Photoperiodism: Can Plants Tell Time?

Can plants tell time? Of course not. Or can they?

Plants have evolved complex strategies to thrive in particular environments. And thriving means being able to reproduce successfully. One adaptation, called photoperiodism, is particularly intriguing because it shows that plants are able to "count" the amount of time that has passed.

The term photoperiodism is used to describe a phenomenon in which physiological changes occur in an organism in response to day length; that is, the relative amounts of light and darkness in a 24-hour period. In some plant species, for example, the onset of flowering is triggered by day length.

This is easily observed in nature. Some plant species bloom in summer, for example, and some produce flowers in fall. This timing coincides with conditions that maximize the species' ability to reproduce; for example, the presence of the plant's primary pollinators.

Day Length: The Long and Short of It

Plants are categorized as long-day, short-day or day-neutral, which refers to the conditions they require in order to trigger the formation of flower buds. Once these triggering conditions are met, the plants switch from purely vegetative growth (growing foliage) to also initiating reproductive growth (producing flowers). Note that the trigger stimulates the *onset* of flower bud formation; the actual flower buds and blooms may not appear on the plant until weeks later.

In general,

- *Long-day plants* begin to set flowers when the days are growing longer in spring; that is, when the number of hours of light per day is approaching its yearly maximum. Summer-blooming Rudbeckia (black-eyed Susan) is a good example.
- *Short-day plants*, on the other hand, initiate flowering when days are growing shorter in late summer. A familiar example is the fall-blooming chrysanthemum.
- For ***day-neutral plants***, day-length doesn't trigger flower bud formation. Instead, other factors are at play, such age the plant's age or developmental stage.

The physiological shift to reproductive growth and flowering based on day length means that, incredibly, long-day and short-day plants are somehow able to keep track of the relative number of hours of light and darkness in each 24-hour period!

The Discovery of Photoperiodism

The phenomenon of photoperiodism was discovered in the 1920s. Researchers studying a type of tobacco found that the plants all flowered at approximately the same time in summer, regardless of when the seed was sown or the age of the plants. Then they discovered a mutant plant in a field of tobacco that grew to an enormous height without ever flowering. They took cuttings of this tobacco plant, grew them in a greenhouse, and found that the cuttings all flowered in December. Based on this and previous experiments, researchers wondered if day length was a factor in the timing of the plants' flowering. They used the term photoperiodism to describe the plants' production of flowers in response to photoperiod — the length of time exposed to light.

Subsequent experiments showed that it was actually the number of hours of uninterrupted darkness, rather than hours of light, that was stimulating the plants' switch from vegetative growth to reproductive growth.

How It Works

Later experiments showed that a light-sensitive protein pigment called phytochrome is involved in a plant's ability to track day length (or, more accurately, night length). This pigment molecule occurs in two forms, an active form and an inactive form. The molecule converts from one form to the other depending upon the type of light it receives.

In total darkness, the active form gradually reverts to the inactive form. The length of time in darkness determines the ratio of the two forms. The ability to monitor this ratio is how a plant "counts" the number of hours of darkness. When this ratio reaches a certain level (which depends upon the species and variety), the plant's darkness requirement met. Only then will the leaves will release the plant growth regulators to travel throughout the plant and initiate the flowering process.

Put the Poinsettia in the Closet

If you've ever tried to keep a poinsettia growing through summer with the hopes of getting the colorful bracts to appear in time for Christmas, you probably learned that this requires some effort and diligence on your part.

Poinsettias are short-day plants native to the mountains of Mexico. In order to stimulate the plants to produce their small yellow flowers — and colorful bracts associated with them — you need to mimic the day-length conditions in their native habitat.

Starting in October, the plants must be in complete darkness for 14 hours per day. Any interruption of darkness — a streetlight, a light switched on in a room — can interfere with the process. One way to provide these conditions is to place the plant in a closet with a tight-fitting door (so no light leaks in) for those 14 hours. For the other 10 hours per day, the plant should be placed in bright, indirect light. If you're diligent, the plants should flower — and color up — in December.

It's easy to imagine the efforts commercial growers must take to meet the exacting needs of poinsettias and other day-length-dependent blooming plants to ensure they're in their full glory at just the right time, when consumers want to buy them. Precise timing systems for lighting and the ability to provide complete darkness to thousands of plants is a massive undertaking. Yet, reliably, every holiday season stores are chock-full of poinsettias.

Imagine what a breakthrough it would be if scientists could fully unlock the secrets to photoperiodism in poinsettias, and create a simpler way for growers to get their poinsettias to color up!