Stems and Leaves

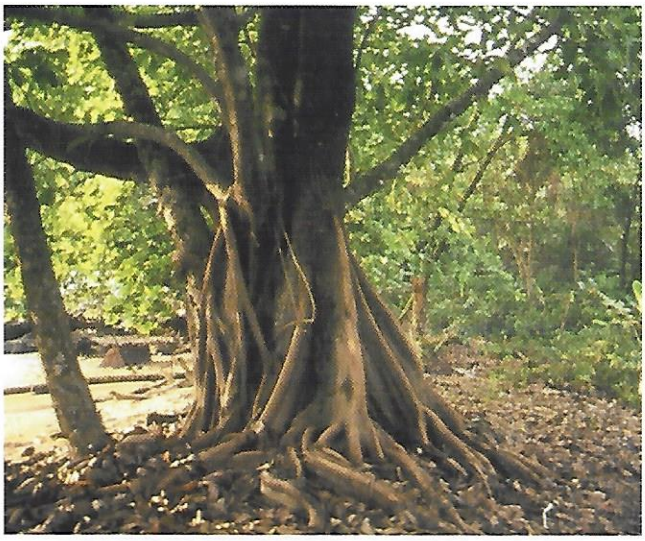
Think about walking through a wooded area or a park on a spring or summer day. You are surrounded by plants—trees above, bushes to the side, grass and flowers underfoot. A wonderful display of greenery of all sizes and shapes. At first glance these plants appear to be very different from one another, but on closer examination you will find that they have many things in common.

Just about all plants have **stems.** They may be green and flexible or rigid and covered by rough bark. The stems establish the basic shape of the plant and provide a structure for positioning **leaves.** Leaves come in many shapes, sizes, and colors, particularly shades of green. Each part of every organism, including stems and leaves of plants, helps the plant survive.

STEMS FOR SUPPORT

Microscopic examination of plant cells shows that they all have a cell wall in addition to the cell membrane. The cell wall is made of a rigid but flexible material called **cellulose.** Wood is made out of cellulose. Trees and shrubs that live for many years usually have hard, woody stems called branches and trunks. Plants that live for only part of a year usually have softer, more flexible stems. In either case the rigid cell walls provide the structure that gives plants their characteristic shape and allows them to support the load of leaves that grows on them.

The stems support and position the leaves, so that they receive just the right exposure to sunlight. Trees in the rain forest that require direct exposure to sunlight need very long stems (trunks) to compete with other Sun-loving plants. Such trees may be over 50 meters tall. Extreme height, however, can be a problem because rain forest soil is very shallow. A tall tree could easily be toppled in a storm. A number of tropical trees have evolved a large bracing structure on their trunks, called a **buttress,** to effectively broaden the base for stability.



Buttressed tree

Smaller plants in a dense forest have other ways of getting their leaves to sunlight. Vines have specialized structures called **tendrils** that allow them to attach to other structures. When a tendril touches an object, it twines tightly around it. As a result the vine can devote more energy to growing long and less energy to building a huge structure. It simply takes advantage of the structure provided by another tree and climbs up to position its leaves in the sunlight.

Other plants don't need soil at all. Instead they grow right on the high branches of established trees. In the rain forest such plants rely on rain to provide the water they need to survive. Many orchids live this way. Plants that live on branches in areas where water is not so readily available have roots that invade the xylem of the host tree's branches and "steal" the water they need. Mistletoe is a plant that does this.

Plants growing on the forest floor have an alternative to long, massive stems. They invest their vital energy in huge leaves. In this way they are able to use much more of the filtered light that makes its way down to the forest floor.

Broad-leafed understory plant

SPECIALIZED STEMS

Plants in the desert face a different problem. Because leaves lose so much water in a dry, hot environment, many desert plants, such as cactus, do not have green leaves. Others, such as the paloverde tree, sprout leaves only for a short time after a rain. How do they carry out photosynthesis and produce the food they need? The stem of the cactus and the trunk and branches of the paloverde tree are green. These stems and branches carry out photosynthesis.

The stems of some plants are adapted to protect the plant. Thorns, bristles, or hairlike coverings are examples of structures that protect plants from being eaten. Redwood trees have thick, shaggy bark that protects the tree from getting too hot during a forest fire. The bark also contains fire-retardant chemicals so that it is less likely to burn. The stems of some plants, including trees such as cedar, pine, creosote, and redwood, contain chemicals that are poisonous to many insects and fungi so that the stem will not be attacked.

