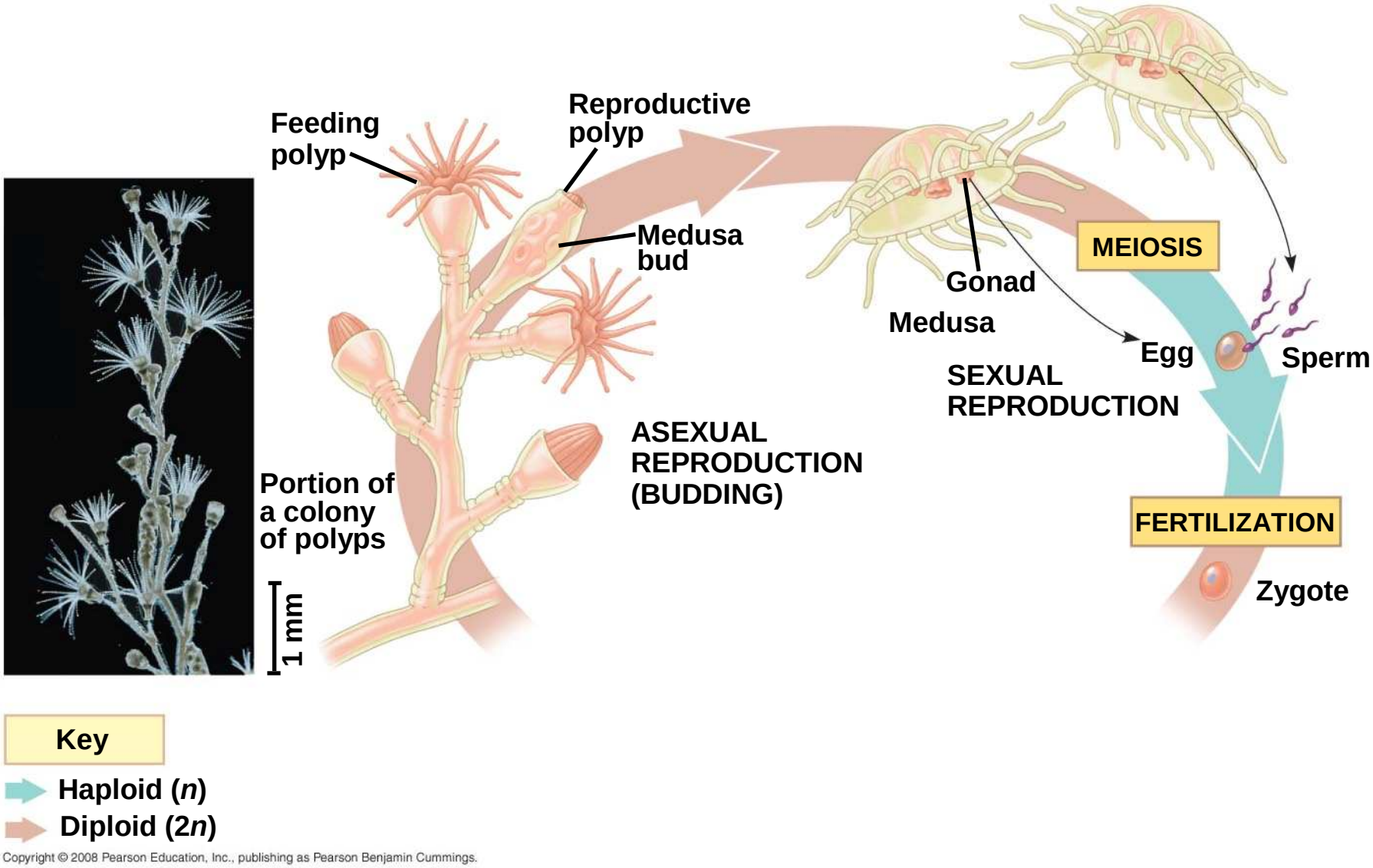
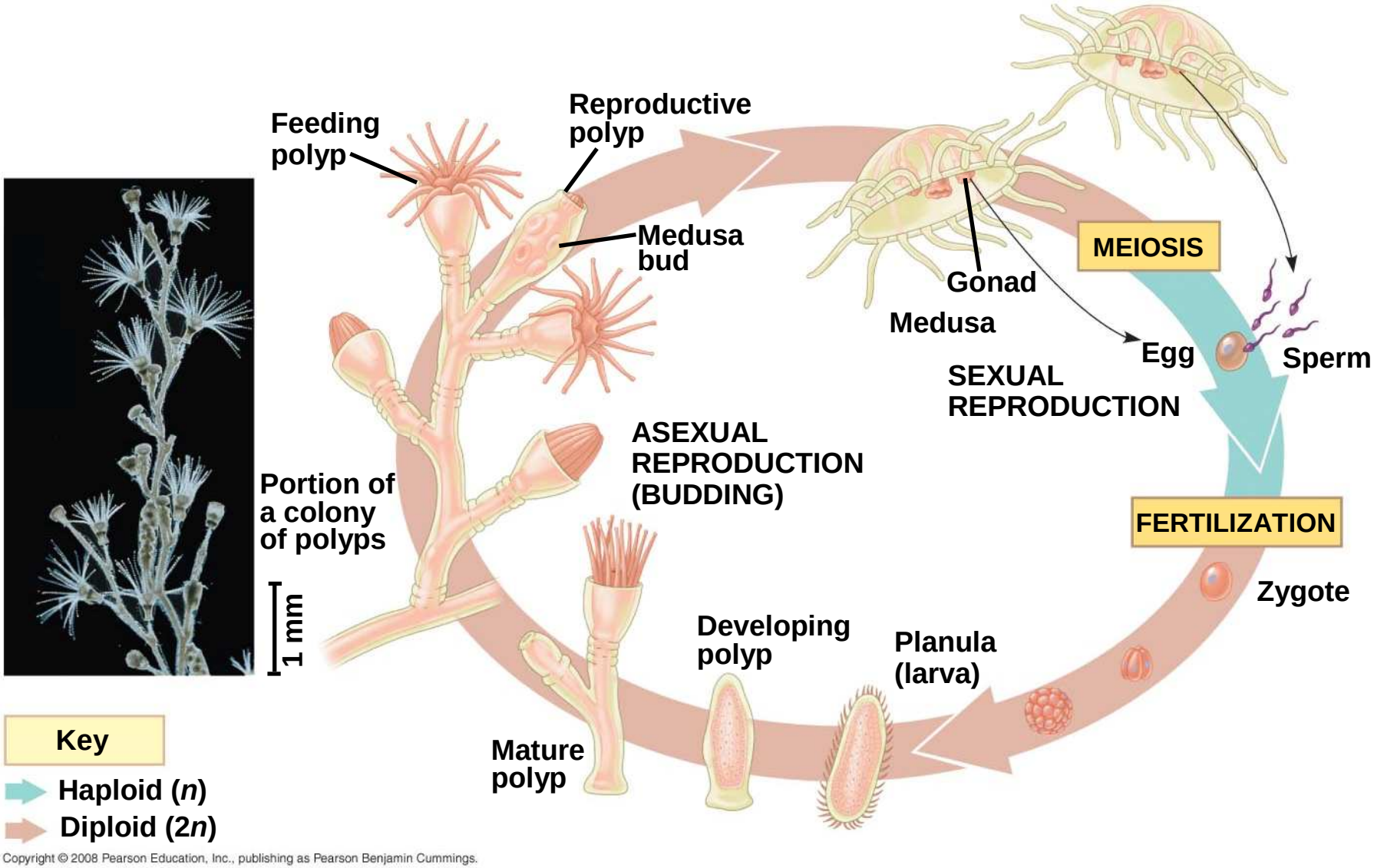


Fig. 33-8-3



Scyphozoans

- In the class Scyphozoa, jellies (medusae) are the prevalent form of the life cycle

PLAY Video: Jelly Swimming

PLAY Video: Thimble Jellies

Cubozoans

- In the class Cubozoa, which includes box jellies and sea wasps, the medusa is box-shaped and has complex eyes
- Cubozoans often have highly toxic cnidocytes

Anthozoans

- Class Anthozoa includes the corals and sea anemones, which occur only as polyps

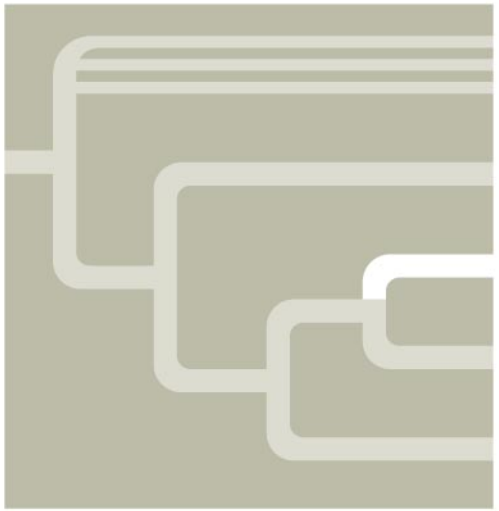
PLAY Video: Clownfish and Anemone

PLAY Video: Coral Reef

Concept 33.3: Lophotrochozoans, a clade identified by molecular data, have the widest range of animal body forms

- Bilaterian animals have bilateral symmetry and triploblastic development
- The clade Bilateria contains Lophotrochozoa, Ecdysozoa, and Deuterostomia

Fig. 33-UN3



Calcarea and Silicea

Cnidaria

Lophotrochozoa

Ecdysozoa

Deuterostomia

- The clade Lophotrochozoa was identified by molecular data
- Some develop a *lophophore* for feeding, others pass through a *trochophore larval stage*, and a few have neither feature
- Lophotrochozoa includes the flatworms, rotifers, ectoprocts, brachiopods, molluscs, and annelids

Flatworms

- Members of phylum Platyhelminthes live in marine, freshwater, and damp terrestrial habitats
- Although flatworms undergo triploblastic development, they are acoelomates
- They are flattened dorsoventrally and have a gastrovascular cavity
- Gas exchange takes place across the surface, and **protonephridia** regulate the osmotic balance

- Flatworms are divided into four classes:
  - Turbellaria (mostly free-living flatworms)
  - Monogenea (monogeneans)
  - Trematoda (trematodes, or flukes)
  - Cestoda (tapeworms)

Table 33-2

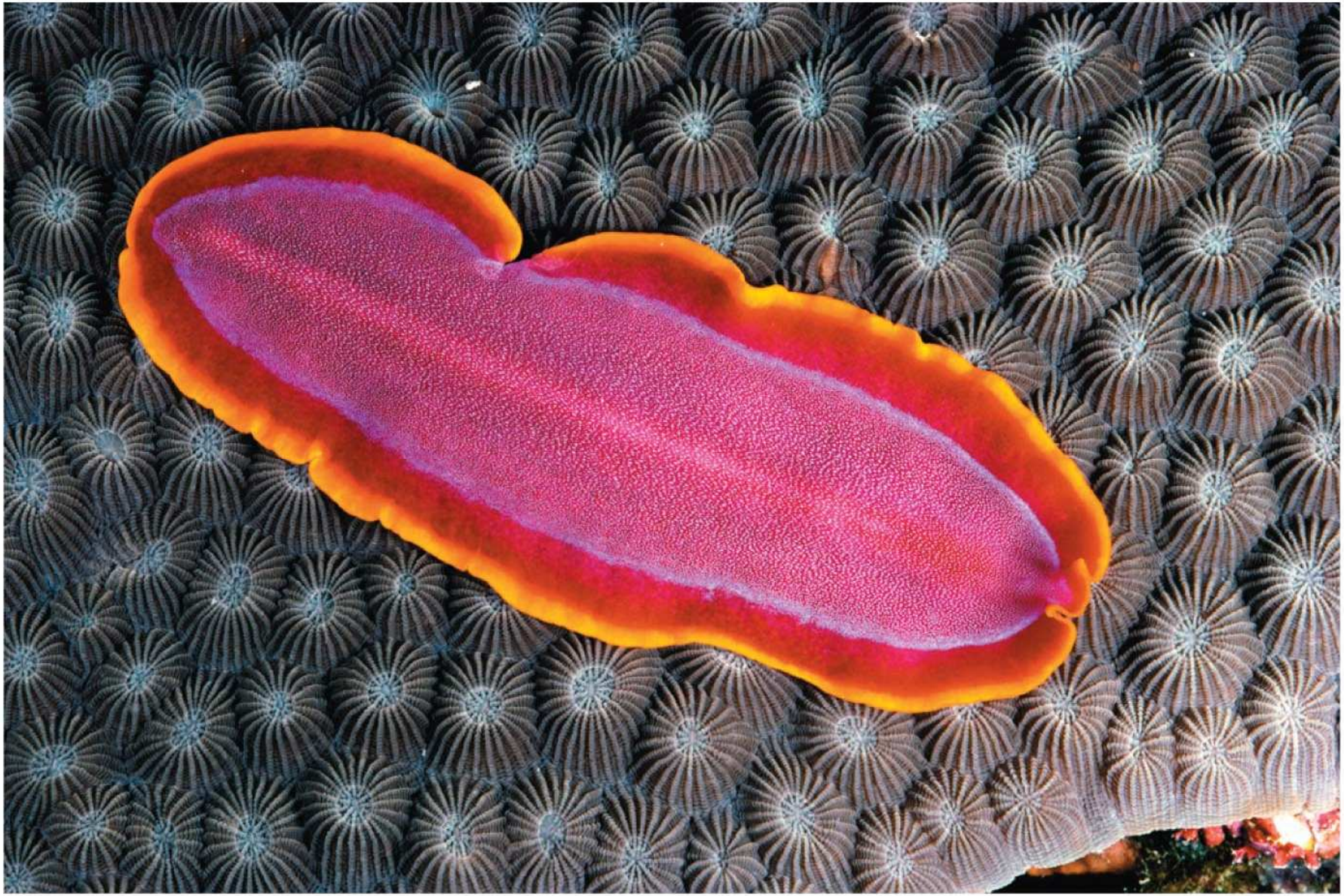
Table 33.2 Classes of Phylum Platyhelminthes

Class and Examples	Main Characteristics
Turbellaria (mostly free-living flatworms, such as *Dugesia)*	Most marine, some freshwater, a few terrestrial; predators and scavengers; body surface ciliated
Monogenea (monogeneans)	Marine and freshwater parasites; most infect external surfaces of fishes; life history simple; ciliated larva starts infection on host
Trematoda (trematodes, also called flukes)	Parasites, mostly of vertebrates; two suckers attach to host; most life cycles include intermediate and final hosts
Cestoda (tapeworms)	Parasites of vertebrates; scolex attaches to host; proglottids produce eggs and break off after fertilization; no head or digestive system; life cycle with one or more intermediate hosts

Turbellarians

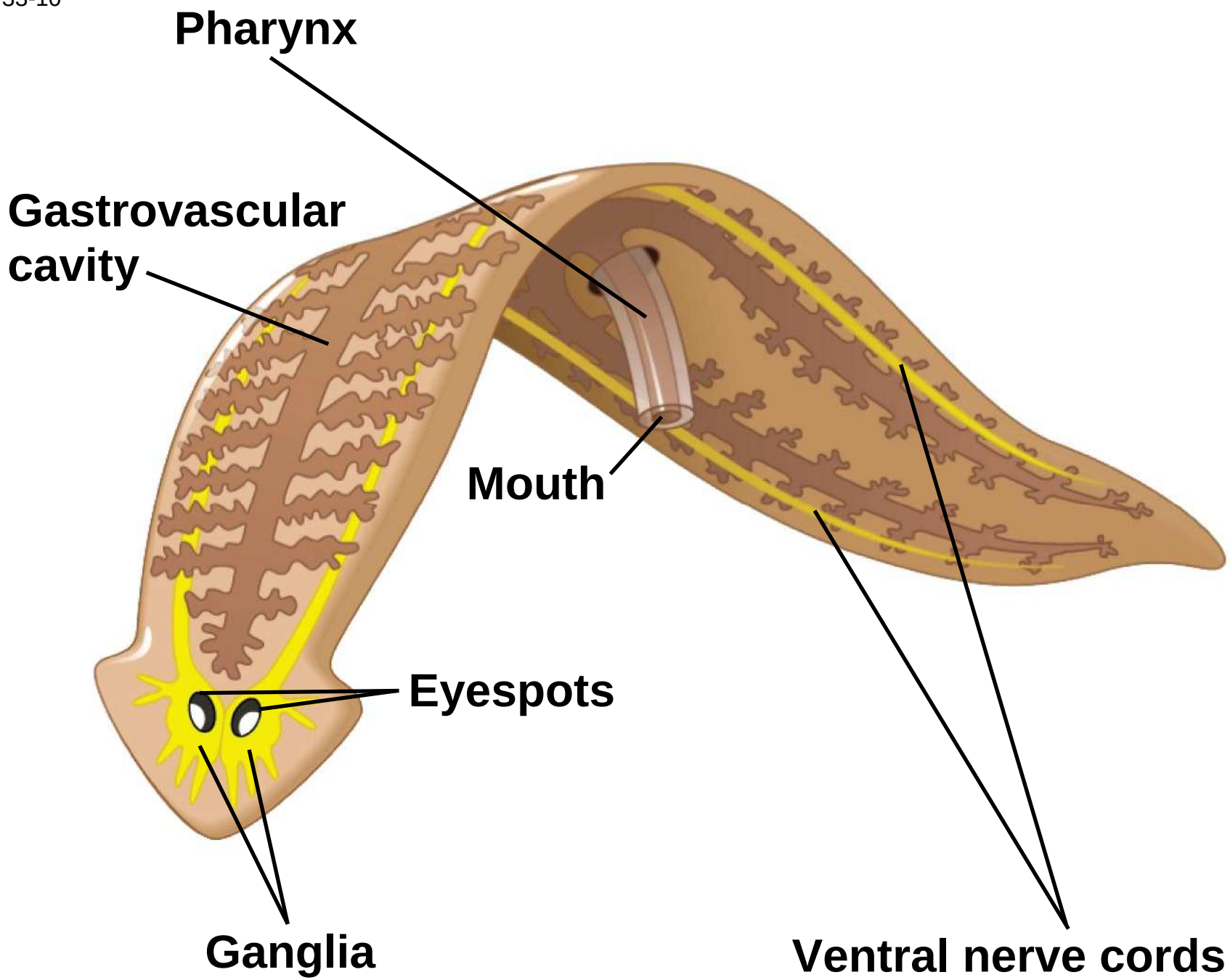
- Turbellarians are nearly all free-living and mostly marine
- The best-known turbellarians are commonly called **planarians**

Fig. 33-9



- Planarians have light-sensitive eyespots and centralized nerve nets
- The planarian nervous system is more complex and centralized than the nerve nets of cnidarians
- Planarians are hermaphrodites and can reproduce sexually, or asexually through fission

