SBI3U-C

The Animal Kingdom

Introduction

The diversity of the animal kingdom fascinates us the most, perhaps because we are animals ourselves. In this lesson, you will learn about the main phyla of animals, and how evolution in the animal body plan has led to species with greater complexity and ecological capabilities.

Research suggests that a diverse ecosystem is better able to withstand environmental stress, and is therefore more productive, than an ecosystem lacking diversity. The loss of a species is thus likely to decrease the ability of the system to maintain itself or to recover from damage or disturbance. Just like a species with high genetic diversity, an ecosystem with high biodiversity has a greater chance of adapting to environmental change. But biodiversity is decreasing everywhere in the world.

This lesson will take you a few hours longer than usual if you are able to carry out a plant survey activity. If you are not able to conduct the survey, sample data is provided so that you can answer the Support Questions.

Once you have completed this lesson and studied for the Final Test, you may take a Practice Test. It will help you prepare for the Final Test. Practice Test Suggested Answers are provided so that you can check your work. Follow the instructions at the end of this lesson.

Planning Your Study

You may find this time grid helpful in planning when and how you will work through this lesson.

Suggested Timing for This Lesson (hours)	
Characteristics of Animals	1
Invertebrates	1
Vertebrates	½
Biodiversity Crisis	¼
Activity: Identifying Invasive Plants	2
Key Questions	1

What You Will Learn

After completing this lesson, you will be able to

- explain why biodiversity is important to maintaining viable ecosystems
- analyze some of the risks and benefits of human intervention to the biodiversity of aquatic or terrestrial ecosystems
- use appropriate terminology related to biodiversity
- use proper sampling techniques to collect various organisms from a field and classify them
- describe unifying and distinguishing anatomical and physiological characteristics of animals
- classify and draw organisms according to their unifying and distinguishing anatomical and physiological characteristics
- explain key structural and functional changes in organisms as they have evolved over time

Characteristics of Animals

So, what exactly is an animal? With so much diversity among different animal species, it is difficult to imagine what they all might have in common. Some characteristics that are common to all animals are:

1. Animals are multicellular, heterotrophic eukaryotes. Animals cannot make their own food as plants do; they must acquire nutrients by ingestion. Animals typically store their carbohydrates as glycogen, whereas plants store them as starch. All animals require oxygen for their metabolism.
2. Animal cells have a cell membrane and lack a cell wall; therefore, they are different from plants, algae, and fungi.
3. Animal cells are organized into tissues that make up different organs and organ systems. Two types of tissue are unique to animals: nervous tissue, which is responsible for impulse conduction, and muscle tissue, which is responsible for movement.
4. Animals have the capacity to reproduce sexually (though many reproduce asexually as well).

Body Plan

A body plan is the overall organization of an animal's body. Scientists categorize animals according to the similarities in their body plan, based on the following six characteristics:

1. Body Symmetry

This refers to the general appearance and arrangement of body parts. Most animals fall into one of two categories: bilateral or radial symmetry. Animals with bilateral symmetry (like humans) can be divided into two sides that are mirror images of each other only along one axis. Animals with radial symmetry (like sea stars) have many similar-looking parts that branch out from the main body. Bilateral symmetry is adaptive for animals that move about in search of food. Radial symmetry is adaptive for animals that live their lives attached to something. Being radially symmetrical makes it possible for them to detect food or predators coming from all directions.

2. Cephalization

Cephalization means the presence of a head. Cephalization occurs in all bilaterally symmetrical animals because there is an advantage in having sense organs located on the end that goes first, as the animal moves. Food can also be captured more effectively if the mouth is located at the front of the body.

3. Complete Gut

Many simple animals do not have a gut with two openings. In some animals the same opening serves as both mouth and anus. Because the cavity into which the mouth opens also serves as a rudimentary circulatory system, it is called a gastrovascular cavity. This arrangement is less efficient because once the gastrovascular cavity is filled with food, the animal must wait until it is all digested before expelling the wastes the same way the food came in. Having a complete gut with an anus means the animal can eat continuously, since there is one-way traffic in the gut.

4. Body Cavity

For large animals, relying on a simple, tubular gut to supply food would mean that the animal would have to stay thin, but grow longer and longer to get the right surface/volume ratio. Long, thin bodies are very fragile. A better solution might be to coil a long gut up inside a short body, but this requires that the body be hollow. The formation of a body cavity, or coelom, represents an important evolutionary advance that helped lead to more complex organisms like vertebrates.

The coelom is usually filled with fluid. A fluid-filled coelom provides several advantages. The fluid, as it sloshes around, can circulate food and oxygen and pick up wastes. Because a fluid cannot be compressed, if an animal flexes the muscles of its body wall around the coelomic fluid, it becomes hard and rigid. This means the coelom can function as a hydrostatic skeleton.

5. Skeletons

Effective movement using limbs to walk or swim requires a skeleton—a hard structure providing internal or external support. Skeletons are defined by their position, either inside or outside the body. Endoskeletons are like our bones, on the inside of the body, forming a structural framework. Exoskeletons, like those of insects and crabs, are on the outside, and look like a suit of armour.

6. Segmentation

A segmented animal has a body that consists of repeating identical or similar units, called segments. This particularly helps in movement. In the annelid worms, such as earthworms, segmentation allows them to burrow in soft mud. In vertebrates, segmentation enables efficient walking and swimming using the muscles, skeleton, and nervous system.

Classification of Animals

The simplest animals have the smallest number of the body plan features described above, and the most complex have the largest number of those features. The development of those features can be used to show the course of evolution. This is demonstrated in the evolutionary, or phylogenetic, tree shown in Figure 20.1, below, which shows the main evolutionary branches of animals along with the main changes in body plan that are associated with them.

