Reference 1

Plant Structure and Photosynthesis

Leaf Structure

At some point in your life, you have probably noticed that plant leaves take on many different shapes and sizes. You may even have identified different species of trees based on the shape of their leaves. One common feature of most leaves is that they are thin and flat. This basic shape helps optimize leaves for capturing sunlight for photosynthesis.

Even though leaves are thin, they have a fairly complex structure inside (figure R1.1). Covering both the upper and the lower surfaces of the leaf is a transparent layer of cells called the epidermis. Epidermal cells secrete a waxy substance that forms a waterproof coating called the cuticle. This waxy cuticle helps prevent the leaf from losing too much water and drying out. Some plants that live in very dry areas have a thicker cuticle to help prevent water loss. Plants that live in wetter areas do not need a thick cuticle because they are less susceptible to drying out.

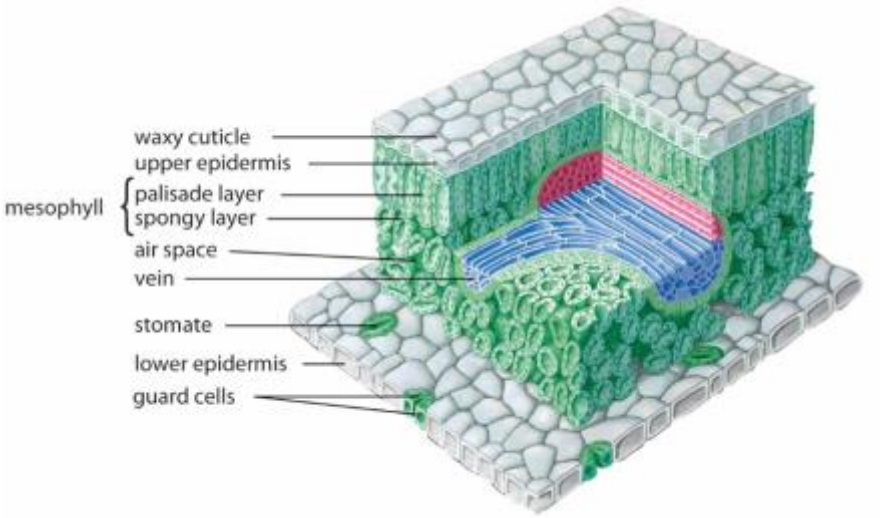

Figure R1.1: This diagram of a section of a leaf shows its internal structures. Although colors are used to highlight the different types of cells and tissues, note that cells that conduct photosynthesis are naturally colored green because they contain chloroplasts.

Photosynthesis occurs in the mesophyll cells that contain numerous chloroplasts. There are two types of mesophyll cells. In the upper palisade layer, the mesophyll cells are elongated and packed together tightly. This space-saving arrangement exposes the maximum number of cells to light in the minimum amount of space. In the lower spongy layer, the mesophyll cells are rounder and packed loosely with many empty air spaces between them. These spaces allow gases to move around freely and diffuse into all the mesophyll cells.

Substances enter and leave the leaf by two different routes: veins and stomates. Veins, which are continuations of the vascular tissues of the stem and root, supply the leaf cells with water and

nutrients. Gases move into and out of a leaf by diffusion through millions of stomates, which are slit-like openings in the leaf surface. The stomates open into the spongy mesophyll's air spaces and allow the carbon dioxide used in photosynthesis and the oxygen used in cellular respiration to reach all the cells of the leaf (figure R1.2).


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Figure R1.2: Scanning electron micrograph of the surface of a leaf. The stomates, surrounded by guard cells, allow gases to enter the leaf.

Guard Cells Regulate Water Loss

Although water molecules are present in the air as water vapor, they are never as abundant in the air as they are in the leaf. Thus, the plant loses water as it diffuses into the air through the stomates. This water loss is called transpiration.