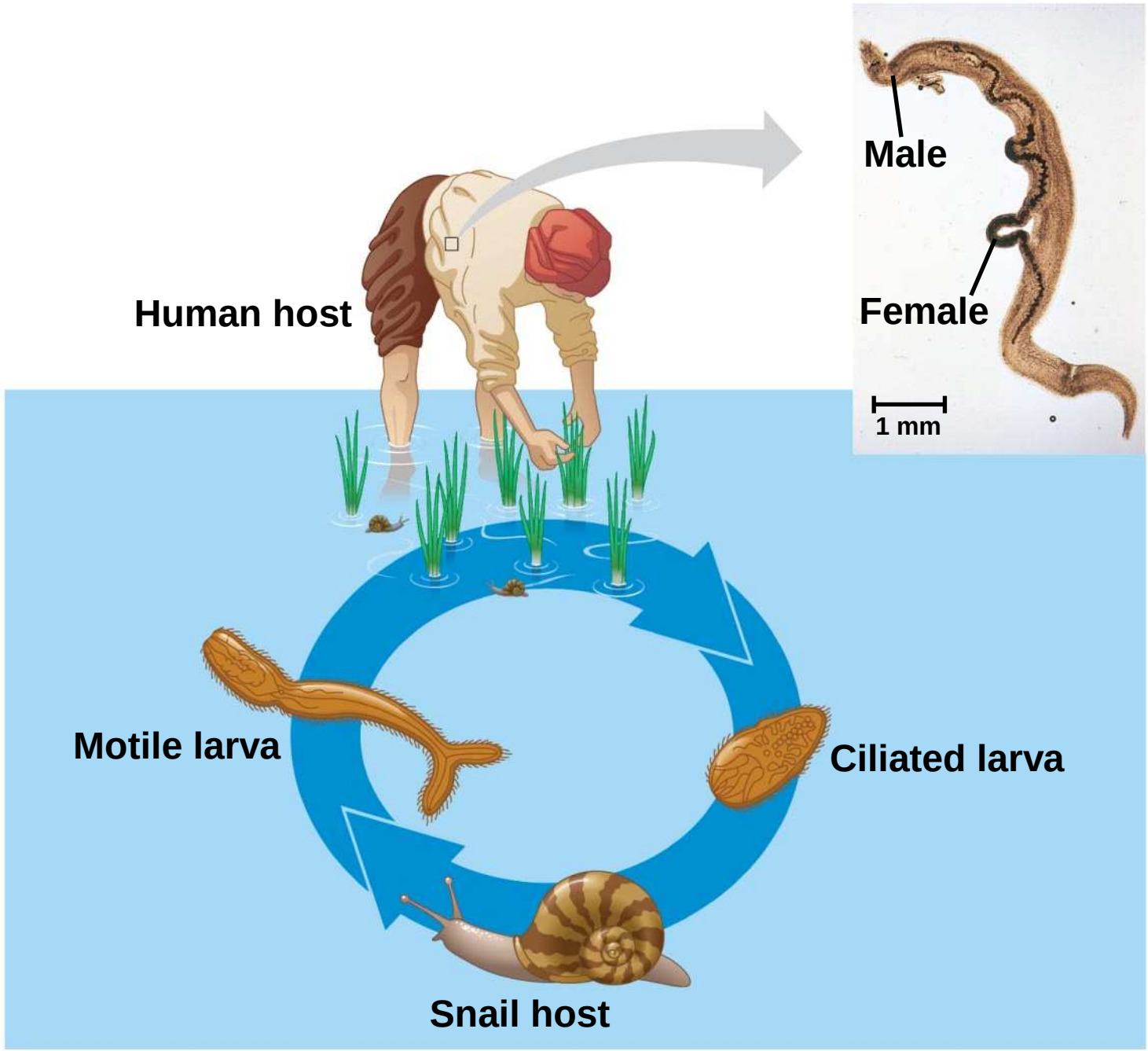
Fig. 33-10



Monogeneans and Trematodes

- Monogeneans and trematodes live as parasites in or on other animals
- They parasitize a wide range of hosts, and most have complex life cycles with alternating sexual and asexual stages
- Trematodes that parasitize humans spend part of their lives in snail hosts
- Most monogeneans are parasites of fish

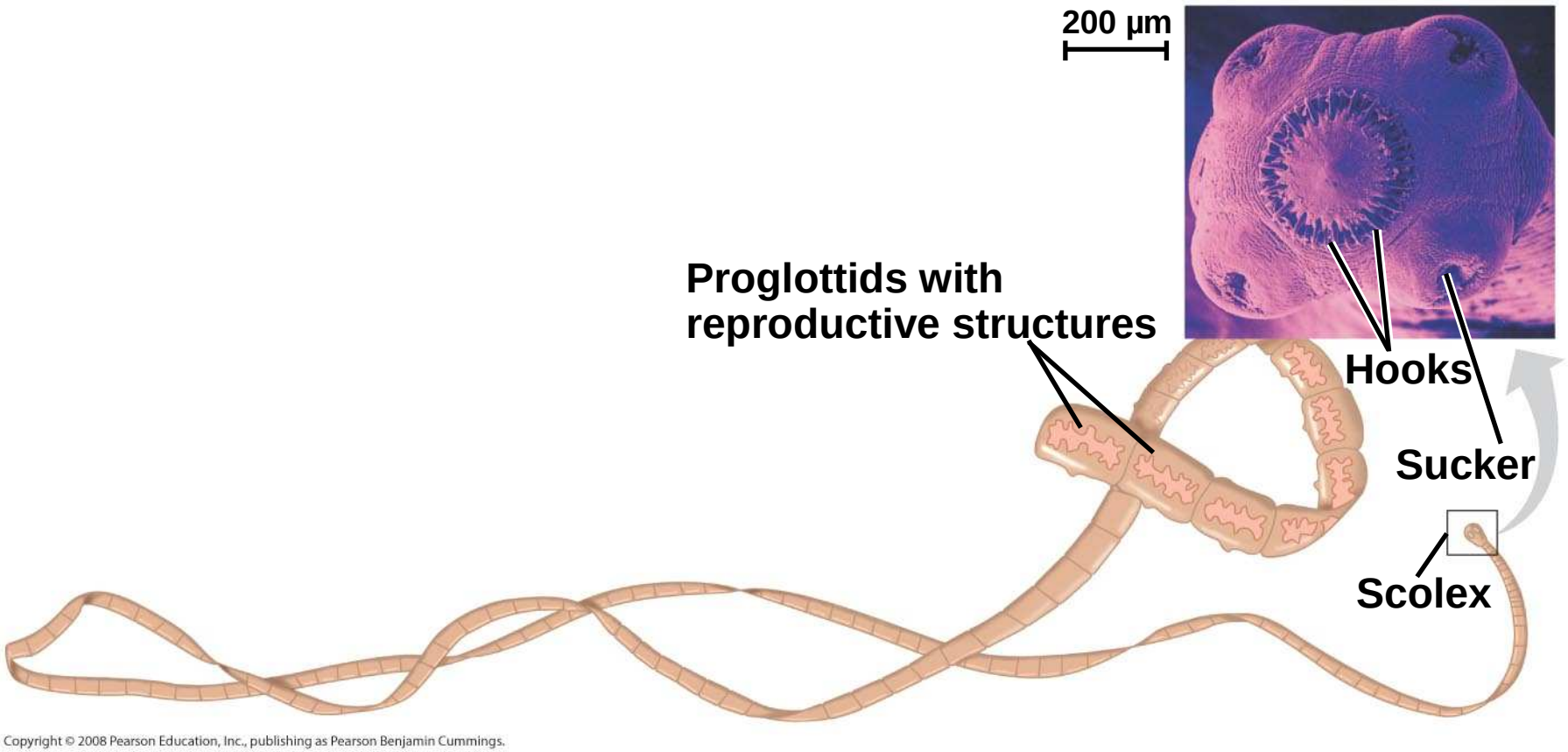
Fig. 33-11



Tapeworms

- Tapeworms are parasites of vertebrates and lack a digestive system
- Tapeworms absorb nutrients from the host's intestine
- Fertilized eggs, produced by sexual reproduction, leave the host's body in feces

Fig. 33-12

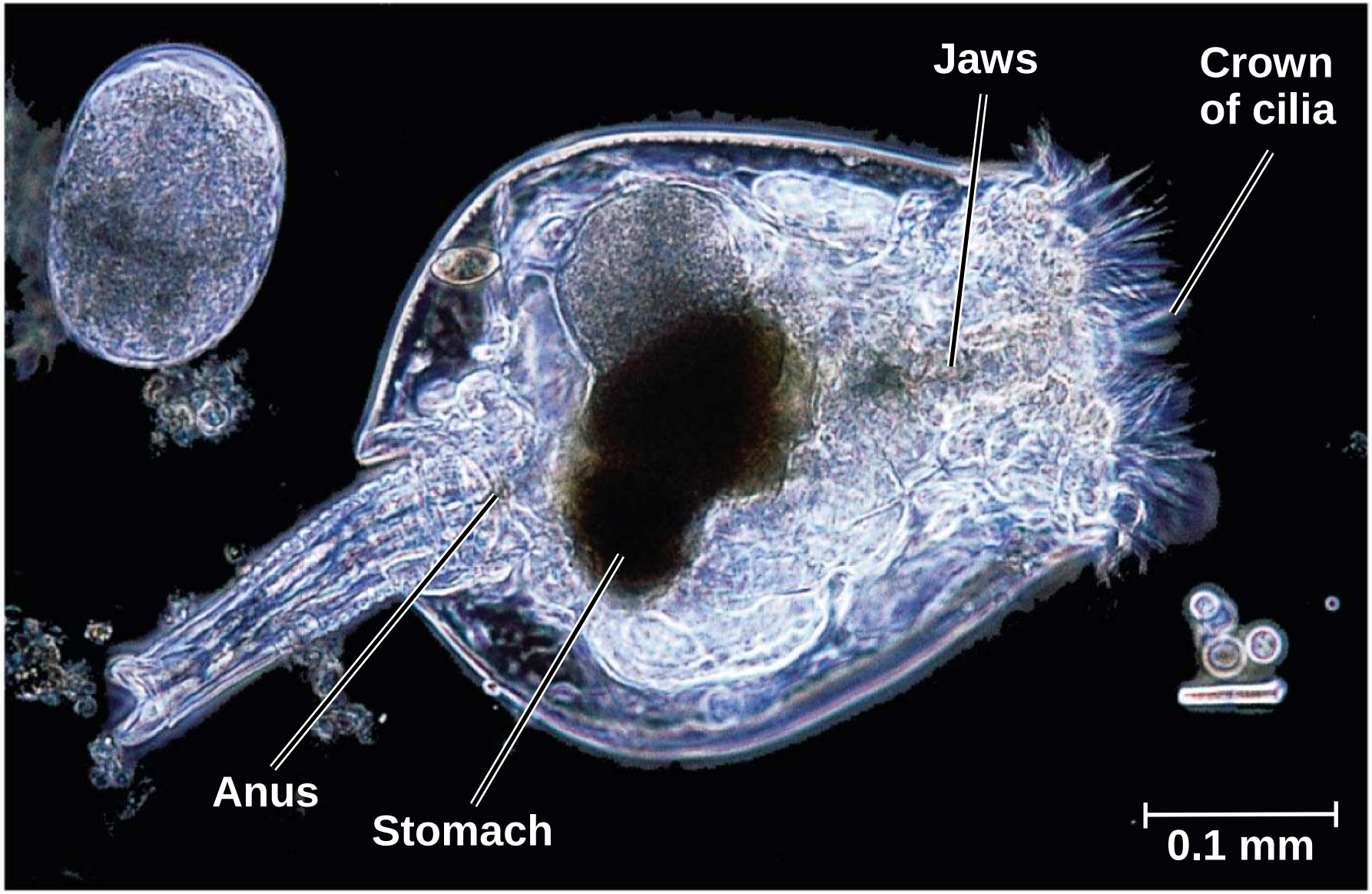


Rotifers

- Rotifers, phylum Rotifera, are tiny animals that inhabit fresh water, the ocean, and damp soil
- Rotifers are smaller than many protists but are truly multicellular and have specialized organ systems

PLAY Video: Rotifer

Fig. 33-13

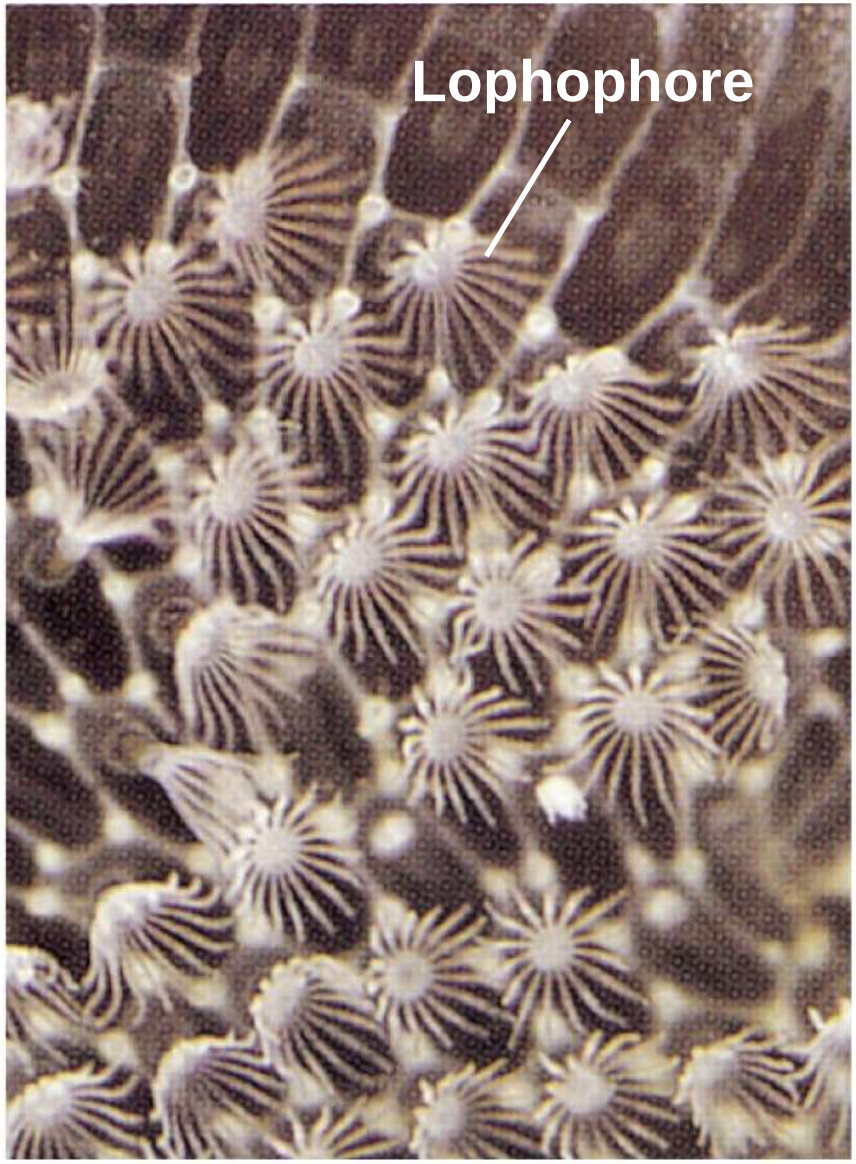


- Rotifers have an **alimentary canal**, a digestive tube with a separate mouth and anus that lies within a fluid-filled pseudocoelom
- Rotifers reproduce by **parthenogenesis**, in which females produce offspring from unfertilized eggs
- Some species are unusual in that they lack males entirely

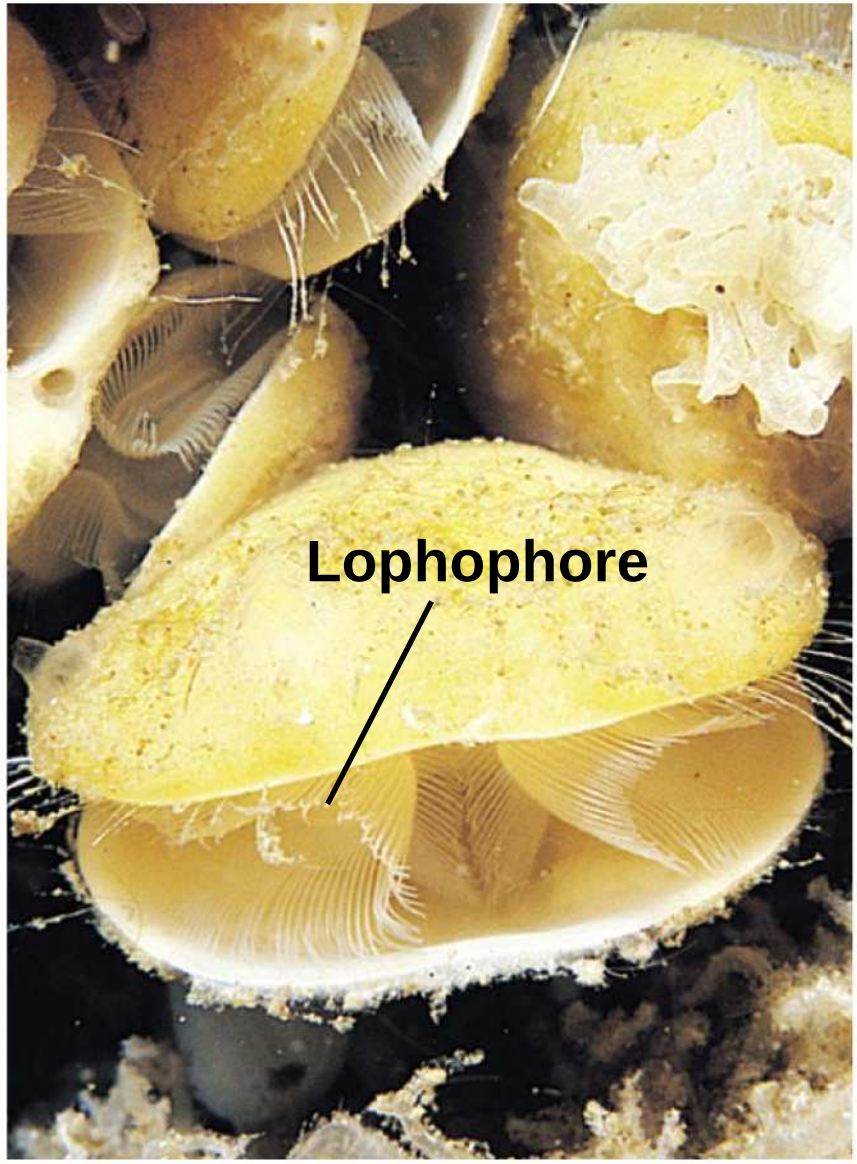
Lophophorates: Ectoprocts and Brachiopods

- Lophophorates have a *lophophore*, a horseshoe-shaped, suspension-feeding organ with ciliated tentacles
- Lophophorates include two phyla: Ectoprocta and Brachiopoda
- **Ectoprocts** (also called bryozoans) are colonial animals that superficially resemble plants
- A hard **exoskeleton** encases the colony, and some species are reef builders

Fig. 33-14

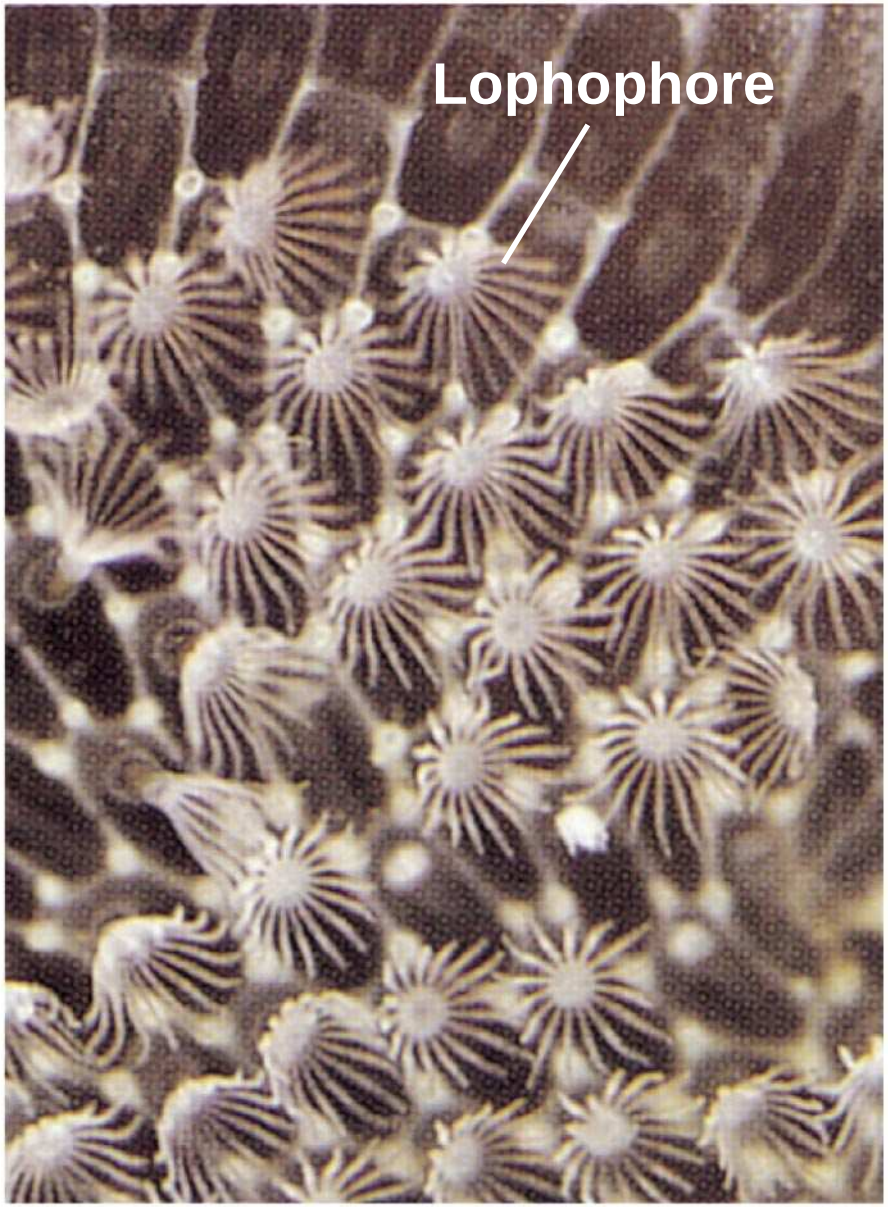


(a) Ectoproct (sea mat)



