Unit 7

Plants

History & Biology

9000 B.C. — **1600**

9000–8001 B.C.
Wheat and barley are the first plants grown as food crops.

300–291 B.C.
Theophrastus, often called the "Father of Botany," describes more than 500 plants in his book *History of Plants.*

1609–1610
Spaniards establish a settlement that will become present-day Santa Fe, New Mexico.

1667
Seed plants are classified as monocots or dicots according to the number of seed leaves (1 or 2) in their seeds.

What You'll Learn

Chapter 21
What is a plant?

Chapter 22
The Diversity of Plants

Chapter 23
Plant Structure and Function

Chapter 24
Reproduction in Plants

Unit 7 Review
BioDigest and Standardized Test Practice

Why It's Important

Although plants have different forms, they have common structures and functions. Over time, adaptations of these structures and functions resulted in the diversity of plants found in the land and water biomes on Earth. In these biomes, plants are an essential resource for many of the other organisms that live there, including humans. These organisms depend on plants for oxygen and, directly or indirectly, for food.

Understanding the Photo

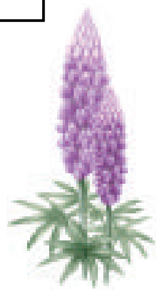
Plant heights vary from a few millimeters to many meters. These conifer trees can grow to be hundreds of times taller than the ferns on the forest floor.

1700 1800 1900 2000

1791
The Bill of Rights is ratified.

1851
It is discovered that alternation of generations is part of the life cycle of plants, such as mosses.

1930
The first packaged, sliced bread is introduced in the U.S.



1967
Ten thousand-year-old frozen lupine seeds are discovered in the Yukon Territory of Canada. They germinate within 48 hours after they thaw.

1986
The first field trials of a genetically altered plant (tobacco) are carried out.

What is a plant?

What You'll Learn

- You will identify and evaluate the structural adaptations of plants to their land environments.
- You will survey and identify the major divisions of plants.

Why It's Important

Plants were the first multicellular organisms to inhabit land over 440 million years ago. Since then, plants have developed into a diverse group of organisms that help provide us with food, oxygen, and shelter.

Understanding the Photo

Because of plant adaptations over time, different plant species grow in the different biomes on Earth. The flowering plants and others growing in this mountain meadow have structural and physiological adaptations that ensure their long-term survival in this environment.

Biology Online

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Section 21.1

Adapting to Life on Land

SECTION PREVIEW

Objectives

Compare and contrast characteristics of algae and plants.

Identify and evaluate structural adaptations of plants to their land environments.

Describe the alternation of generations in land plants.

Review Vocabulary

adaptation: any structure, behavior, or internal process that enables an organism to respond to stimuli and better survive in an environment (p. 9)

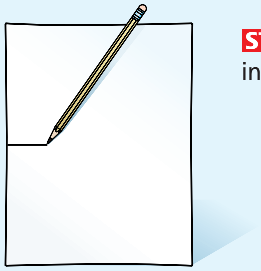
New Vocabulary

cuticle
leaf
root
stem
vascular tissue
vascular plant
nonvascular plant
seed

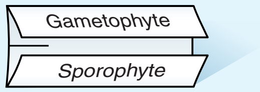
FOLDABLES™ Study Organizer

Alternation of Generations Make the following Foldable to help you illustrate and explain how the lives of all plants have two alternating stages.

STEP 1 **Draw** a mark at the midpoint of a vertical sheet of paper along the side edge.



STEP 2 **Fold** the outside edges in to touch at the midpoint mark.



STEP 3 **Label** the tabs as shown.

Illustrate and Explain As you read Section 21.1, illustrate and explain each stage under its tab.

Origins of Plants

What is a plant? A plant is a multicellular eukaryote. Most plants can produce their own food in the form of glucose through the process of photosynthesis. In addition, plant cells have thick cell walls made of cellulose. The stems and leaves of most plants have a waxy waterproof coating called a **cuticle** (KYEWT ih kul).

Fossils and other geological evidence suggest that a billion years ago, plants had not yet begun to appear on land. No ferns, mosses, trees, grasses, or wildflowers existed. The land was barren except for some algae at the edges of inland seas and oceans. However, the shallow waters that covered much of Earth's surface at that time were teeming with bacteria, algae and other protists, as well as simple animals such as corals, sponges, jellyfish, and worms. Evidence indicates that green algae eventually became adapted to life on land.

Scientists hypothesize that all plants probably evolved from filamentous green algae that lived in the ancient oceans. Some of the evidence for their relationship can be found in modern members of both groups. Green algae and plants have cell walls that contain cellulose. Both groups have the same types of chlorophyll used in photosynthesis and store food in the form of starch. All other major groups of organisms store food in the form of glycogen and other complex sugars, and/or lipids.

Word Origin

cuticle from the Latin word *cutis,* meaning "skin"; The cuticle is the outermost covering of most plants.

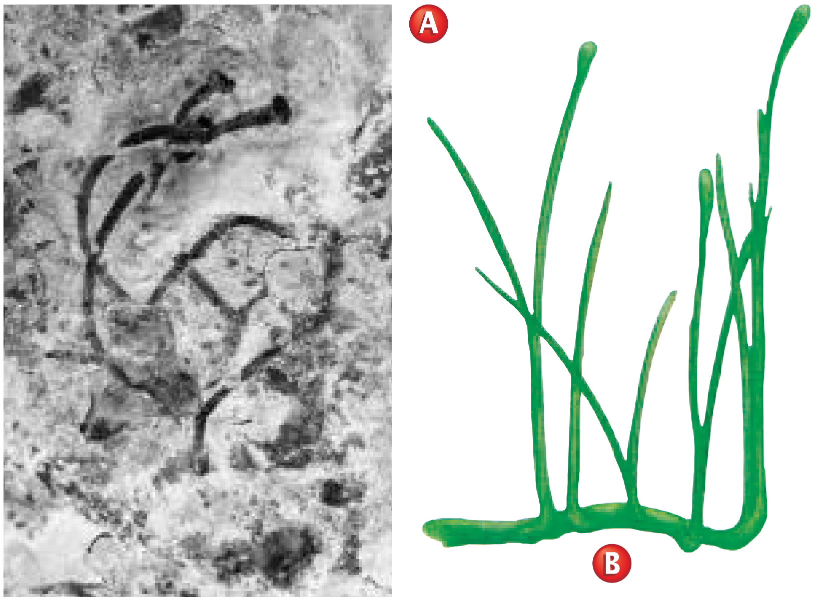


Figure 21.1
This fossil of *Cooksonia* is more than 400 million years old **(A).** *Cooksonia* was probably one of the first vascular plants. The plant had leafless stems **(B).**

The first evidence of plants in the fossil record began to appear over 440 million years ago. These early plants were simple in structure and did not have leaves. They were probably instrumental in turning bare rock into rich soil. The earliest known plant fossils are those of psilophytes (SI luh fites), such as those shown in ***Figure 21.1.***

Reading Check **Explain** how early land plants contributed to the movement of other plants to land.

