22–1 Introduction to Plants

What color is life? That's a silly question, of course, because living things can be just about any color. But consider it in a different way. Imagine yourself in a place on Earth where the sounds and scents of life are all around you. The place is so abundant with life that when you stand on the ground, living things blot out the sun. Now, what color do you see? If you have imagined a thick forest or a teeming jungle, then one color will fill the landscape of your mind—green—the color of plants.

Plants dominate the landscape. Where plants are plentiful, other organisms, such as animals, fungi, and microorganisms, take hold and thrive. Plants provide the base for food chains on land. They also provide shade, shelter, and oxygen for animals of every size and kind. The oldest fossil evidence of plants dates from about 470 million years ago. Since then, plants have colonized and transformed nearly every corner of Earth.

What Is a Plant?

Plants are members of the kingdom Plantae. **Plants are multicellular eukaryotes that have cell walls made of cellulose. They develop from multicellular embryos and carry out photosynthesis using the green pigments chlorophyll *a* and *b*.** Plants include trees, shrubs, and grasses, as well as other organisms, such as mosses and ferns. Most plants, including the one in **Figure 22–1,** are autotrophs, although a few are parasites or saprobes that live on decaying materials.

Plants are so different from animals that sometimes there is a tendency to think of them as not being alive. With few exceptions, plants do not gather food nor do they move about or struggle directly with their predators. Plants can neither run away from danger nor strike blows against an adversary. But as different as they are from animals, plants are everywhere. How have they managed to be so successful?

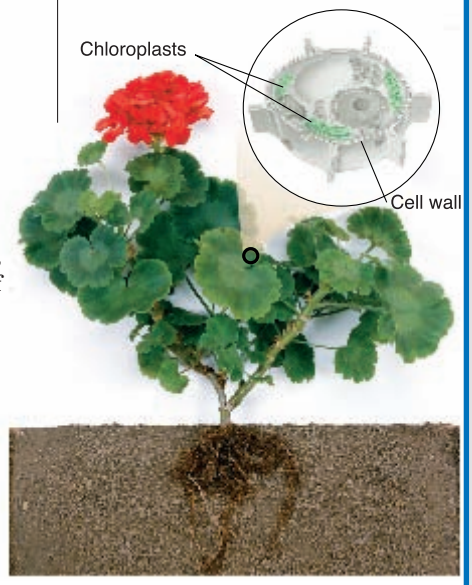
That question has many answers. In the next few chapters, we will explore some of them. For now, it might help to think of plants as a well-known botanist once described them—as "stationary animals that eat sunlight"!

Guide for Reading

Key Concepts
- What is a plant?
- What do plants need to survive?
- How did the first plants evolve?

Vocabulary
sporophyte
gametophyte

Reading Strategy: Using Prior Knowledge
Before you read the chapter, make a list of the different groups of plants that you know. As you read, revise your list to include new information about plant groups.



▶ **Figure 22–1 All plants are multicellular eukaryotes that have cell walls made of cellulose.** Their leaves appear green because of the photosynthetic pigments chlorophyll *a* and *b*, which are located in chloroplasts.

SECTION RESOURCES

Print:
- ***Teaching Resources,*** Lesson Plan 22–1, Adapted Section Summary 22–1, Adapted Worksheets 22–1, Section Summary 22–1, Worksheets 22–1, Section Review 22–1
- ***Reading and Study Workbook A,*** Section 22–1
- ***Adapted Reading and Study Workbook B,*** Section 22–1

Technology:
- ***iText,*** Section 22–1
- ***Transparencies Plus,*** Section 22–1

Section 22–1

1 FOCUS

Objectives
22.1.1 ***Explain*** what a plant is.
22.1.2 ***Describe*** what plants need to survive.
22.1.3 ***Describe*** how the first plants evolved.

Guide for Reading

Vocabulary Preview
Explain to students that the suffix *-phyte* means "plant." Thus, *sporophyte* means "spore plant," and *gametophyte* means "gamete plant."

Reading Strategy
Before students read, ask them to skim the section to find the three boldface Key Concepts. Have them copy each onto a notecard. Then, as they read, they should make notes of supporting details.

2 INSTRUCT

What Is a Plant?

