Plant Diversity II

Chapter 30

- Objectives
  - Name five terrestrial adaptations that contributed to the success of seed plants.
  - Explain why pollen grains were an important adaptation for successful reproduction on land
  - List and distinguish among the four phyla of gymnosperms
  - Describe the life history of a pine; indicate which structures are part of the gametophyte generation and which are part of the sporophyte generation
  - Identify and describe the function of the following floral structures: sepals, petals, stamens, carpels, filament, anther, stigma, style, ovary, and ovule

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- Explain how fruits may be adapted to disperse seeds
- Diagram the generalized life cycle of an angiosperm; indicate which structures are part of the gametophyte generation and which are part of the sporophyte generation
- Explain the significance of Archaefructus and Amborella
- Describe the current threat to plant diversity caused by human population growth

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Introduction

- Seeds changed the course of plant evolution enabling their bearers to become the dominant producers in most terrestrial ecosystems
- In addition to seeds, the following are common to all seed plants
  - Reduced gametophytes
  - Heterospory
  - Ovules
  - Pollen

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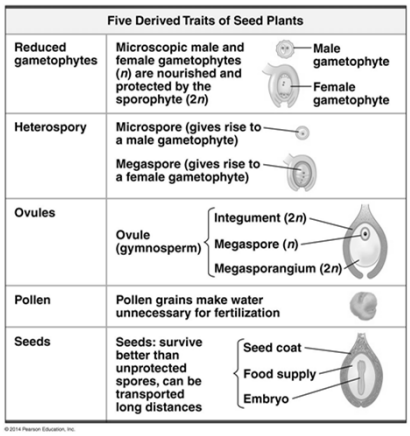

Advantages of Reduced Gametophytes

- The gametophytes of seed plants develop within the walls of spores retained within tissues of the parent sporophyte

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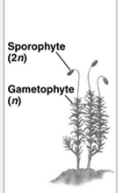
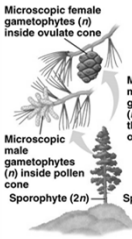
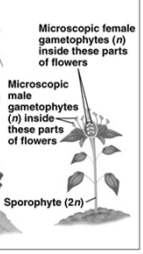
	PLANT GROUP		
	Mosses and other nonvascular plants	Ferns and other seedless vascular plants	Seed plants (gymnosperms and angiosperms)
Gametophyte	Dominant	Reduced, independent (photosynthetic and free-living)	Reduced (usually microscopic), dependent on surrounding sporophyte tissue for nutrition
Sporophyte	Reduced, dependent on gametophyte for nutrition	Dominant	Dominant
Example			Gymnosperm  Angiosperm 

Heterospory: The Rule Among Seed Plants

- Seed plants evolved from plants that had two distinct sporangia
  - megasporangia which produce megaspores that give rise to female gametophytes
  - microsporangia which produce microspores that give rise to male gametophytes

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Ovules to Seeds: An Evolutionary Advantage

- An ovule consists of a megasporangium, megaspore, and protective integuments
- Microspores develop into pollen grains which contain the male gametophytes of plants
  - Pollination is the transfer of pollen to the part of a seed plant containing the ovules
  - Pollen, which can be dispersed by air or animals eliminated the water requirement for fertilization
- A seed develops from the whole ovule
  - It contains a sporophyte embryo, along with its food supply, packaged in a protective coat

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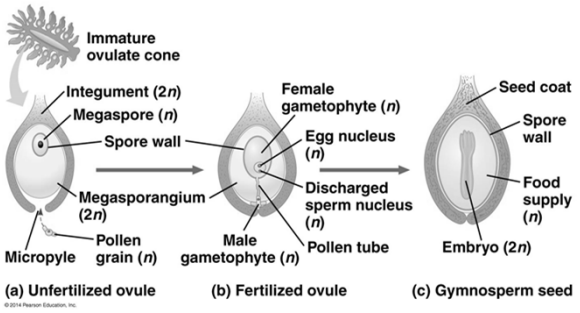

Gymnosperms

- Among the gymnosperms are many well-known conifers or cone-bearing trees, including pine, fir, and redwood
- The gymnosperms include four plant phyla
  - Cycadophyta (cycads)
  - Gingkophyta (one living species: Ginkgo biloba)
  - Gnetophyta (three genera: Gnetum, Ephedra, Welwitschia)
  - Coniferophyta (conifers, such as pine, fir, and redwood)

