SBI3U-C

Lesson 19

Plants, Fungi, and Protists

Introduction

The diversity of life found in the three kingdoms of plants, fungi, and protists is immense. But most people are unaware of their importance, especially fungi and protists.

Plants, fungi, and protists are all vulnerable to changes in their environments such as rising temperatures. Most plants cannot migrate very quickly compared to animals and insects. They are restricted by the distance their seed or pollen can travel and, if current trends continue, the climate will change too fast for many of them to migrate. Human barriers such as farms and urban areas can also impede plant migration. Many animals and insects need specific plants, or types of plants, as part of their habitat. So the loss of plant species would have a ripple effect, leading to the extinction of more animals, plants, protists, and fungi. (You will learn more about the diversity of life in the animal kingdom in Lesson 20.)

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)	
Diversity of Plants, Fungi, and Protists	½
Kingdom Protista	1
Activity: Examining Protists	1
Kingdom Fungi	1
Kingdom Plantae	1
Key Questions	½

What You Will Learn

After completing this lesson, you will be able to

- describe unifying and distinguishing anatomical and physiological characteristics of representative organisms from each of the kingdoms
- classify and draw biological diagrams of representative organisms from each of the kingdoms
- use appropriate terminology related to biodiversity, including genetic diversity, species diversity, structural diversity, protists, bacteria, fungi, binomial nomenclature, and morphology
- use a dichotomous key to identify and classify organisms from each of the kingdoms
- analyze the impact that climate change might have on the diversity of living things

Diversity of Plants, Fungi, and Protists

When we think about the diversity of life, we tend to think of the animal kingdom and examples like lions, panda bears, and eagles. We often forget about the other three kingdoms of plants, fungi, and protists. But these kingdoms are very important to all forms of life on the planet, including us.

For example, biologists in North America are currently struggling to understand a disease called white nose syndrome, caused by a fungus, that has killed more than a million little brown bats over just three winters. The fungus grows on the faces of bats while they hibernate. The fungus irritates the bats, upsetting their natural hibernation rhythms. They become more active, and therefore burn up critical body fat. In some cases, the bats are forced to fly out into the freezing cold in search of food. But their main food source, insects, are not active during the winter months, so the bats starve to death.

How could this situation affect us? Bats are nature's pesticide. One little brown bat is capable of eating up to a thousand insects every night. If those million bats had not died, they would have eaten close to 694 tons of insects each summer. The surviving insects can cause heavy damage to forests and crops. For example, insects like moths and beetles attack cotton and corn, potentially forcing farmers to use much more pesticide. Bats have been around for about 50 million years, but an entire species of bats may be wiped out in less than a decade if this fungus continues to spread.

Habitat Loss

Our planet is continually changing, causing habitats to be modified. Natural changes tend to occur at a gradual pace, usually having only a slight impact on individual species. However, when changes occur at a fast pace, there is little or no time for individual species to adjust to new circumstances. The primary threat to the world's biodiversity is habitat destruction, sometimes referred to as habitat loss. Habitat loss alters or eliminates the conditions needed for plants and animals to survive. Deforestation is of particular concern. Canada's old growth forests, for example, are now under threat from logging activities. Around the world, tropical rain forests are being logged at such a rapid rate that they are becoming some of the most endangered habitats on earth.

Nearly every region of the earth has been affected by human activity. Many ecosystems are already stressed due to logging, excessive grazing, over-fishing, or pollution. The climate is changing faster than at any time in the planet's recent history. Anthropogenic (human-caused) climate change will alter temperatures, precipitation, and sea levels, wiping out some habitats and shifting others faster than many species can migrate or adapt. The loss of microbes in soils that formerly supported tropical forests, the extinction of fish and various aquatic species in polluted waters, and changes in global climate brought about by the release of greenhouse gases are all results of human activity.

Current research suggests that if global temperatures increase 1.8 to 2° Celsius, which is considered a mid-range estimate, a million species would be threatened with extinction over the next fifty years. This could be avoided by rapid reductions in emissions over the next few decades. There is still time to save many species, but it is fast running out. If temperatures get higher, even more species will be lost.