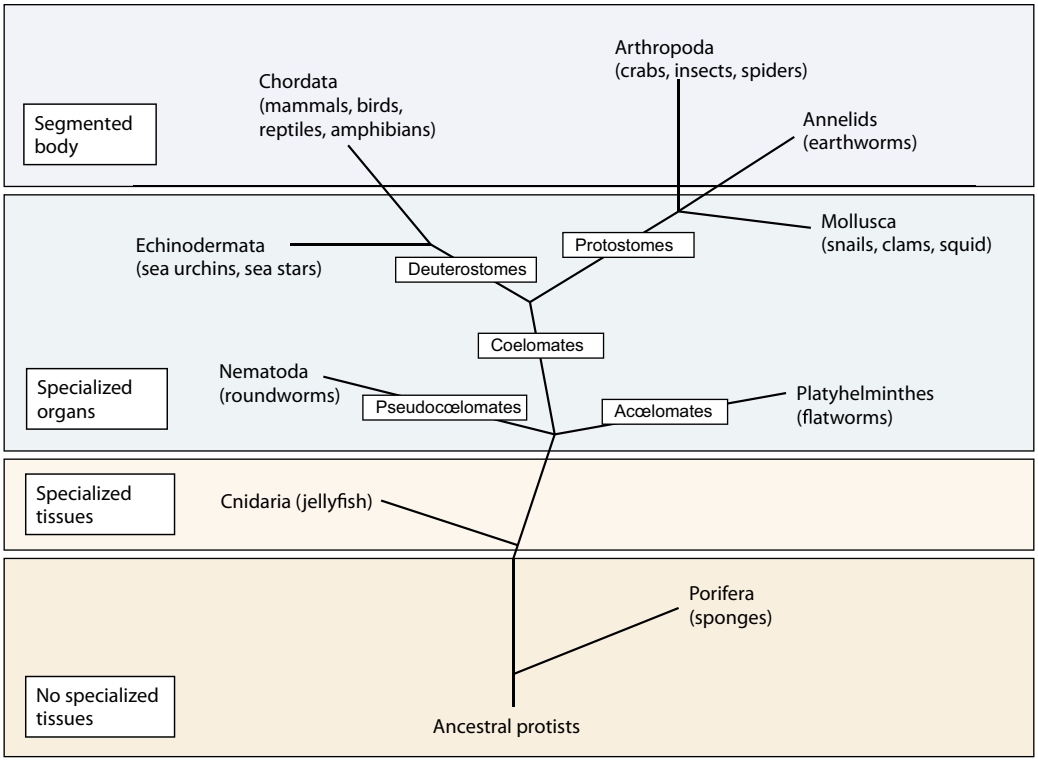


Figure 20.1: Evolutionary tree showing the branching points for common animal phyla. The major evolutionary advances in body plan are indicated in the white boxes.

A group of animals with a similar body plan is called a phylum (plural: phyla).

The animal kingdom can be split up into two main groups: invertebrates (animals without a backbone) and vertebrates (animals with a backbone). Vertebrates will only be described briefly, since you already studied the internal structure and physiology of vertebrate animals (namely, humans) in Unit 3.

Support Questions

Be sure to try the Support Questions on your own before looking at the suggested answers provided.

24. Give a definition of cephalization, and explain how animals became better adapted to movement as they evolved cephalization. Suggested answer

25. What is a body plan? List six characteristics of a body plan. Suggested answer

Invertebrates

Invertebrates are a very diverse group of animals. They include worms, crabs, insects, clams, sponges, spiders, and jellyfish. To keep things simple, in this lesson, invertebrates will be divided into four groups:

- simple
- worm-like
- complex
- joint-legged

Simple Invertebrates

The simplest invertebrates are the sponges and cnidarians. They live in water, usually the ocean.

Phylum Porifera: Sponges

Over 98% of all sponge species are found in marine environments; the rest are found in freshwater lakes and streams. Sponges are among the least complex of all animals. They lack organs and tissues because their cells are generally not specialized. Sponges have no nerves or muscles, but individual cells can sense and react to changes in the environment. Sponges are the only animals to have an asymmetrical body plan (no way to divide them to create mirror images). Sponges are sessile organisms, which means they anchor themselves to one spot for their entire life. They rely on food coming to them, rather than being able to travel to find food (Figure 20.2).

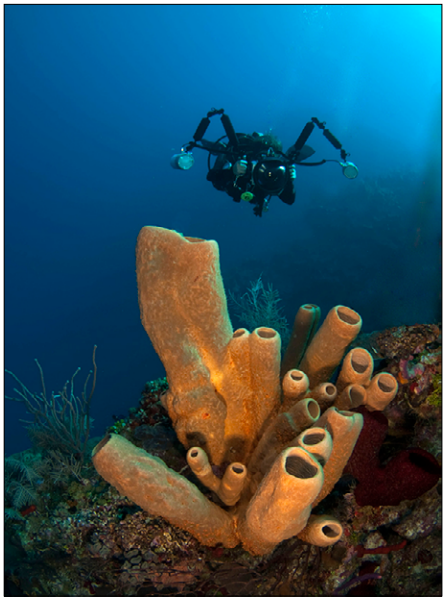


Figure 20.2: Large sponge on a coral reef being photographed by a diver

Source: Wikimedia Commons

Sponges are covered with numerous tiny pores through which water enters. Water leaves through a large opening called the osculum (Figure 20.3). Within the hollow sponge, water travels through canals. During its passage, small organisms are filtered out and eaten, and wastes are released. The sponge's gelatinous body is strengthened by needle-like fibres called spicules.

