The timing of autumn color can largely be attributed to the shortening day length and cooler temperatures that follow the summer solstice. These changing environmental cues initiate leaf senescence and the biochemical processes that cause leaf color to change.

The anthocyanin pigments responsible for the pink, red, and purple leaves of sugar and red maple, sassafras, sumac, white and scarlet oak, shadbush, winged euonymus, and many other woody plants are formed by reactions between various sugars and complex compounds called anthocyanidins. A mixture of red anthocyanin pigment with yellow carotene often give a bright orange color as seen in some species of maples.

Among the most important environmental factors that influence the intensity of color due to anthocyanins are light intensity, temperature, and water supply. Bright light favors red color, and anthocyanin pigments usually develop only in leaves that are exposed to the light. If one leaf is shaded by another, the lower leaf usually does not form the red pigments at all. The degree of color can vary from tree to tree as well, since trees exposed to the sun may turn red while others in the shade may be yellow. A single tree may have branches with different colored leaves.

Cool temperatures common in fall favor the conversion of insoluble starch to soluble sugars. The translocation of these sugars from leaves via the phloem also is reduced by cool temperatures. Once an abscission layer is formed, carbohydrates are trapped in the leaf. Loss of water as leaves dry out in the fall and low nitrogen content resulting from the mobilization of nutrients from leaves into twigs and branches also favor anthocyanin formation.

The dull browns developed by some oaks and other species are due to cell wall structure that becomes apparent as chlorophyll and carotenoids disappear and to another group of pigments in the leaves, the tannins. These pigments are the same bitter substances that color and flavor tea and cause unripe persimmons to pucker your mouth. Tannins are a heterogeneous group of complex compounds of widespread occurrence in plants. They are present in the cell sap inside the vacuole, but also occur in cell walls, often accumulating in considerable amounts in dead tissue. The golden yellow produced in some leaves such as those of breeches, results from the presence of tannins along with the yellow carotenoid pigments.

The Best Weather Conditions

In some years autumn color is more pronounced than in others. The shades of yellow and brown always appear, but it is the brilliant reds and purples mixed with the yellows that impart the awesome beauty to fall landscapes. Climatic conditions have the most effect on production of anthocyanin pigments to intensify the red and scarlet colors.

Fall weather conditions favoring of bright red autumn color are warm sunny days followed by cool nights with temperatures below 45° F, but not freezing. Some photosynthesis still occurs in the leaves during the daytime even while the chlorophyll content is declining. Rainy or cloudy days without much light occurring near the time of peak coloration will actually decrease the intensity of fall colors by limiting photosynthesis. There is an old wive's tale that says rainy days wash the color out of the leaves. While that is not true, these conditions reduce light intensity, and heavy rains and high winds can sweep the leaves off the trees early.

Color combinations for Autumn seem endless

Cool nights limit movement of sugar in the phloem from the leaves. The cool temperature also lowers the rate of respiration which converts the sugars back to carbon dioxide and water, releasing the energy for metabolic processes. From the sugars retained in the leaves anthocyanin pigments are formed. Freezing temperatures and heavy frost can greatly reduce the brilliance of autumn leaf color by killing or severely injuring the leaves before the pigments reach their maximum development. The physiological and enzymatic processes associated with the senescence of leaves require living cells.

City of Modesto

Fall Color Map

For more information on the City Tree Program
call 577-5363
TDD (209) 526-9211 Hearing and Speech Impaired only

FALL COLOR FACTS

Autumn colors have been celebrated in literature, legends, songs, and works of art since ancient times. It was recognized as a scientific phenomenon as early as 285 B.C. by Theophrastus, the Greek philosopher and natural scientist, who included comments on the shedding of leaves from trees in his lectures. Because a clear understanding of the causes of fall coloration was lacking, a number of legends evolved to explain the riot of color that develops with the change of seasons.

Legends include the mythical Jack Frost who supposedly brings reds and purples to the forest by pinching the leaves with his icy fingers. The hues of yellow, gold, and brown are mixed on his paint palette and applied with quick broad strokes of his brush as he silently moves among the trees to decorate them. According to an Indian legend, celestial hunters kill a great bear in the autumn sky and, its blood dripping on the forests, change many leaves to red. Other trees are turned yellow by the fat that splatters out of the kettle as the hunters cook the meat.

Although we still tell these stories today, we are able to explain the how and why of fall color. The explanation involves the geographic distribution and growth habit of trees, physics of light and color, plant pigments, the physiology and anatomy of leaves, and the influence of weather conditions as the seasons change.

