teacher resources: The Basics of Botany

what is a plant?

Although this may seem like an easy answer, a plant may be defined differently depending on group the people. An elementary school teacher may describe a plant as a "living green thing", a high school teacher may narrow this definition, and a plant scientist may have a technical understanding of a plant. All these definitions serve a purpose and the definition needs to be modified depending on the audience.

Plants are "green things", which means they carry out a process called photosynthesis. There are many green, photosynthetic organisms, but some of these, such as bacteria, are not plants. Algae are a group of organisms that may be considered plants by some teachers, but would be called protists by scientists. This distinction is probably not important to school children; the important message is that these organisms use the sun to make their own food. In contrast, a group such as fungi, although plant-like, do not make their own food and should not be considered plants. For the purposes of this handout, we will concentrate on plants that live on land and are familiar to students of all ages and levels.

Defining Characteristics

- **Roots:** absorption of water and minerals; anchorage of plant to the soil; usually found underground
- **Stems:** support of leaves, flowers, and fruits; transportation of water –minerals from roots to leaves; found above and below ground.
- **Leaves:** site of photosynthesis or food-making; usually found above ground.
- **Flowers:** flowers attract animals and provide nectar while completing the needed process of pollination.
- **Fruits:** fruits protect and disperse the seeds inside.
- **Seeds:** Seeds are young plants that continue the lifecycle.

what are the parts of a plant?

The plant body can be divided into three main parts: roots, stems, and leaves. Some botanists refer to the latter two as "shoots". Most students have a good understanding of what these look like, but the distinction between these can sometimes be fuzzy.

Consider that some plants have stems that resemble roots (e.g. ginger), or stems that resemble leaves (e.g. prickly pear cactus). It is important that students understand that plants need certain materials to survive; these may be obtained by roots in some plants but through the stems or leaves in another. The determination of whether a plant part is a root or stem, such as the potato, seems to be less important. The flexibility, adaptability of plants and the function of their parts should be the focus.

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what are roots?

Roots serve as the most fundamental organ to health of most plants. The root or radicle is the first plant part to appear from a seed. Roots act to anchor the plant and absorb water and nutrients for photosynthesis; these are called true roots. True roots are usually divided into two forms: **fibrous** and **tap**. Some plants have a mass of string-like, fibrous roots (*e.g.* grasses); others have a large, main taproot with smaller side roots (*e.g.* oaks, carrots). Sometimes roots "sprout" from the side of a stem, like in a vine; these are called **adventitious** roots. A plant with an underground stem will have adventitious roots.

Functions of roots

- **Absorption:** Absorption of water and nutrients are one of the primary functions of roots. Roots absorb water through a passive, physical process. Water being released from leaves is linked to other water molecules in the plant like a chain. As the water is pulled out of the leaf into the atmosphere, the chain pulls new water molecules up through the stem and into the roots.
- **Anchorage:** Roots also act to anchor the plant in the soil or on rock. Thus, roots act as the major supportive organ for all other organs.
- **Conduit:** Roots (like stems and leaves) serve as the initial pipeline for water that is needed in the plant. Sugars (energy) are also transported down to the actively growing portions of the root.
- **Storage:** Most roots store some quantity of sugars, water, or toxic chemicals (like leaves and stems), but some roots are quite large and fleshy storage organs (*e.g.* carrots).
- **Respiration:** Some swamp or flooded plants produce roots or "knees" that grow up and out of the water, allowing the roots to exchange gases in this oxygen-free environment (*e.g.* bald cypress, mangrove)
- **Support:** Specialized adventitious roots called prop, stilt, and buttress roots can be found on tropical trees that experience frequently flooding (*e.g.* mangrove).
- **Photosynthesis:** In rare cases, plants have green, aerial roots that photosynthesize (*e.g.* orchids).

what are stems?

Stems are the most basic organs on plants. Simple examples of a stem are twigs, branches, and the trunk(s) of a tree. Stems can range from hard & woody to soft & green **(herbaceous)**, but almost all stems serve a supportive function on a plant.

Most people know what a stem looks like, but some plants make the distinction difficult. Some plants have small stems, or underground stems **(rhizomes)**, or leaf-like stems, or stem-like leaves or sometimes lack stems altogether. Although we make neat and clear categories called stems, leaves, and roots, this distinction can be blurred. Grasses are a good example in which the difference between leaf and stem is not easily observable.

