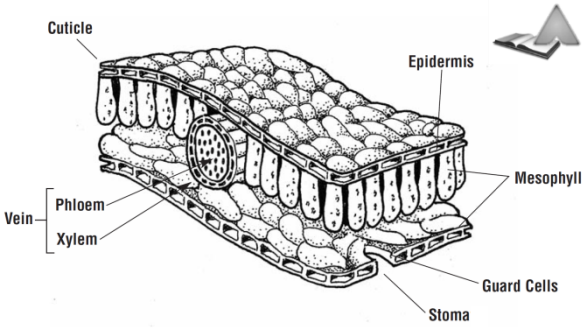
# Plant Systems Interactions

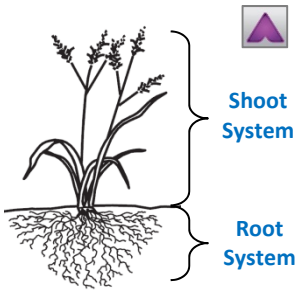
***The student is expected to describe the interactions that occur among systems that perform the functions of transport, reproduction, and response in plants.***

## The Parts of a Plant

Plants contain different levels of organization in the same way that animals do. Plants, like all living things, are made of cells. Plant cells are recognizable because they are surrounded by a **cell wall** made of cellulose and **chloroplasts** which allow plant cells to make food through the process of *photosynthesis*. Plant cells also contain large **central vacuoles** which store water and minerals for the plant cell. Keeping the central vacuole full of water allows the plant cell to maintain its *turgor pressure*. Turgor pressure helps to push the cell into the cell wall that surrounds it. This keeps the cell, and the entire plant, stiff and rigid.




Plants also contain *tissues* which are made from groups of specialized cells. The **epidermis** is a thin tissue that covers the surface of the plant. There are tiny openings throughout the epidermis called **stomata** that allow the plant to exchange gas with the atmosphere. Carbon dioxide gas can enter through the stomata, and oxygen gas and water vapor can leave the plant through the same openings. Around each stoma are **guard cells** which control the size of the opening. These guard cells close the stomata to prevent too much water from leaving the plant. The epidermal cells also produce a waxy coating that covers the plant. This waxy coating, called the **cuticle**, helps prevent water loss from the plant.



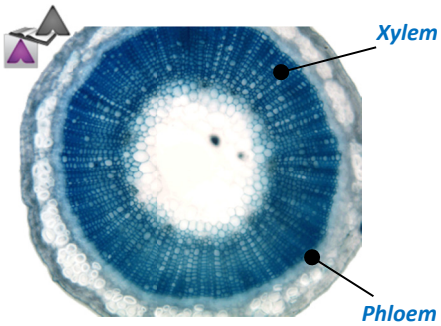

Plants also contain organs and organ systems. The **roots** of a plant are a part of the plant's **root system**. The root system performs three main jobs for the plant. The main job of the roots is to *absorb water and nutrients* for the plant. The roots also anchor the plant to the ground, and extra chemical energy can be stored in the root system of the plant. Many plants have *taproots* or *root vegetables* which store this extra energy for the plant so that the energy can be used later when it is needed.

Everything above the ground including the stems, leaves and reproductive organs of the plant is a part of the **shoot system**. New growths on a plant are called the *shoots*. The **stems** of the plant provide support for the different parts of the plant. Also, water and nutrients are transported through *vascular tissues* inside the stems. The primary job of the **leaves** is the production of sugars that the plant can use as food. Leaves produce these sugars through the process of photosynthesis. The reproductive organs of vascular plants, including **flowers** and **cones**, are also a part of the shoot system.

## Transport

Plants need to transport water, minerals, and organic compounds like sugars from one part of the plant to another. In order to distribute these vital substances, plant systems must interact with each other. In plants, water, minerals and organic compounds are transported through **vascular tissues**. Vascular tissues are long, tube-like structures that run throughout the plant. There are two main types of vascular tissues: the *xylem* and the *phloem*.

Plants absorb water, minerals and nutrients through their root systems. These nutrients include compounds containing nitrogen, phosphorous and potassium which are all essential to a plant's health. Once the water and nutrients have been absorbed by the roots, they travel up through the plant inside of the *xylem*. The **xylem** is the vascular tissue that transports water and minerals up through the plant's shoot system.

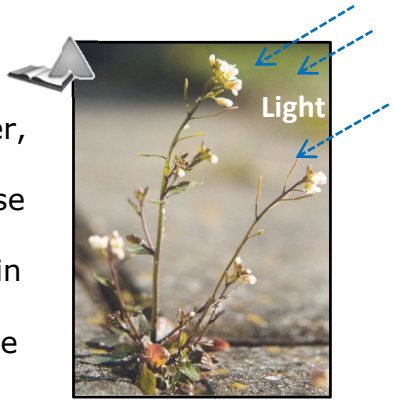


Cross section of a stem

The leaves of the plant use some of the water they receive during the process of photosynthesis. During photosynthesis, the cells in the leaves produce food for the plant in the form of sugars like glucose. All of the plant's cells need to receive some of this sugar. This includes the root cells of the plant which cannot perform photosynthesis on their own since they are not exposed to any light. The sugars that are made in the leaves are transported downward to the roots through the *phloem*. The **phloem** is the vascular tissue that transports sugars and other organic compounds throughout the plant.