Support Questions

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

16. List four reasons for habitat loss caused by humans. Suggested answer

Kingdom Protista

Members of the kingdom Protista are the simplest of the eukaryotes. Most are microscopic, unicellular organisms that appeared about 1.5 billion years ago. Protists are an interesting assemblage of organisms classified for what they are not. Protists lack characteristics shared by plants, fungi, and animals, but they are not bacteria. Essentially, this kingdom is home to the organisms that could not be classified elsewhere.

The kingdom Protista contains close to 115 000 species, and they are diverse in their cell structure, metabolic needs, nutritional acquisition (heterotrophic or autotrophic), and reproduction (sexual, asexual, or a combination of both). They can be unicellular, multicellular or colonial. Some move around and act like animals, others perform photosynthesis like plants, and still others seem to think they are fungi. In this lesson, you will focus on animal-like, fungus-like, and plant-like protists.

Animal-like Protists

Protists that are classified as animal-like were formerly called *protozoans*, because they share some common traits with animals ("zoans"). All animal-like protists are heterotrophs, and are able to move in their environment in order to find their food. Unlike animals, however, animal-like protists are all unicellular. Animal-like protists are divided into four groups based on how they move and live.

Protists with Flagella

These protists move by beating their long whip-like structures called flagella (singular: flagellum). Protists with flagella are called zooflagellates. Some feed on other protists, and some live in the bodies of other organisms. Some are beneficial to their host, while others are harmful parasites. *Giardia lamblia* (Figure 19.1) is a flagellated parasite that colonizes and reproduces in the small intestine of humans, causing giardiasis or beaver fever. Giardia infections are usually associated with poor hygiene and sanitation, resulting in contaminated water supplies. Zooflagellates are the primary component in the marine food chain.

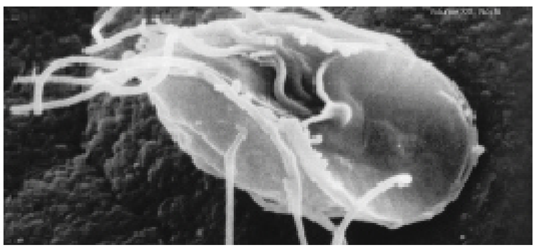


Figure 19.1: Electron microscope image of *Giardia lamblia*. Notice its many flagella.

Source: Wikimedia Commons

Protists with Pseudopods

These protists move by cytoplasmic streaming, the movement of cytoplasm within the protist resulting in the locomotion of the cell itself. This movement creates temporary finger-like projections of cytoplasm called pseudopods (false feet). The pseudopods are used both for movement and for obtaining food by engulfing small organisms (Figure 19.2) in a process called endocytosis.

Amoebas—single-celled organisms with no defined body shape—are an example of protists with pseudopods. Amoebas are of importance both medically and ecologically. Two amoebas that cause human disease are *Naegleria*, which causes amoebic meningitis, and *Entamoeba*, which causes amoebic dysentery. Both diseases are commonly found in the tropics and in countries with poor sanitation. Amoebas are major consumers of bacteria in soil ecosystems, and are believed to occupy the same key role there as flagellates do in aquatic ecosystems (namely, ensuring nutrient regeneration and continued functioning of the ecosystem).