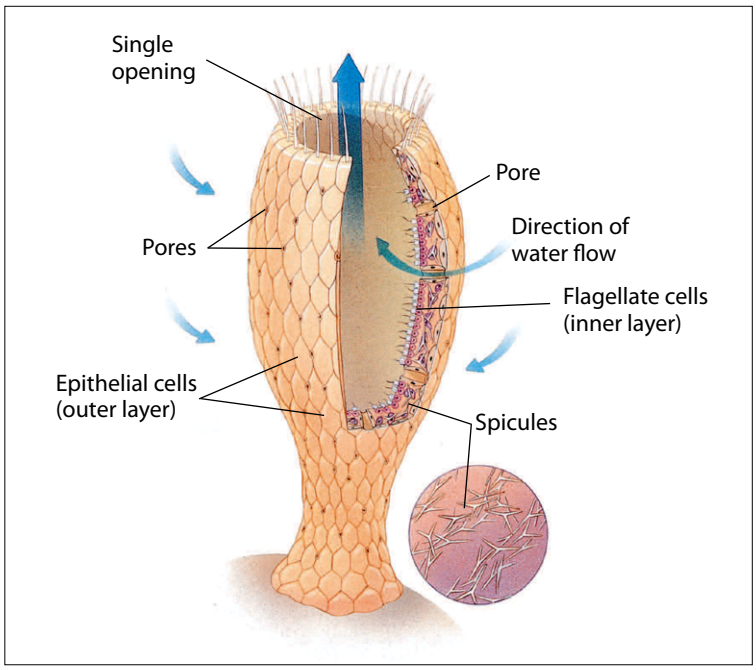


Figure 20.3: Structure of a typical sponge in the phylum Porifera showing how the water flows through it. The osculum is the single opening at the top.

Source: McGraw-Hill Biology 11

Sponges are hermaphrodites, meaning that each individual functions as both male and female in sexual reproduction by producing sperm and eggs. Sponges rely on water currents to carry sperm from one individual to another to fertilize an egg. Sponges also reproduce asexually by budding—new individuals form from outgrowths (buds) on the bodies of mature organisms.

Phylum Cnidaria: Two-layered Animals

Cnidarians include hydrozoans (class Hydrozoa), jellyfish (class Scyphozoa), and sea anemones, sea fans, and corals (class Anthozoa). These are some of the most beautiful animals on earth, and people travel thousands of miles on vacation to scuba dive and snorkel among them (Figure 20.4).

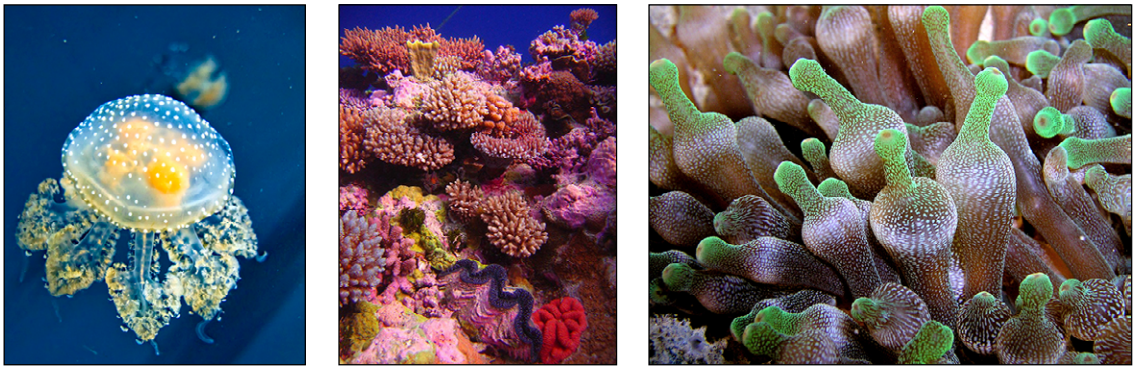


Figure 20.4: a) jellyfish; b) coral; c) sea anemone

Source: Wikimedia Commons

Cnidarians are radially symmetrical. Cnidarians show a more complicated arrangement of cell layers as well as a greater range of cell types than the Porifera. All cnidarians have a single opening into the body which acts as both the mouth and anus, taking in food and expelling waste. In most species, the mouth is lined with tentacles which act to capture food. Nematocysts are common in all cnidarians, and are the one major trait that separates this phylum from the others. A basic nematocyst is a capsule made of a chitin-like substance enclosing a coiled needle-like thread. This thread can be shot out of the capsule to penetrate the skin of the prey and inject a toxin.

Ecological Role of Simple Invertebrates

Simple animals like sponges and cnidarians play important roles in the marine ecosystem. Sponges and jellyfish feed near the bottom of the food chain, filtering out small organisms from the water. They in turn provide food for other animals, and thus help cycle nutrients through the ocean ecosystem.

Coral reefs are some of the oldest ecosystems on the planet. The reefs are home to millions of species of fish and invertebrates, providing them with food, shelter, and a site for breeding. Some species that do not even live in the reef may travel there just to breed. Coral reefs that border land act also as a buffer for the harsh waves. The reefs cause the waves to slow down or stop completely, preventing erosion of the shoreline.

Support Questions

26. Draw a typical sponge and label the following on your diagram: osculum, pores, epithelial cells, and the flow of water. Suggested answer

27. What are nematocysts? Suggested answer

Worm-like Invertebrates

Worm-like animals exhibit bilateral symmetry. Bilaterally symmetrical animals move through their environment with their anterior (front) end forward. The anterior end contains a concentration of sensory organs and nerve cells (cephalization), which is common in bilaterally symmetrical animals. Common worm-like animals include flatworms, roundworms, and segmented worms.

Phylum Platyhelminthes: Flatworms

All flatworms have the following properties in common:

- They have flattened bodies that lack a body cavity.
- They have three body layers: ectoderm, endoderm, and mesoderm.
- There are no circulatory or respiratory systems; oxygen entering and carbon dioxide leaving the body diffuse through the body wall. Therefore, all their cells have to be close to the surface so that they can effectively carry out gas and waste exchange with their environments.
- They have a nervous system with an anterior collection of cells that act like a primitive brain. These cells have both sensory and motor functions.

