TwoOldGuys™ Study Guides
BI114 Biological Concepts for Teachers
Chapter 2. Diversity of Life
2.4. Plants

Based on Indiana's Academic Standards, Science, as adopted by the Indiana State Board of Education, Nov 2000.
Numbers refer to the age-appropriate grade-level for the content.

Review

We developed a tentative definition of life, and applied it to all known life-forms consistent with the cognitive development of the 8th grade mind. To outline the known living things, we expanded the 20-Questions classification scheme to include several ranks of taxa which are recognized as artificial: Kingdom, Phylum, Class, Order, Family, and Genus; plus one real taxon: the species.

The artificial taxa are defined by enumeration. We have already covered the Mammals, Birds and Bugs. This section will continue to develop definitions by enumeration for the major taxa with which your students should be familiar.

Plants

Plant Life Cycle

grades secondary: to college:

Plants exhibit Alternation of Generations

Animals go through a simple series of stages during their lifetime: from fertilized egg, to embryo, pre-reproductive child, and finally to

reproductive adult and sometimes post-reproductive senior. Plants go through a similar series of stages: the fertilized egg, a brief embryo, followed by a lengthy pre-reproductive stage, then reproductive and sometimes post-reproductive stages. However, unlike animals, when plants grown from eggs reproduce they produce spores not gametes. The spores germinate and grow to become male and female plants which produce gametes to form fertilized eggs. The fertilized eggs again develop into (sexless) spore-producing plants. Plant embryos often remain dormant through the non-growing season [such as winter, or the dry season], then germinate at the start of the next growing season.

Sporophyte

The sporophyte is the 'spore producing plant.' When mature, it will develop sporangia (singular: sporangium) which produce spores, some of which will be male and the others will be female. For most plants, the sporophytes themselves are sexless. A few trees (such as *Ginkgo*) are said to have the sexes separate, which means that an individual tree will produce only male or only female spores, not that the trees are male or female since they still do not produce gametes. Male spores develop into male gametophyte plants, and female spores develop into female gametophyte plants.

Gametophyte

The gametophyte is the 'gamete producing plant.' In many plants, the sexes are separate. The male plant develops gametangia (singular: gametangium) which produce flagellated (swimming) gametes called sperms, and the female plant develops gametangia which produce non-motile gametes called eggs. In terrestrial species, the sperms swim across the dew from the male plant to the female plant, or the male

plants themselves are transported by the wind to the female plants. After fertilization the zygote (fertilized egg) develops into a sporophyte.

Higher plants

The sporophyte is the dominant generation. In this context, the term 'dominant' should be interpreted as "the plant everyone thinks of as a flowering plant, as a conifer or as a fern is the sporophyte." The sporophyte may be perfect, monoecious or dioecious. 'Perfect' refers to having both male and female gametophytes produced from the same reproductive structures (flowers or cones). 'Monoecious' refers to having separate structures producing male and female gametophytes, and both are on the same sporophyte plant. 'Dioecious' refers to having separate structures producing the male and female gametophytes, with each on a separate sporophyte plant. The gametophyte is highly reduced.

Lower plants

The gametophyte is the dominant generation. In this context, the term 'dominant' should be interpreted as "the plant everyone thinks of as a moss (or as a moss relative) is the gametophyte." Although the more common arrangement is for the sexes of gametophyte plants to be separate, there are some with both sexes on the same gametophyte plant. The sporophyte is reduced, and attached to female gametophyte plant. The sporophyte plants almost always produce both male and female spores from the same sporangium.

Flowering Plants, Angiosperms

grades 1: to 3:

Flowers and Trees

The plant [or "vegetable"] kind of living things include flowers, trees that lose their leaves in fall, and even weeds. Plants also include the pine [evergreen] trees, but these are discussed later (see the next sub-section: Gymnosperms).