LEAVES

Leaves have been called the energy factories of plants because most of the photosynthesis takes place in them. Most of the cells in leaves contain **chloroplasts** (CLOR•oh•plasts; *chloro* means green; *plast* means formed or molded), which look like tiny green spheres or ovals. They are easily seen in *Elodea* leaves.

PHOTOSYNTHESIS

In land plants, roots and stems bring water to the leaf, and the leaf absorbs carbon dioxide from the air. **Chlorophyll,** a green pigment inside the chloroplasts, captures energy from sunlight. The energy is used to produce carbohydrate (sugar) from water (H_2O) and carbon dioxide (CO_2). This process of creating energy-rich sugar from light, CO_2, and H_2O is **photosynthesis** (*photo* means light; *synthesis* means to put together).

Photosynthesis is one of the most important chemical reactions in life. During photosynthesis, oxygen gas (O_2) is given off by the plant as a waste product. This chemical reaction is written out below.

$$H_2O + CO_2 + \text{Light} = \text{Sugar (energy)} + O_2$$

FOOD STORAGE

The stored energy in the sugar is used by the plant to grow, repair damaged tissue, and make new

structures, such as flowers and seeds. The plant usually makes more sugar than it needs, so some of the sugar is converted into starch and is stored in different parts of the plant. Many plants store food energy in their stems and leaves as well as in their roots.

When animals eat plants, the energy is transferred to the animals. Some plant stems and leaves that humans use for food are celery, cabbage, sugar cane, asparagus, chives, lettuce, and rhubarb. Many animals get their food entirely from the starches and other carbohydrates stored in stems and leaves. These animals are called herbivores and include cows, horses, deer, koalas, and giant pandas. Almost all terrestrial organisms get their energy directly or indirectly from plants.

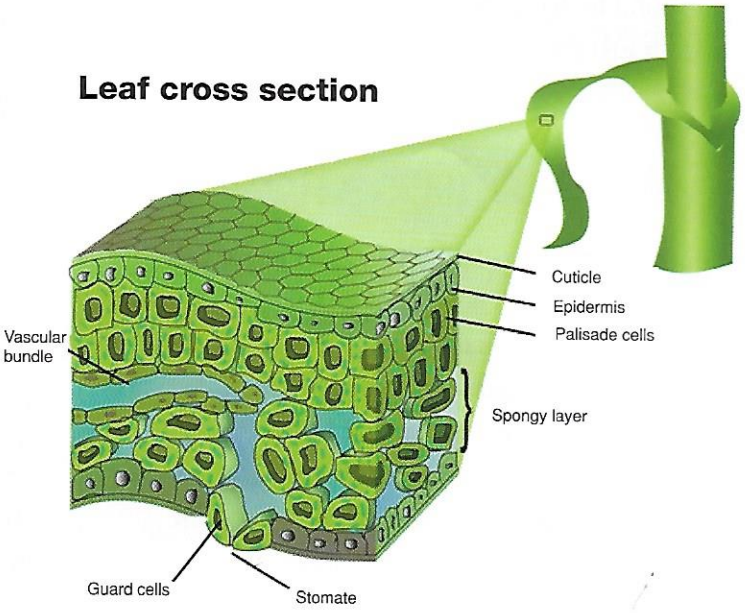
COORDINATION AT THE CELLULAR LEVEL

For photosynthesis to take place, several types of cells in the leaf have to work together. The drawing of a cross section of a leaf shows many kinds of cells in the leaf. These different cells all have different functions.

Fluids flow through plants in **vascular bundles.** Some cells form **xylem** (ZY•lem), which is a bundle of tubes that brings water and minerals to the cells. Other cells form the **phloem** (FLO•um), the tubes that take sugar to other parts of the plant that need it. **Epidermal** cells at the top and bottom surfaces of the leaf form an outer covering, a little bit like skin. These cells are covered with a waxy layer called the **cuticle.**

Cells just under the surface layers contain chloroplasts to capture sunlight for photosynthesis. Cells in the middle of the leaf have air spaces around them, making this part of the leaf rather spongy. This allows carbon dioxide and oxygen to circulate around the cells. The guard cells open and close the **stomates** to let carbon dioxide, oxygen, and water vapor enter and leave the leaf.