what are stems? *(continued)*

Functions of stems

- **Structure:** Most stems serve the role of support in a plant. For example in a tree, the trunk supports the branches, which support the twigs, which support the leaves, flowers, and fruits. In non-woody plants ("herbs"), there is no trunk. Instead, these plants have soft, green stems that support the leaves, flowers, and fruits.
- **Transportation:** Stems serve to transport the materials needed in photosynthesis. Inside a stem there are tissues called xylem and phloem. Both are tubes that transport materials through the plant: xylem water and sugars, respectively *(see xylem & phloem below)*.
- **Storage:** Many stems store food, water, and waste products. An example of a storage stem is the white potato (Solanum tuberosum), which could be called a tuber. Food and water storage in common in arid conditions. Plants cannot easily get rid of harmful chemicals from the air and soil; therefore, they store these chemicals in special cells.
- **Photosynthesis:** Almost all plants have stems that can photosynthesize. Some plants have stems that are always green, such as cacti and palo verde. Other plants, such as oaks, just use their young twigs and leaves for photosynthesis.
- **Protection:** against large animals; these are called thorns. Many trees have thorns (*e.g.* hawthorn, crabapple, honey locust). Note: Cacti and rose bushes do not have thorns, because these are not modified branches *(see leaves and hairs below).*
- **Protection:** In many plants, branches have been modified over time to serve as protection against large animals; these are called thorns. Many trees have thorns (*e.g.* hawthorn, crabapple, honey locust). Note: Cacti and rose bushes do not have thorns, because these are not modified branches *(see leaves & hairs below).*
- **Clonal growth:** Many plants have stems that can creep on top **(stolons)** or under the ground **(rhizome)** producing new "plantlets", which are clones of the parent. Although common in herbaceous plants (*e.g.* strawberries, crabgrass), some trees also exhibit clonal growth. These trees are said to have "suckers" growing from their base (*e.g.* crabapple, aspens).

what are leaves?

Many leaves are composed of three parts: the **blade**, the **petiole**, and **stipules**. The blade is the flat, wide, photosynthetic part of the leaf. The petiole is the thin stalk that holds the blade and attaches the leaf to the stem. Stipules look like tiny leaves that are found at the base of the petiole; they are not always present. An oak leaf has a clear example of blade and petiole, but grass leaves have blades only. Both are example of simple leaves, because the blade is entire and not split/sectioned into leaflets. A leaf that is segmented into leaflets is called a compound leaf.

Discerning a leaf from a leaflet, and thus a simple from a compound leaf, can be challenging. The simplest way is to look at the intersection between the "stem" and the base of the "leaf". If there is a bud at this location, then you are

what are leaves? *(continued)*

observing the attachment of a leaf to a stem. If the bud is missing, then you are looking at a leaflet attached to a larger, compound leaf.

All leaves have stomates, which are pores in the leaf, with guard cells that regulate the exchange of gases and water vapor with the environment. These stomates can be opened and closed to regulate the physiology of the plant. Oaks, like many trees, have stomates only on the bottom of their leaves; grass leaves have stomates on both sides.

Almost all people know what a leaf looks like, but contemporary leaves can range from microscopic (water weed: Wolffia) up to 83 feet long (Raphia palm).

Functions of leaves

- **Photosynthesis:** The leaves of almost all plants photosynthesize. Sunlight is used to convert carbon dioxide and water to sugars and oxygen.
- **Conduit:** Just like stems/roots, there are portions of leaves that transport water and sugars to and from, respectively, those areas of photosynthesis.
- **Storage:** Many leaves store water, sugars, and toxic materials. Some desert plants are succulent in which they store water in their leaves. Food storage is common in underground leaves, such as the fleshy, edible leaves of the onion bulb. Many plants can store toxic chemicals in leaves, and then drop the leaf when "full".
- **Support:** Many vines have modified leaves called tendrils, which are thin, stem-like leaves that wrap around other plants, fences, wire, etc. for support.
- **Protection:** In many plants, leaves have been modified to a sharp point to serve as protection: spines. Many arid-adapted plants, such as cacti, have spines.

what are flowers?

Flowers are beautiful structures that are composed of many parts. The flower forms in a bud, and emerges on a short stalk or stem. The end of this stem has four different parts: **sepals, petals, stamens**, and **pistils.** Each part has a specific function (discussed below) that will ultimately lead to **fertilization** of new seeds.

A group of flowers is called an **inflorescence**. To understand the difference between a flower and an inflorescence, compare the following examples. The largest flower in the world is the stinking corpse lily (Rafflesia arnoldii); flowers can reach 3ft across and weigh 15lbs. The largest inflorescence is from the talipot palm (Corypha umbraculifera), which can reach 30ft tall with millions of flowers.