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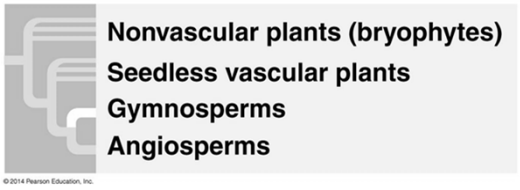

Gymnosperm Evolution

- Fossil evidence reveals that by the late Devonian some plants, called progymnosperms (example Archaeopteris), had begun to acquire some adaptations that characterize seed plants
- Gymnosperms appear early in the fossil record during the Carboniferous and dominated the Mesozoic terrestrial ecosystems

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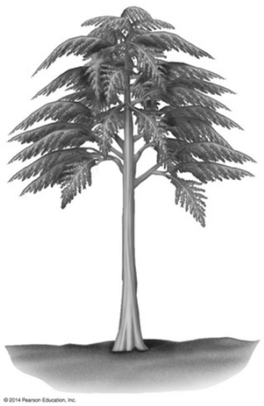

Phylum Cycadophyta

- Individuals have large cones and palmlike leaves
  - These thrived during the Mesozoic, but relatively few species exist today

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Phylum Cycadophyta

Cycas revoluta

Phylum Ginkgophyta

- This phylum consists of a single living species, Ginkgo biloba
  - It has a high tolerance to air pollution and is a popular ornamental tree

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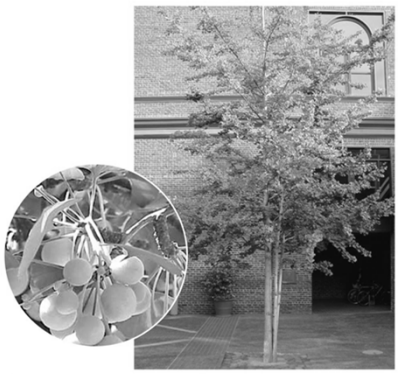
Phylum Ginkgophyta



Ginkgo biloba

Phylum Gnetophyta

- This phylum comprises three genera
- Species vary in appearance, and some are tropical whereas others live in deserts

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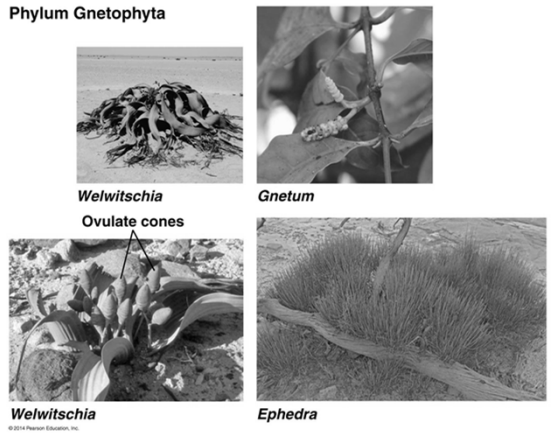

Phylum Coniferophyta

- Conifers largest division
  - Most are evergreens
    - pines, firs, spruces, larches, yews, junipers, cedars, cypresses, and redwoods
    - includes some of the extremes of all living organisms
      - tallest: redwoods
      - largest: giant sequoias
      - oldest: bristle cone pine

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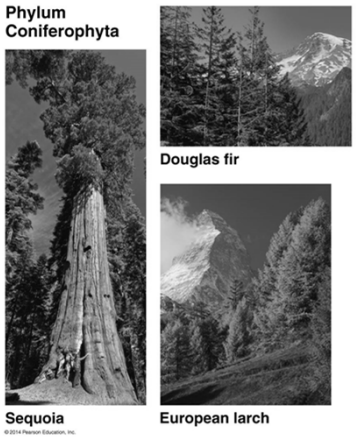

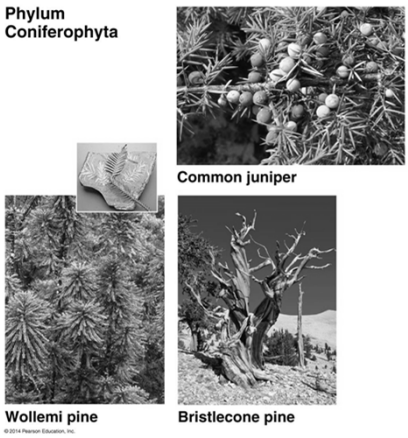

A Closer Look at the Life Cycle of a Pine

- Key features of the gymnosperm life cycle include:
  - Dominance of the sporophyte generation, the pine tree
  - The development of seeds from fertilized ovules
  - The role of pollen in transferring sperm to ovules

