Autumn Changes in Deciduous Trees

By Jeffrey O. Dawson, Professor of Tree Physiology, University of Illinois
jdawson2@uiuc.edu 217/333-9281

Every year the Department of Natural Resources and Environmental Sciences is asked what causes trees to put on their dazzling display of color in the fall. Contrary to popular belief, an early frost does not promote brilliant fall color; in fact, it can kill the foliage, producing dull tones. Rather, bright colors and falling leaves, as well as other less obvious changes in the tree, are due to biochemical reactions triggered by autumn's shortening day length and cool—but not freezing—temperatures.

Color-producing substances

With declining autumn temperatures, tree leaves stop producing chlorophyll, the green pigment of photosynthesis. As the green color fades, yellow carotenoid pigments already present in the leaves are unmasked. The clear yellow color of such trees as hickory is attributable to carotenoid pigments. During the summer, these pigments, primarily carotene and xanthophyll, function in the leaves to transfer light energy for use in the photosynthetic production of carbohydrates. While all trees contain the yellow carotenoid pigments, not all possess the genetic potential for producing anthocyanins, which cause the pink, red, and purple leaf colors. The anthocyanins, which occur in solution in the cell sap, are formed from excess soluble sugars that accumulate in the leaves after the weather turns cool in early fall. Like the carotenoids, anthocyanins are unmasked when autumn temperatures halt the leaves' production of chlorophyll. If the cell sap is acid, the anthocyanin in solution will be red. If the pH of the cell sap is higher (that is, approaching alkalinity), anthocyanin appears purplish to blue. Anthocyanin pigments are responsible for the bright red foliage of the Crimson King variety of Norway maple.

The color of a tree's fall foliage will depend on the combination of pigments in the leaves. Some species, such as alders, show little change and do not have a synchronous leaf fall. Poplars, tulip tree, hickories, beech, birches, and honeylocust have yellowish hues. The most brilliant displays are seen in trees that form large amounts of anthocyanin: sumac, sassafras, and white oaks.

Day length and leaf fall

While trees are responding to the cooler temperatures, they are also reacting to the shorter day lengths of autumn. Trees and other plants "sense" day length by means of a substance called phytochrome. Scientists believe that changes in phytochrome brought about by day length may be linked to the production of plant growth regulators. Long days produce high levels of auxins and gibberellins, which stimulate growth, and low levels of growth inhibitors. Conversely, short days produce low levels of auxins and gibberellins and high levels of inhibitors such as the hormone abscisic acid. Abscisic acid stimulates the formation of a layer of cork-like cells at the base of the leaf petiole. This layer halts the flow of water and nutrients from the tree to its leaves, causing leaf fall. Some trees respond to the stimulus of shortening day length by dropping all their leaves within a period of a few short days or even hours. When day length is artificially extended to 16 hours in a growth chamber, the leaves stay on trees for months longer than on trees grown in chambers where the photoperiod is shortened as it is in the fall. The effect of day length can be observed in tree leaves that grow close to street lights. These leaves stay green longer and are shed later than other leaves on the same tree, providing the tree species is sensitive to day length.

Other seasonal changes

Along with the visible color changes and leaf fall, deciduous trees undergo other important changes as winter approaches. Some of these changes permit the living tissue to "harden," so that it can withstand the potential damage due to sub freezing temperatures. In most deciduous trees, the tissue nitrogen content also changes. Nitrogen and surplus carbohydrates are transported from leaves to twigs and branches before leaf fall, thus conserving nutrients for tree growth the following spring.

Other Interesting Fall Color Web Sites

http://www.fs.fed.us/conf/fall/leaframe.htm

http://www.fs.fed.us/news/fall.shtml

http://bluehen.ags.udel.edu/deces/hyg/hyg-19.htm

http://www.dnr.state.oh.us/odnr/color/science.htm

http://ncnatural.com/wildflwr/fall/science.html

http://www.travelwisconsin.com/seasonal/colorreport.shtml