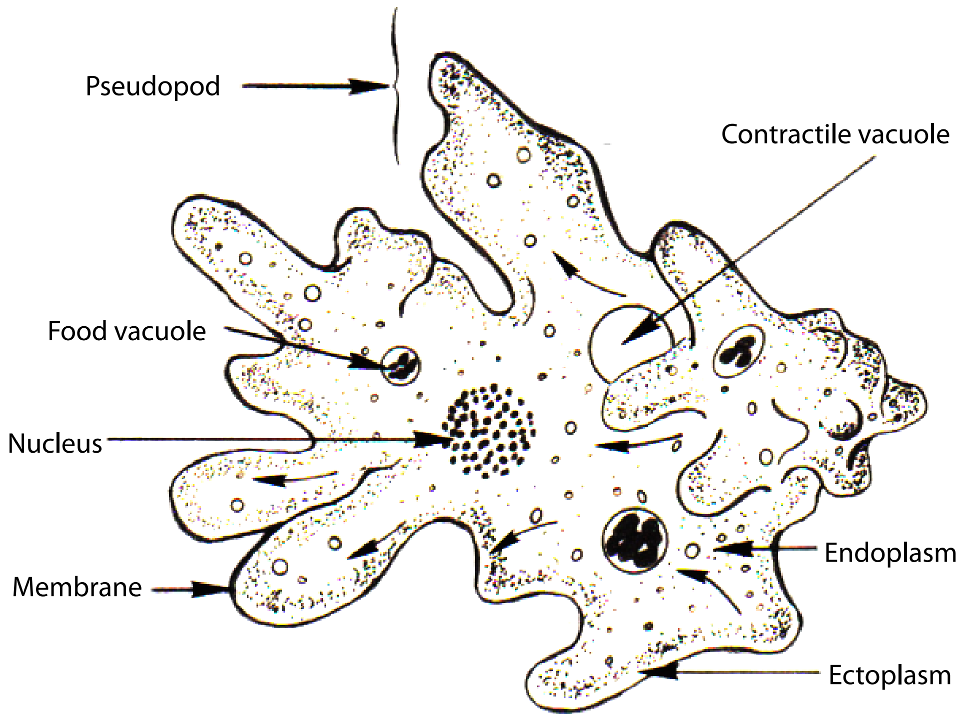


Figure 19.2: Drawing of an amoeba
Source: Wikipedia

Protists with Cilia

These protists, often called ciliates, move by beating tiny hair-like structures called cilia. The cilia act as tiny oars that allow the protist to move through its watery environment. The cilia also help the protists capture food. The freshwater *Paramecium* is one of the most common species in this group, with a shape that resembles the bottom of a shoe.

Ciliates have a skeleton-like covering called a pellicle, made of polysaccharides. Ciliates have two types of nuclei: a single large macronucleus, and one or more smaller micronuclei. The paramecium has one of each. The macronucleus operates as the director of the cell's activities, rather like a little brain. The micronucleus is used for reproduction.

Ciliates have a mouth-like opening at one end of their bodies called the oral groove. Their food—algae, bacteria, and other protozoans—is swept into the oral groove by the cilia. Paramecia can reproduce asexually (through binary fission) or sexually (through conjugation). The only member of the ciliate family to cause human disease is *Balantidium coli* (Figure 19.3), which causes severe diarrhea. Balantidiasis is considered to be rare, and occurs in less than 1% of the human population. The disease poses a problem mostly in developing countries, where water sources may be contaminated with pig or human waste.

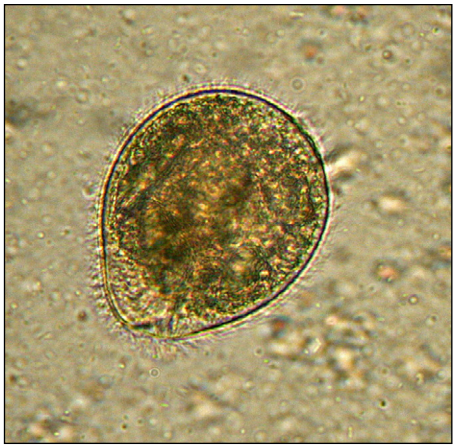


Figure 19.3: Microscope image of *Balantidium coli*
Source: Wikipedia

Sporozoans

These protists are characterized mainly by the way they live. They are non-motile (unable to move) and parasitic, obtaining their nutrients from the body of their host. Sporozoans are the only animal-like protist with no form of movement. They produce spores during part of their reproductive cycle, which is how they got their name. Many of these protists cause diseases; *Plasmodium falciparum*, a well-known sporozoan, is the parasite that causes malaria.

The life cycle of the parasite *Plasmodium falciparum* uses two separate hosts. The first is a female *Anopheles* mosquito. When an infected mosquito then begins to feed on human blood, it transfers sporozoites, or spores, into the bloodstream, infecting the human. These sporozoites begin to infect cells in the liver. Once mature, they rupture and spread merozoite cells. These cells replicate in the liver and further increase through asexual reproduction. As these merozoites increase, they spread and infect the red blood cells. Once these parasites begin infecting red blood cells, the disease of malaria has clinically occurred.

When the *Anopheles* mosquitoes feed on the blood of an infected person, they ingest the infected cells that have been spread. Inside the mosquito, the parasites begin multiplying again. This mosquito-based multiplication is called the sporogonic cycle.