Adaptations in Plants

Life on land has advantages as well as challenges. All organisms need water to survive. A filamentous green alga floating in a pond does not need to conserve water. The alga is completely immersed in a bath of water and dissolved nutrients, which it can absorb directly into its cells. For most land plants, the only available supply of water and minerals is in the soil, and only the portion of the plant that penetrates the soil can absorb these nutrients.

When you studied protists, you learned that algae reproduce by releasing unprotected unicellular gametes into the water, where fertilization and development take place. Land plants evolved structural and physiological adaptations that help protect the gametes from drying out. In some plants, the sperm are released near the egg so they only have to travel a short distance. Other plants have protective structures to ensure the survival of the gametes. Land plants must also withstand the forces of wind and weather and be able to grow against the force of gravity. Over the past 443 million years or so, plants have developed a huge variety of adaptations that reflect both the challenges and advantages of living on land.

Preventing water loss

If you run your fingers over the surface of an apple, a maple leaf, or the stem of a houseplant, you'll probably find that it is smooth and slightly slippery. Most fruits, leaves, and stems are covered with a protective, waxy layer called the cuticle. Waxes and oils are lipids, which are biomolecules that do not dissolve in water. The waxy cuticle creates a barrier that helps prevent the water in the plant's tissues from evaporating into the atmosphere.

Figure 21.2
There is great diversity in leaf shapes and sizes. **Infer** ***What advantage would a broad leaf, like this cottonwood leaf, have over a narrow leaf, like a pine needle?***

Carrying out photosynthesis

The **leaf,** like the one in ***Figure 21.2,*** is a plant organ that grows from a stem and usually is where photosynthesis occurs. Leaves differ greatly in size and shape and they can vary on the same plant. Each plant division has unique leaves or leaflike structures.

Putting down roots

Most plants depend on the soil as their primary source for water and other nutrients. Plants can take in water and nutrients from the soil with their roots. In most plants, a **root** is a plant organ that absorbs water and minerals usually from the soil. Roots contain tissues that transport those nutrients to the stem. Roots anchor a plant usually in the ground. Some roots, such as those of radishes or sweet potatoes, accumulate starch and function as organs of storage. Many people use these storage roots as a food source. Find out more about the uses of plants on pages 1076–1079 in the *Focus On*.

In the *MiniLab* on this page, explore and evaluate some structural adaptations of plants that allow them to survive on land. Also, practice your lab skills by using a dissecting microscope.

Transporting materials

Water moves from the roots of a tree to its leaves, and the sugars produced in the leaves move to the roots through the stem. A **stem** is a plant organ that provides support for growth, as shown in ***Figure 21.3.*** It contains tissues for transporting food, water, and other materials from one part of the plant to another. Stems also can serve as organs for food storage. In green stems, some cells contain chlorophyll and can carry out photosynthesis.

MiniLab 21.1

Apply Concepts

Examining Land Plants
Liverworts are considered to be one of the simplest of all land plants. They show many of the adaptations that other land plants have evolved that enable them to survive on a land environment.

Marchantia

Procedure

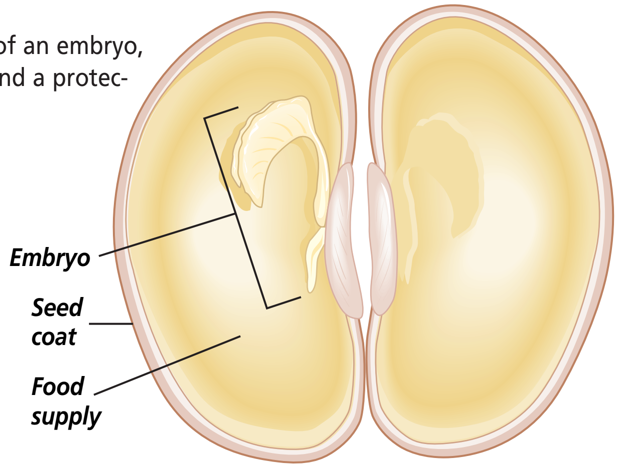
1. Examine a living or preserved sample of *Marchantia.* **CAUTION:** ***Wear protective gloves when handling preserved materials.***
2. Note and record the following observations. Is the plant unicellular or multicellular? Does it have a top and bottom? How do these differ? Is it one cell in thickness or many cells thick? Does the plant seem to grow upright like a tree or close to the ground?
3. Use a dissecting microscope to examine its top and bottom surfaces. Are tiny holes or pores present? If you answer "yes," which surface has pores?

Analysis

1. **Predict** How might having a multicellular, thick body be an advantage to life on land?
2. **Observe** Are rootlike structures present? Evaluate the significance of this adaptation to a land environment.
3. **Infer** What might be the role of any pores observed on the plant? Why is the location of the pores critical to surviving on a land environment?

Figure 21.3
Stems can be soft and flexible like the basil stem shown here **(A).** Other plants, such as this sugar maple tree, have strong, thick stems that provide support and allow the tree to grow to great heights **(B).**

Figure 21.4
A seed consists of an embryo, a food supply, and a protective seed coat.

