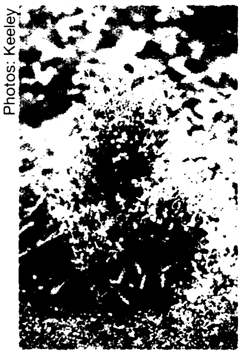
Where there's smoke, there's germination

A wildfire blazes through a chaparral, incinerating the dense brush and charring the scrub oak. The plants that live in this dry western habitat are adapted to the occasional fire, however, and soon re-green the blackened landscape—"almost like magic," says Stanford University ecologist Hal Mooney.

Scientists have long thought that heat is responsible for triggering new growth after a burn, and for some hard-seeded plants that seems to be the case. Heat destroys the outer coat, letting the seed soak up water and germinate.

More recent work shows that chaparral plants respond not to the heat but to the smoke. Out of the cocktail of chemicals gassing from a smoking fire, plant ecologists Jon E. Keeley and C.J. Fotheringham of Occidental College in Los Angeles have found one that has a dramatic effect on germination: nitrogen dioxide.

Photos: Keeley



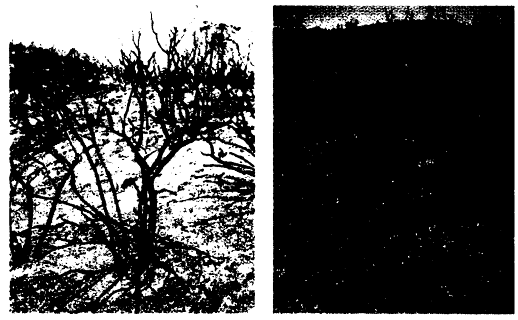
Whispering bells sprout after nitrogen dioxide, a trace gas in smoke, triggers seed germination.

The researchers, reporting in the May 23 SCIENCE, tested the effects of smoke and nitrogen dioxide on seeds of whispering bells (*Emmenanthe penduliflora*), an annual flowering plant that thrives on newly burned ground.

"What we've shown is that the nitrogen dioxide in smoke, at the same levels that occur in smoke, is sufficient to induce complete germination in the species," says Keeley.

In almost all trials, 100 percent of the seeds germinated in response to the experimental treatments, while the control seeds stayed dormant. "It's the difference between night and day," says Keeley.

The response was strong whether the seeds were exposed directly or indirectly to the trigger. The seeds could be gassed with nitrogen dioxide, smoked with a burning twig, or incubated on sand or filter paper that had been exposed to nitrogen dioxide or to smoke. In the nitrogen dioxide treatments, all the seeds germinated in only half a minute.



A fire in the Santa Monica (Calif.) mountains charred the chaparral (left), but wildflowers bloomed the next spring (right).

Fire ecologist William J. Platt of Louisiana State University in Baton Rouge says he likes the newly found role for nitrogen dioxide. "It may be very general because it is very simple."

The smoke signal seems to work in some other species, but it doesn't explain the germination of all fire-adapted plants, says Keeley. Although fire plays a part in many different plant communities, smoke-induced germination seems to be restricted to plants from climates with hot, dry summers, like those of the Mediterranean. Smoke-induced germination has been found in chaparral-like communities in parts of South Africa and Australia. "It's likely that the nitrogen dioxide mechanism will work in some of those systems as well," says Keeley.

The species in chaparral communities are closely related to desert plants and demand a lot of sunlight, says Keeley. It is to their advantage for seeds to lie dormant until a fire burns away the brush, allowing the seedlings to get enough light, he explains.

Exactly how nitrogen dioxide in smoke triggers germination isn't clear. The researchers found that although water can enter a seed whether it is dormant or not, smoke induces a change in the permeability of a barrier under the seed coat, opening it up to certain other molecules.

Seeds lying dormant in the chaparral soil may be affected by nitrogen dioxide from sources other than wildfires, Keeley and Fotheringham point out. Nitrogen oxides are a by-product of fossil fuel combustion, and nitrogen concentrations in polluted areas like Los Angeles are high enough to trigger seed germination, the researchers suggest. Without a fire to clear the brush, the germinating seeds wouldn't survive, potentially threatening the population.

Although ecological and other impacts from increasing amounts of nitrogen in the environment loom large (SN: 2/15/97, p.100), Keeley says there is as yet no evidence that nitrogen pollution is initiating seed germination. —*C. Mlot*

DNA doubles in a four-stranded huddle

DNA's elegant, double helical structure provides the basis for its information storage and copying functions. Using X-ray crystallography, a team of researchers has observed DNA in a novel shape—a quadruplex. Two closed, twisted loops of single-stranded DNA, synthesized by the researchers, nestle side by side, forming a structure with four adjacent strands.

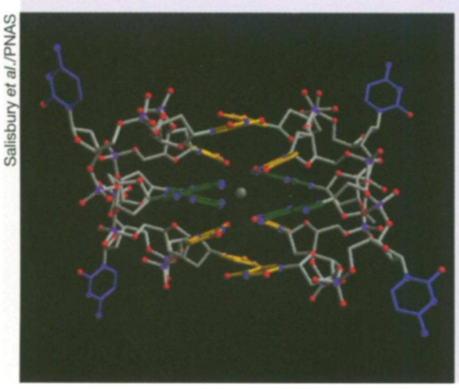
In this image, one loop is on the left, the other on the right. Each contains eight bases: two adenines (green), four thymines (yellow), and two cytosines (blue), arranged ATTCATTC. Base pairs of adenine and thymine run diagonally between the two loops, with unpaired thymines above and below. The cytosines keep to the fringes. A central sodium atom "helps to moderate the electrostatic repulsion" between the bases in the crystallized material, says Stephen A. Salisbury of the University of Cambridge Crystallographic Data Centre in England.

He and his colleagues at the University of Göttingen in Germany and the University of Barcelona in Spain report their findings in the May 27 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

The researchers didn't set out to look for the quadruplex, says Cambridge crystallographer Harold R. Powell. "That was a bit of a surprise to us." Originally, they synthesized the loops to examine the structure of hairpin turns in DNA.

After determining that the DNA formed a quadruplex, the researchers learned that another group had previously seen a similar four-stranded structure held together by cytosine-guanine base pairs. "That's when we started looking at it more closely and felt that it might be a more general structure" rather than an anomalous result of the crystallization, Powell says.

Salisbury *et al.*/PNAS



Scientists have evidence that when chromosomes exchange genes, four strands from two DNA double helixes come together to form an intermediate structure called a Holliday junction, which looks like the street curbs of a four-way intersection. Salisbury and his colleagues speculate that the quadruplex could be an alternative way for DNA to associate during gene swapping.

"It's an interesting motif that requires experimental challenge" to determine its biological significance, says Nadrian C. Seeman of New York University. —C. Wu