

Chapter 30 Green Plants

I. Why Do Biologists Study the Green Plants?

A. Plants are essential to human life.

1. Plants provide ecosystem services.
2. Plants improve the atmosphere, surface water, and soil in a way that benefits other organisms.
 - a. Plants produce oxygen as a by-product of photosynthesis.
 - b. Plants build soil by providing food for decomposers that add organic matter to the soil.
 - c. The network of roots in a plant prevents erosion. (Fig. 30.1)
 - d. Plants hold water, preventing flooding and groundwater depletion.
 - e. Plants moderate local climates by providing shade and blocking wind.
3. Plants are the primary food producers on Earth.
 - a. Plants produce sugars & oils via photosynthesis that provide foundation for the food chain.
 - b. Plants are autotrophs because they make their own food.
 - (1) All other organisms are heterotrophs.
 - (2) Herbivores eat plants, carnivores eat herbivores, and omnivores eat both. (Fig. 30.2)
4. Plants are the key to the carbon cycle on land.
 - a. Plants take CO_2 from the environment and use it to make sugar.
 - b. Plants fix more CO_2 than they generate.

B. To Improve Agricultural Practice

1. Crop domestication parallels the evolution of human culture.
2. Domesticated, modern grains grown today were derived from wild species thousands of years ago. (Fig. 30.3a)
 - a. Domestication of plants occurs via artificial selection.
 - (1) Seeds of plants displaying favorable characteristics were chosen.
 - (2) Only these seeds were used to generate the next crop.
 - (3) Repeating this process selects for certain traits and generates crops in which all of the plants exhibit those traits.
 - b. Artificial selection is largely responsible for many of the existing crops in the world today. (Fig. 30.3b)

C. To Maximize Our Usage of Plants for Fuel and Clothing

1. For thousands of years, wood was the primary fuel source used by humans.
2. In recent centuries, coal has replaced wood as our primary energy source. (Fig. 30.4a)
 - a. Coal is formed from decaying plant matter that is compacted over time. (Fig. 30.4b)
 - b. Recently mined coal is derived from plants that lived millions of years ago.
3. More recently, the use of fossil fuels has replaced wood burning.
 - a. Burning fossil fuels releases more CO_2 into the atmosphere than can be fixed by plants.
 - b. Increase in CO_2 is contributing to global warming.
4. Will other plant-based fuels replace fossil fuels?
 - a. Researchers are working on developing fuels derived from corn.
 - b. It is unlikely that these fuels will replace petroleum anytime soon.
 - c. Solar and wind power are more likely alternatives for the near future.
5. Currently the leading use of wood and other plant materials is in building materials, paper, and clothing.

D. To Discover New Usages for Plants

1. Bioprospecting is exploring new sources for drugs, insecticides, herbicides, etc.
2. Plants have many disease-fighting and preventing compounds. (Table 30.1)
 - a. Vinblastine (anticancer drug) was isolated from the rosy periwinkle plant.
 - b. 25% of all prescriptions written each year in the U.S. have at least one molecule derived from plants.

3. Plants have molecules that naturally repel insects and other predators.
4. Bioprospecting in the lab
 - a. Biologists can grow plants hydroponically in the lab.
 - b. Hydroponic cultures do not need soil and allow scientists to manipulate exactly what the plants take in.
 - c. Scientists can expose the roots of a plant to a bacterial or fungal toxin and collect the defense compounds that the plant produces.
 - d. Some compounds have been shown to have potential therapeutic value for treating cancer.
5. Bioprospecting in the field
 - a. Ethnobotanists study how humans use plants.
 - b. These scientists are collecting plants in areas that are threatened with destruction in order to study their use before they are gone.
 - c. They also interview natural healers of indigenous peoples to learn how they use native plants to heal.