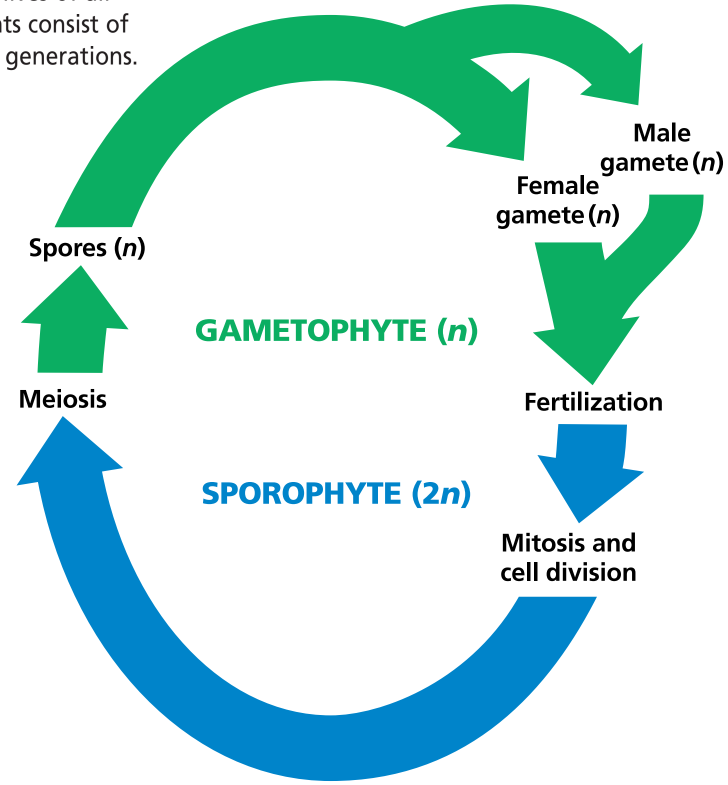


The stems of most plants contain vascular tissues. **Vascular tissues** (VAS kyuh lur) are made up of tubelike, elongated cells through which water, food, and other materials are transported. Plants that possess vascular tissues are known as **vascular plants.** Most of the plants you are familiar with, including pine and maple trees, ferns, rhododendrons, rye grasses, English ivy, and sunflowers, are vascular plants.

Mosses and several other small, less-familiar plants called hornworts and liverworts are usually classified as nonvascular plants. **Nonvascular plants** do not have vascular tissues. The bodies of nonvascular plants are usually no more than a few cells thick, and water and nutrients travel from one cell to another by the processes of osmosis and diffusion.

The evolution of vascular tissues was an important structural adaptation for plants that allowed them to survive in the many habitats on land. Vascular plants can live farther away from water than nonvascular plants. Also, because vascular tissues include thickened cells called fibers that help support growth, vascular plants can grow much larger than nonvascular plants.

Figure 21.5
The lives of all plants consist of two generations.



Reproductive strategies

Adaptations in some land plants include the evolution of seeds. A **seed** is a plant organ that contains an embryo, along with a food supply, and is covered by a protective coat, as shown in ***Figure 21.4.*** A seed protects the embryo from drying out and also can aid in its dispersal. Recall that a spore consists only of a haploid cell with a hard, outer wall. Land plants reproduce by either spores or seeds.

In non-seed plants, which include mosses and ferns, the sperm require a film of water on the gametophyte plant to reach the egg. In seed plants, which include all conifers and flowering plants, sperm reach the egg without using a film of water. This difference is one reason why non-seed plants require wetter habitats than most seed plants.

Alternation of generations

As in algae, the lives of all plants include two stages, or alternating generations, as shown in ***Figure 21.5.*** The gametophyte generation of a plant results in the development of gametes. All cells of the gametophyte, including the gametes, are haploid (*n*). The sporophyte generation begins with fertilization. All cells of the sporophyte are diploid (2*n*) and are produced by mitosis and cell division. The spores are produced in the sporophyte plant body by meiosis, and are therefore haploid (*n*).

In non-seed vascular plants such as ferns, spores have hard outer coverings. Spores are released into the environment where they can grow into haploid gametophyte plants. These plants produce male and female gametes. Following fertilization, the sporophyte plant develops and grows from the gametophyte plant.

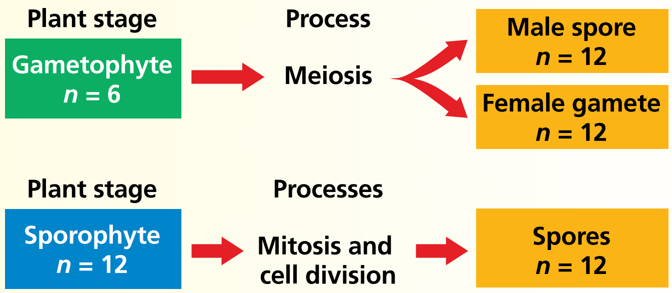
In seed plants, such as conifers and flowering plants, spores develop inside the sporophyte and become the gametophytes. The gametophytes consist of only a few cells. Male and female gametes are produced by these gametophytes. After fertilization, a new sporophyte develops within a seed. The seed eventually is released and the new sporophyte plant grows.

Use the *Problem-Solving Lab* on this page to explore further the differences between the gametophyte and sporophyte generations of plants.

Problem-Solving Lab 21.1

Analyze Information

How do gametophytes and sporophytes compare?
A plant has two stages in its life cycle. The stages are called the gametophyte generation and the sporophyte generation.



Solve the Problem

Diagram A shows the gametophyte generation of a plant. This plant has a haploid chromosome number of 6. Examine the diagram carefully and look for errors.

Diagram B shows the sporophyte generation of a plant. This plant has a diploid chromosome number of 12. Examine the diagram carefully and look for errors.

Thinking Critically

1. **Observe** Analyze diagram A, identify errors, and explain why they are incorrect.
2. **Observe** Analyze diagram B, identify errors, and explain why they are incorrect.
3. **Use Models** Illustrate diagrams A and B correctly so that they connect to one another and form a complete life cycle diagram of a plant.

Section Assessment

Understanding Main Ideas

1. Identify three characteristics that plants share with algae.
2. Explain how the development of the cuticle and the vascular system influenced the evolution of plants on land.
3. How do seeds and spores differ? What are the benefits of producing seeds?
4. List the sequence of events involved in the alternation of generations in land plants. Do all plants have alternation of generations?

