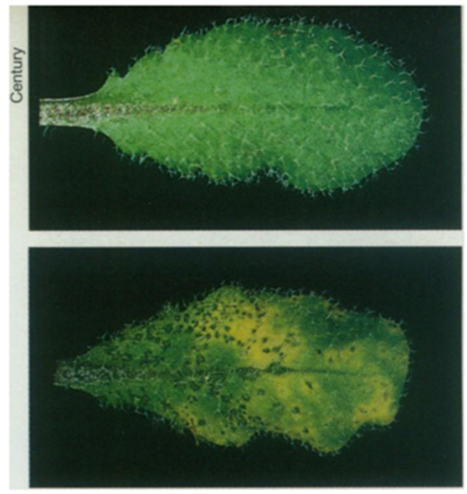
Hunt for a botanical gene for all diseases



A leaf from the mustard plant Arabidopsis *resists attack when inoculated with a bacterial pathogen (top). When a newly identified gene—*NDR1*—involved in general plant disease defense is mutated, the plant succumbs to the bacterium and displays the typical dark spots surrounded by yellow tissue (bottom).*

In the last 5 years, biologists have struck a genetic bonanza in the armamentarium that plants use to avoid getting sick. They've found genes for resistance to bacterial infections in tomatoes, to viruses in cauliflower, to fungi that attack barley, and, just this year, to nematodes that devour sugar beets.

Each of these specific plant genes defends against a single disease-causing organism or, more often, a specific strain or variant of the organism.

Researchers have been looking for a more general defense mechanism that might allow important crops to be bred or genetically engineered to withstand a wide range of assaults. They've found the gene for what seems to be part of such a defense in the simple, widely used experimental plant *Arabidopsis*.

Plant biologists Karen S. Century of San Francisco State University, Brian J. Staskawicz of the University of California, Berkeley, and their colleagues screened plants grown from mutated seeds to find the first evidence of the gene about 2 years ago. They have now come up with its DNA sequence, as well as more evidence that the gene is involved in warding off very different kinds of pathogens.

The gene, labeled *NDR1*, "plays a really central role in plant disease resistance," says Century.

"If you knock it out, you knock out resistance to several strains" of a bacterial pathogen, *Pseudomonas syringae*, that attacks tomatoes. "Even more important," she adds, "it knocks out resistance to fungal pathogens," namely, several strains of the mildew-causing organism *Peronospora parasitica*.

This more general plant response offers some clues about the molecular bucket brigade that swings into action when a microbe or nematode attempts to infect a leaf or shoot.

A strain-specific plant gene seems to maintain a constant supply of a protein that recognizes some marker on the invader. The recognition proteins pass the signal down the line, where it eventually reaches *NDR1*, which is structurally unlike the strain-specific genes. The *NDR1* gene encodes a protein whose amino acid sequence suggests that it's associated with a membrane somewhere in the cell.

Another difference is that production turns on only when a pathogen is present, the researchers report in the Dec. 12 SCIENCE. "It's novel," says Century, "kind of a pioneer protein."

She and her colleagues are now working to determine exactly what the protein does and how it manages to thwart such different invaders. They are also testing it for activity triggered by still more pathogens, including viruses.

Undoubtedly there are other important genes to be found in the general biochemical pathway by which plants resist disease (SN: 8/14/93, p. 103), says molecular biologist Xinnian Dong of Duke University in Durham, N.C., but *NDR1* "is significant."

The gene "may be tying together many different receptors," says Christopher R. Somerville of the Carnegie Institution of Washington in Stanford, Calif. More intriguing is that it may even be tied to the defense system in animals.

Researchers have found similarities between many plant disease resistance genes and the genes that enable the well-studied fruit fly *Drosophila* to fight off fungal attack. The signals in the resistance pathway may therefore have their evolutionary roots in the early development of multicellular organisms.

The genes recently found in *Arabidopsis* can now be used to find their counterparts in crop plants. Century, for example, is working on disease resistance in rice. —*C. Mlot*

Beatin' those low-life blue-laser blues

It took scientists decades to construct a solid-state laser that would shine a beam of blue light. Now, they may finally have built one robust enough to be useful commercially.

Last year, a team of Japanese researchers announced that it had developed gallium nitride (GaN) semiconductor laser diodes that provide a continuous output of blue light at room temperature. Those diodes had a distinct limitation, however: They had an operational lifetime of only 27 hours.

Now, the same team, led by Shuji Nakamura of Nichia Chemical Industries in Tokushima, reports in the Dec. 1 JAPANESE JOURNAL OF APPLIED PHYSICS that it has produced GaN diodes that have already lasted over 100 times longer in tests conducted at room temperature. Tests at higher temperatures indicate that the diodes have an estimated life of over 10,000 hours.

The most likely first use for these blue laser diodes will be in optical data storage, where the amount of information stored on a given area of a disk's surface could be three or four times higher than that written by the infrared laser beams used today. The diodes could also find uses in high-resolution laser printers, full-color electronic displays, and undersea optical communications, says Nakamura.

The researchers used two different fabrication techniques to extend the life of the diodes. First, the new components include 120 layers of GaN, each 25 nanometers thick, alternating with 2.5-nm-thick layers of GaN that also contain small amounts of aluminum. Previous versions of the diodes contained thicker layers of the aluminum gallium nitride material, which tended to crack under stresses induced by temperature changes during operation.

Second, Nakamura's team formed the new laser diodes on top of a 20-millimeter-thick base of GaN specially designed to constrain the growth of crystal defects.

The researchers built the GaN base atop a series of silicon dioxide strips separated by narrow gaps. These strips distort slightly the structure of the GaN base above them, creating physical stresses that steer the spread of any crystal defects. Instead of ascending to the surface, where they would affect the performance of the layered diodes, most of the defects remain confined to the bottom 5 mm of the 20-mm GaN base.

The few crystal defects that eventually grow to the upper surface of the GaN base do so at predictable locations. By selecting other spots on the surface on which to fabricate the diodes, Nakamura's team dramatically improved the laser's useful lifetime.

The laser operates at a wavelength of 401 nanometers, about half the wavelength of red and infrared lasers. Its color lies at the extreme blue end of the visible-light spectrum.

"Producing a blue laser diode is a great step, but you need to get the cost down, the power output up, and the right color to use this in [an electronic] display," says R.L. Melcher of IBM's Thomas J. Watson Research Center in Yorktown Heights, N.Y. —*S. Perkins*