



Anatomy and Physiology of Leaves

I. Leaf Structure and Anatomy

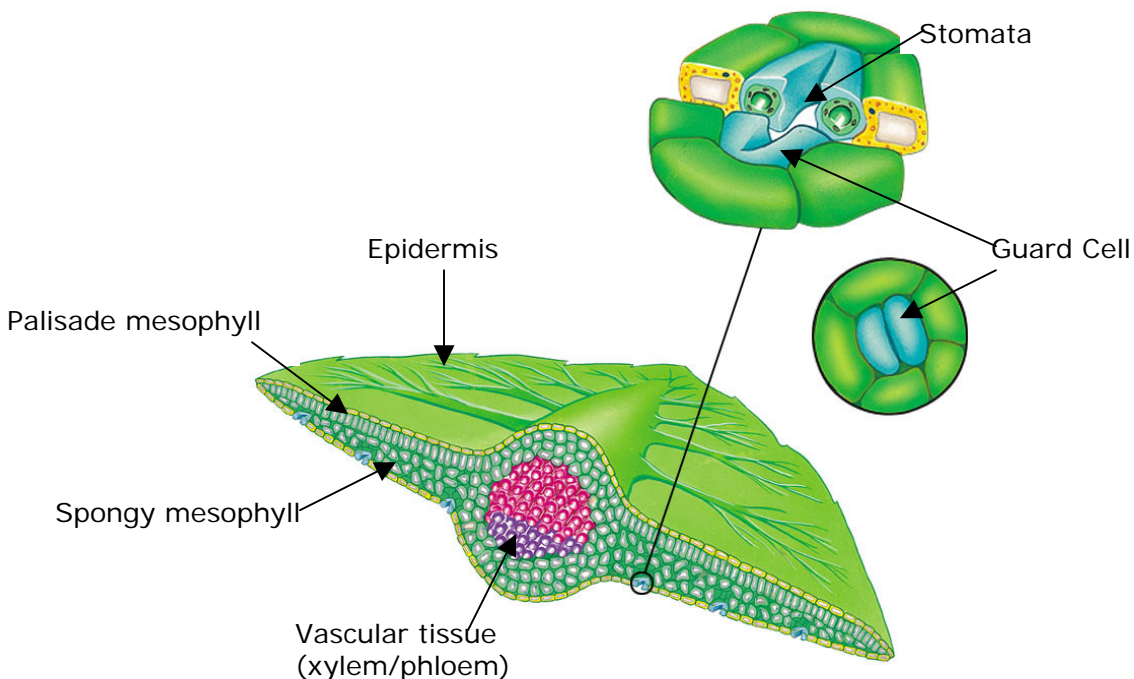
A. Structural Features of the Leaf

Question: How do plants respire? Plants must take in CO_2 from the atmosphere in order to photosynthesize. How does CO_2 get into the leaf?

Answer: Leaves have pores called **stomata** on the epidermal layer of the leaf. Stomata are the openings through which plants respire. The stomata are flanked by two **guard cells**, which control the size of the stomatal openings. Guard cells regulate the flow of gas between the leaf and its environment and control the amount of water passing through a leaf. Plants typically close their stomata at night to avoid too much water loss. Stomata are usually found on the underside of leaves in terrestrial plants. Some floating aquatic plants, like water lilies, have their stomata located on the upper side of the leaf. Submerged aquatic plants do not have stomata.

B. Internal Leaf Structure

Even though leaves are very thin to the naked eye, if you looked at a cross section of a leaf under a microscope you would see several cell layers. The top most layer of a leaf is called the upper **epidermis**. This protects the leaf and may be covered by a waxy **cuticle**. The next layer is the **palisade mesophyll**, which is a layer of closely packed cells that perform photosynthesis. The third layer is the **spongy mesophyll**, a layer of loosely packed photosynthetic cells. Finally, the bottom layer is called the lower epidermis and contains the guard cells with stomatal openings.



C. The Plant Vascular System

Question: How do leaves get the nutrients and water necessary for photosynthesis?

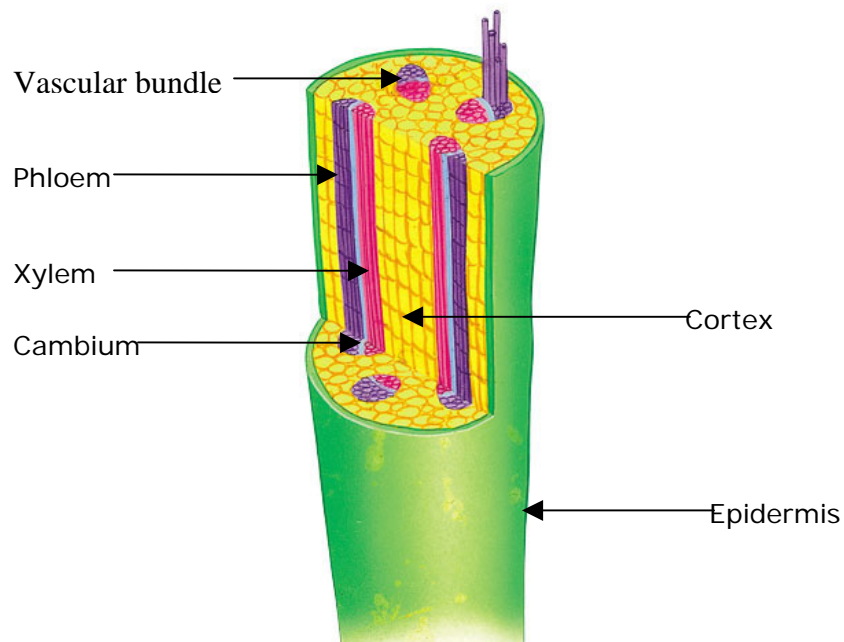
Answer: Usually water and minerals are absorbed by a plant's root system in the soil. Nutrients are made in the leaves during photosynthesis.