Build Science Skills
Observing Take students on a guided tour of the exterior of your school building. Look for the many places that terrestrial plants can grow. You might begin by looking in some of the obvious locations first, such as the lawn or garden of the school. Then, look in some of the less obvious places—in pavement cracks, on the shady sides of the building or walls, on rocks, on trees, or near a source of standing water. Examine each plant and have the students note the following:
- Does it have leaves?
- Does the leaf have veins?
- Where is the plant growing?
- What is the approximate size of the plant?
- Is the plant mosslike, or does it have a green or woody stem? L1 L2

The Plant Life Cycle

Use Visuals

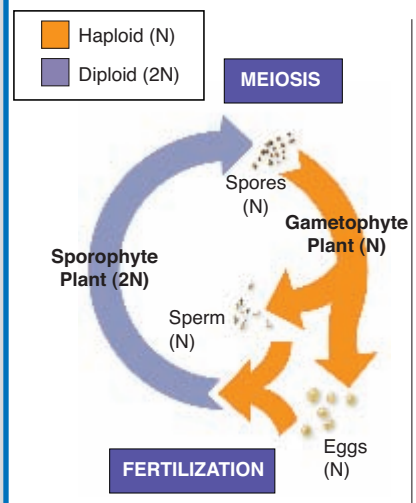
Figure 22–2 Ask students: **Which generation of a plant is diploid and which is haploid?** *(The sporophyte generation is diploid, and the gametophyte generation is haploid.)* **Which generation produces gametes?** *(The gametophyte)* **What does the sporophyte produce?** *(Spores)* **What process produces spores?** *(Meiosis)* **When does mitosis occur in this life cycle?** *(It occurs after meiosis in the gametophyte plant and after fertilization in the growth of the sporophyte.)* L2

Go Online
active art
For: Alternation of Generation activity
Visit: PHSchool.com
Web Code: cbe-7222
Students can interact with the art online.

What Plants Need to Survive

Build Science Skills

Applying Concepts Perhaps the best way to help students understand what plants need to survive is to allow them to grow their own seedlings. Provide potting soil, small containers, and seeds. Any seeds will do, but those that germinate quickly are more fun—small flowers, beans, corn, and so on. Put these in a warm, light area and allow students brief opportunities to observe and care for them every day. You can make this as basic or elaborate as you wish. Challenge students to experiment with the presence and absence of specific plant requirements to observe their effects on growth. The seedlings can be used in subsequent chapters to study plant structure, although some students may want to take them home. L1 L2



▲ **Figure 22–2** All plants have a life cycle with alternation of generations, in which the haploid gametophyte phase alternates with the diploid sporophyte phase.

Go Online
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For: Alternation of Generation activity
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▼ **Figure 22–3** **All plants need sunlight, water, minerals, oxygen, carbon dioxide, and a way to move water and nutrients to all their cells.** Adaptations allow them to live in even the driest locations, such as this desert.

The Plant Life Cycle

Plant life cycles have two alternating phases, a diploid (2N) phase and a haploid (N) phase, known as alternation of generations. During the two phases of the life cycle, shown in **Figure 22–2,** mitosis and meiosis alternate to produce the two types of reproductive cells—gametes and spores. The diploid (2N) phase is known as the **sporophyte,** or spore-producing plant. The haploid (N) phase is known as the **gametophyte,** or gamete-producing plant. Plant spores are haploid (N) reproductive cells formed in the sporophyte plant by meiosis that can grow into new individuals. The new individual is the gametophyte. A gamete is a reproductive cell that is produced by mitosis and fuses during fertilization with another gamete to produce a new individual, the diploid sporophyte.

The earliest plants, mosses and ferns, require water to reproduce. Seed plants, which appeared more recently, have reproductive cycles that can be carried out without water. Many plants also have forms of vegetative, or asexual, reproduction.

What Plants Need to Survive

Surviving as stationary organisms on land is a difficult task, but plants have developed a number of adaptations that enable them to succeed. **The lives of plants center on the need for sunlight, water and minerals, gas exchange, and the transport of water and nutrients throughout the plant body.**

Sunlight Plants use the energy from sunlight to carry out photosynthesis. As a result, every plant displays adaptations shaped by the need to gather sunlight. Photosynthetic organs such as leaves are typically broad and flat and are arranged on the stem so as to maximize light absorption.

