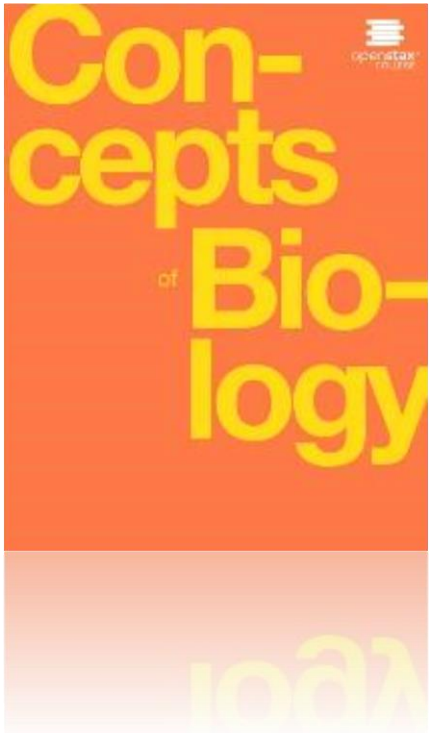
CONCEPTS OF BIOLOGY

Chapter 15 DIVERSITY OF ANIMALS

PowerPoint Image Slideshow



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Information slides by Amanda Brammer, M.S. Associate Professor, NTCC

INTRODUCTION

- We can easily identify dogs, fish, lizards, spiders and worms as animals (Figure 15.1). However, other animals, such as corals or sponges, might be mistaken for plants or some other life form.
- Animal evolution began in the ocean over 600 MYA.
- Over 1 million species of living animals have been identified, but scientists are continually discovering more species.
- The animal classification system characterizes animals based on their anatomy, embryology, and genetic makeup.
- Animals vary greatly in their complexity and exhibit a huge diversity of body forms, so the classification scheme is constantly changing.

FIGURE 15.1 LEAF CHAMELEON

The leaf chameleon (*Brookesia micra*) was discovered in northern Madagascar in 2012. At just over one inch long, it is the smallest known chameleon. (credit: modification of work by Frank Glaw, et al., PLOS)

FEATURES OF THE ANIMAL KINGDOM (15.1)

- All animals are eukaryotic and multicellular.
- Most animals can move, at least during certain life stages.
- Animals are **heterotrophic**, ingesting living or dead organic matter (Figure 15.2).
- Animals can be carnivores, herbivores, omnivores or parasites.
- Most animals reproduce sexually.
- Most animals have specialized tissues. A **tissue** is a collection of similar cells with specialized functions.
    - Examples of animal tissues are epithelial, connective, muscle and nervous.

FIGURE 15.2 HETEROTROPHS

(a) (b)

All animals that derive energy from food are heterotrophs. The (a) black bear is an omnivore, eating both plants and animals. The (b) heartworm *Dirofilaria immitis* is a parasite that derives energy from its hosts. It spends its larval stage in mosquitos and its adult stage infesting the hearts of dogs and other mammals, as shown here. (credit a: modification of work by USDA Forest Service; credit b: modification of work by Clyde Robinson)

BIODIVERSITY CONCEPT IN ACTION

View this video to watch a presentation by biologist E.O. Wilson on the importance of biodiversity.

Link to Video

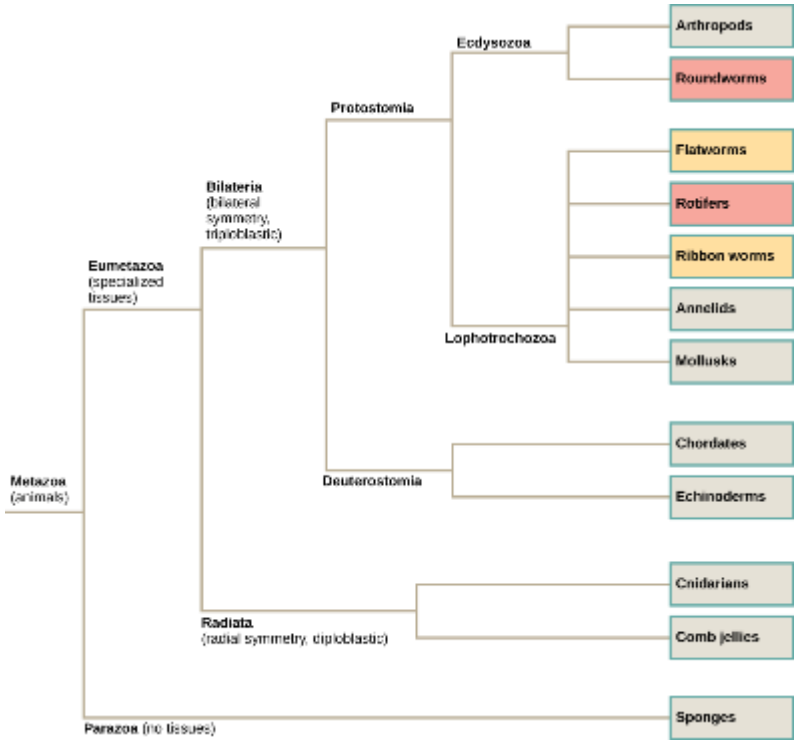
ANIMAL REPRODUCTION AND DEVELOPMENT (15.1)

- Most animals have diploid body (somatic cells) and haploid sex cells (gametes) created by meiosis. Some exceptions do exist.
- Almost all animal species are capable of reproducing sexually and for many, this is the only mode of reproduction.
    - During fertilization, the male and female gametes combine.
    - A zygote is formed and the cells divide and differentiate.
    - Animal cells specialize and form tissues.
    - In many animals, like mammals, they young resembles the adult. In others, like insects, a metamorphosis occurs.
- Some animals, such as invertebrates and some fish, amphibians and reptiles, are capable of asexual reproduction.
    - This produces offspring genetically identical to the parent.
    - The most common methods include budding and fragmentation.

CLASSIFICATION FEATURES OF ANIMALS (15.1)

- Animals are classified by morphological and development characteristics, such as body plan (Figure 15.3).
- A **body plan** is the shape of an animal.
- For most animals (except sponges), the body plan is symmetrical.
- Other classification characteristics are:
  - the number of tissue layers formed during development
  - the presence or absence of an internal body cavity
  - other embryological characteristics

FIGURE 15.3 ANIMAL PHYLOGENY

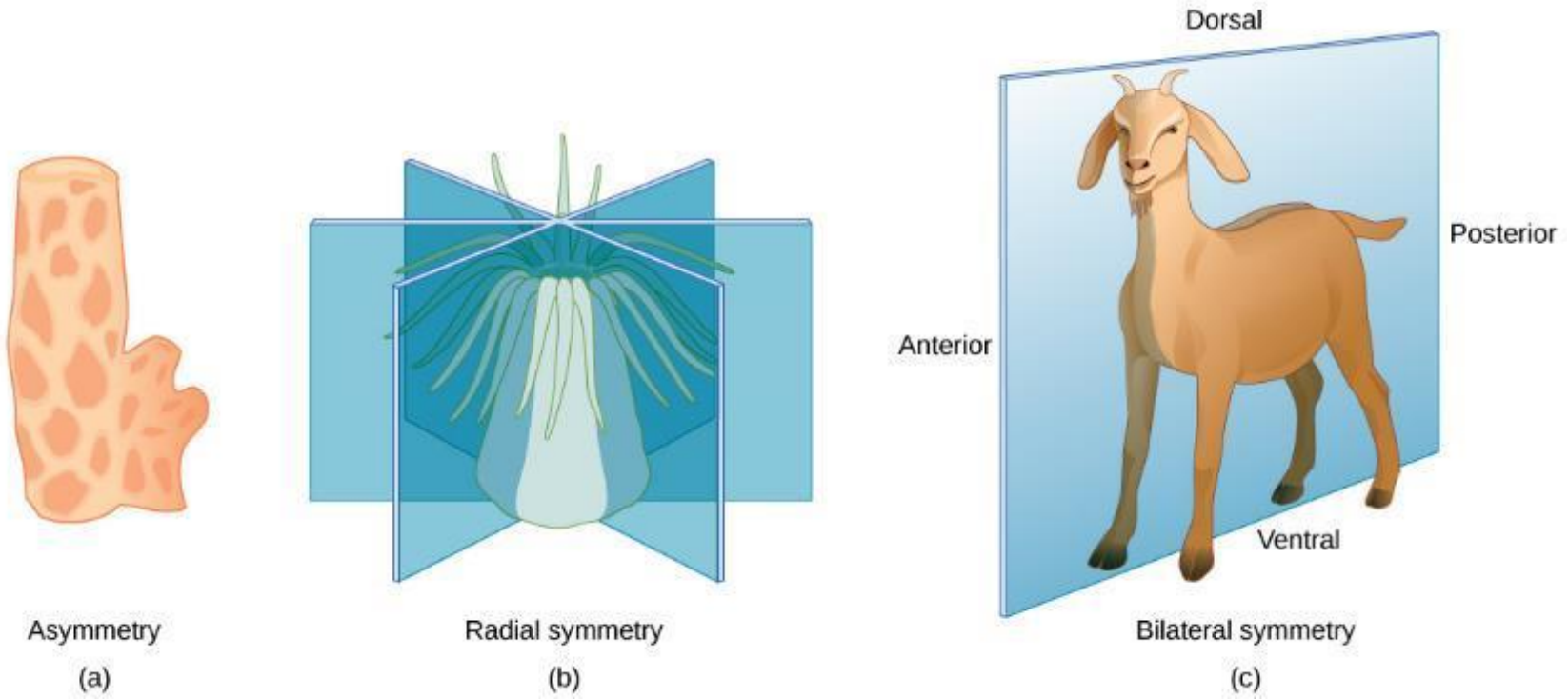


The phylogenetic tree of animals is based on morphological, fossil, and genetic evidence.

BODY SYMMETRY (15.1)

- Symmetry means that the distribution of animal body parts is balanced along an axis.
- Animals can be asymmetrical, radial or bilateral in form (figure 15.4):
    - **Asymmetrical** animals have no pattern of symmetry, for example, a sponge.
    - **Radially symmetrical** animals are oriented up and down, any cut along this up-down axis produces equal, mirror image halves (like a pie). For example, a sea anemone.
    - **Bilaterally symmetrical** animals can only be cut into equal, mirror images along a vertical plane, forming left and right halves. Most animals are bilateral, for example, a goat.

FIGURE 15.4 SYMMETRY



Animals exhibit different types of body symmetry. The (a) sponge is asymmetrical and has no planes of symmetry, the (b) sea anemone has radial symmetry with multiple planes of symmetry, and the (c) goat has bilateral symmetry with one plane of symmetry.

BODY SYMMETRY CONCEPT IN ACTION

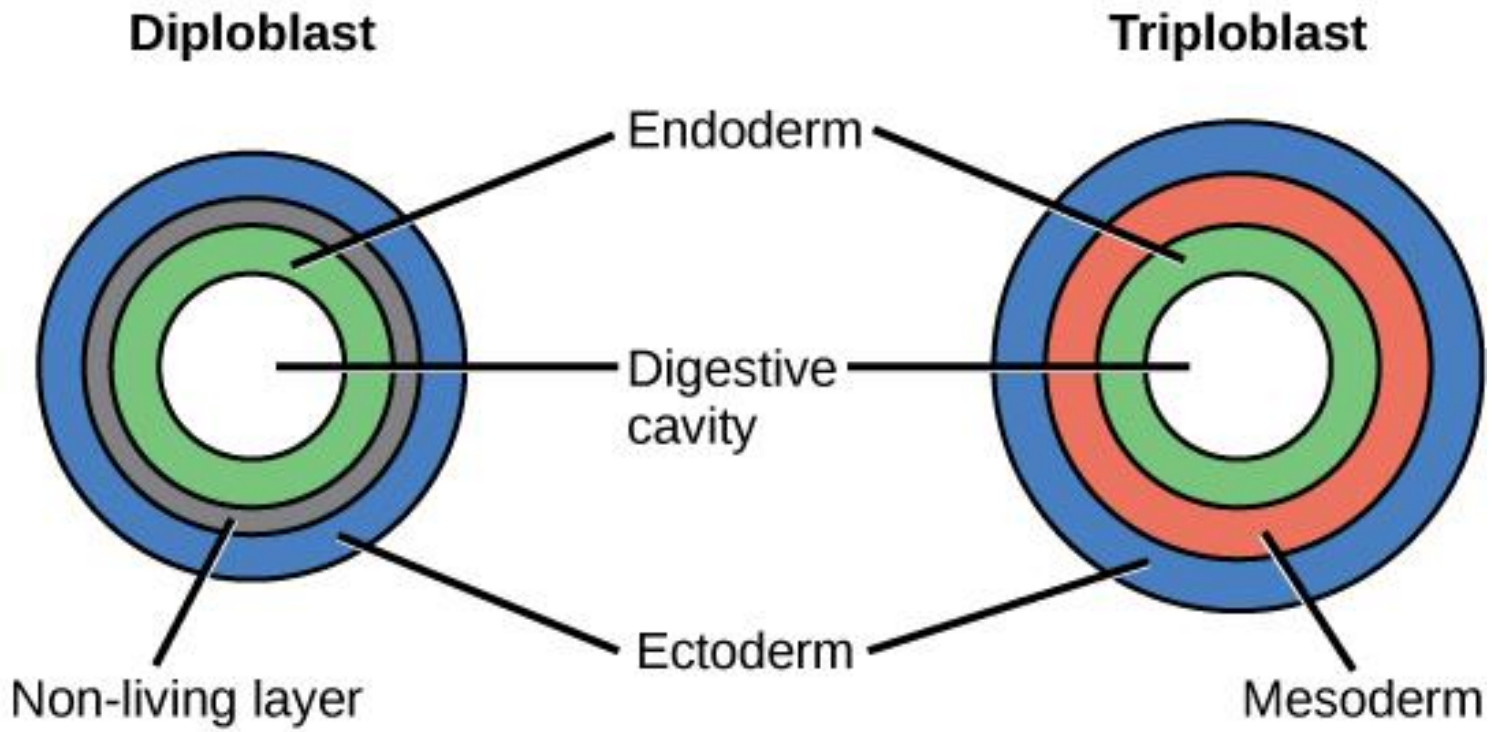
View this video to see a quick sketch of the different types of body symmetry,

Link to Video

LAYERS OF TISSUES (5.1)

- Most animals undergo a layering of tissues during embryonic development. These layers are called **germ layers**, and each develops into a specific set of tissues and organs in the adult.
- Animals develop either 2 or 3 germ layers.
    - Those that develop 2 are called **diploblastic**. Only the cnidarians (jellyfish and relatives) are diploblastic.
    - Those that develop 3 are called **triploblastic**. All bilateral animals are triploblastic.
- Sponges, the most simple animals, do not develop tissues.