Planarians are the most common flatworms, and they live in aquatic habitats. Flukes and tapeworms are both parasitic, and live part of their life cycles inside the digestive tracts of mammals. They have a thick cuticle to protect them from digestive enzymes. Cestodes have bodies with sections, like a tapeworm.

Phylum Nematoda: Roundworms

Nematodes are widely distributed in the soil, the sea, and fresh water. They are the most primitive animal to have a body cavity called a pseudocoelom. Nematodes have been characterized as a tube within a tube, referring to the digestive canal which extends from the mouth to the anus. They represent a major evolutionary advance over the flatworms because they possess a separate mouth and anus, which allows for an efficient, one-way passage of food through the digestive system.

All nematodes have narrow cylindrical unsegmented bodies that are tapered at both ends. The smooth outer cuticle is extremely tough. Nematodes can be free-living or parasitic. Some parasitic nematodes cause diseases in humans, such as elephantiasis and river blindness.

Phylum Annelida: Segmented Worms

Annelid worms, like the common earthworm (Figure 20.5), have much greater mass and size than nematodes and flatworms. Because of this, gas exchange within the body must be carried out using a circulatory system, unlike the simple diffusion used by nematodes and flatworms. The digestive system in annelids is a complete tube with mouth and anus.

Figure 20.5: Annelids, like this earthworm, are very valuable in lawns and gardens.
Source: Wikimedia Commons

Annelids have a coelom. This allows their body to be divided into a series of repeating segments that contain identical copies of internal structures. Segmentation in the body plan is an advantage over that of roundworms for locomotion since the body compartments, each controlled by different muscles, are capable of far greater complexity of movement over non-segmented worms. That is why earthworms can move so quickly and can twist and turn so well.

Ecological Role of Worm-like Invertebrates

Worm-like animals are a vital link in food chains in virtually all the ecosystems of the world, and many species of worms are decomposers, helping to break down dead plants and animals to return nutrients to the soil. Free-living roundworms (nematodes) are important decomposers; they promote nutrient recycling by enhancing fungal and bacterial activity in the soil. Earthworms aerate and mix the soil, help with composting (converting dead organic matter into rich humus), and convert soil particles into accessible nutrients.

Support Questions

28. How does segmentation help with locomotion? Suggested answer

29. What would happen if nematodes were removed from an ecosystem? Suggested answer

More Complex Invertebrates

Invertebrates can be very complex animals. For example, the octopus is an invertebrate in the phylum mollusca, but biologists have recently discovered that it may have a very high level of intelligence.

Phylum Mollusca: Animals with a Shell

Molluscs are bilaterally symmetrical. All molluscs have a similar body plan, with three main parts: a muscular foot (used for movement), a visceral mass (containing internal organs), and a mantle (tissue that may secrete a shell). Other key features that are shared are a soft body covered by a dorsal shell made of calcium carbonate. Most molluscs have an open circulatory system with a heart and an aorta. The system is called open because the blood bathes the tissues directly rather than through a network of capillaries as in mammals (as you learned in Lesson 11). Molluscs possess a digestive system with a mouth and anus. Gaseous exchange occurs in the gills.

The phylum Mollusca is divided into three main classes: class Bivalvia (clams, oysters, scallops, and mussels), class Cephalopoda (squids, octopuses, nautiluses, and cuttlefish), and class Gastropoda (nudibranchs, snails, slugs, limpets, sea hares, and relatives). Many molluscs have an external shell, such as clams, oysters, and snails. Others create an internal shell to which they attach their muscles, such as squids and octopuses.

Most molluscs can move at some point in their lives. As larvae, the bivalves can swim so they can find a suitable home to land on and attach themselves to for the rest of their lives. The gastropods use a large foot to move throughout their life. The cephalopods can swim very rapidly using a jet of water they squirt out of a siphon, which is a modified foot.

Molluscs feed in many different ways. The bivalves are filter feeders, straining tiny organisms out of the water. Gastropods have a very rough tongue-like feeding organ called a radula which they use to graze on algae or other plant material. The cephalopods use a beak-like jaw to bite and inject a poison to immobilize their prey. Some cephalopods, like the octopus and squid, have large complex eyes so they can see their prey from great distances (Figure 20.6). They also have very well-developed brains which help them hunt for food in a complex environment.

Figure 20.6: Notice the large eyes on this squid, which help it locate prey in the dark depths of the ocean.

Source: Wikimedia Commons

Phylum Echinodermata

All echinoderms are marine organisms. The phylum Echinodermata includes sea stars ("starfish"), sea urchins, sand dollars, and sea cucumbers. As adults, echinoderms are radially symmetrical, but as larva, they are bilaterally symmetrical. The body plan of adult echinoderms is based on five equal parts radiating out from a central axis. Because many echinoderms are sessile on the ocean floor, there is no particular advantage to being bilaterally symmetrical. As a result, echinoderms are radially symmetrical and do not show cephalization. Most echinoderms have an internal skeleton that supports and protects the animal. The skeleton is made of calcium plates. They possess a water vascular system, which is a system for locomotion, food and waste transportation, and respiration based on the principles of hydraulics.

Other characteristics of echinoderms include:

- a body cavity that is a true coelom;
- a through-gut with an anus (most species);
- a body shape that is highly variable, but does not include a head;
- a nervous system;
- a poorly-defined open circulatory system; and
- sexual reproduction.