Water and Minerals All cells require a constant supply of water. For this reason, plants must obtain and deliver water to all their cells—even those that grow aboveground in the dry air. Water is one of the raw materials of photosynthesis, so it is used up quickly when the sun is shining. Sunny conditions can cause living tissues to dry out. Thus, plants have developed structures that limit water loss. As they absorb water, plants also absorb minerals. Minerals are nutrients in the soil that are needed for plant growth.

Gas Exchange Plants require oxygen to support cellular respiration as well as carbon dioxide to carry out photosynthesis. They must exchange these gases with the atmosphere without losing excessive amounts of water through evaporation.

Movement of Water and Nutrients Plants take up water and minerals through their roots but make food in their leaves. Most plants have specialized tissues that carry water and nutrients upward from the soil and distribute the products of photosynthesis throughout the plant body. Simpler types of plants carry out these functions by diffusion.

UNIVERSAL ACCESS

Inclusion/Special Needs
Build on students' hands-on experiences of using pipe cleaner chromosomes to model the haploid and diploid cells in the plant life cycle. Students can use two pairs of chromosome pipe cleaners, each pair a different color to model the alternation of generations in plants. Have them draw and label their own life cycle diagram and actually move the pipe cleaner chromosome pairs through it. L1

Less Proficient Readers
Encourage students to look carefully at Figure 22–2 as they read about the plant life cycle. Instruct them to construct a Venn diagram to compare and contrast the gametophyte and the sporophyte phases. Students should use information from Figure 22–2 and the text to complete the Venn diagrams. Ask students to explain how the illustration in the figure helped them understand the plant life cycle. L1 L2

Problem Solving

"Plantastic" Voyage

You are part of a team that is planning a space mission that will send astronauts into space for two years. As part of their food, the astronauts will be growing yam plants, *Dioscorea composita*. Your job is to develop a plan to help plants grow on the spacecraft.

Defining the Problem In your own words, state the problem at hand.

Organizing Information Research the types of conditions these plants would need. What requirements would the plants have for moisture? Soil conditions? Light intensity? Day length?

Creating a Solution Make a detailed scale drawing of a container for growing 10 of these plants. (*Dioscorea* plants are vines; assume that each is 10 cm long and 0.5 cm wide.) Determine what material(s) you will use for your container. As you devise your plan, be sure to keep a journal in which you record your team's ideas, drawings, data, and other information.

Presenting Your Plan Prepare a multimedia presentation for your classmates as if they were the managers of the space mission. Describe how your team solved the problem, the sources of information you used, the design itself, and what you learned during the project.

Early Plants

For most of Earth's history, plants did not exist. Life was concentrated in oceans, lakes, and streams. Algae and photosynthetic prokaryotes added the oxygen to our planet's atmosphere and provided food for animals and microorganisms.

When plants appeared, much of the existing life on Earth changed. As these new photosynthetic organisms colonized the land, they changed the environment in ways that made it possible for other organisms to develop. New ecosystems emerged, and organic matter began to form soil. How did plants adapt to the conditions of life on land? How plants evolved structures that acquire, transport, and conserve water is the key to answering this question.

Origins in the Water You may recall from Chapter 20 that green algae, shown in **Figure 22–4**, are photosynthetic, plantlike protists. Many of these algae are multicellular. **The first plants evolved from an organism much like the multicellular green algae living today.** Multicellular green algae have the size, color, and appearance of plants. But the resemblance of many green algae to plants is more than superficial. They have reproductive cycles that are similar to those of plants. In addition, green algae have cell walls and photosynthetic pigments that are identical to those of plants.

CHECKPOINT *What was the greatest "challenge" to plants as they began to live on land?*

▲ **Figure 22–4** **The first plants evolved from an organism much like the modern multicellular green algae.** The alga *Halimeda* is found in Honduras in Central America. It has many cellular features in common with plants.

