Periodic graphics

A collaboration between C&EN and Andy Brunning, author of the popular graphics blog Compound Interest

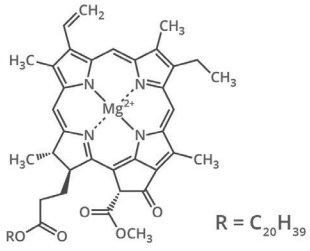
More online

To see more of Brunning's work, go to **compoundchem.com.** To see all of C&EN's Periodic Graphics, visit **cenm.ag/periodicgraphics.**

HOW DO EVERGREEN TREES STAY GREEN?

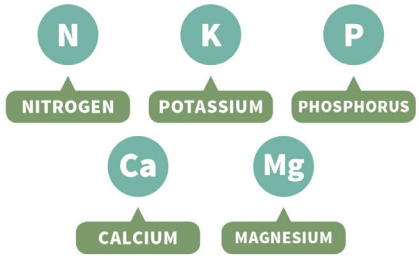
Many trees drop their leaves in the fall, but others stay green even in the depths of winter. Here, we look at the ways in which some trees accomplish this and how they handle the cold.

CHLOROPHYLL



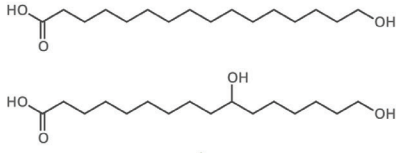
Chlorophyll gives leaves and needles their green color and is essential for photosynthesis. In the fall, low light levels and temperatures reduce production of chlorophyll (type a shown) in deciduous trees. It then breaks down, allowing the yellows, oranges, and reds of carotenoid and anthocyanin pigments to become visible before the leaves fall off.

WHY STAY GREEN?



Coniferous trees stay green in winter to conserve nutrients (key ones shown above) in their needles. This is especially important in the nutrient-poor environments where these trees tend to grow. By keeping their needles, the trees can continue to make small amounts of energy through photosynthesis during winter.

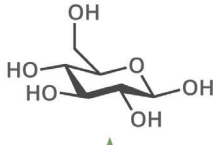
STAYING ALIVE



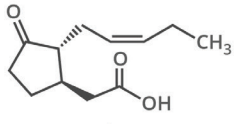
TYPICAL CUTIN MONOMERS

Cutin, a waxy polyester composed of fatty acids, coats evergreen needles and prevents water loss. As winter begins, the water in the needles migrates out of the trees' cells and into the spaces between the cells. In some species, cells with viscous contents vitrify (form an icy glass) rather than freezing, avoiding damage.

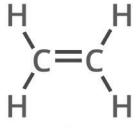
EVERGREEN ANTIFREEZE



GLUCOSE
(antifreeze compound)



JASMONIC ACID



ETHYLENE

(antifreeze-regulating hormones)

Evergreen trees can also protect their needles from ice damage using their own brand of antifreeze. During winter, sugars (such as glucose) and other compounds become more concentrated within the cells of the needles, depressing the freezing point of water.

In addition the trees produce antifreeze proteins, which bind to ice crystals and inhibit their growth. These proteins force crystals to take on a hexagonal shape as opposed to the needlelike structures that damage cells. Calcium and hormones such as ethylene and jasmonic acid have been shown to regulate plant antifreeze activity.