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- Conspicuous multicellular sporophyte
  - Pine tree is sporophyte
    - sporangia located on cones
- Multicellular gametophyte is reduced
  - Develops from spores which are retained in sporangia
    - male gametophyte is pollen grain; no antheridium
    - female gametophyte consists of multicellular nutritive tissue and archegonium that develops in ovule

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- Life cycle is heterosporous
  - Gametes develop from different types of spores produced by separate cones
    - most bear both cone types but on different branches
    - pollen (staminate) cones have microsporangia
      - cells in sporangia undergo meiosis → haploid microspores → pollen grains
    - ovulate cones have megasporangia
      - cells in sporangia undergo meiosis → large megaspores → female gametophyte
      - ovule includes megasporangium (nucellus) enclosed in integuments with single opening called micropyle

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- Requires nearly three years to complete life cycle
  - Windblown pollen falls on ovulate cone and enters ovule through micropyle
  - Pollen germinates in ovule and digests through nucellus
- Megaspore mother cell in nucellus undergoes meiosis → four haploid megaspores
  - One survives and grows by mitosis → immature female gametophyte

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- 2-3 archegonia develop within multicellular gametophyte
- Over one year after pollination, eggs are ready for fertilization
  - Two sperm cells have developed
  - Pollen tube has grown through nucellus to gametophyte

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- Fertilization occurs when one sperm nucleus unites with egg nucleus
  - All eggs may be fertilized but only one zygote develops into embryo
- Embryo has rudimentary root and several embryonic leaves
  - Embedded in female gametophyte which nourishes it until the embryo is capable of photosynthesis
  - Ovule develops into seed; consists of embryo (2n), food source (n), and surrounding seed coat (2n)

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- scales of ovulate cone open to release winged seed
  - Seeds that land in suitable habitat germinate

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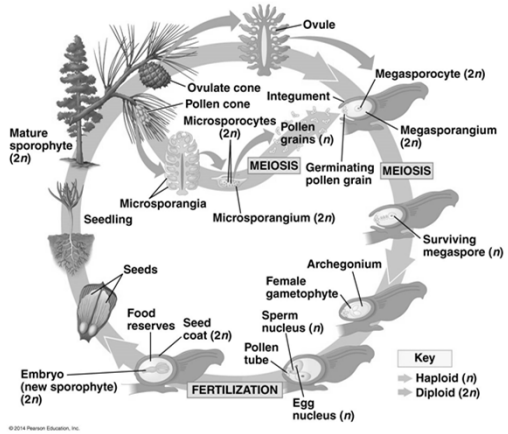

Angiosperms

- Angiosperms are commonly known as flowering plants
  - They are seed plants that produce the reproductive structures called flowers and fruits and are the most widespread and diverse of all plants

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Nonvascular plants (bryophytes)
Seedless vascular plants
Gymnosperms
Angiosperms

Characteristics of Angiosperms

- All angiosperms are classified in a single phylum, Anthophyta
  - The name comes from the Greek anthos, flower
- The key adaptations in the evolution of angiosperms are flowers and fruits

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Flowers

- The flower is an angiosperm structure specialized for sexual reproduction
  - A flower is a specialized shoot with modified leaves
    - Sepals, which enclose the flower
    - Petals, which are brightly colored and attract pollinators
    - Stamens, which produce pollen
    - Carpels, which produce ovules

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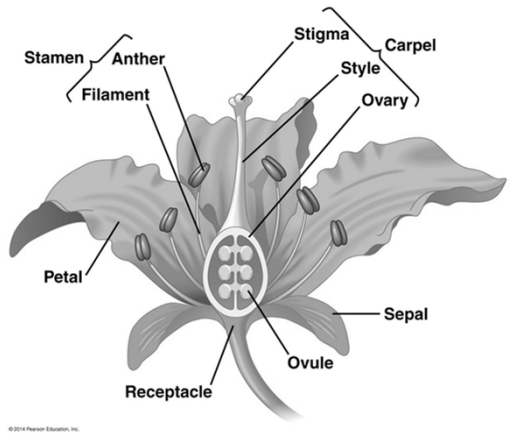

