PLANT GENETICS

A Hidden *Arabidopsis* Emerges Under Stress

The common mustard plant (*Arabidopsis thaliana*) may look drab, but results published online by *Nature* this week show that it has a surprising ability to break out into new forms—some of them weird and exotic—when it is under stress.

The report's authors, Susan Lindquist, now chief of the Whitehead Institute in Cambridge, Massachusetts, and her University of Chicago colleagues Christine Queitsch and Todd Sangster, suggest that this ability may play an important role in evolution, possibly allowing organisms to store up alternative survival strategies and express them only when environmental challenges go beyond the normal range.

Unmasked. The standard plant (*top*) reveals exotic new forms if HSP90 is restricted.

Queitsch says that the current findings grew out of earlier research on fruit flies by Suzanne Rutherford, a member of Lindquist's group when she was at Chicago (*Science*, 4 December 1998, p. 1796). In that work, Rutherford, now at the Fred Hutchinson Cancer Research Center in Seattle, Washington, wanted to see how changing the level of a protein called heat shock protein 90 (HSP90) affects fly development. HSP90, a so-called chaperone, helps protect organisms against the deleterious effects of high temperatures by binding to cell proteins and keeping them from unraveling and clumping together.

Lindquist and her colleagues were investigating how HSP90 protects individual flies from harmful genetic mutations when they discovered that its role is at once broad and transitory. Rutherford found that reducing HSP90 in developing fruit flies produced dramatic morphological changes, such as misshapen wings and abnormal eyes. Some of these mutations became "fixed" and could be passed on to subsequent generations.

The broad pattern suggested that the fruit fly genome harbors many developmental mutations that are normally suppressed by HSP90. Rutherford and Lindquist gave the name "buffering" to this ability to store but not express alternative genetic programs. Queitsch explains that HSP90—which physically stabilizes the function of proteins by altering their shape—is just one of many chaperone proteins that appear to have similarly widespread effects on gene expression. The researchers proposed that this ability allows eukaryotes to experiment with radically new phenotypes when an established phenotype comes under stress.

To see how widespread the phenomenon might be, Queitsch tried a similar experiment in *Arabidopsis*, an organism she says she chose because it is so genetically distant from the fruit fly. If the same pattern emerged, she and her colleagues reasoned, it would strengthen the argument that there may be simple environmental variables—such as concentration of HSP90—that bring about dramatic variations in gene expression. They treated *Arabidopsis* seedlings with a chemical that interferes with *HSP90* genes and produced a stunning array of developmental changes.

They found, for example, that leaves that are normally held at right angles come out in a whirling dervish formation, the plant's ordinary gentle green hue turns dark, and roots that should dive into the earth reach instead for the sky.

A variety of experiments showed that the changes the Lindquist group saw were not due to random drug effects but reflected underlying genetic differences in the plant strains. By crossing different genotypes, inbreeding them, and comparing the effects of HSP90 on offspring, the Chicago researchers say they found that the plants clustered in morphological groups according to their genetic lineage.

The study is "excellent," and the analysis of this genetic puzzle is "really super-interesting," says botanist John Archibald of the University of British Columbia in Vancouver, Canada. It is particularly interesting, according to cellular biochemist F. Ulrich Hartl of the Max Planck Institute for Biochemistry in Martinsried, Germany, because it applies "a protein biochemical concept to phenomena which are normally viewed in a genetic and more deterministic framework." He notes, however, that this paper says less about the heritability of traits than the fruit fly report, suggesting that the authors may be "taking a step back" from the proposal that buffering offers an evolutionary advantage.

Sangster and Queitsch say that there has been no retreat, just a shift in emphasis. They intend to study evolutionary effects in their next experiments. They also plan to use HSP90 to bring out hidden variations that could be valuable in agriculture—looking for ways to modify plants without germ line alterations.