Roots, stems, leaves

Plants have three major parts: roots, stems and leaves. Roots are the underground parts of the plant, used to attach the plant to the ground, and used to collect water and minerals from the soil. Stems are the above ground parts that support the leaves. Leaves are green and convert sunlight into sap (which is similar to 'maple syrup'). It is the sap that provides energy to all parts of the plant that are not green. Leaves also breathe, taking in carbon dioxide during the daylight hours, and releasing oxygen. Since animals breathe differently, inhaling oxygen and exhaling carbon dioxide, plants and animals benefit each other by providing the type of air needed by each other.

flowers, fruit

Flowers and weeds, and even most trees that lose their leaves in the fall have flowers. The plants we call flowers have rather large, brightly colored flowers. Weeds and trees tend to have small flowers that are hard to find. Often these flowers are white or pale yellow, or sometimes

even tan. All plants with flowers also produce fruit, which contains the seeds of the plant.

grades 4: to 6:

Plants with seeds enclosed in fruit

The flowering plants are the only plants with fruit that contains the seeds. Fruit is generally highly edible, attracting animals to eat the fruit and spread the seeds away from the parent plant. The seeds inside the fruit are normally not digestible, so they usually (but not always) survive being eaten.

Flowers

The most familiar characteristic of the flowering plants is their flowers. These structures are complex devices to attract insects and/or birds to pollinate the plant so seeds will form. The parts of a flower may include any of the following:

- pistil, where the egg is produced.
- stamens, where pollen is produced.
- petals, which are believed to be modified leaves with colors to direct animals to the correct location for pollination.
- sepals, which are modified leaves which form the covering of the flower buds.
- bracts, are leaf-like structures normally found below branches (twigs).

roots, stems, leaves

Roots have a hard root-cap which protects the root as it grows through soil, or even through rocks (by secreting acids). Immediately behind the root-cap is an area of actively growing cells called a meristem. I would remind you that 'correct' jargon, such as the term 'meristem,' are

not particularly important to this age group, and should probably be avoided. Other than branches of the root, this is the only growing region in the root. Just above the growing region, the root has very delicate root hairs [microscopic in size], where water absorption occurs. Some roots are modified for food storage [carrots, beets,] or water storage [pumpkins]. Many plants will produce new stems in response to injury to the root.

Stems are either woody or herbaceous ['herbaceous' means "not woody"]. All woody stems exhibit annual growth rings, as summer wood – winter wood or wet season wood – dry season wood. The age of a woody stem plant can be estimated by counting the rings, with deciduous trees reaching ages up to 250-500 years. Stems, like roots, grow in length from the tip, but without the protective root-cap. Growth in diameter occurs only from a thin layer between the bark and the wood. Cutting into this thin layer can cause serious injuries for the plant. Herbaceous stems have their vascular tissue (water and sap conducting tissues) in bundles which may be slightly woody [such as the 'strings' in celery]. Some stems can grow roots in response to injury.

Leaves consist of a green blade and a stem-like petiole. Some leaves are simple, with a single blade attached to the petiole. Others are compound, with a few to several blades (leaflets) attached along a single petiole. Compound leaves are palmate if the leaflets (3 – 5, or 7) all attach at the same point at the tip of the petiole, or pinnate if the leaflets are attached opposite each other along the long petiole. In a few species, the leaves are bi-pinnate, meaning that the main petiole is pinnately branched, with many pinnate leaflets along each petiole branch. For most plants, the leaves are the only green parts and are the only location where photosynthesis captures solar energy into sugar molecules. Only a few plants can grow new plants from leaves.

grades 5: to 8:

Flowering Plants, phylum Magnoliophyta

The most familiar characteristic of the flowering plants is their flowers, although the defining character is the fruit. The parts of a flower may include any of the following:

- pistil with ovary, where the ovary is a female gametophyte which produces a single egg.
- stamens with pollen-producing sporangia, where pollen is a male gametophyte transported by wind or animals to the pistil to pollinate the plant, leading to fertilization of the single egg by the single sperm produced by the pollen.
- petals, are believed to be modified leaves with colors to direct animals to the correct location for pollination.
- sepals, are modified leaves which form the covering of the flower buds.
- bracts, are leaf-like structures normally found below branches (twigs) suggesting that flowers are actually modified branches.

