BLY 122 C. S. Major

Chapter 40 Plant reproduction

I. An Introduction to Plant Life Cycles

A. Sexual Reproduction in Angiosperms

1. Sexual reproduction involves two processes.
   a. Meiosis—a reduction division that generates haploid gametes.
   b. Fertilization—fusion of gametes.
      (1) Male gametes are sperm.
      (2) Female gametes are eggs.
   c. Gametes are formed in flowers. (**Fig. 40.1**)
2. Location of male and female reproductive organs is variable.
   a. Flowers with both male and female organs are perfect.
   b. Flowers with either male or female organs are imperfect.
   c. In monoecious plants, separate male and female flowers are located on the same plant. (**Fig. 40.2a**)
   d. In dioecious plants, male and female flowers are located on different plants. (**Fig. 40.2b**)

B. Plant Life Cycles—an Alternation of Generations

1. Two multicellular generations comprise the plant life cycle.
   a. The generation composed of diploid cells is the sporophyte.
      (1) Cells in the sporophyte generation undergo meiosis and produce haploid spores; this occurs in sporangia.
      (2) Spores divide by mitosis to form the multicellular gametophyte generation; this occurs in gametangia.
   b. The generation composed of haploid cells is the gametophyte.
      (1) Cells in the gametophyte generation produce gametes by mitosis.
      (2) One gamete must fuse with another gamete to form a diploid zygote that develops into the sporophyte generation.
2. Relationship between the generations varies between plant groups.
   a. In mosses and liverworts the sporophyte generation is small, short-lived, and dependent on the gametophyte for nutrients. (**Fig. 40.3a**)
   b. In flowering plants the gametophyte generation is small, short-lived, and dependent on the sporophyte for nutrients. (**Fig. 40.3b**)

C. Asexual Reproduction

1. Asexual reproduction leads to new individuals without meiosis and fertilization.
2. Offspring produced are clones—genetically identical to the parent plant.
   a. Same pairs of alleles are found in same combinations as in parents.
   b. No new alleles are introduced from other individuals.
3. Asexual reproduction is efficient and rapid.
   a. Asexually produced offspring can grow quickly and fill niches before competitors arrive.
   b. Parent plant can provide nutrients for early development.
4. Plants reproduce asexually in various ways.
   a. Rhizomes are horizontal underground stems with nodes that produce shoots and roots. (**Fig. 40.4a**)
   b. Corms are belowground stems that form new individuals. (**Fig. 40.4b**)
   c. Plantlets are formed from meristematic tissue on leaf margins of some plants (**Fig. 40.4c**)
5. Genetic similarity of asexually produced individuals makes them more vulnerable to disease-causing agents.

II. Initiation of Flowering—Depends on External and Internal Signals

A. External Cues

1. Effect of day length
    a. Important cue in latitudes away from equator
    b. Has no role in flower initiation in equatorial regions
2. Moisture plays a significant role, especially when day length is not a cue.

B. Internal Cues
    1. Hormones (**Box 40.1, Fig. 40.5**)
    2. Nutritional status

C. Example: *Arabidopsis thaliana* flowering is normally triggered by long days, but the same plants exposed to short days will flower when treated with gibberellin.