(b) Brachiopods

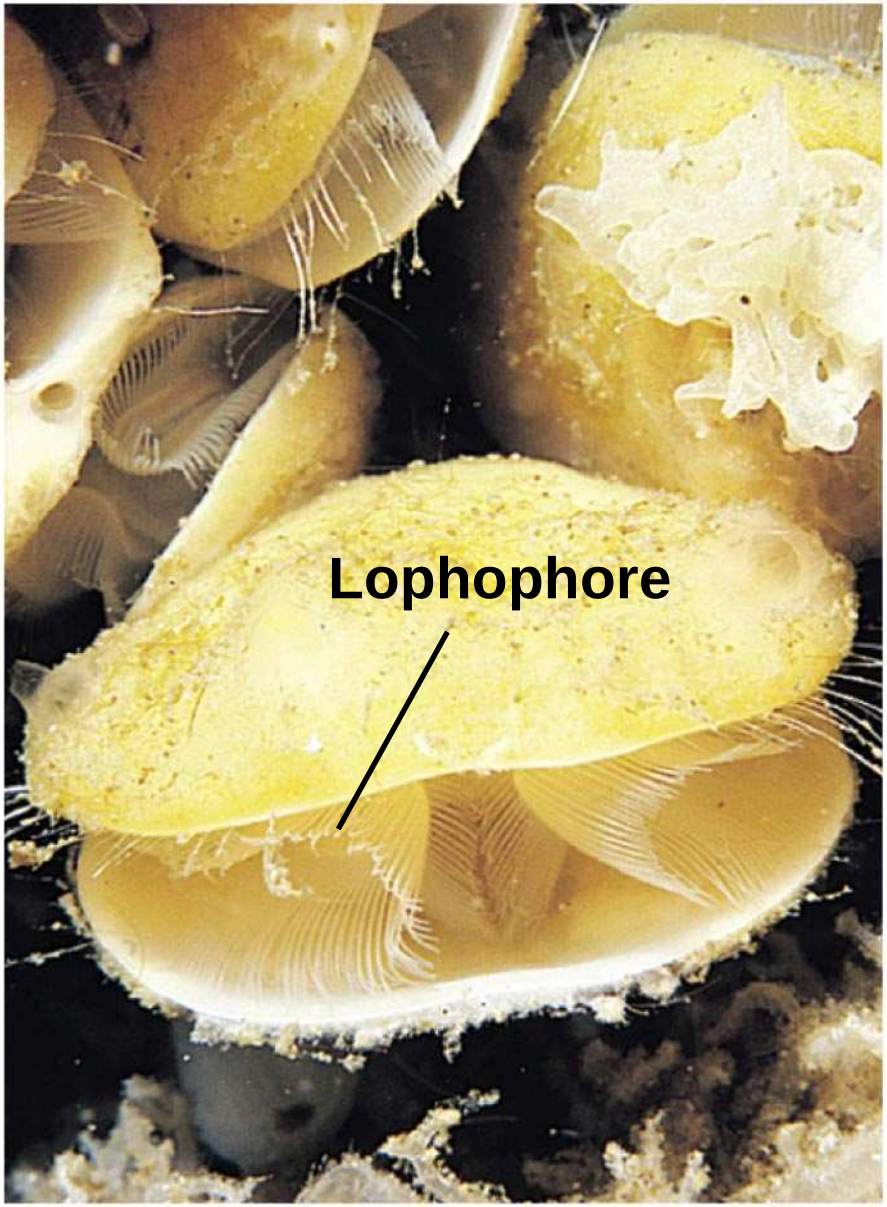
Fig. 33-14a



(a) Ectoproct (sea mat)

- **Brachiopods** superficially resemble clams and other hinge-shelled molluscs, but the two halves of the shell are dorsal and ventral rather than lateral as in clams

Fig. 33-14b



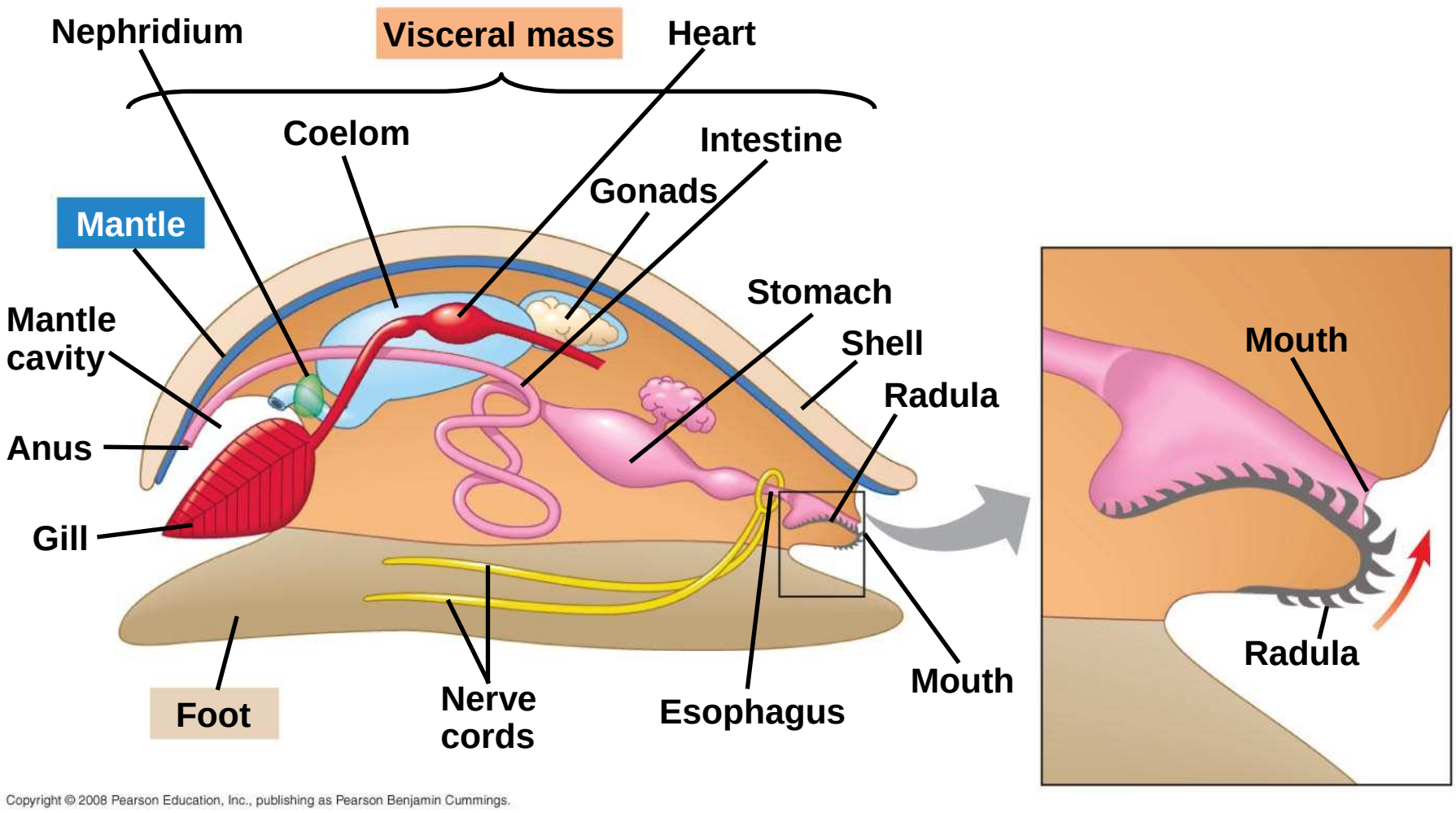
(b) Brachiopods

Molluscs

- Phylum Mollusca includes snails and slugs, oysters and clams, and octopuses and squids
- Most molluscs are marine, though some inhabit fresh water and some are terrestrial
- Molluscs are soft-bodied animals, but most are protected by a hard shell

- All molluscs have a similar body plan with three main parts:
  - Muscular **foot**
  - **Visceral mass**
  - **Mantle**
- Many molluscs also have a water-filled **mantle cavity**, and feed using a rasplike **radula**

Fig. 33-15



- Most molluscs have separate sexes with gonads located in the visceral mass
- The life cycle of many molluscs includes a ciliated larval stage called a trochophore

- There are four major classes of molluscs:
  - Polyplacophora (chitons)
  - Gastropoda (snails and slugs)
  - Bivalvia (clams, oysters, and other bivalves)
  - Cephalopoda (squids, octopuses, cuttlefish, and chambered nautiluses)

Table 33-3

Table 33.3 Major Classes of Phylum Mollusca

Class and Examples	Main Characteristics
Polyplacophora (chitons)	Marine; shell with eight plates; foot used for locomotion; radula; no head
Gastropoda (snails, slugs)	Marine, freshwater, or terrestrial; head present; a symmetrical body, usually with a coiled shell; shell reduced or absent; foot for locomotion; radula
Bivalvia (clams, mussels, scallops, oysters)	Marine and freshwater; flattened shell with two valves; head reduced; paired gills; no radula
Cephalopoda (squids, octopuses, cuttlefishes, chambered nautiluses)	Marine; head surrounded by grasping tentacles, usually with suckers; shell external, internal, or absent; mouth with or without radula; locomotion by jet propulsion

Chitons

- Class Polyplacophora consists of the chitons, oval-shaped marine animals encased in an armor of eight dorsal plates

Fig. 33-16

Gastropods

- About three-quarters of all living species of molluscs are gastropods

PLAY Video: Nudibranchs

Fig. 33-17

(a) A land snail

(b) A sea slug

Fig. 33-17a

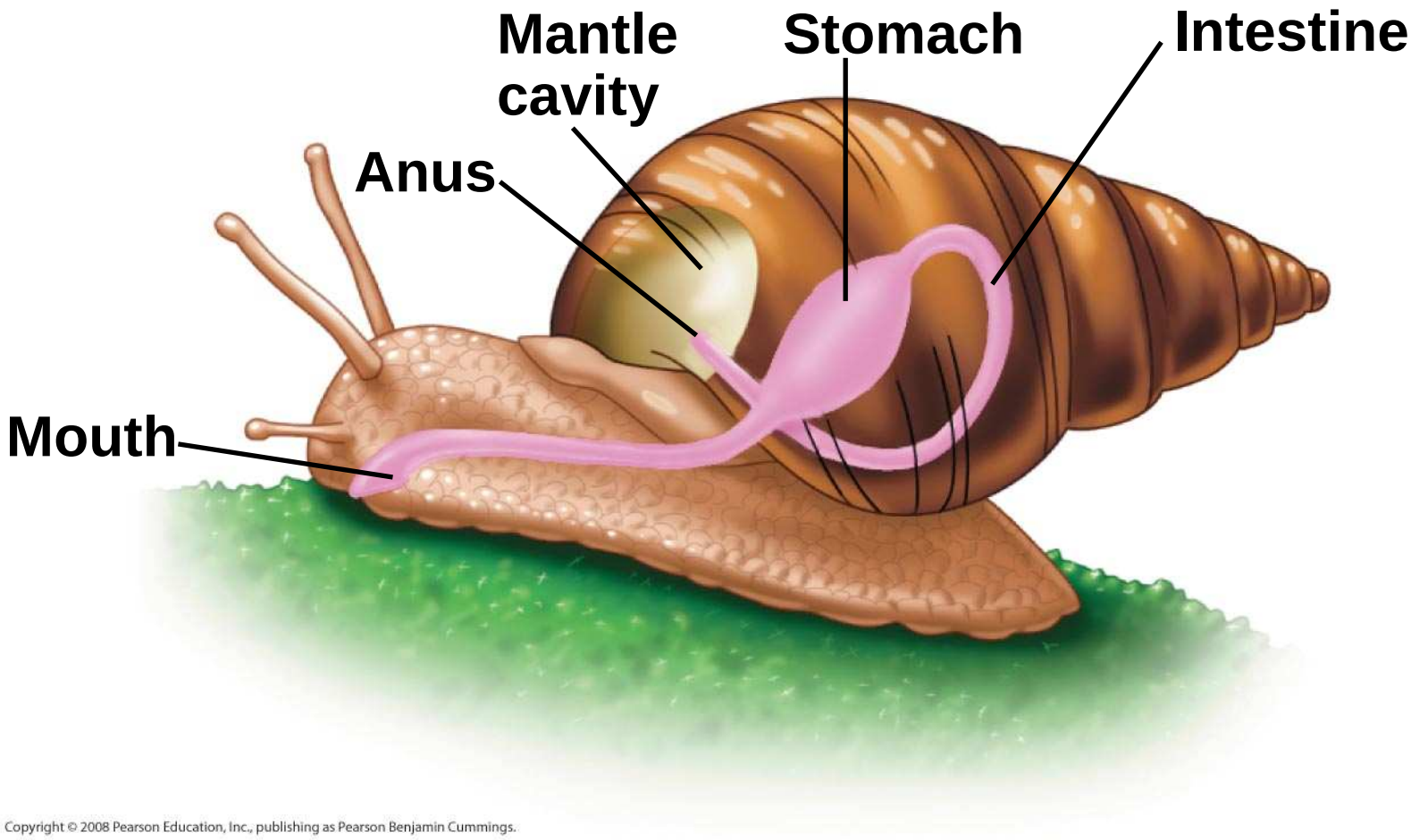
(a) A land snail

Fig. 33-17b

(b) A sea slug

- Most gastropods are marine, but many are freshwater and terrestrial species
- Most have a single, spiraled shell
- Slugs lack a shell or have a reduced shell
- The most distinctive characteristic of gastropods is **torsion**, which causes the animal's anus and mantle to end up above its head

Fig. 33-18



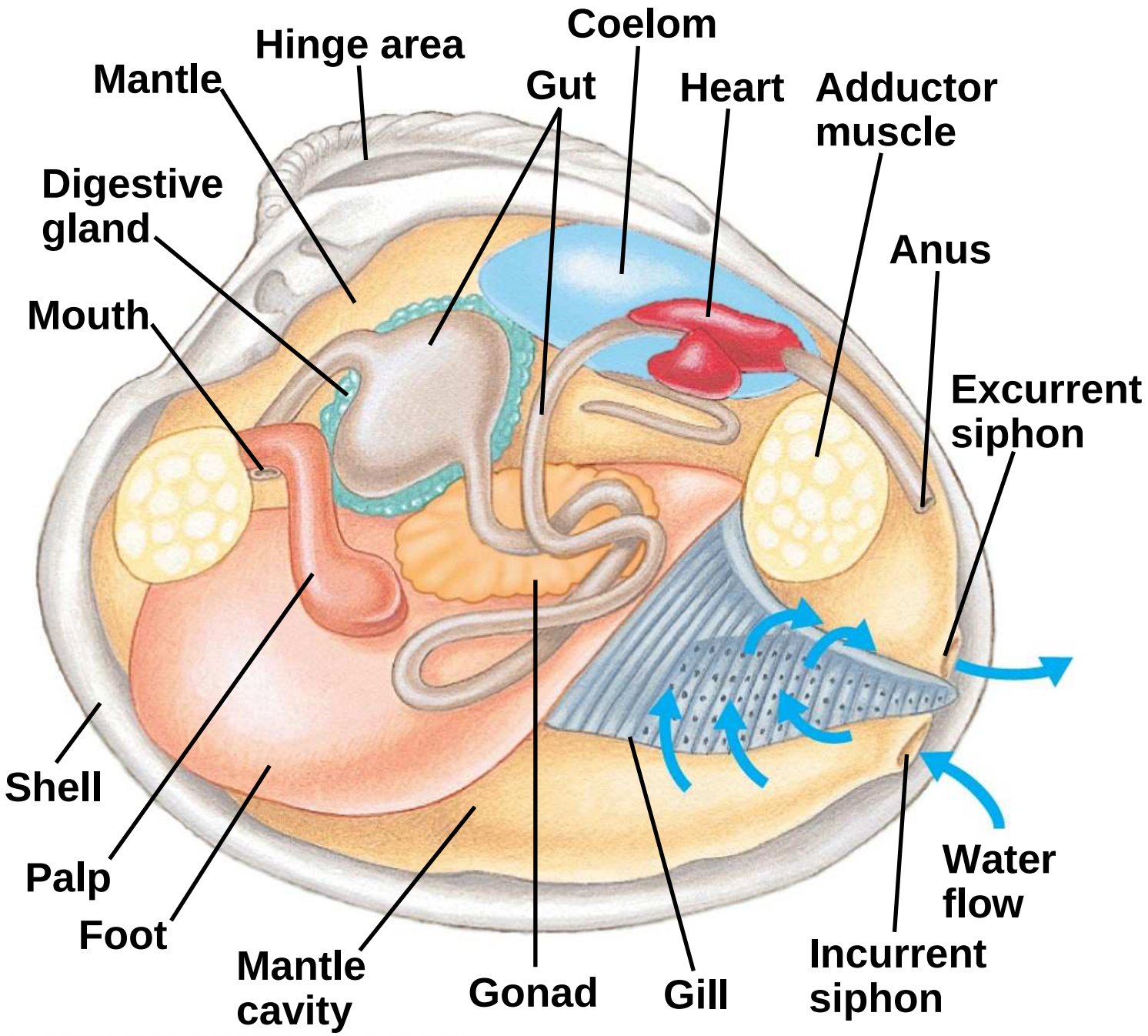
Bivalves

- Molluscs of class Bivalvia include many species of clams, oysters, mussels, and scallops
- They have a shell divided into two halves

Fig. 33-19

- The mantle cavity of a bivalve contains gills that are used for feeding as well as gas exchange

Fig. 33-20



Cephalopods

- Class Cephalopoda includes squids and octopuses, carnivores with beak-like jaws surrounded by tentacles of their modified foot
- Most octopuses creep along the sea floor in search of prey

