The Seed Plants

Two groups of seed plants (Spermatophytes): Gymnosperms and Angiosperms

Sperm = seed
Gymno = uncovered or naked
Angio = covered

The importance of a seed:
embryo = multicelled sporophyte
food supply = either endosperm or fleshy cotyledons
dormancy = certain maturation or environmental conditions must be met before seed can germinate. (Note: Seeds of annual crop plants are not domant; they are merely dry. Once these seeds are imbibed, they will germinate if they are viable.)
dispersal = generally via fruit in the angiosperms

With the seed plants, plants lose dependence on free water for fertilization. The pollen grain, which is the male gametophyte, carries the sperm to the ovules, where the eggs are located. Pollen is carried by a variety of pollination vectors, including wind, insects, mammals, and birds.

The Gymnosperms

Four Divisions
Conifers (Coniferophyta) = the cone bearers: pine, spruce, fir, redwood, cedar, juniper
Cycads (Cycadophyta) = cycads, sago palm (not true palms, which are angiosperms)
Ginkgo (Ginkgophyta) = Gingko is only extant
Gnetophytes (Gnetophyta) = another one of those "none of the above" categories which includes *Ephedra* (Mormon tea), *Welwitschia*, and *Gnetum*

The pollen grain is delivered to the ovule, not to a stigma as it is in the angiosperms. The seeds develop uncovered, i.e., not inside an ovary as they do in the angiosperms.

Secondary Growth: make additional vascular tissues and substantial protective tissues to functionally replace the epidermis
Most gymnosperms lack vessels; therefore, xylem is mostly composed of tracheids.
Pollen grains are wind transferred.

Many of the gymnosperms have leaf feaures that reduce transpiration that are particularly noticeable in the conifers:
long, thin, needle-like leaves
thick cuticle
sunken stomata

The pollen grain is a very reduced male gametophyte.
The ovule contains the female gametophyte which forms archegonia.

Deciduous Plants

Lose their leaves annually. Mostly associated with the woody angiosperms (oak, maple, apple), but some gymnosperms are deciduous (larch, Gingko). All leaves on deciduous plants are the same age.

Evergreen Plants

Lose some leaves periodically. Mostly associated with the conifers (pine, fir, spruce, juniper) and cycads, but some angiosperms are evergreen (holly, mistletoe, citrus trees). The leaves of evergreens will be a variety of ages. Some pines turn over all their needles in a two year span, some take five years, and the bristlecone pine can have needles that are over 30 years old.

Cycads and Gingko = dioecious = separate male and female sporophytes
Conifers = monoecious = male and female gametophytes form in separate cones on the same sporophyte

Sexual Reproduction in Conifers

See diagrams for male and female cones, mature ovule, and mature seed.

sporophyte —> microsporocyte (microspore mother cell) (2n) —> meiosis —> 4 microspores (1n) —> mitosis —> 4 pollen grains (male gametophytes) (1n) —> mitosis —> sperm

sporophyte —> megasporocyte (megaspore mother cell) (2n) —> meiosis —> 4 megaspores (1n) —> 3 disintegrate —> mitosis of remaining megaspore —> female gametophyte (1n) with eggs in archegonia

sperm + egg —> fertilization —> zygote —> mitosis —> embryo in seed (2n = the new sporophyte generation)

Three generation seed: seed coat = integuments from maternal sporophyte
nutritive tissue = female gametophyte tissue
embryo = new sporophyte generation

Economic Uses of the Conifers

paper pulp
lumber: esp. Douglas fir because of the low incidence of knots; redwood and cedar because of natural resistance to fungi, bacteria, and insects; spruce for stringed instruments
resin: for turpentine, rosin

The Angiosperms

Only one division: Anthophyta (the flowering plants)

Two classes:

Dicotyledones = Magnoliopsida (dicots)
Monocotyledones = Liliopsida (monocots)

Important features of the angiosperms that are considered advanced compared to the gymnosperms:
The flower provides attractants and rewards for animal vectors that serve as pollinators.
The seeds develop inside the ovary, which matures into a fruit. The fruit provides for mechanisms other than wind to disperse seeds far from the parent plant.
Double fertilization produces an embryo and nutritive tissue (endosperm). The plant only goes to the energy and resource expense of making nutritive tissue if fertilization occurs.
There is a division of labor in the xylem: vessels for water and mineral transport and fibers for support vs. the dual purpose tracheid of the gymnosperms. (The cellular differences also account for the woody dicots being the hardwoods and the conifers being the softwoods.)

1. Basic Vegetative Structure of Flowering Plants
Root System
Shoot System: stem, leaves (blade + petiole), node (region of stem where leaf attaches), internode (stem segment between two nodes), axillary bud (the bud found at the base of every leaf where it attaches to the node).

While we're at it: leaves can be simple or compound. In a simple leaf, the blade is undivided. In a compound leaf, the blade is divided into several leaflets. The leaflets can be arranged in a pinnate pattern (the petiole extends to form a rachis to which the leaflets are attached) or a palmate pattern (the leaflets arise from a common point). Leaves can also be sessile in their attachment to the stem (no petiole) or non-sessile (with a petiole).

