Kingdom Plantae

Characteristics
- chloroplasts with chlorophyll a & b, and carotenoids
- cellulose cell walls
- formation of cell plate during cell division
- starch used for carbohydrate storage

Life cycle - sporic meiosis or haplodiplonic or alternation of generations
- diploid stage (sporophyte) and haploid stage (gametophyte) are multicellular
- dominant stage varies between groups
- primitive plants - gametophyte is dominant
- advanced plants - sporophyte is dominant

Primitive plants have poorly developed systems for conducting fluids - nonvascular plants
- more advanced plants (vascular plants) have well developed xylem and phloem for conduction
Ten phyla of plants

Three nonvascular (without water conducting vessels)
  P. Bryophyta - mosses
  P. Hepaticophyta - liverworts
  P. Anthocerophyta - hornworts

Nine vascular
  Two seedless
    P. Pterophyta - ferns, whisk ferns, horsetails
    P. Lycophyta - club mosses
  Five seeded
    P. Coniferophyta - conifers
    P. Cycadophyta - cycads
    P. Gnetophyta - gnetophyta
    P. Ginkophyta - ginkgo
    P. Anthophyta - flowering plants - angiosperms

This group is called the gymnosperms
Characteristics of nonvascular plants

lack vessels for conducting water and foodstuffs throughout plant

Gametophytes green, nutritionally independent of, and more
conspicuous than sporophyte

Sporophyte attached to gametophyte, partially nutritionally dependent

Homosporous - spores of equal size

Require external water for fertilization, only common in moist places

In total about 24,700 species

Three Phyla -
Bryophyta (mosses),
Hepaticophyta (liverworts),
Antherocerophyta (hornworts)

collectively called the
“bryophytes”
Terms:
Sporophyte - a multicellular diploid organism that produces spores by meiosis - spores germinate and grow into gametophytes
Gametophyte - a multicellular haploid organism that produces gametes by mitosis can be either male or female, females produce eggs, males produce sperms, fusion of gametes produces a zygote that grow into a multicellular sporophyte
Antheridium - the sperm producing organ of a gametophyte
Archegonium - the egg producing organ of a gametophyte
Homosporous - spores (produced by meiosis) are indistinguishable in size and may give rise to either male or female gametophytes
Heterosporous - spores differ in size
- megaspores produce megagametophytes, which produce eggs
- microspores produce microgametophytes, which produce sperms
Fusion of an egg and sperm produces a zygote that can grow into a multicellular sporophyte

Phylum Bryophyta - mosses
Gametophytes small, spiral or alternate arranged leaves on central axis
Sporophytes grow as stalk from gametophyte
Anchored to substrate by rootlike rhizoids
Consists of several cells that absorb water
- Leaves superficially resemble true leaves
  - green, flattened blade, slightly thickened midrib
  - one cell thick, lack vascular strands and stomata
- Most water used by plant travels up on outside of plant, via capillary action
- Some have specialized food conducting cells
Can withstand long periods of drying
Most abundant plants in Arctic and Antarctic, rare in deserts
Mosses are sensitive to pollutants
Poor competitors in environments favorable to growth of higher plants
Other “bryophytes”

Phylum Hepaticophyta - Liverworts

- similar reproduction to mosses

Phylum Anthocerotophyta - Hornworts

- among earliest land plants
- Sporophyte has stomata, is photosynthetic, and provides much of plant’s energy.
Vascular Plants - have vessels (tubes composed of elongated or cylindrical cells) for conducting water and food
xylem - conducts water from roots to leaves
phloem - conducts carbohydrates in solution from areas of photosynthesis (leaves) to support nonphotosynthetic areas roots, growing shoots, etc.
have a waxy cuticle over leaves to prevent water loss

have stomata (pores) in leaves for gas exchange

all have greater importance and increased size of sporophyte in life cycle than seen in bryophytes

Vascular plants divided into seedless and seeded
seed - resistant structures suited to protect an embryo from drought.

Seedless Vascular Plants -
increased importance of sporophyte in life cycle
large sporophyte nutritionally independent of small gametophyte
most are homosporous, spores produce gametophytes that produce sperm in antheridia and eggs in archegonia swimming sperm, require water for fertilization

Two Phyla
Pterophyta (ferns, whisk ferns, horsetails)
  11,000 spp.
Lycophyta (club mosses)
  1150 spp.
**Phylum Pterophyta** - the ferns, whiskferns, horsetails

**Ferns:** both sporophyte and gametophyte are photosynthetic
sporophyte is large with leaves (fronds)
gametophyte (prothallus) is small, one cell thick, heart-shaped
sporophyte has well developed roots, stems, and leaves
stems are underground - called rhizomes
leaves develop from rhizomes - “fiddleheads” - coiled leaves
leaves can possess spore producing sporangia
sporangia are commonly found in clusters (sori)
a cap (indusium) commonly covers immature sorus