FIGURE 15.5 GERM LAYERS

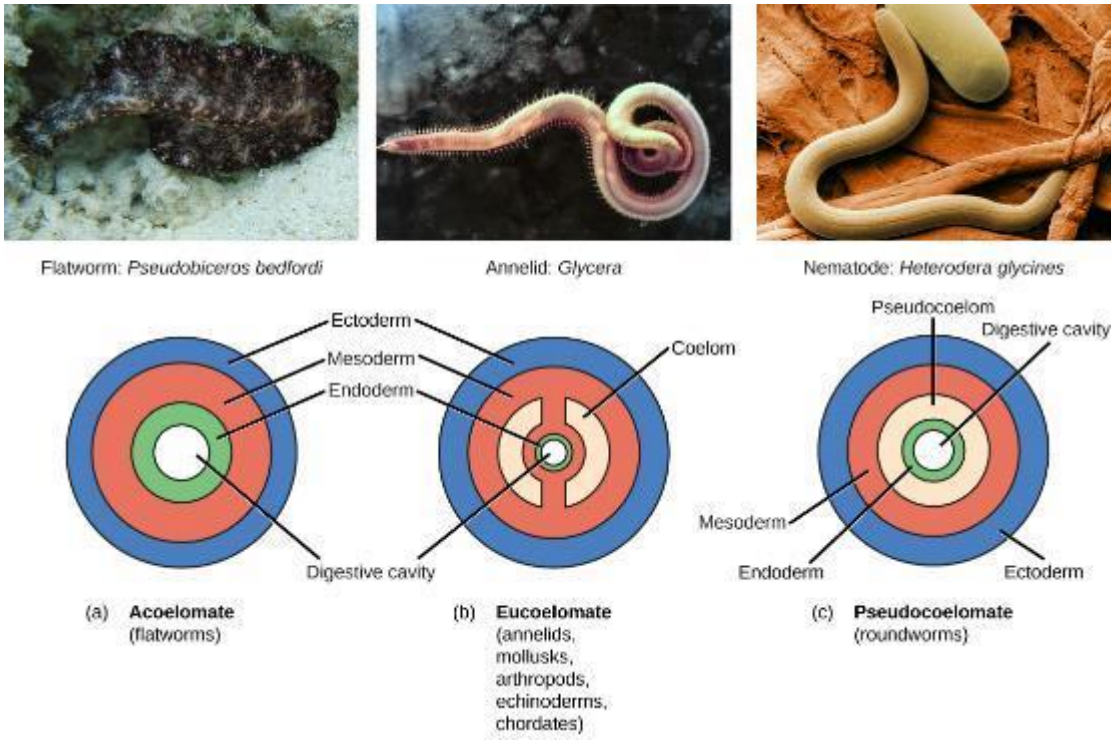


During embryogenesis, diploblasts develop two embryonic germ layers: an ectoderm and an endoderm. Triploblasts develop a third layer—the mesoderm—between the endoderm and ectoderm.

PRESENCE OF ABSENCE OF A BODY CAVITY (15.1)

- Triploblastic animals may develop a fully lined internal body cavity called a **coelom** (Figure 15.6).
    - The coelom lies between the digestive system and the body wall.
    - The coelom comes from mesoderm (one of the germ layers) and houses some organs and the circulatory system.
- Animals that have a true coelom are called **eucoelomate**.
    - Many animals, such as earthworms, snails, insects, starfish and vertebrates are eucoleomate.
- Animals that do not have a coelom are called **acoelomate**.
    - Their bodies are completely filled with tissue, although they do have a gut. An example is a flatworm.
- Some animals have a body cavity but it is not fully lined with mesoderm like a coelom. These animals are called **pseudocoelomate**.
    - An example is a roundworm.

FIGURE 15.6 PRESENCE OF ABSENCE OF A COELOM

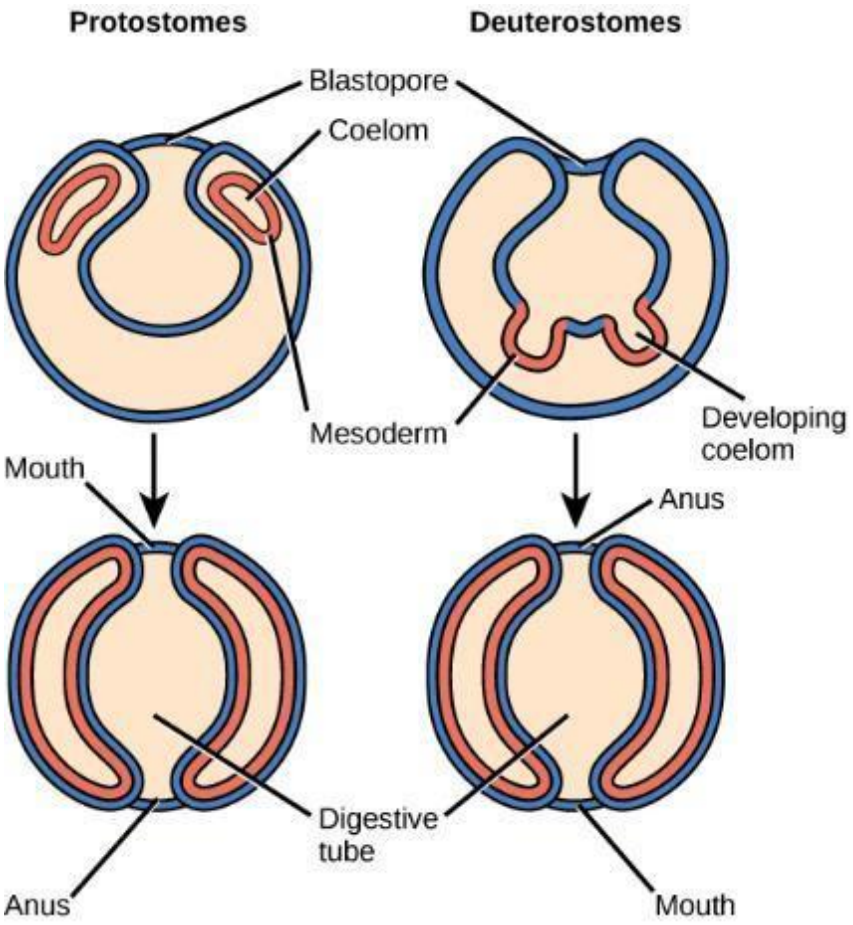


Triploblasts may be acoelomates, eucoelomates, or pseudocoelomates. Eucoelomates have a body cavity within the mesoderm, called a coelom, which is lined with mesoderm tissue. Pseudocoelomates have a similar body cavity, but it is lined with mesoderm and endoderm tissue. (credit a: modification of work by Jan Derk; credit b: modification of work by NOAA; credit c: modification of work by USDA, ARS)

PROTOSTOMES VS DEUTEROSTOMES (15.1)

- During embryonic development, the zygote divides to form a ball of cells. Eventually a pore develops in the ball of cells, which is called the blastopore.
- Eucoelomates can be divided into 2 groups based on differences in their early embryonic development (fate of the blastopore).
- **Protostomes** ('mouth first") include phyla such as arthropods, mollusks and annelids.
    - The blastopore becomes the mouth.
- **Deuterostomes** ("mouth second") include the chordates and echinoderms.
    - The blastopore becomes the anus.
- See Figure 15.7.

FIGURE 15.7
PROTOSTOMES VS DEUTEROSTOMES



Eucoelomates can be divided into two groups, protostomes and deuterostomes, based on their early embryonic development. Two of these differences include the origin of the mouth opening and the way in which the coelom is formed.

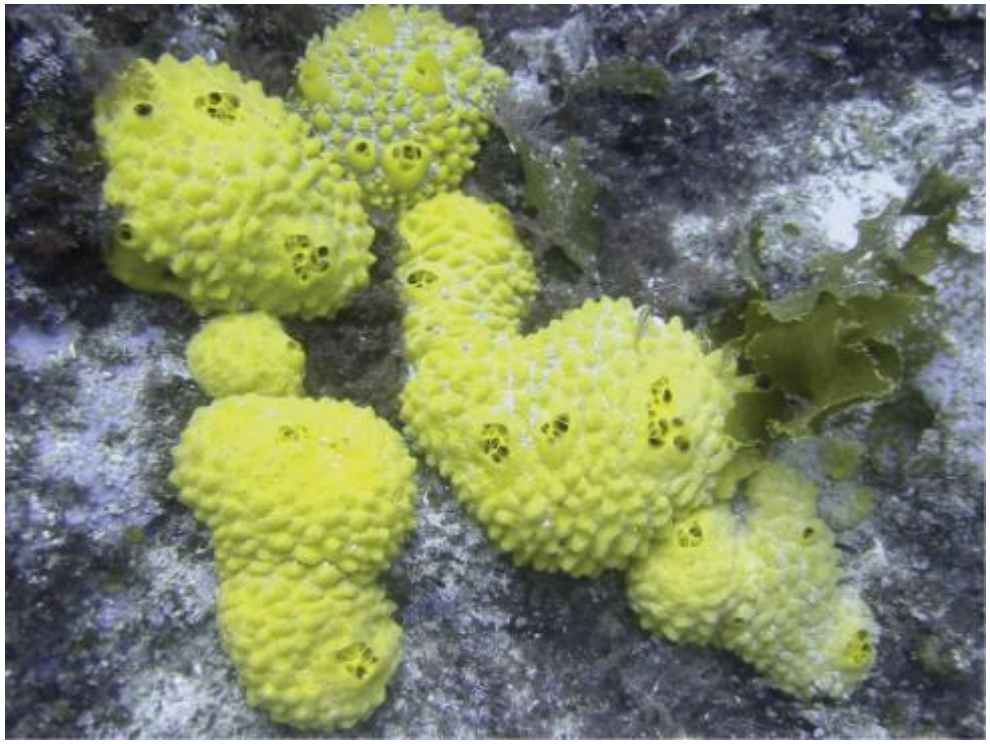
SPONGES AND CNIDARIANS (15.2)

- The kingdom of animals is informally divided into invertebrates (animals without a backbone) and vertebrates (animals with one).
- Although we are most familiar with the vertebrates, 95% of all animals are invertebrates.
- Invertebrates are a huge group with millions of species in 32 phyla. We will just touch on a few.
- The sponges and cnidarians are the simplest animals.
    - Sponges have specialized cells but no true tissues.
    - Cnidarians (jellyfish and relatives) are the simplest group with true tissues, although they are diploblastic.

SPONGES 1 OF 2 (15.2)

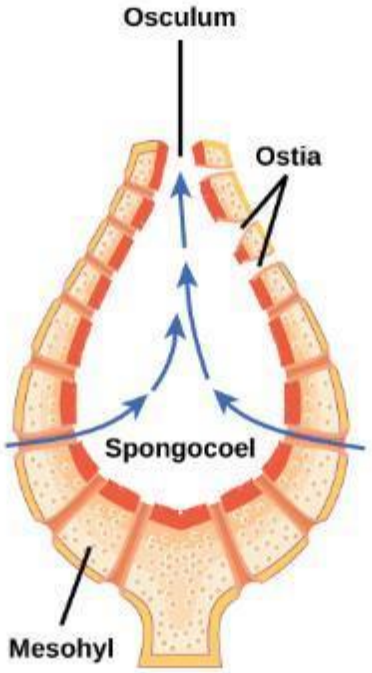
- Sponges fall into phylum **Porifera**.
- All sponges are aquatic and most are marine.
- Sponges move water through their bodies so that they can filter out food, absorb dissolved oxygen and eliminate wastes (Figure 15.8).
- Water enters the central cavity of the sponge through numerous pores in the body wall. The water flows through the sponge and out through a large opening (Figure 15.9).
    - The beating of flagellated cells called **choanocytes** move the water through the sponge.
- Sponges lack a digestive system, so food must be digested inside choanocytes (**intracellular digestion**). This limits the size of food particles that sponges can digest to particles that can fit inside cells.

FIGURE 15.8 SPONGES



Sponges are members of the phylum Porifera, which contains the simplest animals. (credit: Andrew Turner)

FIGURE 15.9 SPONGE BODY PLAN



Basic sponge body plan

The sponge's basic body plan is shown.

SPONGES 2 OF 2 (15.2)

- Sponges reproduce both sexually and asexually.
- Asexual reproduction occurs by:
  - **Budding**—a piece of the sponge breaks off and develops into a new individual
  - **Fragmentation**—an outgrowth of the parent eventually detaches
  - Formation of **gemmules**—clusters of cells surrounded by a tough outer layer, which allows the sponge to be dormant and survive hostile conditions (such as winter).
- Sponges are **hermaphroditic**, meaning that one individual produces both eggs and sperm.
  - Eggs remain in the sponge and sperm are released.
  - Water carries the sperm to other sponges where fertilization can occur.
  - Free-swimming larvae are released, which eventually settle down and become attached to a substrate (**sessile**).

