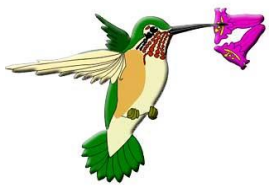
ScienceWatch - Just the Right Balance

"It's really the first attempt to use the tools of molecular biology….to understand how it is that plants solve a really important dilemma, with regard to sex. Because plants want to have sex, just like all other organisms, they want to have the benefit of outcrossing, but they can't move, and they've got to vector their gametes through a, sort of a postal service … through pollinators." - Ian Baldwin

Flowers are all about sex, and they all face the same problem. They need to attract as many pollinators as possible, who, while drinking nectar, will pick up pollen and perform the service of transferring it to other flowers. In this manner the plant not only spreads its own genes, but picks up potentially beneficial ones from others of its kind—a process known as outcrossing. But what if the first visitor takes all the nectar, draining the day's production and leaving the flower unattractive to everyone else? One strategy is to make lots of nectar, but that takes energy and it doesn't stop a greedy pollinator. So how does a plant achieve the right balance of being attractive to pollinators, yet shooing them away so some nectar is left for others?

A team of molecular biologists headed by Ian Baldwin, Max-Planck-Institute, Jena, Germany, has the answer in the August 29, 2008 issue of *Science*. By genetically manipulating two chemical components normally present in the nectar of a desert tobacco plant (*Nicotioana attenuata*), Baldwin and his colleagues show how these compounds influence the amount of nectar removed by pollinators, and the number of visits a flower receives. By using the right combination of chemicals, the flower both attracts and repels its pollinators, which increases the number of visits and optimizes its own reproduction.

Each evening the tobacco plant opens its small white flowers to lure its main pollinators, hawkmoths, like the white-lined sphinx moth (*Hyles lineata*), and hummingbirds, like the black-chinned hummingbird (*Archilocus alexandri*). To attract them it embellishes its nectar with benzyl acetone (BA), a sweet-smelling compound, but it also laces its nectar with bitter-tasting nicotine (N) that acts as repellant.



In order to study the effect of each chemical individually, Baldwin and his colleagues first determined what genes produce these chemicals and then, using a gene silencing technique, made four lines of genetically modified plants. Plants were created that could not make either BA or N, as well as a line that made neither chemical. Lastly, a control line was also genetically manipulated, but without impairing the function of either gene. The transgenic plants were grown in special plots at a field station in the Great Basin Desert in Utah.

To determine the effect of each chemical on pollinator activity, the scientists measured the amount of nectar left by them each morning and also monitored the number and duration of visits with video cameras. Flowers lacking N had about half the nectar volume of those that produced N, verifying that N acts as a deterrent to excessive nectar consumption. Videos also confirmed that N is a deterrent; both pollinators lingered almost twice as long while drinking at flowers lacking N than from those that contained it. The videos also showed that flowers lacking BA, with or without N, received fewer visits from hummingbirds and hawkmoths, confirming that BA is an attractant.

The presence of N not only increased the number of visits per flower, it also deterred flower-devouring caterpillars and nectar-robbing carpenter bees. The bees pierce the bottom of the flower and take nectar without transferring any pollen. Surprisingly, BA also discouraged this activity. Most important from the plant's point of view, DNA analysis of seeds produced by each line of plants, showed that the control group, containing normal levels of BA and N, was most successful at passing pollen along to neighboring plants and receiving pollen from them.

These plants, it seems, have learned that by striking the right balance—not too sweet, not to bitter—they gain the sweet smell of success.

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