Support Questions

17. Summarize information about diseases that are caused by animal-like protists using the table shown below.

Suggested answer

Type of organism	Name of disease	Organism that causes the disease	Source of the disease
Zooflagellates			
Amoebas			
Ciliates			
Sporozoans			

18. What is usually the common factor in the transmission of diseases by animal-like protists?

Suggested answer

Fungus-like Protists

Fungus-like protists are heterotrophs that absorb nutrients from dead or decaying organic matter. They have cell walls made of cellulose, as plants do; however, they are not true fungi because they lack chitin in their cell walls. They also reproduce by forming spores. All fungus-like protists are able to move at some point in their lives.

Fungus-like protists are important recyclers of organic material: they help things rot. They break down dead organisms by releasing digestive enzymes into them, which then release materials that are useful to other living organisms into the surrounding environment. Dark, rich topsoil is the result of their decomposition activity.

There are essentially two types of fungus-like protists: oomycota and slime molds.

Oomycota

Oomycota include water molds, white rust, and downy mildews. Most water molds are decomposers that grow as cottony masses on dead algae and animals. They look like tiny threads with a white fuzzy covering.

Figure 19.4: Photograph of water molds growing on a seed

Source: Wikipedia

White rust and downy mildews are close relatives of water molds, but generally live on land as parasites of plants. Some of the most devastating plant pathogens are oomycota. *Phytophthora infestans* was the cause of the Irish potato famine in the mid-1800s. A type of downy mildew threatened French vineyards in 1870.

Plant-like Protists

Plant-like protists are autotrophic. They can live in soil, on the bark of trees, in fresh water, and in salt water. They can be unicellular, multicellular, or live in colonies. These protists are very important to the planet because they produce a lot of oxygen, and most living things need oxygen to survive. Furthermore, these plant-like protists form the base of aquatic food chains. The plant-like protists are divided into four basic groups: euglenoids, dinoflagellates, diatoms, and green algae.

Euglenoids

Euglenoids or Euglena are unicellular pear-shaped organisms; some have flagella. They are like a plant and also like an animal: they are autotrophs when it is sunny, and heterotrophs when it is dark. They are found mostly in fresh water. Euglena reproduce by fission, splitting lengthwise in two.

Dinoflagellates

Dinoflagellates are unicellular organisms covered by stiff plates, and normally have two flagella. They are abundant in fresh water and marine environments. Most are autotrophs, though some species are heterotrophs. Dinoflagellates can be luminescent. They reproduce asexually by mitosis.

Red tides are a marine phenomenon in which water is stained a red, brown, or yellowish colour because of the abundance of nutrients and a species of pigmented dinoflagellates (these events are known as algal blooms). Sometimes the dinoflagellates involved with red tides synthesize toxic chemicals. The toxins can accumulate in marine organisms that feed by filtering large volumes of water (containing the toxic dinoflagellates) such as clams, oysters, and mussels. If these shellfish are collected while they are significantly contaminated by red tide toxins, they can poison the human beings who eat them. Marine toxins can also affect local ecosystems by poisoning animals.

Recommended Activity:

Do an Internet search using the terms "algal blooms" and watch a video clip or two about these events.

Diatoms

Diatoms are unicellular organisms with thin cell walls of silicon. They are a type of algae, and are autotrophs. Diatoms are found in almost every aquatic environment including fresh and marine waters, as well as in soil and, in fact, almost anywhere moist. They reproduce asexually by cell division. They are very abundant in nature, and are the key food source in marine and freshwater ecosystems. After death, their silica-filled cell walls collect on the bottom of ponds, lakes, and oceans, forming a thick layer of a fine clay-like substance. This substance is often used in toothpastes, scouring products, and to produce very fine filters to purify water.

Green Algae

Green algae may be either unicellular or multicellular, and may form colonies or filaments (long chains that look like threads). Like plants, they are autotrophs; however, they lack the structural adaptations that plants have to succeed on land, such as cellulose in their cell walls, and organs such as roots and stems. Also, multicellular algae develop from a single unprotected cell, not from the well-protected embryos that plants have.