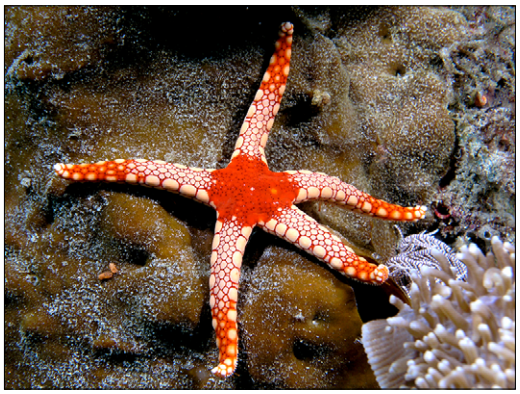


Figure 20.7: Photograph of a sea star. Sometimes they are called starfish, but they are not actually fish.
Source: Wikimedia Commons

Ecological Role of Complex Invertebrates

Molluscs include herbivores, predators, scavengers, and filter feeders; those that live in water help purify it. Some are keystone species—a species whose very presence contributes to the diversity of life, and whose extinction would lead to the extinction of other forms of life. Echinoderms play a key ecological role in ecosystems. The grazing of sea urchins and sea stars prevents the growth of algal mats on coral which could kill the coral. In this way, sea stars and sea urchins are a keystone species for many coral reefs. The burrowing of sand dollars and sea cucumbers in the sea bed in search of food increases the depth to which oxygenation occurs. Echinoderms are also the staple diet of many organisms.

Support Questions

30. Compare and contrast the three classes of molluscs by completing the following chart:

Suggested answer

Characteristic	Bivalves	Gastropods	Cephalopods
Location of shell	External		
Method zof locomotion	Larvae can swim; adults are sessile		
Feeding		Use radula to scrape algae from rocks	

Joint-legged Invertebrates

Phylum Arthropoda: Animals with Exoskeletons

The phylum Arthropoda includes class Arachnida (spiders), class Crustacea (crustaceans), class Insecta (insects), class Diplopoda (millipedes), and class Chilopoda (centipedes). All arthropods are segmented. For survival, the arthropods developed a thickened outer covering made of a strong, waterproof carbohydrate molecule called chitin. This adaptation provided protection and is called an exoskeleton (outer skeleton). The exoskeleton is a defining feature of arthropods (Figure 20.8).

Figure 20.8: The exoskeleton of this crab (crustacean) is brightly coloured, probably to attract a mate.
Source: Wikimedia Commons

Along with the rigid exoskeleton, arthropods evolved appendages that are moved by muscles. In time, these appendages evolved to became jointed, and this adaptation increased the mobility of these animals. Because a rigid exoskeleton cannot expand as the animal grows, the exoskeleton must be shed periodically and replaced with another one of a larger size in a process called molting.

The development of an exoskeleton had the effect of altering the body plan of these animals in significant ways. The coelom was no longer needed as a structure to provide shape to the animal and was reduced in size. Because the exoskeleton reduced the capability of gas exchange through the skin, these animals developed new ways to take in oxygen and release carbon dioxide through the use of gills and other structures. Many arthropods, especially those that lived on land, developed tubes within their bodies, called tracheae, to carry oxygen to the body tissues. An advantage of having a waterproof exoskeleton is that arthropods could resist drying out. With this ability, many arthropod species evolved into land-dwelling organisms, like insects, spiders, millipedes, centipedes, and crabs.

Arachnids and Insects

Two of the most successful classes of arthropods are the insects and arachnids (spiders). There are more than 1.5 million different species of insects and over 40 000 species of spiders. They are found in all habitats except the ocean. At first, spiders and insects appear very similar—but upon closer inspection you can see there are several major differences (Figure 20.9). For example:

- The arachnid body has two parts: the cephalothorax and the abdomen (as in spiders), while the insect body has three parts: head, thorax, and abdomen.
- Arachnids have four pairs of walking legs, while insects have three pairs.
- Arachnids are able to secrete silk to make webs, but insects cannot.
- Some insects can fly using wings, but no spiders have wings.

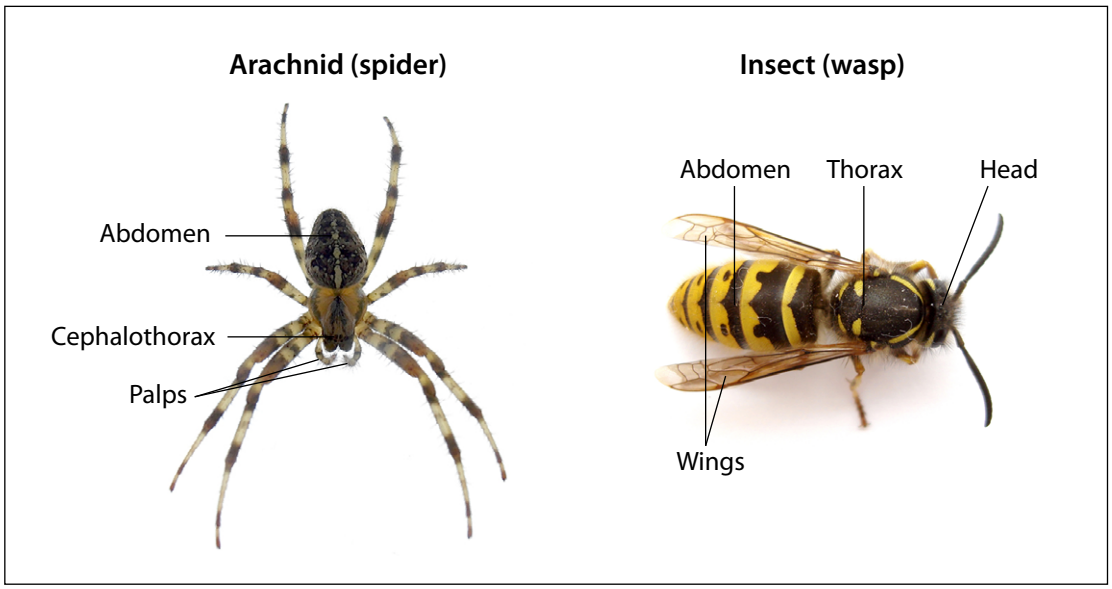


Figure 20.9: Comparison of arachnid and insect body structures
Source: Wikimedia Commons

Ecological Role of Joint-legged Invertebrates

Arthropods are of ecological importance because of their sheer numbers and extreme diversity. Arthropods play key roles in almost every ecosystem. For example, on land, insects are often critically important pollinators. In aquatic environments, tiny crustaceans called copepods are food for almost every other type of organism. Everywhere they are found, arthropods are important nutrient recyclers, and often play the role of a keystone species.