SPONGES CONCEPT IN ACTION

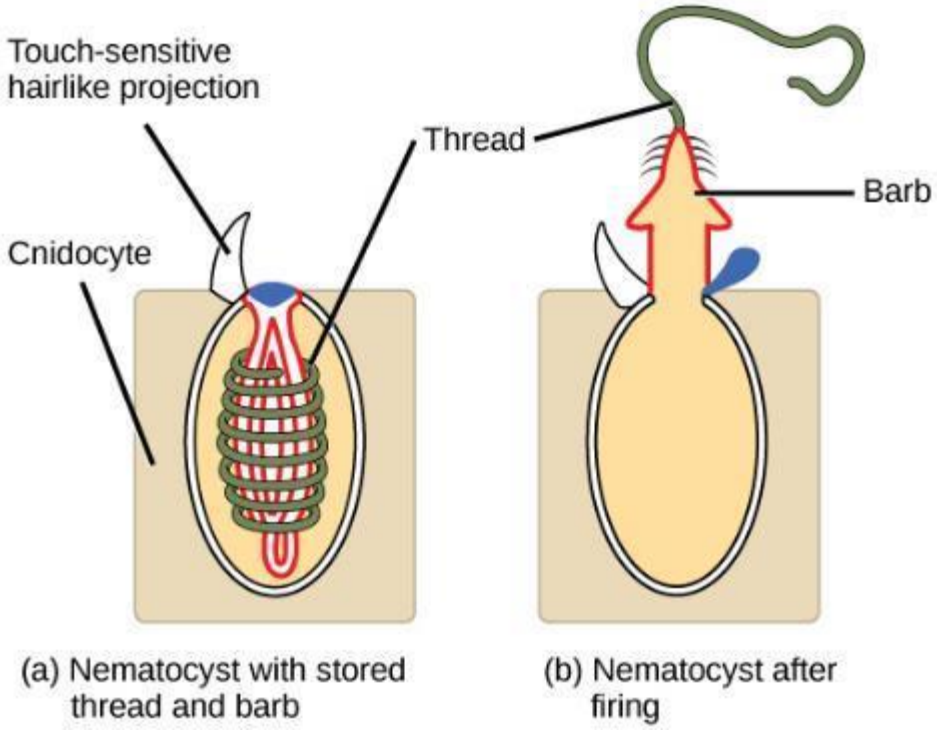
View this video that demonstrates the feeding of sponges.

Link to Video

CNIDARIANS 1 OF 2 (15.2)

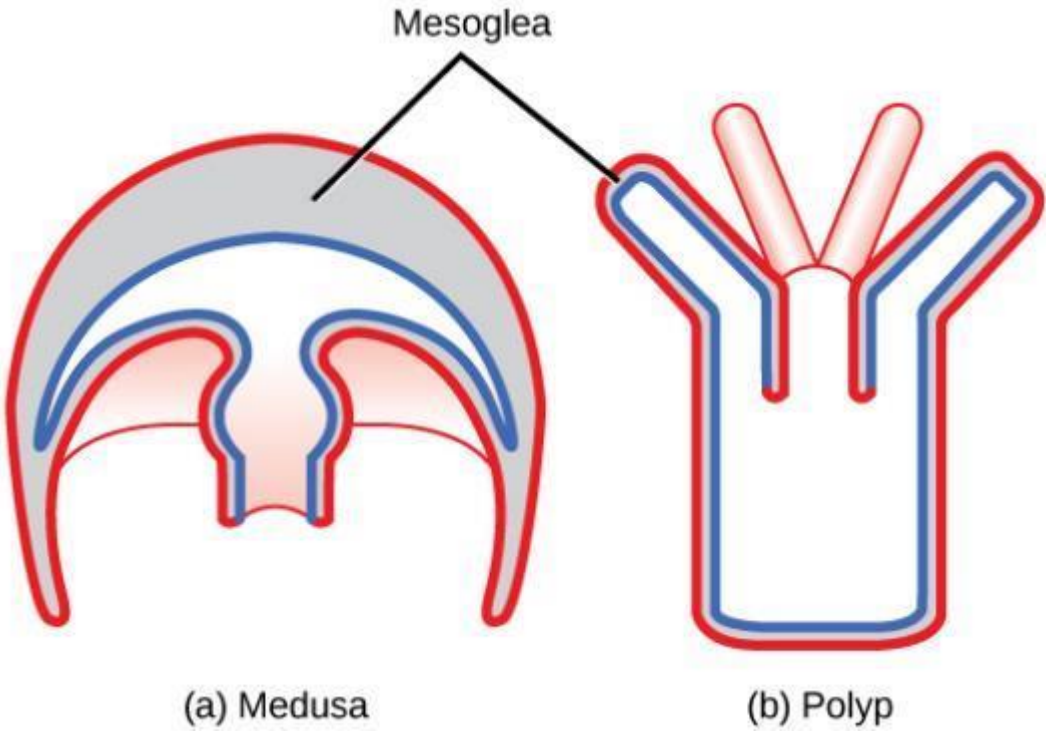
- Phylum **Cnidaria** contains diploblastic animals and includes jellyfish and their relatives. Nearly all are marine.
- The cells of cnidarians are called **cnidocytes**.
- Cnidocytes contain stinging cells called **nematocysts**, which are concentrated around the mouth and tentacles and have toxins.
    - Nematocysts contain coiled threads with barbs which are discharged when something contacts a touch-sensitive hair-like projection (Figure 15.10).
- Cnidarians display 2 distinct body plans (Figure 15.11):
    - **Polyp** (“stalk”), for example *Hydra*
    - **Medusa** (“bell”), jellyfish for example
- Some cnidarians always exist as a polyp and some always exist as a medusa. Others alternate between polyp and medusa forms.

FIGURE 15.10 NEMATOCYSTS



Animals from the phylum Cnidaria have stinging cells called cnidocytes. Cnidocytes contain large organelles called (a) nematocysts that store a coiled thread and barb. When hairlike projections on the cell surface are touched, (b) the thread, barb, and a toxin are fired from the organelle.

FIGURE 15.11 POLYP VS MEDUSA



Cnidarians have two distinct body plans, the (a) medusa and the (b) polyp. All cnidarians have two tissue layers, with a jelly-like mesoglea between them.

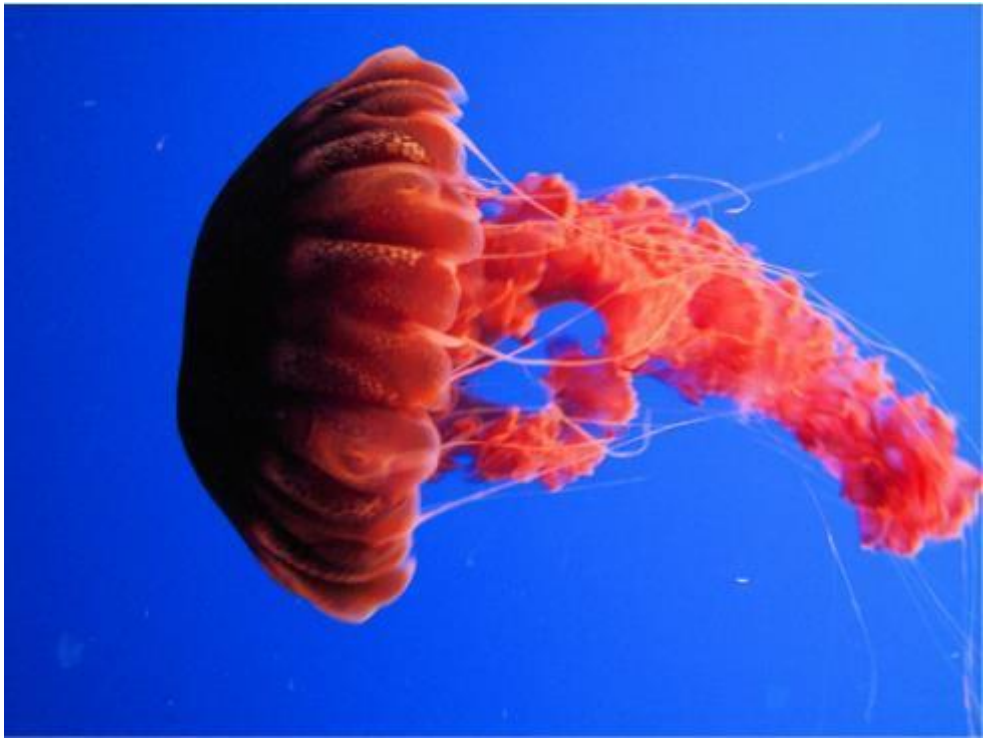
CNIDARIANS 2 OF 2 (15.2)

- All cnidarians have 2 tissue layers with a jelly-like, non-living substance between them called **mesoglea**.
- They have distinct cell types, but no organs or organ systems.
- They have a primitive nervous system, with nerve cells scattered across the body in a network.
- Cnidarians obtain carbon dioxide and oxygen gases by diffusion from the water.
- Cnidarians have extracellular digestion using enzymes secreted into the inside of a cavity called the **gastrovascular cavity**. The cavity has only one opening, which serves as both mouth and anus.
- Phylum Cnidaria contains about 10,000 species in 4 classes (Figures 15.12, 15.13 and 15.14).
    - Examples include sea anemones, corals, jellyfish, box jellies, *Hydra*, Portuguese Man O'War.

FIGURE 15.12 SEA ANEMONE

Sea anemones are cnidarians of class Anthozoa. (credit: “Dancing With Ghosts”/Flickr)

FIGURE 15.13 JELLYFISH



Scyphozoans include the jellies. (credit: “Jimg944”/Flickr)

FIGURE 15.14 BOX JELLY

A (a) box jelly is an example from class Cubozoa. The (b) hydra is from class Hydrozoa. (credit b: scale-bar data from Matt Russell)

JELLYFISH CONCEPT IN ACTION

View this video to learn more about the deadly toxins of the box jellyfish.

Link to Video

FLATWORMS, NEMATODES AND ARTHROPODS (15.3)

- All of the remaining animal phyla we will look at are triploblastic and bilaterally symmetrical.
- Associated with bilateralism is the development of **cephalization**, the evolution of a concentration of nervous tissues and sensory organs in the head region of the organism.
- We will look at three phyla in this section:
    - Flatworms
    - Roundworms
    - Arthropods

FLATWORMS 1 OF 2 (15.3)

- The flatworms (**Phylum Platyhelminthes**) include both free-living and parasitic forms. They are acoelomate.
- Free living forms are predators or scavengers.
- Parasitic forms feed from the tissues of their host.
- Most have a simple digestive system with one opening, the mouth, which is used to take in food and expel wastes (Figure 15.15).
- Flatworms also have a simple excretory system and nervous system.
- They have no circulatory or respiratory system, thus, gas exchange is by diffusion through the body wall. This is why they are so flat.
- Most flatworms are hermaphroditic.
- Some are capable of asexual reproduction, in which an entire organism can be generated from just a piece of the worm.

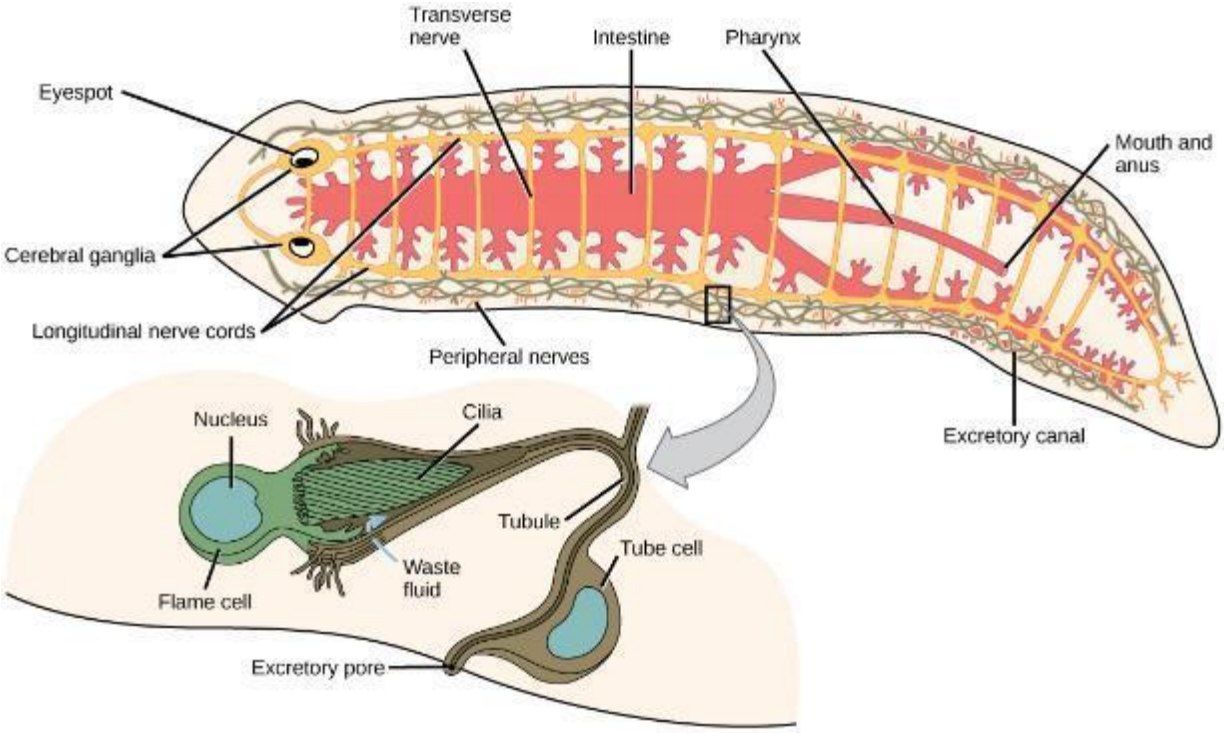
DIVERSITY OF FLATWORMS (15.3)

- Flatworms are classified into 3 classes (Figure 15.16).
- Free living flatworms are called planarians. This group includes mainly marine species, although some live in freshwater or moist terrestrial environments.
- Another group includes external parasites of fish. The adult either produces enzymes that digests the host tissues or grazes on surface mucus and skin particles.
- The flukes are internal parasites of mollusks and other groups, including humans.
    - They have complex life cycles involving multiple hosts.
    - They are responsible for serious human diseases, including schistosomiasis, which is caused by a blood fluke. This disease affects about 200 million people in the tropics.