Some common examples of green algae include *Cladophora*, the colonial *Volvox*, and filamentous *Spirogyra*. These organisms are largely aquatic or marine. A few types are terrestrial, occurring on moist soil, on the trunks of trees, on moist rocks, and even in snowbanks. Various species are highly specialized, some living exclusively on turtles, sloths, or within the gills of marine molluscs. Algae are also the main source of food for other aquatic life. It has been estimated that marine green algae account for more than 90 percent of the world's photosynthetic activity, making them our planet's most important source of oxygen.

The over-fertilization of lakes, due chiefly to pollution by sewage, runoff from the land, and industrial wastes (inorganic nitrates and phosphates) is called eutrophication. These compounds act as nutrients, stimulating algal growth to produce huge blooms. The mass death of these blooms and their subsequent decomposition reduces the oxygen content in the water, killing animals with a high oxygen requirement such as amphibians and fish.

Algae has been used for medical purposes to treat stomach ulcers, high blood pressure, arthritis, and other health problems. Products derived from algae, such as carrageenan, are used to make ice cream, salad dressing, pudding, candy bars, pancake syrup, and eggnog.

Ecological Role of Protists

Protists are easily overlooked when we think about biodiversity conservation. We tend to worry about preserving large trees, big animals, and showy flowers. But protists are of critical importance to ecosystems. For example, protists form the base of aquatic food webs, contribute 50% of global carbon fixation, oxygenate aquatic environments, and recycle critical nutrients. Protists are also causative agents in numerous human illnesses, ranging from malaria to cholera.

Support Questions

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

19. List three reasons that green algae have not been included in the plant kingdom, and are considered protists.

Suggested answer

20. Producers are the first trophic level in a food chain, and serve as a food source for consumers or higher trophic levels.

A water sample was taken from an Ontario lake in early fall, and the following microorganisms were identified: amoebas, paramecia, dinoflagellates, diatoms, and green algae. There was also some debris of decomposing plants in the sample.

a) Which of these organisms are producers?

b) Which of these organisms are consumers?

Suggested answer

Activity: Examining Protists

If you were trying to identify protists in a water sample, you would put a drop of the water on a microscope slide and study it under the microscope. Then you would use a dichotomous key to make the identifications.

Now click on this activity called Examining Protists. Examine samples of the six common types of protists found in ponds. Then, use the following dichotomous key to help you identify the various unknown samples of pond protists labelled A to F.

1a. Has cilia	Paramecium
1b. Has no cilia	go to 2
2a. Has a stalk	Carchesium
2b. Has no stalk	go to 3
3a. Spherical colony of cells	Volvox
3b. Cell shows at least one flagellum	go to 4
4a. Has spiral or coiled chloroplasts inside cell	Spirogyra
4b. Cell has one flagellum	go to 5
5a. Cell is rectangular	Cladophora
5b. Cell is oval with a tapered end	Euglena

Support Questions

21. **a)** Identify the species labelled A to F.

b) Make a drawing of a paramecium. Label the following elements: cytoplasm, cilia, cell membrane, and macronucleus.

Suggested answer

Kingdom Fungi

Fungi were included in the plant kingdom for many years. Fungi are similar to plants because they are usually multicellular and sessile (unable to move by themselves), appear in similar habitats as plants, and often have the same size. However, plants are autotrophic because they possess chlorophyll, while fungi are heterotrophic. Some fungi, unlike plants, are unicellular. Later, scientists determined that fungi are a unique and separate life form. The types of fungi most familiar to you are probably the mushrooms. They come in an amazing diversity of sizes, shapes, and colours (Figure 19.5).

Figure 19.5: A sampling of mushrooms found in Saskatchewan showing the diversity of forms.
Source: Wikipedia

Fungi are eukaryotic organisms that are saprobes, which means they absorb nutrients from the organic material in which they live. Most fungi consist of a tangled mass of hyphae that form a mycelium (Figure 19.6). The mycelium is usually hidden in the soil, in wood, or another food source. The part of the fungus that we see is only the fruit of the organism. Fungi do not have stomachs; they must digest (break down) their food before it can pass through the cell wall into the hyphae. Hyphae secrete acids and enzymes that break the surrounding organic material down into simple molecules the fungi can easily absorb. Most fungi build their cell walls out of chitin—not cellulose, as plants do. Chitin is the same material as the hard outer shells of insects and other arthropods.