—Eliot Marshall

COMPUTING

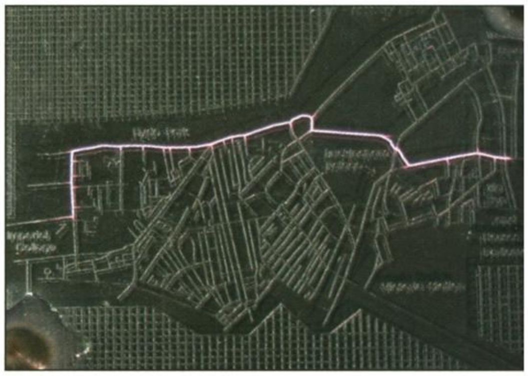
Gas-Filled Chip Bids to Outshine a Computer

Want to take in all the sights of London without wearing out your shoes or make all those sales visits in the shortest possible distance? Let some glowing helium gas do the walking. Andreas Manz and colleagues at the Imperial College of Science, Technology, and Medicine, London, and a Harvard University team led by George Whitesides are taking a crack at the classic "traveling salesman problem" (TSP) in an entirely new way: using a lab on a chip.

Finding the shortest route around a certain number of stops—whether they are tourist attractions, potential customers, or workstations in a factory—is relatively easy if the number of stops is small. But as more stops are added, the complexity of the calculation increases exponentially until it becomes impossible to compute.

Mathematicians and computer scientists have struggled with the TSP for decades, but Manz and Whitesides, specialists in lab-on-a-chip technology, describe a more mechanistic approach in the May edition of the journal *Lab on a Chip*. Essentially, they have etched the problem onto a sliver of glass and let a fluid find the best route. They have so far used this analog device to work out the shortest routes between various landmarks in central London, such as Imperial College and Buckingham Palace. Other researchers call the work an impressive technical demonstration. "It is very, very cool," says microengineer David Beebe of the University of Wisconsin, Madison.

The researchers' first step was to repre-



A to Z. Glowing helium shows the shortest route from Imperial College to Big Ben.

CREDITS: (TOP TO BOTTOM) C. QUEITSCH *ET AL., NATURE* 749 (2002); DARWIN REYES sent the problem graphically by etching a map of London onto a glass chip. They then covered the etched part of the chip with another piece of flat glass to create a network of pipes. They also fixed tiny electrodes to the chip so that they could apply a voltage to various locations.

The researchers then pumped low-pressure helium into the chip through open channels along one edge and filled the pipes. Using the electrodes, they could then apply an electric voltage between two points on the chip. The electric field would then guide an electric discharge along the shortest route between the two points, making the helium glow like a fluorescent tube just along that route. The answer to the problem literally lights up. The team members say the method can at present be used to find the way out of a maze and the shortest route between two points, but they hope to develop it for the more complex TSP and network flow problems. "We had really good fun doing this," Manz says.

Manz concedes that the technique has limitations, such as the fact that once a layout is etched onto a device it cannot be changed. But the team hopes to scale up to much more complex problems soon. "With present knowledge about plasma discharge in narrow capillaries, we can assume to be able to work with 5-micrometer capillaries instead of the current 250-micrometer channels in this example," says Manz. This would allow them to stud a 6-cm^2 chip with 1 million electrodes, providing $2^{1,000,000}$ routes across the chip.

Next the researchers hope to find a way to control the opening and shutting of channels on the fly. That would enable them to create a variable chip that could solve a range of problems by changing the network each time to represent a different maze, map, or network layout. "The new digital wave of technologies has opened up a variety of possibilities that will be very hard to surpass," Manz acknowledges. Still, he says, "this technology would benefit from open-minded engineers with a good feeling for where the future lies in computing."

Whether glass chips can rival a digital computer remains to be seen. "There is no doubt that [this is] a clever piece of work," says computer scientist Paul Purdom of Indiana University, Bloomington. "It is an interesting physics problem to determine whether it can be made to work more rapidly than a traditional computer." Beebe thinks racing a digital computer is pointless. But "I'll bet there are other applications … that none of us have thought of yet," he says.