FLATWORMS 2 OF 2 (15.3)

- The final group of flatworms are the tapeworms. They are also internal parasites, mainly of vertebrates.
    - Tapeworms live in the intestines of the primary host, remaining attached to the intestinal lining by its anterior end.
    - The rest of the tapeworm body is reproductive units, containing sperm and eggs.
    - They do not have a digestive system and absorb nutrients directly from the intestines of the host through their body wall.

FIGURE 15.15 A FREE-LIVING FLATWORM



This planarian is a free-living flatworm that has an incomplete digestive system, an excretory system with a network of tubules throughout the body, and a nervous system made up of nerve cords running the length of the body with a concentration of nerves and photosensory and chemosensory cells at the anterior end.

FIGURE 15.16 DIVERSITY OF FLATWORMS

Phylum Platyhelminthes is divided into four classes: (a) Bedford's Flatworm (*Pseudobiceros bedfordi*) and the (b) planarian belong to class Turbellaria; (c) the Trematoda class includes about 20,000 species, most of which are parasitic; (d) class Cestoda includes tapeworms such as this *Taenia saginata*; and the parasitic class Monogenea (not shown). (credit a: modification of work by Jan Derk; credit c: modification of work by "Sahaquiel9102"/Wikimedia Commons; credit d: modification of work by CDC)

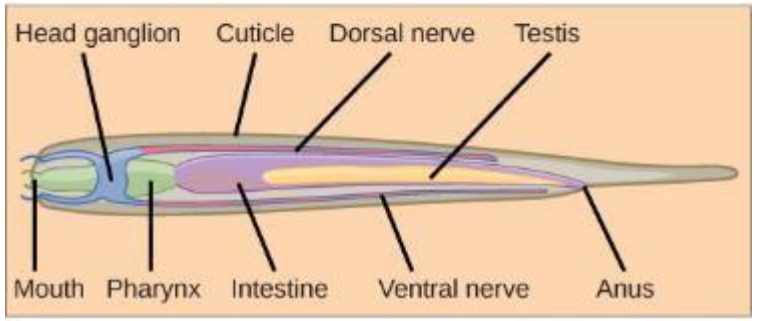
NEMATODES (15.3)

- Phylum **Nematoda** includes roundworms, which are pseudocoelomate.
- They are present in all habitats and are extremely common, although they are usually not visible (Figure 15.17).
- Nematodes have a flexible, outer exoskeleton called a **cuticle**. The cuticle is made of chitin. (Recall that we also saw chitin in fungi).
- Because the cuticle is so tough, it restricts movement of the worm and must be periodically shed. This is called **ecdysis**.
- This group includes both free-living and parasitic forms.
- They have complete digestive systems, with both a mouth and anus.
- Some are hermaphroditic but most have separate sexes.

NEMATODES FIGURE 15.17

(a) An scanning electron micrograph of the nematode *Heterodera glycines* and (b) a schematic representation of the anatomy of a nematode are shown. (credit a: modification of work by USDA, ARS; scale-bar data from Matt Russell)

(a)



(b)

NEMATODES CONCEPT IN ACTION

View this video to see nematodes move about and feed on bacteria.

Link to Video

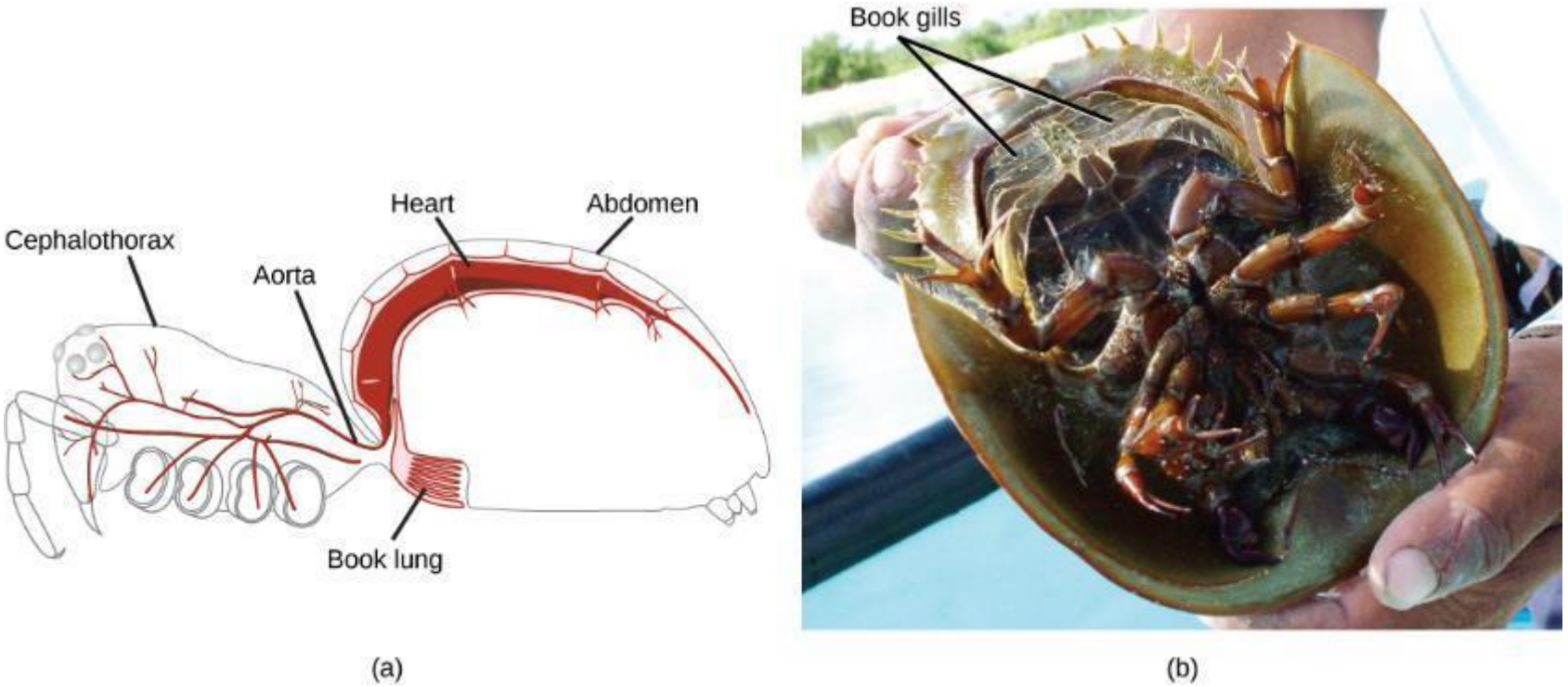
ARTHROPODS (15.3)

- The phylum **Arthropoda** dominates the animal kingdom, with an estimated 85% of known species.
- Important characteristics of this group are segmentation of the body and jointed appendages (Figure 15.18).
- Arthropods are eucoelomate and also shed their tough exoskeleton made of chitin (like nematodes). This is called ecdysis.
- Segments in arthropods fuse to give rise to functional sections of the body. Examples include:
    - Head, thorax, abdomen
    - Cephalothorax (fused head and thorax), abdomen
- This group has more developed body systems, including digestive, nervous, circulatory, respiratory and reproductive (Figure 15.19).

FIGURE 15.18 SEGMENTATION IN ARTHROPODS

Trilobites, like the one in this fossil, are an extinct group of arthropods. (credit: Kevin Walsh)

FIGURE 15.19 RESPIRATORY STRUCTURES

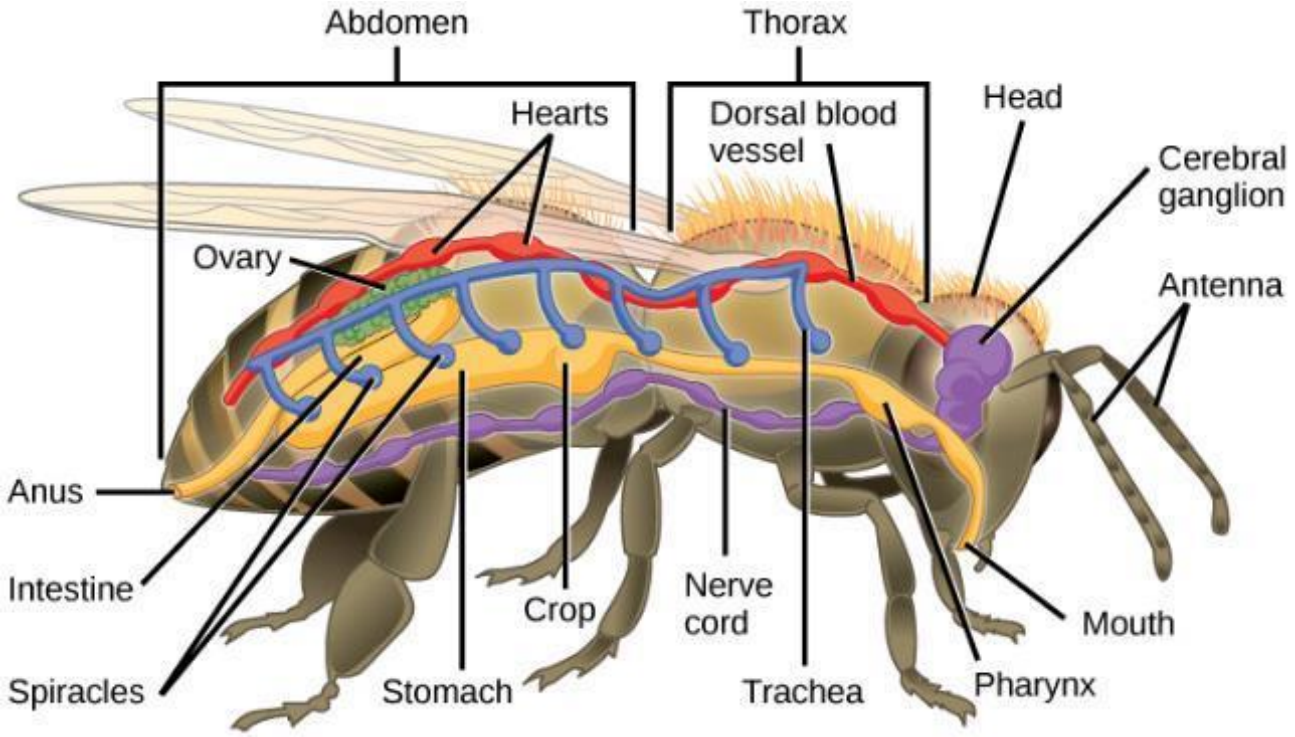


The book lungs of (a) arachnids are made up of alternating air pockets and hemocoel tissue shaped like a stack of books. The book gills of (b) crustaceans are similar to book lungs but are external so that gas exchange can occur with the surrounding water. (credit a: modification of work by Ryan Wilson based on original work by John Henry Comstock; credit b: modification of work by Angel Schatz)

ARTHROPOD DIVERSITY 1 OF 2 (15.3)

- Arthropods have been successful in colonizing terrestrial, aquatic and aerial habitats.
- The phylum is classified into 5 subphyla. One of these is extinct--trilobites, Figure 15.18).
- Hexapods include insects and their relatives. They have a head, thorax and abdomen (Figure 15.20).
    - They have 3 pairs of legs and 2 pairs of wings on the thorax.
    - Examples of hexapods are ants, roaches, butterflies and bees.
- Myriapods include centipedes and millipedes (Figure 15.21).
    - They are terrestrial and prefer a humid environment.
    - They have legs that vary in number from 10-750.

FIGURE 15.20A HEXAPOD



In this basic anatomy of a hexapod, note that insects have a developed digestive system (yellow), a respiratory system (blue), a circulatory system (red), and a nervous system (purple).

FIGURE 15.21 MYRIAPODS

(a) (b)

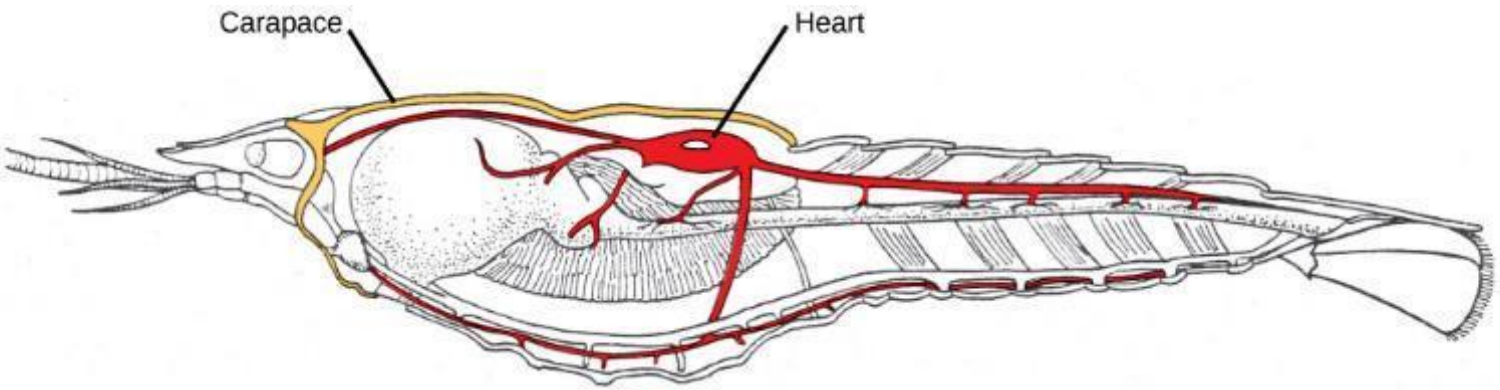
(a) The centipede *Scutigera coleoptrata* has up to 15 pairs of legs.