BIO INSIGHTS

FACTS AND FIGURES

Arriving on land first

When students think of life first emerging from the sea, they invariably envision an amphibian-like creature skulking around the shore. In truth, much smaller animals—such as insects—were the first to colonize dry land. But plants arrived on land before any animal species. Without plants, land animals would have had to remain close to the water or would have had nothing to eat. Some biologists believe that plants did not make the transition to land by themselves. Their theory is that plants coevolved with fungi, developing the very first mycorrhizae. The term *mycorrhiza* (plural: mycorrhizae) refers to the symbiotic relationship between certain fungi and the root cells of some vascular plants, such as orchids. This plant–fungi partnership allowed necessary minerals to be extracted from sterile, inorganic soils.

Problem Solving

A yam is a plant, similar to a sweet potato, in which the branch roots swell and provide storage for large quantities of carbohydrates. The yam plant is thought to have originated in or near India, and these food-storage roots are a staple in some tropical regions of the world. L2

Defining the Problem The problem is to grow yams successfully under artificial conditions aboard a spacecraft.

Organizing Information To determine the optimal conditions a yam plant needs, students might use the reference section of their public library or contact an expert, either at a garden store or the botany department of a local university.

Creating a Solution Teams should make detailed drawings of the proposed container. For 10 plants, the bottom of this container needs to be at least 50 square centimeters. Students might suggest using a container with a solid bottom with tops and sides that have openings, so that gas exchange is adequate.

Presenting Your Plan Budget class time for each team to make its multimedia presentation. All plans should take into account what plants need to survive, including light, water, gas exchange, and nutrients.

Early Plants

Use Visuals

Figure 22–4 As students study the algae in the photograph, ask: **How are green algae like plants?** *(Green algae and plants have chlorophyll, store carbohydrates, and have cell walls made of cellulose. Larger green algae are similar in color and size to some plants and may have alternating generations.)* L2

Answer to . . .

CHECKPOINT *Acquiring, transporting, and conserving water*

22–1 (continued)

Make Connections

Earth Science Display specimens, pictures, or slides of early plant fossils, including mosses and ferns. Review with students the process by which fossils form. For example, these are the steps that occur in the formation of a mold fossil: (1) a plant is buried in sediment; (2) the sediment hardens into rock; (3) the organic material of the plant decays, leaving an empty space in the rock. After reviewing fossil formation, discuss how geologists and paleontologists determine the age of fossils. Explain relative age to students, including the law of superposition. Also explain the basics of radioactive dating, in which the decay of radioactive elements is used to date certain rock formations. L2 L3