III. Flower Anatomy

A. Flowers are composed of four basic parts. (**Fig. 40.6**)
    1. Sepal—outermost whorl of floral parts arranged around the receptacle
        a. Green, slightly thickened leaflike structures
        b. May protect young buds from damage
    2. Petals—collectively called the corolla
        a. Brightly colored parts arranged in whorl interior to sepals
        b. Advertise flower to animals (**Fig. 40.7**)
        c. May have nectary with sugary nectar gathered by animals
    3. Stamens—male reproductive structures
        a. Anther—terminal portion of stamen where meiosis occurs and male gametophytes form (**Fig. 40.9**)
            (1) Products of meiosis in anther are haploid microspores.
            (2) Microspores divide once to form two-celled pollen grain.
            (3) Pollen grain is composed of a generative cell and a vegetative cell.
            (4) Pollen grain is the male gametophyte.
        b. Filament—stalk that supports the anther
    4. Carpels—female reproductive structures
        a. Stigma—terminal portion of carpel
        b. Style—stalk of the carpel
        c. Ovary with one or more ovules inside
        d. Ovule is location of meiosis and female gametophyte formation. (**Fig. 40.8**)
            (1) Progenitor cell divides by meiosis to form four haploid megaspores.
            (2) Three megaspores degenerate, leaving one haploid megaspore.
            (3) The single remaining megaspore divides mitotically to form an eight-nucleate, 7-celled female gametophyte, also called the embryo sac.
            (4) The egg cell is located at the base of the embryo sac near an opening, the micropyle.
            (5) Two polar nuclei are located at the center of the embryo sac.

IV. Pollination and Fertilization

A. Pollination is the transfer of pollen from anther to stigma.
    1. Male gametophyte and female gametophyte are brought together.
    2. Self-pollination, a type of inbreeding, refers to the fusion of gametes from the same individual.
        a. Self-pollination has advantages and disadvantages.
        b. Some plants genetically block self-pollination to ensure outcrossing. (**Box 40.2; Fig. 40.10**)
            (1) Species with pollen grains that are unable to germinate on the stigma of the same flower are self-incompatible.
            (2) Self-incompatibility eliminates inbred offspring with poor fitness.
        c. Outcrossing occurs when gametes from different individuals of the same species fuse.
    3. Animals, especially insects, are common vectors that transfer pollen from one individual to another.
    4. Relationship between animal pollinators and flowers is mutualism.

a. Pollinators obtain reward in form of pollen, nectar, or both.
b. Probability of outcrossing is increased in plants whose male gametophytes are transferred to different individuals.
5. Some plants use "deceit pollination" to trick pollinators without receiving a reward. (**Essay**)
6. Pollination by wind occurs in conifers and some angiosperms.

B. Pollination was an important innovation in plant evolution.
1. The first lineages of plants to evolve had flagellated male gametes that swam to the female gamete. (**Fig. 40.11**)
2. Extant mosses, liverworts, ferns, and other plant groups that require water for fertilization are dependent on wet habitats.
3. The evolution of pollination enabled plants to colonize and survive in drier environments.
4. Pollination by animals made sexual reproduction a more precise and more efficient process.
5. Insect pollination is associated with the evolution of new flower and insect species.
a. Alpine skypilot populations that grow above timberline have large flowers, long stalks, sweet odor, and are pollinated by bumblebees. (**Fig. 40.12**)
b. Alpine skypilots that grow at or below timberline have small flowers, short stalks, "skunky" odor, and are pollinated by flies.
c. Skypilot populations are evolving distinctive characteristics as a result of the pollinators' preferences.
d. Skypilot populations are moving toward becoming distinct species.

C. Pollen-tube growth is followed by double fertilization. (**Fig. 40.13**)
1. Compatible pollen germinates on stigma and forms a pollen tube.
2. Generative cell within pollen tube divides by mitosis to form two sperm nuclei.
3. Pollen tube enters ovule at the micropyle and releases sperm nuclei.
4. Double fertilization occurs. (**Fig. 40.14**)
a. One sperm nucleus fuses with egg nucleus to form a diploid zygote; the zygote divides by mitosis to form an embryo.
b. One sperm nucleus fuses with polar nuclei to form a triploid cell; the triploid cell divides by mitosis to form the endosperm, a nutritive tissue.