(b) This North American millipede (*Narceus americanus)* bears many legs, although not one thousand, as its name might suggest. (credit a: modification of work by Bruce Marlin; credit b: modification of work by Cory Zanker)

ARTHROPOD DIVERSITY 2 OF 2 (15.3)

- Crustaceans (shrimp, lobsters, crabs, crayfish) are the dominant aquatic arthropods (Figure 15.22). There are also a few terrestrial crustaceans like pill (sow) bugs.
    - They sometimes have a fused head and thorax (cephalothorax) and an abdomen.
    - Their exoskeleton is sometimes infused with calcium carbonate, making it very strong.
- Chelicerates include spiders, scorpions, horseshoe crabs and sea spiders (Figure 15.23).
    - The name is derived from their first pair of appendages (their mouthparts) which are called **chelicerae**.
    - Chelicerae are mostly used for feeding but are modified to inject venom into prey in the spiders.
    - This group has a cephalothorax and abdomen.

FIGURE 15.22 A CRUSTACEAN



The crayfish is an example of a crustacean. It has a carapace around the cephalothorax and the heart in the dorsal thorax area. (credit: Jane Whitney)

FIGURE 15.23 CHELICERATES

The chelicerae (first set of appendages) are well developed in the Chelicerata, which includes scorpions (a) and spiders (b). (credit a: modification of work by Kevin Walsh; credit b: modification of work by Marshal Hedin)

ARTHROPOD CONCEPT IN ACTION

Click through this lesson on arthropods to explore interactive habitat maps and more.

Launch Interactive

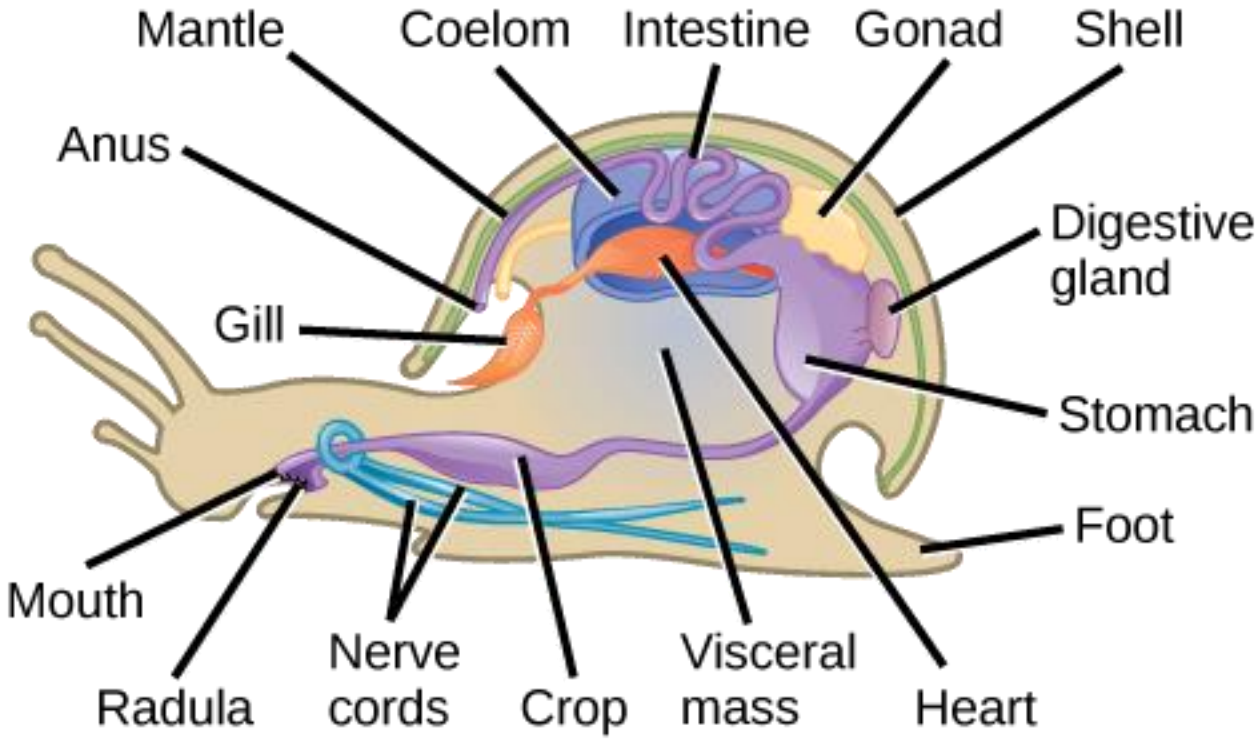
MOLLUSKS AND ANNELIDS (15.4)

- In this section, we will discuss 2 phyla which are related based on analysis of their DNA:
    - Mollusks, which include squid, octopuses, snails, and their relatives.
    - Annelids, which are segmented worms and include earthworms, leeches and a marine group.

PHYLUM MOLLUSCA (15.4)

- Phylum **Mollusca** is the predominant phylum in marine environments.
- It is the second most diverse phylum after arthropods.
- Mollusks are eucoelomate but the coelom is small.
- Many mollusks have a shell made of calcium carbonate.
- Mollusk body forms vary but they share distinct characteristics Figure 15.24):
    - A muscular **foot** that is typically used for locomotion
    - A **visceral mass** that contains most of the organs
    - A **mantle**, which is a flap of tissue over the visceral mass that sometimes secretes a shell
    - A **radula**, which is a scraping structure located at the mouth

FIGURE 15.24 A MOLLUSK



There are many species and variations of mollusks; the gastropod mollusk anatomy is shown here, which shares many characteristics common with other groups.

MOLLUSK DIVERSITY 1 OF 2 (15.4)

- The phylum is composed of 7 classes. We will mention 4 of them.
- Chitons are marine animals that bear armor-like eight-plated shells (Figure 15.25).
    - They have a foot that is adapted for attachment to rocks.
    - They have a radula modified for scraping.
- Bivalves include clams, oysters, mussels and scallops .
    - They are found in marine and freshwater.
    - They are enclosed in a pair of shells that are hinged on the side.
    - Bivalves feed by filtering food from the water and a radula is absent.
    - This group is commercially important as food as wall as for jewelry (pearls, mother of pearl).

FIGURE 15.25 A CHITON

This chiton from the class Polyplacophora has the eight-plated shell indicative of its class. (credit: Jerry Kirkhart)

CLAMS CONCEPT IN ACTION

Watch animations of clams feeding to understand more about bivalves.

Launch Animation

MOLLUSK DIVERSITY 2 OF 2 (15.4)

- Gastropods include snails, slugs and conchs (Figure 15.26).
  - This group includes members with coiled shells as well as members without shells.
  - The foot is modified for crawling and the visceral mass is twisted in shelled species.
  - Most have tentacles with eyes and a complex radula used to scrape food particles.
- Cephalopods include octopuses, squids, cuttlefish and the nautilus (Figure 15.27).
  - This group includes members with and without shells.
  - They display vivid coloration used for camouflage. Some octopuses can rapidly adjust their colors to mimic a background pattern.
  - This group includes the largest and smartest invertebrates.
  - Cephalopods can move quickly via jet propulsion of water from the mantle cavity.

FIGURE 15.26 GASTROPODS

(a) (b)

(a) Like many gastropods, this snail has a stomach foot and a coiled shell.

(b) This slug, which is also a gastropod, lacks a shell. (credit a: modification of work by Murray Stevenson; credit b: modification of work by Rosendahl)

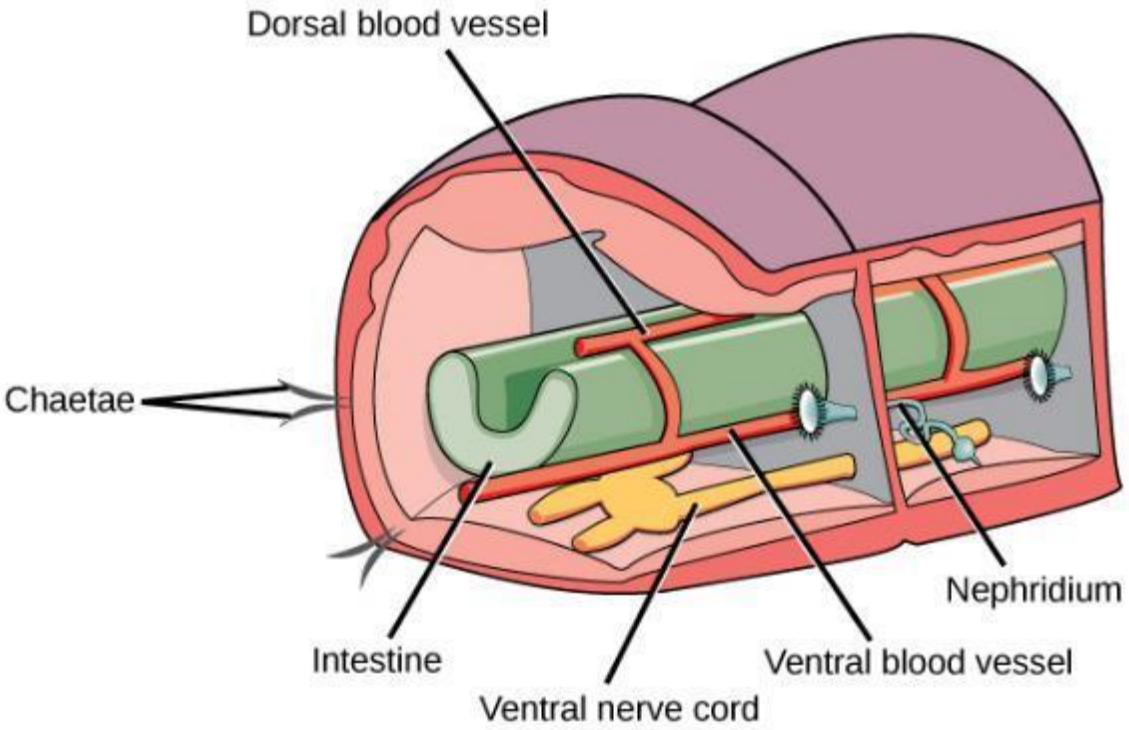
FIGURE 15.27 CEPHALOPODS

The (a) nautilus, (b) giant cuttlefish, (c) reef squid, and (d) blue-ring octopus are all members of the class Cephalopoda. (credit a: modification of work by J. Baecker; credit b: modification of work by Adrian Mohedano; credit c: modification of work by Silke Baron; credit d: modification of work by Angell Williams)

PHYLUM ANNELIDA (15.4)

- Phylum **Annelida** includes segmented worms found in marine, terrestrial and freshwater habitats. They need moisture to survive in terrestrial habitats, however.
- The phylum contains earthworms, polychaetes (marine worms) and leeches.
- Hair-like extensions called **chaetae** are present in every segment in most groups.
- They have 2 layers of muscle underneath their outer covering (cuticle)
- Annelids are eucoelomate and have well-developed body system, including digestive, nervous, excretory and reproductive (Figure 15.29).
- They can be hermaphroditic or have separate sexes.

FIGURE 15.29 ANATOMY OF AN ANNELID



In this schematic showing the basic anatomy of annelids, the digestive system is indicated in green, the nervous system is indicated in yellow, and the circulatory system is indicated in red.

ANNELID ANATOMY CONCEPT IN ACTION

This video and animation provides a close-up look at annelid anatomy.

Link to Video

ANNELID DIVERSITY (15.4)

- Phylum Annelida contains 2 classes (Figure 15.30).
- Polychaetes (mostly marine annelids)
  - Polychaetes are often brightly colored with well developed heads with eyes. Most are predatory.
  - They have many chaetae on each segment.
- Earthworms and leeches
  - Earthworms are distinguished by the **clitellum**, a ring structure that assists in mating and forms a protective cocoon for the eggs.
  - Earthworms have only a few chaetae on each segment and leeches have no chaetae.
  - Leeches differ from other annelids by the development of suckers at each end.
  - Leeches swell when ingesting blood. Only 50% of leeches are blood-sucking, however. The others are scavengers or eat decaying organic material.

