BACK TO BASICS

WHAT ARE STOMATES AND HOW DO THEY WORK?

by Bruce R. Roberts

Stomates, also called stomata, are microscopic openings or pores in the epidermal surface of leaves. In trees, these pores are found mostly on the underside of leaf surfaces and less frequently on the top. It is through these openings that water vapor is lost from the leaf to the surrounding air, a process referred to as transpiration. It is also through these openings that carbon dioxide (an important component of the photosynthetic reaction) diffuses into the leaf from the surrounding atmosphere. Thus, stomates play a critical role in the life of all trees through the exchange of gases (carbon dioxide and water vapor) between the plant and its environment.

Since carbon dioxide and water vapor both diffuse in and out of the same stomatal pores, this can occasionally cause a problem for the tree. Since the inward movement of carbon dioxide is necessary for photosynthesis, it is helpful to have the stomates open as much as possible. On the other hand, with the stomates open, a pathway is provided for water (in the form of water vapor) to escape from the leaf—a situation which can prove harmful under conditions of limited moisture.

Although individual stomatal pores are very small (for most trees, about 400 could fit on the head of a pin), the total number of stomates on each leaf can be quite large (as many as 16,000 per square inch in some oaks). The combined area occupied by these pores when fully open is somewhere between 1% to 3% of the total surface area in most leaves.

Realizing the importance of stomates in the overall well being of higher plants, how then do they work? Surprisingly, we still do not know all the details surrounding the stomatal mechanism. However, some generalizations can be made. First, stomates usually open in the light and close in the dark. Second, stomates tend to open in low concentrations of carbon dioxide and close in high concentrations of carbon dioxide. Third, stomatal opening is influenced by many environmental factors such as temperature, humidity, light, and the presence of gaseous pollutants such as sulfur dioxide and ozone.

The actual mechanism by which stomates open and close is controlled by guard cells, which are specialized epidermal cells surrounding each stomatal pore. A change in the internal pressure of these guard cells (i.e. a change in turgor pressure) affects the degree of stomatal opening. When turgor pressure is high the stomatal pore will increase in size. When turgor pressure is low the stomatal pore will decrease in size. For many years it was thought that changes in turgor pressure were caused by changes in the amounts of sugar and starch in each guard cell. Now, however, we realize that these changes are controlled primarily by the uptake or loss of potassium ions between guard cells and adjoining epidermal cells.

The question is frequently asked: Is there some way to regulate stomatal opening, particularly during periods of drought when continued loss of water might harm the tree? The answer is a qualified "yes". Stomatal opening can be controlled to some degree by applying antitranspirants such as latex emulsions, waxes, alcohols or other chemical substances. But it must be remembered that these materials can cause a reduction in carbon dioxide uptake and a subsequent decline in photosynthesis. Thus, the application of antitranspirants to control stomatal opening has only limited usefulness in most field situations, and it may be more practical to consider other means of preventing dehydration such as supplemental irrigation or mulching.

U.S. Department of Agriculture,
Delaware, OH 43015