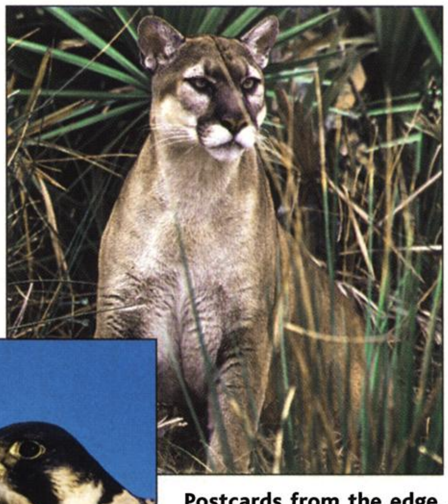
–DAVID BRADLEY

David Bradley is a writer based in Cambridge, U.K.

ENDANGERED SPECIES ACT

Cherished Concepts Faltering in the Field

Scientists at the U.S. Fish and Wildlife Service (FWS) thought they had finally won a measure of respect from their peers after adopting two major revisions in their approach to endangered species: setting aside critical habitat, and taking a big picture, or whole ecosystem, view in writing recovery plans. Now they must be feeling like the Rodney Dangerfields of ecology. A clutch of papers in the June issue of *Ecological Applications* suggests that FWS's new approach is faltering. At stake is the success of a series of high-profile initiatives, including the agency's ambitious plan for protecting the Florida Everglades and its 68 imperiled species.




Postcards from the edge. Unlike the peregrine falcon, the Florida panther remains in grave danger.

CREDITS: (TOP TO BOTTOM) TOM AND PAT LESSON/PHOTO RESEARCHERS; JEFF LEPORE/PHOTO RESEARCHERS

Not that the old modus operandi—essentially viewing an endangered species in a vacuum—was a smashing success. Of roughly 1000 species listed in the United States as endangered, only 13—including the American peregrine falcon and the American alligator—have rebounded enough to warrant removal from the list. For years, sympathetic voices blamed this disappointing record on a welter of litigation that siphoned away FWS funding for implementing recovery plans. "They're getting eaten alive by the day-to-day issues," says James Michael Scott, a University of Idaho, Moscow, zoologist who works extensively with FWS. Critics, however, have derided the agency's grip on current science.

For a sweeping review of protection strategy, FWS and the Society for Conservation Biology launched a massive data-crunching project in 1998 involving more than 300 people at 19 universities. An army of students led

ScienceScope

Eisenstein Leaves NSF The head of the National Science Foundation's biggest directorate surprised colleagues last week by stepping down from the job. Sources say he felt he had lost the confidence of NSF director Rita Colwell.

Robert Eisenstein, assistant director for mathematics and physical sciences (MPS), announced that he plans to spend the next 12 months on professional leave at CERN, Europe's particle physics laboratory near Geneva. A nuclear physicist, the 60-year-old Eisenstein joined NSF in 1992 and has served for 4 1/2 years as head of MPS, a $920 million program that funds several large facilities as well as providing grants to individuals and groups.

"His departure leaves MPS with a big hole to fill," says chemist Billy Joe Evans of the University of Michigan, Ann Arbor, chair of the directorate's advisory committee. "Bob has done a great job, and his departure was totally unexpected."

NSF officials declined to comment on Eisenstein's decision. But Evans says that NSF deputy director Joseph Bordogna told the committee that the agency "is moving toward having a 5-year term limit for [assistant directors]." According to Evans, Bordogna also noted that NSF's widespread use of rotators—academics who come to Washington for a few years—strengthens NSF's management by allowing it "to change course quickly."

Eisenstein, who remains on NSF's payroll, called his NSF stint "a wonderful scientific opportunity." At CERN he will join a team planning the installation of Atlas, one of four detectors for the Large Hadron Collider.

Next Up The longtime director of the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, has agreed to do double duty for the beleaguered parent organization.

Last week, Smithsonian Institution secretary Lawrence Small named Ira Shapiro as the new interim undersecretary of science, a job embroiled in controversy since Small announced his plan last spring to reorganize Smithsonian research. Shapiro succeeds Dennis O'Connor, who is headed for the University of Maryland (*Science*, 12 April, p. 235).

A search committee will hunt for a permanent replacement for O'Connor, who has also served as acting director of the National Museum of Natural History.

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