Fig. 33-21

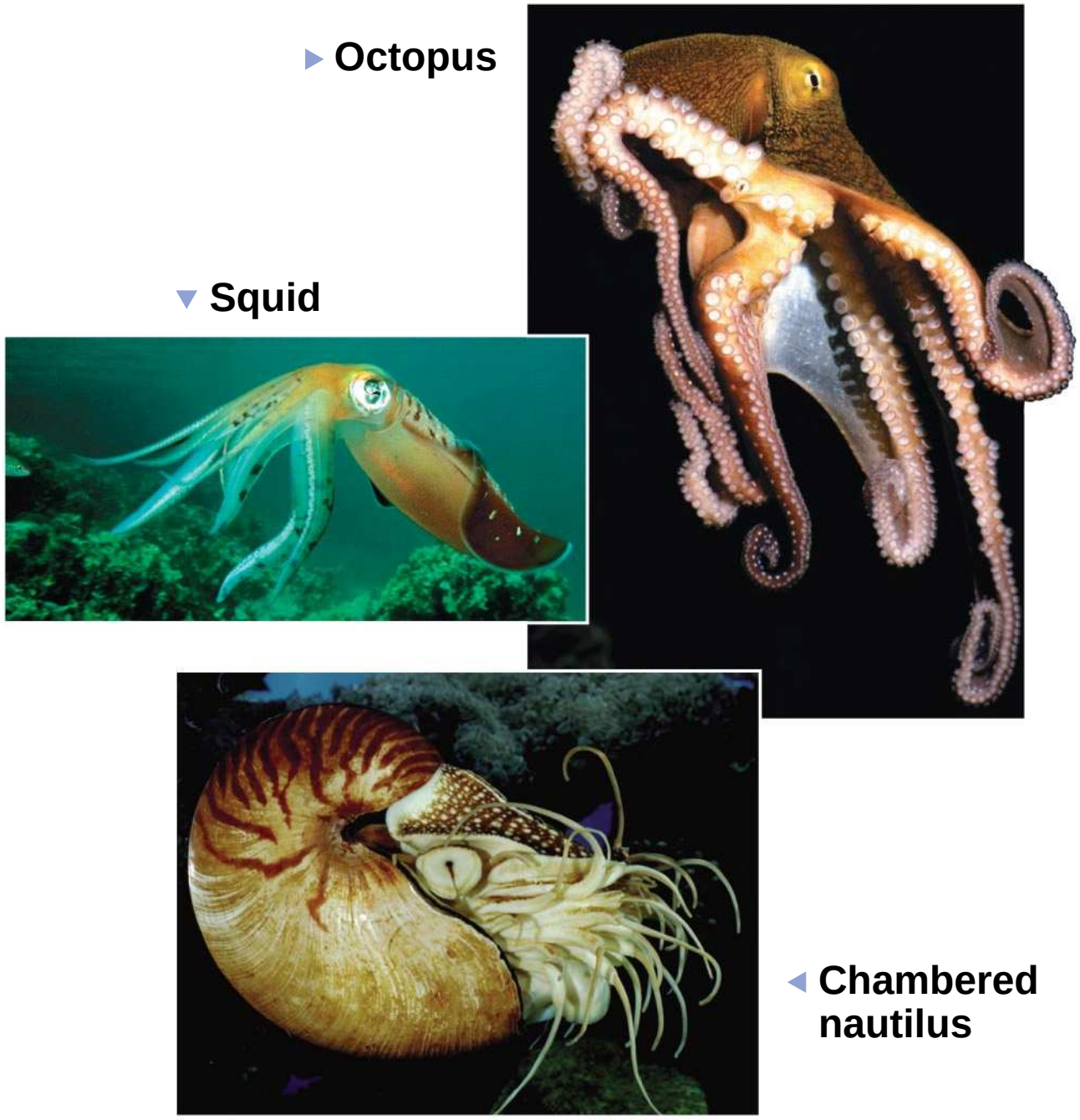


Fig. 33-21a

- **Octopus**

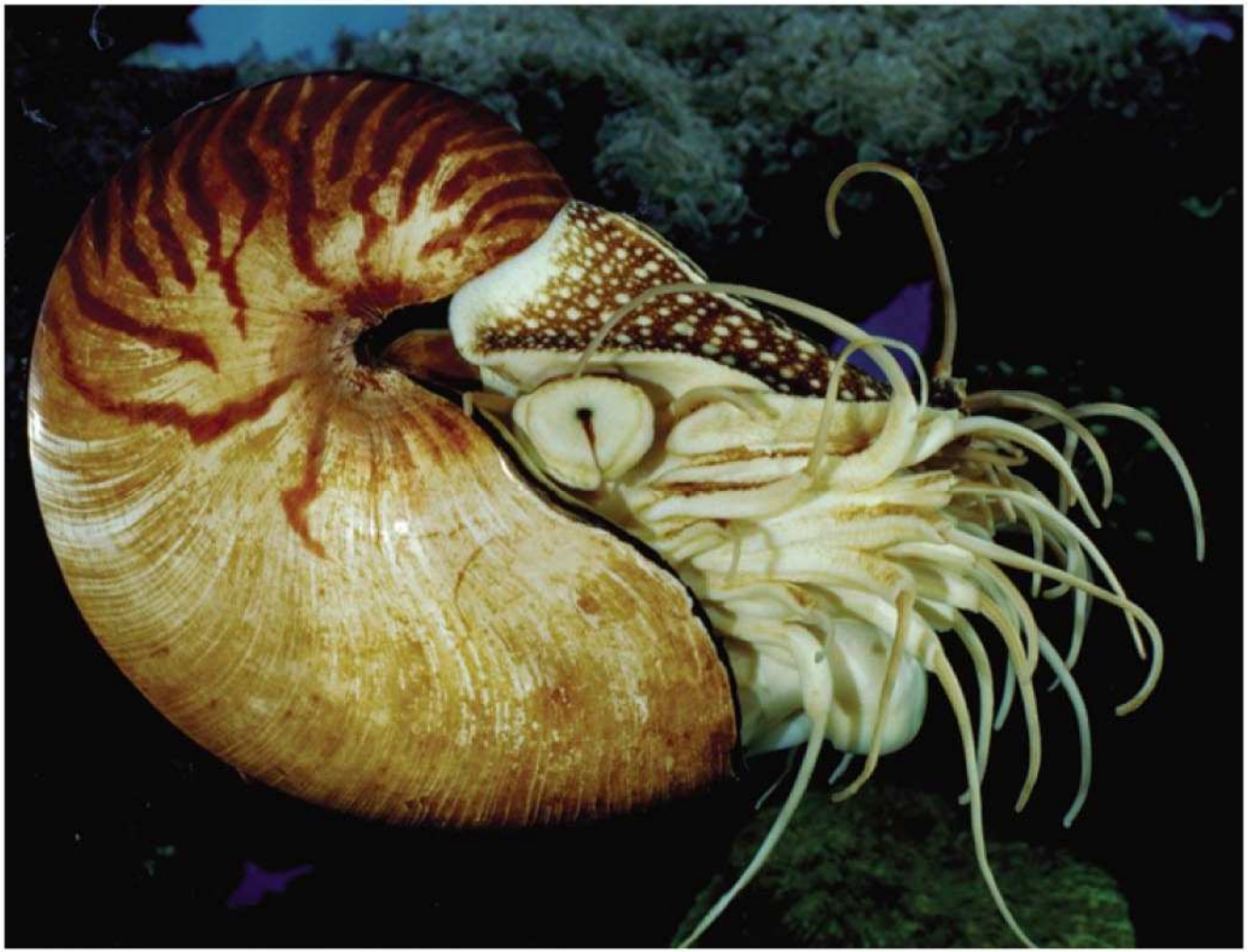
- Squids use their siphon to fire a jet of water, which allows them to swim very quickly

Fig. 33-21b

Squid

- One small group of shelled cephalopods, the nautiluses, survives today

Fig. 33-21c



Chambered nautilus

- Cephalopods have a closed circulatory system, well-developed sense organs, and a complex brain
- Shelled cephalopods called **ammonites** were common but went extinct at the end of the Cretaceous

Annelids

- Annelids have bodies composed of a series of fused rings
- The phylum Annelida is divided into three classes:
  - Oligochaeta (earthworms and their relatives)
  - Polychaeta (polychaetes)
  - Hirudinea (leeches)

Table 33-4

Table 33.4 Classes of Phylum Annelida

Class and Examples	Main Characteristics
Oligochaeta (freshwater, marine, and terrestrial segmented worms)	Reduced head; no parapodia, but chaetae present
Polychaeta (mostly marine segmented worms)	Many have a well-developed head; each segment usually has parapodia with many chaetae; free-living
Hirudinea (leeches)	Body usually flattened, with reduced coelom and segmentation; chaetae usually absent; suckers at anterior and posterior ends; parasites, predators, and scavengers

Oligochaetes

- Oligochaetes (class Oligochaeta) are named for relatively sparse chaetae, bristles made of chitin
- They include the earthworms and a variety of aquatic species
- Earthworms eat through soil, extracting nutrients as the soil moves through the alimentary canal
- Earthworms are hermaphrodites but cross-fertilize

PLAY Video: Earthworm Locomotion

Fig. 33-22

Giant Australian earthworm

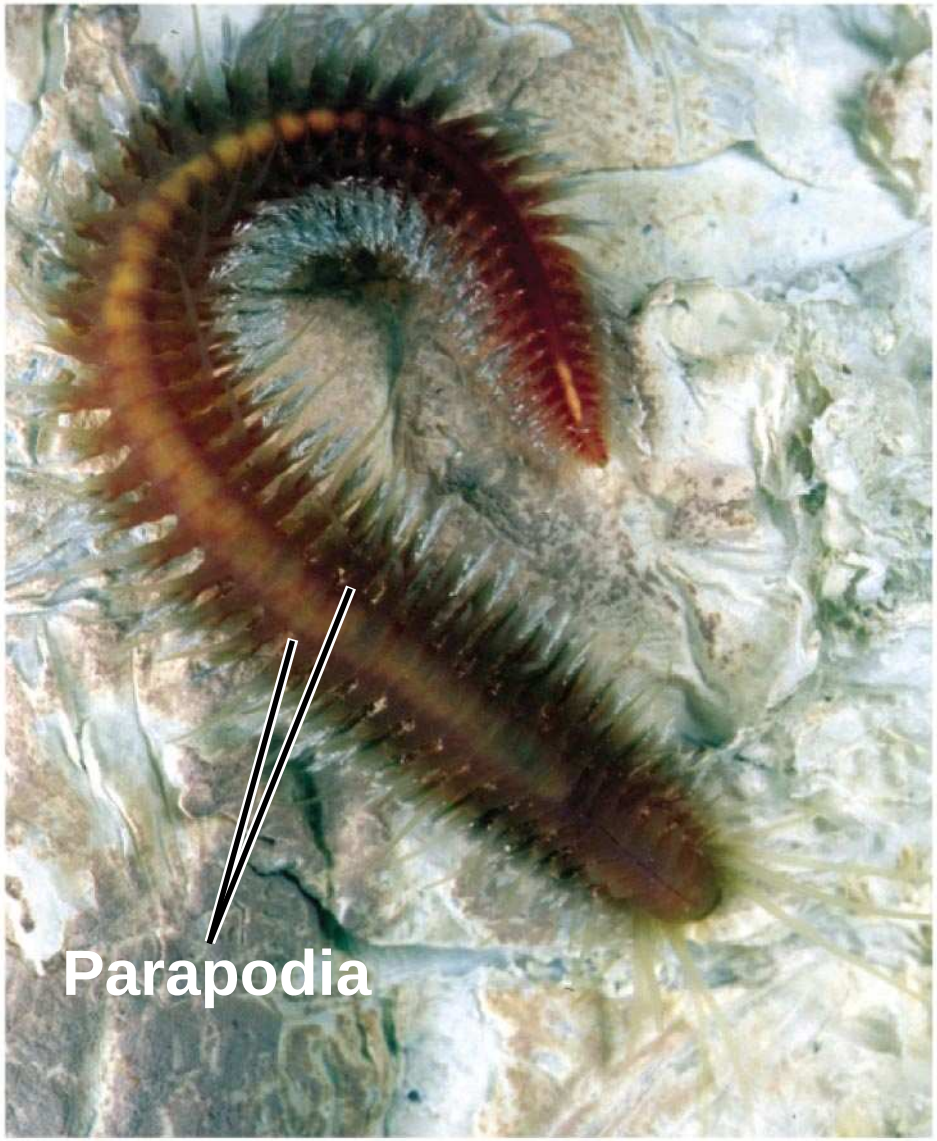
Epidermis
Cuticle
Coelom
Septum (partition between segments)
Circular muscle
Longitudinal muscle
Metanephridium
Anus
Dorsal vessel
Chaetae
Intestine
Fused nerve cords
Ventral vessel
Nephrostome
Clitellum
Metanephridium
Esophagus
Crop
Pharynx
Intestine
Cerebral ganglia
Gizzard
Mouth
Subpharyngeal ganglion
Blood vessels
Ventral nerve cord with segmental ganglia

Polychaetes

- Members of class Polychaetes have paddle-like parapodia that work as gills and aid in locomotion

PLAY Video: Tubeworms

Fig. 33-23



Leeches

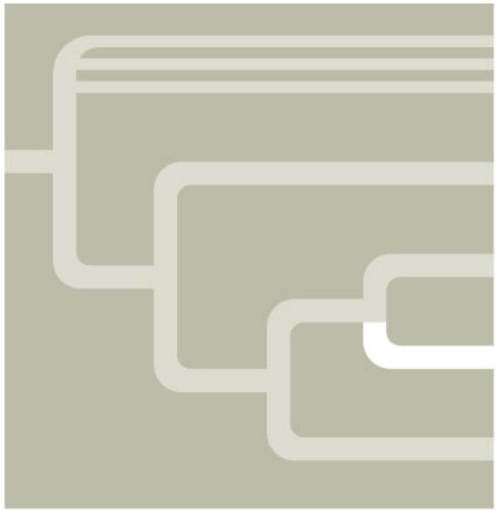
- Members of class Hirudinea are blood-sucking parasites, such as leeches
- Leeches secrete a chemical called hirudin to prevent blood from coagulating

Fig. 33-24

Concept 33.4: Ecdysozoans are the most species-rich animal group

- Ecdysozoans are covered by a tough coat called a **cuticle**
- The cuticle is shed or **molted** through a process called ecdysis
- The two largest phyla are nematodes and arthropods

Fig. 33-UN4



Calcarea and Silicea

Cnidaria

Lophotrochozoa

Ecdysozoa

Deuterostomia

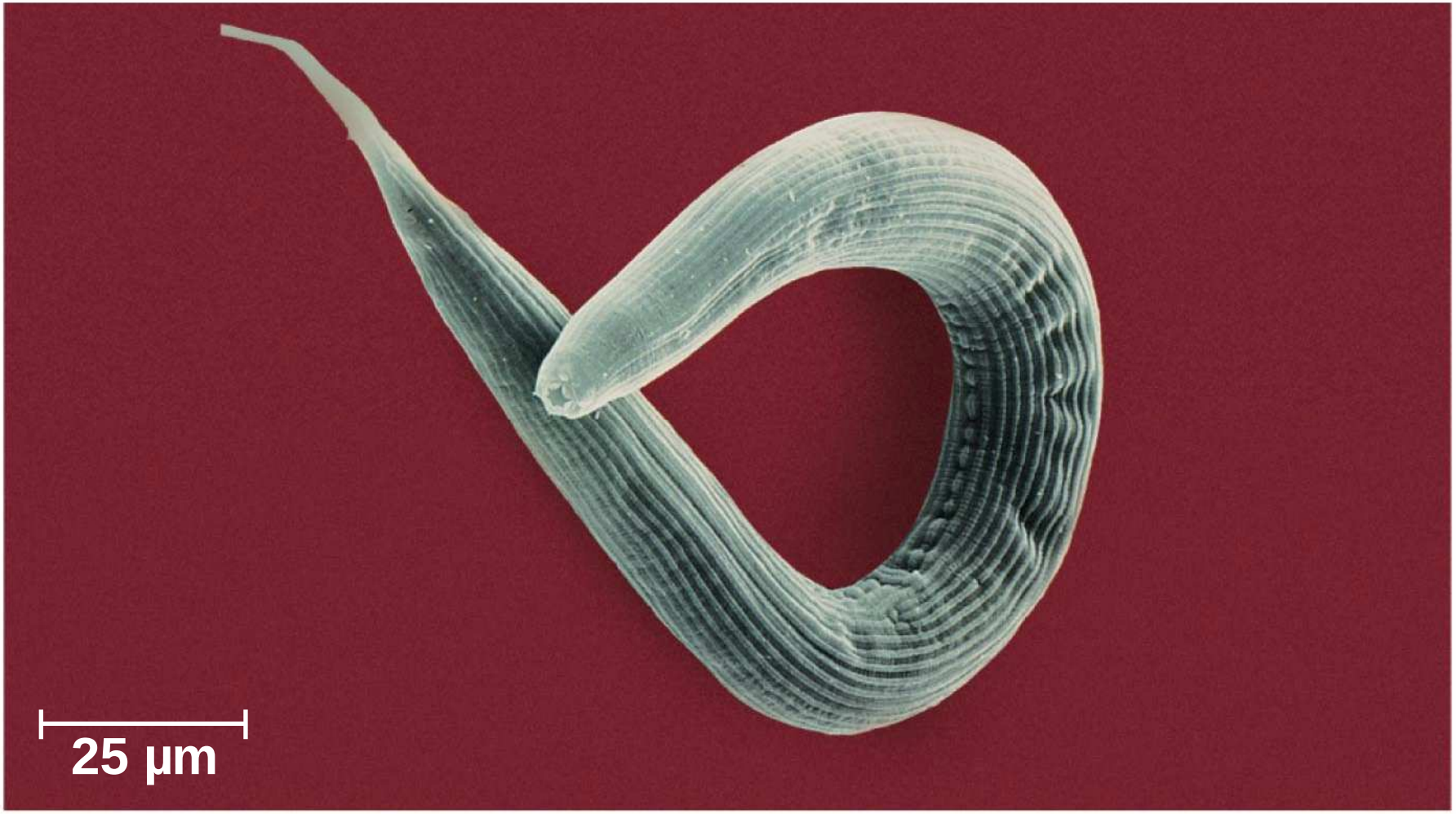
Nematodes

- Nematodes, or roundworms, are found in most aquatic habitats, in the soil, in moist tissues of plants, and in body fluids and tissues of animals
- They have an alimentary canal, but lack a circulatory system
- Reproduction in nematodes is usually sexual, by internal fertilization

PLAY Video: *C. elegans* Crawling

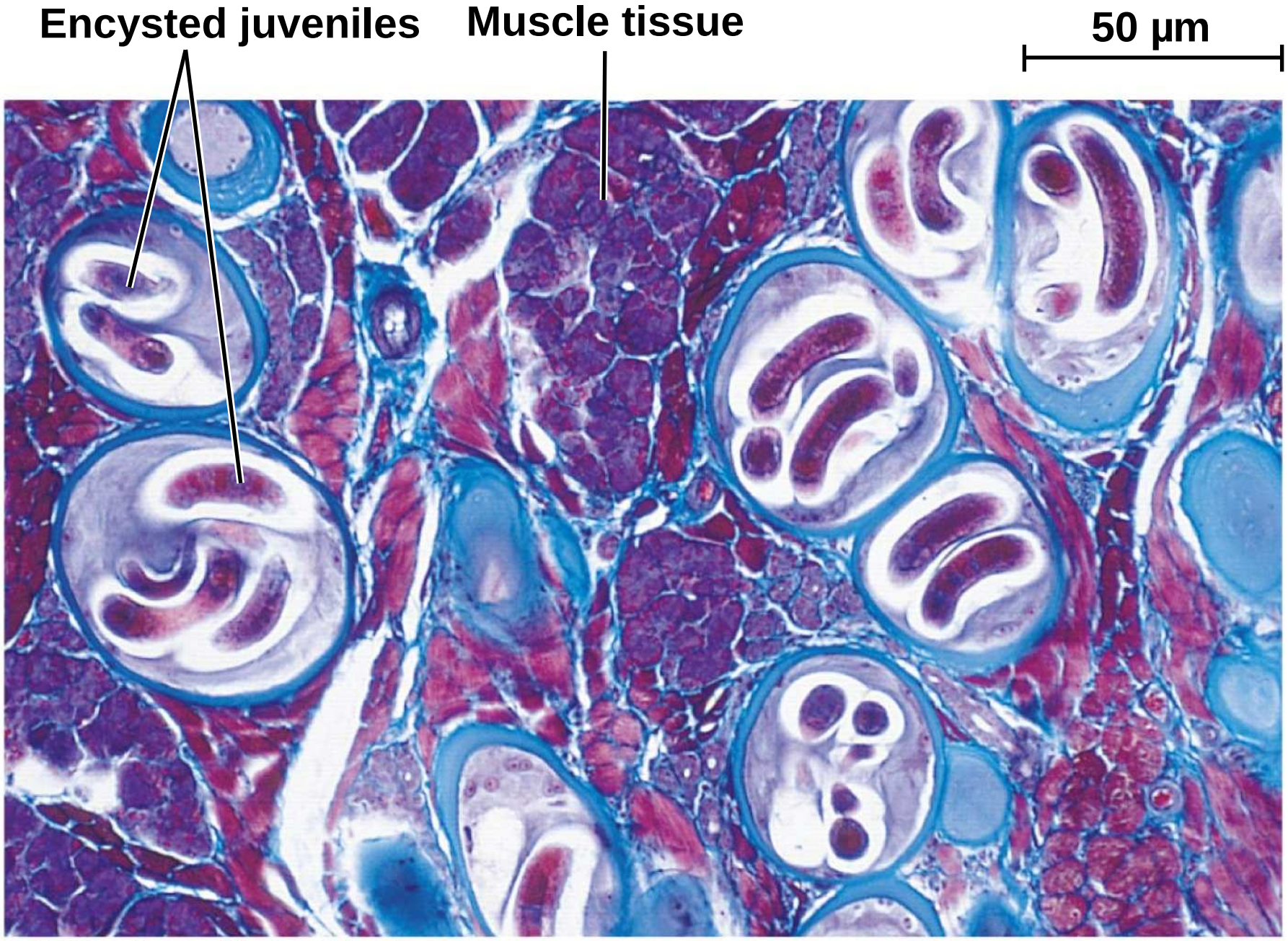
PLAY Video: *C. elegans* Embryo Development (Time Lapse)

