Chapter 22 Organizer

Refer to pages 4T-5T of the Teacher Guide for an explanation of the National Science Education Standards correlations.

Section	Objectives	Activities/Features
Section 22.1 **Nonvascular Plants** National Science Education Standards UCP.1, UCP.5; A.1, A.2; C.1, C.5; G.1-3 (1 session)	1. **Identify** the structures of nonvascular plants. 2. **Compare and contrast** characteristics of the different groups of nonvascular plants.	**Problem-Solving Lab 22-1,** p. 598
Section 22.2 **Non-Seed Vascular Plants** National Science Education Standards UCP.1-5; A.1, A.2; C.1, C.3, C.5, C.6; G.3 (1 session)	3. **Explain** the importance of vascular tissue to life on land. 4. **Identify** the characteristics of the non-seed vascular plant divisions.	**Problem-Solving Lab 22-2,** p. 604 **MiniLab 22-1:** Identifying Fern Sporangia, p. 606
Section 22.3 **Seed Plants** National Science Education Standards UCP.1-5; A.1, A.2; C.1, C.3, C.5, C.6; F.3-6; G.1-3 (2 sessions, 1½ blocks)	5. **Identify** the characteristics of seed plants. 6. **Analyze** the advantages of seed and fruit production.	**MiniLab 22-2:** Comparing Seed Types, p. 609 **Inside Story:** Pine Needles, p. 613 **Careers in Biology:** Lumberjack, p. 616 **Design Your Own BioLab:** How can you make a key for identifying conifers? p. 618 **Biology & Society:** Forestry: Keeping a Balance, p. 620

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551 or at **http://www.carolina.com**

MATERIALS LIST

BioLab

p. 618 conifer twigs, conifer branches, conifer cones

MiniLabs

p. 606 microscope, microscope slide, coverslip, forceps, water, glycerin, live fern frond

p. 609 lima beans, grass seeds, rice, peas, rye seeds, forceps, iodine stain, dropper, pencil, paper

Alternative Lab

p. 612 microscope, prepared slide of conifer leaf cross section

Quick Demos

p. 599 flowerpots (2), sand, peat moss, water

p. 602 capillary tube, petri dish, water, food coloring

p. 610 assorted conifer cones

Key to Teaching Strategies

- **L1** Level 1 activities should be appropriate for students with learning difficulties.
- **L2** Level 2 activities should be within the ability range of all students.
- **L3** Level 3 activities are designed for above-average students.
- **ELL** ELL activities should be within the ability range of English Language Learners.
- **COOP LEARN** Cooperative Learning activities are designed for small group work.
- **P** These strategies represent student products that can be placed into a best-work portfolio.
- These strategies are useful in a block scheduling format.

Teacher Classroom Resources

Section	Reproducible Masters	Transparencies
Section 22.1 **Nonvascular Plants**	**Reinforcement and Study Guide,** p. 97 L2 **Content Mastery,** pp. 109-110, 112 L1	**Section Focus Transparency 52** L1 ELL
Section 22.2 **Non-Seed Vascular Plants**	**Reinforcement and Study Guide,** pp. 98-99 L2 **BioLab and MiniLab Worksheets,** p. 101 L2 **Laboratory Manual,** pp. 153-156 L2 **Content Mastery,** pp. 109-110, 112 L1	**Section Focus Transparency 53** L1 ELL
Section 22.3 **Seed Plants**	**Reinforcement and Study Guide,** p. 100 L2 **Concept Mapping,** p. 22 L3 ELL **Critical Thinking/Problem Solving,** p. 22 L3 **BioLab and MiniLab Worksheets,** pp. 102-104 L2 **Laboratory Manual,** pp. 157-160 L2 **Content Mastery,** pp. 109, 111-112 L1	**Section Focus Transparency 54** L1 ELL **Basic Concepts Transparency 34** L2 ELL **Basic Concepts Transparency 35** L2 ELL

Assessment Resources

Chapter Assessment, pp. 127-132
MindJogger Videoquizzes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 22 quiz

Additional Resources

Spanish Resources L1 ELL
English/Spanish Audiocassettes L1 ELL
Cooperative Learning in the Science Classroom COOP LEARN
Lesson Plans/Block Scheduling

NATIONAL GEOGRAPHIC Teacher's Corner

Products Available From Glencoe

To order the following products, call Glencoe at 1-800-334-7344:

CD-ROM
NGS PictureShow: What It Means to Be Green
Curriculum Kit
GeoKit: Plants
Transparency Set
NGS PicturePack: What It Means to Be Green
Videodisc
STV: Plants

Index to National Geographic Magazine

The following articles may be used for research relating to this chapter:

"The Gift of Gardening," by William S. Ellis, May 1992.

GLENCOE TECHNOLOGY

The following multimedia resources are available from Glencoe.

Biology: The Dynamics of Life
CD-ROM ELL
Animation: *Life Cycle of a Moss*
Exploration: *The Six Kingdoms*
BioQuest: *Biodiversity Park*
Video: *Fern Development*
Exploration: *Classifying Pines*
Video: *Giant Redwoods*
Exploration: *Angiosperm*
Video: *Blooming Flowers*

The Infinite Voyage
Life in the Balance

Chapter 22

Getting Started Demo

Visual-Spatial Show students pictures or live samples of a variety of vascular and nonvascular plants. Ask students to compare and contrast the plants. L1

Theme Development

The theme **unity within diversity** is carried out within this chapter as students learn about features shared by nonvascular plants and vascular plants such as the plant life cycle, which includes alternation of generations. Diversity is illustrated through the unique adaptations found in members of the different divisions. **Evolution** is apparent through the discussions of the many adaptations plants exhibit that aid in their survival.

0:00 Out of Time?

If time does not permit teaching the entire chapter, use the BioDigest at the end of the unit as an overview.

Resource Manager

Section Focus Transparency 52 and Master L1 ELL

Chapter

22 The Diversity of Plants

What You'll Learn

- You will identify the characteristics of the major plant groups.
- You will compare the distinguishing features of vascular and nonvascular plants.
- You will analyze the advantages of seed production.

Why It's Important

We classify plants according to their characteristics. Knowing about the major characteristics of plants will help you appreciate the beauty and diversity of the plants around you.

Getting Started

Comparing Seeds and Fruits

Examine a number of different seeds and fruits. *How do you think these seeds and fruits might be transported away from their parent plant?*

interNET CONNECTION To find out more about the diversity of plants, visit the Glencoe Science Web Site. **www.glencoe.com/sec/science**

Members of the plant kingdom exhibit a wide variety of characteristics. Some plants produce large, colorful fruits. Others, including mosses, produce tiny spores.

Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

Kinesthetic Enrichment, p. 603; Meeting Individual Needs, p. 604; Project, p. 605

Visual-Spatial Portfolio, pp. 598, 603, 614; Meeting Individual Needs, p. 602; Extension, pp. 607, 617; Quick Demo, p. 610; Chalkboard Activity, p. 612

Interpersonal Activity, p. 600

Intrapersonal Enrichment, p. 611;

Linguistic Biology Journal, pp. 599, 603; Cultural Diversity, p. 609; Meeting Individual Needs, p. 611

Logical-Mathematical Chalkboard Activity, p. 605; Biology Journal, p. 610

Naturalist Meeting Individual Needs, p. 598; Discussion, p. 607

Section

22.1 Nonvascular Plants

SECTION PREVIEW

Objectives

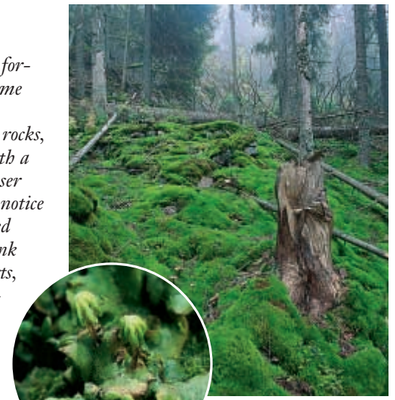
Identify the structures of nonvascular plants.

Compare and contrast characteristics of the different groups of nonvascular plants.

Vocabulary

antheridium
archegonium

As you hike in a shady forest, you are sure to come across patches of soft, feathery mosses covering soil, rocks, rotting wood, or tree bark with a velvety layer of green. On closer examination, you might also notice shiny liverworts or odd-shaped hornworts along the stony bank of a stream. Mosses, liverworts, and hornworts are nonvascular plants. These small plants usually live in moist, cool environments.



Moss-covered forest floor and liverwort (inset)

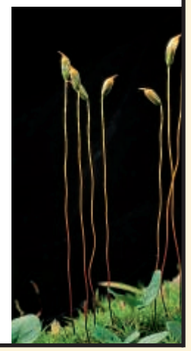
What Is a Nonvascular Plant?

Nonvascular plants are not as common or as widespread in their distribution as vascular plants because life functions, including photosynthesis and reproduction, require a close association with water. Because a steady supply of water is not available everywhere, nonvascular plants are limited to moist habitats by streams and rivers or in temperate and tropical rain forests. Recall that a lack of vascular tissue also limits the size of a plant. In drier soils, nonvascular plants cannot compete with neighboring vascular plants, which can easily overgrow them and cut them off from sunlight and atmospheric gases. But even with these limitations, nonvascular plants are successful in habitats with adequate water.

Alternation of generations

As in all plants, the life cycle of nonvascular plants includes an alternation of generations between a diploid sporophyte and a haploid gametophyte. However, nonvascular plants are the only plant divisions in which the gametophyte generation is dominant. The gametophytes are dominant and the sporophytes are physically attached to the gametophytes, as shown in ***Figure 22.1***, and dependent on them for most of their nutrition.

Figure 22.1 Brown stalks and spore capsules of the sporophyte generation can be seen growing from the green, leafy gametophyte of this moss.



Assessment Planner

Portfolio Assessment
- **Assessment, TWE,** p. 600
- **MiniLab, TWE,** p. 609

Performance Assessment
- **MiniLab, SE,** pp. 606, 609
- **Alternative Lab, TWE,** p. 612
- **BioLab, SE,** p. 618-619
- **BioLab, TWE,** p. 619

Knowledge Assessment
- **Problem-Solving Lab, TWE,** p. 598
- **Section Assessment, SE,** pp. 600, 607, 617
- **MiniLab, TWE,** p. 606
- **Assessment, TWE,** pp. 607, 610, 615
- **Chapter Assessment, SE,** pp. 621-623

Skill Assessment
- **Assessment, TWE,** pp. 599, 602, 617
- **Problem-Solving Lab,** p. 604
- **Alternative Lab, TWE,** p. 613

Prepare

Key Concepts

Characteristics of three divisions of nonvascular plants are examined with emphasis on their lack of vascular tissue and the limitations this places on mosses, liverworts, and hornworts. A brief discussion of alternation of generations among nonvascular plants is included.

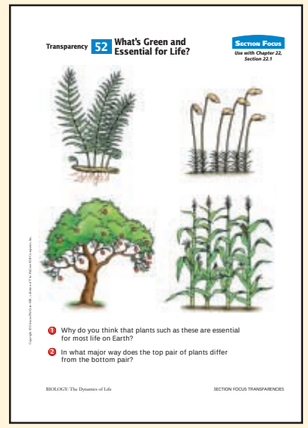
Planning

- Purchase fruits and seeds for the Getting Started Demo.
- Collect pictures of nonvascular plants for the Display.
- Purchase sand and peat moss for the Quick Demo.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 52** on the overhead projector and have students answer the accompanying questions. L1 ELL



2 Teach

Problem-Solving Lab 22-1

Purpose

Students will determine from various clues that they are observing plant gametophytes.

Process Skills

observe and infer, think critically, analyze information, interpret scientific illustrations

Background

It is not unusual to find male and female bryophyte gametophytes. The plant being used in this lab is a liverwort.

Teaching Strategies

- Advise students to pay close attention to the scale of magnification included on the diagrams.
- Students will have to have already studied alternation of generations and be familiar with the contributions of the gametophyte generation in order to understand this lab.