Leaf cross section

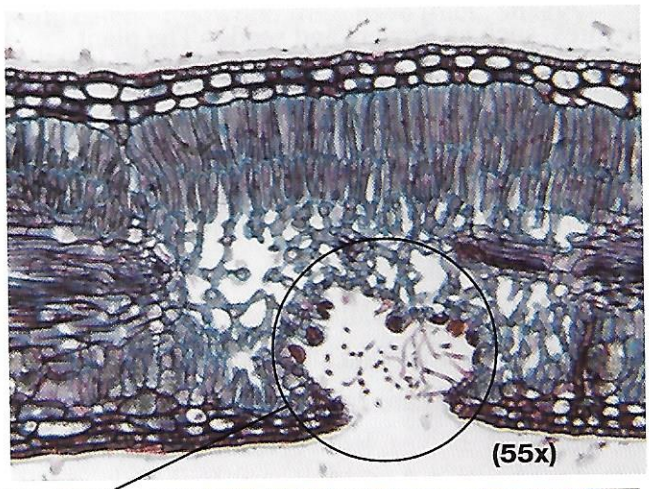


RETAINING WATER

All cells in the plant need a supply of sugar produced by photosynthesis to keep growing and building new tissue. For photosynthesis, plants need a lot of carbon dioxide coming in through the stomates and water coming up from the roots. However, water can quickly evaporate from the cells in the leaves. Most of this water vapor is lost through the stomates. The process of water vapor leaving the cells through the stomates is called **transpiration.**

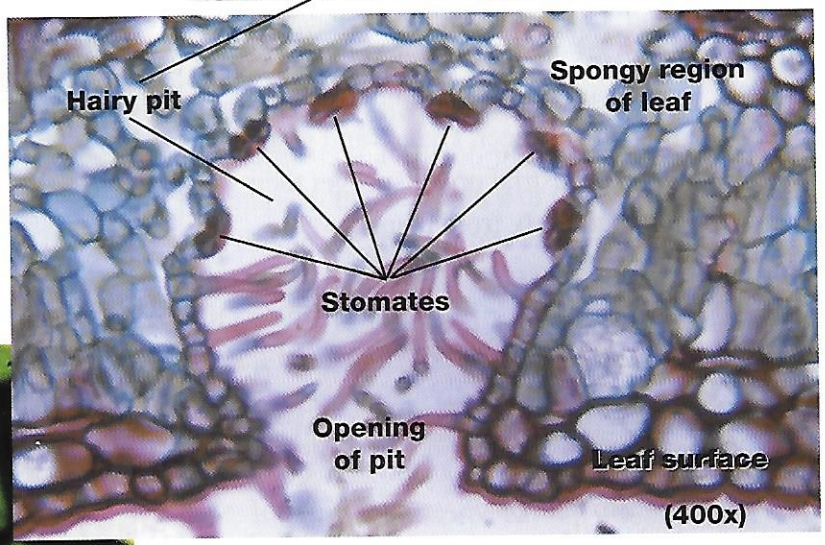
If the cells in the leaf lose too much water, the cells will shrink (a condition we call wilting), chemical reactions in the cells will stop, and if water is not soon restored, the cells will die. Even so, a little bit of wilting can actually benefit a plant when the water supply is low. When the leaf is drooping, it is not in position to capture the maximum amount of sunlight. Reduced sunlight slows the rate of water loss in the leaves.

When the weather is hot, the Sun is shining, a breeze is blowing, and the humidity is low, water evaporates very quickly. In these conditions plants can rapidly lose valuable water. Plants are able to respond to dry conditions to reduce the amount of water lost from their leaves.