II. How Do Scientists Study Green Plants?

- A. Comparing Morphological Traits of Different Plants
 1. Morphological analysis of green plants has led to the identification of several distinct groups of green algae and 12 major phyla of land plants.
 2. Green algae are closely related to plants. (**Fig. 30.6**)
 - a. Both plants and green algae have . . .
 - (1) chloroplasts with chlorophyll *a* and *b*.
 - (2) cell walls of similar composition.
 - (3) similar sperm and peroxisomes.
 - b. Green algae types vary in size and habitat.
 - (1) Some green algae are unicellular and some are multicellular.
 - (2) Some green algae live in marine habitats; others live in freshwater.
 3. Unlike algae, most plants live on land and can be divided into three main groupings.
 - a. Nonvascular plants lack vascular tissue, are small, and grow close to the ground. (**Fig. 30.7a**)
 - b. Seedless vascular plants have vascular tissue but do not make seeds, and are traditionally small. (**Fig. 30.7b**)
 - c. Seed plants have vascular tissue and make seeds and can grow to be very large. (**Fig. 30.7c**)
 - (1) Gymnosperms make "naked" seeds.
 - (2) Angiosperms, flowering plants, make seeds enclosed in a protective structure such as a fruit.
- B. Using the Fossil Record (**Fig. 30.8**)
 1. Origin of land plants from green algae
 - a. Oldest known land plant fossils are microscopic and were deposited 475 million years ago (mya).
 - b. These fossils resemble today's land plants in that they show evidence of . . .
 - (1) sheets of waxy cuticle.
 - (2) spores with sporopollenin-containing walls.
 - (3) spores contained within specialized structures called sporangia.
 2. Silurian/Devonian explosion—the appearance of nonvascular seedless plants
 - a. Macroscopic fossils from all major lineages of land plants are found, dating to about 400 mya.
 - b. Most structural adaptations to terrestrial life appeared: wood, vascular tissue, roots.
 3. Carboniferous—the appearance of seedless vascular plants
 - a. Dominance of woody lycopods—350 mya
 - b. Extensive coal deposits form—carbon-rich rock is packed with fossil spores, branches, and leaves; many from lycopods.
 - c. Evidence of swamps—coal formation thought to begin only in water.
 4. Age of Gymnosperms—the appearance of seed plants
 - a. Fossil gymnosperms dominate—250 mya.

- b. Plants move to drier habitats—gymnosperms grow well in dry habitats.
- 5. Age of flowering plants
 - a. First angiosperms appear in fossil record—125 mya.
 - b. Woody ancestral angiosperms give rise to huge variety of forms today.
- C. Using Molecular Phylogenies to Confirm the Fossil Record
 - 1. The "Deep Green Project" is a worldwide effort to determine the phylogenies of all land plants.
 - a. This project involves both morphological and DNA sequence data to determine evolutionary relationships.
 - b. Participating scientists meet regularly to share data, construct and revise phylogenetic trees.
 - 2. The current phylogenetic tree is a product of the "Deep Green Project" and implies the following relationships. (**Fig. 30.9**)
 - a. The root of the tree is an ancestor of green algae.
 - b. The green algal group Charales is the sister group to land plants.
 - (1) Charales is multicellular and dwells in freshwater.
 - (2) Land plants presumably evolved from a multicellular ancestor that lived in ponds and lakes.
 - c. Land plants are monophyletic and are derived from a single ancestor.
 - (1) Nonvascular plants such as liverworts, hornworts, and mosses are the earliest branching plants, but are not a monophyletic group.
 - (2) Lycopods are the most basal group of the monophyletic seedless vascular plants.
 - (3) Gymnosperms and angiosperms are monophyletic.

III. What Themes Occur in the Diversification of Green Plants?

- A. How Did Plants Adapt to Dry Conditions? (**Fig. 30.12**)
 - 1. Advantages of colonizing land
 - a. Sunlight is not screened out by water, as it is in an aquatic habitat.
 - b. CO_2 is readily available and diffuses more easily through air.
 - 2. Adaptations that allowed plants to avoid dehydration on land
 - a. Cuticle—waxy sealant that prevents H_2O loss but also inhibits uptake of CO_2 . (**Fig. 30.10a**)
 - b. Stomata—pores bounded by guard cells enable uptake of CO_2 while controlling water loss. (**Fig. 30.10b**)
 - (1) First appear in some members of Rhyniopsida.
 - (2) Liverworts have simple pores; all other land plants today have stomata.
 - 3. Adaptations that enabled transport of water and erect growth habit
 - a. Evolution of roots facilitated uptake of water from soil.
 - b. Development of vascular tissue allowed transport against gravity.
 - (1) Tracheids (**Fig. 30.11a, c**)
 - (a) Long, thin, tapered ends
 - (b) Water flows from one tracheid to another through pits.
 - (c) Tracheids evolved 380 mya, occur in all phyla of living vascular land plants.
 - (d) Tracheids provide structural support to the plant.
 - (e) Provide enough water for turgor pressure in tissues
 - (f) Lignin rings in cell walls of tracheids give rigid support.
 - (g) Lignified tracheids packed together to form wood.
 - (h) Erect growth habit enables plants to compete for sunlight.
 - (2) Vessels (**Fig. 30.11b, c**)
 - (a) Shorter, wider, stacked end to end
 - (b) The ends have perforations that lack cell wall material, making the transport of water very efficient.
 - (c) Open areas in primary wall enable high-volume water transport.
- B. How Do Plants Reproduce in Dry Conditions?
 - 1. Alternations of generations