Fig. 33-25



- Some species of nematodes are important parasites of plants and animals

Fig. 33-26



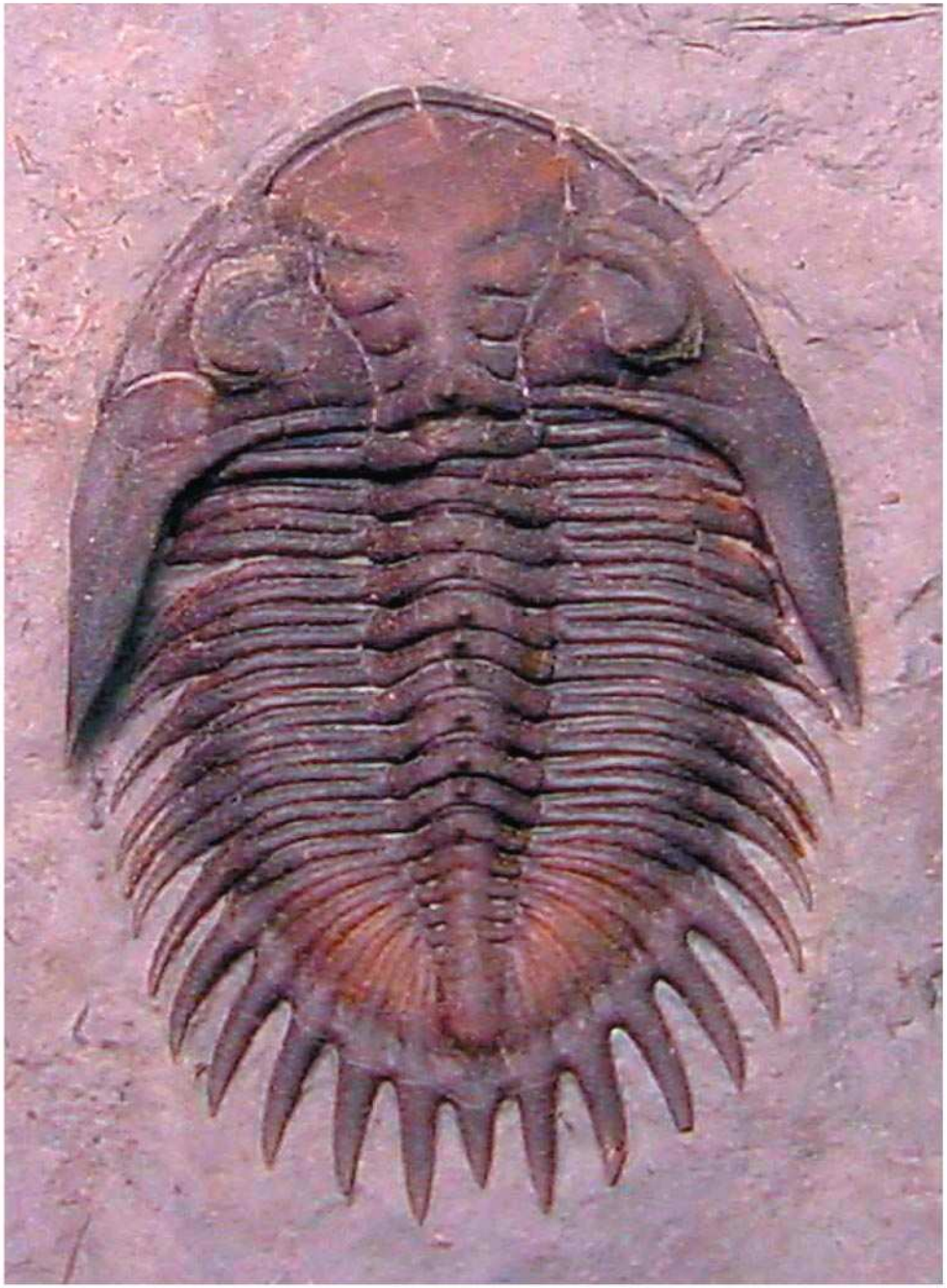
Arthropods

- Two out of every three known species of animals are arthropods
- Members of the phylum Arthropoda are found in nearly all habitats of the biosphere

Arthropod Origins

- The **arthropod** body plan consists of a segmented body, hard exoskeleton, and jointed appendages, and dates to the Cambrian explosion (535–525 million years ago)
- Early arthropods show little variation from segment to segment

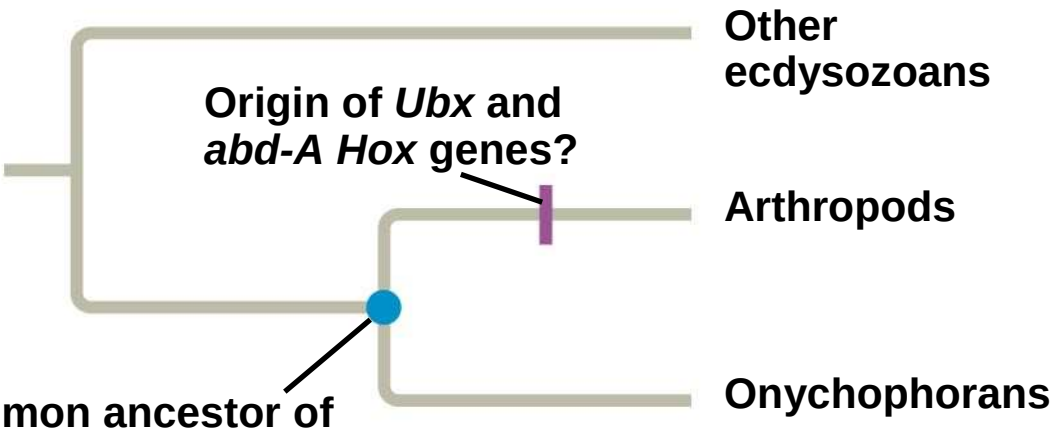
Fig. 33-27



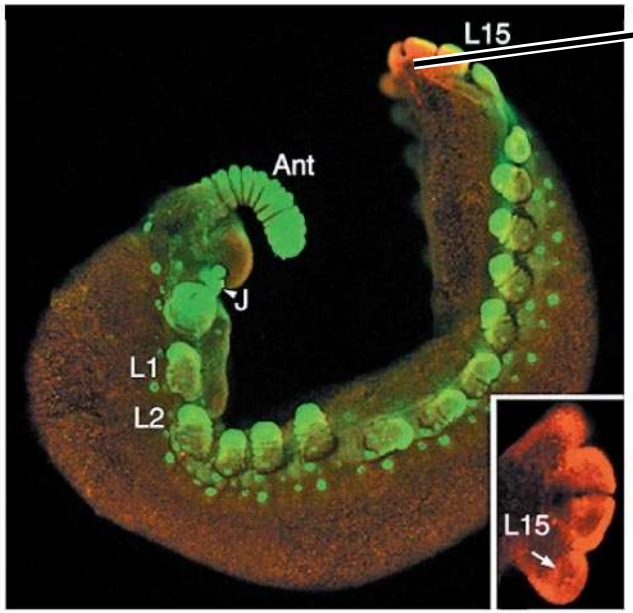
- Arthropod evolution is characterized by a decrease in the number of segments and an increase in appendage specialization
- These changes may have been caused by changes in *Hox* gene sequence or regulation

Fig. 33-28

EXPERIMENT



RESULTS



***Ubx* or *abd-A* genes expressed**

Ant = antenna
J = jaws
L1–L15 = body segments

Fig. 33-28a

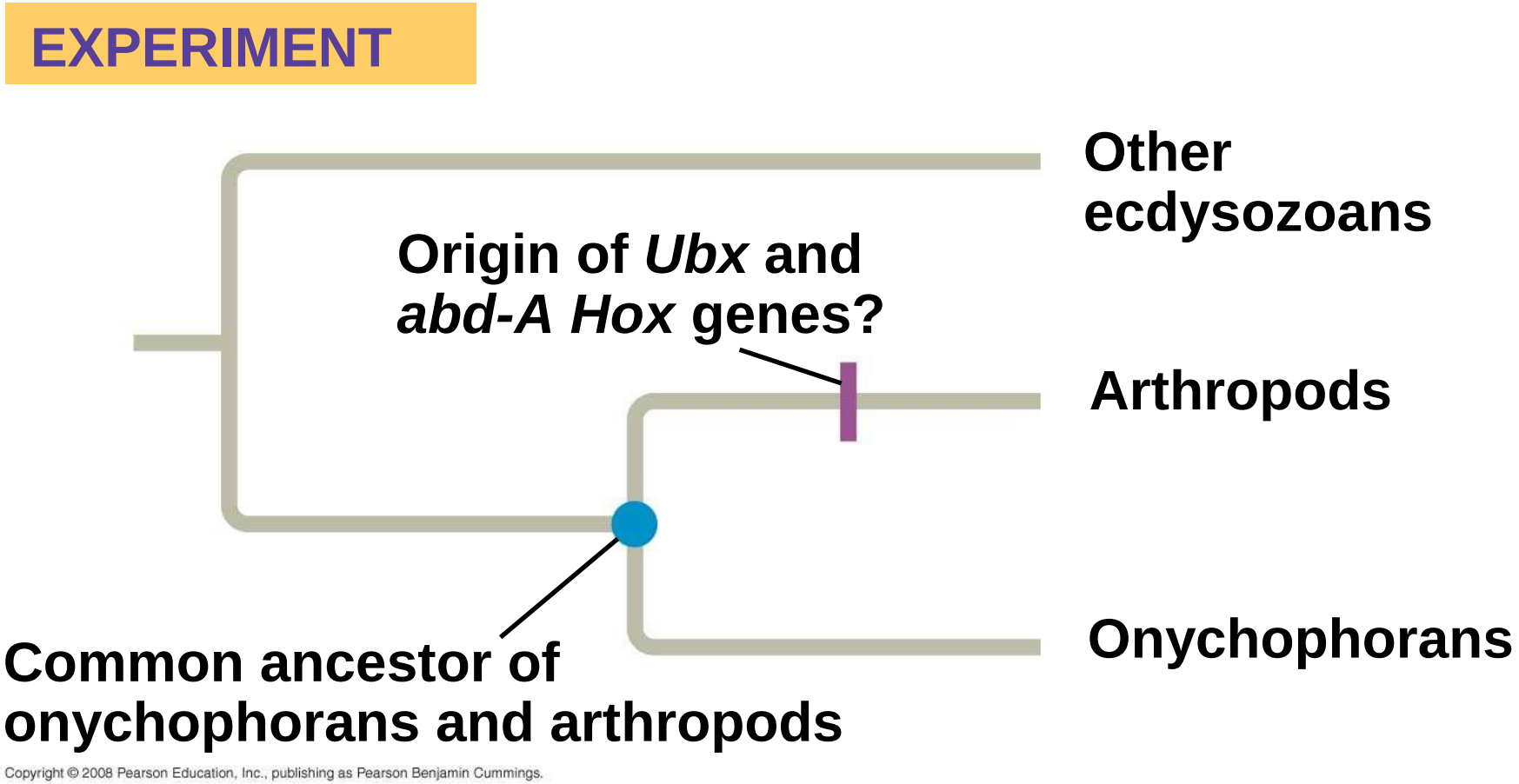
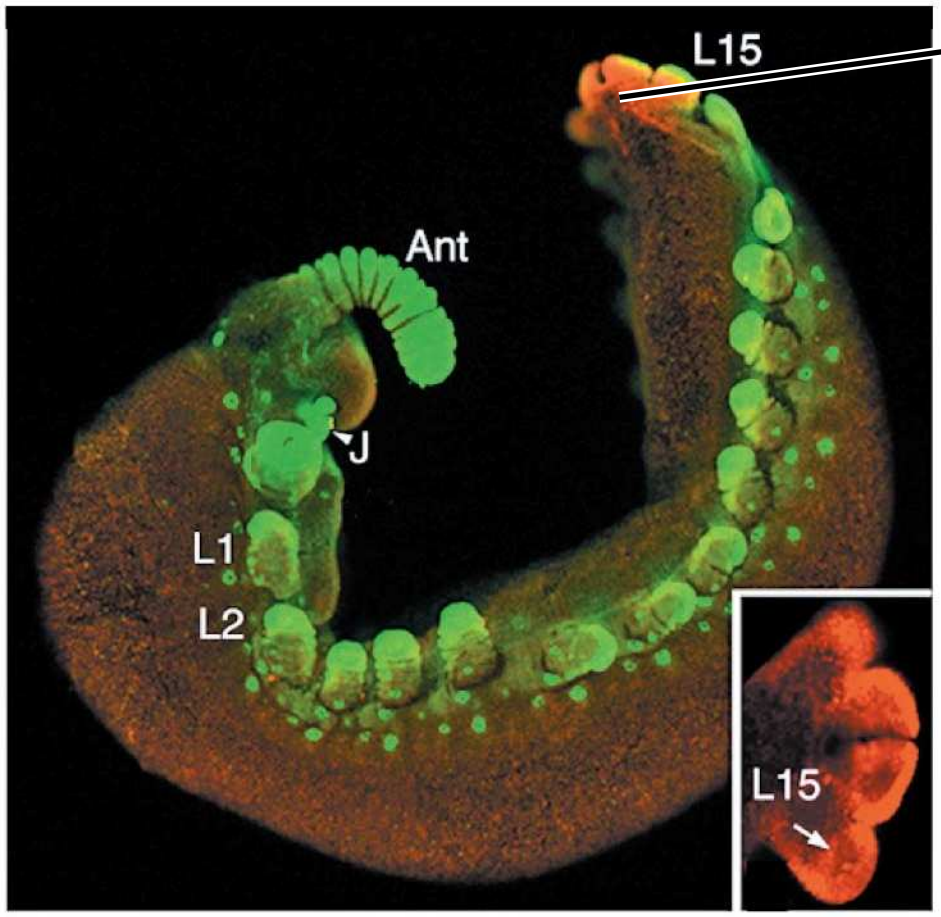


Fig. 33-28b

RESULTS



***Ubx* or *abd-A* genes expressed**

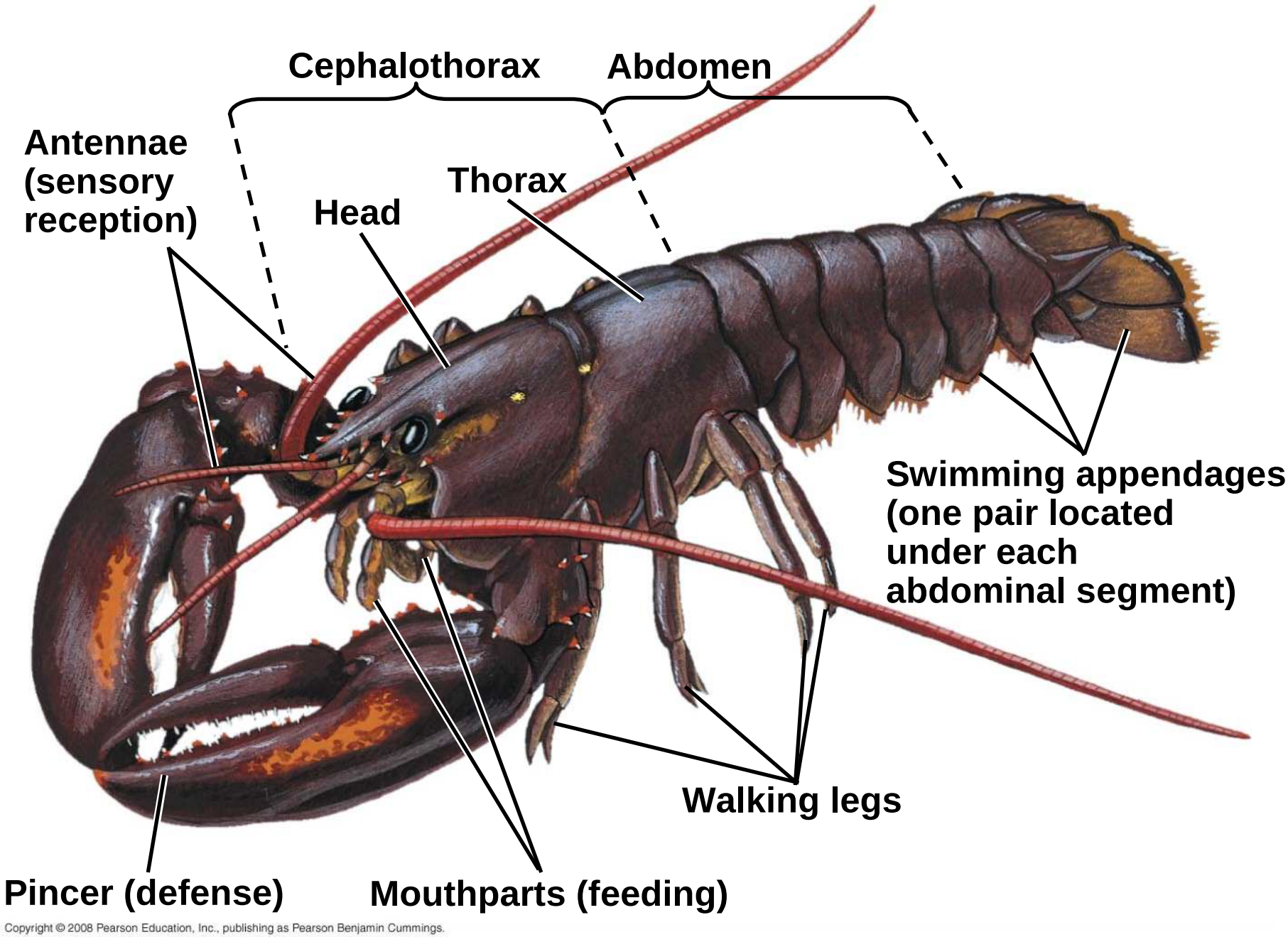
Ant = antenna
J = jaws
L1–L15 = body segments

General Characteristics of Arthropods

- The appendages of some living arthropods are modified for many different functions

PLAY Video: Lobster Mouth Parts

Fig. 33-29



- The body of an arthropod is completely covered by the cuticle, an exoskeleton made of layers of protein and the polysaccharide chitin
- When an arthropod grows, it molts its exoskeleton

- Arthropods have an **open circulatory system** in which fluid called *hemolymph* is circulated into the spaces surrounding the tissues and organs
- A variety of organs specialized for gas exchange have evolved in arthropods

- Molecular evidence suggests that living arthropods consist of four major lineages that diverged early in the phylum's evolution:
  - **Cheliceriforms** (sea spiders, horseshoe crabs, scorpions, ticks, mites, and spiders)
  - **Myriapods** (centipedes and millipedes)
  - **Hexapods** (insects and relatives)
  - **Crustaceans** (crabs, lobsters, shrimps, barnacles, and many others)

Table 33-5

Table 33.5 Subphyla of Phylum Arthropoda

Subphylum and Examples	Main Characteristics
Cheliceriformes (horseshoe crabs, spiders, scorpions, ticks, mites)	Body having one or two main parts; six pairs of appendages mostly terrestrial or marine
Myriapoda (millipedes and centipedes)	Distinct head bearing antennae and chewing mouthparts; terrestrial
Hexapoda (insects, springtails)	Body divided into head, thorax, and abdomen; antennae present; three pairs of legs and usually two pairs of wings; mostly terrestrial
Crustacea (crabs, lobsters, crayfishes, shrimps)	Body of two or three parts; antennae present; chewing mouthparts; three or more pairs of legs; mostly marine and freshwater

Cheliceriforms

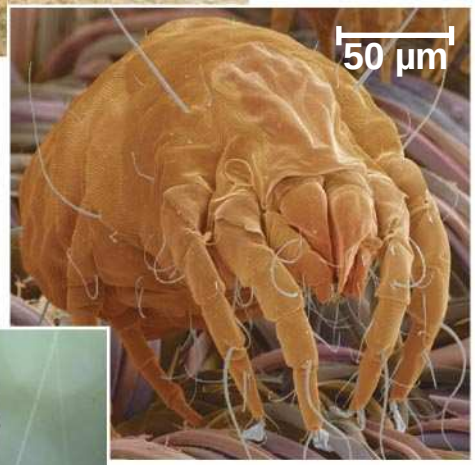
- Cheliceriforms, subphylum Cheliceriformes, are named for clawlike feeding appendages called **chelicerae**
- The earliest cheliceriforms were **eurypterids** (water scorpions)
- Most marine cheliceriforms (including eurypterids) are extinct, but some species survive today, including horseshoe crabs