The golden glitter of Ginkgo trees

Visible Light and Color

The various leaf colors we see are due to the physics of sunlight striking pigments in the leaves. Light energy arrives from the sun in an electromagnetic spectrum of wavelengths. The portion of this energy spectrum that the human eye can see is called visible light. Because of their structure, all objects, including leaves, selectively absorb certain wavelengths and reflect others. It is the reflected light that determines the color we see. Things that appear black absorb virtually all of the light which strikes them. Objects appear white because almost all the light is reflected. A leaf is green because it reflects primarily the green wavelengths of the spectrum. The other wavelengths are absorbed by the pigments and other structural components of the leaf. Changes in the pigments in leaves during the autumn alter the relative absorption and reflection of wavelengths of the visible spectrum and hence the colors we perceive, too.

Leaf Pigments and Physiological Changes

For an explanation of fall color, four broad categories of pigments are recognized. Chlorophylls, carotenoids, anthocyanins, and tannins. It is these same pigments that also account for the array of color in flowers. During spring and summer, the leaves serve as the principal site for the photosynthetic process in which carbon dioxide and water are transformed to the carbohydrates necessary for tree growth. This food making process takes place in the leaf in numerous cells containing the pigment chlorophyll which gives the leaf its green color. Chlorophyll is contained in specialized cell organelles known as chloroplasts.

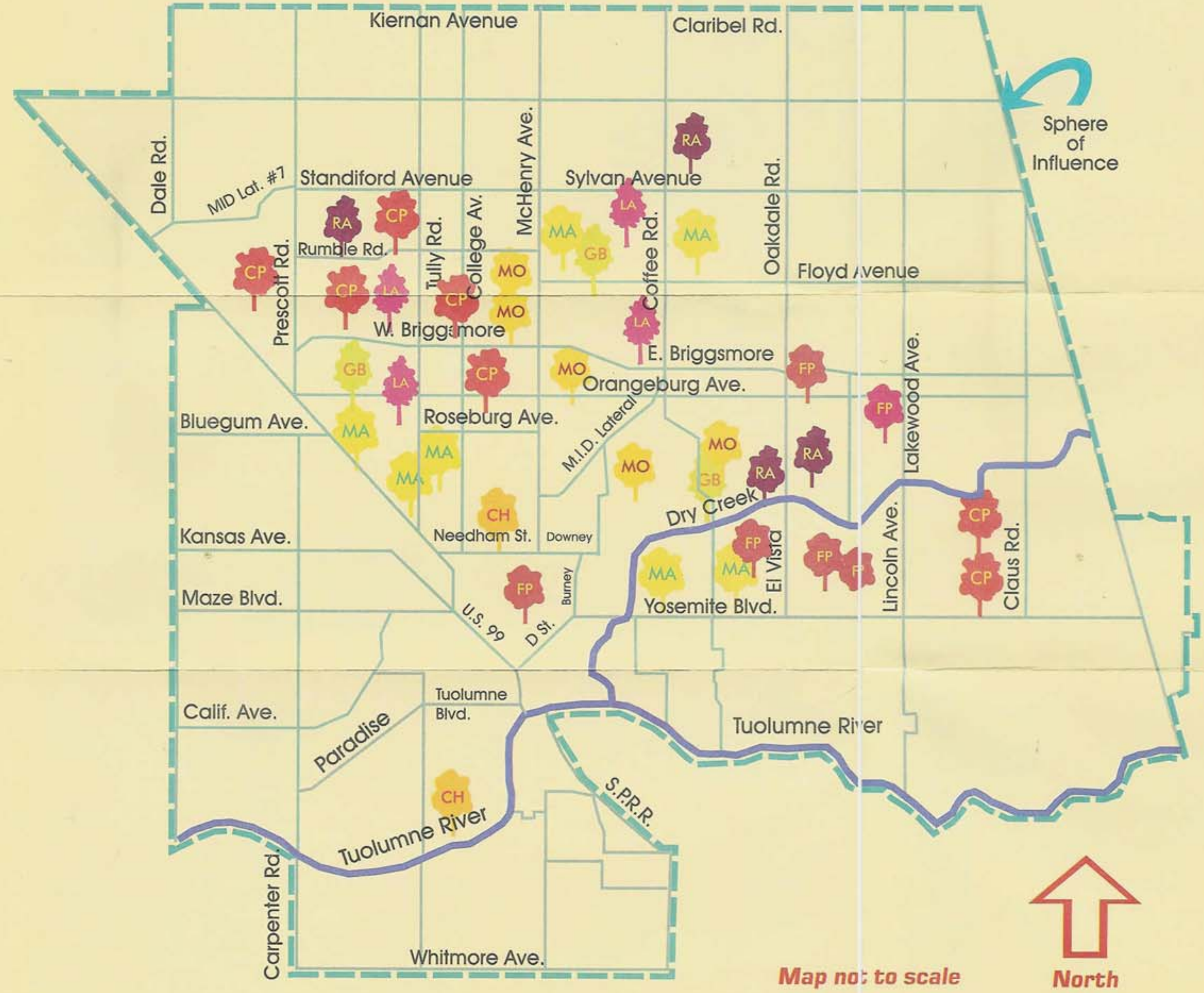
The chlorophyll content of tree leaves is due to a balance between chlorophyll synthesis and chlorophyll destruction. Throughout the year chlorophyll is constantly being produced and degraded. Even though light is necessary for the formation of chlorophyll in most species, there is evidence that continued exposure to sunlight will destroy chlorophyll. Ultra-violet light seems to be the chief cause of this destruction. Therefore, if a leaf is to remain green, new chlorophyll must be made constantly. This means that conditions must be favorable. As the days get shorter and temperatures get cooler in the fall, there is a decline in synthesis of new chlorophyll. The green color disappears and the rate of photosynthesis declines. The trees become very frugal and even more efficient by pulling nutrients such as nitrogen and phosphorus into twigs and branches to be stored for the winter, further enhancing the loss of chlorophyll.