Thinking Critically

5. Explain why vascular plants are more likely to survive in a dry environment than nonvascular plants.

Skill Review

6. **Make and Use Tables** Make a table of the different structural adaptations plants evolved that allow them to live on land. Include an evaluation of how each specific adaptation helped plants survive on land. For more help, refer to *Make and Use Tables* in the **Skill Handbook.**

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CONTENTS

Section

21.2

Survey of the Plant Kingdom

SECTION PREVIEW

Objectives

Describe the phylogenic relationships among divisions of plants.

Identify the plant kingdom divisions.

Review Vocabulary

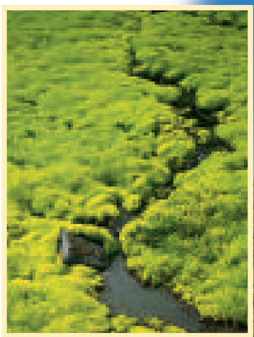
evolution: gradual change in an organism through adaptations over time (p. 10)

New Vocabulary

frond
cone

Different Plants in Different Places

Using Prior Knowledge Members of the plant kingdom are found worldwide. Plants survive on the cold tundra, in arid deserts, in oceans, in freshwater lakes, and in your community. If you have ever traveled far from home, you may have seen plants that do not grow naturally where you live. Even near your home you may have noticed that some plants grow only in sunny locations and others thrive in shady, damp areas.



Infer *What structural and physiological adaptations do plants, such as the cactus and mosses shown here, have that would allow them to survive in different biomes on Earth? Compare and then evaluate the significance of these adaptations.*

A *Saguaro* cactus (right) and mosses (left)

Physical Science Connection

Movement of landmasses Landmasses continually move over Earth's surface. Earth's outer layer is broken into huge sections called plates. These plates move slowly over the material underneath. Many scientists think that the motion of hot material deep within Earth generates the forces that cause plates to move.

Phylogeny of Plants

Many geological and climate changes have taken place since the first plants became adapted to life on land. Landmasses have moved from place to place over Earth's surface, climates have changed, and bodies of water have formed and disappeared. Hundreds of thousands of plant species evolved, and countless numbers of these became extinct as conditions continually changed. These processes of evolution and extinction continue to be affected by local and global changes. As plant species evolved in this changing landscape, they retained many of their old characteristics and also developed new ones. These processes of evolution and extinction continue today.

Some botanists use plant characteristics to classify plants into divisions. Recall that a plant division is similar to a phylum in other kingdoms. The highlights of plant evolution include origins of plants from green algae, the production of a waxy cuticle, the development of vascular tissue and roots, and the production of seeds. The production of seeds can be used as a basis to separate the divisions into two groups—non-seed plants and seed plants.

Figure 21.6
The plant kingdom includes several divisions of non-seed plants.

A *Selaginella,* a spike moss, is a lycophyte. Lycophytes are vascular plants adapted to moist environments.

B All ferns are pterophytes. The cinnamon fern, *Osmunda cinnamomea,* grows in swampy habitats throughout the United States.

C *Equisetum* is an arthrophyte. It has roots, stems, and leaves, but the stems are hollow and appear jointed.

D *Sphagnum* is a bryophyte. It grows in peat bogs.

E *Marchantia* is a hepaticophyte. It is found on damp rocks.

F *Anthoceros,* a hornwort, is an anthocerophyte. It is found in moist, shady habitats.

G *Psilotum* sporophytes have simple stems but no leaves or roots.

Non-seed Plants

The divisions of non-seed plants are shown in ***Figure 21.6.*** These plants produce hard-walled reproductive cells called spores. Non-seed plants include vascular and nonvascular organisms.

Hepaticophyta

Hepaticophytes (heh PAH tih koh fites) include small plants commonly called liverworts. Their flattened bodies resemble the lobes of an animal's liver. Liverworts are nonvascular plants that grow only in moist environments. Water and nutrients move throughout a liverwort by osmosis and diffusion. Studies comparing the biochemistry of different plant divisions suggest that liverworts may be the ancestors of all plants.

There are two kinds of liverworts: thallose liverworts and leafy liverworts. Thallose liverworts have a broad body that looks like a lobed leaf. Leafy liverworts are creeping plants with three rows of thin leaves attached to a stem.

Anthocerophyta

Anthocerophytes (an THOH ser oh fites) are also small thallose plants.

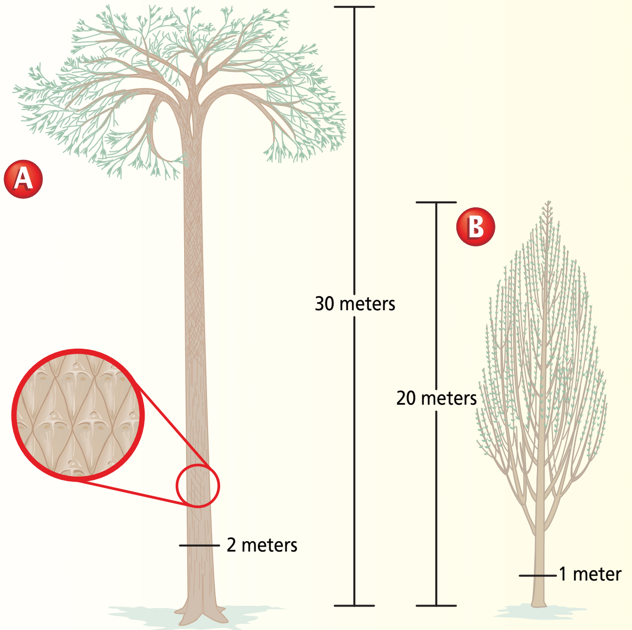
Word Origin

hepato- from the Greek word *hepar,* meaning "liver"; Hepaticophytes have liver-shaped gametophytes.

MiniLab 21.2

Compare and Contrast

Looking at Modern and Fossil Plants Many modern plants have relatives that are known only from the fossil record. Are modern plants similar to their fossil relatives? Are there any differences?