Support Questions

31. What are the five major classes in the phylum Arthropoda? Suggested answer

32. State two advantages of an exoskeleton and one disadvantage. Suggested answer

Vertebrates

The phylum Chordata, or vertebrates, contains animals with a backbone. You are a vertebrate, as are most animals you see around you every day like birds, squirrels, dogs, cats, and fish. Vertebrates are also referred to as chordates. All chordates, at some stage in their life, have a dorsal, hollow nerve cord called a notochord. Because the skeleton provides an internal support structure, it has allowed vertebrates to achieve greater size and mobility compared to all other phyla.

Vertebrate animals have two pairs of appendages attached to the vertebral column. The faster locomotion afforded by these appendages helped give rise to the evolution of a large brain. Vertebrates have a large coelom in which the internal organs are housed. A well-developed circulatory system delivers oxygen to the tissues through the pumping of a heart. In aquatic vertebrates, gas exchange takes place in the gills, while in terrestrial vertebrates, it occurs in the lungs. The body is covered in skin which often forms accessory structures, such as glands, scales, feathers, hair, nails, claws, horns, and hoofs.

Phylum Chordata is divided into seven classes:

- class Agnatha (jawless fish);
- class Chondrichthyes (cartilaginous fish);
- class Osteichthyes (bony fish);
- class Amphibia (amphibians);
- class Reptilia (reptiles);
- class Aves (birds); and
- class Mammalia (mammals).

Only one class of vertebrates will be described in detail in the next sections to save time. However, you can use the Internet to discover many fascinating things about the other classes.

Class Mammalia

The class of vertebrates of most interest to us are the mammals, perhaps because humans are mammals. The defining feature of mammals are the mammary glands in females that are used to produce milk to nourish the young.

There are three different types of mammals: monotremes, marsupials, and placentals. Monotremes are egg-laying mammals, and have been largely unsuccessful due to their vulnerability to predators. Only two species currently survive: the platypus and the spiny anteater. Marsupials are pouched mammals and, due to their protection in the mother's pouch, have a better chance to survive in dry, hot environments. Both monotremes and marsupials are now confined mostly to Australia and the surrounding islands.

Placentals are mammals that nourish their young via a membrane attached to the uterus called the placenta. Due to the longer gestation of the young in placental mammals, the infants are better able to survive in a wide variety of environments, which is why placental mammals have displaced marsupial and monotreme mammals on almost every continent.

Controlling Body Temperature

Sometimes it is helpful to classify vertebrates into two groups based on whether they generate their own heat, as this can help us predict where they can live and how much they need to eat. Cold-blooded vertebrates (ectotherms) can't generate their own body heat, and must rely on the external environment to control their body temperature. Warm-blooded vertebrates (endotherms) are able to maintain a constant internal temperature because they can generate their own internal heat through metabolism.

Most cold-blooded vertebrates (reptiles, fish, and amphibians) live in or close to water, or in usually warm areas where the temperature does not vary a lot. This is necessary for their body's chemical reactions to continue normally, as the enzymes that catalyze them usually have a narrow range of temperatures in which they can function properly. Ectotherms frequently develop elaborate patterns of behaviour to try and regulate their body temperatures, such as basking in the sun. Endotherms (birds and mammals) can keep their body temperature constant regardless of the external temperature, so their metabolic reactions can continue easily. This is why mammals and birds are able to survive in some of the coldest areas on the planet.

Because they need to maintain a constant body temperature, endothermic animals have far greater food requirements than ectotherms. Endotherms have to eat more, and more regularly, than ectotherms in order to survive. It also means that the circulatory systems of endotherms have to be even more efficient in delivering oxygen to the cells, because their metabolism is always running at a high level.

Ecological Role of Vertebrates

Vertebrates are found in every ecosystem, at every trophic level, and play many roles. Some are large predators at the top of the food web (such as polar bears), while others are very small, feed on plants, and are prey for many animals (such as mice). Aside from their role in the food web, their ecological roles also include:

Aeration of soil—lizards, moles, ground squirrels, and other burrowing vertebrates dig through the soil, providing passages for air and water.

Pollination—tropical birds and fruit bats are major pollinators in tropical rain forest ecosystems.

Seed dispersal—many vertebrates disperse seeds, either through their feces or on the outside of their bodies.

Vectors of disease—vertebrates carry many diseases, and can transport them to other species. For example, bats in central Africa may carry the deadly ebola virus that occasionally infects humans.

Support Questions

33. Describe the main feature of vertebrates that gives them an advantage over other kinds of organisms.

Suggested answer

34. Why do endothermic animals have far greater energy requirements than ectotherms?

Suggested answer

Biodiversity Crisis

Our planet has gone through at least five major extinctions in the four billion years of its existence. The reasons are not always fully known, but massive climate change is always part of the explanation. The first one occurred 450 million years ago, shortly after the evolution of land-based plants whose production of oxygen through photosynthesis "poisoned" the atmosphere for many species used to a low-oxygen atmosphere. The fifth mass extinction occurred 65 million years ago when a huge asteroid hit the earth and ended the age of the dinosaurs. Biologists warn that we are currently losing species at a rate similar to that of the five great mass extinctions of the geological past. Some biologists say we are on the verge of the sixth mass extinction, and that human activities are the cause.