When plant cells have adequate supplies of water, the water exerts a pressure known as turgor pressure against the cell walls. Turgor pressure supports the stems and leaves. If more water is lost from a plant by transpiration than is replaced through the roots, the cells lose turgor pressure. As a result, the stems and leaves are no longer held upright and the plant wilts. If the water is not replaced, the cells and then the plant will die.

How can a plant conserve water and still allow the needed carbon dioxide to enter? Each stomate is surrounded by a pair of specialized cells called guard cells (figure R1.3). When water is abundant, the guard cells fill with water. This causes the guard cells to bend outward and the stomates open allowing carbon dioxide to diffuse into the leaf. When a plant loses more water than it can replace, the turgor pressure of the guard cells decreases. The guard cells no longer bend outward and, as a result, the stomates close. In this manner, the plant is able to reduce the loss of water under dry conditions. During these times, however, little photosynthesis takes place because there is little carbon dioxide available to be converted into sugars.

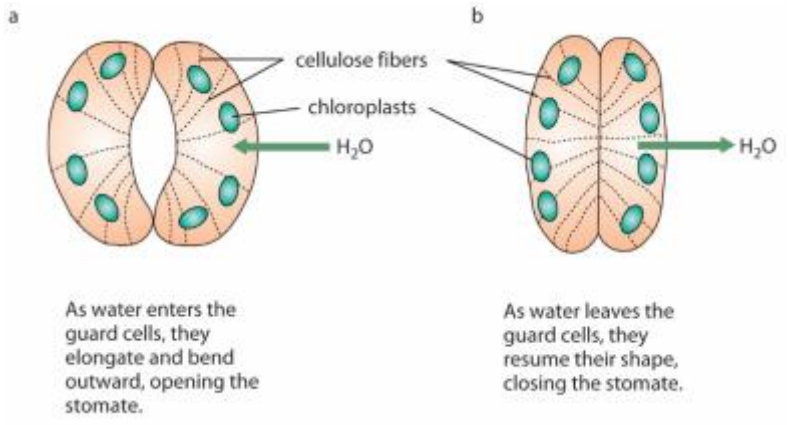

Figure R1.3: Guard cells control the opening of stomates. Because they are attached to each other at both ends and encircled by rigid cellulose fibers, the guard cells elongate and bend outward when they take up water.

Not All Leaves Photosynthesize and Photosynthesis May Take Place in Other Parts of the Plant

Although the major function of most leaves is photosynthesis, some leaves photosynthesize very little, if at all. These leaves have other functions that are adapted to the environmental conditions in which the plants live. For example, the spines on spurge and on cacti are modified leaves that are hard, sharp, and nonphotosynthetic (figure R1.4). Their function is help protect the plant against predators that want to eat them. Plants with smaller leaves (and, therefore, less surface area) lose less water than do plants with larger leaves because water loss occurs mostly from leaves.

Figure R1.4: Members of the spurge family have spines that actually are modified leaves. Photosynthesis takes place in the stems of plants like spurge and cacti to minimize the amount of water lost from the plant through the leaves.

In addition to leaves, photosynthesis takes place in green stems of plants. You are probably familiar with green asparagus in your grocery store. Have you ever seen white asparagus? White asparagus is the same plant as green asparagus. The difference results from the way the asparagus is grown. To grow white asparagus, farmers cover the asparagus shoots with dirt or plastic that blocks the light from getting to the plants, thereby preventing photosynthesis from occurring. Cacti are another example of plants where photosynthesis occurs in stems. In the dry habitats in which cacti are found, spines reduce water loss and help protect the cactus from herbivores. Photosynthesis takes place in the stems of the cacti rather than the spines (leaves).

Other plants in dry habitats have modified leaves that function to store water in addition to carrying out their role in photosynthesis. These plants, known as succulents, have tissues filled with so much water that water can be squeezed from them. After a rainstorm, the roots of succulents quickly absorb more water than the plant can use immediately. The water is stored in the leaves of succulents (and in the stems of cacti) until the plant needs it. A waxy cuticle so thick it can be scraped off with a fingernail helps the leaves hold water.