The vein pattern of the leaf can be used to distinguish between monocots and dicots. In the monocots, the major veins are evenly spaced and run the length of the leaf. This is parallel venation. In dicots, the major veins form either a palmate or a pinnate pattern, with extensive branching of the smaller veins. This is netted venation.

Woody (secondary growth) vs. herbaceous (primary growth)

2. Vegetative Reproduction
a. Uses vegetative part(s) of the plant.
b. Is a type of asexual reproduction.
c. Nuclear division process is mitosis. This means that all cells produced will be genetically identical.
d. Plant cells, particularly parenchyma cells, are totipotent. This means that a mature, specialized cell has the ability to de-specialize and divide to produce many more cells. The new cells made can specialize into any plant cell type.

adventitious = plant organs that develop on different organs. For example, when a stem cutting forms roots, the roots are adventitious roots.

Some vegetative reproduction occurs naturally, usually via modified vegetative organs.
rhizomes = horizontal, underground stems. Adventitious roots form at nodes. Iris, crabgrass.
stolons (runners) = horizontal, above ground stems. Adventitious roots form at nodes. Strawberries, spider plant.
root sprouts = adventitious buds form on roots. Aspen, misc. shrubs (raspberry)
tubers = underground stem with an enlarged (fleshy) tip. Potato (the eyes are buds).
plantlets = some plants form small plants along leaf margins (Bryophyllum = mother of thousands) or other plant part (pregnant onion).
layering = a long stem bends down into the soil and adventitious roots grow. Roses, raspberries, blackberries.

Some vegetative reproduction is human-assisted.
layering
leaf cuttings = African violet, Peperomia, Begonia
stem cuttings = Geranium, Coleus
Leaf and stem cuttings are sometimes treated with rooting powder to encourage adventitious root formation.
Tissue culture = plants are grown under sterile conditions in special media. Pieces of a plant (explants) are sterilized with bleach and placed in culture vessels. The vessels contain a pH-adjusted growth medium that includes mineral nutrients, sugar, vitamins, plant hormones (to control plant development), and agar (to solidify the medium). The explants form callus followed by shoot and root development. Under some hormone mixtures, the plants are transferred to a new medium for each developmental step (callus ----> shoot ----> root). Under some conditions, callus will form entire plantlets. Once plants have formed in culture, they are transplanted to sterile soil and hardened off.

3. Sexual Reproduction

In sexual reproduction, two cells (the gametes) fuse to form a new individual (zygote). Meiosis must occur before the cell fusion (fertilization) in order to cut the ploidy in half. Fertilization restores the original ploidy.

Sexual reproduction gives the flowering plants two opportunities to spread genetic diversity: via pollen and via seeds.

A. Flowers
Four floral whorls: sepals (calyx), petals (corolla), stamens (filament + anther), carpels/pistil (stigma + style + ovary; ovule). These floral parts attach at the receptacle.

A complete flower has all four whorls. An incomplete flower is missing at least one.
A perfect flower has both stamens and pistils. An imperfect flower is missing one or the other.
If a plant has both male flowers and female flowers, the plant is moneocious (corn, squash). If male flowers and female flowers occur on separate plants of the same species, that plant is dioecious (willow, hops, spinach).
A regular flower has radial symmetry (rose); an irregular flower has bilateral symmetry (iris).

A superior ovary is located above the attachment point of the other three whorls. An inferior ovary is located below the attachment point of the other whorls.
A solitary flower is the only flower on the stalk (peduncle). An inflorescence has multiple flowers on a single penduncle. Inflorescence types include head (sunflower), umbel (dill), spike (lilac), and raceme (mustard).

Remember the sporic life cycle?

sporophyte (2n) ---meiosis---> spores (1n) ---mitosis---> gametophyte (1n) ---mitosis---> gametes (1n) ---fertilization---> zygote (2n) ---mitosis---> new sporophyte (2n)

Pollen grains form inside the anthers. Inside each anther are hundreds of microsporocytes. Each microsporocyte (2n) goes through meiosis and makes four microspores. Each microspore (1n) goes through mitosis to form a pollen grain. Each pollen grain is a male gametophyte and will produce two sperm by mitosis.

One to dozens of ovules are found in each ovary. Inside each ovule is a megasporocyte (2n). The megasporocyte goes through meiosis to make four megaspores (1n). Three of the megaspores disintegrate. The remaining megaspore goes through mitosis to form at least 8 nuclei that arrange themselves to be the embryo sac. The embryo sac is the female gametophyte. One of the nuclei will be in the egg. Two of the nuclei will be polar nuclei. The layers of cells that cover the ovule are called the integuments.