Most threats to biodiversity are directly or indirectly the result of human activity: habitat loss, invasive species, over-exploitation, pollution, and climate change. As the human population

grows, we are devastating more and more natural habitats. Today, we may be losing 30 000 species a year—a much faster rate than at any time since the most recent global extinction. There is hope that conservation measures, sustainable development, and stabilization of human population numbers may help us stop species loss and thus prevent the sixth mass extinction.

Invasive species

After habitat loss, the biggest threat to biodiversity is the introduction of invasive species. Invasive species are non-native species introduced deliberately, or by accident, into a new environment. Native species are those that are naturally found in a particular ecosystem and are integrated into its food web. As a result, their populations are naturally controlled by the other competitors, predators, and parasites present. Non-native species are recent introductions to a food web, and usually lack these natural controls on their populations. Not all non-native species become invasive. Invasive species are those that have particularly serious impacts on the ecosystems they have recently entered. Invasive species often rapidly expand in numbers and spread quickly over wide areas. They out-compete or prey on the native species, leading to the local extinction of many native species.

Some famous examples of invasive species destroying biodiversity can be found on many tropical islands. As early European sailing ships arrived to open up trade routes 200 years ago they left behind rats, cats, pigs, and goats. Each of these species found abundant food supplies and islands free of predators and disease. Their populations exploded in size and they rapidly ate many of the native species into extinction.

Invasive species are also a problem in Ontario. For example, zebra mussels arrived from Europe with ships visiting the Great Lakes during the 1980s. Within a decade, they had spread throughout the Great Lakes and many smaller lakes. They feed at the base of the food chain, filtering the water to obtain the tiny organisms they eat. As their numbers grew, they were consuming so much of the food in the water that other species could no longer find enough to eat. This caused dramatic reductions in many native species of invertebrates and fish.

Invasive plants are also a problem in Ontario. It is very easy for their small seeds or spores to be introduced accidentally when goods are shipped between continents. As well, people deliberately plant non-native species in their gardens without knowing that these have the potential to be invasive. For example, the pretty purple loosestrife is an invasive plant in Ontario that lives in wet soil and drives out native wetland plant species; until recently, it was sold in packets of flower seeds for gardeners.

Invasive species can be found in any habitat, but they are especially likely to occur in habitats that have been recently disturbed. A disturbance can be anything that returns the habitat to an earlier successional state. Events such as fire, forest clearing, mowing, plowing, application of pesticides, urban development, or flooding all tend to disturb habitats and make them easier for an invader to gain a foothold. Disturbed areas lack some of the biological interactions that might otherwise control the establishment and spread of an invasive species.

Support Questions

35. List three threats to biodiversity. Suggested answer

36. How can invasive species cause loss of biodiversity? Describe one example where this happened. Suggested answer

Activity: Identifying Invasive Plants

In this activity, you will sample a patch of natural habitat in your area to determine the presence and extent of five invasive plant species. Plants are easier for you to survey than animals because identification can be easier, and they have the benefit of not running away. Obviously, this survey can only be done in seasons when the plants are fully grown. If you are unable to conduct this field survey, a table of sample data is provided. You can use that sample data to answer the Support Questions that follow the activity.

Background

The first steps in controlling invasive species are learning to recognize them and recording where they occur. The five invasive plant species you are looking for are:

- Dog strangling vine (*Cyanchum rossicum*)
- Garlic mustard (*Alliaria petiolata*)
- Purple loosestrife (*Lythrum salicaria*)
- Japanese knotweed (*Fallopia japonica*)
- Common buckthorn (*Rhamnus cathartica*)

Depending on your area, you may have all five, some, or even none of these invasive species present in your sample.

Field Site

You can choose any natural habitat that is convenient for you. Possible locations include a meadow, overgrown roadside, stream bank, park edge, or the edge of a forest. You need a patch of naturalized habitat that is about 100 m long because you are going to sample along a 100 m line, called a transect.

Be Safe:

- Throughout this activity be conscious of personal safety.
- Choose a location that you can walk along safely. Avoid steep hills or embankments and the edges of fast-flowing rivers. If you are choosing a roadside, make sure you are well away from any traffic.
- It is always best to have a friend come along. This helps keeps you safe, and it will speed up the sampling if you have a friend to help record the data for you.
- Make sure someone at home knows where you are going and when you are expected to return.

Materials

- Proper clothing:
  - Wear clothing appropriate for the weather conditions. Long pants are always better than shorts because they protect your legs from scrapes, insect bites, and irritating plants like stinging nettle or poison ivy. Gloves can be helpful for the same reasons. A hat will protect you from the sun, wind, rain, and insect bites.
- Good footwear:
  - Your choice will depend on the local conditions and weather. Use your best judgment. Rubber boots are always good because they keep your feet dry and protect your lower legs. Hiking or sturdy running shoes can be good, especially in dry, flat areas along roadsides or park edges.
- Data recording table
- Pen or pencil
- A clipboard or something hard to write on
- Identification guide for the invasive plants. You will need to download and print this document to take with you to the field.

Procedure

1. Choose the location for the transect line in your sample area. You will walk approximately 100 m along this line, which is about 120 paces for most people.
2. You will sample at 10 points along this transect line. You want to choose your points more or less randomly, but you should skip any large patches of bare earth.
3. At each sample point, stop, spread your arms out, and turn around in a circle. The circle is your sample area. You will record the percent cover of native and invasive species found within that circle (which is about 1.5–2 m in diameter).
4. Use your plant identification data sheets to help you recognize the five invasive plants.