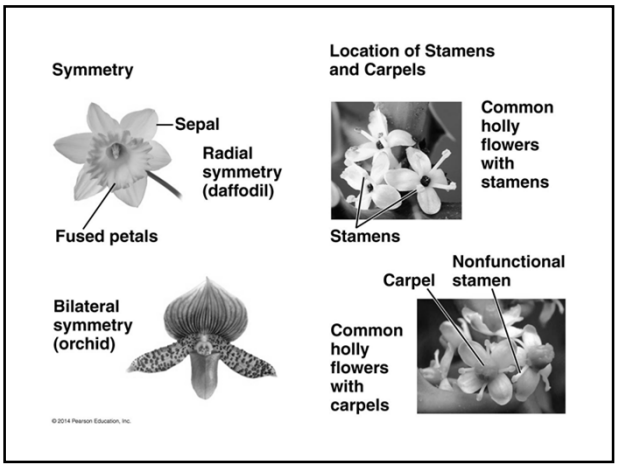

Fruits

- Fruits typically consist of a mature ovary
  - Fruits protect seeds and aid in their dispersal
  - Mature fruits can be either fleshy or dry

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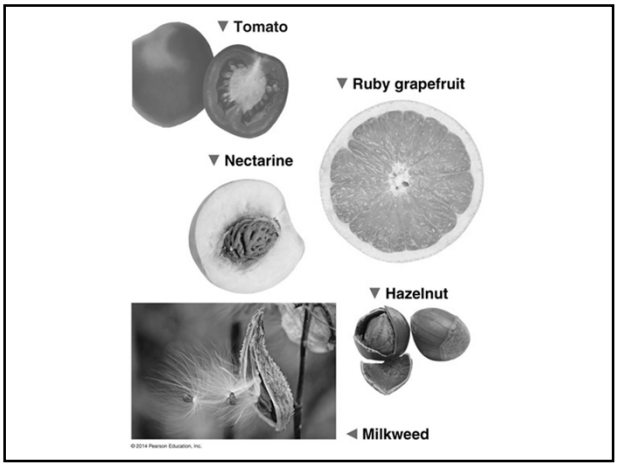

- Various fruit adaptations help disperse seeds
- Seeds can be carried by wind, water, or animals to new locations

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The Angiosperm Life Cycle

- In the angiosperm life cycle double fertilization occurs when a pollen tube discharges two sperm into the female gametophyte within an ovule
  - One sperm fertilizes the egg, while the other combines with two nuclei in the center cell of the female gametophyte and initiates development of food-storing endosperm
- The endosperm nourishes the developing embryo

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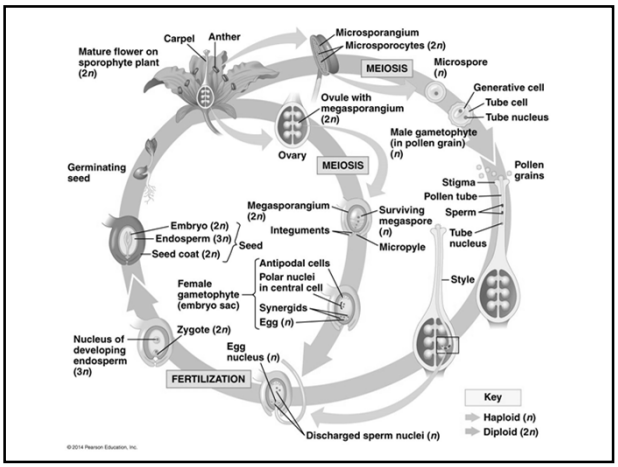

Angiosperm Evolution

- Clarifying the origin and diversification of angiosperms poses fascinating challenges to evolutionary biologists
- Angiosperms originated at least 140 million years ago
  - During the late Mesozoic the major branches of the clade diverged from their common ancestor

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Fossil Angiosperms

- Primitive fossils of 125-million-year-old angiosperms display both derived and primitive traits
  - Archaefructus sinensis, for example, has anthers and seeds but lacks petals and sepals