Fig. 33-30

- Most modern cheliceriforms are **arachnids**, which include spiders, scorpions, ticks, and mites

Fig. 33-31

▲ Scorpion



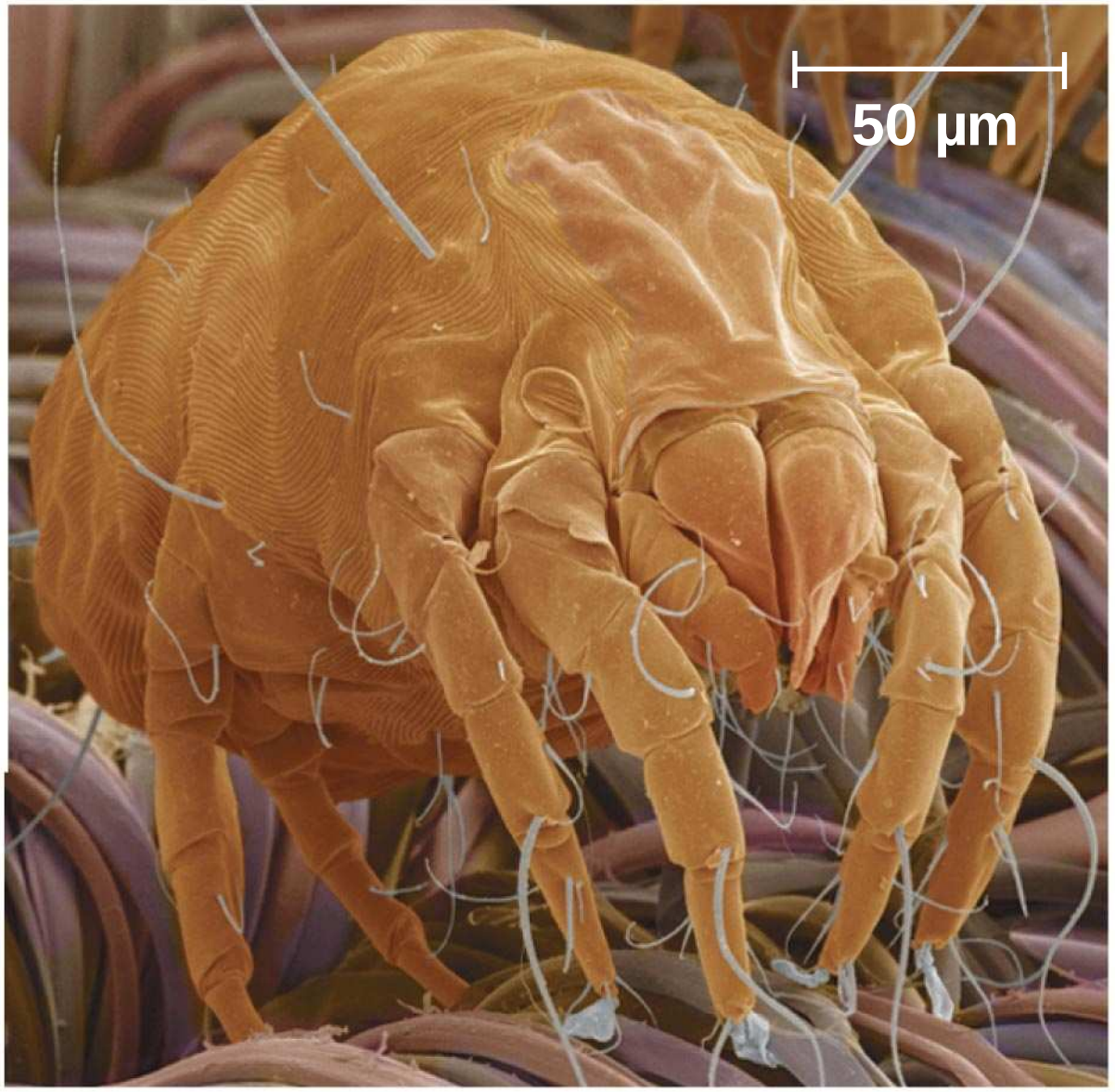
▲ Dust mite

◀ Web-building spider

Fig. 33-31a

Scorpion

Fig. 33-31b



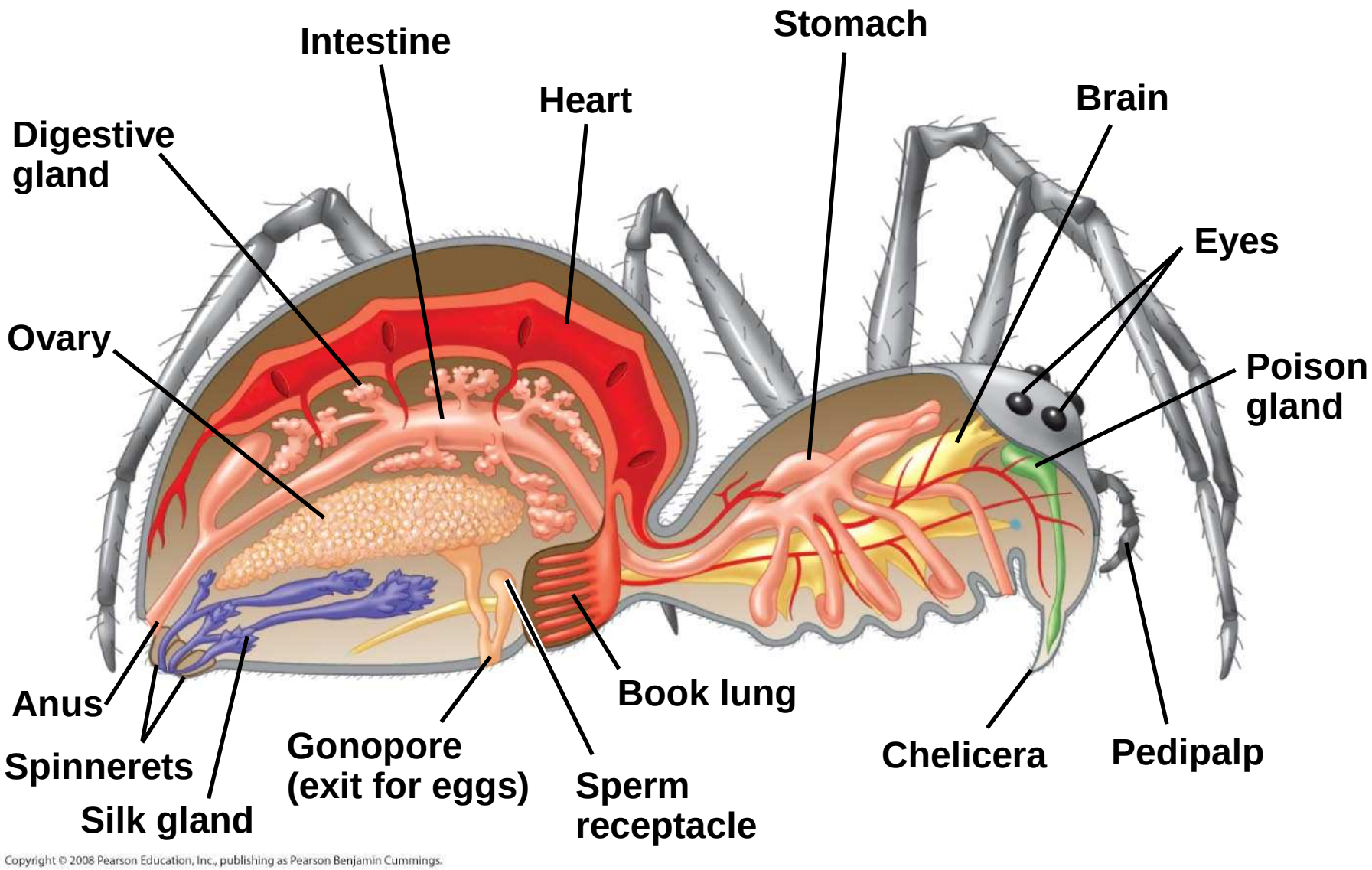
▲ **Dust mite**

Fig. 33-31c

◄ **Web-building spider**

- Arachnids have an abdomen and a cephalothorax, which has six pairs of appendages, the most anterior of which are the chelicerae
- Gas exchange in spiders occurs in respiratory organs called **book lungs**
- Many spiders produce silk, a liquid protein, from specialized abdominal glands

Fig. 33-32



Myriapods

- Subphylum Myriapoda includes millipedes and centipedes
  - Myriapods are terrestrial, and have jaw-like **mandibles**
- Millipedes, class Diplopoda, have many legs
  - Each trunk segment has two pairs of legs

Fig. 33-33

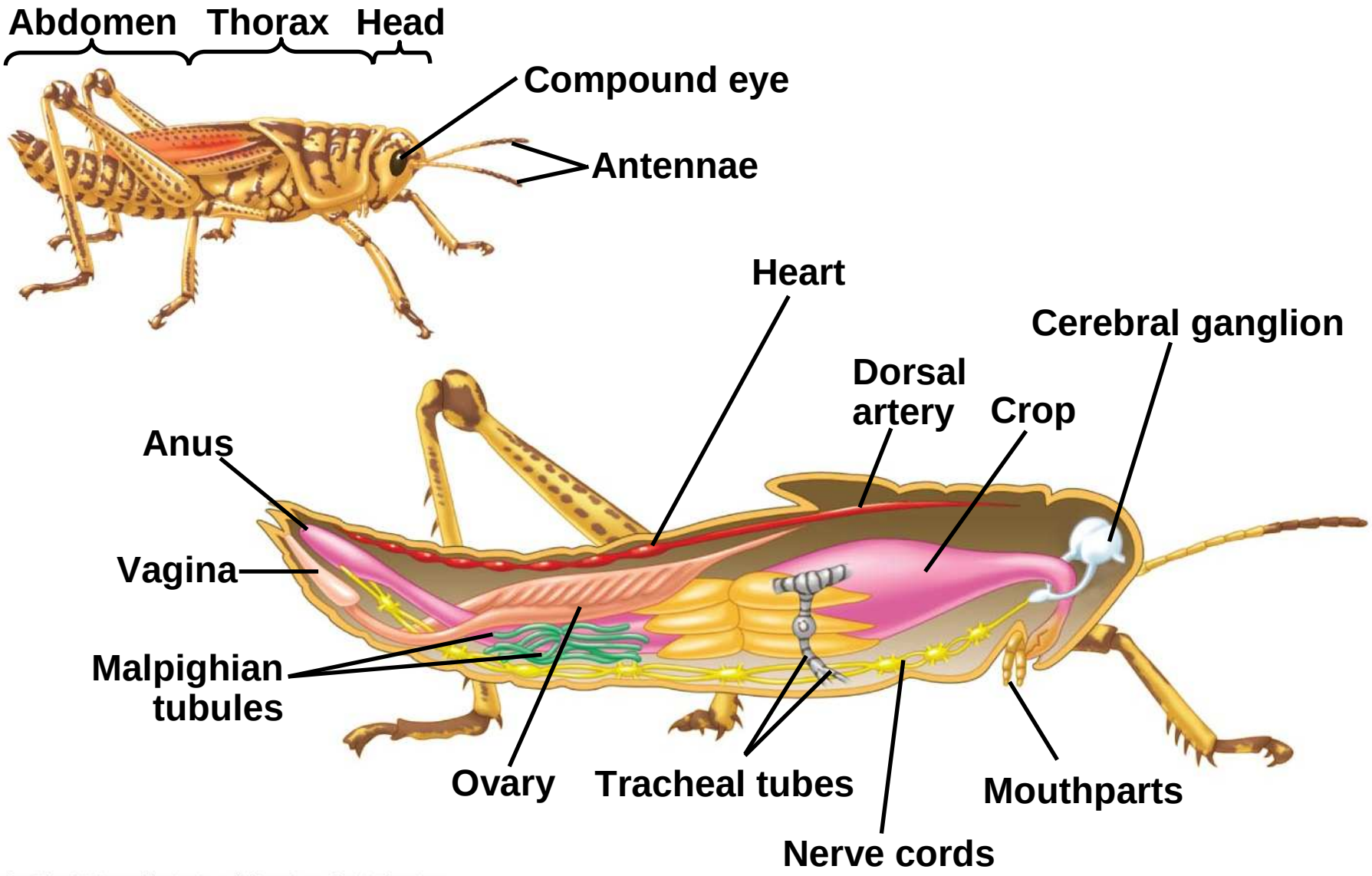
- Centipedes, class Chilopoda, are carnivores
  - They have one pair of legs per trunk segment

Fig. 33-34

Insects

- Subphylum Hexapoda, insects and relatives, has more species than all other forms of life combined
- They live in almost every terrestrial habitat and in fresh water
- The internal anatomy of an insect includes several complex organ systems

Fig. 33-35



- Insects diversified several times following the evolution of flight, adaptation to feeding on gymnosperms, and the expansion of angiosperms
- Insect and plant diversity declined during the Cretaceous extinction, but have been increasing in the 65 million years since

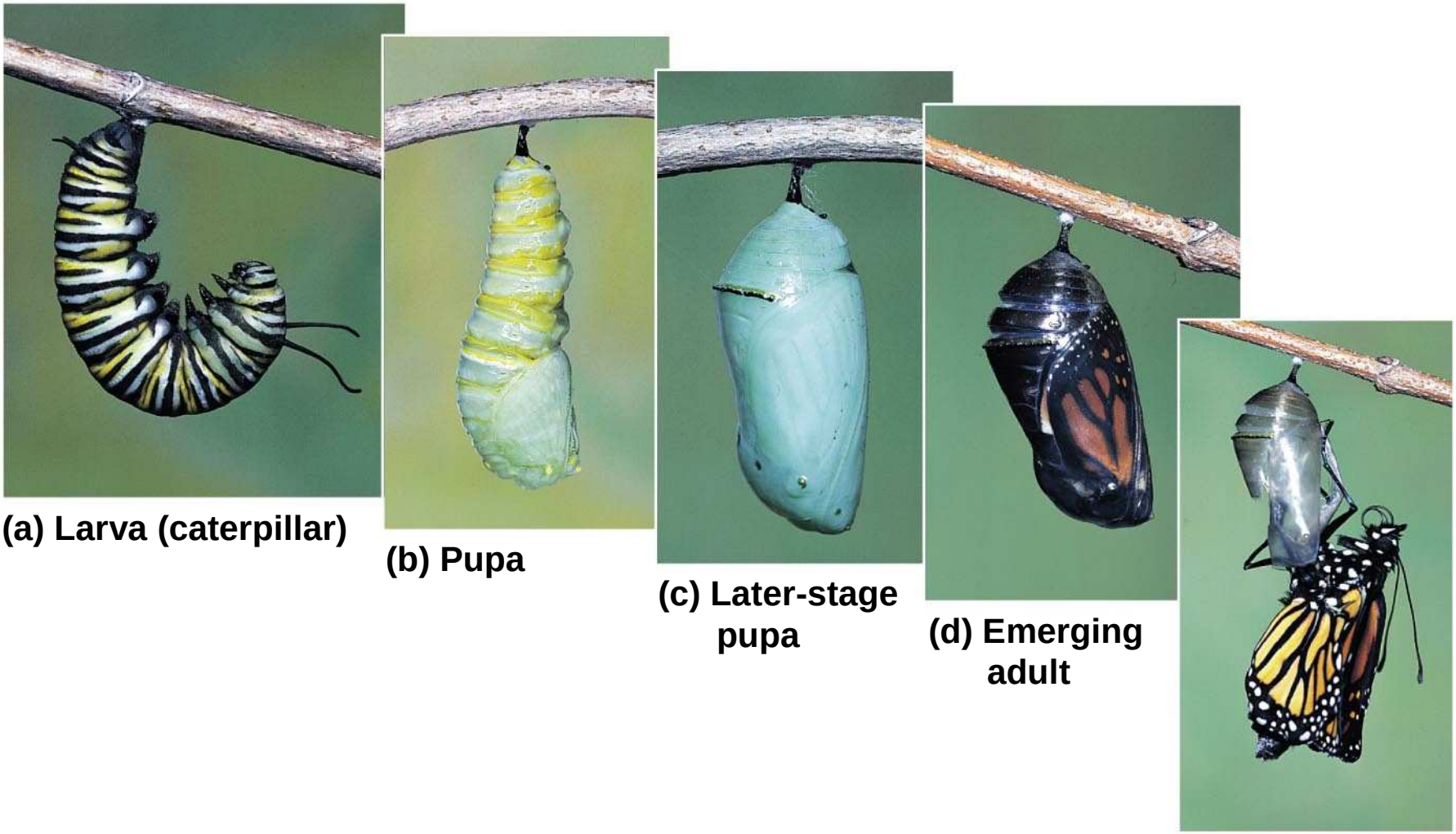
- Flight is one key to the great success of insects
- An animal that can fly can escape predators, find food, and disperse to new habitats much faster than organisms that can only crawl

- Many insects undergo metamorphosis during their development
- In **incomplete metamorphosis**, the young, called nymphs, resemble adults but are smaller and go through a series of molts until they reach full size

- Insects with **complete metamorphosis** have larval stages known by such names as maggot, grub, or caterpillar
- The larval stage looks entirely different from the adult stage

PLAY Video: Butterfly Emerging

Fig. 33-36



(a) Larva (caterpillar)

(b) Pupa

(c) Later-stage pupa

(d) Emerging adult

(e) Adult

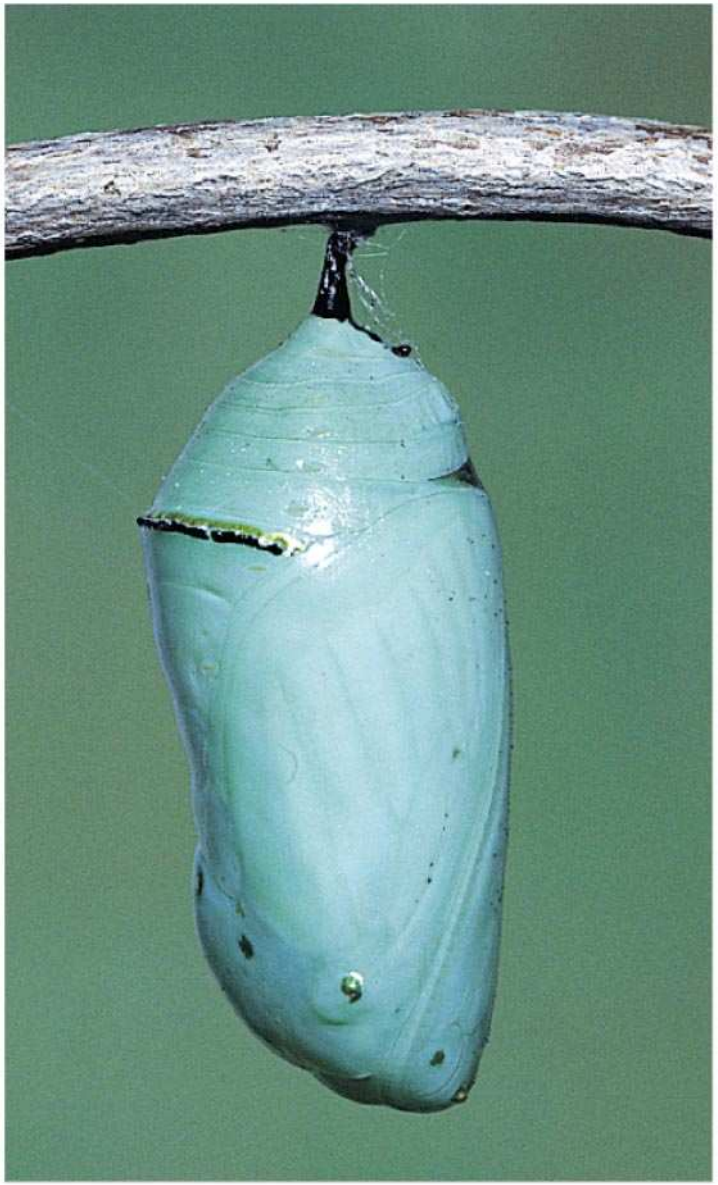
Fig. 33-36a

(a) Larva (caterpillar)

