Angiosperms: Phylum Anthophyta, the flowering plants

1. Overview of seed plant evolution
2. Traits of flowering plants
3. The angiosperm life cycle
4. Pollen and seed (fruit) dispersal

Figure 38.2 Simplified overview of angiosperm life cycle

Figure 38.4 Development of angiosperm gametophytes

Figure 38.6 Growth of the pollen tube and double fertilization

Figure 38.7 The development of a dicot plant embryo
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Pollination: getting pollen to the stigma

- Required for sexual reproduction in plants: pollination allows fertilization to take place. What are the potential advantages and disadvantages of sexual reproduction?

- A huge variety of adaptations have evolved in plants to ensure successful pollination, including biotic (via animals) and abiotic (via wind or water) mechanisms

Sexual vs. asexual reproduction

- Key potential advantage of sex: genetic variation in the offspring, which could allow some to survive when faced with a rapidly changing environment (such as rapidly evolving diseases or a changing climate)

- Potential disadvantages of sex:
  - Only half of the population (females) can produce offspring. In an asexual species, all individuals can reproduce, by cloning themselves
  - Sexual structures (e.g. flowers) are often costly
  - Pollination can sometimes be difficult, if animal pollinators or wind are not available, or if other members of the species are sparse
  - Sex can break up successful genotypes: offspring may be less-suited for the current environment than are the parents
Ways to reproduce and avoid the disadvantages of sexual reproduction

1. Self-pollination or “selfing.” This is sexual reproduction (i.e. it involves meiosis and fertilization), but offspring from selfing are genetically very similar to the parent.

2. Asexual reproduction, or cloning. Only mitosis is involved, and offspring are genetically identical to the parent (unless mutations occur during DNA replication).

Mechanisms for avoiding self-pollination in sexual reproduction

1. Being dioecious: male and female parts on separate plants.
2. In monoecious plants, with separate male and female flowers on the same plant, these flowers mature at different times or are physically separated.
3. Dichogamy: stamens and carpels mature at different times on the same flower.
4. Stamens and carpels are physically separated in the same flower.
5. Genetic self-incompatibility: pollen will not successfully fertilize if its self-sterility genes match those of the recipient plant.

Genetic basis of self-incompatibility. Pollen germination only occurs when the self-compatibility alleles of the pollen grain and the receiving plant do not match.

Pollination ecology

- 2 main modes of dispersal for pollen: abiotic (mostly wind but also water) and biotic (usually animals such as insects, birds, and bats).
- These 2 strategies are thought to have different advantages in different environments.

Wind pollination

- May be advantageous in habitats that lack reliable animal pollinators, such as a newly-colonized habitat.
- More common in open habitats and at higher latitudes and elevations, with low humidity and rainfall.
- Feathery stigmas and long stamens.
- Pollen grains abundant, small, and smooth.
- Flowers usually lack nectar, fragrance, and petals, and are unisexual.
- Most grasses, and many trees (such as birches, and most gymnosperms).
Inflorescences of hazel (Corylus avellana), a wind-pollinated plant. The male inflorescences are long and dangle downward, and the female inflorescences are smaller and exhibit feathery stigmas. (Inflorescence = a cluster of flowers)

**Biotic (animal) pollination**
- Only advantageous in habitats that have reliable animal pollinators, such as bees
- Common in a wide variety of habitats, from dry to moist, tropical to temperate
- Simple stigmas and variable stamens
- Pollen grains less abundant, variable in size, and often with elaborate ornamentation
- Flowers usually have nectar, fragrance, and a showy perianth (petals and/or sepals), and are usually bisexual

**Pollination “syndromes” in flowers**
- Some flowering plant species have evolved specific morphologies that attract certain kinds of animal pollinators
- However, remember that many important pollinators (such as honey bees) are generalists, i.e. they associate with many different kinds of plant species, and many plant species attract a variety of pollinators

**Examples of pollinator-specific flower morphologies**
- Hummingbird-pollinated: red, odorless, with long corolla tube and copious nectar
- Moth or bat-pollinated: white, with strong sweet odor emitted only at night
- Bee-pollinated: brightly-colored yellow or blue petals with distinct markings, and a landing platform
- Fly-pollinated: dark red-brown color with foul odor (like rotting flesh)

Many orchids (plant family Orchidaceae) have evolved very specific pollination relationships with bees. For example, some mimic the body and pheromones of female bees, to attract the males as pollinators.

