

Chapter 29 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.
 3. Plants are the primary food producers on Earth.
 4. Plants are the key to the carbon cycle on land.
- 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.
- 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.
 3. More recently, the use of fossil fuels has replaced wood burning.
 4. Will other plant-based fuels replace fossil fuels?
 5. Currently leading use of wood & 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.
 3. Plants have molecules that naturally repel insects and other predators.
 4. Bioprospecting in the lab
 5. Bioprospecting in the field

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.
 - a. Both plants and green algae have . . .
 - b. Green algae types vary in size and habitat.
 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.
 - b. Seedless vascular plants have vascular tissue but do not make seeds, and traditionally small.
 - c. Seed plants have vascular tissue and make seeds and can grow to be very large.
- B. Using the Fossil Record
 1. Origin of land plants from green algae
 - a. Oldest known land plant fossils are microscopic & were deposited 475 million years ago (mya).
 - b. These fossils resemble today's land plants in that they show evidence of . . .
 2. Silurian/Devonian explosion—the appearance of nonvascular seedless plants
 3. Carboniferous—the appearance of seedless vascular plants
 4. Age of Gymnosperms—the appearance of seed plants
 5. Age of flowering plants
- 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.
 2. Current phylogenetic tree a product of “Deep Green Project” & implies the following relationships.
 - 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.
 - c. Land plants are monophyletic and are derived from a single ancestor.

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

- A. How Did Plants Adapt to Dry Conditions?
 1. Advantages of colonizing land
 - a. Sunlight is not screened out by water, as it is in an aquatic habitat.
 - b. CO₂ 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 H₂O loss but also inhibits uptake of CO₂.
 - b. Stomata—pores bounded by guard cells enable uptake of CO₂ while controlling water loss.
 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.

- B. How Do Plants Reproduce in Dry Conditions?
1. Alternations of generations
 - a. In the green algae Charales, multicellular form is haploid; the only diploid form is the zygote.
 - b. Plants have multicellular haploid stage - gametophyte & multicellular diploid stage - 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.
 - d. All seed plants are heterosporous
 - e. Most seedless plants are homosporous & generate only 1 type of spore that develops into bisexual gametophytes.
 2. Retaining and nourishing offspring on land
 - a. Two major adaptations appeared early in land plant evolutionary history.
 - b. Gametangia are the reproductive organs in which gametes are produced.
 - c. Eggs retained in archegonia; once fertilized, zygote receives nutrients from mother plant.
 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.
 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.
 - e. Some seeds have structures that aid in dispersal by water, air, or animals.
 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
 - d. Why is there so much variation in flower shape, size and coloration?
 - e. 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.
 2. The angiosperm radiation resulted in two major lineages.
 - a. Monocots
 - b. Dicots
- IV. What are the key lineages in green plant evolution?
- A. Green Algae
1. Ulvobionta
 - a. A monophyletic group with about 4000 species that range from unicellular to multicellular
 - b. Habitat:
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impacts: Primary producers in freshwater and coastal marine environments
 2. Coleochaetales
 - a. 19 multicellular species that mostly grow as flat sheets.
 - b. Habitat:
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impact: Give scientists insight into how plants colonized land
 3. Charales
 - a. Several hundred multicellular species
 - b. Habitat:
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impacts: Provide food and shelter for fish, geese, and ducks
- B. Nonvascular Plants ("Bryophytes")
1. Hepaticophyta
 - 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:
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impacts: Contribute to initial soil production
 2. Anthocerotophyta (Hornworts)
 - a. Sporophytes have a hornlike appearance.

- b. Adaptations to land: stomata
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impacts: Some species harbor cyanobacteria that fix nitrogen.
3. Bryophyta (Mosses)
 - a. Form a large, diverse monophyletic group with over 12,000 species
 - b. Adaptations to land:
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impacts:
- C. Seedless Vascular Plants
1. Lycophyta (Lycophytes or Club Mosses)
 - a. 1000+ species of small plants that live on forest floor, or on tropical trees
 - b. Adaptations to land:
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impacts: Dominated the coal-generating forests during the Carboniferous period
 2. Psilotophyta (Whisk Ferns)
 - a. Only 6 distinct species that live in tropical regions.
 - b. Adaptations to land:
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impacts: Popular landscaping plants.
 3. Sphenophyta, or Equisetophyta (Horsetails)
 - a. 15 species that are abundant in wet habitats
 - b. Adaptations to land:
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impacts: Rich in silica granules that are used for scouring pots and pans
 4. Pteridophyta (Ferns)
 - a. Over 12,000 species that live mostly in tropical climates
 - b. Adaptations to land:
 - c. Reproduction:
 - d. Life cycle:
 - 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
 - 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)
 - 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
 4. Ginkgophyta (Ginkgoes)
 - a. Only one species living today.
 - b. Adaptations to land:
 - c. Reproduction:
 - d. Life cycle: Heterosporous
 - e. Human and ecological impacts: Ornamental and used in many landscapes.
 5. Coniferophyta (Conifers)
 - a. Comprised of familiar plants like pines, cedars, spruce, and so on
 - b. Adaptations to land:
 - c. Reproduction:
 - d. Life cycle:
 - e. Human and ecological impacts:
- E. Anthophyta (Angiosperms)
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.
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.

Chapter Vocabulary

green plants
herbivores
carnivores
omnivores

ecosystem
ecosystem services
artificial selection
bioprospecting
chemical prospecting
ethnobotanists

phyla
nonvascular plants
seedless vascular plants
seed plants
gymnosperms
flowering plants/angiosperms
annual
perennial
Arabidopsis thaliana

spores
cuticle
sporopollenin
sporangia/sporangium

guard cells
stomata
vascular tissue
tracheids
vessels
perforations

lignin
wood

alternation of generations
gametophyte
sporophyte
pollen grain
gametangia/gametangium
antheridium/antheridium
archegonium/archegonia
embryophytes
placental transfer cell
heterosporous
microsporangia
microspore
megasporangia
megaspores
homosporous
pollination

green algae
lichens
ulvobionta
Volvox
coleochaetales
charales
stoneworts

bryophytes
rhizoids
anthocerotophyta
hornworts

mosses
Sphagnum
lycophyta

club mosses
psilotophyta
rhizomes
epiphytes
sphenophyta
horsetails
Equisetum

pterophyta
ferns

gnetophyta
Ephedra
cycadophyta
ginkophyta
coniferophyta

anthophyta
angiosperm
adaptive radiation
monocots
dicots
cotyledons
eucots
Lemna gibba
flower
petals
sepals
fruit ovary
ovules
fruits
endosperm
double fertilization
nectar