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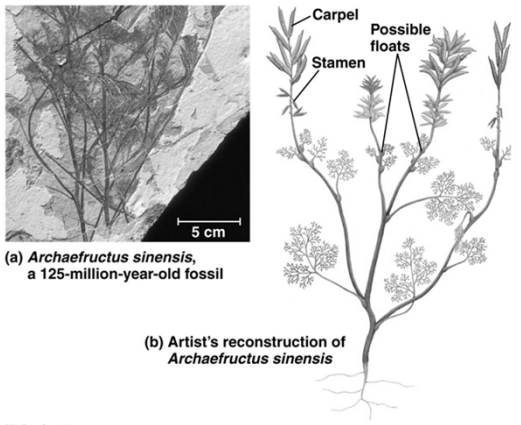

Angiosperm Phylogeny

- The ancestors of angiosperms and gymnosperms diverged about 305 million years ago
  - Angiosperms may be closely related to Bennettitales, extinct seed plants with flowerlike structures
  - Amborella and water lilies are likely descended from two of the most ancient angiosperm lineages

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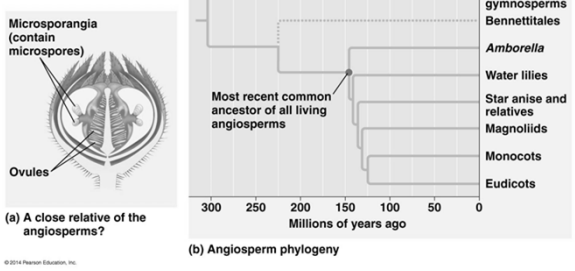

Developmental Patterns in Angiosperms

- Egg formation in the angiosperm Amborella resembles that of the gymnosperms
  - Researchers are currently studying expression of flower development genes in gymnosperm and angiosperm species

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Angiosperm Diversity

- The two main groups of angiosperms are monocots and eudicots
  - Basal angiosperms are less derived and include the flowering plants belonging to the oldest lineages
  - Magnoliids share some traits with basal angiosperms but are more closely related to monocots and eudicots

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Basal Angiosperms

- Three small lineages constitute the basal angiosperms
- These include Amborella trichopoda, water lilies, and star anise

Basal angiosperms

Water lily (*Nymphaea "Rene Gerard"*)

Star anise (*Illicium*)

Amborella trichopoda

Magnoliids

- Magnoliids include magnolias, laurels, and black pepper plants
- Magnoliids are more closely related to monocots and eudicots than basal angiosperms

Magnoliids

Southern magnolia (*Magnolia grandiflora*)

Monocots

- More than one-quarter of angiosperm species are monocots

Monocots

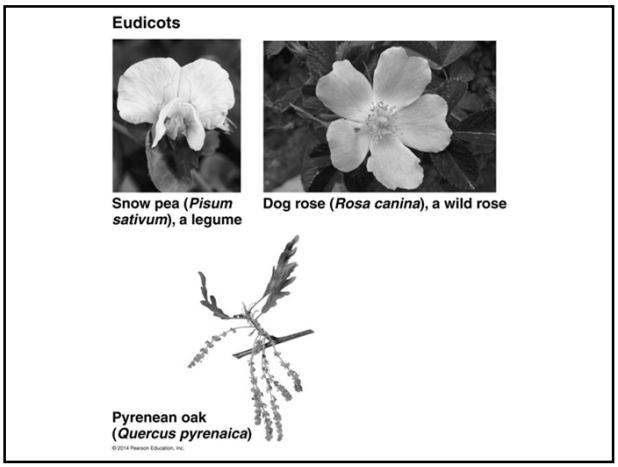
Orchid *(Lemboglossum rossii)*

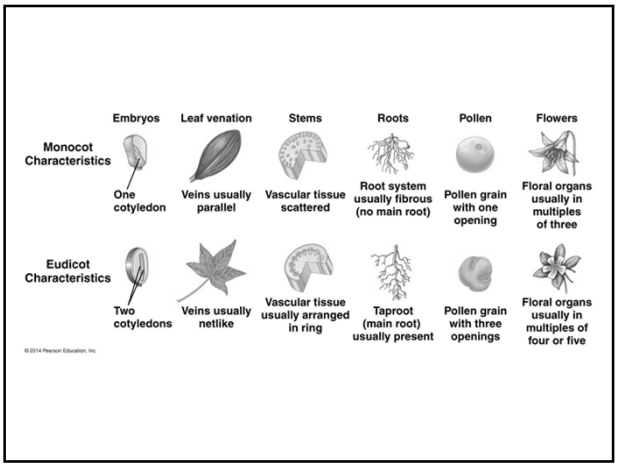
Pygmy date palm *(Phoenix roebelenii)*

Barley *(Hordeum vulgare)*, a grass

Eudicots

- More than two-thirds of angiosperm species are eudicots





Evolutionary Links Between Angiosperms and Animals

- Pollination of flowers by animals and transport of seeds by animals are two important relationships in terrestrial ecosystems