Thinking Critically

1. Sperm cell; there are numerous cells with flagella.
2. Egg cell; it is a single cell much larger than part a.
3. Gametophytes; the gametophyte generation forms gametes.
4. Mitosis; haploid—gametophytes form gametes by mitosis.
5. Haploid; all parts of the gametophyte are haploid.

Assessment

Knowledge Ask students to copy the diagrams and add labels to the antheridium and archegonium. Have students diagram the rest of this plant's life cycle. Use the Performance Task Assessment List for Scientific Drawing in **PASC,** p. 55. L2

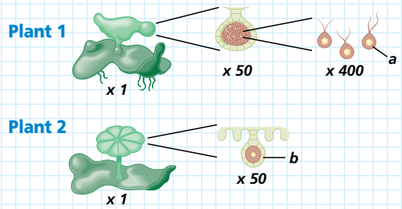
Problem-Solving Lab 22-1

Observing and Inferring

Is it a sporophyte or a gametophyte? You have just discovered a new plant species and have classified it as a nonvascular plant. You have two almost identical specimens, and microscopic examination reveals the internal structures of plants 1 and 2 below.

Analysis

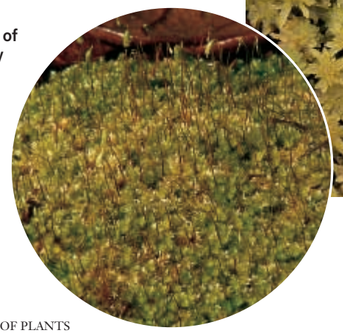
Formulate a hypothesis as to the nature of plants 1 and 2.



Thinking Critically

1. Compare part a to b. What is part a? How do you know?
2. What is part b? How do you know?
3. Knowing that this is a nonvascular plant, are plants 1 and 2 sporophytes or gametophytes? How do you know?
4. Are parts a and b formed by mitosis or meiosis? Are a and b haploid or diploid? Explain.
5. Are plants 1 and 2 haploid or diploid? Explain.

Figure 22.2
Mosses have a central stem surrounded by small, thin leaves. They also have rhizoids, one-cell-thick rootlike structures, which absorb water and nutrients.



A ***Bryum*** **is a type of moss frequently found in moist forest habitats.**

B Peat moss, ***Sphagnum,*** **is well-known because of its usefulness to humans as fuel and in the horticultural industry.**

Gametophytes produce two kinds of sexual reproductive structures. The **antheridium** (an thuh RIHD ee um) is the male reproductive structure in which sperm are produced. The **archegonium** (ar kih GOH nee um) is the female reproductive structure in which eggs are produced. Think of ways you can identify the phases of a nonvascular plant's life cycle in the *Problem-Solving Lab* shown here.

Adaptations in Bryophyta

There are several divisions of nonvascular plants. The first division you'll study are the mosses, or bryophytes. Bryophytes are the most familiar of the nonvascular plant divisions. Mosses are small plants with leafy stems. The leaves of mosses are usually one cell thick. Mosses have rhizoids, colorless multicellular structures, which help anchor the stem to the soil. Although mosses do not contain true vascular tissue, some species do have a few, long water-conducting cells in their stems.

Mosses usually grow in dense carpets of hundreds of plants. Some have upright stems; others have creeping stems that hang from steep banks or tree branches. Some mosses form extensive mats that retard erosion on exposed rocky slopes.

Mosses grow in a wide variety of habitats. They grow even in the arctic in places where there is sufficient moisture.

One of the most well-known mosses is *Sphagnum* moss, also known to gardeners as peat moss. This plant thrives in acidic bogs in northern regions of the world. It has been harvested for use as fuel and is a commonly used soil additive. Dried peat moss absorbs large amounts of water, so florists and gardeners use it to increase the water-holding ability of soil. See ***Figure 22.2*** to examine the characteristics of *Bryum* and *Sphagnum* mosses.

a

b

Figure 22.3
Liverworts may have a flattened thallus (a) or flattened leaves in three ranks borne on a stem (b).

Adaptations in Hepatophyta

Another division of nonvascular plants is the liverworts, or hepatophytes. Like mosses, liverworts are small plants that usually grow in clumps or masses in moist habitats. The name of the division is derived from the word *hepatic*, which refers to the liver. The flattened body of a liverwort gametophyte is thought to resemble the shape of the lobes of an animal's liver. Liverworts occur in many environments, from the Arctic to the Antarctic. They include two groups: the thallose liverworts and the leafy liverworts, ***Figure 22.3.*** The body of a thallose liverwort is a thallus. It is a broad, ribbonlike body that resembles a fleshy, lobed leaf. Leafy liverworts are creeping plants with three rows of flat, thin leaves attached to a stem. Like mosses, liverworts have rhizoids; however, the rhizoids of liverworts are each composed of only one elongated cell. Most liverworts have an oily or shiny surface that helps reduce evaporation of water from the plant's tissues.

Adaptations in Anthocerophyta

Anthocerophytes are the smallest division of nonvascular plants, currently consisting of only about 100 species. Also known as hornworts, these nonvascular plants are similar

WORD Origin

antheridium
From the Greek word *anthera*, meaning "flowery." Sperm are produced in the antheridium.

archegonium
From the Greek word *archegonos*, meaning "originator." Eggs are produced in the archegonium.

Assessment

Skill Ask students to construct a table comparing and contrasting the three divisions of nonvascular plants. L2

Quick Demo

Show students the water absorption capabilities of peat moss by pouring water into two flowerpots: one containing sand and the other containing a mix of sand and peat moss.

Display

Make a bulletin board display of nonvascular plants.

3 Assess

Check for Understanding

Ask students to explain the relationships for the following word pairs. L1 ELL

a. sperm—antheridium
b. egg—archegonium

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
A Moss

CD-ROM
Biology: The Dynamics of Life
Animation; *Life Cycle of a Moss*
Disc 3

MEETING INDIVIDUAL NEEDS

Learning Disabled

Naturalist Have students list as many characteristics as possible that distinguish the nonvascular plant divisions from other plant groups. Organizing these characteristics into lists will help students with learning disabilities to distinguish these plant divisions. L1

Portfolio

Alternation of Generations

Visual-Spatial Have students prepare a simple flowchart diagram that depicts alternation of generations. The diagram must include these terms: gametophyte generation, sporophyte generation, spore, gamete, diploid, and haploid. Have students place the flowchart in their portfolio. L2 P

BIOLOGY JOURNAL

Development or Conservation?

Linguistic Tell students a hypothetical story involving the construction of an affordable housing development in a particularly attractive wooded area. Tell students this area is known for the many varieties of nonvascular plants found growing there. They are to write letters to the local government agency either supporting the development or calling for conservation of the area. Tell students they must include reasons for their views in this letter. L3

Reteach

Linguistic Have students outline the section and write a definition for each vocabulary term. L2

Extension

Naturalist Have students prepare a key that will enable them to distinguish among the three divisions of nonvascular plants. L3

Assessment

Portfolio Have students draw plants from each division. Students should label the distinguishing features on their drawings and place the drawings in their portfolios. L1 P

4 Close

Activity

Interpersonal Have students write three questions based on the material covered in this section. Have students read their questions while their classmates provide the answers. L2

Resource Manager

Reinforcement and Study Guide, p. 97 L2
Content Mastery, p. 110 L1

Figure 22.4
The upright sporophyte of the hornwort resembles an animal horn and gives the plant its name.

to liverworts in several respects. Like some liverworts, hornworts have a thallose body. As you can see in ***Figure 22.4,*** the sporophyte of a hornwort resembles the horn of an animal, which is why members of this division are commonly called "hornworts." Another feature unique to hornworts is the presence of a single large chloroplast in each cell. This feature suggests that hornworts may be closely related to algae, which also have only one large chloroplast in each cell.

Origins of Nonvascular Plants

Fossil and genetic evidence suggests that liverworts were the first land plants. Fossils that have been positively identified as nonvascular plants first appear in rocks from the early Paleozoic period, about 430 million years ago. However, paleobotanists think that nonvascular plants were present much earlier than current fossil evidence suggests. Both nonvascular and vascular plants probably share a common ancestor that had alternating sporophyte and gametophyte generations, cellulose in their cell walls, and chlorophyll for photosynthesis.

Section Assessment

Understanding Main Ideas

1. How can you tell a leafy liverwort from a thallose liverwort?
2. In what way is the sporophyte generation of a moss dependent on the gametophyte generation?
3. What are some characteristics shared by all nonvascular plants?
4. Explain why nonvascular plants are usually found in moist shady areas.

Thinking Critically

5. Explain why it is an advantage for mosses to grow in mats or mounds composed of many individual plants.

Skill Review

6. **Compare and Contrast** the gametophyte and sporophyte generations of nonvascular plants. For more help, refer to *Thinking Critically* in the **Skill Handbook.**

Section

22.2 Non-Seed Vascular Plants

SECTION PREVIEW

Objectives

Explain the importance of vascular tissue to life on land.

Identify the characteristics of the non-seed vascular plant divisions.

Vocabulary

strobilus
prothallus
rhizome
sorus

Imagine traveling back in time nearly 300 million years—50 million years before dinosaurs evolved. As you look around Earth's forests, you see a bewildering array of leafy vascular plants, some oddly familiar. Towering above the forest floor are incredibly tall, unusual-looking trees. Paleobotanists know what these ancient plants looked like because many were preserved as fossils. Living on Earth today are plants that are reminiscent of these ancient vascular plants, including the club mosses, horsetails, and ferns.

Tree fern and horsetails (inset)

What Is a Non-Seed Vascular Plant?

The obvious difference between a vascular and a nonvascular plant is the presence of vascular tissue. As you may remember, vascular tissue is made up of tubelike, elongated cells through which water and sugars are transported. Vascular plants are able to adapt to changes in the availability of water, and thus are found in a variety of habitats. You will learn about three divisions of non-seed vascular plants: Lycophyta, Sphenophyta, and Pterophyta.

Alternation of generations

Vascular plants, like all plants, exhibit an alternation of generations. Unlike nonvascular plants, though, the spore-producing sporophyte is dominant, ***Figure 22.5.*** The sporophyte is much larger in size than the gametophyte. The mature sporophyte

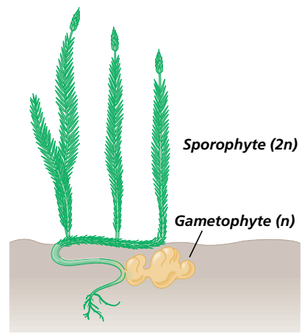


Figure 22.5
In non-seed vascular plants, the sporophyte generation is dominant.

Prepare

Key Concepts

The non-seed vascular plant divisions Lycophyta, Sphenophyta, and Pterophyta are presented along with the traits that distinguish these divisions from each other.

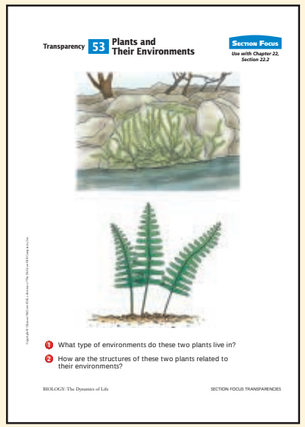
Planning

- Obtain a glass tube and colored water for the Quick Demo.
- Purchase a resurrection plant for the Enrichment.
- Collect or purchase fern spores for the MiniLab.
- Collect pictures of non-seed vascular plants for the Display.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 53** on the overhead projector and have students answer the accompanying questions. L1 ELL



Section Assessment

1. Thallose liverworts have a broad, ribbon-like body that resembles a fleshy, lobed leaf. Leafy liverworts have three rows of flat, thin leaves attached to a stem.
2. The sporophyte generation is small and obtains food, water, and minerals from the larger gametophyte generation.
3. Nonvascular plants lack vascular tissue, are typically small in size, have a dominant gametophyte generation, and grow in moist, shady areas.
4. Since these plants rely on diffusion and osmosis for the transport of water and minerals, they tend to be found in areas where water is plentiful.
5. The dense mats retain water and help reduce evaporation.
6. The gametophyte and sporophyte generations are both stages of the nonvascular plant life cycle. The sporophyte generation is smaller and dependent upon the gametophyte. The gametophyte generation is haploid and produces gametes, whereas the sporophyte generation is diploid and produces spores.