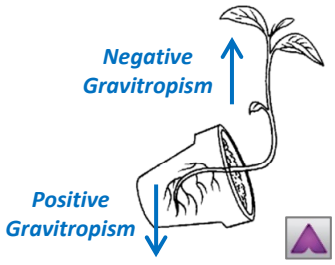
## Response

Plants are not usually thought of as being able to respond, but plants can respond to stimuli in their environment like light, water, and touch. These responses often involve the plant changing its growth pattern so that it grows towards or away from one of these stimuli. **Tropisms** describe the growth of plants in response to stimuli such as light or touch. Plants alter their growth patterns in response to these stimuli through the action of *hormones* like *auxins*. Auxins promote the growth of plant cells, and when these hormones are concentrated on one side of a stem they can make that side of the stem grow longer than the other. This uneven growth causes the stem to bend.



Plant exhibiting positive phototropism

In some plants, cells that receive less sunlight produce more auxins. As a result of producing more of these hormones, the stems of these plants bend towards to the light. This benefits the plant by allowing the plant to receive more of the sunlight it needs to perform photosynthesis. The growth of the plant in response to light is called **phototropism**.




When seeds germinate, the roots always grow downward and the stems always grow upward no matter how the seeds were placed into the ground. This is because the plant is growing in response to gravity. When plants grow is response to gravity, it is called **gravitropism** (or **geotropism**). The roots of the plant grow in the direction of the gravitational force. Because the roots are growing towards the force of gravity, we say that they are exhibiting *positive* gravitropism. A tropism is positive when the plant grows towards the stimuli. The stems of the plant exhibit *negative* gravitropism because they grow upward against the pull of gravity.

A redvine showing thigmotropism

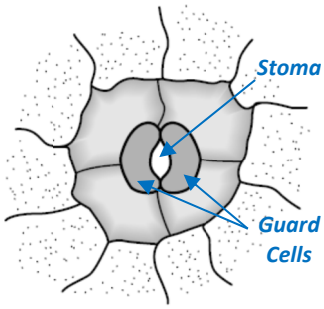
Plants can also grow in response to *water*, and this is called **hydrotropism**. The root systems of plants in arid environments often exhibit positive hydrotropism. This benefits these plants by allowing the roots to grow towards sources of water. Other plants grow in response to *touch* which allows them to wrap themselves around the surface they are touching. Growing in response to touch is called **thigmotropism**, and it is especially important for plants like vines that grow above the ground on other surfaces.

*The Venus flytrap demonstrates thigmonasty when catching its prey*

Tropisms are very slow processes that affect the growth of the plant and can only be seen over long periods of time. However, some plants can perform rapid motions that we call **nastic movements**. Nastic movements are not the result of growth. Plants are able to cause leaves and stems to move rapidly by controlling the turgor pressure in the cells of these plant organs. Water diffuses into and out of the central vacuoles of these cells through the process of *osmosis*. Plants can release ions like $Ca^{+2}$ and $K^{+}$ to affect this movement of water. If water quickly leaves the vacuoles, then the turgor pressure inside these cells will drop and the stems and leaves will *droop*. If water quickly enters the central vacuoles of these cells, the cells will become more rigid and the stems and leaves will become stiffer.

Some species of plants respond quickly to touch, and this response to touch is called a **thigmonasty**. *Mimosa pudica* is a species that causes its leaves to quickly droop in response to touch. This response benefits the plant by causing any herbivorous insects on its leaves to fall to the ground. This rapid motion may also scare away larger herbivores that would eat the plant. Nastic movements can also be in response to other stimuli like light. *Oxalis triangularis* is a species of plant that quickly responds to changes in light. Quickly responding to changes in light is called **photonasty**. The leaves of this plant open during the day, but at night when light levels are low the leaves fall and droop as the turgor pressure in the leaves drops.

Plants can also respond to changes in their environment that allow them to conserve resources like water. Conserving water is especially important for plants that live in arid habitats like deserts. Water can be lost by plants through the process of *transpiration*. Transpiration occurs when water evaporates from the plant. Water vapor is able to leave the plant by traveling through tiny pores in the epidermis of the plant called *stomata*. The size of each of these openings is controlled by *guard cells*. During the heat of the day or when water is scarce, plants can keep their stomata closed. This prevents water from escaping through the process of transpiration. However, plants cannot keep their stomata closed all of the time since these are the same pores that allow carbon dioxide gas to enter the plant.




*Gases, including water vapor and carbon dioxide, enter and exit through stomata*

## Reproduction


*Flowers and cones are reproductive organs in vascular plants*

In vascular plants, **flowers** and **cones** serve as the primary reproductive organs. These reproductive organs allow plants to sexually reproduce. In many flowering plants, parts of the flower eventually turn into *fruit* once sexual reproduction has occurred. Fruits contain large amounts of sugar, and these sugars are produced in the leaves of the plant. The sugars that eventually become part of the fruit travel from the leaves through the *phloem*.

Plants also require trace amounts of nutrients like *copper* and *boron* for healthy reproductive growth. These nutrients are absorbed from the soil by the *root system*. The nutrients then travel up through the stems in the *xylem* until they are delivered to the plant's reproductive organs. By working together, plant systems are able to provide the nutrients needed to reproduce new offspring.