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-

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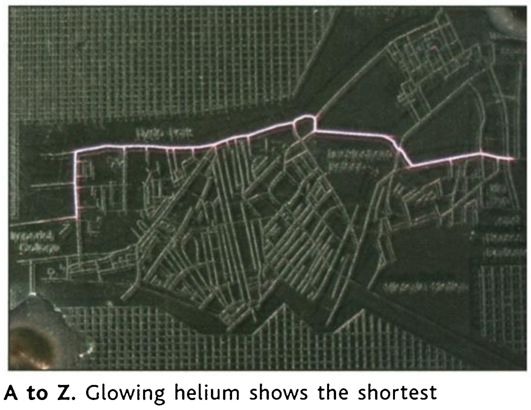

A to Z. Glowing helium shows the shortest route from Imperial College to Big Ben.