FIGURE 15.30 EARTHWORM AND LEECH

(a)

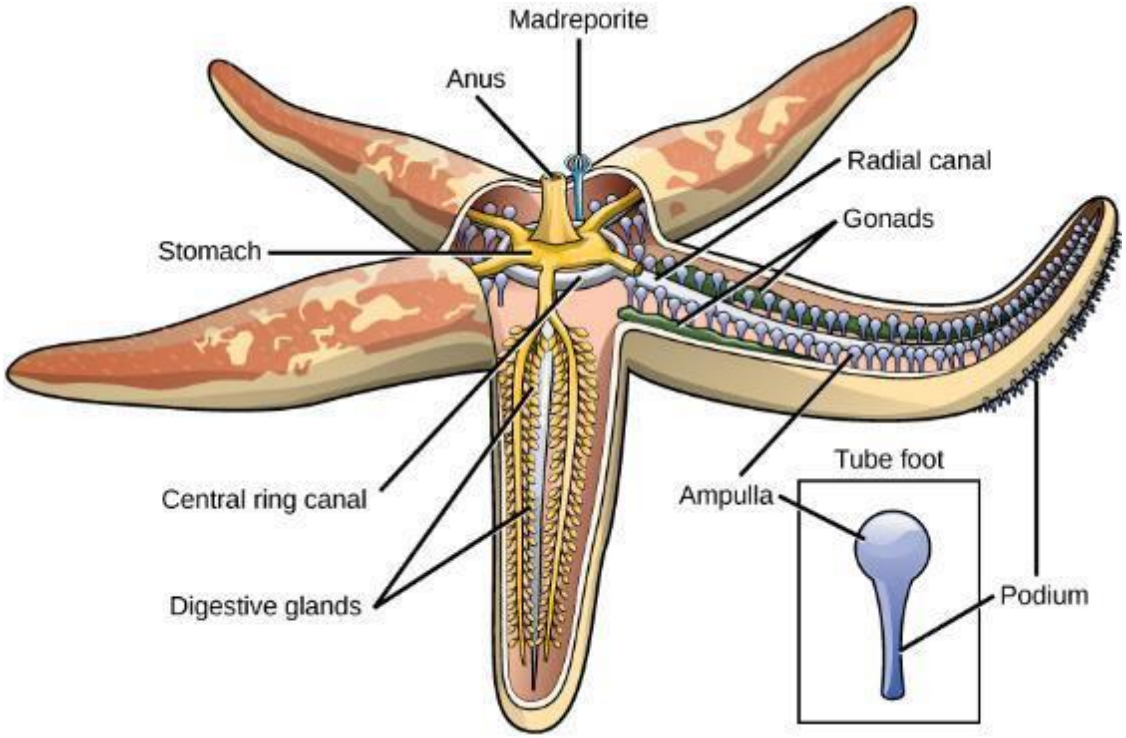
(b)

The (a) earthworm and (b) leech are both annelids. (credit a: modification of work by “schizoform”/Flickr; credit b: modification of work by “Sarah G…”/Flickr)

ECHINODERMS (15.5)

- Phylum **Echinodermata** is an exclusively marine group.
- All adults have radial symmetry although the larvae are bilateral.
- They have an endoskeleton made of calcium carbonate.
- Echinoderms have amazing powers of regeneration.
- They are deuterostomes (blastopore becomes the anus) and eucoelomate (have a true coelom).
- A distinguishing characteristic of this group is the presence of a **water-vascular system**, which is a system that is used for gas exchange, nutrient circulation and locomotion.
- A part of the water-vascular system called tube feet can be filled with water and extended to produce movement or pry the shells of prey open.
- The body systems are arranged around the center of the animal and extend into the arms (Figure 15.31).

FIGURE 15.31 ANATOMY OF A SEA STAR

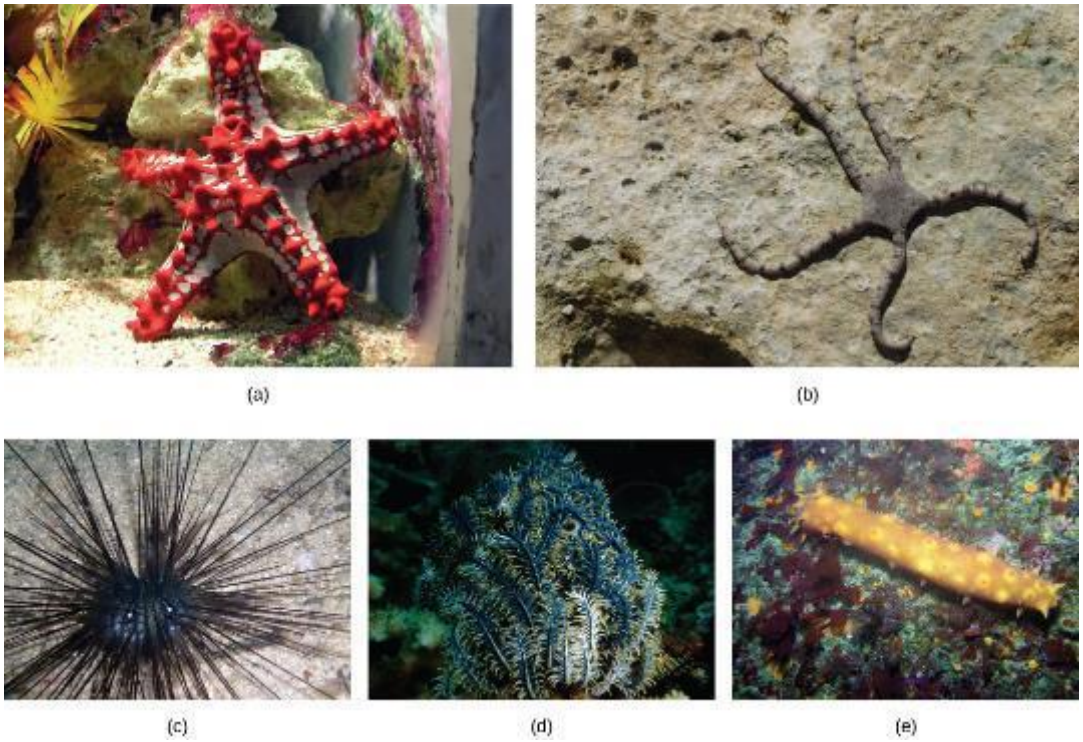


This diagram shows the anatomy of a sea star.

ECHINODERM DIVERSITY (15.5)

- Sea stars are the best-known echinoderms.
  - They have thick arms that extend from the central disk area.
  - The arms contain organs.
  - Sea stars use their tube feet to grasp prey and for gripping.
- Brittle stars have long thin arms that do not contain organs.
  - They are the most mobile of the echinoderms.
- Sea urchins and sand dollars do not have arms and are flattened.
- Sea lilies and feather stars are stalked and they filter feed food from the water.
- Sea cucumbers are soft-bodied.
  - They have tube feet modified into tentacles around the mouth for feeding.
  - If they are startled, they can extrude their entire digestive system and grow a new one.

FIGURE 15.32 ECHINODERM DIVERSITY



Different members of Echinodermata include the (a) sea star in class Asteroidea, (b) the brittle star in class Ophiuroidea, (c) the sea urchins of class Echinoidea, (d) the sea lilies belonging to class Crinoidea, and (e) sea cucumbers representing class Holothuroidea. (credit a: modification of work by Adrian Pingstone; credit b: modification of work by Joshua Ganderson; credit c: modification of work by Samuel Chow; credit d: modification of work by Sarah Depper; credit e: modification of work by Ed Bierman)

SEA STAR CONCEPT IN ACTION

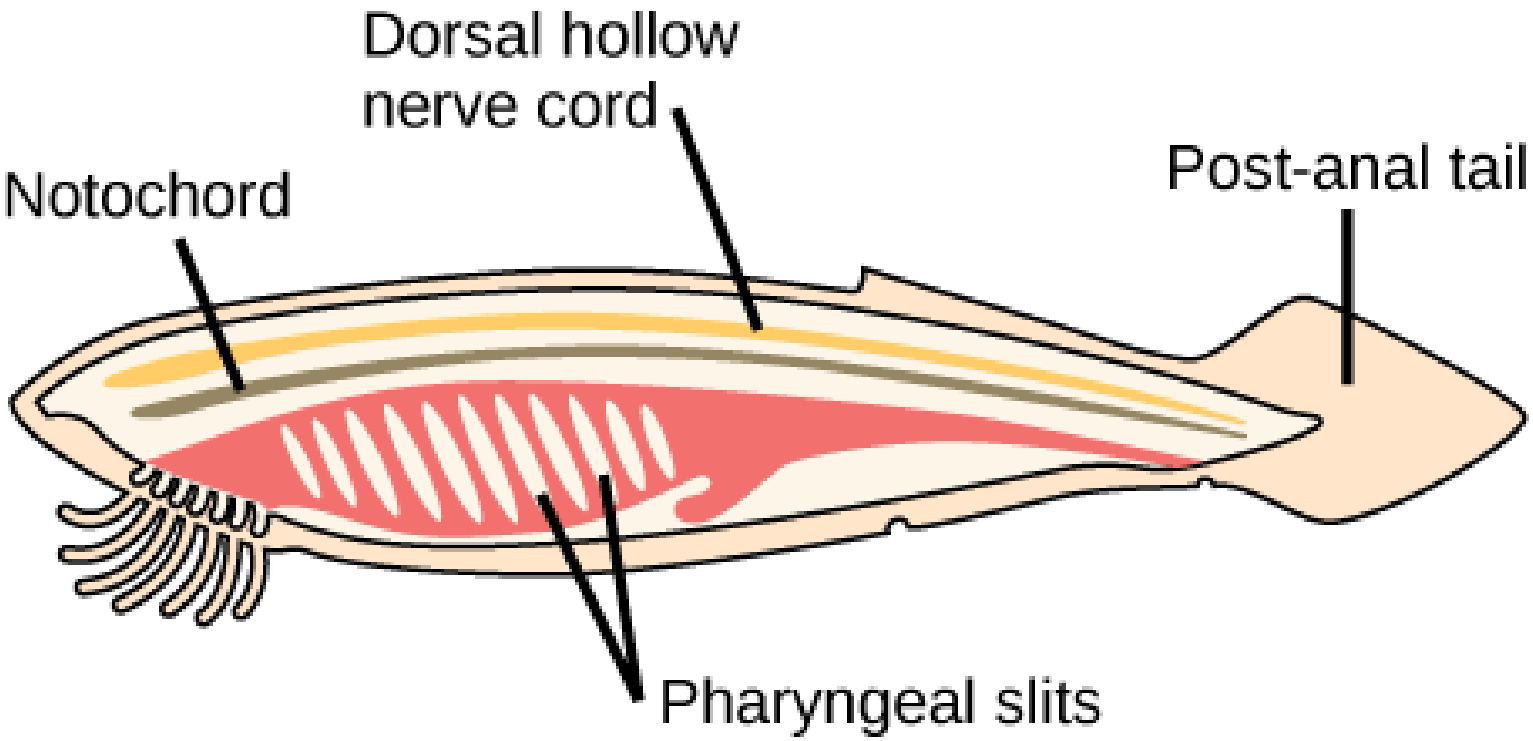
View this video to explore a sea star’s body plan up close, watch one move across the sea floor, and see it devour a mussel.

Link to Video

CHORDATES (15.5)

- The majority of species in the phylum **Chordata** are vertebrates.
- Major groups of vertebrates are fishes, amphibians, reptiles, birds and mammals.
- Animals in the phylum Chordata share key features that appear at some stage of their development (Figure 15.33):
    - **Notochord**—a flexible, rod-shaped structure that provides skeletal support through the length of the body; in vertebrates becomes the vertebral column
    - **Dorsal hollow nerve cord**—a hollow tube that develops into the brain and spinal cord in most chordates
    - **Pharyngeal slits**—openings in the pharynx that open to the outside environment
    - **Post-anal tail**—a posterior elongation of the body that extends beyond the anus

FIGURE 15.33 CHORDATE FEATURES

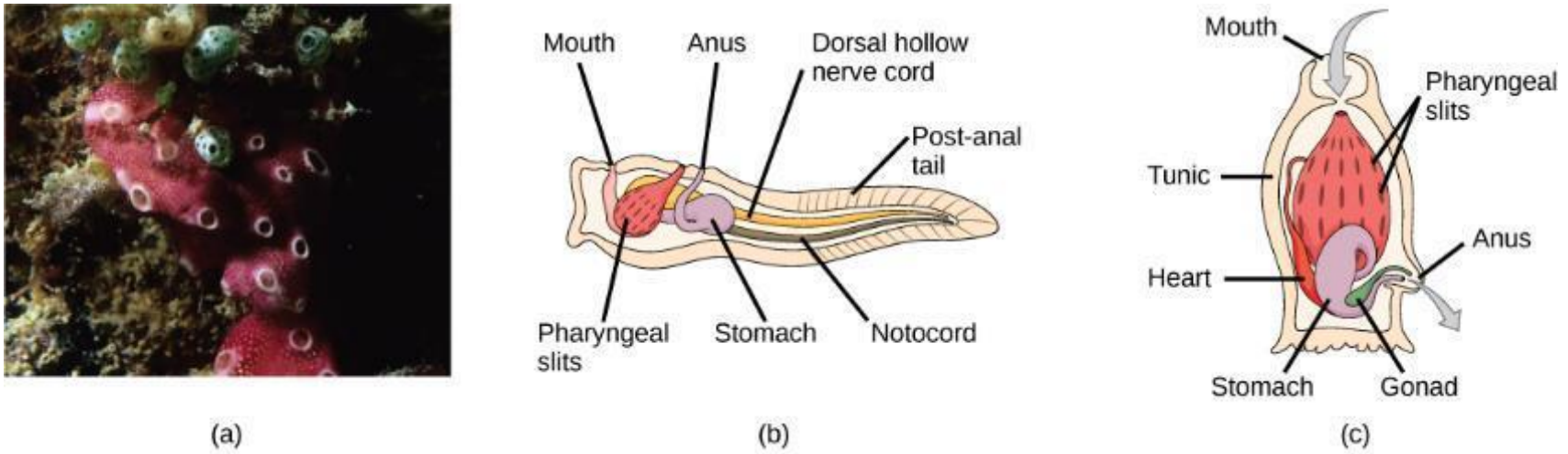


In chordates, four common features appear at some point in development: a notochord, a dorsal hollow nerve cord, pharyngeal slits, and a post-anal tail. The anatomy of a cephalochordate shown here illustrates all of these features.