- a. In the green algae Charales, the multicellular form is haploid; the only diploid form is the zygote. (Fig. 30.15)
 - b. Plants have a multicellular haploid stage called the gametophyte and a multicellular diploid stage called the sporophyte.
 - c. Gametophytes produce gametes via mitosis; they are joined in fertilization to form the zygote, which grows via mitosis into the sporophyte, which produces spores via meiosis that grow via mitosis into the gametophyte. (Fig. 30.16)
 - (1) In nonvascular plants, the dominant photosynthetic form is the gametophyte. (Fig. 30.17a)
 - (2) In ferns, both the gametophyte and sporophyte generations photosynthesize, although the sporophyte is larger. (Fig. 30.17b)
 - (3) In gymnosperms and angiosperms the sporophyte is dominant, and the gametophyte is retained within the sporophyte. (Figs. 30.17b)
 - d. All seed plants are heterosporous (Fig. 29.15a)
 - (1) Sporophytes have two distinct spore-producing structures.
 - (2) Microsporangia make microspores that develop into sperm.
 - (3) Megasporangia make megaspores that develop into eggs.
 - e. Most seedless plants are homosporous and generate only one type of spore that develops into bisexual gametophytes. (Fig. 30.19)
2. Retaining and nourishing offspring on land
 - a. Two major adaptations appeared early in land plant evolutionary history.
 - (1) Gametes were produced in complex, multicellular structures.
 - (2) The embryo remained in the mother plant and was nourished by it.
 - b. Gametangia are the reproductive organs in which gametes are produced.
 - (1) Antheridia produce sperm. (Fig. 30.13a)
 - (2) Archegonia produce eggs. (Fig. 30.13b)
 - c. Eggs are retained in archegonia; once fertilized, the zygote receives nutrients from the mother plant.
 - (1) For this reason, plants are called embryophytes. (Fig. 30.14)
 - (2) The embryophyte condition is analogous to pregnancy in animals.
 - (3) Plant embryos have placental transfer cells that facilitate the transfer of nutrients from the parent plant. (Fig. 30.14)
 3. Pollen
 - a. Sporophyte-dominant life cycles were accompanied with the appearance of pollen.
 - b. Reduced male gametophyte, the pollen grain remains inside spore wall.
 - (1) Sporopollenin wall protects gametophyte from desiccation.
 - (2) Pollen can be transferred to female by wind or animal.
 - (3) Removes dependence on water for reproduction
 4. Seed
 - a. The embryophyte condition lets offspring be nourished directly by parent.
 - b. Reduced female gametophyte is present in the immature seed.
 - c. Pollen tube delivers sperm; embryo forms inside seed.
 - d. Seed has protective coat, nutritive tissue for embryo. (Fig. 30.20a)
 - e. Some seeds have structures that aid in dispersal by water, air, or animals. (Fig. 30.20b)
 - (1) Angiosperms generate fruit that is derived from the ovary tissue.
 - (2) The ovary encloses the ovules where eggs are made, and fertilization takes place, forming the seed.
 - (3) Fruits enclose seeds and attract animals that eat them and disperse the seed.
 5. Flower
 - a. Flowering plants are the most successful land plants.
 - b. Angiosperms do not have gametangia; their reproductive organs are contained within the flower.
 - c. Unique characteristics of the flower
 - (1) Colorful petals attract animals.