Question: How do water and nutrients get to and from the leaves?

Answer: In plants water and nutrients travel through the **vascular system**. The **vascular system** in plants is similar to our circulatory system. Just as we depend on our circulatory system to deliver nutrients and oxygen to our cells, plants rely on their vascular system to deliver water and nutrients to their cells. The plants vascular system is comprised of two main types of vascular tissue:

1. **Xylem** – Xylem conducts water and dissolved minerals absorbed from the soil through the plant. Xylem tissue is made up of vessels that are connected end to end to move water around quickly. Xylem also has a secondary function of support. Plants are like huge pumps. Some can pump up to 1000 gallons of water through their trunks or stems and into their leaves every hour through the xylem! 90% of this water is lost through the stomata and goes back into the atmosphere to form rain clouds.
2. **Phloem** – Leaves use the water and minerals that they get from the xylem along with sunlight to photosynthesize. Photosynthesis is the process by which plants make sugars and other nutrients. The phloem conducts these nutrients, which are made in the leaves, to all the cells in the plant so that the plant can have the materials it needs to grow and reproduce.

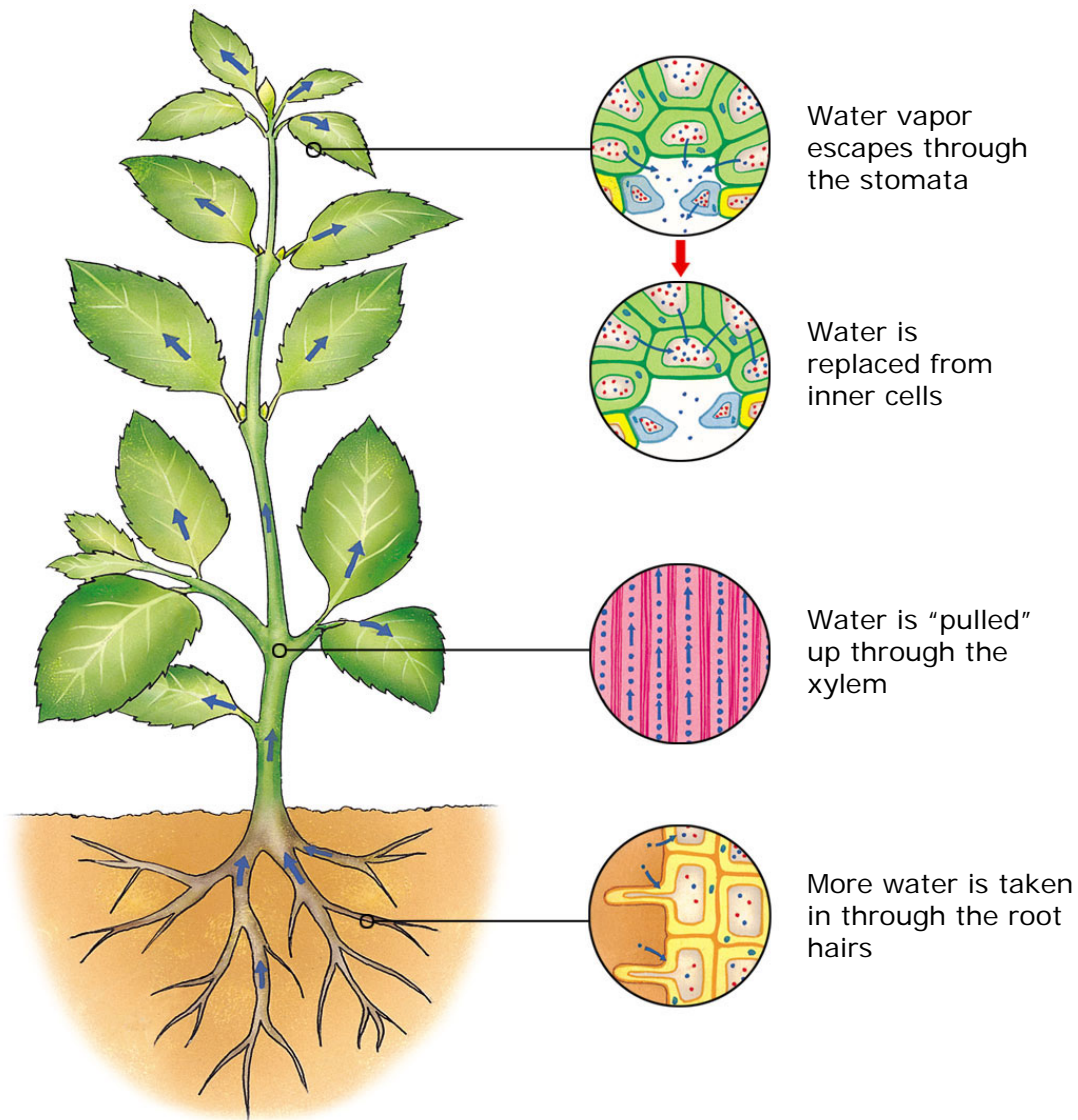
Xylem and phloem are often arranged in **vascular bundles**, surrounded by tissue called **cortex**. Between the xylem and phloem is a layer of thin cells called **cambium**.