Representation of *Lepidodendron*

Representation of *Calamites*

Procedure

1. Examine a preserved or living sample of *Lycopodium*, a club moss. **CAUTION:** ***Wear protective gloves when handling preserved material.***
2. Note and record the following observations:
   - **a.** Does the plant grow flat or upright like a tree?
   - **b.** Describe the appearance of its leaves and its stem.
   - **c.** Measure the plant's height and diameter in centimeters.
3. Repeat step 2 for diagram A, a fossil relative.
4. Repeat steps 1–3 using a preserved or living sample of *Equisetum,* a horsetail and diagram B, a fossil relative.

Analysis

1. **Compare and Contrast** Describe the similarities and differences between *Lycopodium* and *Lepidodendron.* Do your observations justify their closeness as relatives? Explain.
2. **Compare and Contrast** Describe the similarities and differences between *Equisetum* and *Calamites.* Do your observations justify their closeness as relatives? Explain.

The sporophytes of these plants, which resemble the horns of an animal, give the plants their common name—hornworts. These nonvascular plants grow in damp, shady habitats and rely on osmosis and diffusion to transport nutrients.

Bryophyta

Bryophytes (BRI uh fites), the mosses, are nonvascular plants that rely on osmosis and diffusion to transport materials. However, some mosses have elongated cells that conduct water and sugars. Moss plants are usually less than 5 cm tall and have leaflike structures that are usually only one to two cells thick. Their spores are formed in capsules.

Psilophyta

Psilophytes, known as whisk ferns, consist of thin, green stems. The psilophytes are unique vascular plants because they have neither roots nor leaves. Small scales that are flat, rigid, overlapping structures cover each stem. The two known genera of psilophytes are tropical or subtropical. Only one genus is found in the southern United States.

Reading Check **Describe** the main difference between bryophytes and psilophytes.

Lycophyta

Lycophytes (LI koh fites), the club mosses, are vascular plants adapted primarily to moist environments. Lycophytes have stems, roots, and leaves. Their leaves, although very small, contain vascular tissue. Species existing today are usually less than 25 cm high, but their ancestors grew as tall as 30 m and formed a large part of the vegetation of Paleozoic forests. The plants of these ancient forests have become part of the coal that is now used by people for fuel.

Try *MiniLab 21.2* to explore the similarities and differences between modern and fossil lycophytes.

Arthrophyta

Arthrophytes (AR throh fites), the horsetails, are vascular plants. They have hollow, jointed stems surrounded by whorls of scalelike leaves. The cells covering the stems of some arthrophytes contain large deposits of silica. Although primarily a fossil group, about 15 species of arthrophytes exist today. All modern horsetails are small, but their fossil relatives were the size of trees.

Pterophyta

Pterophytes (TER oh fites), ferns, are the most well-known and diverse group of non-seed vascular plants. Ferns were abundant in Paleozoic and Mesozoic forests. They have leaves called **fronds** that vary in length from 1 cm to 500 cm. The large size and complexity of fronds is one difference between pterophytes and other groups of seedless vascular plants. Although ferns are found nearly everywhere, most grow in the tropics.

Seed Plants

Seed plants produce seeds, which in a dry environment are a more effective means of reproduction than spores. A seed consists of an embryonic plant and a food supply covered by a hard protective seed coat. All seed plants have vascular tissues. In *Problem-Solving Lab 21.2*, you can compare a characteristic common to seed plants and non-seed plants.

Cycadophyta

Cycads (SI kuds) were abundant during the Mesozoic Era. Today, there are about 100 species of cycads. They are palmlike trees with scaly trunks and can be short or more than 20 m in height. Cycads produce male and female cones on separate trees. **Cones** are scaly structures that support male or female reproductive structures. Cycad cones can be as long as 1 m. Seeds are produced in female cones. Male cones produce clouds of pollen.

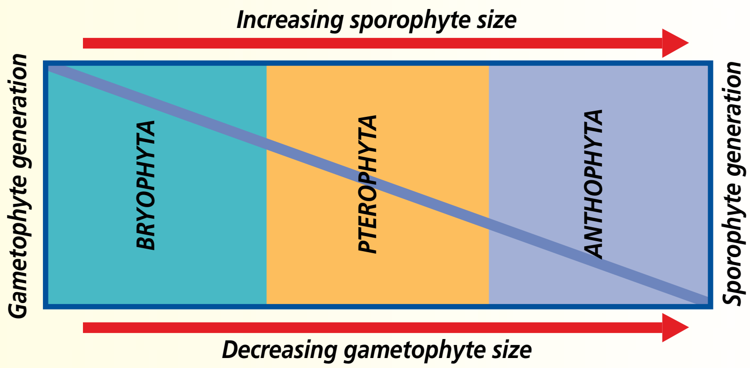
Problem-Solving Lab 21.2

Apply Concepts

What trend in size is seen with gametophyte and sporophyte generations? All plants undergo alternation of generations. There is a specific trend, however, that occurs in size as one goes from one plant division to the next.

Solve the Problem

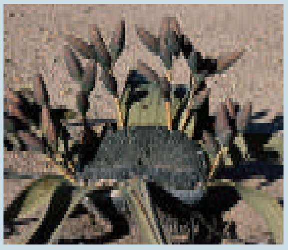
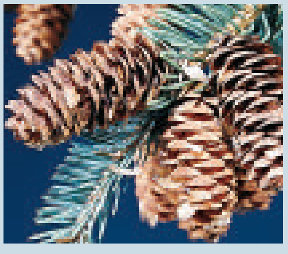
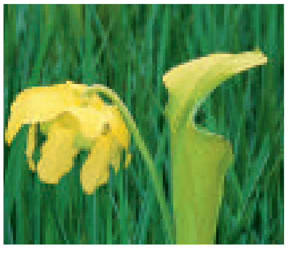
The following graph shows the trend that occurs within the plant kingdom as one compares the size of sporophyte and gametophyte generations in three major divisions.



Thinking Critically

1. **Analyze** Describe the trend that occurs to the size of the gametophyte generation as one moves from bryophytes to anthophytes.
2. **Analyze** Describe the trend that occurs to the size of the sporophyte generation as one moves from bryophytes to anthophytes.
3. **Predict** Estimate the size of the gametophyte generation compared with the sporophyte generation in:
   a. Coniferophyta. Explain.
   b. Lycophyta. Explain.
4. **Infer** You are looking at a giant redwood tree. Which generation is it and how do you know?