Internet Address Book

interNET CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

2 Teach

Quick Demo

Stand a capillary tube in a petri dish filled with colored water. Have students note the rise of water within the tube. Explain that this movement occurs due to capillary action. Ask students to correlate the movement of water in the glass tube to the movement of water in vascular plants. Use this demonstration to explain the relationship between the evolution of vascular tissue and the increased size of plants, and the efficiency of water and mineral movement throughout the plants.

Assessment

Skill Have students make a concept map that illustrates the major characteristics of Lycophytes, Sphenophytes, and Pterophytes.

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Exploration: *The Six Kingdoms*
Disc 3

Resource Manager
Section Focus Transparency 53 and Master L1 ELL

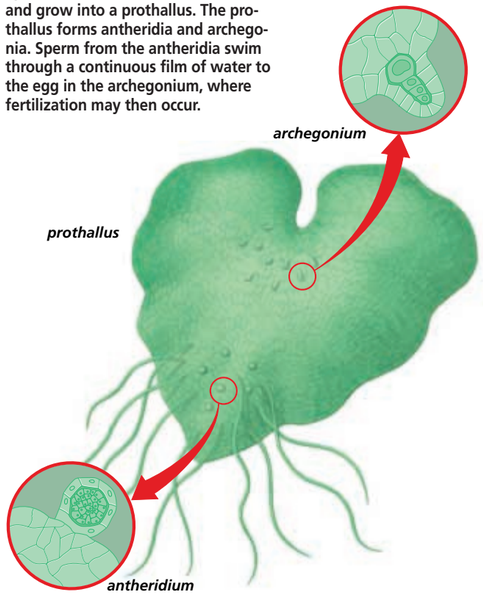


Figure 22.6
Spores are released from a strobilus and grow into a prothallus. The prothallus forms antheridia and archegonia. Sperm from the antheridia swim through a continuous film of water to the egg in the archegonium, where fertilization may then occur.

Figure 22.7
Lycophytes are non-seed vascular plants with roots, stems, and leaves, and spores produced in a strobilus.

does not depend on the gametophyte for water or nutrients.

A major advance in this group of vascular plants was the adaptation of leaves to form structures that protect the developing reproductive cells. In some non-seed vascular plants, spore-bearing leaves form a compact cluster called a **strobilus** (STROH bih lus). The spores are released from the strobilus and then grow to form the gametophyte, called a **prothallus** (proh THAL us). The prothallus is relatively small and lives in or on the soil. The prothallus then forms antheridia and archegonia, ***Figure 22.6.*** Sperm are released from the antheridium and swim through a continuous film of water to the egg in the archegonium. Fertilization occurs and a large, dominant sporophyte plant grows from the fertilized zygote.

Adaptations in Lycophyta

From fossil evidence it is known that tree-sized lycophytes were once members of the early forest community. Modern lycophytes are much smaller than their early ancestors. Lycophytes are commonly called club mosses and spike mosses because their leafy stems resemble moss gametophytes, and their reproductive structures are club shaped, as shown in ***Figure 22.7.*** However, unlike mosses, the sporophyte generation of the lycophytes is dominant. It has roots, stems, and small leaves. The leaves occur as pairs, whorls, or spirals along the stem. A single vein of vascular tissue runs through each leaf. The stems of lycophytes may be upright or creeping and have roots growing from the base of the stem.

The club moss, *Lycopodium*, is commonly called ground pine because it is evergreen and resembles a miniature pine tree. Some species of ground pine have been collected for decorative uses in such numbers that the plants have become endangered.

Adaptations in Sphenophyta

Sphenophytes, or horsetails, represent a second group of ancient vascular plants. Like the lycophytes, early horsetails were tree-sized members of the forest community. There are only about 15 species in existence today, all of the genus *Equisetum*. The name horsetail refers to the bushy appearance of some species. These plants are also called scouring rushes because they contain silica, an abrasive substance, and were once used to scour cooking utensils. If you run your finger along a horsetail stem, you can feel how rough it is.

Today's sphenophytes are much smaller than their ancestors, usually growing to about 1 m tall. Most horsetails, like the one shown in ***Figure 22.8,*** are found in marshes, shallow ponds, stream banks, and other areas with damp soil. Some species are common in the drier soil of fields and roadsides. The stem structure of horsetails is unlike most other vascular plants; it is ribbed and hollow, and appears jointed. At each joint, there is a whorl of tiny, scale-like leaves.

Like lycophytes, sphenophyte spores are produced in a strobilus that is formed at the tip of some stems. After the spores are released, they may grow into a prothallus with antheridia and archgonia.

Figure 22.8
This is the sporophyte generation of a horsetail, *Equisetum.* It has thin, narrow leaves that circle each joint of the slender, hollow stem. Plants with sporangia form a strobilus at the tips of some stems.

WORD ORIGIN
strobilus
From the Greek word *strobos*, meaning "whirling." Spore-bearing leaves form a compact cluster called a strobilus.

Visual Learning

Figure 22.8 Point out that the strobili at the tips of the horsetail stems are formed by leaves with spores. Have students use the appearance of the plant to speculate as to why it was named a horsetail. *The plant looks roughly like the tail of a horse.*

Enrichment

Kinesthetic Purchase a resurrection plant *(Selaginella lepidophylla)*. Have students examine the plant and decide if it is still alive. Soak the plant in water overnight and place it beneath a plant light. Have students observe the plant again and consider if they should revise their original conclusion about whether or not the plant is alive. L1

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
BioQuest: *BioDiversity Park*
Disc 3, 4

Meeting Individual Needs

English Language Learners

Visual-Spatial Pair students with limited English proficiency and students with strong English skills. Have them review together the life cycle of vascular plants. Ask students to draw and label a diagram that illustrates alternation of generations. L1 ELL COOP LEARN

NATIONAL GEOGRAPHIC

VIDEODISC
STV: Plants
What is a Plant?
Unit 1, Side 1, 3 min. 40 sec. *Types of Plants*

Portfolio

Horsetails Cross Section

Visual-Spatial Have students use information they have read about horsetails to prepare what they believe would be cross-section diagrams of the stem of this plant. Have them add appropriate labels to structures where needed. L2 P

Biology Journal

Spike and Club Moss Question

Linguistic Have students write a brief essay to explain why club mosses are not common in desert habitats and why most people never see the gametophyte generation of these plants. Have students explain why these plants are not related to the mosses that were discussed in Section 22.1. L3

Problem-Solving Lab 22-2

Purpose

Students will review the need for water in the process of fertilization among certain plant divisions.

Process Skills

think critically, acquire information, apply concepts, predict

Teaching Strategies

- Students will have to consult their text to determine the answers to the column marked "Sperm must swim to egg?" You may wish to advise them of the page references to be used in researching the answer.
- A "yes" or "no" answer is required for the completion of both columns.
- All correct answers should be "yes."

Thinking Critically

1. yes to all
2. Sperm can swim only in a film of water. Therefore, this column must also be marked with a yes.
3. Water is needed for fertilization. Therefore, these plants must grow in areas with sufficient moisture.
4. wind, insects, birds, mammals

Assessment

Skill Ask students to review the need for a film of water for fertilization of the Bryophytes. With the answer in mind, have them hypothesize the general environment surrounding these plants millions of years ago. Use the Performance Task Assessment List for Formulating a Hypothesis in **PASC,** p. 21. L3

Problem-Solving Lab 22-2 Applying Concepts

Is water needed for fertilization? Non-seed vascular plants have a number of shared characteristics. One of these characteristics is related to certain requirements needed for reproduction.

Analysis

Examine the following data table. Notice that some of the information is incomplete.

Data Table

Division	Example	Sperm must swim to egg?	Water needed for fertilization?
Lycophyta	club moss		
Sphenophyta	horsetail		
Pterophyta	ferns		

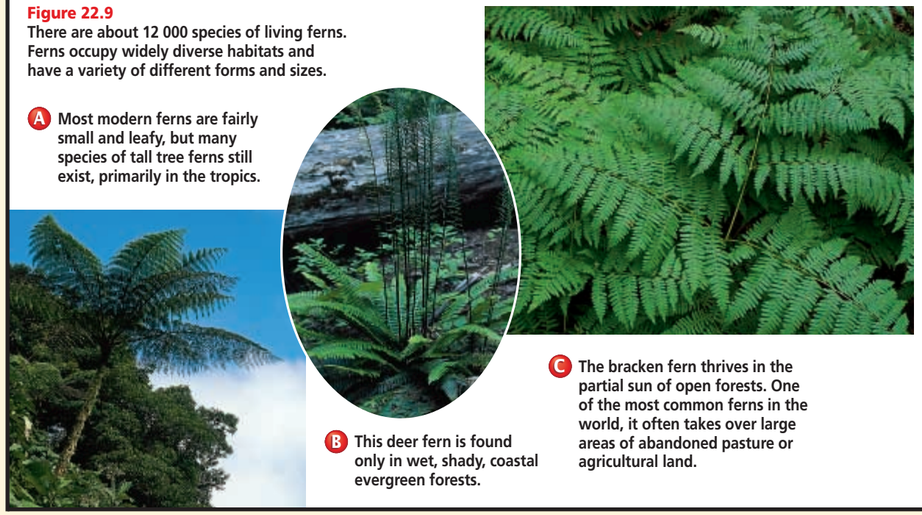
Thinking Critically

1. How would you complete the column marked "Sperm must swim to egg?"
2. Explain how the column marked "Water needed for fertilization" is related to answers in the previous column.
3. Explain why the three plant divisions must all grow in the same type of environment and what this environment is.
4. What other means might be possible for plant sperm delivery to eggs without the use of water?

Adaptations in Pterophyta

Ferns first appeared nearly 400 million years ago according to the fossil record, at about the same time that club mosses and horsetails were the prominent members of Earth's plant population. Ferns, division Pterophyta, grew tall and treelike, forming vast fern forests. You are probably more familiar with ferns than with club mosses and horsetails, primarily because ferns evolved into many more species and are more abundant. Ferns can be found in many types of environments. You may have seen shrub-sized ferns such as those pictured in ***Figure 22.9,*** on the damp forest floor or along stream banks. Some ferns inhabit dry areas, becoming dormant when moisture is scarce and resuming growth and reproduction when water becomes available again. Explore the relationship between water and non-seed vascular plants in the *Problem-Solving Lab* on this page.

Figure 22.9
There are about 12 000 species of living ferns. Ferns occupy widely diverse habitats and have a variety of different forms and sizes.



A Most modern ferns are fairly small and leafy, but many species of tall tree ferns still exist, primarily in the tropics.

B This deer fern is found only in wet, shady, coastal evergreen forests.

C The bracken fern thrives in the partial sun of open forests. One of the most common ferns in the world, it often takes over large areas of abandoned pasture or agricultural land.

Figure 22.10
Most ferns in warm climates are perennial plants that live from year to year, gradually enlarging in size. The fronds of ferns that live in temperate climates die back during the winter.

A The creeping, underground rhizome of a fern is a modified, condensed stem, with roots growing downward from each joint of stem and frond.

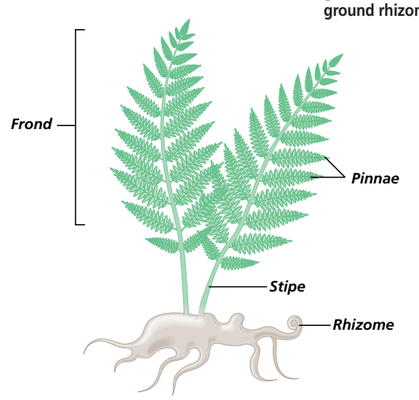
B A fern frond has a stem-like stipe and green, often finely divided leaflets called pinnae.