Fig. 33-36b

(b) Pupa

Fig. 33-36c



(c) Later-stage pupa

Fig. 33-36d

(d) Emerging adult

Fig. 33-36e

(e) Adult

- Most insects have separate males and females and reproduce sexually
- Individuals find and recognize members of their own species by bright colors, sound, or odors
- Some insects are beneficial as pollinators, while others are harmful as carriers of diseases, or pests of crops
- Insects are classified into more than 30 orders

PLAY Video: Bee Pollinating

Fig. 33-37

Order	Approximate Number of Species	Examples
Blattodea	4,000	German cockroach 
Coleoptera	350,000	Japanese beetle 
Dermaptera	1,200	 Earwig
Diptera	151,000	Horsefly 
Hemiptera	85,000	Leaf-footed bug 
Hymenoptera	125,000	 Cicada-killer wasp
Isoptera	2,000	 Termite

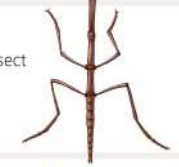
Order	Approximate Number of Species	Examples
Lepidoptera	120,000	Swallowtail butterfly 
Odonata	5,000	 Dragonfly
Orthoptera	13,000	 Katydid
Phasmatodea	2,600	Stick insect 
Phthiraptera	2,400	Human body louse 
Siphonaptera	2,400	 Flea
Thysanura	450	 Silverfish
Trichoptera	7,100	 Caddisfly

Fig. 33-37a

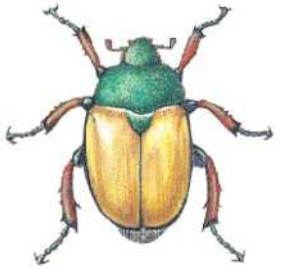
Order	Approximate Number of Species	Examples
Blattodea	4,000	German cockroach 
Coleoptera	350,000	Japanese beetle 
Dermaptera	1,200	 Earwig

Fig. 33-37b

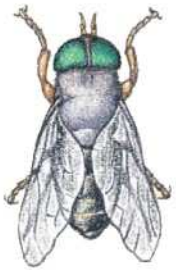
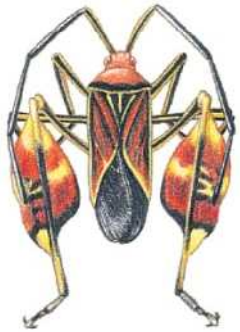
Order	Approximate Number of Species	Examples
Diptera	151,000	Horsefly 
Hemiptera	85,000	Leaf-footed bug 
Hymenoptera	125,000	 Cicada-killer wasp

Fig. 33-37c

Order	Approximate Number of Species	Examples
Isoptera	2,000	 Termite
Lepidoptera	120,000	Swallowtail butterfly 
Odonata	5,000	 Dragonfly

Fig. 33-37d

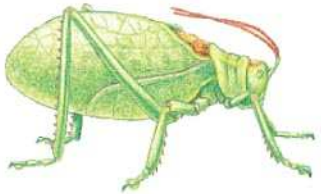
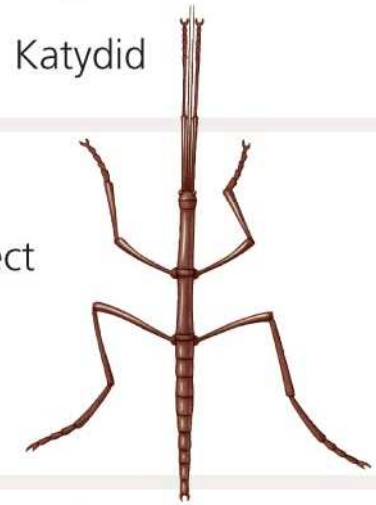
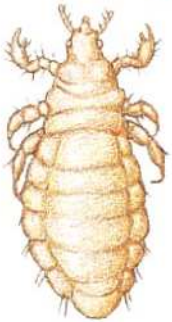
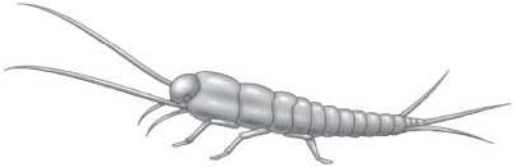
Order	Approximate Number of Species	Examples
Orthoptera	13,000	 Katydid
Phasmatodea	2,600	Stick insect 
Phthiraptera	2,400	Human body louse 

Fig. 33-37e

Order	Approximate Number of Species	Examples
Siphonaptera	2,400	 Flea
Thysanura	450	 Silverfish
Trichoptera	7,100	 Caddisfly

Crustaceans

- While arachnids and insects thrive on land, crustaceans, for the most part, have remained in marine and freshwater environments
- Crustaceans, subphylum Crustacea, typically have branched appendages that are extensively specialized for feeding and locomotion
- Most crustaceans have separate males and females

- **Isopods** include terrestrial, freshwater, and marine species
  - Pill bugs are a well known group of terrestrial isopods
- **Decapods** are all relatively large crustaceans and include lobsters, crabs, crayfish, and shrimp

Fig. 33-38

(a) Ghost crab

(b) Krill

(c) Barnacles

Fig. 33-38a

(a) Ghost crab

- Planktonic crustaceans include many species of **copepods**, which are among the most numerous of all animals

Fig. 33-38b

(b) Krill

- Barnacles are a group of mostly sessile crustaceans
- They have a cuticle that is hardened into a shell

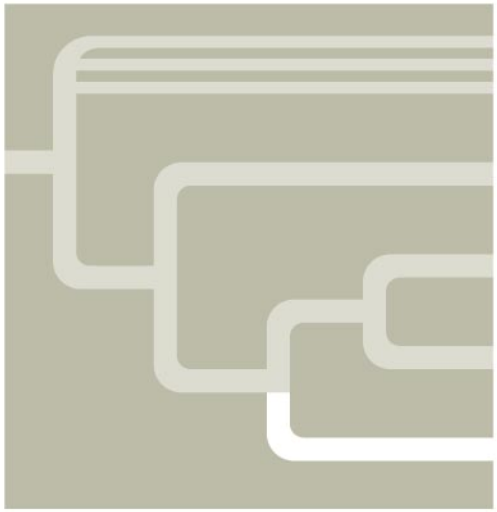
Fig. 33-38c

(c) Barnacles

Concept 33.5: Echinoderms and chordates are deuterostomes

- Sea stars and other echinoderms, phylum Echinodermata, may seem to have little in common with phylum Chordata, which includes the vertebrates
- Shared characteristics define deuterostomes (Chordates and Echinoderms)
  - Radial cleavage
  - Formation of the mouth at the end of the embryo opposite the blastopore

Fig. 33-UN5



Calcarea and Silicea

Cnidaria

Lophotrochozoa

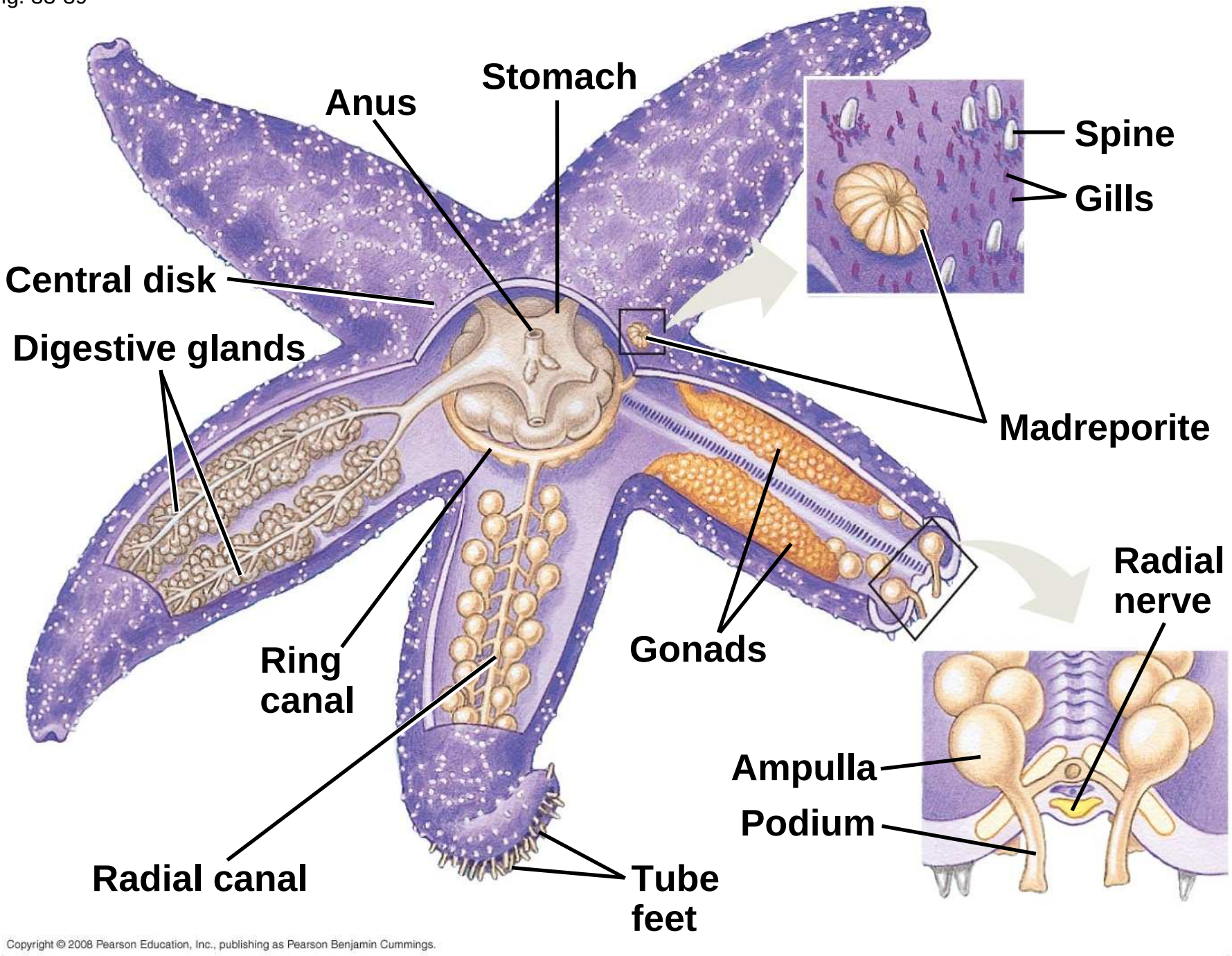
Ecdysozoa

Deuterostomia

Echinoderms

- Sea stars and most other **echinoderms** are slow-moving or sessile marine animals
- A thin epidermis covers an endoskeleton of hard calcareous plates
- Echinoderms have a unique **water vascular system**, a network of hydraulic canals branching into **tube feet** that function in locomotion, feeding, and gas exchange
- Males and females are usually separate, and sexual reproduction is external

Fig. 33-39



- Living echinoderms are divided into six classes:
  - Asteroidia (sea stars)
  - Ophiuroidea (brittle stars)
  - Echinoidea (sea urchins and sand dollars)
  - Crinoidea (sea lilies and feather stars)
  - Holothuroidea (sea cucumbers)
  - Concentricycloidea (sea daisies)

PLAY Video: Echinoderm Tube Feet

Table 33-6

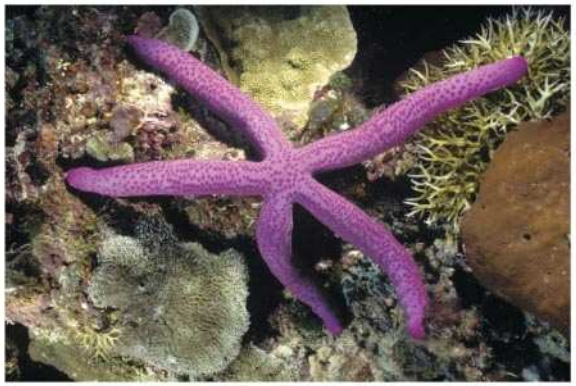
Table 33.6 Classes of Phylum Echinodermata

Class and Examples	Main Characteristics
Asteroidea (sea stars)	Star-shaped body with multiple arms; mouth directed to substrate
Ophiuroidea (brittle stars)	Distinct central disk; long, flexible arms; incomplete digestive system
Echinoidea (sea urchins, sand dollars)	Roughly spherical or disk-shaped; no arms; five rows of tube feet; mouth ringed by complex, jaw-like structure
Crinoidea (sea lilies, feather stars)	Feathered arms surrounding upward-pointing mouth
Holothuroidea (sea cucumbers)	Cucumber-shaped body; five rows of tube feet; reduced skeleton; no spines
Concentricycloidea (sea daisies)	Armless, disk-shaped body ringed with small spines; incomplete digestive system

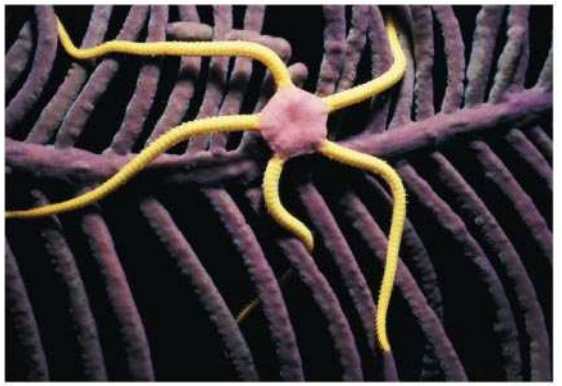
Sea Stars

- Sea stars, class Asteroidea, have multiple arms radiating from a central disk
- The undersurfaces of the arms bear tube feet, each of which can act like a suction disk
- Sea stars can regrow lost arms

Fig. 33-40



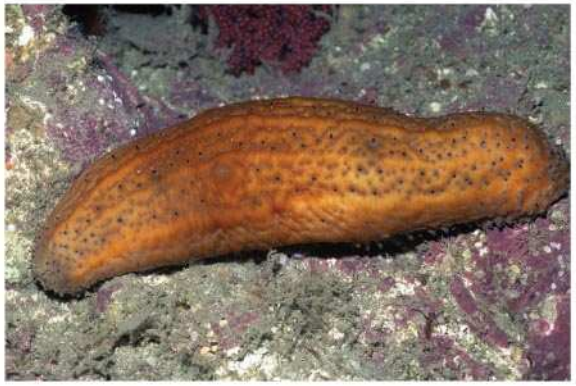
(a) A sea star (class Asteroidea)



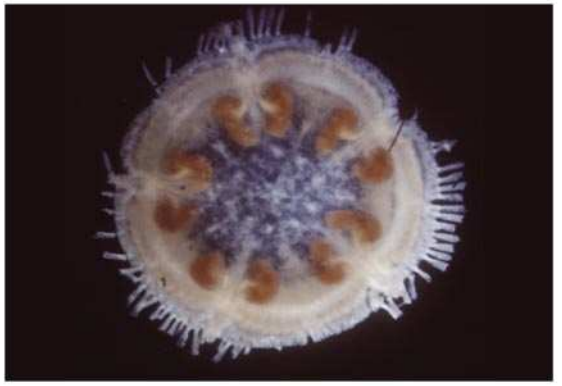
(b) A brittle star (class Ophiuroidea)

(c) A sea urchin (class Echinoidea)

(d) A feather star (class Crinoidea)

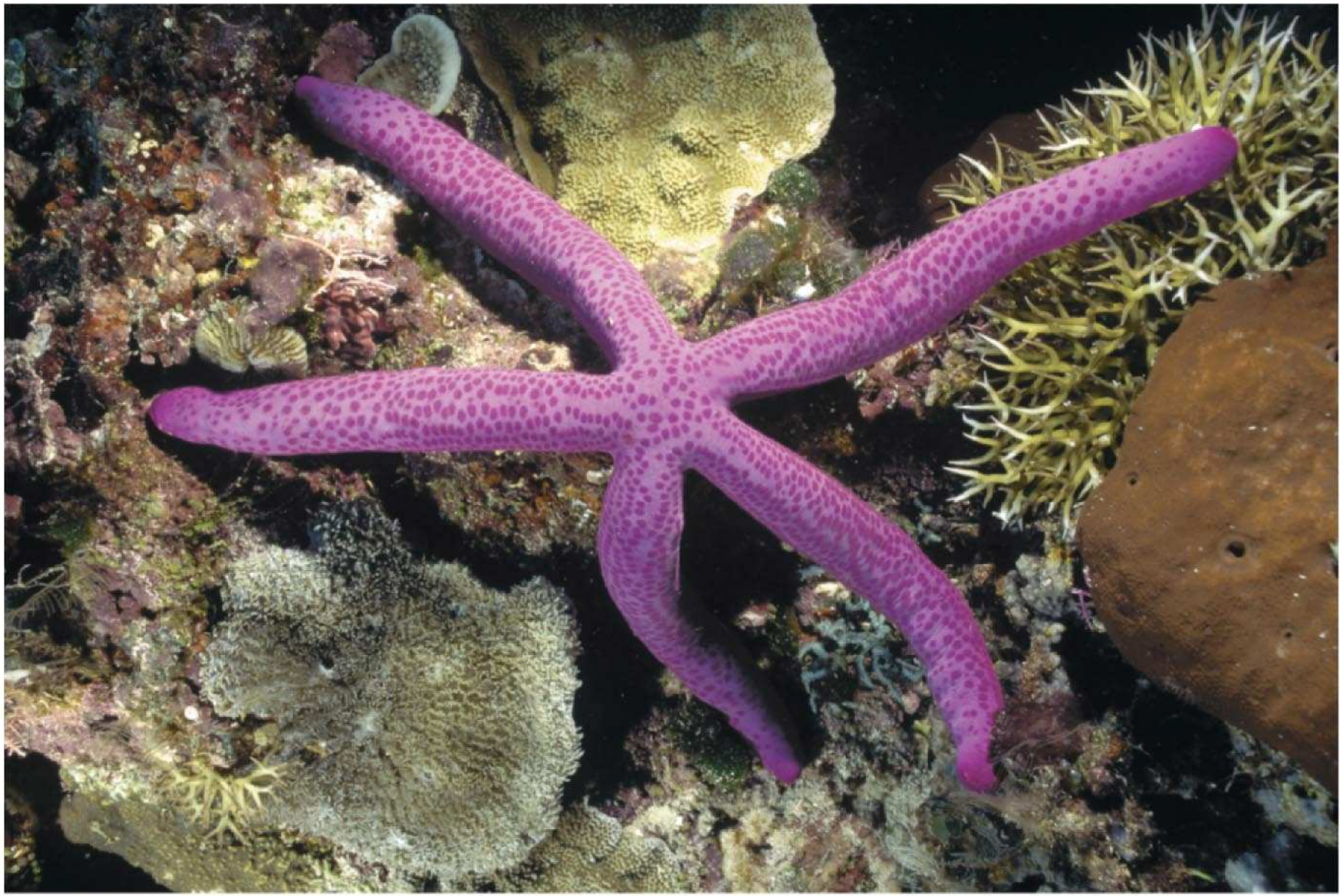


(e) A sea cucumber (class Holothuroidea)



(f) A sea daisy (class Concentricycloidea)

