Leaf Chemistry: Color Change in the Fall

By Susan Camp

Every few years, someone will ask me how and why leaves change color in the fall. I love this question. To a child, leaf color change seems like a magical occurrence. Mother Nature sends Jack Frost out to touch the leaves with his icy wand, and suddenly, green leaves turn red and gold and orange.

In reality, a kind of magic does occur, but it is the magic of chemistry, a science that some of us slept through in high school, absorbing just enough to earn a passing grade. I'm not saying I did this, but you know if you did.

In reality, the green leaves of deciduous trees turn color in the fall because of chemical changes that occur to leaf pigments, the most important of which are chlorophyll and the carotenoids. Chlorophyll is the chemical that gives leaves their green hue. Chlorophyll is necessary for photosynthesis, the chemical process by which plants utilize sunlight to change water and carbon dioxide into sugars for nutrition. Carotene and xanthophyll are carotenoids that produce orange, yellow, and brown leaves. The dominant chlorophyll masks the carotenoids' colors in leaves most of the year. A third pigment, anthocyanin, produces red shades in fruits, flowers, and other plant parts.

As the days grow shorter and nights grow longer and the temperature drops, chlorophyll production slows down and gradually stops. Carotenoid pigments are unmasked, and yellow, orange, and brown leaves appear. The leaves of some trees, including sycamores and tulip poplars, turn brown and yellow and drop without displaying vibrant hues.

Warm, sunny days and cool nights above freezing cause the production of anthocyanin pigments that help trees recover and store the sugars they need to survive during the cold winter months. Anthocyanin results in a spectacular fall display of fiery reds and luscious purples in trees like maples, dogwoods, sweet gums, and black gums.

Soil moisture affects color, as do a late, cool spring and a period of summer drought, both of which serve to delay the onset of leaf change. The ideal weather for vibrant color includes a warm, wet spring; a summer without temperature extremes; and sunny fall days and cool nights. I had concerns that we would see little fall color this year because of the long periods of high summer temperatures without rain, then massive downpours. When the tulip poplar leaves turned brown and crunchy even earlier than usual, I was certain the trees would put on a drab display this fall. Happily, I was wrong.

The brilliantly-hued leaves can't last forever. A deciduous tree's leaves, unlike its twigs and branches, aren't hardy enough to withstand freezing weather. The thin leaves are composed of

watery, sap-filled cells, so trees have evolved a means of sealing off and shedding the leaves. As the days shorten, the leaf veins close and a layer of cells, called the abscission layer, is produced at the junction of a twig and the end of a leaf stem. This cell layer functions to separate the leaf from the tree. As the weather begins to cool at the end of summer, the cells of the abscission layer release enzymes that seal off the point where the two structures interface. Over time, the abscission layer weakens, and then disintegrates, causing the leaf to drop off.

When the leaf falls, the tree seals the wound with a leaf scar. The leaves of some juvenile oaks and beeches remain attached until spring, a phenomenon known as marcescence. In years, without an early killing frost, the reason for marcescence remains a matter of scientific speculation. The simplest explanation is that the age of the tree may dictate the occurrence of marcescence, but several related, underlying reasons are offered in the literature, making marcescence an interesting topic for a future column.

See the USDA Forest Service Northeastern Area article “Why Leaves Change Color” and the SUNY College of Environment Science and Forestry publication “Why Leaves Change Color” for further information.