Monocots, class Liliopsida

- seeds with one cotyledon
- flower parts in 3's
- leaves with parallel (unbranched) veins

Dicots, class Magnoliopsida:

- seeds with two cotyledons
- flower parts in 5's (sometimes 4's)
- leaves with branched veins

grades 7: to 8:

Phylum Magnoliophyta

The flowering plants are classified as the phylum Magnoliophyta [the suffix "-ophyta" means phylum, and the suffix "-opsida" means class]. The Magnoliophyta are divided into two classes: the Liliopsida (monocots) and Magnoliopsida (dicots).

All members of the phylum have dominant sporophytes, which are normally referred to as perfect because the structures which produce the gametophytes are found in the same flowers. Technically, this makes them monoeious because there are separate structures (pistil produces female spores and gametophytes; stamens produce male spores and gametophytes) borne on the same sporophyte plant. Many are dioecious.

The gametophyte generation is reduced. The male gametophytes are dust-sized pollen grains, consisting of two cells: the pollen tube cell and the sperm cell. When pollen lands on the receptive area (stigma) at the top of the pistil, the pollen tube cell grows into a long tube which travels down to the bottom the pistil where the female gametophyte is located. The female gametophyte consists of seven cells: five vegetative cells (three at the top of the gametophyte, two at the bottom), one egg cell at the bottom, and one large cell with two nuclei in the center. The egg cell is fertilized by the sperm cell, and becomes the embryo and cotyledon(s). The vegetative cells develop into the seed coat [for example, the papery red layer on spanish peanuts, and the hard shell on orange seeds]. The large central cell becomes a soft tissue to provide food for the developing embryo. Outside the seed coat of the Magnoliophyta, there is a fruit which grows from the parent sporophyte, and is frequently edible, and attractive to various animals which will eat the fruit and then 'plant' the seeds at some distance from the parent plant. If the fruit of these plants seems to complex to explain to any one under 8th grade, you may have a good grasp of the nature of fruit. Based on my assessments of student

learning by secondary students [sophomore and senior], the cognitive development of secondary students limits their ability to understand the fruit, although some of them can memorize the details quite well.

Grasses (monocot)

The grasses are classified as monocots (class Magnoliopsida) in all texts and references. However the grasses have several characteristics which more closely resemble the Auracariaceae, a family of conifers [phylum Pinophyta] found in Australia and New Zealand, than they resemble the rest of the flowering plants [phylum Magnoliophyta] (LaFrance, unpublished).

- seeds with reduced cotyledon; extensive endosperm
- reduced flowers, superficially resembling loose pine cones more than they resemble flowers
- leaves grow from base, without petioles. leaves shaped like flattened needles.
- stomata (breathing pores) are located on upper leaf surface [typical flowering plants have stomata on lower leaf surface].
- leaves frequently contain crystals of silicon

The point of this unnecessary information is that the grasses are very strange members of the phylum Magnoliophyta, class Liliopsida. My best advice to you is mention only that grasses are considered to be monocot flowering plants, and hope that none of your students ask any questions about them.

Gymnosperms (Phyla Pinophyta, Ginkgophyta, Cycadophyta, Gnetophyta)

grades 1: to 3:

Flowers and Trees

The plant [or “vegetable”] kind of living things include flowers, trees that lose their leaves in fall, and even weeds (discussed above). Plants also include the pine [evergreen] trees, discussed here.

Roots, stems, leaves

Roots and stems are basically the same as for the flowering plants. Leaves however are needles.

Cones

Seeds are produced in woody cones. The pine trees have two different kinds of cones: there are small cones on top of the tree where pollen is produced, and large cones on the lower branches where seeds are produced.

grades 4: to 6:

Plants with seeds not enclosed in fruit

The name, 'Gymnosperm,' literally means 'naked seeds,' referring to the absence of fruit surrounding the seeds. The seeds develop inside tightly closed cones, which then open to release the seeds. Several of the pines have winged seeds so the wind can carry them away from the parent tree.