Fig. 33-40a

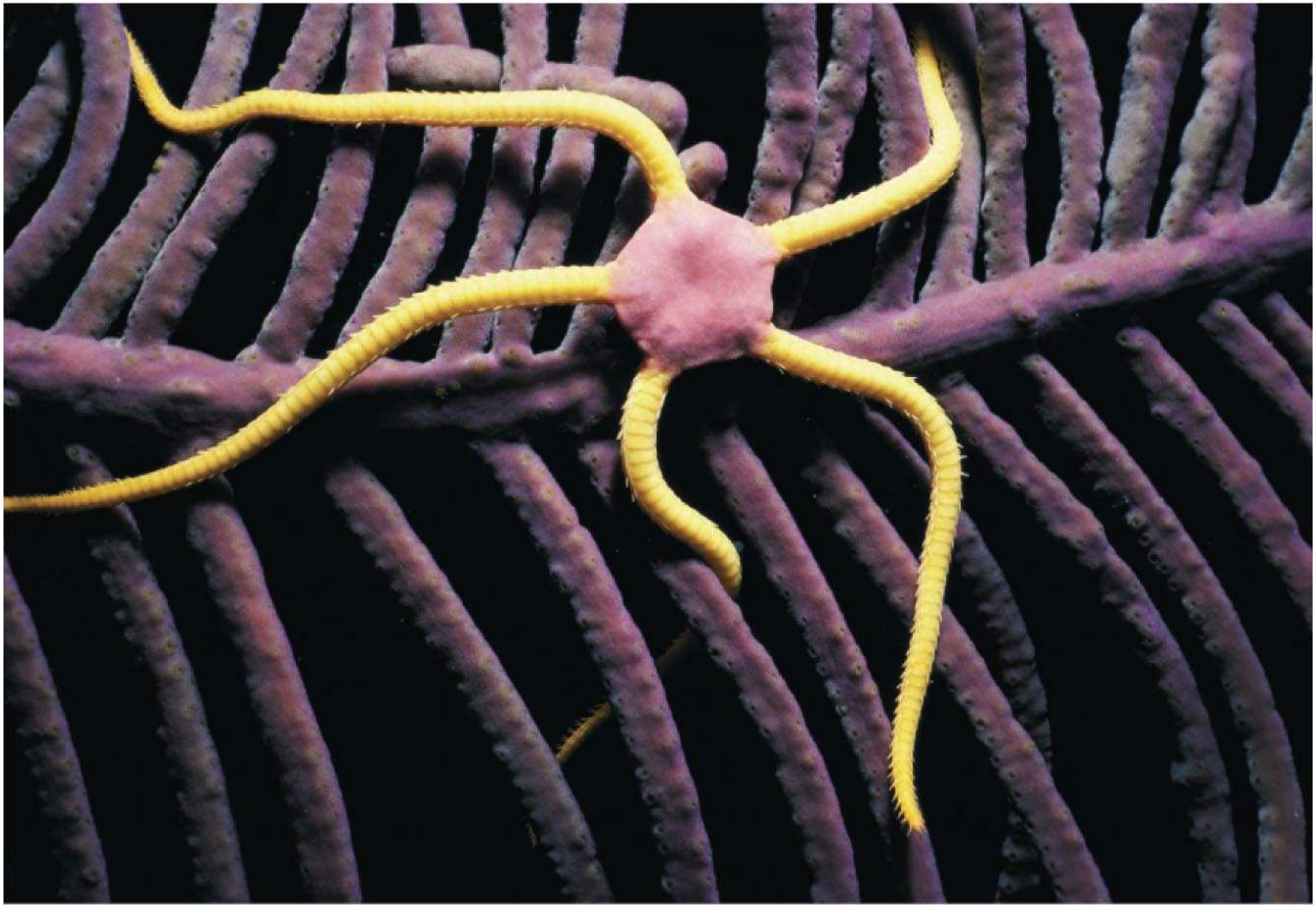


(a) A sea star (class Asteroidea)

Brittle Stars

- Brittle stars have a distinct central disk and long, flexible arms, which they use for movement

Fig. 33-40b

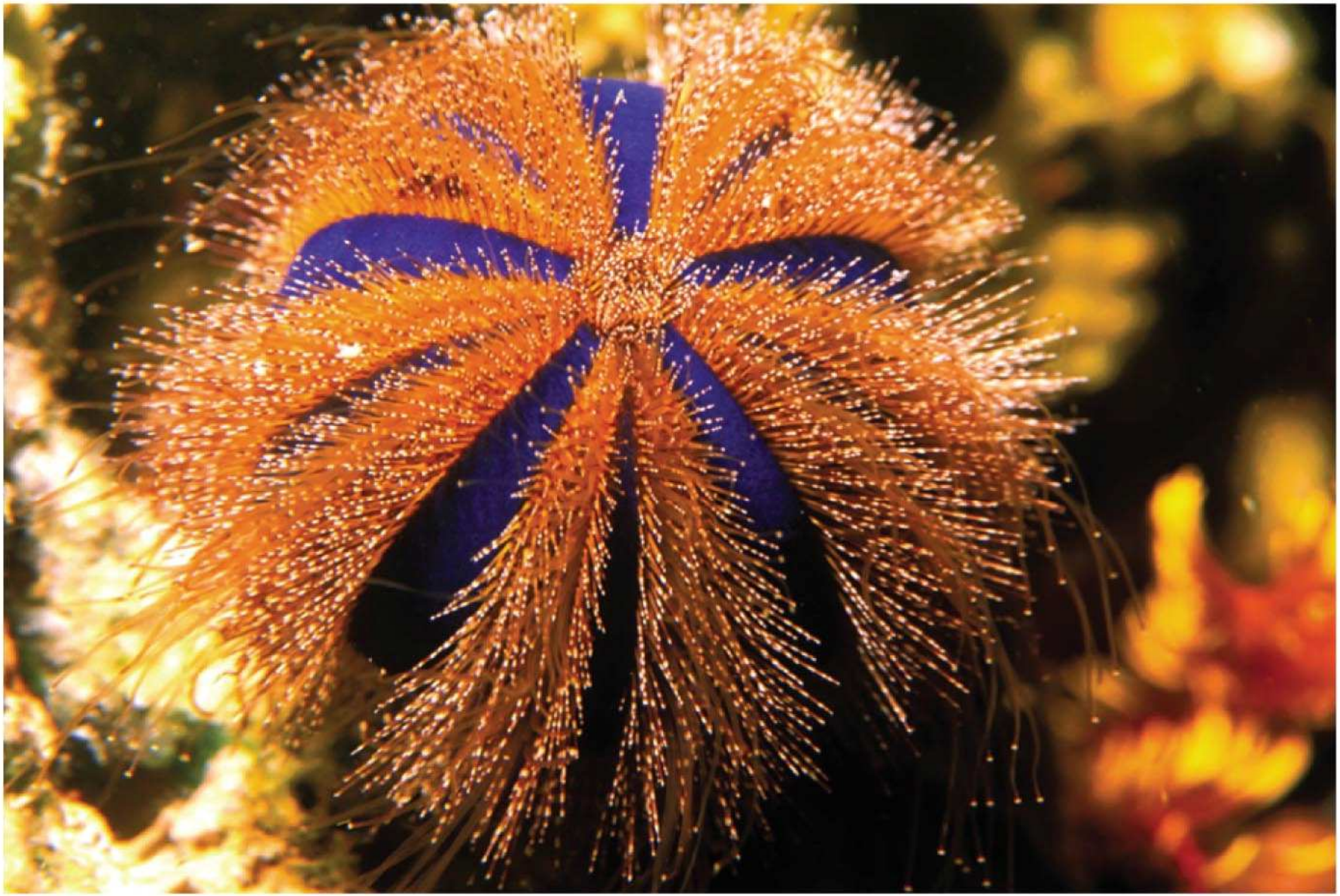


(b) A brittle star (class Ophiuroidea)

Sea Urchins and Sand Dollars

- Sea urchins and sand dollars have no arms but have five rows of tube feet

Fig. 33-40c

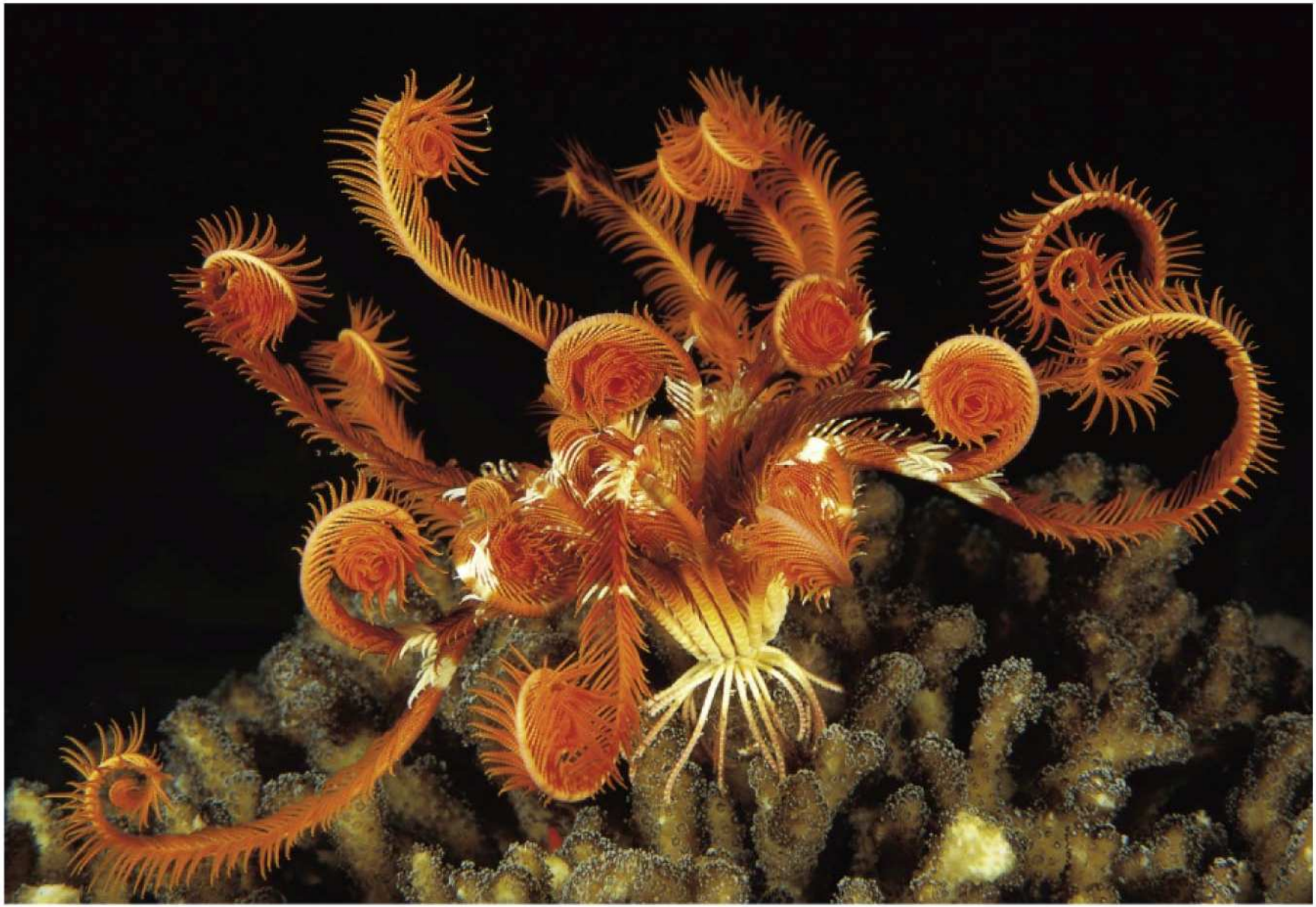


(c) A sea urchin (class Echinoidea)

Sea Lilies and Feather Stars

- Sea lilies live attached to the substrate by a stalk
- Feather stars can crawl using long, flexible arms

Fig. 33-40d



(d) A feather star (class Crinoidea)

Sea Cucumbers

- Sea cucumbers lack spines, have a very reduced endoskeleton, and do not look much like other echinoderms
- Sea cucumbers have five rows of tube feet; some of these are developed as feeding tentacles

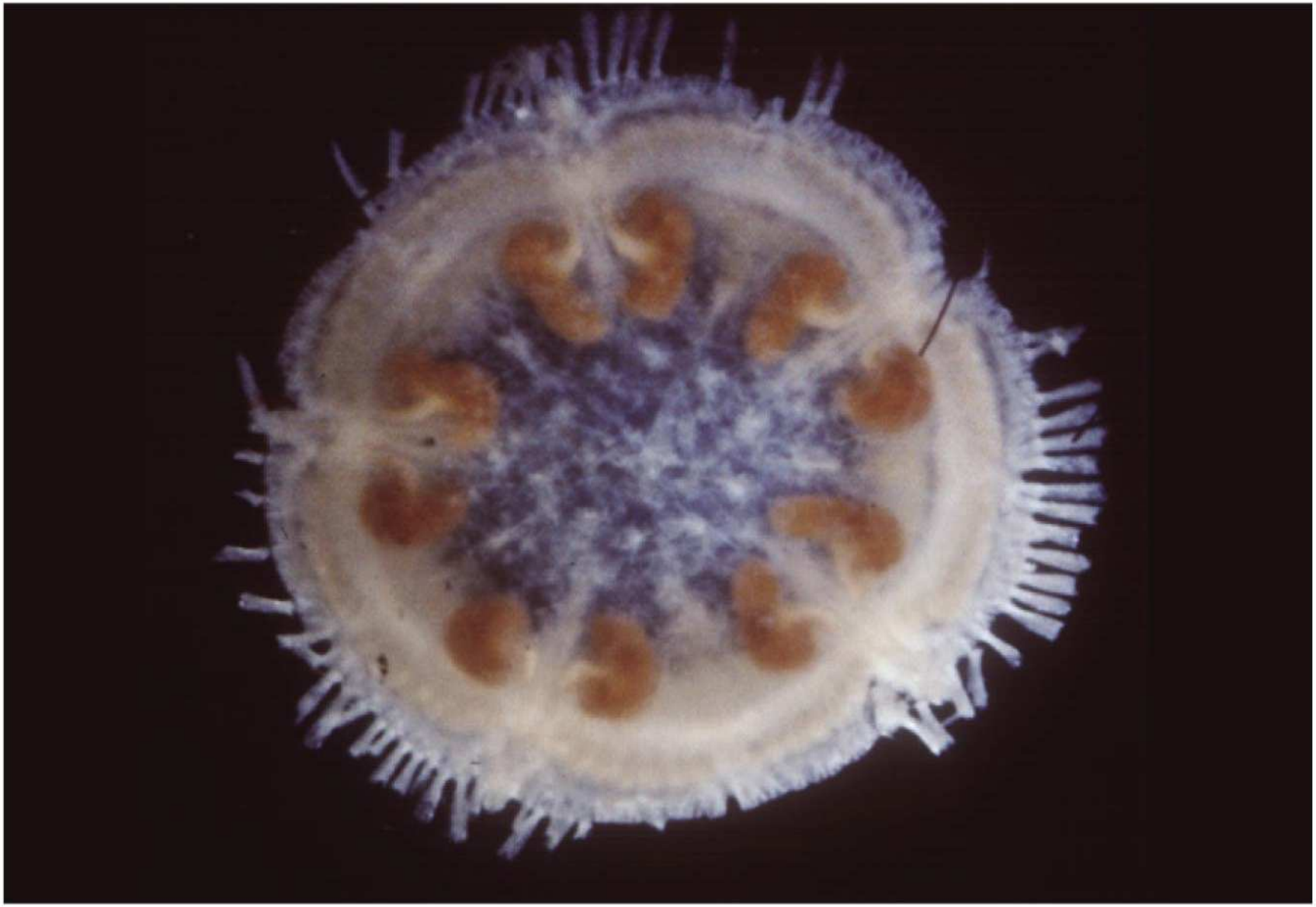
Fig. 33-40e

(e) A sea cucumber (class Holothuroidea)

Sea Daisies

- Sea daisies were discovered in 1986, and only three species are known

Fig. 33-40f



(f) A sea daisy (class Concentricycloidea)

Chordates

- Phylum Chordata consists of two subphyla of invertebrates as well as hagfishes and vertebrates
- Chordates share many features of embryonic development with echinoderms, but have evolved separately for at least 500 million years

Fig. 33-UN6

Key Concept	Phylum		Description
Concept 33.1 Sponges are basal animals that lack true tissues	Calcarea, Silicea (sponges)		Lack true tissues; have choanocytes (collar cells—flagellated cells that ingest bacteria and tiny food particles)
Concept 33.2 Cnidarians are an ancient phylum of eumetazoans	Cnidaria (hydras, jellies, sea anemones, corals)		Unique stinging structures (cnidae), each housed in a specialized cell (cnidocyte); diploblastic; radially symmetrical; gastrovascular cavity (digestive compartment with a single opening)
Concept 33.3 Lophotrochozoans, a clade identified by molecular data, have the widest range of animal body forms	Platyhelminthes (flatworms)		Dorsoventrally flattened, unsegmented acoelomates; gastrovascular cavity or no digestive tract
	Rotifera (rotifers)		Pseudocoelomates with alimentary canal (digestive tube with mouth and anus); jaws (trophi) in pharynx; head with ciliated crown
	Lophophorates: Ectoprocta, Brachiopoda		Coelomates with lophophores (feeding structures bearing ciliated tentacles)
	Mollusca (clams, snails, squids)		Coelomates with three main body parts (muscular foot, visceral mass, mantle); coelom reduced; most have hard shell made of calcium carbonate
	Annelida (segmented worms)		Coelomates with segmented body wall and internal organs (except digestive tract, which is unsegmented)
Concept 33.4 Ecdysozoans are the most species-rich animal group	Nematoda (roundworms)		Cylindrical, unsegmented pseudocoelomates with tapered ends; no circulatory system; undergoes ecdysis
	Arthropoda (crustaceans, insects, spiders)		Coelomates with segmented body, jointed appendages, and exoskeleton made of protein and chitin
Concept 33.5 Echinoderms and chordates are deuterostomes	Echinodermata (sea stars, sea urchins)		Coelomates with bilaterally symmetrical larvae and five-part body organization as adults; unique water vascular system; endoskeleton
	Chordata (lancelets, tunicates, vertebrates)		Coelomates with notochord; dorsal, hollow nerve cord; pharyngeal slits; post-anal tail (see Chapter 34)

Metazoa
Eumetazoa
Bilateria
Lophotrochozoa
Ecdysozoa
Deuterostomia

Fig. 33-UN6a

Key Concept	Phylum	Description
Concept 33.1 Sponges are basal animals that lack true tissues	Calcarea, Silicea (sponges)	Lack true tissues; have choanocytes (collar cells—flagellated cells that ingest bacteria and tiny food particles)

Fig. 33-UN6b

Key Concept	Phylum	Description
Concept 33.2 Cnidarians are an ancient phylum of eumetazoans	Cnidaria (hydras, jellies, sea anemones, corals)	Unique stinging structures (cnidae), each housed in a specialized cell (cnidocyte); diploblastic; radially symmetrical; gastrovascular cavity (digestive compartment with a single opening)

Fig. 33-UN6c

Key Concept	Phylum	Description
Concept 33.3 Lophotrochozoans, a clade identified by molecular data, have the widest range of animal body forms	Platyhelminthes (flatworms)	Dorsoventrally flattened, unsegmented acoelomates; gastrovascular cavity or no digestive tract
	Rotifera (rotifers)	Pseudocoelomates with alimentary canal (digestive tube with mouth and anus); jaws (trophi) in pharynx; head with ciliated crown
	Lophophorates: Ectoprocta, Brachiopoda	Coelomates with lophophores (feeding structures bearing ciliated tentacles)
	Mollusca (clams, snails, squids)	Coelomates with three main body parts (muscular foot, visceral mass, mantle); coelom reduced; most have hard shell made of calcium carbonate
	Annelida (segmented worms)	Coelomates with segmented body wall and internal organs (except digestive tract, which is unsegmented)

Fig. 33-UN6d

Key Concept	Phylum	Description
Concept 33.4 Ecdysozoans are the most species-rich animal group	Nematoda (roundworms)	Cylindrical, unsegmented pseudocoelomates with tapered ends; no circulatory system; undergoes ecdysis
	Arthropoda (crustaceans, insects, spiders)	Coelomates with segmented body, jointed appendages, and exoskeleton made of protein and chitin

Fig. 33-UN6e

Key Concept	Phylum	Description
Concept 33.5 Echinoderms and chordates are deuterostomes	Echinodermata (sea stars, sea urchins)	Coelomates with bilaterally symmetrical larvae and five-part body organization as adults; unique water vascular system; endoskeleton
	Chordata (lancelets, tunicates, vertebrates)	Coelomates with notochord; dorsal, hollow nerve cord; pharyngeal slits; post-anal tail (see Chapter 34)

You should now be able to:

1. Describe how a sponge feeds and digests its food
2. List the characteristics of the phylum Cnidaria that distinguish it from other animal phyla
3. List the four classes of Cnidaria and distinguish among them based on life cycle morphology
4. List the characteristics of Platyhelminthes and distinguish among the four classes

5. Describe a lophophore and name two lophophorate phyla
6. Describe the features of molluscs and distinguish among the four classes
7. Describe the features of annelids and distinguish among the three classes
8. List the characteristics of nematodes that distinguish them from other wormlike animals

9. List three features that account for the success of arthropods

10. Define and distinguish among the four major arthropod lineages

11. Describe the developmental similarities between echinoderms and chordates

12. Distinguish among the six classes of echinoderms