Table 21.1 Seed Plant Divisions

Division	Example	Common Names	Characteristics
Cycadophyta		Sago palm, cycad, zamia, dioon	Cycads grow in tropical or subtropical environments. These plants are slow-growing trees with unbranched trunks. Their leaves are palmlike. Seeds are produced in cones on female plants.
Gnetophyta		Joint fir, *Gnetum, Welwitschia*	Gnetophytes are usually found in desert or arid environments, but some are tropical. They exhibit diverse growth habits from vines to low-growing forms. These plants produce seeds in conelike structures.
Ginkgophyta		Ginkgo, maiden-hair tree	Ginkgoes are tolerant of a wide range of habitats from urban to open environments. These trees drop their leaves in the fall. Their seeds are surrounded by soft, fruitlike structures.
Coniferophyta		Pine, spruce, juniper, redwood, fir, yew, hemlock, arborvitae, cedar	Conifers grow in a wide range of habitats. Depending on the species, conifers can be tall trees or ground-covering shrubs. The leaves of conifers are needlelike or scalelike. Seeds develop in cones or berrylike structures.
Anthophyta		Rice, tomato, rose, corn, basil, apple, oak, grass, cattail, grape, bluebell	Anthophytes are found worldwide. The division includes a great diversity of growth habits, forms, and sizes. All anthophytes produce flowers from which dry or fleshy fruits with one or more seeds develop.

Gnetophyta

There are three genera of gnetophytes (NEE toh fites) and each has distinct characteristics. *Gnetum* (NEE tum) includes about 30 species of tropical trees and climbing vines. There are about 35 *Ephedra* (eh FEH dra) species that grow as shrubby plants in desert and arid regions. *Welwitschia* (wel WITCH ee uh) has only one species, which is found in the deserts of southwest Africa. Its leaves grow from the base of a short stem that resembles a large, shallow cap.

Ginkgophyta

This division has only one living species, *Ginkgo biloba*, a distinctive tree with small, fan-shaped leaves. Like cycads, ginkgoes (GING kohs) have male and female reproductive structures on separate trees. The seeds produced on female trees have an unpleasant smell, so ginkgoes planted in city parks are usually male trees. Ginkgoes are hardy and resistant to insects and to air pollution.

Figure 21.7
These fruits and seeds developed from flowers.
List ***Can you name three vegetables that are really fruits?***

Coniferophyta

These are the conifers (KAH nuh furz), cone-bearing trees such as pine, fir, cypress, and redwood. Conifers are vascular seed plants that produce seeds in cones. Species of conifers can be identified by the characteristics of their cones or leaves that are needle-like or scaly. You can learn more about how to identify conifers in the *BioLab* at the end of the chapter.

Bristlecone pines, the oldest known living trees in the world, are members of this plant division. Another type of conifer, the Pacific yew, is a source of cancer-fighting drugs. Read more about medicinal plants in the *Connection to Health* at the end of this chapter.

Anthophyta

Anthophytes (AN thoh fites), commonly called the flowering plants, are the largest, most diverse group of seed plants living on Earth. There are approximately 250 000 species of anthophytes. Fossils of the Anthophyta date to early in the Cretaceous Period. Unlike conifers, anthophytes produce flowers from which fruits develop, like those in ***Figure 21.7.*** A fruit usually contains one or more seeds. This division has two classes: the monocotyledons (mah nuh kah tul EE dunz) and dicotyledons (di kah tul EE dunz). You will learn more about the distinctions between monocots and dicots when you read about anthophyte tissues in Chapter 23.

Table 21.1 lists some information about the divisions of seed plants. Do you recognize any of the common names of the plants? Can you add to the list of common names?

Word Origin

conifero- from the Latin word *conifer*, meaning "cone bearing"; Many plants in the division Coniferophyta produce their seeds on cones.

Section Assessment

Understanding Main Ideas

1. What is the primary difference between the seeds of conifers and anthophytes?
2. Why are seeds an important structural adaptation? What plant divisions produce seeds? Which plant divisions do not produce seeds?
3. What structural adaptation allows pterophytes to grow larger than bryophytes?
4. Compare and contrast anthophytes and anthocerophytes.

Thinking Critically

5. In which division would you expect to find apple trees? Why?

Skill Review

6. **Get the Big Picture** Make a table of the plant divisions. Label columns: Division, Seed Plants, Non-seed Plants, Vascular Plants, Nonvascular Plants, and Seeds in Fruits. For more help, refer to *Get the Big Picture* in the **Skill Handbook.**

ca.bdol.glencoe.com/self_check_quiz

DESIGN YOUR OWN

BioLab

How can you make a key for identifying conifers?

INQUIRY

Before You Begin

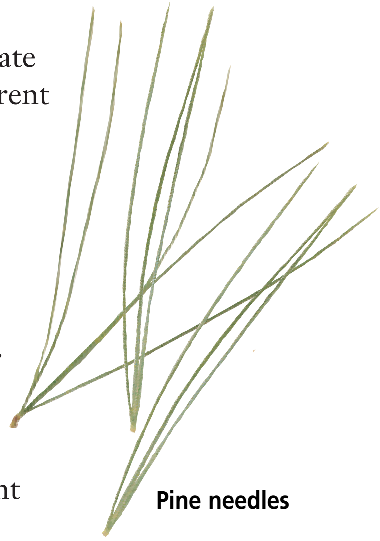
Each conifer species has a unique cone. The leaves of conifer species also have different characteristics. How would you identify a conifer? You would probably use a dichotomous key. Dichotomous keys list features of related organisms in a way that allows you to determine each organism's scientific name. Below is an example from a dichotomous key that might be used to identify trees.

Needles grouped in bundles
Needles not grouped in bundles
Needlelike leaves
Flat, thin leaves
Leaves composed of three or more leaflets
Leaves not made up of leaflets

PREPARATION

Problem

What characteristics can be used to create a dichotomous key for identifying different kinds of conifers?



Pine needles

Hypotheses

State your hypothesis according to the kinds of characteristics you predict will best serve to distinguish among several conifer groups. Explain your reasoning.