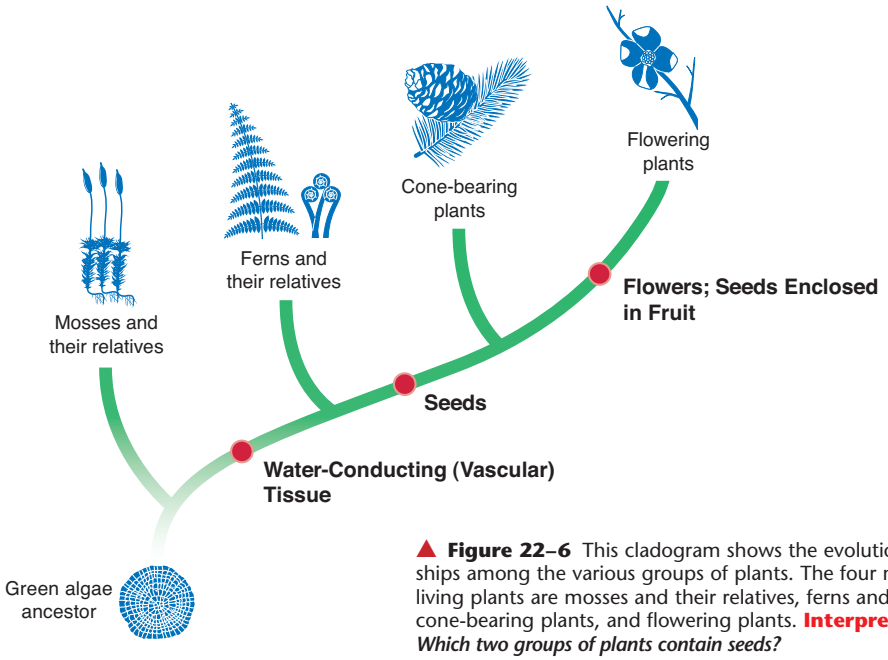
Use Visuals

Figure 22–6 After students have studied the cladogram, ask: **What are the four main groups of plants?** *(Mosses and their relatives, ferns and their relatives, cone-bearing plants [gymnosperms], and flowering plants [angiosperms])* **What do mosses and their relatives lack that all other plants have?** *(Vascular tissue)* **Which groups of plants don't have seeds?** *(Mosses and their relatives and ferns and their relatives)* **How do the seeds of flowering plants differ from the seeds of cone-bearing plants?** *(Flowering plants have seeds enclosed in fruit.)* L2

▲ **Figure 22–5** One of the earliest fossil vascular plants was *Cooksonia,* which looked similar to mosses living today. *Cooksonia* had simple branched stalks that bore reproductive structures at their tips. The figure above shows an artist's drawing of *Cooksonia* and a photograph of the fossil. **Inferring** ***Which structures of this early plant might have carried out photosynthesis? Obtained water and minerals?***

The First Plants Plants share many characteristics with the green algae described in Chapter 20, including their photosynthetic pigments and the composition of their cell walls. DNA sequences confirm that plants are closely related to certain groups of green algae, further suggesting that the ancestors of the first plants were indeed algae. The oldest known fossils of plants, nearly 450 million years old, show that the earliest plants were similar to today's mosses. As shown in **Figure 22–5,** they had a simple structure and grew close to the damp ground. The fossils also suggest that the first true plants were still dependent on water to complete their life cycles. Over time, the demands of life on land favored the evolution of plants more resistant to the drying rays of the sun, more capable of conserving water, and more capable of reproducing without water.

From these plant pioneers, several major groups of plants evolved. One group developed into the mosses and their relatives. Another lineage gave rise to all the other plants on Earth today—ferns, cone-bearing plants, and flowering plants. All of these groups of plants are now successful in living on dry land, but they have evolved very different adaptations for a wide range of terrestrial environments.

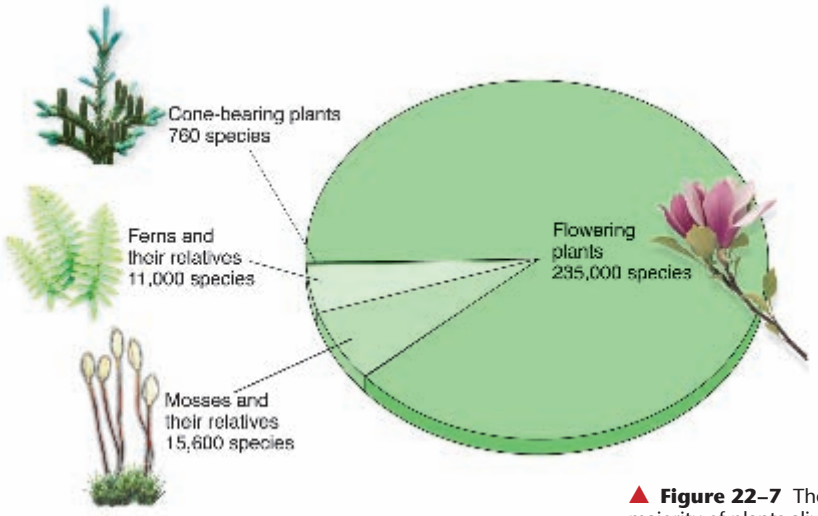


▲ **Figure 22–6** This cladogram shows the evolutionary relationships among the various groups of plants. The four main groups of living plants are mosses and their relatives, ferns and their relatives, cone-bearing plants, and flowering plants. **Interpreting Graphics** ***Which two groups of plants contain seeds?***

TEACHER TO TEACHER

Before beginning the chapter on plants, give each student a bottle cap (or have students bring them to class). If you have a wooded area near your school, have each student find a plant that can be grown in a bottle cap. Limiting the size of the plant to a bottle cap will force students to look beyond the obvious common plants that they normally observe. If there is not a wooded area available, ask students to bring plants to class from areas near their homes. Place the caps in a large plastic container. All the caps from one lab group should fit in one container. During the course of the unit, students should be able to identify their plant species, as well as any reproductive structures that appear.