C Young fern fronds unfurl as they grow and are called fiddleheads because their shape is similar to the neck of a violin.

Fern structures

As with most vascular plants, it is the sporophyte generation of the fern that has roots, stems, and leaves. The part of the fern plant that we most commonly recognize is the sporophyte generation. The gametophyte in most ferns is a thin, flat structure that is independent of the sporophyte. In most ferns, the main stem is underground, ***Figure 22.10.*** This thick, underground stem is called a **rhizome.** It contains many starch-filled cells for storage. The leaves of a fern are called fronds and grow upward from the rhizome, as shown in ***Figure 22.11.*** The fronds are often divided into leaflets called pinnae, which are attached to a central stipe. Ferns are the first of the vascular plants to have evolved leaves with branching veins of vascular tissue. The branched veins in ferns transport water and food to and from all the cells.

Figure 22.11
Fern leaves are called fronds. The fronds of the fern sporophyte grow from an underground rhizome.



Display

Add pictures of non-seed vascular plants to the bulletin board display.

Chalkboard Activity

Logical-Mathematical Ask students to use information about the number of plant species to prepare a bar graph. On the chalkboard, write the following information.
Bryophyta = 10 000
Hepatophyta = 6500
Anthocerophyta = 100
Lycophyta = 1000
Sphenophyta = 15
Pterophyta = 12 000

Tell students that these numbers represent the approximate number of living species for each non-seed plant division studied so far. L2

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Video: *Fern Development*
Disc 3

Resource Manager

Laboratory Manual, pp. 153-156 L2

Meeting Individual Needs

Visually Impaired

Kinesthetic Have visually impaired students examine a fern plant or frond that has raised sori on the back of the frond. Have students feel the sori on the back of the fronds. Ask students what makes up these groups of sori and if any other vascular non-seed plants have these structures. L1 ELL

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Life Cycle of a Fern

PROJECT

Growing Fern Prothallia from Spores

Kinesthetic Have students grow their own fern prothallia by following the procedure given. C-Fern spores and growing media are available from Carolina Biological (catalog #15-6700). Spores will germinate within 5 days and prothallia within 8 to 12 days. Students can design an experiment to determine the effect of environment on spore germination and prothallia development. These cultures can be maintained and used to study fern reproduction in Chapter 24. L3

MiniLab 22-1

Purpose
Students will observe the release of spores from a sporangium.

Process Skills
compare and contrast, hypothesize, observe and infer

Teaching Strategies
- Ferns with sori may be obtained from a biological supply company.
- Glycerin will cause sporangia to enlarge and break open, releasing spores. This event can be observed by students if they exercise a little patience while viewing the sporangia under the microscope. Glycerin will cause both fresh and preserved sporangia to break open.
- Use of a single-edged razor rather than a forceps to lift sori will reduce the amount of rupture to the sporangia. Caution students to use care when working with a razor blade.

Expected Results
Students will see a few spores released from sporangia under water but should see many more in glycerin.

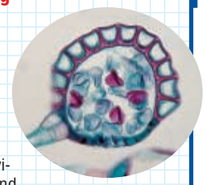
Analysis
1. glycerin
2. Glycerin caused the sporangia to break open.
3. Student answers may vary—drying out of sporangium, absorption of water.
4. Student answers may vary—glycerin causes osmotic imbalance.

Assessment

Knowledge Ask students to describe the events that would follow the release of fern spores. Use the Performance Task Assessment List for Events Chain in **PASC,** p. 91. L2

MiniLab 22-1 Experimenting

Identifying Fern Sporangia When you admire a fern growing in a garden or forest, you are admiring the plant's sporophyte generation. Upon further examination, you should be able to see evidence of spores being formed. Typically, the evidence you are looking for can be found on the underside of the ferns' fronds.



Fern sporangium

Procedure
1. Place a drop of water and a drop of glycerin at opposite ends of a glass slide.
2. Use forceps to gently pick off one sorus from a frond. Place it in the drop of water and add a cover slip.
3. Add a second sorus to the glycerin and add a cover slip.
4. Observe both preparations under low-power magnification and note any similarities and differences. Look for large sporangia (resembling heads on a stalk) and spores (tiny round bodies released from a sporangium).
CAUTION: ***Use caution when working with a microscope, microscope slides, and cover slips.***

Analysis
1. Were spores more visible in water or in glycerin?
2. What did the glycerin do to the sporangium?
3. Formulate a hypothesis that may explain how sporangia naturally burst.
4. Formulate a hypothesis that may explain how sporangia were affected by glycerin.

The fern life cycle is representative of other non-seed vascular plants. Fern spores are produced in structures called sporangia.

Clusters of sporangia form a structure called a **sorus** (plural, sori). The sori are usually found on the undersides of the pinnae, ***Figure 22.12,*** but in some ferns, spores are borne on whole, modified fronds. Practice your lab skills and learn more about fern spores and sporangia in the *MiniLab* on this page.

Origins of Non-Seed Vascular Plants

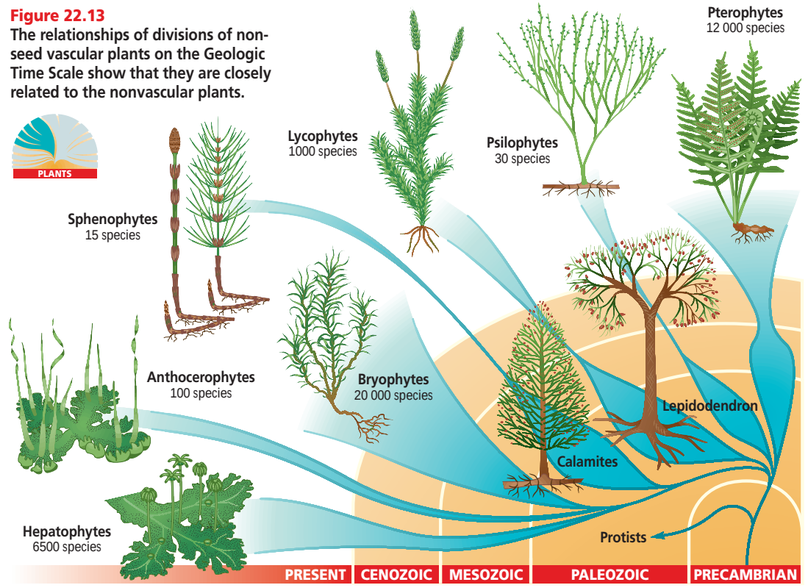
The earliest evidence of non-seed vascular plants is found in fossils from the early Paleozoic period, around 390 million years ago. Large tree-sized lycophytes, sphenophytes, and pterophytes were extremely abundant in the warm, moist forests that dominated Earth during the Carboniferous period. Ancient lycophyte species grew as tall as 30 m. Many of these species of non-seed vascular plants died out about 280 million years ago, when it has been determined that Earth's climate became cooler and drier. Today's non-seed nonvascular plants are much smaller and less widespread in their distribution than their prehistoric ancestors.

Figure 22.12
Sori found on the underside of fern fronds look like brown or rust-colored dust.

A Most sori are found as round clusters on the pinnae. The shape of the clusters and arrangement on the pinnae vary with species.

B Some species of ferns have sori on the edges of the pinnae, such as this *Osmunda* fern.

Figure 22.13
The relationships of divisions of non-seed vascular plants on the Geologic Time Scale show that they are closely related to the nonvascular plants.



The evolution of vascular tissue enabled these plants to live on land and to maintain larger body sizes in comparison with nonvascular plants. As you can tell from ***Figure 22.13,*** non-seed vascular plants are closely related to nonvascular plants.

Section Assessment

Understanding Main Ideas
1. Why do most non-seed vascular plants live in moist habitats?
2. Compare and contrast the structure of lycophyte and pterophyte sporophytes.
3. What are the major differences between non-seed vascular plants that exist today and those that lived in the Carboniferous forests?
4. How does the sporophyte of a vascular plant differ from the sporophyte of a nonvascular plant?

Thinking Critically
5. Why do you think there are fewer non-seed vascular plants on Earth today than there were 300 million years ago?

Skill Review
6. **Observing and Inferring** How do you think the presence of silica in the stems of sphenophytes might protect these plants from being eaten by animals? For more help, refer to *Thinking Critically* in the **Skill Handbook.**

3 Assess

Check for Understanding
Have students explain how the terms in each of the following groups are related. L2 ELL
- **a.** strobilus—sphenophytes
- **b.** prothallus—gametophyte—fern
- **c.** sporophyte—dominant—lycophytes

Reteach
Have students list three characteristics for each division: Lycophyta, Sphenophyta, and Pterophyta. L1

Extension
Visual-Spatial Have students make a concept map to explain the changes in size in the sporophyte and gametophyte generations of Bryophyta, Lycophyta, and Pterophyta. L3

Assessment

Knowledge Provide students with unlabeled photos or drawings of gametophytes and sporophytes from each of the non-seed vascular divisions. Have students identify each picture. L2

4 Close

Discussion
Naturalist Ask students to compare the gametophyte generations of mosses and ferns. *Moss is large and green; fern is small and green.* Have them do the same for the sporophyte generation. *Moss is small and nongreen; fern is large and green.* L1

Resource Manager
BioLab and MiniLab Worksheets, p. 101 L2
Reinforcement and Study Guide, pp. 98-99 L2
Content Mastery, p. 110 L1

Section Assessment

1. Sperm cells must be able to swim through a continuous film of water to fertilize egg cells within the archegonia.
2. Lycophytes are small, grow close to the ground, and have stems covered by small, narrow leaves. Roots, stems, and leaves are present. Pterophytes also have roots, stems, and leaves. The stem is underground. Leaves called fronds are usually finely divided into pinnae. Spores are found within sori on the undersides of the fronds.
3. Ancient species were much larger in size and more abundant.
4. The sporophyte of a vascular plant is larger and is not dependent on the gametophyte generation.
5. Earth's climate has changed, reducing the number of damp areas in which non-seed vascular plants could survive.
6. The silica in the stems would be hard for predators to digest. It might also cut the delicate tissues of their digestive tracts.

Section 22.3

Prepare

Key Concepts

The major characteristics of seed plants are examined. The five divisions described are Cycadophyta, Ginkgophyta, Gnetophyta, Coniferophyta, and Anthophyta.

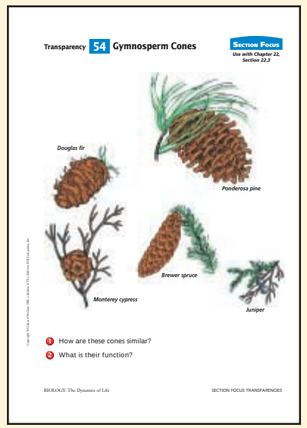
Planning

- Collect seeds for the MiniLab.
- Collect pictures of seed plants for the Display.
- Collect examples of monocot and dicot leaves for the Visual Learning.
- Collect gardening books and seed/flower catalogs for the Tech Prep Activity.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 54** on the overhead projector and have students answer the accompanying questions. L1 ELL



SECTION PREVIEW

Objectives

Identify the characteristics of seed plants.

Analyze the advantages of seed and fruit production.

Vocabulary

pollen grain
ovule
embryo
cotyledon
fruit
deciduous plant
monocotyledons
dicotyledons
annuals
biennials
perennials

Section

22.3 Seed Plants

About 280 million years ago, when club mosses, ferns, and other non-seed plants had reached their greatest numbers and diversity, it has been shown in rocks that Earth's climate changed. Freezing weather and drought may have caused many non-seed plants to become extinct, but a few of the seed plants were adapted to these extreme conditions and they were able to survive. These ancient survivors are the ancestors of today's vascular seed plants.