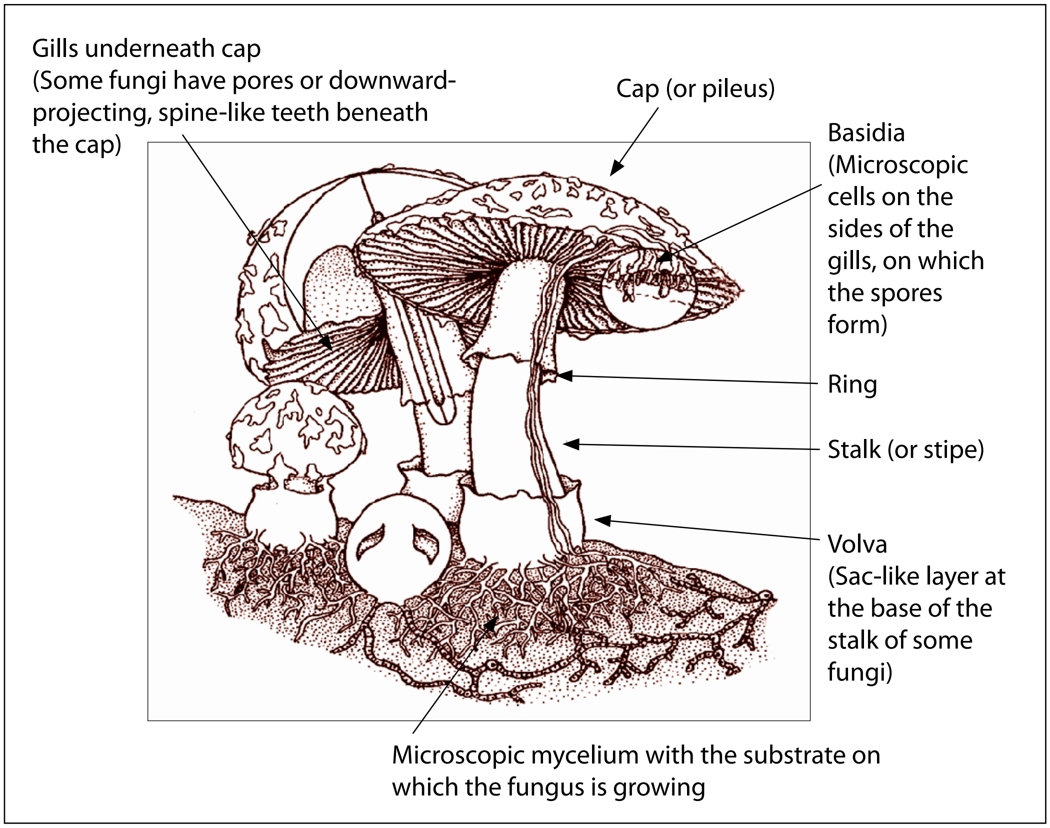


Figure 19.6: Diagram showing the structure of a mushroom

Source: Biodidac

Fungi have evolved to use a lot of different items for food. Some are decomposers, living on dead organic material like leaves. Some cause disease by using living organisms for food; these fungi infect plants, animals, and even other fungi. Athlete's foot and ringworm are two fungal diseases in humans. Mycorrhizae are fungi that associate with plant roots, and form a symbiotic relationship (both organisms rely on each other for survival). The plant provides the fungus with carbohydrates, and the fungus increases the plant's access to water and certain nutrients. Some fungi show commensalism (one organism benefits while the other, neither benefits nor suffers), such as fungi that grow on trees without harming them.

Fungi can reproduce asexually as well as sexually.

Lichens

Lichens are not pure fungi. They are a symbiotic union between fungus and algae (or sometimes photosynthesizing bacteria or cyanobacteria). The algae provide nutrients, while the fungus protects them from the elements. Lichens are an example of mutualism; that is, both the fungus and the alga benefit from the interaction. The result is a new organism distinctly different from its component species. If fungi are nature's recyclers, lichens are nature's pioneers. Lichens find their homes in some of the most barren and inhospitable parts of the world (Figure 19.7). From there, they slowly begin the process of creating a foundation for habitation by others.