- (2) Nectaries provide food reward to animals.
- d. Why is there so much variation in flower shape, size and coloration? (Fig. 30.23)
 - (1) Hypothesis: Flowers are an adaptation that increases the probability that pollination will occur.
 - (2) Observational evidence in carrion flower
 - (a) The carrion flower smells of rotting flesh.
 - (b) Smell attracts flies that normally lay their eggs in decaying meat.
 - (c) While laying eggs, the flies are dusted with pollen.
 - (3) Correlational evidence in hummingbird-pollinated flowers
 - (a) Flowers pollinated by hummingbirds have long, tubelike structures that fit the shape of the hummingbird beak.
 - (b) Hummingbird flowers tend to be red or purple, and hummingbird vision is particularly good at those wavelengths.
- e. Experimental evidence (Johnson and Steiner)
 - (1) Spur length studies of *Disa draconis* orchid
 - (a) Spurs on flowers lead to nectaries.
 - (b) Pollinators pick up or leave off pollen as they probe the spur.
 - (2) Hypothesis: Length of spur is matched to pollinator to result in maximal deposition of pollen on the pistil.
 - (3) Compare two populations of *Disa*: (Fig. 30.24)
 - (a) Short-spur flowers pollinated by short-probosci horseflies.
 - (b) Long-spur flowers pollinated by long-probosci tanglewing flies.
 - (c) Long-spur flowers whose spurs have been artificially shortened by tying with yarn.
 - (d) Control: Long-spur flowers with yarn tied in a position that does not affect spur length.
 - (4) Results:
 - (a) Individuals with artificially shortened spurs received less pollen than those with long spurs.
 - (b) Controls received more pollen than those with artificially shortened spurs.
 - (5) Supports conclusion that spur length is an adaptation that increases frequency of pollination.
- f. Experiments suggest that angiosperm diversity is partly due to natural selection exerted by diverse types of pollinators.

C. The Angiosperm Radiation

- 1. Angiosperms represent one of the significant adaptive radiations in evolutionary history.
 - a. Adaptive radiation occurs when a single lineage produces a large number of descendant species that are adapted to many different habitats.
 - b. As a result of the emergence of vessels, flowers and fruits, angiosperms dominate today's land plants.
- 2. The angiosperm radiation resulted in two major lineages. (Fig. 30.28)
 - a. Monocots
 - (1) Grasses, orchids, palms, and lilies
 - (2) Have one cotyledon, or embryonic leaf
 - b. Dicots
 - (1) Roses, buttercups, daisies, oaks, and maples
 - (2) Have two cotyledons
 - (3) Genetic analysis has shown that dicots are not a monophyletic group. (Fig. 30.28)
 - (4) Eudicots are a true monophyletic group that includes roses, daisies, and maples.

IV. What are the key lineages in green plant evolution?

A. Green Algae (Fig. 30.30)

- 1. Ulvobionta (Fig. 30.32)
 - a. A monophyletic group with about 4000 species that range from unicellular to multicellular
 - b. Habitat:

- (1) Coastal and intertidal
 - (2) Unicellular species inhabit freshwater streams and lakes.
 - c. Reproduction:
 - (1) Both sexual and asexual
 - (2) Asexual reproduction occurs with flagellated spores.
 - (3) Gametes are shed into the water and fertilization takes place away from the parent.
 - d. Life cycle:
 - (1) Unicellular forms are diploid only as zygotes.
 - (2) Alternation of generations occurs in multicellular forms.
 - e. Human and ecological impacts: Primary producers in freshwater and coastal marine environments
 - 2. Coleochaetales (**Fig. 30.31**)
 - a. 19 multicellular species that mostly grow as flat sheets.
 - b. Habitat:
 - (1) Strictly freshwater
 - (2) Grow attached to aquatic plants or on submerged rocks in lakes and ponds
 - c. Reproduction:
 - (1) Asexual reproduction occurs via flagellated spores.
 - (2) During sexual reproduction, eggs are retained in the parent and nourished via placental transfer cells.
 - (3) Some species have individuals that produce only eggs, and other individuals that produce only sperm.
 - d. Life cycle:
 - (1) No alternation of generations
 - (2) Multicellular individuals are haploid.
 - (3) Zygote is the only diploid stage.
 - e. Human and ecological impact: Give scientists insight into how plants colonized land
 - 3. Charales (**Fig. 30.33**)
 - a. Several hundred multicellular species
 - b. Habitat:
 - (1) Strictly freshwater, both shallow and deep
 - (2) Accumulate crusts of calcium carbonate on their surface
 - c. Reproduction:
 - (1) Primary sexual reproduction occurs.
 - (2) Multicellular gametangia are similar to those on land plants.
 - (3) Eggs are retained and nourished within parent plant.
 - d. Life cycle:
 - (1) No alternation of generations
 - (2) Multicellular individuals are haploid.
 - (3) Zygote is the only diploid stage.
 - e. Human and ecological impacts: Provide food and shelter for fish, geese, and ducks
- B. Nonvascular Plants ("Bryophytes")**
- 1. Hepaticophyta (**Fig. 30.35**)
 - a. Liverworts have liver-shaped leaves and are most commonly found growing on damp forest floors or riverbanks in dense mats.
 - b. Adaptations to land:
 - (1) Covered with cuticle
 - (2) Have pores for gas exchange
 - c. Reproduction:
 - (1) Asexual reproduction from cuttings
 - (2) Also reproduce asexually via gemmae that break off to grow independently
 - (3) Sexual reproduction via sperm and egg produced in gametangia
 - d. Life cycle:
 - (1) Dominant gametophyte