—Kathey A. Roberts
Biology Teacher
Lakeside High School
Hot Springs, AR



▲ **Figure 22–7** The great majority of plants alive today are angiosperms, which are also known as flowering plants. **Interpreting Graphics** *What is the second largest group of plants?*

Overview of the Plant Kingdom

Botanists divide the plant kingdom into four groups based on three important features: water-conducting tissues, seeds, and flowers. The relationship of these groups is shown in **Figure 22–6.** There are, of course, many other features by which plants are classified, including reproductive structures and body plan.

Today, plant scientists can classify plants more precisely by comparing the DNA sequences of various species. Since 1994, a team of biologists from twelve nations has begun to change our view of plant relationships. Their project, Deep Green, has provided strong evidence that the first plants evolved from green algae living in fresh water, not in the sea as had been thought.

In the rest of this chapter, we will explore how important plant traits evolved over the course of millions of years. In particular, we will examine the success of the flowering plants. As shown in **Figure 22–7,** flowering plants consist of 235,000 species—almost 90 percent of all living species of plants.

Go Online NSTA SCILINKS
For: Links on classifying plants
Visit: www.SciLinks.org
Web Code: cbn-7221

22–1 Section Assessment

1. **Key Concept** Identify the characteristics of the plant kingdom.
2. **Key Concept** To live successfully on land, what substances must plants obtain from their environment?
3. **Key Concept** From which group of protists did the first plants evolve? How are plants similar to these protists?
4. **Critical Thinking Comparing and Contrasting** Compare the gametophyte and sporophyte stages of the plant life cycle. Which is haploid? Which is diploid?
5. **Critical Thinking Comparing and Contrasting** Compare the roles of mitosis and meiosis in a plant life cycle. Which of these processes is related to sexual reproduction? To asexual reproduction?

Focus on the BIG Idea

Structure and Function
How do the cells of plants differ from those of animals? How are they different from those of fungi? You may wish to use labeled diagrams or a compare-and-contrast table to present your results. Refer to Chapters 7 and 21 for help in answering these questions.

22–1 Section Assessment

1. Multicellular eukaryotes; cell walls made of cellulose; develop from multicellular embryos; the green pigments, chlorophyll *a* and *b*, carry out photosynthesis

2. Sunlight, water and minerals, and oxygen and carbon dioxide

3. Multicellular green algae; similar in size, color, appearance, reproductive cycles, cell walls, and photosynthetic pigments

4. Gametophyte: haploid, produces eggs and sperm by mitosis, formed from spores; Sporophyte: diploid, produces spores by meiosis, formed during fertilization with fusion of egg and sperm

5. Mitosis: sexual reproduction; occurs in the haploid gametophytes to produce the haploid gametes. Meiosis: asexual reproduction; produces haploid spores in the sporophyte, which grow into the gametophyte.

Overview of the Plant Kingdom

Use Visuals

Figure 22–7 Ask students: **What are the three most important features of plants that botanists use to classify them into four groups?** *(Water-conducting tissue, seeds, and flowers)* **From what kind of organism did all plants evolve?** *(Freshwater green algae)* L2

Go Online NSTA SCILINKS
Download a worksheet on classifying plants for students to complete, and find additional teacher support from NSTA SciLinks.

3 ASSESS

Evaluate Understanding

Call on students at random to list the main groups of the plant kingdom, explain which plant characteristics were important in the evolution of the different groups, and describe the generalized plant life cycle.

Reteach

Have students list the characteristics that define a living thing as a plant. Then, review the characteristics that divide plants into major groups.

Focus on the BIG Idea

Plant cells contain cell walls made of cellulose, large vacuoles, and chloroplasts. Animal cells do not have cell walls or chloroplasts. The cells of fungi have no chloroplasts and have cell walls made of chitin rather than cellulose.

Interactive Textbook

If your class subscribes to the iText, use it to review the Key Concepts in Section 22–1.

Answers to . . .

Figure 22–5 *The green, stemlike structures; the rootlike structures*

Figure 22–6 *Cone-bearing plants and flowering plants*

Figure 22–7 *Mosses and their relatives*