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Some stems have specialized functions in addition to support and conduction.

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The cork cambium produces secondary dermal tissue.
Bark consists of all the tissues external to the vascular cambium.

Growth Patterns in Wood and Bark
The vascular cambium produces secondary xylem, secondary phloem, and ray parenchyma, as well as more vascular cambium.
Sapwood conducts water and minerals, but heartwood does not.
Growth rings in wood reflect the history of secondary growth in a tree.
Dendrochronology is the science of tree ring dating and climate interpretation.
Growth patterns in reaction wood counteract leaning.
The cork cambium is reformed as the stems and roots enlarge.
Lenticels are pathways in the bark for gas exchange.

Commercial Uses of Wood and Bark
Wood is used mainly for fuel, paper products, and construction.
Wood structure can be studied from three cutting planes.
Wood can vary in properties such as hardness and grain.
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Molecular Movement Across Membranes
Diffusion is the spontaneous movement of molecules down a concentration gradient. Facilitated diffusion and active transport use proteins to assist in movement across membranes. Exocytosis and endocytosis transport large molecules. Osmosis is the movement of water across a selectively permeable membrane. In plant cell growth, the osmotic potential inside the cell interacts with pressure generated by the cell wall.

Movement and Uptake of Water and Solutes in Plants
Water evaporation from leaves pulls water through the xylem from the roots. Stomata control gas exchange and water loss for the plant. Sugars and other organic molecules move from leaves to roots in the phloem.

Soil, Minerals, and Plant Nutrition
Soil is made of ground-up particles of rocks surrounded by negative charges that bind water and minerals.

Plants require 17 essential elements, most of which are obtained from soil. Soil particles bind water and mineral ions. Bacteria in the soil make nitrogen available to plants.

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Genes can be transferred between species through genetic engineering.
Plasmids often serve as vectors for gene transfer in plants.
Restriction enzymes and DNA ligase are used to make recombinant DNA.
Cloning produces multiple copies of recombinant DNA.
The polymerase chain reaction clones DNA without using cells.
Several methods can be used to insert cloned genes into plant cells.
In tissue culture, whole plants are grown from isolated cells or tissues.

The Accomplishments and Opportunities of Plant Biotechnology

Genetic engineering has made plants that are more resistant to pests and harsh soil conditions as well as more productive.
Transgenic plants contribute to human health and nutrition.
Genetically engineered crops require extensive field and market testing before they are released.
Genetically engineered crops must be safe for the environment and for consumers.
The future holds many opportunities for plant biotechnology.

Genomics and proteomics will provide information needed for future efforts in genetic engineering.

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Unit Four

EVOLUTION AND DIVERSITY

15 Evolution

History of Evolution on Earth

Fossils and molecular dating provide evidence of evolution.
Biogeography, anatomy, embryology, and physiology supply further evidence of evolution.
Chemosynthesis may have been the first event in the origin of life on Earth.
Prokaryotes were the predominant form of life for more than a billion years.
Plate tectonics and celestial cycles have shaped evolution on Earth.
Extinction is a fact of life on Earth.

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Evolution is a change in the frequency of alleles in a population over time.
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The Intriguing World of Plants: The Wollemi Pine: A Living Fossil

23 Angiosperms: Flowering Plants

Sexual Reproduction in Flowering Plants

Angiosperms, like gymnosperms, have a dominant sporophyte and dependent gametophyte

Self-pollination and cross-pollination are both common in angiosperms

The Evolution of Flowers and Fruits

The selective advantages of flowering plants account for their success

Flowers have evolved as collections of highly modified leaves

The evolution of angiosperms began during the Mesozoic era

During the Cretaceous period, angiosperms spread rapidly throughout the world

A Sampling of Angiosperm Diversity

Phylum Anthophyta contains more than 450 families, classified mainly by flower structure

Several families illustrate the diversity of floral and fruit structure

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Biotechnology: Superweeds

Evolution: The Origins of Domesticated Corn, Wheat, and Rice

The Intriguing World of Plants: A Recently Discovered Orchid

Unit Five

ECOLOGY

24 Ecology and the Biosphere

Abiotic Factors in Ecology

Abiotic factors are physical variables in an organism's environment

The tilt of Earth's axis causes seasons and affects temperatures

The atmosphere circulates in six global cells

The rotation and topography of Earth affect global patterns of wind and precipitation

Ecosystems

The biosphere can be divided into biogeographic realms and biomes

Terrestrial biomes are characterized by rainfall, temperature, and vegetation

Light penetration, temperature, and nutrients are important abiotic factors in aquatic biomes

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The Intriguing World of Plants: Weeds

Conservation Biology: El Niño and La Niña

25 Ecosystem Dynamics: How Ecosystems Work

Populations

The reproductive characteristics of plants create challenges in studies of plant populations

The distribution of plants in a population may be random, uniform, or clumped
Age distributions and survivorship curves describe the age structure of populations. The growth of populations over time is limited by environmental resources. The growth of plant populations depends on reproductive patterns.

Interactions Between Organisms in Ecosystems
Commensalism and mutualism are interactions in which at least one species benefits. Predation, herbivory, and parasitism are interactions in which at least one species is harmed. Plants compete for resources with members of their own and other species.

Communities and Ecosystems
Communities can be characterized by species composition and by vertical and horizontal species distribution. Apparently uniform environments are often composed of different microenvironments. A moderate level of disturbance can increase the number of species in an ecosystem. Ecological succession describes variation in communities over time. The energy stored in photosynthetic organisms passes inefficiently to other organisms in the same ecosystem. Biological magnification increases the concentration of some toxic substances at higher trophic levels. Water and nutrients cycle between biotic and abiotic components of ecosystems. Human activity has fragmented stable ecosystems into distinctive patches.

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26 Conservation Biology 548

Human Population Growth
Human population is increasing exponentially. Increased food production will involve genetically altered plants, improved growing practices, and more efficient food distribution systems.

Human Impacts on Ecosystems
The presence and activities of large human populations disturb ecosystems. The geographic information system provides a new tool to record changes in ecosystems.

The Future
The future of human interactions with ecosystems can be modeled on worst-case or best-case scenarios. Achieving a best-case scenario for the biosphere would involve a marked reversal of current trends. A number of problems would have to be overcome to reverse current trends of ecosystem destruction and modification. It is important to establish models of success in promoting ecosystem restoration.

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Conservation Biology: Land Races and Seed Banks
The Intriguing World of Plants: Kudzu
Biotechnology: Recreating Lost Worlds Through Genomics and Proteomics

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