V. Seed and Fruit Development

A. Embryo develops within ovule.
1. Zygote divides to form two daughter cells.
a. Terminal cell produces cells of embryo. (**Fig. 40.15**)
(1) Embryonic cells sort into progenitors of three adult tissue types.
(2) Long axis of embryo emerges.
(3) Cotyledons develop and take up nutrients from the endosperm.
(4) Hypocotyl, the stem region below cotyledons, and radicle, the first root, differentiate.
(5) Seed tissues dry.
(*a*) Water loss prevents seeds from germinating while on parent plant.
(*b*) Drying ensures that germination will not occur without available water.
(*c*) Research demonstrates that cell components of dry seeds are protected by a viscous, glassy sugar coating. (**Box 40.3**)
b. Bottom cell forms row of cells that transport nutrients from parent to embryo.

B. Ovary develops into a fruit.
1. Ovary cells surrounding the developing seeds form the pericarp.
2. Mature pericarp with seeds inside is the fruit. (**Fig. 40.17**)
3. Fruit has a variety of functions:
a. Protect seeds from mechanical damage and seed predators.
b. Provide nutrients for early seedling development in some plants.
c. Aid in dispersal from the parent plant.

(1) Wind, animals, and propulsion (**Fig. 40.18**) facilitate dispersal.
(2) Dispersal of fleshy fruits (**Fig. 40.19**) by animals is another example of mutualism associated with plant reproduction.
(*a*) Fruit provides sugars and other nutrients to the animal.
(*b*) Animal dispersal results in wider distribution of plant species and provides supply of fertilizer when seeds are excreted.

C. Seed Dormancy and Seed Germination
1. Dormancy occurs in seeds of plants that grow in seasonal environments.
a. Seeds can remain viable until conditions are favorable for growth.
b. No single factor is responsible for initiating and maintaining dormancy.
(1) Desert seeds with high levels of abscisic acid (ABA) in seed coats remain dormant until rains leach ABA out.
(2) In some seeds, sensitivity to ABA levels changes during seed maturation.
2. Numerous environmental cues break dormancy.
a. Scarification (breaking) of the seed coat
(1) From fire
(2) Passage through digestive tract of animal
(3) Abrasion against soil particles
b. Cold, wet conditions
(1) Seeds of plant species native to northern or alpine habitats.
(2) Perception of change in conditions and molecular mechanism are unknown.
c. Light: red-light exposure for small seeds
d. Chemical requirement: a component in smoke from fires
3. Germination occurs when dormancy is broken and environmental conditions are favorable.
a. Three phases of water uptake occur during germination. (**Fig. 40.20**)
(1) First phase: Water uptake occurs, oxygen is consumed, proteins are synthesized, no mRNA synthesis occurs.
(2) Second phase: Water uptake ceases, new mRNAs are synthesized, and mitochondria increase in number.
(3) Third phase: Water uptake resumes, embryonic cells enlarge, and radicle emerges through the seed coat.
b. Monocot and dicot seedlings germinate differently. (**Fig. 40.21**)
b. Seedling is established when it is photosynthetically independent and no longer relies on stored food reserves in the seed.

Chapter Vocabulary

flowers
seeds
angiosperms

sexual reproduction
meiosis
fertilization
sperm
egg
zygote
outcrossing
self-fertilization
inbreeding
self-incompatible

haploid
diploid
alternation of generations
sporophyte
gametophyte
sporangia
gametangia
spore
gamete

asexual reproduction
clones
rhizome
stolon
runner

corms
plantlets

florigen
reporter gene

perfect
imperfect
pollination
monoecious
dioecious

sepals
petals
receptacle
corolla
nectary
nectar
stamen
anther
filament
pistil
stigma
style

female gametophyte
megasporocyte
megasporangium
megaspores
ovary
ovule

embryo sac
micropyle

male gametophyte
microsporocyte
microsporangium
microspores
pollen grain
vegetative cell
generative cell
pollen tube

germination
double fertilization
endosperm
seed
seed coat
fruit
pericarp
cotyledons
hypocotyl
radicle
epicotyl
dormancy
scarify
abscisic acid
cross pollination
outcrossing
self-pollination
mutualism
inbreeding