Chinese Pistache dazzle with fluorescent colors

Along with chlorophyll, leaves also contain in the chloroplasts yellow or orange carotenoid pigments. This is the same pigment which gives the carrot its familiar color and also lends color to eyes, feathers, and scales of certain animals. Most of the year these yellowish colors are masked in leaves by the greater amount of green chlorophyll.

The carotenoid pigments play an important role in photosynthesis since they are able to capture light energy and transfer it to the primary chlorophyll pigment. As chlorophyll degrades, the yellowish colors become visible and give the leaves part of their fall splendor. It is the unmasking of the carotenoids that account for the yellow and golden color of Norway maple, Ohio buckeye, yellow poplar, sycamore, birches, hickories, ashes, and many other species of trees. This same process also may account for the yellowing of leaves at any time during the year due to nutrient deficiency or disease that reduces the normal synthesis of chlorophyll.

Variations among species in the timing of autumn color often reflect wide differences in the rate and amount of chlorophyll breakdown. Where trees are exposed to extra light from street lamps, the leaves closest to the lights often remain green longer and are shed last. Some leaves will lose practically all of their chlorophyll prior to shedding, whereas others will still retain a high proportion when the leaves fall. In English oak and sycamore maple, both chlorophyll and carotenoids decrease almost to zero, resulting in brown leaves. In English oak these pigments are depleted simultaneously, whereas in sycamore maple the decline in chlorophyll precedes that of carotenoids, resulting in yellow coloration before the leaves turn brown.



Key

	Botanical name **Common Name**	
GB	*Ginkgo biloba* **Ginkgo**	Wylie Dr Idywood Ct. Goldenwood Dr. Sandalwood Dr. Silkwood Dr. Claremont Av. Hampshire Ln. Heartwood Wy.
MA	*Fraxinus velutina* *'Modesto Ash'* **Modesto Ash**	La Loma Del Monte Av. Del Mar Av. E. Rumble Rd. Stanford Av. Princeton Av. Miller Av. College area
MO	*Fraxinus holotricha* *'Moraine'* **Moraine Ash**	Sherwood Av. Kirkwood Av. E. Orangeburg Av. El Vecino Av. Scottsdale Wy. Kruger Dr.
CH	*Celtis occidentalis* **Common Hackberry**	Mills Av. Wright St. Western Wy.
RA	*Fraxinus oxycarpa* *'Raywood'* **Raywood Ash**	Wylie Dr. Beyer Park Dr. Montclair Dr. Strathmore Dr. Sheldon Dr. Stone Crop Ln.
LA	*Liquidamber Styraciflua* **American Sweet Gum**	Dragoo Pk. Dr. David Ct. Del Rey Av. Greenwood Dr. Kingsbury Av. Theo Av. Suzanne Dr.
CP	*Pistacia chinensis* **Chinese Pistache**	College Av. Mt. Vernon Dr. W/ Rumble Rd. Creekwood Dr. McHenry Av. Tully Rd.
FP	*Pyrus calleryana* **Flowering Pear**	La Palma Dr. Edgebrook Dr. St. Pauls Wy. Elpasado Dr. 11th st. & I st. Lakewood Dr.