Anthophyte fruits and seeds and coniferophyte cones and seeds (inset)

What Is a Seed Plant?

Some vascular plants produce seeds, which are reduced sporophyte plants enclosed within a protective coat. The seeds may be surrounded by a fruit or carried naked on the scales of a cone.

Seed plants produce spores

In seed plants, as in all other plants, spores are produced by the sporophyte generation. These spores develop into the male and female gametophytes. The male gametophyte develops inside a structure called a **pollen grain** that includes sperm cells, nutrients, and a protective outer covering. The female gametophyte, which produces the egg cell, is contained within a sporophyte structure called an **ovule.**

Fertilization and reproduction

The union of the sperm and egg forms the sporophyte. In most seed plants, this process, called fertilization, does not require a continuous layer of water for fertilization, as do nonvascular and non-seed vascular plants. Remember that in non-seed plants, the sperm must swim through a continuous film of water in order to reach the egg in the archegonia of a gametophyte. Because they do not require a continuous film of water for fertilization, seed plants are able to grow and reproduce in a wide variety of habitats that have limited water availability.

After fertilization, the zygote develops into an embryo. An **embryo** is an organism at an early stage of development. In plants, an embryo is the young diploid sporophyte of the plant. Embryos of seed plants include one or more cotyledons. **Cotyledons** are tiny seed leaves that store or absorb food for the developing embryo. In conifers and many flowering plants, cotyledons are the plant's first leaves when it emerges from the soil.

Advantages of seeds

A seed consists of an embryo and its food supply enclosed in a tough, protective coat, ***Figure 22.14.*** Seed plants have several important advantages over non-seed plants. The seed contains a supply of food to nourish the young plant during the early stages of growth. This food is used by the plant until its leaves are developed enough to carry out photosynthesis. In conifers and some flowering plants, the food supply is stored in the cotyledons. The embryo is protected during harsh conditions by a tough seed coat. The seeds of many species are also adapted for easy dispersal to new areas, so the young plant does not have to compete with its parent for sunlight, water, soil nutrients, and living space. You can learn more about seed structure in the *MiniLab* shown here.

MiniLab 22-2 Comparing and Contrasting

Comparing Seed Types Anthophytes are classified into two classes, the monocotyledons (monocots) and dicotyledons (dicots) based on the number of seed leaves.

Procedure

1. Copy the data table shown below.
2. Examine the variety of seeds given to you. Use forceps to gently remove the seed coat or covering from each seed if one is present.
3. Determine the number of cotyledons present. If two cotyledons are present, the seed will easily separate into two equal halves. If one cotyledon is present, it will not separate into halves. Record your observations in the Data Table.
4. Add a drop of iodine stain to rice and a lima bean seed. Note the color change. **CAUTION:** ***Wash your hands with soap and water after handling chemicals.*** Record your observations in the Data Table.

Data Table

Seed name	Number of cotyledons	Monocot or dicot	Color with iodine
Lima bean			
Rice			
Pea			——
Rye			——

Analysis

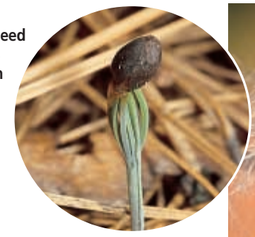
1. Starch turns purple when iodine is added to it. Describe the color change when iodine was added to rice and lima bean seeds.
2. Hypothesize why seeds contain stored starch.

Figure 22.14
Seeds exhibit a variety of structural adaptations.

A The pine embryo includes seven to nine cotyledons, which serve as an initial food supply when growth begins.

B The tough protective seed coat breaks down when growth begins.

C The feathery tuft attached to milkweed seeds aids in their dispersal.



Internet Address Book

internNET CONNECTION

Note Internet addresses that you find useful in the space below for quick reference.

Cultural Diversity

Importance of Non-flowering Seed Plants

Linguistic Many species of non-flowering seed plants play significant roles as timber trees, food plants, and sources of essential oils and soaps in the economies of countries. Initiate a discussion about the cultural importance of the ginkgo tree in China and Japan. *Ginkgo biloba* is the only living representative of the Ginkgophyta division and no longer exists in the wild. It has been cultivated for thousands of years for use as an ornamental plant in Chinese and Japanese temple gardens. Have students choose different types of non-flowering seed plants and present reports on their economic value or cultural significance in different countries. L3

2 Teach

MiniLab 22-2

Purpose
Students will determine how to tell if a seed is from a monocot or dicot plant and test for the presence of starch in seeds.

Process Skills
acquire information, apply concepts, classify, compare and contrast, predict

Teaching Strategies

- Presoak all seeds overnight so that seed coats come off easily.
- Supply single-edged razor blades to remove seed coats.
- Seeds are available from grocery stores, hardware stores (rye), or pet shops (bird feed).
- Use a dilute iodine solution when testing for starch (3 g potassium iodide and 1 g iodine to 300 mL of water). Place in dropper bottles for ease in student dispensing. Caution students that iodine is toxic and an eye irritant. If it is spilled on skin or clothing it should be washed immediately.

Expected Results
The lima bean, pea, and sunflower are dicots. All others are monocots. Rice and lima beans will turn blue.

Analysis

1. The seeds turn purple.
2. Starch supplies a growing embryo with food.

Assessment

Portfolio Have students diagram the lima bean seeds they dissected and color in the area that stained purple. Ask students to write a paragraph about the advantages of seed production beneath their diagram and place their work in their portfolios. Use the Performance Task Assessment List for Scientific Drawing in **PASC,** p. 55. L2 P

Quick Demo

Visual-Spatial Provide students with a variety of cones. Ask them to describe what might be found within or upon each wooden scale. *Some students may say seeds.* Have them gently pry the scales open to reveal the seeds within. L1 ELL

Assessment

Knowledge Have students construct a table that includes the five divisions of seed plants and their major characteristics. L2

NATIONAL GEOGRAPHIC

VIDEODISC
STV: Plants
What Is a Seed?
Unit 4, Side 3, 13 min. 45 sec.
What Is a Seed?

Resource Manager

Section Focus Transparency 54 and Master L1 ELL
BioLab and MiniLab Worksheets, p. 102 L2
Critical Thinking/Problem Solving, p. 22 L3

a

b

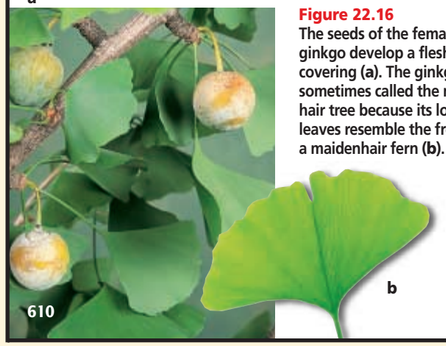
Figure 22.15
Cycads have a terminal rosette of leaves. The male plant has cones that produce pollen grains that are released in great masses into the air (a). The female plant produces cones that contain ovules with eggs (b).

Diversity of seed plants

Some plants produce seeds on the scales of woody strobili called cones. This group of plants is sometimes referred to as gymnosperms. The term gymnosperm means "naked seed" and is used with these plants because they are not protected by a fruit. The gymnosperm plant divisions you will learn about are Cycadophyta, Ginkgophyta, Gnetophyta, and Coniferophyta.

Flowering plants, also called angiosperms, produce seeds enclosed within a fruit. A **fruit** is the ripened ovary of a flower. The fruit provides protection and aids in seed dispersal. The Anthophyta division contains all species of flowering plants.

a



b

Figure 22.16
The seeds of the female ginkgo develop a fleshy outer covering (a). The ginkgo is sometimes called the maidenhair tree because its lobed leaves resemble the fronds of a maidenhair fern (b).

Adaptations in Cycadophyta

About 100 species of cycads exist today, exclusively in the tropics and subtropics. The only present-day species that grows wild in the United States is found in Florida, although you may see cycads cultivated in greenhouses or botanical gardens, as shown in ***Figure 22.15***.

All cycads have separate male and female plants. The cones of male plants produce pollen. The cones of female plants produce seeds. Cycads are one of the few seed plants that produce motile sperm. The trunks and leaves of many species resemble palm trees, but cycads are not closely related to palms, which are anthophytes.

Adaptations in Ginkgophyta

Like cycads, ginkgos produce male and female reproductive structures on separate plants. The male ginkgo produces pollen in strobiluslike cones that grow from the bases of leaf clusters. The female ginkgo produces the seeds, which develop a fleshy, apricot-colored seed coat that covers the seeds as they ripen, ***Figure 22.16***. Ginkgos are often planted in urban areas because they are able to tolerate smog and pollution. Gardeners and landscapers usually prefer the male trees because the fleshy seed coat on seeds produced by the female trees has an unpleasant smell.

Today, the division is represented by only one living species, *Ginkgo biloba*. The ginkgo tree is considered sacred in China and Japan, and has been cultivated in temple gardens for thousands of years. These Asian temple gardens probably prevented the tree from becoming extinct.

Adaptations in Gnetophyta

Most living gnetophytes can be found in the deserts or mountains of Asia, Africa, North America, and Central or South America. The division Gnetophyta contains only three genera, which are all different in structure and adaptations. The genus *Gnetum* is composed of tropical climbing plants. The genus *Ephedra* contains shrublike plants and is the only gnetophyte genus found in the United States. The third genus, *Welwitschia*, is a bizarre-looking plant found only in South Africa. It grows close to the ground, has a large tuberous root, and may live 100 years. *Ephedra* and *Welwitschia* are pictured in ***Figure 22.17***.

Adaptations in Coniferophyta

The sugar pine is one of many familiar-looking forest trees that belong to the division Coniferophyta. The conifers are trees and shrubs with needle- or scalelike leaves. They are abundant in forests throughout the world, and include pine, fir, spruce, juniper, cedar, redwood, yew, and larch. A few representative conifers are shown in ***Figure 22.18***. Think of ways that you could distinguish among the different species of conifers in the *BioLab* at the end of this chapter.

A

Members of the genus *Ephedra* are a source of ephedrine, a medicine used to treat asthma, emphysema, and hay fever.

B

***Welwitschia* may live 100 years. The plant has only two leaves, which continue to lengthen as the plant grows older.**

Figure 22.17
Most gnetophytes have separate male and female plants.

Figure 22.18
Conifers are named for the woody cones in which the seeds of most species develop.

A **The Douglas fir is one of the most important lumber trees in North America. It grows straight and tall, to a height of 100 m.**

B **Spruce trees are popular ornamental trees because of their graceful shape and color variations.**

Biology Journal

Is It a Cycad?

Logical-Mathematical Have students imagine that they are traveling through Florida with a friend. Their friend identifies a plant as a cycad that is forming seeds. They search the surrounding area for more cycads but find none within a 20-kilometer radius. Have students write in their journals as many reasons as possible to explain why they believe their friend incorrectly identified the plant as a cycad. *Cycads are either male or female; therefore, the male plant must be close to the female to provide pollen. Palms can self-fertilize—being both male and female—and can grow alone and reproduce. Thus it is likely that this plant was a palm.* L2

Meeting Individual Needs

Gifted

Linguistic Have students use references to determine and record the scientific names for all conifers listed in this section. Have them describe the traits that are represented in the scientific names. L3

Concept Development

Ask students to compare and contrast Gnetophyta with Ginkgophyta. As a means for doing this, have students prepare a chart with the headings "Gnetophyta and Ginkgophyta Similarities" and "Gnetophyta and Ginkgophyta Differences." Have students include comparisons of reproductive structures as well as general traits. Ask them also to include where each plant is found in the world, the number of species alive today, the number of genera present today, and economic uses of these plants. L2

Enrichment

Intrapersonal The drug ephedrine has been used by the Chinese for more than five thousand years. It is called *ma huang*, which means "astringent and yellow." The words refer to the drug's taste and color. Ephedrine decreases smooth and cardiac muscle action, raises blood pressure, dilates the pupils, and reduces congestion. Have interested students research this drug and write a report on its uses and its source. L3

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Exploration: *Classifying Pines*
Disc 3
Video: *Giant Redwoods*
Disc 3

Display

Add pictures of seed plants to the bulletin board.

