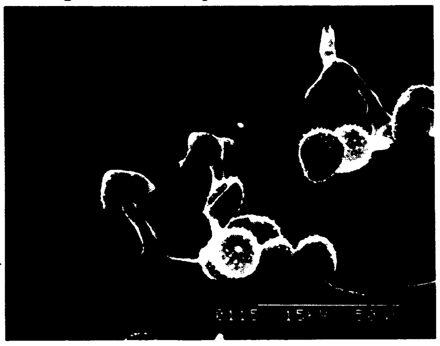
Fungi feel their way to feast

From a fungus's point of view, the surface of a bean leaf is a complex terrain of ridges and valleys. Yet the bean rust fungus seems to know exactly where it is going in its quest to invade the leaf's stomata, or pores. Cornell University researchers now have shown that, unlike many other organisms that rely heavily on chemical signals to survive, the bean rust fungus uses very specific, *tactile* clues to navigate and infest bean leaves. This finding may give agricultural researchers a new weapon for battling plant fungal diseases, which annually cause hundreds of millions of dollars worth of damage to U.S. crops.



Hoch et al./SCIENCE

Bean rust hyphae balloon into infection bulbs when they encounter 0.5-micron-high ridges of an artificial terrain.

In the March 27 SCIENCE, Harvey C. Hoch and his colleagues report that a plant's step-like ridges of a specific height induce the fungus to form the stomatal infection structures from which it launches its attack into the leaf. They found that the fungus's hyphae, or thread-like cells that explore the leaf's surface, are most likely to balloon into the infection structure when they encounter a 0.5-micron-high ridge.

The researchers tested the response of the fungus by letting it wander over plastic surfaces that were molded from silicon wafers etched with ridges, ranging in height from 0.03 to 5 microns. According to Hoch, a plant pathologist at Cornell's New York State Agricultural Experiment Station in Geneva, N.Y., infection structures formed at 0.5-micron-tall ridges more than 70 percent of the time; no structures grew over any ridges that were shorter than 0.1 micron or taller than 1 micron. The spacing between ridges is also important both for directing the hypha's path along the surface and in determining whether an infection structure will be constructed.

Hoch's co-workers at Cornell in Ithaca, N.Y., include plant researcher Richard C. Staples and Brian Whitehead, Jerry Comeau and Edward D. Wolf, who made the submicron terrains.

The fungus's preference for 0.5-micron-high ridges on the silicon terrains makes sense because, as Hoch's group later discovered with a scanning electron microscope, the "guard cells" of bean leaf stomata have lips or ridges that measure about 0.49 microns high. In previous work with chemically inert plastic replicas of bean leaves, Willard Wynn, a plant pathologist at the University of Georgia in Athens, had suggested that the fungal infection structures are triggered solely by the topography of these stomatal cells. But, writes Hoch's group, "the nature, size and location of these topographical signals have until now only been surmised."

Now that they have identified the topographical trigger, researchers can use this knowledge to foil the fungus by developing bean strains that have either no stomatal lips or lips that are taller or shorter than 0.5 microns, says Hoch. "This would make the plant completely immune [to bean rust fungus]," says Wynn. "It's not just a matter of being resistant. It would be completely disease free. It's really quite important."

Today, bean plants are designed to resist rust fungus by walling it off or by releasing toxins once the fungus has invaded the plant through the stomata. The problem with this approach, notes Hoch, is that "the fungus can [quickly] change genetically to overcome the chemical resistance of the plant. . . . But we think a physical feature is something that it may not adapt to so fast."

Apart from its importance to agriculture, Wynn says, Hoch's work is fascinating from a biological point of view. "I don't think that in animals or bacteria or higher plants, there is any other recognition system quite the same [as the rust fungus's tactile response]," he says, although two other classes of plant fungi do seem to take similar physical clues from their environment.

Hoch and his colleagues are now studying the detailed mechanism that enables the rust fungus to translate a physical stimulus into a message to build an infection structure. Hoch says they've identified a half dozen proteins and genes that seem to be involved in the construction of infection structures. They plan to investigate the function of these genes by putting them into other kinds of fungi and seeing whether these fungi grow structures when they encounter physical stimuli. — *S. Weisburd*

U.S. river quality: Not all signs are good

The first major long-term study of water quality in the nation's rivers shows some diverging trends. Though it reports that between 1974 and 1981 there were widespread decreases in contamination from fecal bacteria and inorganic lead, it also reports widespread increases in nitrate levels, river salinity and concentrations of the toxic metals arsenic and cadmium. What will make these increases especially difficult to manage, the water researchers say, is that they are largely linked to diffuse sources of pollution — ones not addressed by the Environmental Protection Agency's massive program for upgrading water quality through better sewage treatment.

The new study, reported in the March 27 SCIENCE, quantifies trends for 24 different measures of water quality. It is based on data collected over seven and a half years by two nationwide sampling networks, which together surveyed more than 300 major U.S. river sites.

"Perhaps the foremost surprise," says hydrologist Richard A. Smith of the U.S. Geological Survey in Reston, Va., one of the study's authors, is the nitrate trend. Over the sampling period, there was about a 50 percent increase in nitrate concentrations at 116 sampling sites, he points out. The main factors contributing to this increase were fertilizer runoff and acid rain.

Nitrates contribute to the oxygen depletion — and eventual oxygen starvation — of coastal estuaries, Smith says; at levels higher than those measured in this study, they can be a human health hazard as well. And there is growing concern that nitrates might develop into carcinogens. For example, Smith says, "It's possible that nitrates in drinking water could get converted into [carcinogenic] nitrosamines by the body." Studies are under way to explore this at the University of Nebraska in Omaha.

Another surprising finding was that the growing levels of cadmium and arsenic found polluting many rivers come not from direct discharge into the waters by industry, but rather from atmospheric deposition of air pollutants — especially coal-combustion emissions. As for the increased salinity found in more than a third of the sampling sites, the researchers were able to correlate much of it to the use of road salt.

Finally, while their analysis confirms the benefits of sewage treatment plants in lowering fecal bacteria levels in river water, it raises questions about the plants' overall significance in limiting biologically serious oxygen depletion. Limiting oxygen depletion by removing oxygen-demanding wastes has been a primary justification for investing in better plants — at a national cost of more than $100 billion over the past 15 years. But, says Smith, though previous studies had suggested that as much as 13 percent of U.S. streams (as measured in miles) might be benefiting from better sewage treatment, this more comprehensive analysis now suggests the benefit is closer to 1 or 2 percent. — *J. Raloff*