Figure 19.7: Photograph of lichens growing on a rock in a barren landscape
Source: Wikipedia

Ecological Role of Fungi

Fungi are heterotrophs and decomposers (they break down dead organisms), and they actively participate in the recycling of organic material in ecosystems. Some fungi keep a mutualistic ecological interaction with algae or cyanobacteria (forming lichens) and with plant roots (forming mycorrhizae). Fungi play an important role in the ecosystem as decomposers. Though some of them are pathogens, many are widely used for preparation and preservation of food like wine, beer, bread, cheese, and soy products. Mushrooms and truffles, both fungi, are important sources of food. Currently, many fungi species are also used to produce antibiotics like penicillin and cephalosporin, as well as many important vitamins.

Kingdom Plantae

You studied plants in detail in Unit 4, so this section will only provide an overview of the basic features of plants. Members of kingdom Plantae are all multicellular organisms with cell walls made of cellulose, photosynthetic pigments such as chlorophyll, and a life cycle in which generations alternate between gametophytes and sporophytes. As photosynthetic autotrophs, plants use solar energy to produce organic compounds from carbon dioxide and water. Plants develop from embryos protected by tissues of the parent plant; this is one reason why algae are not classified as plants.

The plant kingdom consists of three major groups: nonvascular plants, seedless vascular plants, and seed-producing vascular plants (gymnosperms and angiosperms).

Nonvascular Plants

Bryophytes are small, nonvascular plants that first evolved approximately 500 million years ago. The earliest land plants were most likely bryophytes. Bryophytes lack vascular tissue (xylem and phloem) and have life cycles dominated by the gametophyte phase. The lack of conducting cells limits the size of the plants, generally keeping them under five inches high. These plants lack true roots, stems, and leaves. They have root-like structures known as rhizoids. The group includes the hornworts, liverworts, and mosses (Figure 19.8).

Figure 19.8: Photograph of a patch of moss growing at the base of a pine tree in Ontario

Most reproduction of bryophytes is asexual, usually occurring by fragmentation of body parts.

Ecological Role of Nonvascular Plants

Many bryophytes are pioneer plants, growing on bare rock and contributing to soil development. In bogs and mountain forests, they form a thick carpet, reducing erosion. In forest ecosystems, they act like a sponge, retaining and slowly releasing water.

Vascular Plants

Tracheophytes (vascular plants) have tissues called xylem that transport water and food to tissues called phloem. Together, the xylem and the phloem are called vascular tissue. Vascular plants have roots, stems, and leaves. Vascular plants tend to be larger and more complex than bryophytes, and have a life cycle where the sporophyte stage is more prominent than the gametophyte stage. Vascular plants also demonstrate increased levels of organization by having organs and organ systems. Vascular plants are divided into two groups: the spore-producing plants and the seed-producing plants.

Spore-producing Vascular Plants

Before flowering plants and conifers arrived in the natural world, plant reproduction was carried out by spores. Instead of forming a seed with a protected embryo inside, plants would release many small spores into the environment which, when favourable conditions were found, would germinate and grow into a new plant. Vascular plants that reproduce by spores include horsetails, liverworts, club mosses, and ferns (Figure 19.9). The spores form on the bottom of the leaves in little enclosed sacs called sori, or spore cases. When conditions are right, the spores are released into the environment, where they may grow into new plants.

Figure 19.9: Photograph of a patch of ferns in northern Australia
Source: Wikipedia

Seed-producing Vascular Plants

Each seed has food storage tissue and a hard protective shell (seed coat). Seeds protect new growth better than spores. They also can be spread over a greater distance than spores when animals like birds and squirrels carry them from place to place. Both gymnosperms (conifers) and angiosperms produce seeds. The seeds of angiosperms often provide food for humans (Figure 19.10).

Figure 19.10: The coconut is one of the biggest seeds in the plant kingdom.
Source: Wikimedia Commons

Ecological Role of Vascular Plants

Life on earth depends on plants. Humans, like other animals, cannot produce their own food. Directly or indirectly, what they eat comes from plants. Plants are responsible for the presence of oxygen, a gas most organisms that currently inhabit our planet need to breathe. Plants have protected us for many millennia from global warming by absorbing the excess of carbon dioxide. Unfortunately, the burning of fossil fuels has increased CO_2 levels in such a way that plants themselves, progressively decreasing in number and variety, are no longer able to solve the problem of a planet that is getting increasingly hot.