INVERTEBRATES CHORDATES (15.5)

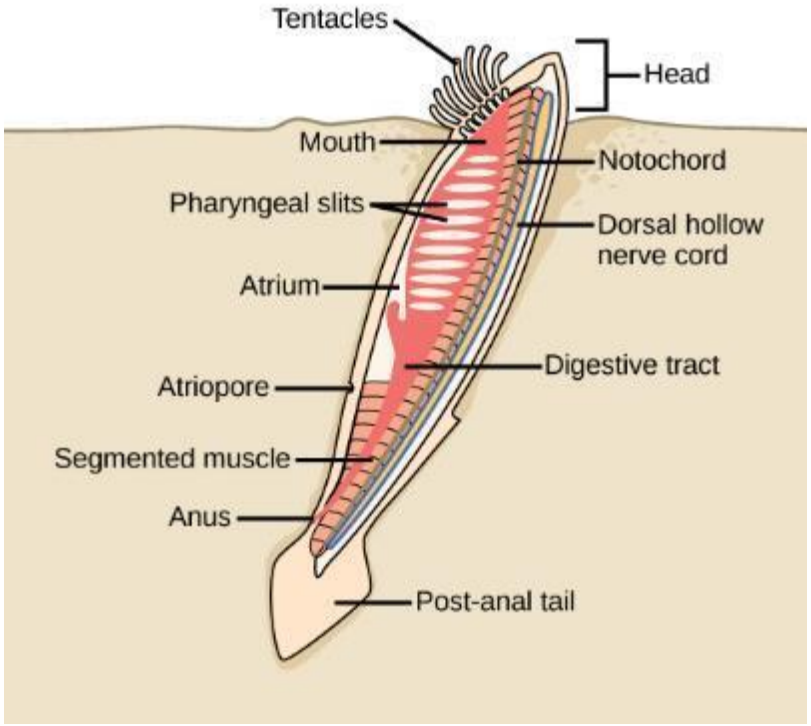
- Most chordates are vertebrates…they contain a vertebral column.
- There are 2 invertebrate chordates that possess the chordate characteristics but do not have a vertebral column:
- Tunicates are also called sea squirts (Figure 15.34).
    - They make a tunic out of cellulose (a material common in plants but usually not found in animals).
    - They have all 4 chordate characteristics as larvae but not as adults.
    - Larvae are free-swimming but after a few days, they find a suitable surface to attach and begin suspension feeding.
- Lancelets have all 4 chordate characteristics as adults (Figure 15.35).
    - They are suspension feeders like tunicates.
    - They are only a few cm long and usually found buried in the sand at the bottom of the sea.
    - They are named for a double-edged surgical knife.

FIGURE 15.34 TUNICATES



(a) This photograph shows a colony of the tunicate *Botrylloides violaceus*. In the (b) larval stage, the tunicate can swim freely until it attaches to a substrate to become (c) an adult. (credit a: modification of work by Dr. Dwayne Meadows, NOAA/NMFS/OPR)

FIGURE 15.35 A LANCELET



Adult lancelets retain the four key features of chordates: a notochord, a dorsal hollow nerve cord, pharyngeal slits, and a post-anal tail.

VERTEBRATES (15.6)

- Vertebrates are among the most recognizable organisms of the animal kingdom.
- Major groups of vertebrates include fishes, amphibians, reptiles, birds and mammals.
- More than 62,000 species exist, but this represents only a small portion of the vertebrates that have existed.
- The best known extinct vertebrates are the dinosaurs, which were the dominant terrestrial animals for 150 million years.
    - They went extinct about 65 MYA in a mass extinction.
    - Vertebrates that are currently critically endangered are pictured in Figure 15.36.

FIGURE 15.36

Examples of critically endangered vertebrate species include (a) the Siberian tiger *(Panthera tigris altaica*), (b) the Panamanian golden frog (*Atelopus zeteki*), and (c) the Philippine eagle (*Pithecophaga jefferyi*). (credit a: modification of work by Dave Pape; credit b: modification of work by Brian Gratwicke; credit c: modification of work by “cuatrok77”/Flickr)

FISHES (15.6)

- Modern fishes include about 31,000 species.
- Fishes were the earliest vertebrates.
- There are 3 major groups of fishes:
  - Jawless fish—fish without jaws (hagfish and lamprey)
  - Cartilaginous fish—fish with cartilage skeletons (sharks and rays)
  - Bony fish—all other fish

JAWLESS FISHES (15.6)

- Hagfish are eel-like scavengers that live on the ocean floor and feed on dead invertebrates, other fishes and marine mammals (Figure 15.37).
    - They are entirely marine and found in oceans around the world.
    - Their skeleton is made of cartilage.
    - They release an extraordinary amount of mucus from slime glands beneath the skin. This helps them to escape predators.
    - They can enter the bodies of dead or dying animals and devour them from the inside.
- Lampreys are similar to hagfish in size and shape (Figure 15.37).
    - As adults, they have a toothed, funnel-like sucking mouth.
    - Many species are free-living but some are parasitic on other fish. They attach to the fish and feed on body fluids.
    - They live in coastal and fresh waters primarily and have a wide distribution.

FIGURE 15.37 JAWLESS FISH

(a) (b)

(a) Pacific hagfishes are scavengers that live on the ocean floor.

(b) These parasitic sea lampreys attach to their lake trout host by suction and use their rough tongues to rasp away flesh in order to feed on the trout's blood. (credit a: modification of work by Linda Snook, NOAA/CBNMS; credit b: modification of work by USGS)

CARTILAGINOUS FISHES (15.6)

- The cartilaginous fish includes sharks, rays and skates (Figure 15.38).
- They have paired fins and a skeleton made of cartilage.
- Most live in marine habitats with a few species living in fresh water.
- Most are carnivorous but a few are suspension feeders that feed on plankton.
- Sharks, along with bony fish, have a sense organ called the **lateral line**, that detects movement and vibration in the water (like our ear).
    - Sharks have a keen sense of smell and electroreception, useful in locating prey.
    - Sharks reproduce sexually and eggs are fertilized internally. In most sharks, eggs develop in the mothers body, hatch in the uterus, and the young are born alive and fully functional.
- Rays and skates have flattened bodies, enlarged pectoral fins fused to the head and gill slits on the belly.
    - Most rays and skates are marine and live on the sea floor with a world-wide distribution.

FIGURE 15.38 CARTILAGINOUS FISH

(a) (b)

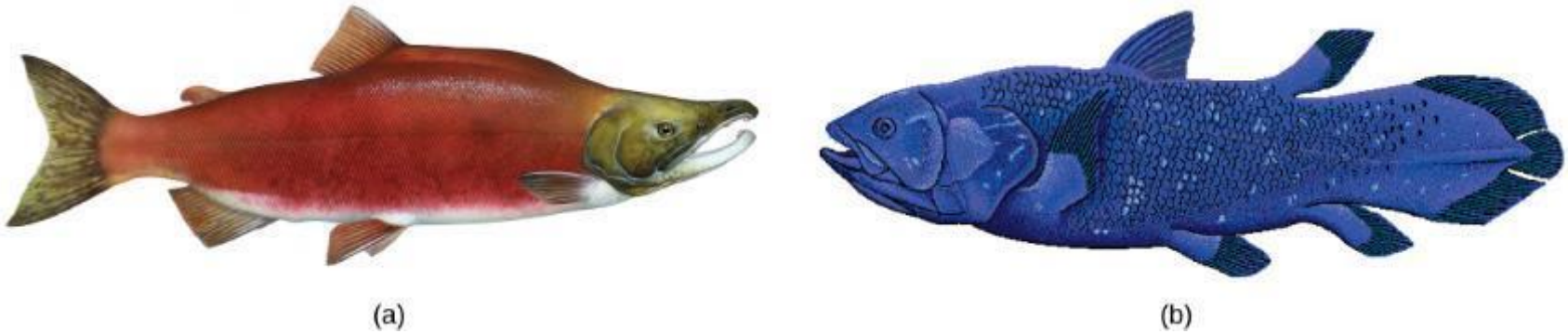
(a) This hammerhead shark is an example of a predatory cartilaginous fish.

(b) This stingray blends into the sandy bottom of the ocean floor when it is feeding or awaiting prey. (credit a: modification of work by Masashi Sugawara; credit b: modification of work by “Sailn1”/Flickr)

BONY FISHES (15.6)

- The bony fish have a skeleton made of bone. This group includes the vast majority of present-day fishes (about 30,000 species).
- The skin of bony fishes is often covered in overlapping scales and glands in the skin secrete mucus that reduces drag while swimming.
- All fishes use gills to breathe. Bony fish have evolved two structures not found in cartilaginous fish:
    - A protective cover over the gills called the **operculum.**
    - A **swim bladder**, which is a gas-filled organ that is used to regulate the buoyancy of the fish.
- Bony fishes are divided into 2 groups (Figure 15.39).
- Ray-finned fishes have webs of skin supported by bony spines called rays. This group includes most familiar fish (tuna, bass, trout, salmon, etc.)
- Lobe-finned fishes have fleshy fins supported by bone. This group includes the lungfishes and the coelacanth.

FIGURE 15.39 BONY FISHES



The (a) sockeye salmon and (b) coelacanth are both bony fishes of the Osteichthyes clade. The coelacanth, sometimes called a lobe-finned fish, was thought to have gone extinct in the Late Cretaceous period 100 million years ago until one was discovered in 1938 between Africa and Madagascar. (credit a: modification of work by Timothy Knepp, USFWS; credit b: modification of work by Robbie Cada)

AMPHIBIANS (15.6)

- Amphibians, reptiles, birds and mammals are called **tetrapods** (four-footed animals).
- The term amphibian means “dual-life” because of:
  - The metamorphosis that many frogs undergo from tadpole to adult and
  - The mixture of aquatic and terrestrial environments in their life cycle.
- Amphibians have moist, permeable skin with mucus glands. The moist skin allows **cutaneous respiration**, gas exchange with the environment.
- All living adult amphibians are carnivorous and some terrestrial amphibians have a sticky tongue used to capture prey.
- Most amphibians lay eggs in moist environments, which are then fertilized externally.
- There are about 6500 species of amphibians in tropical and temperate regions around the world.

AMPHIBIAN DIVERSITY (15.6)

- Amphibians are classified into 3 main groups.
- Salamanders have four limbs and a tail (Figure 15.40).
  - Some are aquatic, others are terrestrial and some live on land only as adults.
  - Some lack lungs and respiration occurs through the skin or gills.
- Frogs (and toads) are the most diverse group of amphibians.
  - They have a body plan specialized for movement on land.
  - They have modifications to avoid predation (camouflage, defensive chemicals, etc.)
  - The life cycle of a frog includes the larval stage (tadpole) followed by metamorphosis to the adult form (Figure 15.41).
- Caecilians lack external limbs and resemble giant earthworms (Figure 15.42).
  - They inhabit soil in tropical areas and are adapted to a soil burrowing lifestyle and are nearly blind.
  - They have internal fertilization and give birth to live young.

FIGURE 15.40 AMPHIBIAN DIVERSITY

(a) (b)

(a) Most salamanders have legs and a tail, but respiration varies among species.

(b) The Australian green tree frog is a nocturnal predator that lives in the canopies of trees near a water source. (credit a: modification of work by Valentina Storti; credit b: modification of work by Evan Pickett)

FIGURE 15.41 METAMORPHOSIS

A frog begins as a (a) tadpole and undergoes metamorphosis to become (b) a juvenile and finally (c) an adult. (credit: modification of work by Brian Gratwicke)

FIGURE 15.42 CAECILIAN

Caecilians lack external limbs and are well adapted for a soil-burrowing lifestyle. (credit: modification of work by “cliff1066”/Flickr)

SALAMANDERS CONCEPT IN ACTION

Watch this video about an unusually large salamander species.

Link to Video

REPTILES AND BIRDS (15.6)

- The **amniotes** include reptiles, birds and mammals.
  - They have a shelled egg which is adapted to terrestrial life.
  - They have an embryo protected by amniotic membranes which allows amniotes to survive in drier environments.
  - Amphibians were restricted to moist environments because of their shell-less eggs.
- Division of amniotes has been into 3 groups in the past:
  - Reptiles
  - Birds
  - Mammals
- However, birds are descended from dinosaurs, so this scheme results in groups that are not true clades (birds should be classified with reptiles).

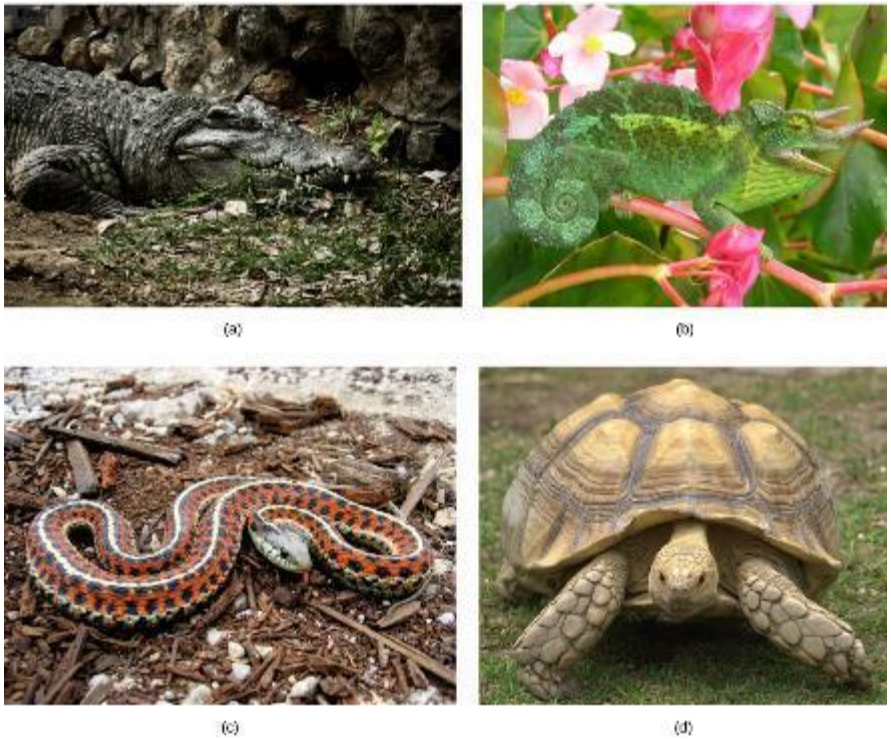
REPTILES 1 OF 2 (15.6)

- Reptiles are tetrapods.
- They lay shelled eggs on land. Even aquatic reptiles return to the land to lay eggs.
- They reproduce sexually and have internal fertilization.
- An important adaptation is the development of scaly skin, which prevented water loss from the skin.
    - This prevents respiration through the skin and thus, reptiles have lungs.
- Reptiles are **ectotherms**, animals whose main source of body heat comes from the environment (basking in the sun, seeking burrows or shade, etc.)
- Reptiles are divided into 4 groups (Figure 15.43).