**Layers of the pericarp**
- Exocarp: outermost “skin”
- Mesocarp: in the middle
- Endocarp: innermost layer, closest to the seed
Fruit and Seed dispersal

- Fruits protect seeds during development and sometimes aid in their dispersal
- Fleshy fruits or seeds are adapted to animal dispersal
- Dry fruits can be adapted to air or water dispersal, animal dispersal, or to release the seeds at maturity
- Seeds themselves often have their own dispersal-adapted morphology, and adaptations for survival and germination

2 main kinds of fruit: dry vs. fleshy

Figure 38.9 Classification of Fleshy Fruits

- There are 3 main kinds of simple fruits...

Pome: develops from flower with inferior ovary and compound pistil. Receptacle / floral tube becomes major fleshy part of the fruit.

Dry fruits: dehiscent vs. indehiscent.

Dehiscent fruits split open at maturity

Indehiscent fruits do not split open at maturity
The seeds of many plants have elaiosomes—fleshy attachments which attract ants. Ants carry the seeds back to their nests, eat the elaiosome, and often discard the seed. (One example is our native wild ginger, Asarum caudatum)

Seed adaptations for survival and germination

- Many seeds exhibit dormancy, a temporary condition of low metabolism and no growth or development. Some seeds can survive like this for decades or more. What are the potential benefits of dormancy?
- Dormancy in some seeds is simply broken by favorable environmental conditions, but others only germinate after specific cues
- What would you expect the cues to be for seeds living in deserts, fire-prone habitats (such as California chaparral), or at high latitudes? How about for seeds borne in berries eaten by mammals?
Land Plant Lifecycles: all have...

- Alternation of gametophyte (n) and sporophyte (2n) generations
- Sporophyte (2n) produces spores (n) through meiosis
- Spores (n) grow into gametophyte (n)
- Gametophyte (n) makes gametes (eggs or sperm, both n) through mitosis
- Gametes (n) fuse to form zygote (2n) through fertilization, zygote (2n) grows into sporophyte (2n)

Land Plant Lifecycles: differences...

- Which generation (sporophyte/gametophyte) is dominant: larger, longer lived?
- Is the other generation dependent or independent?
- Homosporous or heterosporous?
- Is free water required for fertilization?
- Is the embryo (young sporophyte) enclosed in a seed?
- Is the seed produced by a flower? Enclosed in a fruit? Is there double fertilization?

Gymnosperm vs. Angiosperm

- Seeds
  - Food Supply: Haploid
  - Female Gametophyte
  - Embryo: Diploid
  - Seed Coat: Diploid
  - Food Supply: Triploid
  - Endosperm

- Bryophytes
  - 8 shared, derived traits of land plants
  - Life cycle characteristics of bryophytes
  - Where to find sporophytes in mosses, liverworts
  - Gemmae and asexual reproduction in liverworts
  - Basic ecology of bryophytes: where do they live? How big are they?

Seedless Vascular

- Significance of lignified vascular tissues
- True roots, stems, and leaves (know about microphylls vs. megaphylls)
- First forests during Carboniferous
- Which groups are homosporous vs. heterosporous
- Sori vs. strobili
- Basic seedless vascular plant ecology
- Ecological advantages of the seed
- Fern life cycle

Gymnosperms

- Ecological advantages of the seed (and pollen)
- Be able to distinguish ginkgos, cycads, gnetophytes, and conifers; know the important characters of each group
- Ecology of early gymnosperms, environmental conditions favoring gymnosperms over seedless plants
- Modern diversity and ecological place of conifers
- Pine life cycle
### Angiosperms

- Traits distinguishing angiosperms from gymnosperms
- Parts of the flower
  - Be careful: ovule vs. ovary vs. carpel
- Double fertilization: what it results in, what its advantage is over single fertilization
  - Be careful: endosperm vs. fruit flesh
- Monocots vs. dicots
- Flower terminology

### Review of flower terminology

- 4 floral organs: sepal, petal, stamen, carpel
  - Also: ovule vs. ovary, parts of carpel
- radial vs. bilateral symmetry
- complete vs. incomplete flowers
- bisexual (perfect) vs. unisexual (imperfect) flowers
- monoecious vs. dioecious plants
- inflorescences and composite flowers
- ovary position

### Angiosperms

- Angiosperm life cycle, double fertilization
  - Be careful about megaspore mother cell vs. megaspore
  - Recognize stages as coming before/after meiosis, fertilization
- Advantages and disadvantages of sexual vs. asexual reproduction, environments favoring each
- Advantages and disadvantages of selfing, mechanisms to avoid selfing
- Biotic vs abiotic pollen dispersal, advantages of each; pollination syndromes

### Angiosperms

- Fruits vs. seeds (ovaries vs. ovules)
- Fruit types
- Ecology of fruit dispersal
- Advantages of seed dormancy, cues and mechanisms for breaking dormancy
- Germination process, roles of the radicle and hypocotyl/cotyledon