- (2) Small, dependent sporophyte
 - (3) Dispersed when spores are released and spread by wind or rain.
 - e. Human and ecological impacts: Contribute to initial soil production
 - 2. Anthocerotophyta (Hornworts) (Fig. 30.37)
 - a. Sporophytes have a hornlike appearance.
 - b. Adaptations to land: stomata
 - c. Reproduction:
 - (1) Certain species have gametophytes that are either male or female.
 - (2) Other species have gametangia that produce both egg and sperm.
 - d. Life cycle:
 - (1) Have sporophytes with chloroplasts
 - (2) Sporophytes make their own food, but also get nutrients from gametophyte.
 - (3) Spores disperse via wind and rain.
 - e. Human and ecological impacts: Some species harbor cyanobacteria that fix nitrogen.
 - 3. Bryophyta (Mosses) (Fig. 30.35)
 - a. Form a large, diverse monophyletic group with over 12,000 species
 - b. Adaptations to land:
 - (1) Simple conducting tissue
 - (2) Conductive tissue not supported by lignin, so not technically vessels.
 - c. Reproduction:
 - (1) Asexual reproduction by fragmentation
 - (2) Sexes are separated, so one individual can make only egg or sperm.
 - (3) Spores dispersed by wind.
 - d. Life cycle:
 - (1) Dominant gametophyte
 - (2) Sporophyte retained and dependent on gametophyte
 - e. Human and ecological impacts:
 - (1) *Sphagnum* is the most abundant plant on Earth.
 - (2) Moss forms peat when it partially decays.
 - (a) Forms a carbon sink; therefore if peatlands burn or decay, more CO₂ will be released speeding up global warming.
 - (b) Peat is harvested for heating and cooking oil in Ireland.
 - (c) Often used as a gardening additive because it can hold water.
- C. Seedless Vascular Plants
1. Lycophyta (Lycophytes or Club Mosses) (Fig. 30.39)
 - a. 1000+ species of small plants that live on forest floor, or on tropical trees
 - b. Adaptations to land:
 - (1) Roots
 - (2) Contain vascular tissue
 - c. Reproduction:
 - (1) Asexual reproduction via fragmentation
 - (2) Sexual reproduction gives rise to bisexual gametophytes.
 - d. Life cycle:
 - (1) Gametophytes of some species live underground and live off symbiotic fungi.
 - (2) Gametophytes live a long time and produce many sporophytes.
 - e. Human and ecological impacts: Dominated the coal-generating forests during the Carboniferous period
 2. Psilotophyta (Whisk Ferns) (Fig. 30.40)
 - a. Only 6 distinct species that live in tropical regions.
 - b. Adaptations to land:
 - (1) No roots
 - (2) Gain nutrients from fungi in rhizomes
 - (3) Some are epiphytes that grow on other plants.
 - c. Reproduction:

- (1) Asexual reproduction via rhizome extension
 - (2) Sexually produced spores are dispersed by wind and generate bisexual gametophytes.
 - d. Life cycle:
 - (1) Large sporophyte
 - (2) Gametophyte is small and gets nutrients from soil.
 - (3) Sporophytes grow on gametophyte.
 - e. Human and ecological impacts: Popular landscaping plants.
 - 3. Sphenophyta, or Equisetophyta (Horsetails) (**Fig. 30.41**)
 - a. 15 species that are abundant in wet habitats
 - b. Adaptations to land:
 - (1) Hollow stems that allow oxygen diffusion to roots
 - (2) Allow for growth in anaerobic conditions
 - c. Reproduction:
 - (1) Asexual reproduction via rhizome extension
 - (2) Rhizomes can produce stems bearing clusters of sporangia that produce spores via mitosis.
 - d. Life cycle:
 - (1) Gametophytes are small and short lived.
 - (2) Gametophytes have both archegonia and antheridia that produce egg and sperm at different times to prevent self-fertilization.
 - e. Human and ecological impacts: Rich in silica granules that are used for scouring pots and pans
 - 4. Pteridophyta (Ferns) (**Fig. 30.42**)
 - a. Over 12,000 species that live mostly in tropical climates
 - b. Adaptations to land:
 - (1) Have large leaves called fronds
 - (2) These provide a large surface area for light capture to fuel photosynthesis.
 - c. Reproduction:
 - (1) Can produce asexually via gemmae
 - (2) Most species reproduce sexually.
 - d. Life cycle:
 - (1) Dominant sporophyte.
 - (2) Gametophyte is photosynthetic.
 - (3) Sporangia are found in clusters called sori on the underside of leaves.
 - e. Human and ecological impacts: Young ferns can be eaten; many are used as ornamental plants in landscaping.
- D. Seed Plants
- 1. Seed plants are a monophyletic group that is defined by the production of seeds and pollen grains.
 - 2. Gnetophyta (**Fig. 30.46**)
 - a. Composed of three widely diverse genera:
 - (1) One contains vines and trees that grow in the tropics.
 - (2) One contains desert-dwelling shrubs.
 - (3) One contains a single species that is native to southwest Africa.
 - b. Adaptations to land: Wood
 - c. Reproduction: Pollinated by insects and wind
 - d. Life cycle: Sporangia clustered at ends of stalks
 - e. Human and ecological impacts: The drug ephedrine was isolated from a gnetophyte, *Ephedra*.
 - 3. Cycadophyta (Cycads) (**Fig. 30.44**)
 - a. 140 species that live in the tropics and look like palm trees
 - b. Adaptations to land: Wood
 - c. Reproduction: Pollinated by insects and wind
 - d. Life cycle: Heterosporous
 - e. Human and ecological impacts: Harbor large amounts of nitrogen-fixing cyanobacteria in specialized above-ground root structures - Popular landscaping plants
 - 4. Ginkgophyta (Ginkgoes) (**Fig. 30.45**)

- a. Only one species living today.
 - b. Adaptations to land:
 - (1) Deciduous, meaning that it loses its leaves in the autumn
 - (2) Allows the plant to go dormant in the winter or dry season
 - c. Reproduction:
 - (1) Pollinated by wind
 - (2) Sperm have flagella.
 - (3) Sperm leave the pollen grain and swim to the egg cells.
 - d. Life cycle: Heterosporous
 - e. Human and ecological impacts: Ornamental and used in many landscapes.
5. **Coniferophyta (Conifers) (Figs. 30.47 & 30.48)**
- a. Comprised of familiar plants like pines, cedars, spruce, and so on
 - (1) Generate cones in which sporangia are produced
 - (2) Are the largest and longest-living plants
 - b. Adaptations to land:
 - (1) Narrow, needle-like leaves that reduce water loss
 - (2) Therefore, confers are able to grow in dry, cold habitats.
 - c. Reproduction:
 - (1) Wind pollinated
 - (2) Fertilization and seed development occur in the female cone.
 - d. Life cycle:
 - (1) Heterosporous
 - (2) Most individuals have both male and female cones.
 - (3) Pollination and fertilization are separated in time; it takes almost a year for the sperm to mature once a female cone has been pollinated.
 - e. Human and ecological impacts:
 - (1) Important food source for many animals
 - (2) Wood used in paper products and building materials
- E. **Anthophyta (Angiosperms) (Figs. 30.49)**
- 1. 235,000 species described that vary greatly in size and habitat.
 - a. Defined by the presence of a flower.
 - b. Flowers contain both male and female organs enclosed by petals.
 - c. Developing flower is enclosed by sepals that protect the growing flower.
 - d. Nectar is produced at the base of the flower.
 - e. Most angiosperms are pollinated by animals that are attracted to the attractive, sweet-smelling and sweet-tasting flowers.
 - f. The few wind-pollinated species lack showy flowers. (Fig. 30.49b)
 - 2. Adaptations to land:
 - a. Flowers
 - b. Vessels
 - 3. Reproduction:
 - a. Pollinated by animals or wind
 - b. Egg is enclosed in immature seed; upon fertilization it houses the zygote.
 - c. Double fertilization: One sperm fertilizes the egg to form the zygote, the other fertilizes two polar nuclei to form the nutritive, triploid endosperm.
 - 4. Life cycle:
 - a. Sporophyte dominant
 - b. Gametophytes are only a few cells that divide mitotically to form sperm and egg.
 - 5. Human and ecological impacts:
 - a. Supplies food to all herbivorous species
 - b. Fruits supply food to almost all human cultures.