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# How Plants Keep Their Cool

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## THEY CAN'T MOVE OUT OF THE SUN; HOW DO THEY SURVIVE?

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It has been a long hot summer. All the desert creatures, and we human desert dwellers, would seek the shade or the air conditioning as temperatures climb into the upper 90's or top the 100° F mark. But what about the plants? They cannot get out of the sun; they just have to tough it out. Once a seed germinates and a plant becomes established, it is "rooted" in that location, and there it stays through heat and cold, rain or drought, until it dies. So just how do plants in the Upper Sonoran Desert cope with temperatures over 100°F and prolonged periods without rain?

The undisturbed desert and xeriscape gardens, favored by water conscientious residents, contain many different native and nonnative, desert adapted species. Each of these species has its own method of coping with heat and drought, but they share many common traits that adapt them to desert environments. The high solar radiation from our clear blue summer skies is the major challenge that desert plants must deal with to survive.

Part of the solar radiation (wavelengths of 400-700 nm) is used to provide the energy for photosynthesis, the process by which plants make sugars and carbohydrates. But leaves also receive short wave solar radiation directly



Cactus spines serve to provide protection for the cactus from the sun. At first, it is hard to believe that tiny cactus spines offer any real protection from the intense desert sun. But when you consider that a cactus can have thousands of spines and each spine provides a small amount of shade and multiply that by 1,000 - well it becomes easier to believe that spines really do offer some protection from the sun for the skin of the cactus.



from the sun and long wave infrared radiation reflected from the plant's surroundings; absorbing these types of energy is what makes a leaf (and a person) hot when out in the sun. People can reduce the amount of solar radiation they receive by standing in the shade and staying away from the walls of dark colored buildings. One way that plants reduce solar radiation is by reflecting it away.

Color, hairs and spines, salt glands, shape, size and orientation, and growth form are some of the ways that plants deal with excess thermal energy. The color of a plant affects the amount of solar radiation absorbed by leaves. Leaves that are shiny, light green or gray/silver in color have a high albedo or reflectivity and absorb less. Many desert shrubs including brittle bush (*Encelia farinosa*) and white bursage (*Ambrosia dumosa*) use color to stay cool.

Other desert shrubs such as woolly butterfly bush (*Buddleia marrubifolia*) have leaves covered with white hairs, while many cacti have white or light yellow spines, which are highly reflective and reduce their surface temperature. Experiments document that removing the reflective spines from a barrel cactus (*Ferocactus cylindraceus*) increased its average daytime surface temperature by 7.2°F. The salt-bushes (*Atriplex* species) get their common name from the salt glands on the leaves that are also reflective.

Vertical plants such as saguaros (*Carnegiea gigantea*) and most chollas and those with steeply inclined leaves (*Agave* species) decrease energy loads by reducing the amount of horizontal surface exposed to the rays of the sun, and thus lower leaf temperatures during stressful midday conditions. Many desert shrubs and trees have compound leaves made up of many small leaflets that are each less than 1/8" in diameter. These compound leaves have the ability to fold in half, changing from a horizontal to a vertical orientation as temperatures climb. When leaflets are that narrow, they also lose heat by convection



**Saguaro at Gateway Desert Awareness Park  
in Cave Creek**



(the loss of heat due to air movement across the leaf surface) which helps them stay at or even slightly below air temperature.

Of all the plant growth forms in the desert, perennial shrubs have the greatest ability to reduce leaf absorptance of solar radiation; that is one of the reasons shrubs



**Triangle-leaf Bursage**

*Ambrosia deltoidea*

**The “lynchpin” of the Sonoran Desert**

are so common in the Upper Sonoran Desert. A contrasting life form is that of desert winter annuals. These brief visitors to our landscape often have large, dark green leaves, with little ability to reduce the absorptance of solar radiation. Winter annuals only grow where or when water is readily available, and they need all of the solar energy they can get because they must photosynthesize at a high rate, grow fast, and produce seeds before they die when water disappears.



Losing water is another way plants stay cool in the desert. Evaporation from the surface of a leaf cools the leaf just as a swamp cooler cools a room. However, water is usually in short supply in a desert. Plants use water loss as a cooling mechanism only as a cost of carbon acquisition for photosynthesis. To live and grow plants use carbon dioxide from the air as a source for carbon to build sugars and carbohydrates through the process of photosynthesis. The carbon dioxide gets into the leaf through tiny pores called stomata. When these pores open to let the carbon dioxide diffuse into the leaf down a concentration gradient, water escapes out the pores because the air outside the leaf is drier than the air inside the cavity below the pore opening. This process of transpiration is costly in water because water molecules are smaller than carbon dioxide molecules, and the plant loses about six water molecules for every carbon dioxide molecule it gains.

Most perennial desert plants can only “afford” to grow when there is enough water in the soil to support the water loss that goes along with the uptake of carbon dioxide, and they certainly do not want to waste water by using it just to stay cool. So long-lived desert plants have adapted by using color, hairs, spines, small leaves, and an upright stature to reflect away solar radiation and stay cool.

However, there are tradeoffs to being highly reflective. When a desert plant reflects away solar energy, it is also reflecting away energy needed for photosynthesis. Dark green leaves typically absorb 85 percent of the incident solar radiation; a desert shrub with highly developed surface modifications may absorb only 30 to 40 percent. What the plant loses in its ability to photosynthesize, it gains in lower leaf temperatures; decreases in leaf temperatures of 8 to 18°F as a result of increased solar reflection are common.

Native and desert adapted plant species do well in our gardens. Many of the other plants available in local nurseries can survive only with large inputs of water. Water is a limited and costly commodity in the Upper Sonoran Desert; 80 to 90 percent of household water consumption is related to landscape irrigation. What kinds of plants do you have in your yard?