Cones

The cones consist of a spiral of modified branches called bracts, with two sporangia on the side of the bract closest to the tip of the cone. The smaller, male cones produce pollen in large quantities. For a brief period (a few weeks), usually in the spring, the male cones open and release the pollen which is blown by the wind. Some of the pollen lands inside the open female cones. At the end of the pollination season, the female cones reclose, and the seeds develop. This can take up to 2-3 years, or sometimes longer. Depending on the type of pine tree, the seeds will be

released in the fall after they are fully developed, or may be held until after the next forest fire.

roots, stems, leaves

The stems differ from those of the flowering plants in that there are 'rays' which cut across the growth rings from the center of the tree toward the bark. These rays produce resin which is the sticky stuff on the outside of a Christmas tree, and which becomes amber (a reddish, glassy rock) over geologic time. Some amber has been found with fossil insects inside. Surprisingly, the insects in the amber look almost exactly like modern, living insects.

grades 5: to 8:

Plants with "naked" seeds

At one time all of the gymnosperms were lumped into a single phylum, but current thinking is that they should be divided into four separate phyla. The idea is that the similarities among these plants is superficial, while they are quite distinct in some important characteristics. The only important similarity among these otherwise different plants is that their seeds are not surrounded by fruit, although they still have seed coats.

Cones

Typically, the gymnosperm seeds develop in cones. Some of these cones are hard and woody [like pine cones], while others have fleshy cones or even berry-like structures which are cup-shaped covering about half of the seed. The woody cones are considered to be made of a spiral

of bracts. The fleshy cones are considered to be a spiral of scales [although there is no clear definition of the difference between a bract and a scale]. The berry-like 'cones' consist of a single fleshy scale, rolled loosely around the sporangium.

The cones almost always produce either male or female spores, but almost never both. There are no known exceptions; however, since we have recently found some previously undiscovered gymnosperm plants, with unexpected characteristics, we are hesitant to declare that all cones are one or the other sex. The most surprising part of these discoveries was not how the new plants differ from known gymnosperms, but that these plants are alive, since we thought about three decades ago that most of the gymnosperm species went extinct 220 million years ago. Dividing the gymnosperms into four separate phyla is a result of the information we have gained from these unusual plants.

Pinophyta (Conifers)

The conifers were described as typical gymnosperms when the gymnosperms were considered to be a single phylum. The majority of the species are trees whose leaves are needles. They include the largest living plants [giant sequoia tree, up to 275 ft tall or 36 ft diameter], and the oldest living organism [4,862 years when cut in 1964, or still alive at 4,772 years in 2006]. Most of the genera are evergreens [Pine, Spruce, Fir] with needles living about 5 years and falling off continually, a few at a time. One genus is deciduous [Larch] with needles that turn straw yellow and fall off every autumn. Other individuals are shrubs, called krummholtz, growing at high elevations [at, but not above, timberline].

Two families of Pinophyta have berry-like 'cones:' Cupressaceae [junipers and yews] with scale [short, close to twig] leaves on green twigs,

and Podocarpaceae [podocarps, of New Zealand and circum-tropical islands] with soft needle-like leaves.

Gnetophyta (*Gnetum* spp.)

The Gnetophyta are poorly known tropical to sub-tropical vines and shrubs. The leaves are broad leaves that look like the leaves of flowering plants (dicots). The 'cones' are round, woody structures. The Gnetophyte seeds are the only known seeds with multiple viable embryos per seed.

Ginkgophyta (*Ginkgo*)

The known Ginkgophytes are a single species, *Ginkgo biloba*, as the only surviving species of a phylum that once was a dominant member of fossil forests. *Ginko* is known only from monastery gardens in Mongolia and China, and now Japan [specimens transplanted from Mongolia]. There are unconfirmed reports of *Ginkgo* growing wild in Mongolia and Tibet. The leaves are broad, resembling a dicot (flowering plant), with parallel veins resembling a monocot.

Cycadophyta (Cycads)

The living cycads, found in tropical and sub-tropical areas (for example, Central America and Southeast Asia) and hurricane-prone areas of the North American coastal plain north to South Carolina, are small trees resembling short palms, with large fleshy cones. Unlike most gymnosperm cones which hang down, the cycad cones are upright.

The Cycadophyta were the dominant trees of Triassic & Jurassic, or at least they dominate the fossils of the periods.