Chapter 30

Plant Diversity II: The Evolution of Seed Plants

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Overview: Transforming the World

- Seeds changed the course of plant evolution, enabling their bearers to become the dominant producers in most terrestrial ecosystems
- A **seed** consists of an embryo and nutrients surrounded by a protective coat

Concept 30.1: Seeds and pollen grains are key adaptations for life on land

- In addition to seeds, the following are common to all seed plants
  - Reduced gametophytes
  - Heterospory
  - Ovules
  - Pollen

Advantages of Reduced Gametophytes

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

Heterospory: The Rule Among Seed Plants

- The ancestors of seed plants were likely homosporous, while seed plants are heterosporous
- Megasporangia produce megaspores that give rise to female gametophytes
- Microsporangia produce microspores that give rise to male gametophytes

Ovules and Production of Eggs

- An **ovule** consists of a megasporangium, megaspore, and one or more protective **integuments**
- Gymnosperm megaspores have one integument
- Angiosperm megaspores usually have two integuments

Pollen and Production of Sperm

- Microspores develop into **pollen grains**, which contain the male gametophytes
- **Pollination** is the transfer of pollen to the part of a seed plant containing the ovules
- Pollen eliminates the need for a film of water and can be dispersed great distances by air or animals
- If a pollen grain germinates, it gives rise to a pollen tube that discharges two sperm into the female gametophyte within the ovule

The Evolutionary Advantage of Seeds

- A seed develops from the whole ovule
- A seed is a sporophyte embryo, along with its food supply, packaged in a protective coat
- Seeds provide some evolutionary advantages over spores:
  - They may remain dormant for days to years, until conditions are favorable for germination
  - They may be transported long distances by wind or animals

Concept 30.2: Gymnosperms bear "naked" seeds, typically on cones

- The gymnosperms have "naked" seeds not enclosed by ovaries and consist of four phyla:
  - Cycadophyta (cycads)
  - Gingkophyta (one living species: *Ginkgo biloba*)
  - Gnetophyta (three genera: *Gnetum, Ephedra, Welwitschia*)
  - Coniferophyta (conifers, such as pine, fir, and redwood)

Gymnosperm Evolution

- Fossil evidence reveals that by the late Devonian period some plants, called **progymnosperms**, had begun to acquire some adaptations that characterize seed plants

- Living seed plants can be divided into two clades: gymnosperms and angiosperms
- Gymnosperms appear early in the fossil record and dominated the Mesozoic terrestrial ecosystems
- Gymnosperms were better suited than nonvascular plants to drier conditions
- Today, cone-bearing gymnosperms called **conifers** dominate in the northern latitudes

Phylum Cycadophyta

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

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

Phylum Gnetophyta

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

Phylum Coniferophyta

- This phylum is by far the largest of the gymnosperm phyla
- Most conifers are evergreens and can carry out photosynthesis year round

The Life Cycle of a Pine: *A Closer Look*

- Three key features of the gymnosperm life cycle are:
  - Dominance of the sporophyte generation
  - Development of seeds from fertilized ovules
  - The transfer of sperm to ovules by pollen
- The life cycle of a pine provides an example

PLAY Animation: Pine Life Cycle

- The pine tree is the sporophyte and produces sporangia in male and female cones
- Small cones produce microspores called pollen grains, each of which contains a male gametophyte
- The familiar larger cones contain ovules, which produce megaspores that develop into female gametophytes
- It takes nearly three years from cone production to mature seed

Concept 30.3: The reproductive adaptations of angiosperms include flowers and fruits

- Angiosperms are seed plants with reproductive structures called flowers and fruits
- They are the most widespread and diverse of all plants

Characteristics of Angiosperms

- All angiosperms are classified in a single phylum, Anthophyta
- The name comes from the Greek *anthos*, flower

Flowers

- The **flower** is an angiosperm structure specialized for sexual reproduction
- Many species are pollinated by insects or animals, while some species are wind-pollinated

- A flower is a specialized shoot with up to four types of modified leaves:
  - **Sepals**, which enclose the flower
  - **Petals**, which are brightly colored and attract pollinators
  - **Stamens**, which produce pollen on their terminal **anthers**
  - **Carpels**, which produce ovules

- A carpel consists of an **ovary** at the base and a **style** leading up to a **stigma**, where pollen is received

PLAY Video: Flower Blooming (time lapse)

Fruits

- A **fruit** typically consists of a mature ovary but can also include other flower parts
- Fruits protect seeds and aid in their dispersal
- Mature fruits can be either fleshy or dry

PLAY Animation: Fruit Development

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

The Angiosperm Life Cycle

- The flower of the sporophyte is composed of both male and female structures
- Male gametophytes are contained within pollen grains produced by the microsporangia of anthers
- The female gametophyte, or **embryo sac**, develops within an ovule contained within an ovary at the base of a stigma
- Most flowers have mechanisms to ensure **cross-pollination** between flowers from different plants of the same species

- A pollen grain that has landed on a stigma germinates and the pollen tube of the male gametophyte grows down to the ovary
- The ovule is entered by a pore called the **micropyle**
- **Double fertilization** occurs when the 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 central cell of the female gametophyte and initiates development of food-storing **endosperm**
- The endosperm nourishes the developing embryo
- Within a seed, the embryo consists of a root and two seed leaves called **cotyledons**

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

Fossil Angiosperms

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

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

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

Angiosperm Diversity

- The two main groups of angiosperms are **monocots** (one cotyledon) and **eudicots** ("true" dicots)
- The clade eudicot includes some groups formerly assigned to the paraphyletic **dicot** (two cotyledons) group

- **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

Basal Angiosperms

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

Magnoliids

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

Monocots

- More than one-quarter of angiosperm species are monocots

Eudicots

- More than two-thirds of angiosperm species are eudicots

Evolutionary Links Between Angiosperms and Animals

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

PLAY Video: Bee Pollinating

PLAY Video: Bat Pollinating Agave Plant

Concept 30.4: Human welfare depends greatly on seed plants

- No group of plants is more important to human survival than seed plants
- Plants are key sources of food, fuel, wood products, and medicine
- Our reliance on seed plants makes preservation of plant diversity critical

Products from Seed Plants

- 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
- Many seed plants provide wood
- Secondary compounds of seed plants are used in medicines

Threats to Plant Diversity

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

You should now be able to:

1. Explain why pollen grains were an important adaptation for successful reproduction on land
2. List and distinguish among the four phyla of gymnosperms
3. Describe the life history of a pine; indicate which structures are part of the gametophyte generation and which are part of the sporophyte generation

You should now be able to:

4. Identify and describe the function of the following floral structures: sepals, petals, stamens, carpels, filament, anther, stigma, style, ovary, and ovule

5. Explain how fruits may be adapted to disperse seeds

6. 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

7. Explain the significance of *Archaefructus* and *Amborella*

8. Describe the current threat to plant diversity caused by human population growth