How Plants Protect Themselves From Too Much Sunlight

If it gets too hot outside, all you have to do is step into the shade.

Plants, unfortunately, cannot do that, as they are exposed to sunlight day in and day out. They need just the right amount of sunlight to make food for themselves, as well as the entire food chain that depends on them.

However, too much or too little light can stress them out. So, when the amount of sunlight fluctuates, how do they keep a cool head, so to speak?

The secret lies in the many quick and efficient ways in which they react, such as disposing the excess light in the form of heat, or producing their own sunscreen. Excess sunlight can damage plant cells, especially the parts that manufacture food. This is because, among other things, excess light triggers the release of unstable and highly reactive compounds that can break down the cell.

Fortunately, cells respond quickly: when these compounds pile up inside the cell, alarm signals are immediately sent to specific genes that produce enzymes to neutralize the harmful compounds.
Many parts of this stress-response system have remained a mystery to plant biologists. Scientists have long tried to figure out how the alarm signal gets passed on from the chloroplast (the pigment that picks up the sunlight first) to the genes inside the cell's nucleus.

Earlier studies have shown that the signal starts inside the chloroplast from the photosynthesis chain (the series of reactions that uses sunlight to make food) specifically from a protein called plastoquinone (PQ). PQ passes electric signals from one part of the plant's food factory to another.

When the amount of sunlight is just right, photosynthesis proceeds smoothly. When there is too much or too little light, however, the signal stops with PQ, keeping it in a reduced state – where it is devoid of oxygen. The piling up of reduced PQ molecules is the first sign that something is wrong.

Now, researchers have uncovered the missing link between this pool of reduced PQ and the genes: a set of proteins called heat-shock proteins.

Plants normally produce heat-shock proteins under stress, when the outside temperature shoots up – as their name suggests. These proteins latch on to specific parts of the plant’s DNA and start or stop production of proteins that protect or damage the cell, respectively.

Under excess light, the presence of the reduced PQ pool also triggers the release of heat-shock proteins, the researchers found. These proteins move from the outer area of the cell into the nucleus. Once inside, they bind to a specific gene and boost production of a key enzyme that breaks down toxic compounds.

The plant's stress response is so quick that excess light alone is enough to trigger the release of the heat-shock proteins, even if there is no change in heat, the researchers observed from plants growing in a temperature-controlled room.

Plants reacted in a similar manner when they were also treated with low light and herbicide, albeit not as quickly as when they were under excess light, the researchers found.

*Arabidopsis*, the common flowering plant used in the study, produces 21 different types of heat shock proteins. By constructing artificial gene models producing each type separately, the researchers were able to narrow the search down to the three heat-shock proteins that were directly involved. They found that one particular type boosted enzyme production under multiple stress conditions.

Heat-shock proteins are only one piece in this complex puzzle of how plants react to changes in the environment. Further research is needed to figure out how other signals from the chloroplast work in tandem with the heat-shock proteins. Figuring out these mechanisms could also shed light on how plants cope with other environmental stresses.

These findings were published in the journal *Proceedings of the National Academy of Sciences*. 