Support Questions

22. What does it mean for a plant to be nonvascular? Suggested answer

23. List five characteristics shared by all plants. 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.

(17 marks)

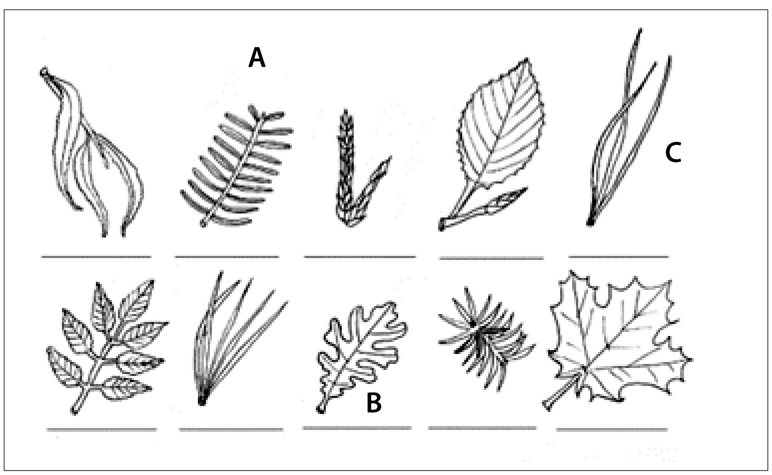
59. Match the description with the letter assigned to the term. **(7 marks: ½ mark for each)**

Description	Term
1. A shapeless protozoan	A. plasmodium
2. A very common freshwater ciliate	B. giant ferns
3. The larger of two nuclei	C. endocytosis
4. The parasite that causes malaria	D. green algae
5. Protists that produce spores to reproduce asexually	E. dinoflagellates
6. Over-fertilization of lakes	F. mycorrhizae
7. The process by which food is engulfed	G. euglena
8. A protist with features of both animals and plants	H. hyphae
9. A protist that can cause red tides and shellfish poisoning	I. eutrophication
10. They produce most of the earth's oxygen	J. alternate generations
11. They secrete acids and enzymes that break the surrounding organic material down into simple molecules that can be easily absorbed	K. paramecium
12. A fungus that can increase a plant's access to water and certain nutrients	L. amoeba
13. A characteristic of a plant's life cycle	M. macronucleus
14. These plants produced most of the world's coal deposits	N. sporozoa

60. If global warming trends continue, many species, including protists and fungi, may become extinct due to habitat loss. State two ecological roles of protists and two ecological roles of fungi. **(4 marks: 1 mark for each role)**

61. Using the following dichotomous key, for common trees of northeastern Canada, identify the three types of leaves labeled A to C in the figure below. **(6 marks: 2 marks for each type of leaf)**

1a. Leaves are thin and needle-like	go to 2
1b. Leaves are flat and broad	go to 6
2a. Needles are over one inch long, arranged in clusters	go to 3
2b. Needles are one half-inch long or shorter	go to 4
3a. Needles in clusters of three	Pitch pine (*Pinus rigida*)
3b. Needles in clusters of five	Eastern white pine (*Pinus strobus*)
4a. Needles scale-like, sharp, cover twigs	Eastern red cedar (*Juniperus virginiana*)
4b. Needles protrude from twigs	go to 5
5a. Needles flat, rounded tips, in two rows along twig	Eastern hemlock (*Tsuga canadensis*)
5b. Needles in whorl around the stem	White spruce (*Picea glauca*)
6a. Compound leaves divided into 7 leaflets	White ash (*Fraxinus americana*)
6b. Simple leaves	go to 7
7a. Lobed, rounded leaves with 7 to 9 lobes	White oak (*Quercus alba*)
7b. Toothed leaves	go to 8
8a. Long slender leaves that droop	Weeping willow (*Salix babylonica*)
8b. Leaves are less than twice as long as broad	go to 9
9a. Leaves have an elliptical shape	American beech (*Fagus grandifolia*)
9b. Leaves are toothed and lobed	Sugar maple (*Acer Saccharum*)



Now go on to Lesson 20. Send your answers to the Key Questions to the ILC when you have completed Unit 5 (Lessons 17 to 20).