B. Pollination

Pollination is the transfer of pollen from the anther to the stigma. Some flowers self-pollinate (and therefore self-fertilize). Plants with these types of flowers have very low genetic diversity because there is essentially uniparental inheritance (in-breeding). Example: peas, which bring us the expression "alike as two peas in a pod." If sexual reproduction is to result in genetic mixing, then cross-pollination (and the resultant cross-fertilization) needs to occur.
Several mechanisms promote out-breeding:
dioecious
monoecious
different maturation times for anthers and stigmas
anatomy of the anthers and stigmas
self-incompatibility

Pollen vectors (pollinators): agents that transfer pollen from one flower to another. Flower structure matches the vector.
i. Wind
Flowers are generally nondescript, lacking petals, scent, and nectar. Copious amounts of light, dry pollen are produced. Anthers and stigmas are well exposed.

ii. Animals
In general, these flowers will have colorful petals (color is vector specific) and will produce heavy and sticky pollen. Nectar might be made in nectaries. A scent might be present that is

vector specific.

Bees
See yellow and blue. Can also see UV. Often the color pattern of the petals serves as a pollen guide. Nectar. Sweet or other pleasant scent.

Butterflies
See red and orange. The corolla often forms a long tube, with nectar at the base. Not much scent.

Moths
White or light colored to be seen at night. Strongly scented.

Other insects
Generally strong odors, like rotting meat to attract carrion flies.

Bats
More white or light colored petals. Strong musky or fruity scent. The flowers are generally robust.

Birds
Red and yellow flowers. Not much, if any, scent. Robust flowers. The sugar in the nectar is not as concentrated as it is for insect-pollinated flowers. The flower construction will generally place the pollen on the bird's head. (Pollen sticks to feathers great; beaks, not so much.) Classic hummingbird flower: red, with a long tubular corolla.

Some flowers mimic female insects, producing a scent that matches a specific insect pheromone and forming structures that look (sometimes very vaguely) like a female. When the male insects try to mate with these flowers, they end up transferring pollen. As a group, orchids are probably the most notorious mimics.

VIDEO!! Part 3 of The Private Life of Plants: The Birds and the Bees. Starring every PBS fanatic's favorite guide to the natural world, David Attenborough. The video will show many pollinators in action (including some male wasps having quite a tussle with some orchids), explain how different flower features match specific pollinators, and mention some of the mechanisms to avoid self-fertilization. Take notes!!

Review

Basic Vegetative Plant Structure
Root System: fibrous roots vs. tap roots
Shoot System: stem, leaves (blade + petiole), sessile leaves, node, internode, axillary bud.
simple leaves vs. compound leaves; pinnately compound leaves vs. palmately compound leaves;

Vegetative Reproduction
What is meant by vegetative reproduction? Which cell division process is involved? How vegetative reproduction related to totipotency? If a root is described as adventitious, what does this mean?

Be able to explain the role of each of the following in different occurrences of vegetative reproduction. Be able to give an example of each. rhizomes, stolons (runners), root sprouts, tubers, plantlets, layering, cuttings, tissue culture.

Sexual Reproduction
How does sexual reproduction differ from vegetative reproduction? Sexual reproduction gives the flowering plants two opportunities to spread genetic diversity: what are they?

Be able to identify the parts of a flower: sepals (calyx), petals (corolla), stamens (filament + anther), carpels/pistil (stigma + style + ovary; ovule), receptacle, peduncle. (Refer to the diagram on your first exam or the web reference.)

Be able to distinguish between the following pairs of words:
complete flower == incomplete flower
perfect flower == imperfect flower
monoecious plant == dioecious plant
regular flower == irregular flower
superior ovary == inferior ovary
solitary flower == inflorescence
sporophyte == gametophyte
spore == gamete

Be able to describe and give an example of each of the following types of inflorescences: head, umbel, spike, and raceme.
Remember the sporic life cycle:
sporophyte (2n) ---meiosis---> spores (1n) ---mitosis---> gametophyte (1n) ---mitosis---> gametes (1n) ---fertilization---> zygote (2n) ---mitosis---> new sporophyte (2n)

Be able to describe pollen grain formation.
Be able to describe embryo sac formation.

In the flowering plants, what is the male gametophyte? What is the female gametophyte?

What is pollination? What are pollination vectors? Be able to associate specific flower characteristics with specific vectors. BE SURE TO GO OVER THE VIEWING GUIDE FOR **THE BIRDS AND THE BEES** VIDEO!!

What are some of the mechanisms (other than pollinator attractants) used by the flowering plants to promote out-breeding?

double fertilization
zygote
endosperm
cotyledons
integuments
seed coat (testa)
ovary
fruit
pericarp: exocarp, mesocarp, and endocarp.

What are the functions of a fruit with regard to seeds?
Be able to describe various ways in which seeds can be dispersed.

Seed dormancy
What is seed dormancy? What are some ways in which it is broken? Why is it important for seeds to be able to be dormant? Why was dormancy bred out of annual crops when they were domesticated?

Types of fruits: be able to describe and distinguish between the following types of fruits. Also be able to give at least one example of each type.
Simple fruits: follicle, legume, silique, capsule, grain or caryopsis, achene, nut, samara, berry, hesperidium, drupe, pepo, pome
Compound fruits: aggregate fruit, multiple fruit
Accessory fruit
Parthenocarpic