II. Leaf Function and Physiology

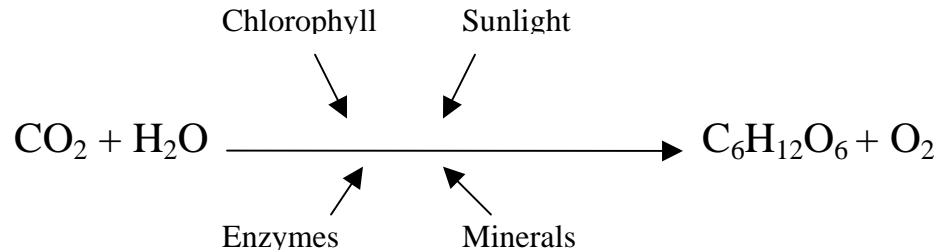
A. Transpiration

Have you ever noticed how much cooler it is under the shade of a tree in the summer than under the shade of a building? This is partly because of **transpiration**. Though you can't see it, the plant is releasing water molecules into the air, which cools the air around it. As discussed, plants can act as giant pumps, pumping water up from the soil into the leaves. Some of the water is used in the photosynthetic process, and a great deal of it escapes through the stomata. Water that escapes goes back into the atmosphere. Much of the water released by the plants will eventually form clouds and become rain, which falls back to the soil and begins this process all over again. If plants did not do this, much of the rain that falls would stay in the ground and never be put back into the atmosphere to become rain again. Thus the planet would be much hotter with a lot less rainfall, as in a desert.



B. Photosynthesis

The process by which plants make their food is called **photosynthesis**. Plants take in CO₂ and water (H₂O), and utilizing the power of sunlight along with minerals, enzymes and chlorophyll, produce oxygen (O₂) and carbon compounds such as glucose (C₆H₁₂O₆).



Plants can produce a variety of **carbon compounds** through this process, including oils, proteins, and starches. Plants use these compounds to build all of their materials for survival and reproduction. We use these materials for our food, medicines, dyes, perfumes, fibers etc.

Plants are considered primary producers, which means they make their own food without having to “eat” anything. Without plants, almost nothing could live on earth. There would be no food for anything else to eat, nor oxygen for animals to breathe. All animals on earth are dependent on plants.

III. Leaf Defenses

When you can't move, you have to find creative ways to defend yourself. Plants can fall prey to a whole host of hungry **herbivores**, from the tiny bugs like aphids to large mammals like giraffes, and many critters in between. Here are some ways that plants defend themselves:

- A. *Physical* – Physical defenses include spines (which are modified leaves, like a cactus), thorns (which are modified stems, like roses), or irritating hairs (like nettles). These act mainly to deter larger herbivores like mammals. Smaller herbivores like insects can often navigate around these physical defenses.

- B. *Chemical* – Plants can produce many compounds, including deadly ones. Some plants produce chemicals that actually kill herbivores or make them very sick. These can act to deter both small and large herbivores. Ironically, some of these compounds are good for humans, though they may be deadly to other animals. It is many of these compounds that we use as medicine. However in large enough concentrations, many of these medicinal compounds can become poisons.

- C. *Indigestibility* – Some plants simply are difficult or impossible to digest. Although plants produce many nutrients, they also have a number of materials that are difficult or impossible for animals to digest, such as **cellulose**. Thus, some plants have evolved to have more cellulose in their tissues, making them harder to digest. Grasses, for instance, are very high in cellulose because they are eaten heavily by grazing animals. However, many grazing animals have evolved ways of coping with this - for instance cows and other ruminants have a four-chambered stomach, which is specially designed to break down cellulose!

- D. *Mechanical* – Though it is rare, some leaves defend themselves by folding up in response to the stimulus of touch. This makes it difficult for an insect to get at the tissue of the leaf. There are even leaves that fold up, trap and digest insects (like the Venus fly trap) then use the nutrients from these digested insects for their own benefit.