REPTILES 2 OF 2 (15.6)

- Crocodilians include crocodiles, alligators and caimans.
    - They are found in freshwater habitats and spend much of their time in the water.
    - They live in the tropics of Africa, South America, the southeastern United States, Asia and Australia.
- Tuataras resemble lizards but are a distinct group living in New Zealand that shares characteristics found in birds and turtles.
- Lizards and snakes are the largest living group of reptiles.
    - Lizards have four limbs, eyelids and external ears, which are lacking in snakes.
    - Snakes are thought to have evolved from burrowing or aquatic lizards. All are carnivorous.
- Turtles have a bony or cartilaginous shell.
    - They evolved before crocodiles, lizards and snakes.
    - They lay eggs on land although many live in or near water.

FIGURE 15.43 REPTILE DIVERSITY



(a) Crocodilians, such as this Siamese crocodile, provide parental care for their offspring. (b) This Jackson's chameleon blends in with its surroundings. (c) The garter snake belongs to the genus *Thamnophis*, the most widely distributed reptile genus in North America. (d) The African spurred tortoise lives at the southern edge of the Sahara Desert. It is the third largest tortoise in the world. (credit a: modification of work by Keshav Mukund Kandhadai; credit c: modification of work by Steve Jurvetson; credit d: modification of work by Jim Bowen)

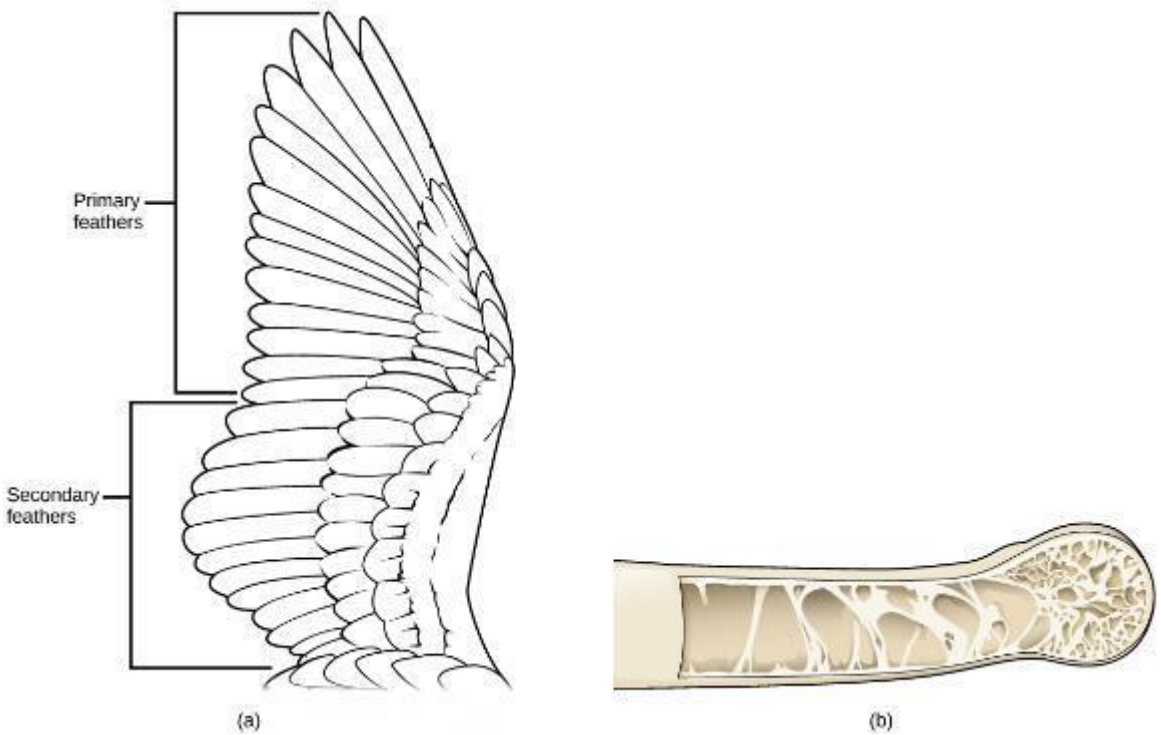
BIRDS 1 OF 2 (15.6)

- Birds belong to the reptile clade but they display a number of unique adaptations that set them apart (Figure 15.44).
- Birds are **endothermic**, they generate their own body heat through metabolic processes. Mammals are also endothermic.
- Birds have feathers, which are modified reptilian scales.
    - They have several types of feathers that are specialized for specific functions.
    - Feathers are not only for flight, but for insulation. This assists with the maintenance of endothermy.

BIRDS 2 OF 2 (15.6)

- Powering a flying animal means limiting the amount of body weight. This is accomplished in several ways:
  - **Pneumatic** (hollow) bones with air sacs and air spaces
  - Parts of the vertebral skeleton and braincase are fused to increase strength and lighten weight
  - No teeth in the jaw
  - One ovary instead of 2
- Birds have a system of air sacs branching from the main airway that diverts the path of air so that it flows in one direction through the lung
  - This is more efficient than mammalian lungs in which the air flows in 2 directions

FIGURE 15.44 FEATHERS AND HOLLOW BONES



(a) Primary feathers are located at the wing tip and provide thrust; secondary feathers are located close to the body and provide lift.

(b) Many birds have hollow pneumatic bones, which make flight easier.

MAMMALS 1 OF 2 (15.6)

- Mammals are vertebrates that have hair and mammary glands to provide nutrition for their young.
- The presence of hair is one of the key characteristics of mammals. Hair has several functions:
  - Provides insulation by trapping a layer of air close to the body (for endothermy).
  - Sensory function through the use of whiskers
  - Provides protective coloration
- Mammalian skin contains secretory glands for various functions.
  - Oil glands produce oil that is used for water resistance and lubrication.
  - Sweat glands produce sweat and scent that is useful for thermoregulation and communication.
  - Mammary glands produce milk that is used to feed newborns.

MAMMALS 2 OF 2 (15.6)

- The skeletal system of mammals possesses unique features that differentiate them from other vertebrates.
    - They have different types and shapes of teeth that allow them to feed on different types of foods.
    - Most mammals have 2 sets of teeth in their lifetimes.
- Modern mammals are placed into 3 groups: monotremes, marsupials and eutherians (placentals).
- **Monotremes** include two species of echidna (spiny anteaters) and the platypus (Figure 15.45).
    - They lay leathery eggs similar to reptilian eggs.
    - They are found in Australia and New Guinea.
    - The female secretes milk along a ridge on her belly.
    - They have one opening for urinary, fecal and reproductive products, rather than 3 separate openings.
    - Adults lack teeth.

FIGURE 15.45 MONOTREMES

The platypus (left), a monotreme, possesses a leathery beak and lays eggs rather than giving birth to live young. An echidna, another monotreme, is shown in the right photo. (credit “echidna”: modification of work by Barry Thomas)

MAMMALS (15.6)

- **Marsupials** are primarily found in Australia and the nearby islands,
  - The opossum is a marsupial found in the Americas.
  - Examples of Australian marsupials include the kangaroo, koala and Tasmanian devil (Figure 15.46).
  - Most marsupials have a pouch in which the young reside after birth because the young are born much less developed than placentals. They complete their development in the pouch.
- **Eutherians** (placentals) are the most widespread of mammals, occurring throughout the world.
  - All species have a complex placenta that connects the fetus to the mother and allows gas, fluid, waste and nutrient exchange.
  - There are several major groups, including insect eaters, toothless anteaters, rodents, bats, aquatic mammals, carnivorous mammals and primates (the group that includes humans).

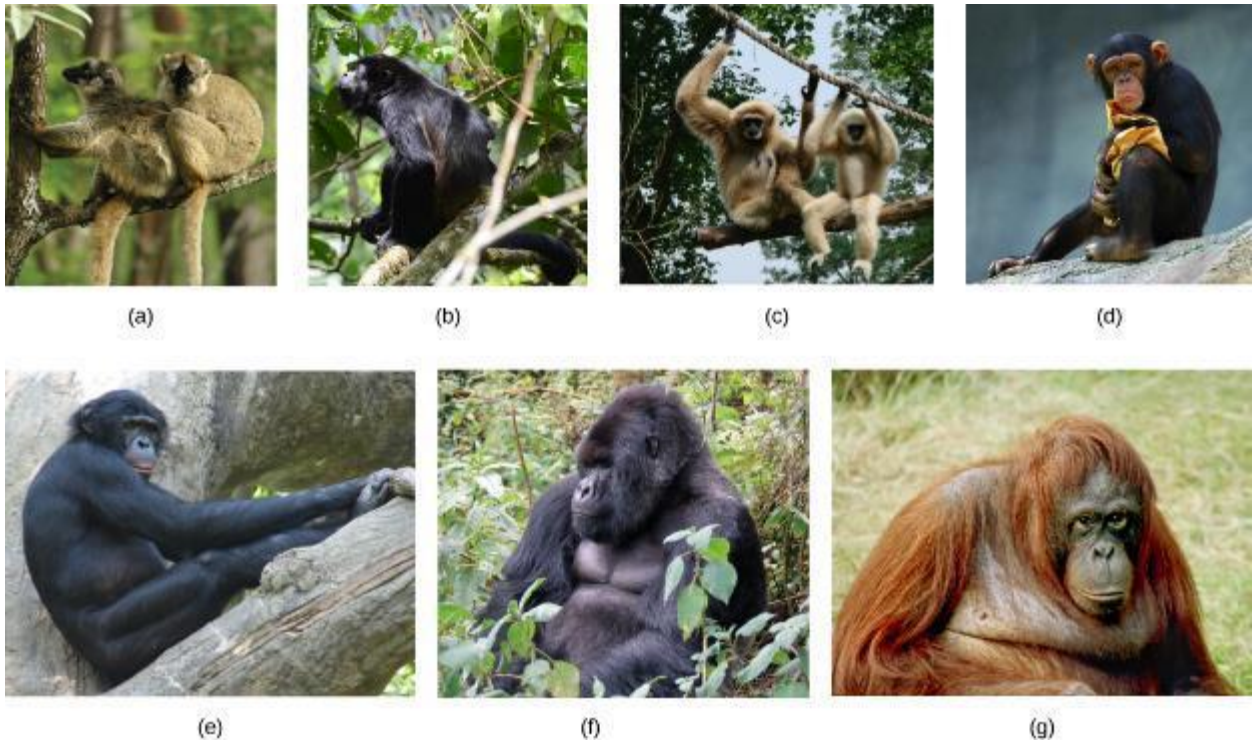
FIGURE 15.46 A MARSUPIAL

The Tasmanian devil is one of several marsupials native to Australia. (credit: Wayne McLean)

PRIMATES (15.6)

- Order Primates is a mammalian group that includes lemurs, tarsiers, monkeys and apes, which includes humans (Figure 15.47).
- Non-human primates live primarily in tropical and sub-tropical areas in South America, Africa and Asia.
- All primates have adaptations for climbing trees because they all descended from tree-dwellers.
    - This resulted in hands and feet adapted to climbing and swinging through trees.
- Other characteristics of primates include brains that are larger than many other mammals, claws modified into flattened nails, typically only one offspring per pregnancy and a trend toward an upright body.

FIGURE 15.47 PRIMATES



Primates can be divided into prosimians, such as the (a) lemur, and anthropoids. Anthropoids include monkeys, such as the (b) howler monkey; lesser apes, such as the (c) gibbon; and great apes, such as the (d) chimpanzee, (e) bonobo, (f) gorilla, and (g) orangutan. (credit a: modification of work by Frank Vassen; credit b: modification of work by Xavi Talleda; credit d: modification of work by Aaron Logan; credit e: modification of work by Trisha Shears; credit f: modification of work by Dave Proffer; credit g: modification of work by Julie Langford)

VOCABULARY 1 OF 2

- Heterotrophic
- Tissue
- Body plan
- Asymmetrical
- Radially symmetrical
- Bilaterally symmetrical
- Germ layers
- Diploblastic
- Triploblastic
- Coelom
- Acoelomate
- Eucoelomate
- Pseudocoelomoate
- Protostomes
- Deuterostomes
- Choanocytes
- Intracellular digestion
- Budding
- Fragmentation
- Gemmules
- Hermaphroditic
- Sessile
- Cnidocytes
- Nematocysts
- Polyp
- Medusa
- Mesoglea
- Gastrovascular cavity
- Cephalization
- Cuticle
- Ecdysis

VOCABULARY 2 OF 2

- Chelicerae
- Foot
- Visceral mass
- Mantle
- Radula
- Chaetae
- Clitellum
- Water-vascular system
- Notochord
- Dorsal, hollow nerve cord
- Pharyngeal slits
- Post-anal tail
- Lateral line
- Operculum
- Swim bladder
- Tetrapods
- Cutaneous respiration
- Amniotes
- Ectotherms
- Endotherms
- Pneumatic bones
- Monotremes
- marsupials
- Eutherians
- Porifera
- Cnidaria
- Platyhelminthes
- Nematoda
- Arthropoda
- Mollusca
- Annelida
- Echinodermata
- Chordata