Objectives

In this BioLab, you will:

- **Compare** structures of several different conifer specimens.
- **Identify** which characteristics can be used to distinguish one conifer from another.
- **Develop a model** of a hierarchical classification system (division, genus, species) based on similarities and differences using taxonomic nomenclature.

Possible Materials

twigs, branches, and cones from several different conifers that have been identified for you

Safety Precautions

CAUTION: ***Always wash your hands after handling biological materials. Always wear goggles in the lab.***

Skill Handbook

If you need help with this lab, refer to the **Skill Handbook.**

Arborvitae

Hemlock

Matt Meadows

CONTENTS

Plan the Experiment

1. Make a list of characteristics that could be included in your key. You might consider using shape, color, size, habitat, or other factors.
2. Determine which of those characteristics would be most helpful in classifying your conifers.
3. Determine in what order the characteristics should appear in your key.
4. Decide how to describe each characteristic.

Check the Plan

1. The traits described at each step in a key are often pairs of contrasting characteristics. For example, the first step in a key to conifers might compare "needles grouped in bundles" with "needles attached singly."
2. Someone who is not familiar with conifer identification should be able to use your key to correctly identify any conifer it includes.
3. ***Make sure your teacher has approved your experimental plan before you proceed further.***
4. Carry out your plan by creating your key.
5. **CLEANUP AND DISPOSAL** Return all conifer specimens to the location specified by your teacher for reuse by other students. Wash your hands thoroughly.

Spruce

Analyze and Conclude

1. **Check Your Hypothesis** Have someone outside your lab group use your key to identify a conifer specimen. If he or she cannot identify it, try to determine what the problem is and make improvements to your key.
2. **Relate Concepts** Give one or more examples of situations in which a dichotomous key would be a useful tool.
3. **ERROR ANALYSIS** Is there only one correct way to design a dichotomous key for your specimens? Explain why or why not.

Apply Your Skill

Project Design a different dichotomous key that would also work to identify your specimens. You may expand your key to include additional conifers.

Web Links To find out more about conifers, visit ca.bdol.glencoe.com/conifers

Connection to Health

Medicines from Plants

Madagascar rosy periwinkle

What comes to mind when you hear the word *plant?* A vase full of flowers? A fruit and vegetable garden? An evergreen forest? Although these examples are what most people think of when they hear the word *plant*, plants provide us with much more than bouquets, food, and lumber. Nearly 80 percent of the world's population relies on medications derived from plants. In fact, just fewer than 100 plants provide the active ingredients used in the ten dozen or so plant-derived medicines currently on the market.

For thousands of years, the words *plants* and *medicines* were used synonymously. In the fifth century A.D., doctors of the Byzantine Empire used the autumn crocus to effectively treat rheumatism and arthritis. Hundreds of years ago, certain groups of Native North Americans used the rhizomes of the mayapple as a laxative, a remedy for intestinal worms, and as a topical treatment for warts and other skin growths. The oils from peppermint leaves have long been used to settle an upset stomach. Lotions containing the liquid from the plant *Aloe vera* are often used to relieve the pain associated with minor burns, including sunburn. "Herbal" medicines have again begun to play an important role in so-called modern medicine.

Aspirin—The wonder drug Evidence suggests that almost 2500 years ago, a Greek physician named Hippocrates used a substance from the bark of a white willow tree to treat minor pains and fever. The substance, which is called salicin, unfortunately upset the stomach. Research in the late 1800s led to the discovery of acetylsalicylic acid (ah SEE till sa lih SIH lick • A sid), or aspirin. Aspirin originally was developed by chemist Felix Hoffmann to relieve the joint discomfort associated with rheumatism. Salicylic acid—a major component of aspirin—was finally synthesized in the laboratory in the early 1900s. Since then, aspirin's use has become widespread.

New drugs for cancer Drugs that fight two types of cancer—Hodgkin's disease and leukemia—have been derived from the Madagascar rosy periwinkle. Drugs produced from the needles and bark of the Pacific yew have been used to treat breast, ovarian, lung, and other cancers. Although the interest in medicinal plants by consumers, medical experts, and pharmaceutical companies is growing, it is estimated that less than five percent of the 250 000 different flowering plant species have been studied for their potential use in the field of medicine.

Researching in Biology

Project Identify a plant not mentioned in this feature that is known to have medicinal properties. Research the plant's geographic distribution on Earth, its use(s), the active ingredient derived from the plant, and whether or not a synthetic form of the active ingredient is available for use. As a class, compile all findings and create a classroom display.

To find out more about medicines derived from plants, visit ca.bdol.glencoe.com/health

Chapter 21 Assessment

Study Guide

Section 21.1

Adapting to Life on Land

Key Concepts

- Plants are multicellular eukaryotes with cells that have cell walls containing cellulose. A waterproof cuticle covers the outer surface of most plants. Most plants undergo photosynthesis, which produces glucose, a form of food.
- All plants on Earth probably evolved from filamentous green algae that lived in ancient oceans. The first plants to eventually move from water to land probably were leafless forms.
- Adaptations for life on land include a cuticle; the development of leaves, roots, stems, and vascular tissues; alternation of generations; and the evolution of the seed.

Vocabulary

cuticle (p. 559)
leaf (p. 561)
nonvascular plant (p. 562)
root (p. 561)
seed (p. 562)
stem (p. 561)
vascular plant (p. 562)
vascular tissue (p. 562)

Section 21.2

Survey of the Plant Kingdom

Key Concepts

- The plant kingdom is grouped into major categories called divisions.
- Nonvascular plants are in the divisions Anthocerophyta, Hepaticophyta, and Bryophyta. They reproduce mainly by using spores. Nonvascular plants do not produce seeds.
- Non-seed vascular plants are in the divisions Psilophyta, Lycophyta, Arthrophyta, and Pterophyta. These plants have tissues that conduct water and other materials and reproduce mainly by spores.
- Vascular seed plants in the divisions Cycadophyta, Gnetophyta, Ginkgophyta, and Coniferophyta produce seeds on cones. Male cones and female cones can be on separate plants or the same plant.
- The division Anthophyta includes vascular, seed-producing plants that flower. Fruits with seeds develop from flowers. Anthophytes are divided into two groups—monocotyledons and dicotyledons.