Chalkboard Activity

Visual-Spatial Have students construct a time line that marks the era when different types of land plants evolved. Ask students to describe what the climate was like during each time period. L2

DESIGN YOUR OWN BioLab

The BioLab at the end of the chapter can be used at this point in the lesson.

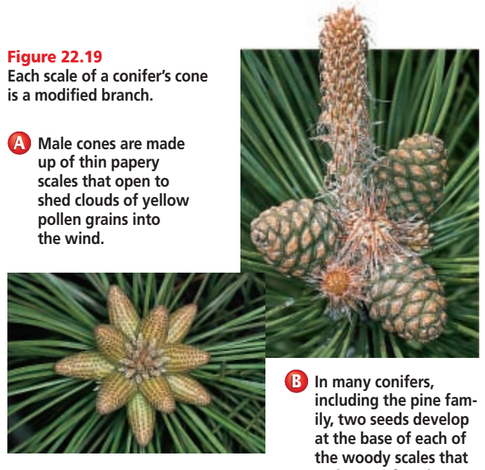


Figure 22.19
Each scale of a conifer's cone is a modified branch.

A Male cones are made up of thin papery scales that open to shed clouds of yellow pollen grains into the wind.

B In many conifers, including the pine family, two seeds develop at the base of each of the woody scales that make up a female cone.

The reproductive structures of most conifers are produced in cones. Most conifers have male and female cones on different branches of the same tree. The male cones produce pollen. They are small and easy to overlook. Female cones are much larger. They stay on the tree until the seeds have matured. Examples of both types of cones are shown in *Figure 22.19*.

Figure 22.20
Some trees, including these bald cypress trees, lose their leaves in the fall as an adaptation for reducing water loss.

WORD Origin

deciduous
From the Latin word *deciduus*, meaning to "fall off." Deciduous trees drop all of their leaves at the same time.

Conifers are evergreens

Most conifers are evergreen plants, that is, they retain their leaves all year. Although individual leaves drop off as they age or are damaged, the tree never loses all its leaves at once. Pine needles, for example, may remain on the tree for anywhere from two to 40 years, depending on the species.

Trees that retain their leaves begin photosynthesis in the early spring as soon as the temperature warms. Evergreen leaves usually have a heavy coating of cutin, an insoluble waxy material. Evergreens are often found where the warm growing season is short, so keeping leaves year-round gives them a head start on growth. Because they do not need to produce a whole new set of leaves each year, they are able to grow where nutrients are scarce. How do the needlelike leaves of pines prevent water loss? To find out read the *Inside Story*.

Deciduous trees lose their leaves

A few conifers, including larches and bald cypress trees, are deciduous, *Figure 22.20*. **Deciduous plants** lose all their leaves at the same time. Dropping all leaves is an adaptation for reducing water loss when water is unavailable as it can be the case in the tundra, in deserts, or during wintertime. Plants lose most of their water through the leaves; very little is lost through bark or roots. However, a tree with no leaves cannot photosynthesize and must remain dormant during this time.

INSIDE STORY

Pine Needles

When you look at a snow-covered pine forest, you may be surprised to learn that winter can be considered a dry time for plants. The cold temperature means that the soil moisture is unavailable because it is frozen. The needles of pines have several adaptations that enable the plants to conserve water during the cold dry winter and the dry heat of the summer.

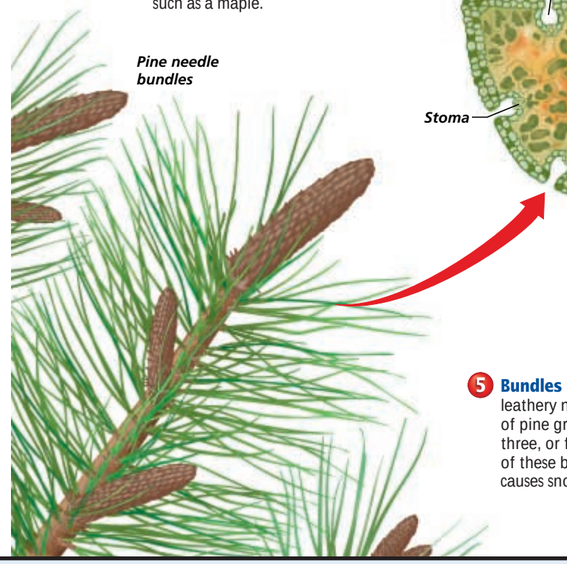
Snow-covered pines

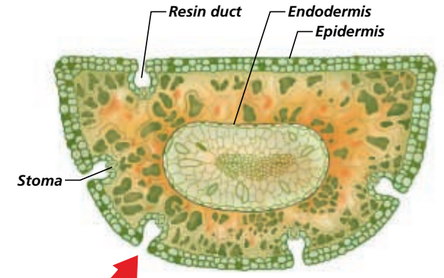
Critical Thinking ***How do the shape and structure of pine needles enable conifers to survive hot and dry summers as well as cold and snowy winters?***

1 Shape reduces water loss Pine needles are usually semicircular or round. This shape reduces the surface area. Less water is lost to evaporation because of the smaller surface area from which it can evaporate compared with the large surface area of broad-leaf tree leaves, such as a maple.

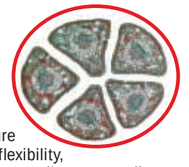
2 Modified epidermis The epidermis has two modifications that are important in reducing water loss. The walls of the epidermal cells are very thick and the epidermis is covered with a waterproof waxy cuticle.

3 Resin ducts Resin is secreted from resin ducts in the leaves and bark. It protects the tree from insects.





4 Recessed stomata The stomata are recessed into the epidermal layer, the outermost layer of plant tissue. This position helps retain water in the leaf tissues.



5 Bundles of needles The thick, leathery needles of many species of pine grow in bundles of two, three, or five. The cylindrical nature of these bundles, as well as their flexibility, causes snow and ice to slide off the needles more easily.

INSIDE STORY

Purpose

Students examine the adaptations that enable conifers to survive in harsh environments.

Teaching Strategies

■ Have students describe common everyday structures or objects that are analogous to structures found in pine needles. *Students may correlate cuticle to wax paper, or stomata to skin pores.* L2

Visual Learning

Have students examine a prepared slide of the cross section of a pine needle. L1 ELL

Critical Thinking

Pine needles have several structural adaptations that reduce evaporation. These features help conifers survive times when water is scarce.

Alternative Lab

The Conifer Leaf

Purpose

Students will observe, diagram, and label the structures of a typical conifer leaf.

Materials

microscope, prepared slide of conifer leaf cross section.

Procedure

Give students the following directions.

1. Observe the slide under low power.
2. Diagram what you see. Label the following structures using these descriptions as a guide: (a) cuticle—noncellular layer, thin covering over leaf; (b) epidermis—below cuticle, one cell in thickness; (c) mesophyll (spongy layer)—large cells, thick layer just below epidermis; (d) endodermis—one-cell-layer thick, surrounds large oval central area; (e) palisade layer—many cells in thickness, surrounded by endodermis; (f) vascular tissue—very center of leaf, two types are present.
3. Look again at the leaf using the microscope. Check for evidence of stomata on the epidermis and the presence of several ringlike parts, called resin ducts, in the mesophyll. Add these parts and labels to your diagram.

Analysis

1. How does the cross-section view of a conifer leaf differ from what you would see in a deciduous tree leaf? *round rather than flat and long*
2. What may be the role of the normally green mesophyll and palisade layers? *responsible for food production*
3. What is the function of the cuticle and vascular tissue? *retain water, transport materials*

Assessment

Skill Diagram or describe how a cross-section slice of a conifer leaf would be made. Use the Performance Task Assessment List for Model in **PASC,** p. 51. L2

TechPrep

Designing a Garden

Have students in groups design the layout of a flower garden for the schoolyard or a local park. They should start by measuring the space and making a scale diagram. Using gardening books and flower/seed catalogs (using the library or the Internet), they can choose appropriate plants for their garden. The garden should include annuals and perennials as well as a few flowering shrubs or trees. Students can select plants for specific locations based on size and flower color.

L2 ELL COOP LEARN

Resource Manager

Concept Mapping, p. 22
L3 ELL

Laboratory Manual, pp. 157-160 L2

Figure 22.21
A florist's display is a good place to see an assortment of flowering plants. How many can you recognize?

Adaptations in Anthophyta

Flowering plants are classified in the division Anthophyta and are the most well-known plants on Earth with more than 240 000 identified species. See if you are familiar with some of the plants in ***Figure 22.21.*** Like other seed plants, anthophytes have roots, stems, and leaves. But unlike the other seed plants, anthophytes produce flowers and form seeds enclosed in a fruit. Many different species of flowering plants inhabit tropical forests. As you will discover in *Biology & Society* at the end of this chapter, different groups of people have different viewpoints on preserving this rich habitat.

Fruit production

Anthophytes are unique in that they are the only division of plants that produce fruits, the ripened ovary of a flower. A fruit may contain one or more seeds. One of the advantages of fruit-enclosed seeds is the added protection the fruit provides for the young embryo. Fruits often aid in the dispersal of seeds. Animals may eat them or carry them off to store for food. Seeds of some species that are eaten may pass through the animal's digestive tract unharmed and are distributed as the animal wanders. In fact, some seeds must pass through a digestive tract before they can begin to grow a new plant. Some fruits have structural adaptations that help disperse the seed by wind or water. Some examples of fruits are illustrated in ***Figure 22.22.***

Monocots and dicots

The division Anthophyta is divided into two classes: monocotyledons and dicotyledons. The two classes are named for the number of seed leaves, or cotyledons, contained within the seed. **Monocotyledons** have one seed leaf; **dicotyledons** have two seed leaves. The names of these two classes are often abbreviated to monocots and dicots. Monocots are the smaller group, with about 60 000 identified species that include families such as grasses, orchids, lilies, and palms, ***Figure 22.23.*** Dicots make up the majority of flowering plants with about 170 000 identified species. They include nearly all the familiar shrubs, trees (except conifers), wildflowers, garden flowers, and herbs. Familiar dicots are shown in ***Figure 22.24.***

Life spans of anthophytes

Why do some plants live longer than people, and others live only a few weeks? The life span of a plant reflects its strategies for surviving periods of cold, drought, or other harsh conditions.

Annual plants live for only a year or less. They sprout from seeds, grow, reproduce, and die in a single growing season. Most annuals are herbaceous, which means their stems are green and do not contain woody tissue. Many food plants such as corn, wheat, peas, beans, and squash are annuals, as are many weeds of the temperate garden. Annuals form drought-resistant seeds that survive the winter.

Figure 22.22
Fruits exhibit a wide variety of structural adaptations that aid in seed protection and dispersal.

A The maple seed has a winglike structure that helps keep it airborne.

B The fruit of a magnolia contains many seeds surrounded with a bright red covering that attracts birds and small animals.

C The tough fibrous fruit of a coconut provides protection as well as a flotation device.

Figure 22.23
Monocots usually have leaves with parallel veins and flower parts in multiples of three.

A The grass family includes important cereal grains, such as rice and wheat, as well as sugarcane (left) and bamboo.

B The lily family includes asparagus and onions as well as the ornamental lilies (left) grown by many home gardeners.

Figure 22.24
Dicots usually have leaves with branched veins and flower parts in multiples of four or five.

A The mustard family includes many important food plants, such as cabbage, mustard, broccoli (shown here in flower), radish, turnip, collards, and kale.

B The rose family includes blackberries (below), raspberries, apples, plums, peaches, pears, and hundreds of cultivars of garden roses.

C The daisy family includes sunflowers (above), lettuce, dandelions, chrysanthemums, and goldenrod.