**Fern reproduction:**
sporangia produce spores, germinate to produce prothalli,
prothalli produces eggs in archegonia, sperms in antheridia
sperm swim to eggs for fertilization,
sporophyte grows from archegonium as gametophyte dies
Whisk Ferns
remnants of earliest vascular plants
sporophyte consists of branching green stems
lack roots or leaves
Gametophytes found in soil beneath sporophytes
  Colorless, filamentous form
  Have saprobic or parasitic associations with fungi to obtain nutrients

Horsetails
Commonly called scouring rushes, “cajun kudzu”
A single genus, Equisetum
worldwide, mostly in damp places
Sporophytes are ribbed, jointed stems
Arise from underground rhizomes
Whorl of scalelike leaves at each stem node
Stems are hollow, contain silica deposits in epidermal cells
Two groups - branched and unbranched
  branched form resembles a horse's tail
Spores have two ribbonlike elaters (wings)
  aid in spore dispersal when dry
  curl around spore when damp
Gametophytes are small
  Numerous flagellated sperm swim to archegonia
**Phylum Lycophyta: Club Mosses**
Worldwide, most common in tropics & moist temperate regions
Resemble mosses, clearly different in internal structures
Sporophytes have leafy stems
*Lycopodium* is typical
Sporangia produced in cone-like clusters on stems or in upper leaves
Leaves (microphylls) are short, linear and in whorls or spirals
*Lycopodium* gametophytes are tiny and carrot-shaped

some club mosses are used as ornaments (e.g. resurrection plant) many are now endangered species

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**Seed Plants**
first appear in fossil record in rocks dating to about 425 million years old -
Seeds: have protective seed coat, protects embryo from drying out, from predators, provides for food storage for embryonic plant, many have adaptations for dispersal

All heterosporous, gametophyte dependent upon sporophyte
Microgametophytes are called pollen and contain sperm
Megagametophytes are multicellular, contain an egg, and are found within an ovule on the sporophyte
Pollination precedes fertilization and fertilization may be delayed

Divided into two informal groups
gymnosperms (naked seeds) - ovule not enclosed in sporophyte tissue when first formed (ovule is naked)
angiosperms (covered seeds) - ovule enclosed in sporophyte tissue when first formed (ovule is enclosed)
Gymnosperms comprise 4 phyla
Coniferophyta (conifers) - 601 spp.
Cycadophyta (cycads) - 206 spp.
Gnetophyta (gnetophytes) - 65 spp.
Ginkophyta (ginkgo) - 1 sp.

Ovule rests on exposed scale - “naked”

Seed may be covered with sporophyte tissue at maturity

Sperm may be flagellated but is delivered within pollen grain

Phylum Coniferophyta - the conifers
Includes pine, spruce, fir, hemlock and cypress
Redwood is tallest plant, bristlecone pine is oldest
Found in cooler, temperate, drier regions of world
Great economic value, timber, paper, resins, turpentine
One hundred species native to northern hemisphere

Most have needle-like leaves, in clusters of two to five needles - tough needles retard loss of water
have resins that deter insect and fungal attack
Wood consists primarily of tracheids
Lack vessels or fibers
absence of fibers causes wood to be "soft"
Thick bark is an adaptation to survive fires and subzero temperatures
**Conifer reproduction:**

- **Heterosporous**
- Pollen grains produced in male cones, cluster at tips of lower branches
- Male cones composed of small, papery scales arranged in spiral or whorl
- Pair of microsporangia form within each scale
- Microspore mother cells undergo meiosis, form four microspores
- Microspores develop into 4-celled pollen grains with pair of air sacs

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**Conifer reproduction:**

- Female cones produced on upper branches
- Larger than male cones, scales become woody at maturity
- Two ovules develop toward base of each scale
- Ovule contains megasporangium embedded in nutritive nucellus
- Nucellus completely surrounded by thick integument, opening called micropyle
- One integument layer becomes seed coat
- Single megaspore mother cells undergoes meiosis, forms row of four megaspores
- Three break down, one develops into female gametophyte
- Each gametophyte produces two to six archegonia, each contains an egg
**Conifer reproduction:**
Female cones may take two or more years to mature
During first spring are green, with scales spread apart
Pollen grains carried by wind, catch on fluid oozing out of micropyle
Pollen grains drawn through micropyle to top of nucellus
Scales then close
Archegonia and other female parts not mature for another year
Pollen tube emerges from pollen grain at bottom of micropyle
Digests through nucellus into archegonia

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**Conifer reproduction:**
Pollen's generative cell divides by mitosis, one cell divides again
Last two cells function as sperm
Mature male gametophyte is germinated
pollen grain = pollen tube + two sperm
In 15 months pollen tube reaches an archegonium
Discharges contents into it
One sperm unites with egg forming zygote
Other sperm and other cells degenerate

Zygote develops into embryo within a seed
Seed disperses, germinates, grows into new sporophyte tree
Phylum Cycadophyta: Cycads
Slow growing, found in tropics and subtropics
Cycads resemble pines, ferns and palms