Vocabulary

cone (p. 567)
frond (p. 567)

FOLDABLES™ Study Organizer To help you review plant adaptations to land, use the Organizational Study Fold on page 559.

ca.bdol.glencoe.com/vocabulary_puzzlemaker

Chapter 21 Assessment

Vocabulary Review

Review the Chapter 21 vocabulary words listed in the Study Guide on page 573. Match the words with the definitions below.

1. plants in which the transport of water and other substances is mainly by osmosis and diffusion from cell to cell
2. the organ that anchors a plant and absorbs most of the water and minerals used by a plant
3. for plants such as pines and spruces, it is the organ that contains reproductive structures
4. the plant organ that is usually the site of photosynthesis
5. a group of tubelike, elongated cells through which water and other materials are transported throughout a plant

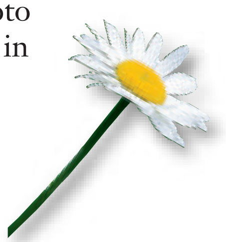
Understanding Key Concepts

6. Which of these traits is NOT common to plants and green algae?
A. reproduce by fission
B. contain cellulose in cell walls
C. store food as starch
D. contain the same kind of chlorophyll

7. Vascular tissues are found in ________.
A. bacteria **C.** ferns
B. algae **D.** hornworts

8. Which of the following characteristics is NOT found in plants?
A. eukaryotic cells **C.** prokaryotic cells
B. cellulose cell walls **D.** waxy cuticle

9. The plant organ in the photo to the right is from a plant in division ________.



A. Anthocerophyta
B. Coniferophyta
C. Lycophyta
D. Anthophyta

10. Which group of organisms is probably the ancestor of land plants?
A. cyanobacteria **C.** bryophytes
B. archaebacteria **D.** green algae

11. Seeds enclosed in a fruit is a structural adaptation of ________.
A. Anthophytes **C.** Coniferophytes
B. Bryophytes **D.** Pterophytes

12. The fern structure to the right is called a ________.

A. rhizome
B. root
C. gametophyte
D. frond

Constructed Response

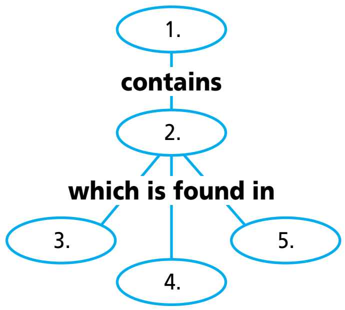
13. **Open Ended** Explain why biologists hypothesize that the first plants to adapt to life on land may have been similar to liverworts.

14. **Open Ended** Anthophytes are found worldwide and include the greatest number of known plant species. Identify, describe, and evaluate characteristics of this division that were important to its success. Explain your choices.

15. **Open Ended** Observe the plants in ***Figure 21.6 D*** and ***E.*** Describe the structural adaptations that contribute to their long-term survival in moist environments.

Thinking Critically

16. **Concept Map** Copy the concept map below then complete it the using the following terms: leaves, roots, stems, vascular tissue, vascular plant.



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Chapter 21 Assessment

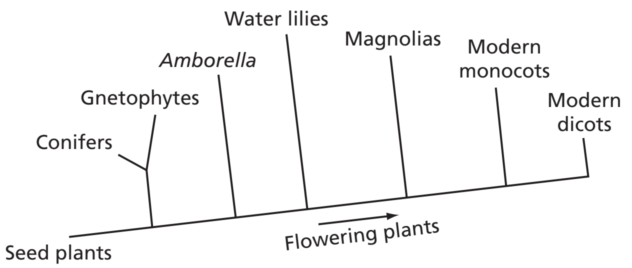
17. **REAL WORLD BIOCHALLENGE** You are appointed to a committee at school that is to plan and plant a flower garden. What factors must be considered when selecting plants for this garden? Visit **ca.bdol.glencoe.com** to research plants and plan the garden. Sketch a plan and list your plant selections. Explain why each plant was chosen.

California Standards Practice

All questions aligned and verified by The Princeton Review

Part 1 Multiple Choice

Study the cladogram below and answer questions 18–20.



18. The cladogram shows the evolution of some flowering plants. According to the cladogram, modern monocots developed ________ *Amborella*.

A. at the same time as
B. before
C. after
D. none of these

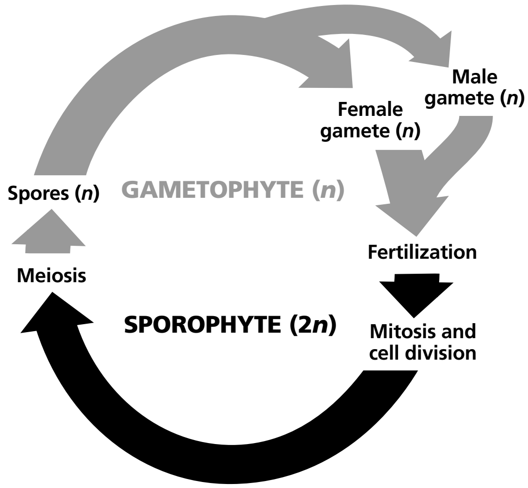
19. *Amborella* is most closely related to ________.

A. modern monocots
B. modern dicots
C. water lilies
D. magnolias

20. Which of the following plant types evolved before *Amborella?*

A. gnetophytes
B. modern dicots
C. magnolias
D. water lilies

Use the diagram below to answer questions 21 and 22.



21. The sporophyte produces spores by the process of ________.

A. mitosis
B. meiosis
C. fission
D. fertilization

22. Which of the following would NOT have a haploid or *n* number of chromosomes?

A. gametophyte
B. spore
C. sporophyte
D. gamete

Part 2 Constructed Response/Grid In

Record your answers or fill in the bubbles on your answer document using the correct place value.

23. **Grid In** The sporophyte of corn has 20 chromosomes. How many chromosomes would you expect to find in corn gametes?

24. **Open Ended** Describe the differences between seed and non-seed plants. Considering structural and physiological adaptations of these two plant types, infer why seed plants are found in more diverse environments than non-seed plants.