Portfolio

Seed Dispersal Methods

Visual-Spatial Students should collect and identify pictures of seeds from many different types of seed plants. The students should label each picture with how they think the seeds are dispersed. L1 ELL P

Visual Learning

Show students examples of common monocot and dicot leaves. Ask students how the vein patterns in dicot leaves differ from those of monocots.

Assessment

Knowledge Have students discuss the adaptive value of annual, biennial and perennial life spans. L2

Glencoe Technology

CD-ROM
Biology: The Dynamics of Life
Exploration: *Angiosperm*
Disc 3
Video: *Blooming Flowers*
Disc 3

Careers in Biology

Career Path

Courses in high school: mathematics, electronics, shop courses involving machinery
College: courses in forestry or logging; two-year degree to become a forest technician
Other education sources: on-the-job training

Career Issue

Some groups are trying to stop logging, especially in old-growth forests. Discuss whether students think most lumberjacks and other logging industry workers are concerned about the future of the forests.

For More Information

For more information about working in the logging industry, students can write to:

Society of American Foresters
5400 Grosvenor Lane
Bethesda, MD 20814

3 Assess

Check for Understanding

Have students explain the differences between: fruits and cones; deciduous and evergreen; monocot and dicot; annual and perennial; and gymnosperm and angiosperm. L2

Careers in Biology

Lumberjack

If you like to spend time in the forest, consider a career as a lumberjack or a logging industry worker. Besides being outdoors, you will get lots of exercise.

Skills for the Job

The logging industry now includes many different workers. Cruisers choose which trees to cut. Fallers use chainsaws and axes to cut or "fell" the chosen trees. Buckers saw off the limbs and cut the trunk into pieces. Logging supervisors oversee these tasks. Other workers turn the tree into logs or wood chips that are used to make paper. After finishing high school, most loggers learn on the job. However, with a two-year degree, you can become a forest technician. A four-year degree qualifies you as a professional forester who manages the forest resources. Most logging jobs are in the Northwest, Northeast, South, and Great Lakes regions.

internet CONNECTION For more careers in related fields, be sure to check the Glencoe Science Web Site.
www.glencoe.com/sec/science.

Biennials have a life span that lasts two years. Many biennials are plants that develop large storage roots, such as carrots, beets, and turnips. During the first year, biennials grow many leaves and develop a strong root system. Over the winter, the aboveground portion of the plant dies back, but the roots remain alive. Underground roots are able to survive conditions that leaves and stems cannot endure. During the second spring, food stored in the root is used to produce new shoots that produce flowers and seeds.

Perennials live for several years, producing flowers and seeds periodically—usually once each year. They survive harsh conditions by dropping their leaves or dying back to soil level, while their woody stems or underground storage organs remain intact and dormant. Examples of plants with different lifespans are shown in ***Figure 22.25.***

Figure 22.25
Anthophytes may be annuals, biennials, or perennials.

A Vegetable gardeners grow biennial Swiss chard for its leaves.

B Woody perennials, like this maple, drop their leaves and become dormant during the winter.

C These blue lupines and orange poppies are annual plants.

D Herbaceous perennials often have underground storage organs used for overwintering.

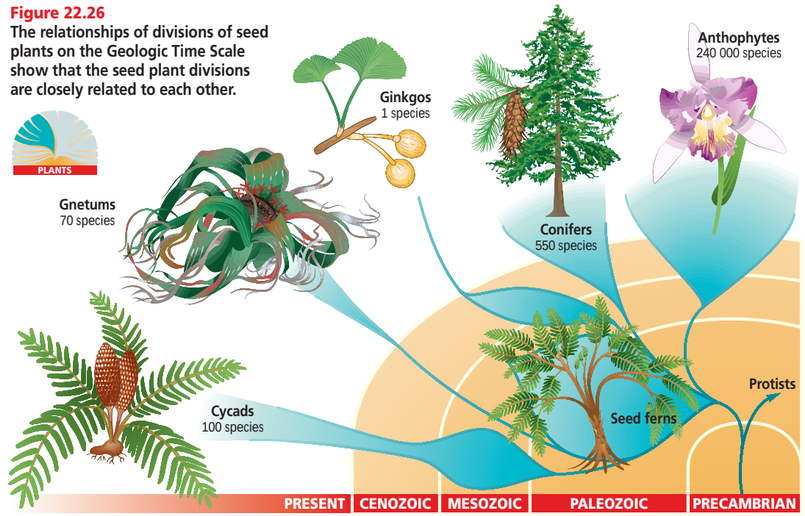
TechPrep

Tree Farms

Tree farms allow foresters to meet increased demands for wood and wood products and reduce the demand for trees from natural forests. Some people oppose this monoculture technique. Monoculture refers to the practice of growing only one species of tree.

Monocultures are susceptible to insect pests and diseases. Have interested students research the types of trees harvested by foresters in their region of the United States. Ask students to find out if any of these trees are grown in monoculture stands. Have students give an oral report based on their findings.

Figure 22.26
The relationships of divisions of seed plants on the Geologic Time Scale show that the seed plant divisions are closely related to each other.



Origins of Seed Plants

Seed plants first appear as fossils 360 million years ago. Some seed plants, such as cycads and ginkgos, shared Earth's forests with the dinosaurs during the Triassic and Cretaceous periods. However, like the dinosaurs, most members of the Ginkgophyta died out about 66 million years ago.

According to fossil evidence, the first conifers emerged around 280 million years ago. During the Jurassic period, conifers became prominent forest inhabitants and remain so today.

Anthophytes first appear in the early Cretaceous period.

Seed plants are closely related to each other and to other groups of non-seed vascular plants as shown in ***Figure 22.26.***

Section Assessment

Understanding Main Ideas

1. Name two ways that seeds help plants reproduce on land.
2. How are needlelike leaves an adaptation to life in climates where water may be limited?
3. Why are flowering plants so successful?
4. What are the major characteristics of anthophytes that distinguish them from coniferophytes?

Thinking Critically

5. How do you think the development of the seed might have affected the lives of herbivorous animals living in Earth's ancient forests?

Skill Review

6. **Compare and Contrast** Compare the formation of a spore in ferns and a seed in conifers. For more help, refer to *Thinking Critically* in the **Skill Handbook.**

Section Assessment

1. Seeds contain a food supply for the developing embryo and protect the embryo from harsh conditions.
2. The thick cuticle, reduced surface area, and sunken stomata limit evaporation.
3. Flowering plants produce fruits that protect the seeds and aid in seed dispersal.
4. Anthophytes produce flowers and fruits. Coniferophytes do not.
5. By eating seeds, herbivores were able to take advantage of the food supply intended for the young plant embryo.
6. Fern spores are produced in sporangia. Clusters of sporangia form sori that are found on the pinnae. Conifer seeds are produced on the scales of the cone.

Reteach

Have students name plants that are examples of each of the terms listed in Check for Understanding. L1

Extension

Visual-Spatial Have students prepare an illustrated report that depicts uses for five types of non-flowering seed plants. Have students identify each plant with its common and scientific name. L3

Assessment

Skill Have students prepare questions about the characteristics of seed plants. Ask students to read their questions aloud and have the class provide the answers. L2

4 Close

Discussion

Have students describe the adaptations for survival that are exhibited by seed plants in a land environment. L2

Resource Manager

Basic Concepts Transparency 34 and Master L2 ELL
Basic Concepts Transparency 35 and Master L2 ELL
Reinforcement and Study Guide, p. 100 L2
Content Mastery pp. 109, 111-112 L1

DESIGN YOUR OWN BioLab

Time Allotment
One class period

Process Skills
observe and infer, classify, compare and contrast, organize data

Safety Precautions
Some of the needle and cone specimens are very sharp. Warn students of the possibility of sticking themselves with the pointed ends.

Preparation

Alternative Materials
- Specimens should contain both leaves and cones. If unavailable, substitute scale diagrams of a variety of conifer leaf and cone specimens.

Possible Hypotheses
- The number of leaves per bundle, length of leaves, shape of leaves, color of leaves, and appearance of the sheath at the base of the leaves are useful in classifying conifers.
- Cone shape, length, and diameter may be used to classify conifers.

Resource Manager

BioLab and MiniLab Worksheets, pp. 103-104 L2

DESIGN YOUR OWN BioLab

How can you make a key for identifying conifers?

Most conifers have cones and needle- or scalelike leaves. Different species have cones of different sizes, shapes, and thickness. The leaves of different species also have different characteristics. How would you go about identifying a conifer you are unfamiliar with? You would probably use a biological identification key. Biological keys list features of related organisms in a way that allows you to determine each organism's scientific name. Below is an example of the selections that could be found in a key that might be used to identify trees.

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

Pine needles

Hemlock

Preparation

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

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

Arborvitae

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.
- **Communicate** to others the distinguishing features of different conifers.

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

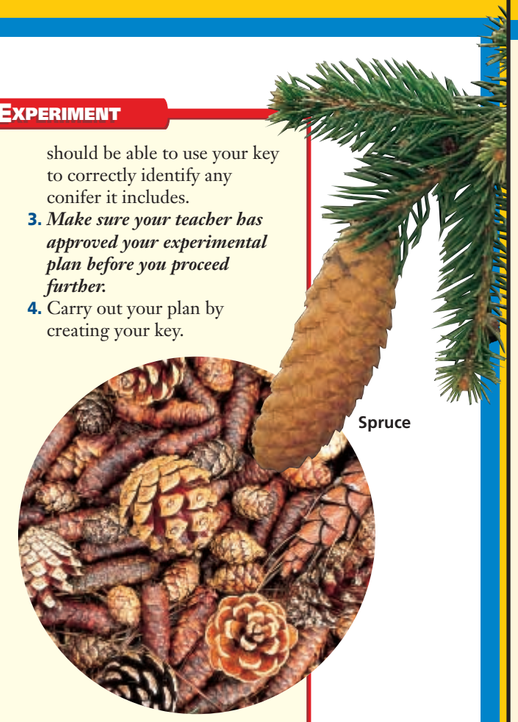
Safety Precautions
Always wash your hands after handling biological materials. Always wear goggles in the lab.

Skill Handbook
Use the **Skill Handbook** if you need additional help with this lab.

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 fork in a key are often pairs of contrasting characteristics. For example, the first fork 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.



Spruce

Analyze and Conclude

1. **Checking Your Hypothesis** Have someone outside your lab group try using your key to identify your conifer specimens. If they are unable to make it work, try to determine where the problem is and make improvements.
2. **Making Inferences** Is there only one correct way to design a key for your specimens? Explain why or why not.
3. **Relating Concepts** Give one or more examples of situations in which a key would be a useful tool.

Going Further

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

interNET CONNECTION To find out more about conifers, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

DESIGN YOUR OWN BioLab

Analyze and Conclude

1. By using student key design on the overhead, the entire class can determine whether or not the key works.
2. Student key designs placed on the overhead will illustrate the diversity of student trait choices used to organize and design each key.
3. It can distinguish poisonous from nonpoisonous plants, and harmful from nonharmful insects.

Error Analysis
Make sure students understand that their keys must distinguish among several similar conifers, each of which must be uniquely identified. Each fork in their key must be specific and identifiable.

Assessment

Performance Provide students with a bag of common laboratory items such as: glass slide, coverslip, paper clip, thumbtack, rubber band, staple, and dissecting needle. Ask them to prepare a key that identifies each item. Use the Performance Task Assessment List for Making and Using a Classification System in **PASC,** p. 49. L1

Going Further
Ask students to explain why a key design based on leaf odor or habitat may not be workable or practical.

Plan the Experiment

Teaching Strategies
- Label the samples with either their scientific names or generic labels such as Conifer A, Conifer B, etc. This will allow students to establish whether or not a key actually works when identification is attempted by another group.
- Illustrate on the chalkboard or an overhead what an ideal key may look like. Point out the nature of the opposite trait being used at the fork.