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(a) **A flower pollinated by honeybees.** This honeybee is harvesting pollen and nectar (a sugary solution secreted by flower glands) from a Scottish broom flower. The flower has a tripping mechanism that arches the stamens over the bee and dusts it with pollen, some of which will rub off onto the stigma of the next flower the bee visits.

(b) **A flower pollinated by hummingbirds.** The long, thin beak and tongue of this rufous hummingbird enable the animal to probe flowers that secrete nectar deep within floral tubes. Before the hummer leaves, anthers will dust its beak and head feathers with pollen. Many flowers that are pollinated by birds are red or pink, colors to which bird eyes are especially sensitive.

(c) **A flower pollinated by nocturnal animals.** Some angiosperms, such as this cactus, depend mainly on nocturnal pollinators, including bats. Common adaptations of such plants include large, light-colored, highly fragrant flowers that nighttime pollinators can locate.

- Clades with bilaterally symmetrical flowers have more species than those with radially symmetrical flowers
  - This is likely because bilateral symmetry affects the movement of pollinators and reduces gene flow in diverging populations

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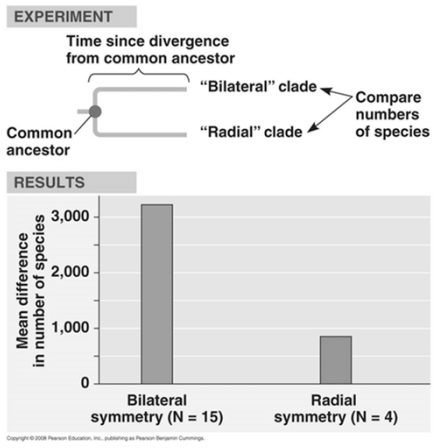

Plants and Humans

- Human welfare depends greatly on seed plants
  - No group is more important to human survival
- Humans depend on seed plants for
  - Food
  - Wood
  - Many medicines

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- Most of our food comes from angiosperms
  - Six crops (wheat, rice, maize, potatoes, cassava, and sweet potatoes) yield 80% of the calories consumed by humans
  - Modern crops are products of relatively recent genetic change resulting from artificial selection
- Secondary compounds of seed plants are used in medicines

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Table 30.1 Examples of Plant-Derived Medicines

Compound	Source	Use
Atropine	Belladonna plant	Eye pupil dilator
Digitalin	Foxglove	Heart medication
Menthol	Eucalyptus tree	Throat soother
Quinine	Cinchona tree	Malaria preventive
Taxol	Pacific yew	Ovarian cancer drug
Tubocurarine	Curare tree	Muscle relaxant
Vinblastine	Periwinkle	Leukemia drug

- Global impact
  - Plants transformed the atmosphere
    - decreased carbon dioxide
      - global cooling
      - terrestrial life more habitable

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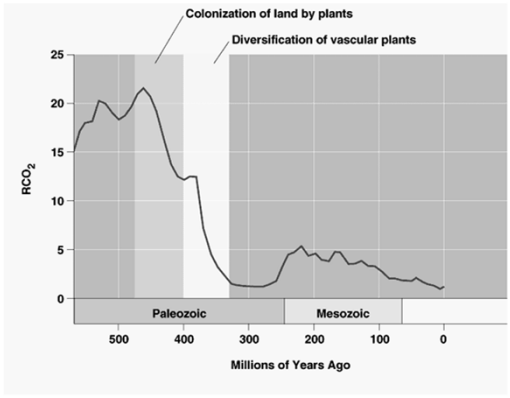

Threats to Plant Diversity

- Destruction of habitat is causing extinction of many plant species and the animal species they support
  - At the current rate of habitat loss, 50% of Earth's species will become extinct within the next 100–200 years

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