5. At each sample point, record the approximate percent cover of the five invasive plants into a table like the one shown below. The percent cover is an estimate of how much of the circle the plant occupies as you look down on it. You can usually estimate fairly accurately in increments of 10 to 20 per cent. If a plant is not present, its percent cover will be zero. The total percentage of all plants in the circle will not always add up to 100% if there are bare patches of dirt present.
6. After recording data from your 10 samples along the transect, calculate an average for the percent cover of each invasive plant species in your transect.
7. Answer Support Questions 39–41.

Results

Sample #	Percent cover of invasive species					Percent cover of other plants
	Dog strangling vine	Purple loosestrife	Garlic mustard	Japanese knotweed	Common buckthorn	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Average % cover						

Percent cover of five invasive plant species along a 100 m transect

Support Questions

37. **a)** How many of the five invasive species were found in your sample?

b) What invasive species, if any, had the highest average percent cover in your sample?

Suggested answer

38. **a)** Do you feel that your survey accurately represented the vegetation community you see around you?

b) How could you improve your survey to make it more accurate? Suggested answer

39. Did it appear that any of these five invasive plants was a threat in your area? Suggested answer

40. What features of your area may have led to your results? Suggested answer

Key Questions

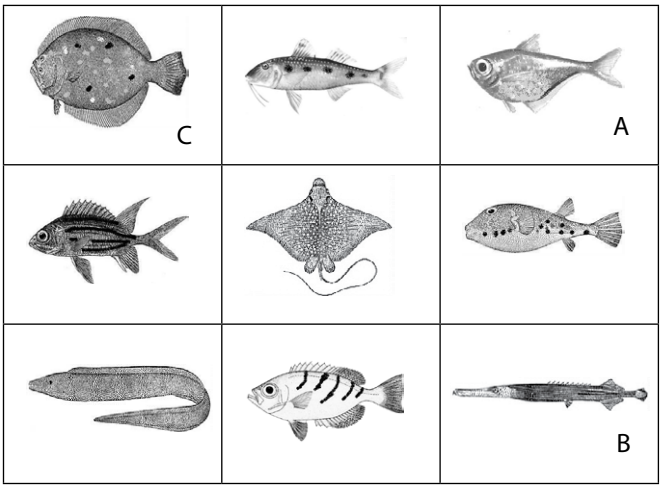
Now work on your Key Questions in the online submission tool. You may continue to work at this task over several sessions, but be sure to save your work each time. When you have answered all the unit's Key Questions, submit your work to the ILC.

(18 marks)

62. For the following question, match the description with the letter assigned to the term. **(5 marks: ½ mark for each)**

Description	Term
1. They belong to the phylum Porifera.	A. ectoderm
2. They possess both male and female reproductive organs.	B. ectotherms
3. The outer body layer of an organism	C. hermaphrodites
4. When discharged, the thread penetrates the skin of the prey and a toxin can be injected.A characteristic of cnidarians.	D. bilateral symmetry
5. A species whose very presence contributes to a diversity of life and whose extinction would consequently lead to the extinction of other forms of life.	E. nematodes
6. Two sides mirroring each other along an imaginary line	F. cephalization
7. The concentration of nerve cells at the anterior end of an animal	G. mammals
8. The phylum that consists of roundworms	H. nematocysts
9. Animals that lack a constant body temperature	I. keystone species
10. Animals that produce milk	J. sponges

63. Using the dichotomous key below for common fish found in the ocean, identify the three fish labeled A to C. **(6 marks: 2 marks for each fish)**



Source: ILC, adapted from Wikimedia Commons

1a. Fish shape is long and thin	go to 2
1b. Fish shape is not long and thin	go to 3
2a. Fish has a long nose	Trumpet fish
2b. Fish has a blunt nose	Spotted moray eel
3a. Fish has a long whip-like tail	Spotted eagle ray
3b. Fish does not have a long whip-like tail	go to 4
4a. Fish is nearly circular in shape	Peacock flounder
4b. Fish has oval shape	go to 5
5a. Fish has spots	go to 6
5b. Fish does not have spots	go to 7
6a. Fish has chin "whiskers"	Spotted goat fish
6b. Fish does not have chin "whiskers"	Band-tail puffer
7a. Fish has stripes	go to 8
7b. Fish does not have stripes	Glassy sweeper
8a. Fish has a v-shaped tail	Squirrel fish
8b. Fish has a blunt tail	Glass-eye snapper

64. Give a definition of body segmentation, and explain how animals became better adapted to movement as they evolved segments. **(3 marks)**

65. Explain why a non-native species is not always considered to be an invasive species. **(2 marks)**

66. In a survey of a stream bank in northeastern Ontario, a local naturalist group found that 20% of the plant cover was made up of purple loosestrife. Briefly describe two possible reasons for the presence of this invasive species on the stream bank. **(2 marks)**

Congratulations! You have completed all of the lessons in the course. When you have completed all the Key Questions for this unit, submit your work to the ILC. A teacher will mark it and you will receive your results online.

Prepare for the Final Test as you wait for your results. The ILC will get in touch with you about writing the test. To prepare for it, review the course material and do the Practice Test.

Practice Test

To help prepare you for the Final Test, you will take a Practice Test. The Practice Test is organized in the same way as the Final Test, so you will know what to expect. The front page is like the one you will see when you write the Final Test. Read over the instructions so that you are familiar with them, and so that there are no surprises at the time of the real test.

You will have two hours to write the Final Test. Time yourself when you do this Practice Test to see if you can complete the work in two hours. At the beginning of each section, you are told how long that section should take you to complete.

You can access the Practice Test here.

When you have completed the Practice Test, check the Practice Test Suggested Answers to see how well you have done.

If you had trouble with any of the questions on the Practice Test, go back to that section of the course and review the material and Support Questions carefully.

If you have trouble completing the test in two hours, it may be because you are not familiar with some of the ideas you need to know. Plan to review the course material fully before the Final Test.

Do not send the Practice Test in to the ILC for marking. It is for your own use, as practice for the real thing!