OUTDOOR DISCOVERY

Tom Lindsay

Nature's Color Palette

by Abby Alger

Autumn in New York means a dazzling display of fall foliage; the rich tones of red, orange, yellow and gold make the world seem alight. It's one of nature's most impressive scenes, and also one of her most closely guarded secrets. Like a skilled magician, she makes the impossible seem simple. Only close examination of the process reveals its complexities.

Summer Splendor

The brilliant green of summer foliage is little more than a mask for the fiery hues that lie underneath. The leaves of the sunny seasons are rich in chlorophyll, a common green plant pigment. Chlorophyll is essential to the plant's survival. It plays a vital role in photosynthesis, the tree's food-making process that takes place in the leaves. The pigment absorbs energy from sunlight, fueling chemical reactions that break down chlorophyll and produce simple sugars and oxygen from carbon dioxide and water. The oxygen is released to the environment, but the sugar is saved as fuel for the tree. The energy, in turn, allows the tree's chlorophyll to be replenished.

Hidden to our eyes—but still present in the leaves—are yellow and orange pigments known as carotenoids. They also absorb energy from sunlight, and that energy is then passed along to chlorophyll so photosynthesis can take place. Carotenoids are chemically stable, and so they don't naturally break down at a high rate like chlorophyll. As a result, they're in the leaf from when it buds to when it falls from the tree. But in the leaf's version of an eclipse, the chlorophyll hides the carotenoids' colors until fall arrives.

...Becomes Fall Foliage

The spring-to-summer cycle of a tree's life is well-understood. It's the transformation to fall—really, why leaves change color—that sparks debate. Trees "sense" the change of season as days shorten and temperatures cool. Energy pools start to drain; with fewer daylight hours, there's less opportunity for photosynthesis, and therefore less sugar and chlorophyll produced. If it is to survive the impending winter, the tree must use its remaining resources to gather nutrients. More than half of those in the leaf are shipped to the tree, and cell layers begin to grow at the leaf's stem to start severing it from the tree. The tree can survive on stored sugar for the winter, but it can't keep its leaves alive with it.

Even while the leaves are "shutting down" for winter, they are making a new type of pigment in the fall. Known as anthocyanins, this group of pigments is responsible for red and violet hues. Its production begins in the late summer. Anthocyanins play an important part in the life of the aging leaves: they are a natural sun-block. Since levels of chlorophyll are depleted, the leaf cannot use all the sun energy that hits it. Anthocyanins absorb the excess so that the sun's rays don't damage leaf tissues.

As chlorophyll becomes less present in the leaves, the brightness of their underlying colors appears. This transformation is broken into a "fall color wave" sweeping from north to south; first yellow, then orange, and then red hues paint the landscape. The colors result from the interaction of carotenoids and anthocyanins, which are dominant. Leaves with mostly anthocyanins are red; those with very little are yellow, and the ones with a mix of the two pigments appear orange.

Best Weather

The intensity and duration of autumn foliage is affected by a number of factors, including temperature, sunlight, and soil pH. The best weather for brilliant fall colors is undoubtedly dry, bright days with cool, frost-free nights.

The largest variants in fall color are anthocyanins, since they are the only pigments actually produced in the fall. Lower temperatures and dry weather favor their production; and, as an added "bonus," hasten the destruction of chlorophyll. Soil pH will also influence anthocyanins, not in quantity but in color. At the extremes of pH "highly acidic and highly basic" anthocyanins are blueish, while at the middle of the spectrum they take on violet undertones.

Frost and rain will do the most damage to a beautiful autumn landscape. Freezing temperatures harden the cell layer between leaf stem and tree faster; as a result, colorful leaves will stay on the tree for shorter time periods. Rainy weather will also "leach" the water-soluble anthocyanins from leaves, and have an overall dampening effect on the fiery colors. Rain can also strip leaves off the trees.

Did You Know?

For decades, the changing colors of fall were accepted as merely a by-product of leaf death. However, in the 1990s, discussion and debate were revived to focus on a series of still unanswered questions. Simply, why would leaves change color? Is there an evolutionary benefit? And doesn't the production of additional pigments, anthocyanins, imply that there is a purpose?

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Nature trades her green summer dress for a bright and colorful fall gown.

The "leaf signal" theory is one of two that predominates scientific discussion. Dr. Marco Archetti (University of Fribourg, Switzerland) and Dr. Sam Brown (University of Texas) proposed it in a paper published in 2000; the idea first came from their late professor, Dr. William Hamilton (Oxford University). They argue that leaves take on bright colors in the fall to ward off insects seeking a winter home. The shades have long-been the warning sign of poisonous species, so their position is that fall foliage is the "war paint" of trees.

However, in 2002, Dr. David Wilkinson (Liverpool John Moores University, England) and Dr. H. Martin Schaefer (University of Freiburg, Germany) argued against this conclusion, and offered their own explanation. Rather than war paint, they say, leaves are sun-block in the fall. Anthocyanins are produced because they absorb excess sunlight, and prevent damage to the leaf. The brilliant coloration is merely incidental: the yellows and oranges appear after natural destruction of chlorophyll, and the reds only because anthocyanins are essential.

Abby Alger recently finished her summer as a *Conservationist* staff assistant. She is currently a sophomore at Duke University.

What do you think?

Write to us at *Conservationist*, re: Leaves, 625 Broadway, Albany, NY, 12233-4502.

Ray Minnick