Parts and functions of flowers

- **Sepals:** The sepals are usually green, thick and very leaf-like, but in some cases (*e.g.* tulips, lilies), they petal-like. Sometimes a mature flower lacks sepals all together. If present, sepals are the lowest most part on the flower. Sepals serve as a series of scales that *protect the unopened flower.*

what are flowers? *(continued)*

Parts and functions of flowers *(continued)*

- **Petals:** The petals are usually colored, thin, and leaf-like in appearance. The petals are above the sepals on a flower. Plants that are **wind-pollinated** usually do not have large, showy petals. The main function of the petals is to *attract pollinators* (insects, birds, or mammals).
- **Stamens:** Above the petals are the male or pollen-producing parts. The stamens can range in size and shape, but most are composed of two parts: the **anther** and the **filament**. Some animals collect pollen for food (*e.g.* bees), but others feed on different parts of the flower (*e.g.* nectar). The main *function of the anther is to produce pollen* (the "male" part of the plant). The filament's function depends on its shape and size.
- **Pistils:** The innermost part of the flower is the pistil, or the female portion of the flower. A pistil is the composed of three parts: **ovary, style,** and **stigma**. Inside the ovary are **ovules** or pre-seeds, which are unfertilized seeds. The stigma is the landing-pad for the pollen, and the site of **pollination**. The style is a thin stalk that raises the stigma up so it can catch the pollen. After fertilization, the ovary becomes a fruit. As this fruit grows and matures, many other flower parts like petals and stamens wither and fall off.

what are fruits?

Fruits are, by definition, the mature, seed-containing ovaries of flowers. We sometimes use the terms "fruit" and "vegetable", which are frequently confused. The term "fruit" is a botanical term (ovary after fertilization), but "vegetable" is not. For simplicity, any plant structure that contains seeds is a botanical fruit; those edible plant parts that are roots, stems, or leaves could be considered vegetables. Some plant parts may be a plant's fruit, but a grocery store vegetable (*e.g.* tomato).

Fruits come in a wide variety of shapes, sizes, and colors, but not all fruits are edible to humans or other animals. The smallest fruit belongs to the smallest plant, the waterweed (Wolffia), which has fruits the size of a salt grain. The largest fruit on record is something in the gourd family; specifically a pumpkin that weighed 1,300 lbs. The largest fruit from a tree is the jackfruit (Artocarpus heterophyllus), which can weigh up to 75 lbs.

Functions of fruits

- **Protection:** Fruits are a plants way of protecting their young: the seeds.
- **Dispersal:** Fruits disperse their seeds through a variety of methods. Fruits are commonly thought of as large, juicy structures, such as grapefruits, apples, or pumpkins, but they can be dry and hardened structures as well.

what are seeds?

Seeds are baby plants, or the fertilized ovules of a plant. Seeds come in a range of size and shapes. The smallest seed belongs to orchids, which can been dust-sized and weigh as little as 0.0000035 oz. The largest seed comes from the coco-de-mer or "double coconut" palm (Lodoicea maldivica), which can be 12 in long, and weigh up 40 lbs. In every flowering plant, seeds are born in fruits

Functions of seeds

- **Protection:** The seed seems to have evolved as a way to protect the embryo from the environment; a seed allows the plant young to survive dry or harsh condition for short periods.
- **Dispersal:** Besides the fruit, some seeds have special features that aid in their dispersal by animal, wind or water.
- **Warning:** Some seeds are poisonous and exhibit a coloration pattern that warns animals; these seeds do not need an animal disperser, and use other dispersal methods.

what examples of plant form exist?

Most students can recognize that plants come in many different heights, widths, and overall forms. Below is a listing of some of general plant forms that exist in the world.

Trees: Plants that are large or tall and possess wood are considered trees by botanists. Trees may be shade-tolerant or prefer full sun. These are usually flowering dicots or cone-bearing evergreens. True trees (vs. tree-like plants) are the height record breakers, such as the redwoods of California (Sequoia sempervirens), which can reach almost 400 feet tall.

Tree-like plants: Many monocots and some ferns reach tree size and stature, such as palms, bananas, bamboo and tree ferns. Botanists avoid calling these plants "trees", because they do not contain wood. Woody trees increase in girth over time, but these plants remain the same width from top to bottom. Therefore, they use roots, leaves and other features to support their height.

Shrubs or bushes: Similar to trees, shrubs are plants that are small and woody. Unlike most trees, shrubs produce many smaller stems than one large trunk. Shrubs may grow in full sun as a successional species, or as a shade-tolerant plant in a forest. Shrubs are usually dicots.

Vines and lianas: Unlike the other plants mentioned, vines and lianas obtain light by growing up on top of other trees or structures. Vines are usually herbaceous, but lianas are woody. Young vines are adapted to low-light, but mature plants are usually in full-light of the tree canopy. This form exists in dicots, monocots, gymnosperms and even ferns!

Herbaceous plants or herbs: Plants that are soft and green are called herbaceous. Herb is short for herbaceous, but we usually think of fragrant plants used for cooking. These plants are usually small or smaller than trees. Ferns, grasses, tulips, and most vegetable crops are examples of herbaceous plants.