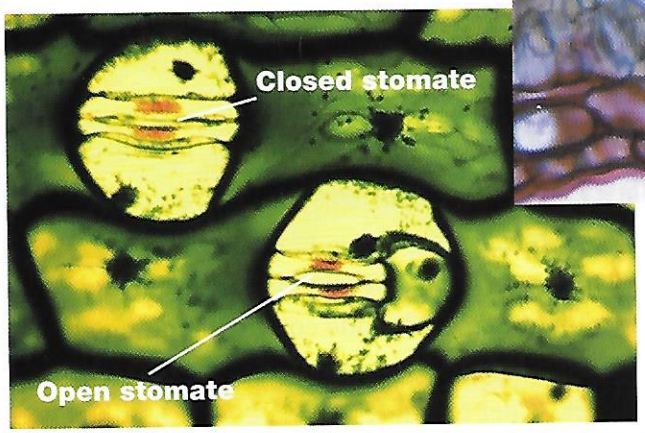


WATER CONSERVATION

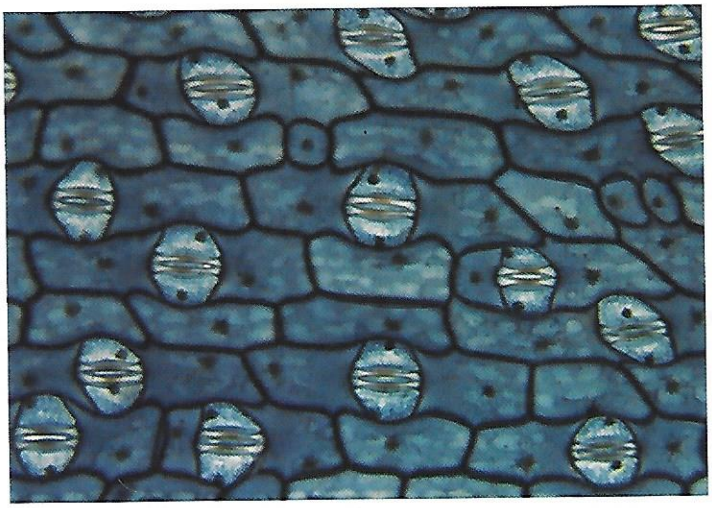
Fully hydrated (filled with water) guard cells are banana shaped. The curved guard cells hold the stomates open. When the cells in the leaf start to dehydrate, the guard cells lose water and flatten out. The result is that the stomate closes and water loss is reduced significantly.



Cross sections of oleander leaf



When the stomates are closed, carbon dioxide inside the leaf is quickly used up and the synthesis of sugars stops. For the plant it is more important in the short run to close the stomates to keep enough water in the cells to stay alive than it is to make more sugar.



Some plants have pits in the surfaces of their leaves. The pits are filled with numerous hairlike structures. Stomates are clustered in these pits. Because the breeze can't blow directly across the stomates, less water transpires from stomates in pits.

Most leaves have more stomates on the bottom surface than on the top surface. This makes sense because the Sun usually heats the top surface of the leaf more than the bottom.

The cuticle, a layer of waxy material on the surface of the leaf, reduces the amount of water that evaporates out of the cells and into the air. In dry climates the cuticle can be very thick.

Some plants have very thick leaves that can hold a lot of water. Because the leaves are so thick, most of the water in the leaf is farther from the surface and the stomates. Many desert plants have small leaves, resulting in less surface for transpiration. However, the small surface also cuts down on photosynthesis. This usually works out fine because sunlight is rarely a problem for desert plants. The paloverde tree and all cacti have chloroplasts in their stems, and photosynthesis occurs there.

One desert plant has a remarkable way of conserving water. The *Fenestraria* plant of South Africa grows underground with only the tips of the leaves above ground. The leaves are very thick, and the center part is packed with water-filled cells. The cells surrounding these water-tank cells contain chloroplasts. The leaves have a clear "window" at the exposed tip. Sunshine passes through the window into the center of the leaf to the underground cells containing the chloroplasts. The cells are protected from being dried out, and they also get plenty of sunlight.

LEAVES THAT COLLECT WATER

Some plants actually collect the water they need. For example, the redwoods along the California and Oregon coast obtain about half their water from the fog that comes off the ocean. The tiny droplets of fog collect on the short, thin needles of the redwood trees and drip off. During one night of heavy fog as much water can drip off a redwood as during a drenching rain. This keeps the trees and the plants under them alive during the summer months when there is little rain, but plenty of fog.

Other plants growing in dry climates have fuzzy leaves that collect moisture from dew. The fuzz increases the surface area of the leaf, creating more area for vapor to condense into liquid water. Dew collected by hairy-leaf plants keeps the soil moister than around plants with smooth leaves.

OTHER SPECIALIZED LEAF ADAPTATIONS

Plants all over the world have leaf adaptations that help them survive and reproduce. Plants growing in windy areas often have slender, flexible leaves to yield to the force of the wind. Trees living in rainy regions often have leaves with points along the margin to speed the flow of water off the leaves. Some plants that grow in cold regions have hairy leaves that fold up around the plant at night, acting like a blanket to hold warmth.

Next time you are in a garden, park, woods, or field, look closely at the leaves on the plants. Compare their size, shape, surface, flexibility, thickness, color, and pattern. They all serve the same basic functions, photosynthesis and water management, but each different leaf performs those functions in a way that contributes to the success of the plant on which it grows.

THINK QUESTIONS

1. What is the main purpose of leaves?
2. List five different adaptations plants have to keep from losing water.
3. What do they do in the grocery store to keep produce from wilting? Why?
4. Explain how humans live on energy from the Sun.
5. Why is coastal fog so important to the plants and animals that live there?