Possible Procedures
- Student procedures will vary. However, the general organization of the key itself will be similar from group to group. Making branches with opposite characteristics will help with the key design.

Data and Observations
Have students record their keys and turn them in at the end of class. Make transparencies of sample keys and use them in class the following day as a means for illustrating correct and incorrect key design.

Biology & SOCIETY

Purpose

Students are exposed to the pros and cons of traditional rain forest logging practices and sustainable harvesting alternatives.

Background

The Amazon rain forest is shrinking by nearly 5 million acres per year, losing an area the size of seven football fields every minute.

Traditional logging practices damage the forest and threaten biodiversity. In addition, logging companies build roads through forested areas. Farmers and ranchers then use these roads to gain access to new areas of forest. Trees and vegetation are burned and the land cleared alongside the roads to make room for roads and pastures.

Teaching Strategies

- Encourage students to do an Internet search for information about rain forest conservation programs. Ask students to evaluate the feasibility of these programs in protecting rain forests while satisfying the economic needs of people living in these regions.

Investigating the Issue

If consumers can be persuaded to use nontropical woods and building materials, the demand for tropical timber would be reduced. This would reduce the need for logging and decrease the amount of land lost to farming and ranching.

Biology & SOCIETY

Forestry: Keeping a Balance

Tropical rain forests are Earth's most biologically diverse ecosystems. Large areas of these forests are lost each year due to logging and the clearing of land for crops and cattle.

Hundreds of different kinds of trees grow in tropical forests. But only a few are valuable to the logging industry. Traditionally, loggers go after only the most economically valuable timber species, but in doing so they invade and clearcut millions of acres of forest each year. When loggers remove the economically valuable trees, neighboring trees are often destroyed, and the delicate ecology of the area is upset.

A "Sustainable" Harvest Many ecologists and conservation groups have worked to promote "sustainable" forestry as an alternative to traditional logging. Sustainable forestry involves harvesting a limited number of trees from specific areas of rain forest, and then nurturing young trees to replace those that are cut. The philosophy behind sustainable forestry is that it will create a constantly regenerating supply of valuable timber and restrict logging to certain areas that are carefully managed.

Logged rain forest

Different Viewpoints

Although hundreds of millions of dollars have been spent on sustainable forestry, only a tiny fraction (less than 0.02 percent) of the world's tropical forests are managed sustainably. Logging companies make more money by logging forests the traditional way. Until logging companies can make profits using sustainable forestry methods, there is little economic incentive for them to change their harvesting techniques.

More harm than good? Evidence suggests that sustainable forestry may threaten biodiversity more than traditional logging. Researchers have discovered that the longer an area of forest is disturbed, the greater the threat to the plants and animals that live there. With sustainable forestry, an area is disturbed for a long period of time. This may damage the biodiversity of a forest.

Still the best hope Sustainable forestry advocates maintain that although their alternative isn't perfect, it may still be the best way to prevent widespread damage to tropical forests by restricting the damage that logging can do to smaller, controlled areas.

Investigating the Issue

Analyzing the Issues Brainstorm in groups as to why some rain forest trees are more "valuable" than others. Discuss the link between the demand for certain kinds of wood and rain forest destruction. How might the demand be lessened?

interNET CONNECTION To find out more about rain forest destruction and sustainable forestry, visit the Glencoe Science Web Site. **www.glencoe.com/sec/science.**

Going Further

Linguistic Have students write an essay comparing the methods and results of sustainable harvest with traditional logging. Have students propose alternative forestry methods that might be better than either alternative. L3

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage:
Life in the Balance
Rondonia: Home of a Dying Rain Forest
(Ch. 3) 4 min.

Chapter 22 Assessment

Summary

Section 22.1
Nonvascular Plants

Main Ideas
- Nonvascular plants lack vascular tissue and reproduce by producing spores. The gametophyte generation is dominant.
- There are three divisions of nonvascular plants: Bryophyta, Hepatophyta, and Anthocerophyta.

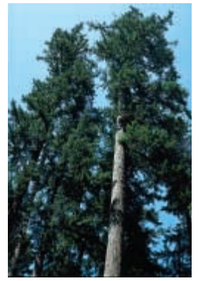
Vocabulary
archegonium (p. 598)
antheridium (p. 598)

Section 22.2
Non-Seed Vascular Plants

Main Ideas
- The non-seed vascular plants were prominent members of Earth's ancient forests. They are represented by modern species.
- Vascular tissues provide the structural support that enables vascular plants to grow taller than nonvascular plants.
- There are three divisions of non-seed vascular plants: Lycophyta, Sphenophyta, and Pterophyta.

Vocabulary
prothallus (p. 602)
rhizome (p. 605)
sorus (p. 606)
strobilus (p. 602)

Section 22.3
Seed Plants



Main Ideas
- There are four divisions of vascular plants that produce naked seeds: Cycadophyta, Gnetophyta, Ginkgophyta, and Coniferophyta.
- Seeds contain a supply of food to nourish the young plant, protect the embryo during harsh conditions, and provide methods of dispersal.
- Anthophytes produce flowers and have seeds enclosed in a fruit.
- Anthophytes are either monocots or dicots based on the number of cotyledons present in the seed.
- Fruits provide protection for the seeds and aid in their dispersal.
- Anthophytes may be annuals, biennials, or perennials.

Vocabulary
annuals (p. 615)
biennials (p. 616)
cotyledon (p. 609)
deciduous plant (p. 612)
dicotyledons (p. 615)
embryo (p. 608)
fruit (p. 610)
monocotyledons (p. 615)
ovule (p. 608)
perennials (p. 616)
pollen grain (p. 608)

GLENCOE TECHNOLOGY

VIDEOTAPE
MindJogger Videoquizzes
Chapter 22: *The Diversity of Plants*
Have students work in groups as they play the videoquiz game to review key chapter concepts.

Resource Manager

Chapter Assessment, pp. 127-132
MindJogger Videoquizzes
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 22 quiz

Main Ideas

Summary statements can be used by students to review the major concepts of the chapter.

Using the Vocabulary

To reinforce chapter vocabulary, use the Content Mastery Booklet and the activities in the Interactive Tutor for Biology: The Dynamics of Life on the Glencoe Science Web Site.
www.glencoe.com/sec/science

THE PRINCETON REVIEW

All Chapter Assessment questions and answers have been validated for accuracy and suitability by The Princeton Review.

Understanding Main Ideas

1. c
2. d
3. d
4. a
5. c
6. b
7. a
8. d
9. a
10. d
11. ovule
12. rhizome
13. water
14. gametophyte
15. sorus
16. silica
17. cotyledon
18. chloroplast

Chapter 22 Assessment

Understanding Main Ideas

1. Bryophytes, hepatophytes, and anthocerophytes are the three divisions of _____ plants.
   a. vascular **c.** nonvascular
   b. seed **d.** evergreen
2. The _____ is the gametophyte of a lycophyte.
   a. sorus **c.** strobilus
   b. frond **d.** prothallus
3. Lycophytes include _____.
   a. ferns **c.** mosses
   b. conifers **d.** club mosses
4. Anthophytes and coniferophytes are divisions that are BOTH _____.
   a. vascular and seed-producing
   b. vascular and non-seed
   c. nonvascular and non-seed
   d. nonvascular and seed-producing
5. Vascular tissue is important because it helps the plant to _____.
   a. anchor into the soil
   b. reproduce
   c. transport water and nutrients
   d. photosynthesize
6. The plant in the photograph is a(n) _____.
   a. Anthophyte
   c. Sphenophyte
   b. Pterophyte
   d. Gnetophyte

7. About 280 million years ago, many of the non-seed plants became extinct because of _____.
   a. long periods of freezing and drought
   b. a change to a warm, wet climate
   c. environmental pollution by humans
   d. being eaten by dinosaurs
8. The gametophyte generation is dominant in which of the following plants?
   a. pine trees **c.** apple trees
   b. ferns **d.** mosses
9. Which of the following is NOT a part of a seed?
   a. gametophyte **c.** food supply
   b. protective coat **d.** embryo
10. An orange tree would be classified in the same division as which of the following?
    a. pine tree **c.** cycad
    b. moss **d.** sunflower
11. The sporophyte structure shown here that protects the developing female gametophyte is the _____.

12. The thick, underground stem of a fern is the _____.
13. Seed plants do not require a continuous film of _____ to transport sperm to egg in fertilization
14. The moss sporophyte is dependent upon the _____ for nutrition.
15. A _____ is a group of sporangia found on a fern leaf.
16. The stems of sphenophytes contain _____ that gives them a rough texture.
17. Monocotyledons have only one seed leaf or _____.
18. The presence of a single large _____ in the cells of hornworts suggests they may be closely related to algae.

Test-Taking Tip

Cramming Is Not a Good Strategy

If you don't know the material by the week before the test, you're less likely to do well. Set up a time line for your practice and preparation so that you're not rushed; then you will have time to deal with those problem areas.

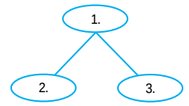
19. Because mosses lack vascular tissue, the amount of _____ in their environment is often the limiting factor.
20. Plants that have a life span that lasts two years are called _____.

Applying Main Ideas

21. What is the adaptive advantage of fertilization that no longer requires a continuous film of water for the sperm to reach the eggs?
22. Why are conifers more abundant than flowering trees in Canada, Alaska, and Siberia?
23. Explain how evergreen and deciduous plants differ, and describe the adaptive value of each.
24. What might be the evolutionary advantages of having a gametophyte dependent on a sporophyte?

Thinking Critically

25. **Comparing and Contrasting** Compare and contrast cones and fruits.
26. **Observing and Inferring** What traits could you use to identify anthophytes?
27. **Concept Mapping** Complete the concept map by using the following vocabulary terms: prothallus, archegonium, antheridium.

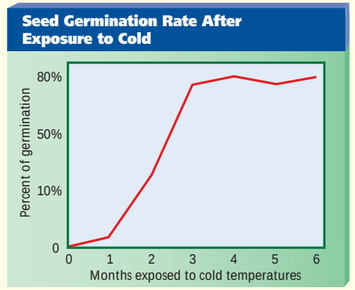


CD-ROM

For additional review, use the assessment options for this chapter found on the ***Biology: The Dynamics of Life Interactive CD-ROM*** and on the Glencoe Science Web Site.
www.glencoe.com/sec/science

Assessing Knowledge & Skills

The germination rate of seeds is the percentage of planted seeds that eventually sprout to produce new plants. The seeds of the bristlecone pine must be exposed to cold temperatures before they will sprout.



Using a Graph Answer the following questions based on the graph.

1. What would be the minimum time you would keep bristlecone pine seeds under refrigeration before planting?
   a. 1 month **c.** 6 months
   b. 3 months **d.** 80 months
2. How long does it take to get 50 percent germination?
   a. 2-1/2 months **c.** 1 month
   b. 6 months **d.** 80 months
3. **Interpreting Scientific Illustrations** Examine the cross section of a conifer needle as diagrammed in the *Inside Story* and answer the following question. How do the positions of stomata and vascular tissues in the leaf help to prevent water loss?

Chapter 22 Assessment

19. moisture/water
20. biennials

Applying Main Ideas

21. Fertilization may occur at any time because it is no longer dependent on water.
22. Conifer leaf adaptations allow them to survive in cold, harsh climates.
23. Evergreens retain leaves all year long and can start to photosynthesize as soon as the growing season starts. Deciduous plants lose their leaves, reducing water loss during the winter.
24. The sporophyte protects the gametophyte and provides nourishment.

Thinking Critically

25. Cones and fruits both contain seeds. However, the seeds in cones are borne on scales while the seeds contained within fruits are protected by the fruit.
26. Anthophytes have flowers and seeds contained within fruits.
27. 1. Prothallus; 2. Archegonium; 3. Antheridium

Assessing Knowledge & Skills

1. b
2. a
3. Sunken stomata and internal vascular tissue help prevent water loss.