Reproduction
Produce cones, have life cycle similar to pines
Female cones develop upright among leaf bases
Sperm have thousands of spirally arranged flagella
Sperm conveyed to archegonium by pollen tube
Several species facing extinction
Sago palm is used in landscaping
Phylum Gnetophyta: Gnetophytes
Closest living relative of angiosperms
They are the only gymnosperms with vessels in their xylem
Gnetophytes differ greatly from one another
*Welwitschia* stem shaped like large, shallow cup
Tapers into tap root
Two strap-shaped, leathery leaves that grow continuously
Reproductive structures are cone-like, appear at bases of leaves
Produced on separate male and female plants
*Ephedra* comprises more than 35 species
Common in arid regions of U.S and Mexico
Shrubby plants with jointed stems, scalelike leaves at each node
Natural source for drug ephedrine

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Phylum Ginkgophyta: Ginkgo
Fossils show species once widely distributed
Only one species remains: *Ginkgo biloba*
Historically found in Japan and China
Commonly used in landscaping but no longer exists in wild
Fan-shaped leaves resemble leaflets of fern
Reproductive features
- Sperm have flagella
- Reproductive structures produced on separate trees
- Fruits have foul odor
- Male plants generally planted, propagated from shoots
- Very resistant to air pollution, often planted in cities
Angiosperms - one phylum

**Phylum Anthophyta** - flowering plants - 250,000 spp.
Flowers, heterosporous, double fertilization
ovule and seeds enclosed in sporophytic tissue - carpel
at maturity carpels form fruit around seed

Great variety:
huge trees, tiny duckweed,
microscopic seeds to
coconuts
mostly photosynthetic
autotrophs, some parasitic

**Flower structure:**
modified stems bearing modified leaves
base is pedicel, with receptacle, to which all other parts attach
four whorls of modified leaves: calyx composed of sepals,
corolla composed of petals,
androecium composed of stamens,
gynoecium composed of carpels or pistils

Ovary completely encloses ovule
Stigma is to accept pollen
Anther produces pollen
Many flowers produce nectar
**Angiosperm life cycle**

Megaspore mother cell produces four cells via meiosis
Three disintegrate, one survives, divides mitotically
Each daughter nucleus divides twice resulting in eight haploid nuclei - arranged in two groups of four
One nucleus from each group migrates to center - polar nuclei
Cell membranes and walls form around remaining nuclei
Cell closest to micropyle functions as egg - others called synergids

Integument layers become seed coat - with small opening - micropyle

The mature female gametophyte is called an embryo sac - with eight nuclei in seven cells

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**Angiosperm life cycle**

Male gametophyte develops in the anthers
Anthers have four patches of tissue
Each patch composed of many diploid microspore mother cells
Undergo meiosis to produce four microspores each
Nucleus of each divides once by mitosis
Two layered wall develops around each microspore
Binucleate microspores are now pollen grains
Outer layer called exine, sculpted, contains chemicals
May also have apertures through which pollen tube may emerge
Pollination:
The movement of pollen from the anther to the stigma
Pollen grain contains two nuclei:
tube nucleus
generative nucleus
Tube nucleus begins formation of pollen tube - extends into style
Generative nucleus follows and divides to form two sperm nuclei - pollen now considered mature gametophyte
Tube nucleus enters embryo sac at micropyle
Sperm nuclei follow

Double fertilization:
One sperm nucleus fuses with egg to form zygote
The other sperm nucleus fuses with both polar nuclei to form triploid (3N) endosperm nucleus
Endosperm multiplies to serve as nutrition for developing embryo

Seed consists of:
diploid embryo - derived from a sperm and egg
triploid endosperm - derived from a sperm and two polar nuclei
diploid seed coat - derived from sporophyte parent

Fruit develops from ovary - is derived from sporophyte parent
Angiosperm success:

First appeared about 200 million years ago (Jurassic) and became dominant plant group by the end of the Cretaceous (70 million years ago).

First pollinating insects appeared about 50 million years ago.

Flowers attract pollinators and allow more efficient dispersal of pollen.

Fruits protect seeds and aid in seed dispersal.

Endosperm provides additional nutrition for developing embryo.
### Classes of Angiosperms:

**Class Monocotyledonae** - “monocots” - 65,000 spp. - lilies, grasses, palms, agaves, yuccas, orchids, irises, bananas

**Class Dicotyledonae** - “dicots” - 175,000 spp. - most familiar flowering plants - most trees and shrubs, most familiar flowers and garden plants

<table>
<thead>
<tr>
<th>Monocots:</th>
<th>Dicots:</th>
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</thead>
<tbody>
<tr>
<td>one cotyledon - “seed leaf”</td>
<td>two cotyledons</td>
</tr>
<tr>
<td>parallel venation in leaves</td>
<td>netted venation in leaves</td>
</tr>
<tr>
<td>lateral meristems rare - no lateral growth</td>
<td>lateral meristems common</td>
</tr>
<tr>
<td>flower parts in multiples of 3</td>
<td>flower parts in multiples of 4 or 5</td>
</tr>
<tr>
<td>few annual species</td>
<td>many annual species</td>
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<tr>
<td>many with bulbs or underground storage organs</td>
<td>few underground storage organs</td>
</tr>
<tr>
<td>no true wood (secondary xylem)</td>
<td>true wood in many species</td>
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</tbody>
</table>